# CALIFORNIA HIGH-SPEED TRAIN

Technical Report


# DRAFT

## Fresno to Bakersfield Section

# Geology, Soils, and Seismicity

July 2011

CALIFORNIA High-Speed Rail Authority

U.S. Department of Transportation
Federal Railroad Administration

**California High-Speed Train Project EIR/EIS**

# Geology, Soils, and Seismicity Technical Report

*Prepared by:*
URS/HMM/Arup Joint Venture

July 2011

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## Acronyms and Abbreviations

| | |
|---|---|
| AP Act | Alquist-Priolo Earthquake Fault Zoning Act |
| CDMG | California Division of Mines and Geology |
| CEQA | California Environmental Quality Act |
| CGS | California Geological Survey |
| CWA | Clean Water Act |
| EIR/EIS | Environmental Impact Report/ Environmental Impact Statement |
| DOGGR | Division of Oil, Gas, and Geothermal Resources |
| EL | elevation |
| FRA | Federal Rail Administration |
| g | gravity |
| HMF | Heavy Maintenance Facility |
| HST | High-Speed Train |
| InSAR | interferometric synthetic aperture radar |
| MA | million years ago |
| mph | miles per hour |
| MRZ | Mineral Resource Zone |
| msl | mean sea level |
| NASA | National Aeronautics and Space Administration |
| NEPA | National Environmental Policy Act |
| NRCS | Natural Resources Conservation Service |
| OSHA/Cal-OSHA | Occupational Safety & Health Administration/California Occupational Safety and Health Administration |
| P-C | Production-Consumption |
| PCC | Portland cement concrete |
| PEIR/PEIS | Program Environmental Impact Report/Program Environmental Impact Statement |
| PGA | peak ground acceleration |
| ROD | Record of Decision |

| | |
|---|---|
| RWQCB | Regional Water Quality Control Board |
| SCS | Soil Conservation Service |
| SMARA | Surface Mining and Reclamation Act |
| SR | State Route |
| SWPPP | Stormwater Pollution Prevention Plan |
| USACE | U.S. Army Corps of Engineers |
| USDA | U.S. Department of Agriculture |
| USGS | U.S. Geological Survey |

# Chapter 1.0
## Introduction

# 1.0 Introduction

The California High-Speed Rail Authority (Authority) proposes to construct, operate, and maintain an electric-powered High-Speed Train (HST) system in California. When completed, the nearly 800-mile train system would provide new passenger rail service to more than 90% of the state's population. More than 200 weekday trains would serve the statewide intercity travel market. The HST would be capable of operating speeds of up to 220 miles per hour (mph), with state-of-the art safety, signaling, and automated train control systems. The system would connect and serve the major metropolitan areas of California, extending from San Francisco and Sacramento in the north to San Diego in the south.

In 2005, the Authority and the Federal Railroad Administration (FRA) prepared a Program Environmental Impact Report/Environmental Impact Statement (Statewide Program EIR/EIS) evaluating HST's ability to meet the existing and future capacity demands on California's intercity transportation system (Authority and FRA 2005). This was the first phase of a tiered environmental review process (Tier 1) for the proposed statewide HST system. The Authority and the FRA completed a second Program EIR/EIS in July 2008 to identify a preferred alignment for the Bay Area to Central Valley section (Authority and FRA [2008] 2010).

The Authority and FRA are now undertaking second-tier, project environmental evaluations for sections of the statewide HST system. This Geology, Soils, and Seismicity Technical Report is for the Fresno to Bakersfield Section. The Fresno to Bakersfield Section begins at the proposed Fresno HST station in downtown Fresno and extends south just past the proposed Bakersfield HST station in downtown Bakersfield to Union Street. Information from this report is summarized in the project EIR/EIS for the Fresno to Bakersfield HST Section and will be part of the administrative record supporting the environmental review of the proposed project.

For the HST system, including the Fresno to Bakersfield Section, the FRA is the lead federal agency for compliance with the National Environmental Policy Act (NEPA) and other federal laws. The Authority is serving as a joint-lead agency under NEPA and is the lead agency for compliance with the California Environmental Quality Act (CEQA). The U.S. Army Corps of Engineers (USACE) is serving as a cooperating agency under NEPA for the Fresno to Bakersfield Section.

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# Chapter 2.0

## Project Description

# 2.0 Project Description

## 2.1 Project Introduction

The Fresno to Bakersfield Section of the HST project would be approximately 114 miles long, varying in length by only a few miles based on the route alternatives selected. To comply with the Authority's guidance to use existing transportation corridors when feasible, the Fresno to Bakersfield HST Section would be primarily located adjacent to the existing BNSF Railway right-of-way. Alternative alignments are being considered where engineering constraints require deviation from the existing railroad corridor, and to avoid environmental impacts.

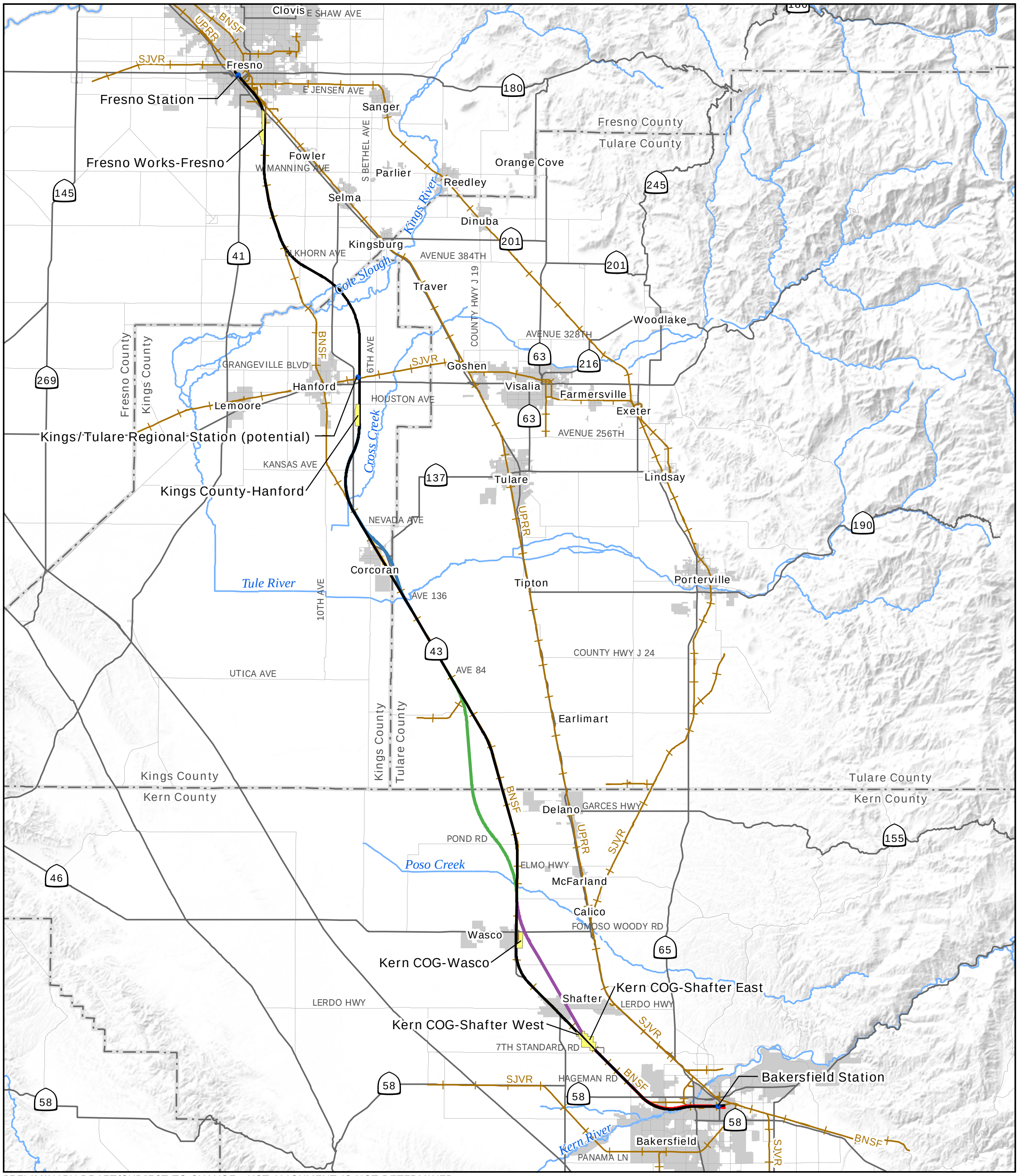
The Fresno to Bakersfield HST Section would cross both urban and rural lands and include a station in both Fresno and Bakersfield, a potential Kings/Tulare Regional Station in the vicinity of Hanford, a potential heavy maintenance facility (HMF), and power substations along the alignment. The HST alignment would be entirely grade-separated, meaning that crossings with roads, railroads, and other transport facilities would be located at different heights (overpasses or underpasses) so that the HST would not interrupt nor interface with other modes of transport. The HST right-of-way would also be fenced to prohibit public or automobile access. The project footprint would consist primarily of the train right-of-way, which would include both a northbound and southbound track in an area typically 100 feet wide. Additional right-of-way would be required to accommodate stations, multiple track at stations, maintenance facilities, and power substations.

The Fresno to Bakersfield Section would include at-grade, below-grade, and elevated track segments. The at-grade track would be laid on an earthen rail bed topped with rock ballast approximately 6 feet off of the ground; fill and ballast for the rail bed would be obtained from permitted borrow sites and quarries. Below-grade track would be laid in an open or covered trench at a depth which would allow roadway and other grade-level uses above the track. Elevated track segments would span long sections of urban development or aerial roadway structures and consist of steel truss aerial structures with cast in place reinforced-concrete columns supporting the box girders and platforms. The height of elevated track sections would depend on the height of existing structures below, and would range from 40 to 80 feet. Columns would be spaced 60 feet to 120 feet apart.

## 2.2 Project Alternatives

### 2.2.1 Alignment Alternatives

This section describes the Fresno to Bakersfield HST Section project alternatives, including the No Project Alternative. The project EIR/EIS for the Fresno to Bakersfield HST Section examines alternative alignments, stations, and HMF sites within the general BNSF Railway corridor. Discussion of the HST project alternatives begins with a single continuous alignment (the BNSF Alternative) from Fresno to Bakersfield. This alternative most closely aligns with the preferred alignment identified in the Record of Decision (ROD) for the Statewide Program EIR/EIS. Descriptions of the additional five alternative alignments that deviate from the BNSF Alternative for portions of the route then follow. The alternative alignments that deviate from the BNSF Alternative were selected to avoid environmental, land use, or community issues identified for portions of the BNSF Alternative (Figure 2-1).




PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

May 16, 2011

Source: URS, 2011

- BNSF Alternative
- Corcoran Elevated
- Corcoran Bypass
- Allensworth Bypass
- Wasco-Shafter Bypass
- Bakersfield South
- Station location
- Alternative heavy maintenance facility (HMF)
- Stream
- Existing rail line
- Community/Urban area
- County boundary

N

0 5 10 Miles

0 10 20 Kilometers

Figure 2-1
Fresno to Bakersfield HST alignments

### A. NO PROJECT ALTERNATIVE

Under the No Project Alternative, the HST System would not be built. The No Project Alternative represents the condition of the Fresno to Bakersfield Section as it existed in 2009 (when the Notice of Preparation was issued), and as it would exist without the HST project at the planning horizon (2035). To assess future conditions, it was assumed that all currently known programmed and funded improvements to the intercity transportation system (highway, rail, and transit), and reasonably foreseeable local development projects (with funding sources identified), would be developed by 2035. The No Project Alternative is based on a review of Regional Transportation Plans (RTPs) for all modes of travel, the State of California Office of Planning and Research CEQAnet Database, the Federal Aviation Administration Air Carrier Activity Information System and Airport Improvement Plan grant data, the State Transportation Improvement Program, airport master plans and interviews with airport officials, intercity passenger rail plans, and city and county general plans and interviews with planning officials.

### B. BNSF ALTERNATIVE ALIGNMENT

The BNSF Alternative Alignment would extend approximately 114 miles from Fresno to Bakersfield and would lie adjacent to the BNSF Railway route to the extent feasible (Figure 2-1). Minor deviations from the BNSF Railway corridor would be necessary to accommodate engineering constraints, namely wider curves necessary to accommodate the HST (as compared with the existing lower-speed freight line track alignment). The largest of these deviations occurs between approximately Elk Avenue in Fresno County and Nevada Avenue in Kings County. This segment of the BNSF Alternative would depart from BNSF Railway corridor and instead curve to the east on the northern side of the Kings River and away from Hanford, and would rejoin the BNSF Railway corridor north of Corcoran.

Although the majority of the alignment would be at-grade, the BNSF Alternative would include aerial structures in all of the four counties through which it travels. In Fresno County, an aerial structure would carry the alignment over Golden State Boulevard and SR 99 and a second would cross over the BNSF Railway tracks in the vicinity of East Conejo Avenue. The alignment would be at-grade with bridges where it crosses Cole Slough and the Kings River into Kings County.

In Kings County, the BNSF Alternative would be elevated east of Hanford where the alignment would pass over the San Joaquin Valley Railroad and SR 198. The alignment would also be elevated over Cross Creek, and again at the southern end of the city of Corcoran to avoid a BNSF Railway spur. In Tulare County, the BNSF Alternative would be elevated at the crossing of the Tule River and at the crossing of the Alpaugh railroad spur that runs west from the BNSF Railway mainline. In Kern County, the BNSF Alternative would be elevated over Poso Creek and through the cities of Wasco, Shafter, and Bakersfield. The BNSF Alternative would be at-grade through the rural areas between these cities.

The BNSF Alternative Alignment would provide wildlife crossing opportunities by means of a variety of engineered structures. Dedicated wildlife crossing structures would be provided from approximately Cross Creek (Kings County) south to Poso Creek (Kern County) in at-grade portions of the railroad embankment at approximately 0.3-mile intervals. In addition to those structures, wildlife crossing opportunities would be available at elevated portions of the alignment, bridges over riparian corridors, road overcrossings and undercrossings, and drainage facilities (i.e., large diameter [60 to 120 inches] culverts and paired 30-inch culverts). Where bridges, aerial structures, and road crossings coincide with proposed dedicated wildlife crossing structures, such features would serve the function of, and supersede the need for, dedicated wildlife crossing structures.

The preliminary wildlife crossing structure design consists of a modified culvert in the embankment that would support the HST tracks. The typical culvert would be 72 feet long from end to end (crossing structure distance), would span a width of approximately 8 feet (crossing structure width), and would provide 4 feet of vertical clearance (crossing structure height). Additional wildlife crossing structure designs could include circular or elliptical pipe culverts, and larger (longer) culverts with crossing structure distances of up to 100 feet. The design of the wildlife crossing structures may change depending on site-specific conditions and engineering considerations.

### C. CORCORAN ELEVATED ALTERNATIVE ALIGNMENT

The Corcoran Elevated Alternative Alignment would be the same as the corresponding section of the BNSF Alternative Alignment from approximately Idaho Avenue south of Hanford to Avenue 136, except that it would pass through the city of Corcoran on the eastern side of the BNSF Railway right-of-way on an aerial structure. The aerial structure begins at Niles Avenue and returns to grade at 4th Avenue. Dedicated wildlife crossing structures would be provided from approximately Cross Creek south to Avenue 136 in at-grade portions of the railroad embankment at intervals of approximately 0.3 mile. Dedicated wildlife crossing structures would also be placed between 100 and 500 feet to the north and south of both the Cross Creek and Tule River crossings.

This alternative alignment would cross SR 43 and pass over several local roads on an aerial structure. Santa Fe Avenue would be closed at the HST right-of-way.

### D. CORCORAN BYPASS ALTERNATIVE ALIGNMENT

The Corcoran Bypass Alternative Alignment would run parallel to the BNSF Alternative Alignment from approximately Idaho Avenue south of Hanford, to approximately Nevada Avenue north of Corcoran. The Corcoran Bypass Alternative would then diverge from the BNSF Alternative and swing east of Corcoran, rejoining the BNSF Railway route at Avenue 136. The total length of the Corcoran Bypass would be approximately 21 miles.

Similar to the corresponding section of the BNSF Alternative, most of the Corcoran Bypass Alternative would be at-grade. However, one elevated structure would carry the HST over Cross Creek, and another would travel over SR 43, the BNSF Railway, and the Tule River. Dedicated wildlife crossing structures would be provided from approximately Cross Creek south to Avenue 136 in at-grade portions of the railroad embankment at intervals of approximately 0.3 mile. Dedicated wildlife crossing structures would also be placed between 100 and 500 feet to the north and south of each of the Cross Creek and Tule River crossings.

This alternative alignment would cross SR 43, Whitley Avenue/SR 137, and several local roads. SR 43, Waukena Avenue, and Whitley Avenue would be grade-separated from the HST with an overcrossing/undercrossing; other roads would be closed at the HST right-of-way.

### E. ALLENSWORTH BYPASS ALTERNATIVE ALIGNMENT

The Allensworth Bypass Alternative Alignment would pass west of the BNSF Alternative, avoiding Allensworth Ecological Reserve and the Allensworth State Historic Park. This alignment was refined over the course of environmental studies to reduce impacts to wetlands and orchards. The total length of the Allensworth Bypass Alternative Alignment would be approximately 19 miles, beginning at Avenue 84 and rejoining the BNSF Alternative at Elmo Highway.

The Allensworth Bypass Alternative would be constructed on an elevated structure only where the alignment crosses the Alpaugh railroad spur and Deer Creek. The alignment would pass through Tulare County mostly at-grade. Dedicated wildlife crossing structures would be provided from approximately Avenue 84 to Poso Creek at intervals of approximately 0.3 mile. Dedicated wildlife crossing structures would also be placed between 100 and 500 feet to the north and south of both the Deer Creek and Poso Creek crossings.

The Allensworth Bypass would cross County Road J22, Scofield Avenue, Garces Highway, Woollomes Avenue, Magnolia Avenue, Palm Avenue, Pond Road, Peterson Road, and Elmo Highway. Woollomes Avenue and Elmo Highway would be closed at the HST right-of-way, while the other roads would be realigned and/or grade-separated from the HST with overcrossings.

The Allensworth Bypass Alternative includes an option to relocate the existing BNSF Railway tracks to be adjacent to the HST right-of-way for the length of this alignment. The possibility of relocating the BNSF Railway tracks along this alignment has not yet been discussed with BNSF Railway; however, if this option is selected, it is assumed that the existing BNSF Railway right-of-way would be abandoned between Avenue 84 and Elmo Highway, and the relocated BNSF Railway right-of-way would be 100 feet wide and adjacent to the eastern side of the Allensworth Bypass Alternative right-of-way.

#### F. WASCO-SHAFTER BYPASS ALTERNATIVE ALIGNMENT

The Wasco-Shafter Bypass Alternative Alignment would diverge from the BNSF Alternative between Sherwood Avenue and Fresno Avenue, crossing over to the eastern side of the BNSF Railway tracks and bypassing Wasco and Shafter to the east. The Wasco-Shafter Bypass Alternative would be at grade except where it travels over 7th Standard Road and the BNSF Railway to rejoin the BNSF Alternative. The total length of the alternative alignment would be approximately 24 miles.

The Wasco-Shafter Bypass was refined to avoid the Occidental Petroleum tank farm as well as a historic property potentially eligible for listing on the National Register of Historic Places. The Wasco-Shafter Bypass would cross SR 43, SR 46, East Lerdo Highway, and several local roads. SR 46, Kimberlina Road, Shafter Avenue, Beech Avenue, Cherry Avenue, and Kratzmeyer Road would be grade-separated from the HST with overcrossings/undercrossings; other roads would be closed at the HST right-of-way.

#### G. BAKERSFIELD SOUTH ALTERNATIVE ALIGNMENT

From the Rosedale Highway (SR 58) in Bakersfield, the Bakersfield South Alternative Alignment would run parallel to the BNSF Alternative Alignment at varying distances to the north. At Chester Avenue, the Bakersfield South Alternative curves south, and runs parallel to California Avenue. As with the BNSF Alternative, the Bakersfield South Alternative would begin at grade and become elevated starting at Palm Avenue through Bakersfield to its terminus at the southern end of the Bakersfield station tracks. The elevated section would range in height from 50 to 70 feet. Dedicated wildlife crossing structures would be placed between 100 and 500 feet to the north and south of the Kern River.

The Bakersfield South Alternative would be approximately 9 miles long and would cross the same roads as the BNSF Alternative. This alternative includes the Bakersfield Station–South Alternative.

### 2.2.2 Station Alternatives

The Fresno to Bakersfield HST Section would include a new station in Fresno and a new station in Bakersfield. An optional third station, the Kings/Tulare Regional Station, is under consideration.

Stations would be designed to address the purpose of the HST, particularly to allow for intercity travel and connection to local transit, airports, and highways. Stations would include the station platforms, a station building and associated access structure, as well as lengths of bypass tracks to accommodate local and express service at the stations. All stations would contain the following elements:

- Passenger boarding and alighting platforms.
- Station head house with ticketing, waiting areas, passenger amenities, vertical circulation, administration and employee areas, and baggage and freight-handling service.
- Vehicle parking (short-term and long-term) and "kiss and ride[1]".
- Motorcycle/scooter parking.
- Bicycle parking.
- Waiting areas and queuing space for taxis and shuttle buses.
- Pedestrian walkway connections.

## A. FRESNO STATION ALTERNATIVES

Two alternative sites are under consideration for the Fresno Station.

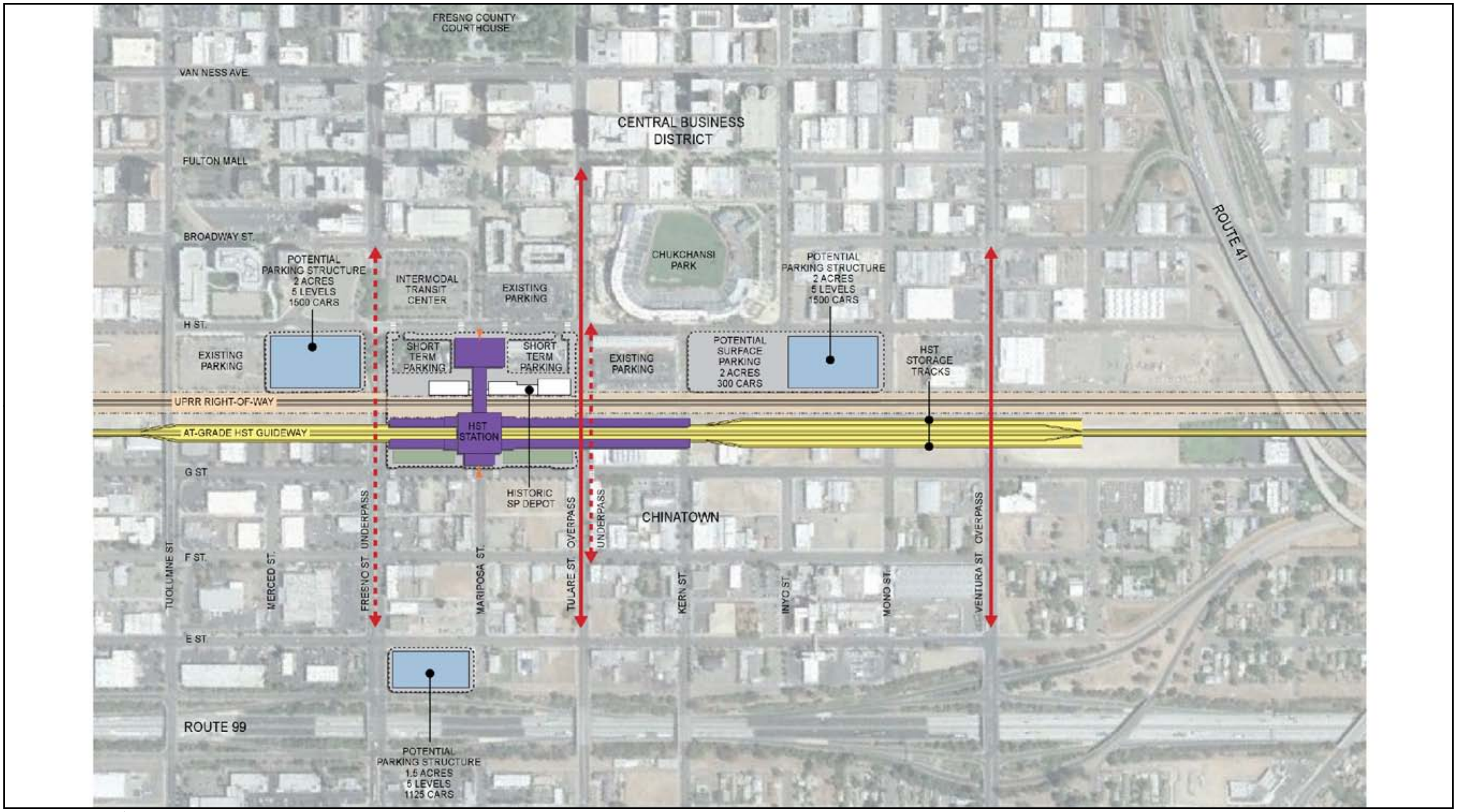
### Fresno Station–Mariposa Alternative

The Fresno Station–Mariposa Alternative would be in downtown Fresno, less than 0.5 mile east of SR 99 on the BNSF Alternative. The station would be centered on Mariposa Street and bordered by Fresno Street on the north, Tulare Street on the south, H Street on the east, and G Street on the west. The station building would be approximately 75,000 square feet, with a maximum height of approximately 64 feet.

The two-level station would be at-grade; with passenger access provided both east and west of the HST guideway and the UPRR tracks, which would run parallel with one another adjacent to the station. The first level would contain the public concourse, passenger service areas, and station and operation offices. The second level would include the mezzanine, a pedestrian overcrossing above the HST guideway and the UPRR tracks, and an additional public concourse area. Entrances would be located at both G and H streets. A conceptual site plan of the Fresno Station–Mariposa Alternative is provided in Figure 2-2.

The majority of station facilities would be east of the UPRR tracks. The station and associated facilities would occupy approximately 20.5 acres, including 13 acres dedicated to the station, short term parking, and kiss-and-ride accommodations. A new intermodal facility, not a part of this proposed undertaking, would be located on the parcel bordered by Fresno Street to the north, Mariposa Street to the south, Broadway Street to the east, and H Street to the west (designated "Intermodal Transit Center" in Figure 2-2). Among other uses, the intermodal facility would accommodate the Greyhound facilities and services that would be relocated from the northwestern corner of Tulare and H streets.

[1] "Kiss and ride" refers to the station area where riders may be dropped off or picked up before or after riding the HST.

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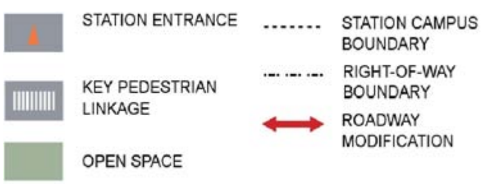
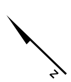



NOT TO SCALE

Figure 2-2
Fresno Station-Mariposa Alternative

The site proposal includes the potential for up to three parking structures occupying a total of approximately 5.5 acres. Two of the three potential parking structures would each sit on 2 acres, and each would have a capacity of approximately 1,500 cars. The third parking structure would be slightly smaller in footprint (1.5 acres), with five levels and a capacity of approximately 1,100 cars. An additional 2-acre surface parking lot would provide approximately 300 parking spaces.

Under this alternative, the historic Southern Pacific Railroad depot and associated Pullman Sheds would remain intact. While these structures could be used for station-related purposes, they are not assumed to be functionally required for the HST project and are thus, not proposed to be physically altered as part of the project. The Mariposa station building footprint has been configured to preserve views of the historic railroad depot and associated sheds.

**Fresno Station–Kern Alternative**

The Fresno Station–Kern Alternative would be similarly situated in downtown Fresno and would be located on the BNSF Alternative, centered on Kern Street between Tulare Street and Inyo Street (Figure 2-3). This station would include the same components as the Fresno Station–Mariposa Alternative, but under this alternative, the station would not encroach on the historic Southern Pacific Railroad depot just north of Tulare Street and would not require relocation of existing Greyhound facilities.

The station building would be approximately 75,000 square feet, with a maximum height of approximately 64 feet. The station building would have two levels housing the same facilities as the Fresno Station–Mariposa Alternative (UPRR tracks, HST tracks, mezzanine, and station office). The approximately 18.5-acre site would include 13 acres dedicated to the station, bus transit center, short term parking, and kiss-and-ride accommodations.

Two of the three potential parking structures would each sit on 2 acres, and each would have a capacity of approximately 1,500 cars. The third structure would be slightly smaller in footprint (1.5 acres) and have a capacity of approximately 1,100 cars. Surface parking lots would provide approximately 600 additional parking spaces. Like the Fresno Station–Mariposa Alternative, the majority of station facilities under the Kern Alternative would be sited east of the HST tracks.

### B. KINGS/TULARE REGIONAL STATION

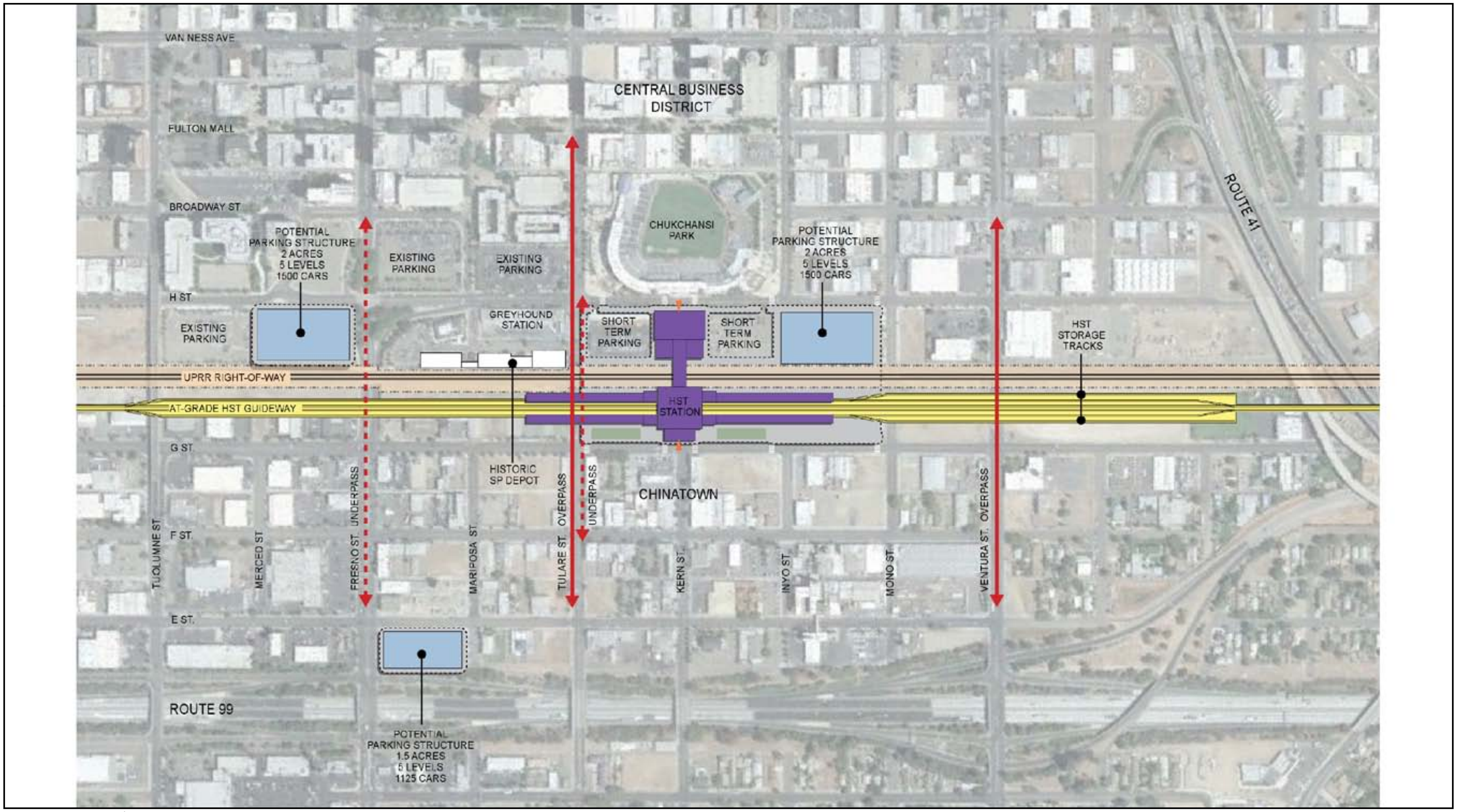
The potential Kings/Tulare Regional Station would be located east of SR 43 (Avenue 8) and north of the Cross Valley Rail Line (San Joaquin Valley Railroad) (Figure 2-4). The station building would be approximately 40,000 square feet with a maximum height of approximately 75 feet. The entire site would be approximately 27 acres, including 8 acres designated for the station, bus transit center, short-term parking, and kiss-and-ride. An additional approximately 19 acres would support a surface parking lot with approximately 1,600 spaces.

### C. BAKERSFIELD STATION ALTERNATIVES

Two options are under consideration for the Bakersfield Station.

**Bakersfield Station–North Alternative**

The Bakersfield Station–North Alternative would be located at the corner of Truxtun and Union Avenue/SR 204 along the BNSF Alternative Alignment (Figure 2-5). The three-level station building would be 52,000 square feet, with a maximum height of approximately 95 feet. The first level would house station operation offices and would also accommodate trains running along the

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May 16, 2011

STATION ENTRANCE

KEY PEDESTRIAN LINKAGE

OPEN SPACE

STATION CAMPUS BOUNDARY

RIGHT-OF-WAY BOUNDARY

ROADWAY MODIFICATION

NOT TO SCALE

Figure 2-3
Fresno Station-Kern Alternative


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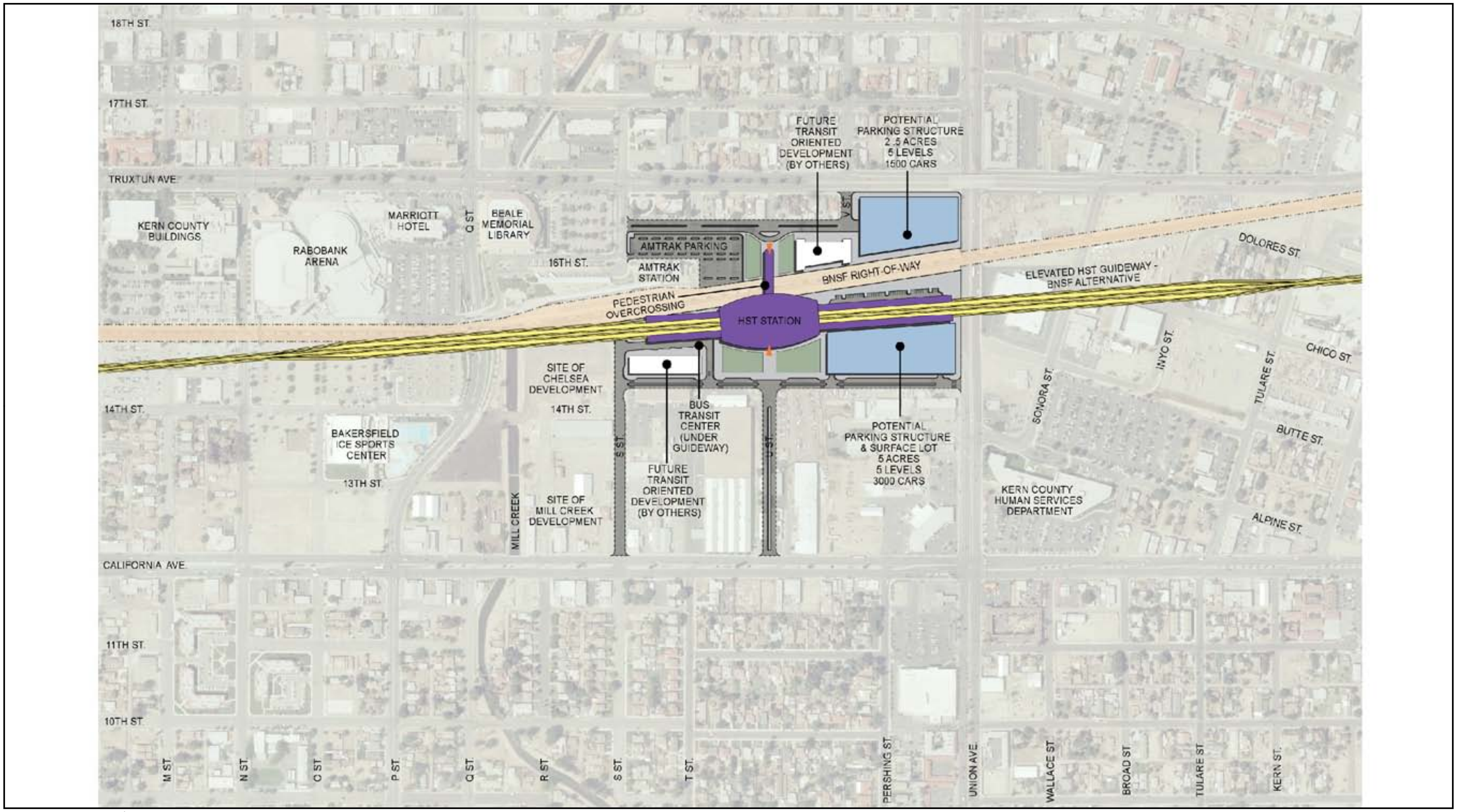
NOT TO SCALE

Figure 2-4
Kings/Tulare Regional Station (potential)

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NOT TO SCALE

Figure 2-5
Bakersfield Station-North Alternative

BNSF Railway line. The second level would include the mezzanine; the HST platforms and guideway would pass through the third level. Under this alternative, the station building would be located at the western end of the parcel footprint. Two new boulevards would be constructed to access the station and the supporting facilities.

The 19-acre site would designate 11.5 acres for the station, bus transit center, short-term parking, and kiss-and-ride. An additional 7.5 acres would house two parking structures that together would accommodate approximately 4,500 cars. The bus transit center and the smaller of the two parking structures (2.5 acres) would be located north of the HST tracks. The BNSF Railway line would run through the station at-grade, with the HST alignment running on an elevated guideway.

**Bakersfield Station–South Alternative**

The Bakersfield Station–South Alternative would be would be similarly located in downtown Bakersfield, but situated on the Bakersfield South Alternative Alignment along Union and California avenues, just south of the BNSF Railway right-of-way (Figure 2-6). The two-level station building would be 51,000 square feet, with a maximum height of approximately 95 feet. The first floor would house the concourse, and the platforms and the guideway would be on the second floor. Access to the site would be from two new boulevards, one branching off from California Avenue and the other from Union Avenue.

The entire site would be 20 acres, with 15 acres designated for the station, bus transit center, short-term parking, and kiss-and-ride. An additional 5 acres would support one six-level parking structure with a capacity of approximately 4,500 cars. Unlike the Bakersfield Station–North Alternative, this station site would be located entirely south of the BNSF Railway right-of-way.

### 2.2.3 Heavy Maintenance Facility (HMF)

One HST heavy vehicle maintenance and layover facility would be sited along either the Merced to Fresno or Fresno to Bakersfield HST section. Before the startup of initial operations, the HMF would support the assembly, testing, commissioning, and acceptance of high-speed rolling stock. During regular operations, the HMF would provide maintenance and repair functions, activation of new rolling stock, and train storage. The HMF concept plan indicates that the site would encompass approximately 150 acres to accommodate shops, tracks, parking, administration, roadways, power substation, and storage areas. The HMF would include tracks that allow trains to enter and leave under their own electric power or under tow. The HMF would also have management, administrative, and employee support facilities. Up to 1,500 employees could work at the HMF during any 24-hour period.

The Authority has determined that one HMF would be located between Merced and Bakersfield; however, the specific location has not yet been finalized. Five HMF sites are under consideration in the Fresno to Bakersfield Section (Figure 2-1):

- The Fresno Works–Fresno HMF site lies within the southern limits of the city of Fresno and county of Fresno next to the BNSF Railway right-of-way between SR 99 and Adams Avenue. Up to 590 acres are available for the facility at this site.
- The Kings County–Hanford HMF site lies southeast of the city of Hanford, adjacent to and east of SR 43, between Houston and Idaho Avenues. Up to 510 acres are available at the site.
- The Kern Council of Governments–Wasco HMF site lies directly east of Wasco between SR 46 and Filburn Street. Up to 420 acres are available for the facility at this site.


PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

May 16, 2011


N

NOT TO SCALE

Figure 2-6
Bakersfield Station-South Alternative

- The Kern Council of Governments–Shafter East HMF site lies in the city of Shafter between Burbank Street and 7th Standard Road to the east of the BNSF Railway right-of-way. This site has up to 490 acres available for the facility.
- The Kern Council of Governments–Shafter West HMF site lies in the city of Shafter between Burbank Street and 7th Standard Road to the west of the BNSF Railway right-of-way. This site has up to 480 acres available for the facility.

## 2.3 Power

To provide power for the HST, high-voltage electricity at 115 kV and above would be drawn from the utility grid and transformed down to 25,000 volts. The voltage would then be distributed to the trains via an overhead catenary system. The project would not include the construction of a separate power source, although it would include the extension of power lines to a series of power substations positioned along the HST corridor. The transformation and distribution of electricity would occur in three types of stations:

- Traction power supply stations (TPSSs) transform high-voltage electricity supplied by public utilities to the train operating voltage. TPSSs would be sited adjacent to existing utility transmission lines and the HST right-of-way, and would be located approximately every 30 miles along the route. Each TPSS would be 200 feet by 160 feet.
- Switching stations connect and balance the electrical load between tracks, and switch power on or off to tracks in the event of a power outage or emergency. Switching stations would be located midway between, and approximately 15 miles from, the nearest TPSS. Each switching station would be 120 feet by 80 feet and located adjacent to the HST right-of-way.
- Paralleling stations, or autotransformer stations, provide voltage stabilization and equalize current flow. Paralleling stations would be located every 5 miles between the TPSSs and the switching stations. Each paralleling station would be 100 feet by 80 feet and located adjacent to the HST right-of-way.

## 2.4 Project Construction

The construction plan developed by the Authority and described below would maintain eligibility for eligibility for federal American Recovery and Reinvestment Act (ARRA) funding. For the Fresno to Bakersfield Section, specific construction elements would include at-grade, below-grade, and elevated track, track work, grade crossings, and installation of a positive train control system. At-grade track sections would be built using conventional railroad construction techniques. A typical sequence includes clearing, grubbing, grading, and compacting of the rail bed; application of crushed rock ballast; laying of track; and installation of electrical and communications systems.

The precast segmental construction method is proposed for elevated track sections. In this construction method, large concrete bridge segments would be mass-produced at an onsite temporary casting yard. Precast segments would then be transported atop the already completed portions of the elevated track and installed using a special gantry crane positioned on the aerial structure. Although the precast segmental method is the favored technique for aerial structure construction, other methods may be used, including cast-in-place, box girder, or precast span-by-span techniques.

Pre-construction activities would be conducted during final design and include geotechnical investigations, identification of staging areas, initiation of site preparation and demolition, relocation of utilities, and implementation of temporary, long-term, and permanent road closures.

Additional studies and investigations to develop construction requirements and worksite traffic control plans would be conducted as needed.

Major construction activities for the Fresno to Bakersfield Section would include earthwork and excavation support systems construction, bridge and viaduct construction, railroad systems construction (including trackwork, traction electrification, signaling, and communications), and station construction. During peak construction periods, work is envisioned to be underway at several locations along the route, with overlapping construction of various project elements. Working hours and workers present at any time will vary depending on the activities being performed.

The Authority intends to build the project using sustainable methods that:

- Minimize the use of nonrenewable resources.
- Minimize the impacts on the natural environment.
- Protect environmental diversity.
- Emphasize the use of renewable resources in a sustainable manner.

The overall schedule for construction is provided in Table 2-1.

**Table 2-1**
Construction Schedule

| Activity | Tasks | Duration |
|---|---|---|
| Mobilization | Safety devices and special construction equipment mobilization | March–October 2013 |
| Site Preparation | Utilities relocation; clearing/grubbing right-of-way; establishment of detours and haul routes; preparation of construction equipment yards, stockpile materials, and precast concrete segment casting yard | April–August 2013 |
| Earthmoving | Excavation and earth support structures | August 2013–August 2015 |
| Construction of Road Crossings | Surface street modifications, grade separations | June 2013–December 2017 |
| Construction of Elevated Structures | Viaduct and bridge foundations, substructure, and superstructure | June 2013–December 2017 |
| Track Laying | Includes backfilling operations and drainage facilities | January 2014–August 2017 |
| Systems | Train control systems, overhead contact system, communication system, signaling equipment | July 2016–November 2018 |
| Demobilization | Includes site cleanup | August 2017–December 2019 |
| HMF Phase 1[a] | Test track assembly and storage | August–November 2017 |
| Maintenance-of-Way Facility | Potentially co-located with HMF[a] | January–December 2018 |
| HMF Phase 2[a] | Test track light maintenance facility | June–December 2018 |
| HMF Phase 3[a] | Heavy Maintenance Facility | January–July 2021 |
| HST Stations | Demolition, site preparation, foundations, structural frame, electrical and mechanical systems, finishes | Fresno:<br>December 2014–October 2019<br>Kings/Tulare Regional: TBD[b]<br>Bakersfield: |

**Table 2-1**
Construction Schedule

| Activity | Tasks | Duration |
|---|---|---|
| | | January 2015–November 2019 |

Notes:
[a] The HMF would be sited along either the Merced to Fresno Section or the Fresno to Bakersfield Section.
[b] Right-of-way would be acquired for the Kings/Tulare Regional Station; however, the station itself would not be part of initial construction.
Acronym: TBD = to be determined

# Chapter 3.0
## Regulatory Framework

# 3.0 Regulatory Framework

Key regulations pertaining to geology, soils, and seismicity that are most relevant to the proposed project are summarized below.

## 3.1 Federal Regulations

**National Environmental Policy Act (NEPA) [42 U.S.C. Section 4321 et seq.]**

NEPA requires the consideration of potential environmental impacts, including potential impacts to geology, soils, and seismicity, in the evaluation of any proposed federal agency action. NEPA also obligates federal agencies to consider the environmental consequences and costs in their projects and programs as part of the planning process. General NEPA procedures are set forth in the Council on Environmental Quality (CEQ) regulations 23 CFR 771.

## 3.2 State Regulations

**California Environmental Quality Act (CEQA) [Section 21000 et seq.] and CEQA Guidelines [Section 15000 et seq.]**

CEQA requires state and local agencies to identify the significant environmental impacts of their actions, including potential significant impacts to geology, soils, and seismicity, and to avoid or mitigate those impacts, when feasible.

**Alquist-Priolo Earthquake Fault Zoning Act [California Code of Regulations Section 2621 et seq.]**

This act provides policies and criteria to assist cities, counties, and state agencies in the exercise of their responsibility to prohibit the location of developments and structures for human occupancy across the trace of active faults.

**Seismic Hazards Mapping Act [Public Resources Code Sections 2690 to 2699.6]**

The Seismic Hazards Mapping Act requires that site-specific geotechnical investigations be performed prior to permitting development within the seismic hazard zones.

**Surface Mining and Reclamation Act [Public Resources Code, Division 2, Chapter 9, Section 2710 et seq.]**

This act was enacted to address the need for a continuing supply of mineral resources, and to prevent or minimize the adverse impacts of surface mining to public health, property and the environment.

**California Building Standards Code [California Code of Regulations Title 24]**

The California Building Standards Code governs the design and construction of buildings, associated facilities and equipment, and applies to buildings in California.

## 3.3 Regional and Local Regulations

California Government Code Section 65302(g) requires general plans to include a safety element for the protection of the community from any unreasonable risks associated with the effects of seismically induced surface rupture, ground shaking, ground failure, tsunami, seiche, and dam failure; slope instability leading to mudslides and landslides; subsidence, and other geologic hazards known to the legislative body. Each of the counties (Fresno, Kings, Tulare, and Kern) and incorporated communities (Fresno, Hanford, Corcoran, Wasco, Shafter, and Bakersfield) that are crossed by the Fresno to Bakersfield Section have a Health and Safety Element in their General Plans and corresponding ordinances to enforce General Plan policies related to protection of public health and welfare from geologic hazards. In general, these policies and ordinances require soils engineering and geologic-seismic analysis of developments, including public infrastructure, in areas prone to geologic or seismic hazards, and enforce the California Building Standards Codes.

### 3.3.1 Fresno County Ordinance Code, Chapter 15.28 Grading and Excavation

The Fresno County Ordinance Code, Chapter 15.28, establishes standards for grading and excavation in unincorporated Fresno County; sets forth rules and regulations to control excavation, grading, and earthwork construction, including fills and embankments; establishes the administrative procedure for issuance of permits; and provides for approval of plans and inspection of grading construction.

### 3.3.2 Kings County Code Title 16 Building and Construction Standards, Chapter 16.82 Clearing and Grading

Kings County Code Title 16 regulates clearing and removal of vegetation, excavation, grading and earthwork construction including cuts and fills, gravel pits, dumping, quarrying, and mining operations in Kings County to protect public health, safety, and welfare by:

1. Minimizing adverse stormwater impacts generated by the removal of vegetation and alteration of landforms
2. Protecting water quality from the adverse impacts associated with erosion and sedimentation
3. Minimizing aquatic and terrestrial wildlife habitat loss caused by the removal of vegetation
4. Protecting sensitive areas from adverse clearing and grading activities
5. Facilitating and encouraging long-term forest practice and agricultural production operations where appropriate
6. Minimizing the adverse impacts associated with materials processing, quarrying, and mining operations
7. Preventing damage to property and harm to persons caused by excavation and fills
8. Establishing administrative procedures for the issuance of permits, approval of plans, and inspection of clearing and grading operations
9. Providing penalties for violations to clearing and grading regulations

### 3.3.3 Tulare County Code Part 7 Land Use Regulation and Planning, Chapter 15 Building Regulations, Article 7 Excavation and Grading

Tulare County Code Part 7, Chapter 15, establishes standards to safeguard the public, minimize hazards to property, control erosion, and protect against sedimentation of watercourses and protect the safety, use, and stability of public rights of way; provides regulations to control excavation, grading, and earthwork construction; and establishes procedures for issuance of grading permits.

### 3.3.4 Kern County Grading Code, Chapter 17.28

Kern County Grade Code, Chapter 17.28 regulates grading on private property to safeguard life, limb, property and the public welfare; sets forth rules and regulations to control excavation, grading, and earthwork construction, including fills and embankments; establishes the administrative procedure for issuance of permits; and provides for approval of plans and inspection of grading construction.

### 3.3.5 City of Shafter Municipal Code, Title 15 Buildings and Construction, Chapter 15.28 Grading Code

The City of Shafter Municipal Code, Title 15 regulates grading on private property to safeguard life, limb, property and the public welfare; sets forth rules and regulations to control excavation, grading, and earthwork construction, including fills and embankments; establishes the administrative procedure for issuance of permits; and provides for approval of plans and inspection of grading construction.

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# Chapter 4.0
## Affected Environment

# 4.0 Affected Environment

## 4.1 Definition of Study Area

The study area for geology, soils, and seismicity for the Fresno to Bakersfield Section is defined as the corridor up to 200 feet on each side of the alignment alternative centerlines; and a 1/2-mile radius around each station site. Research for seismicity was conducted out to 62 miles (100 kilometers) from the project alignments. The Fresno to Bakersfield Section is divided into three segments, as shown on Figure 4.1-1:

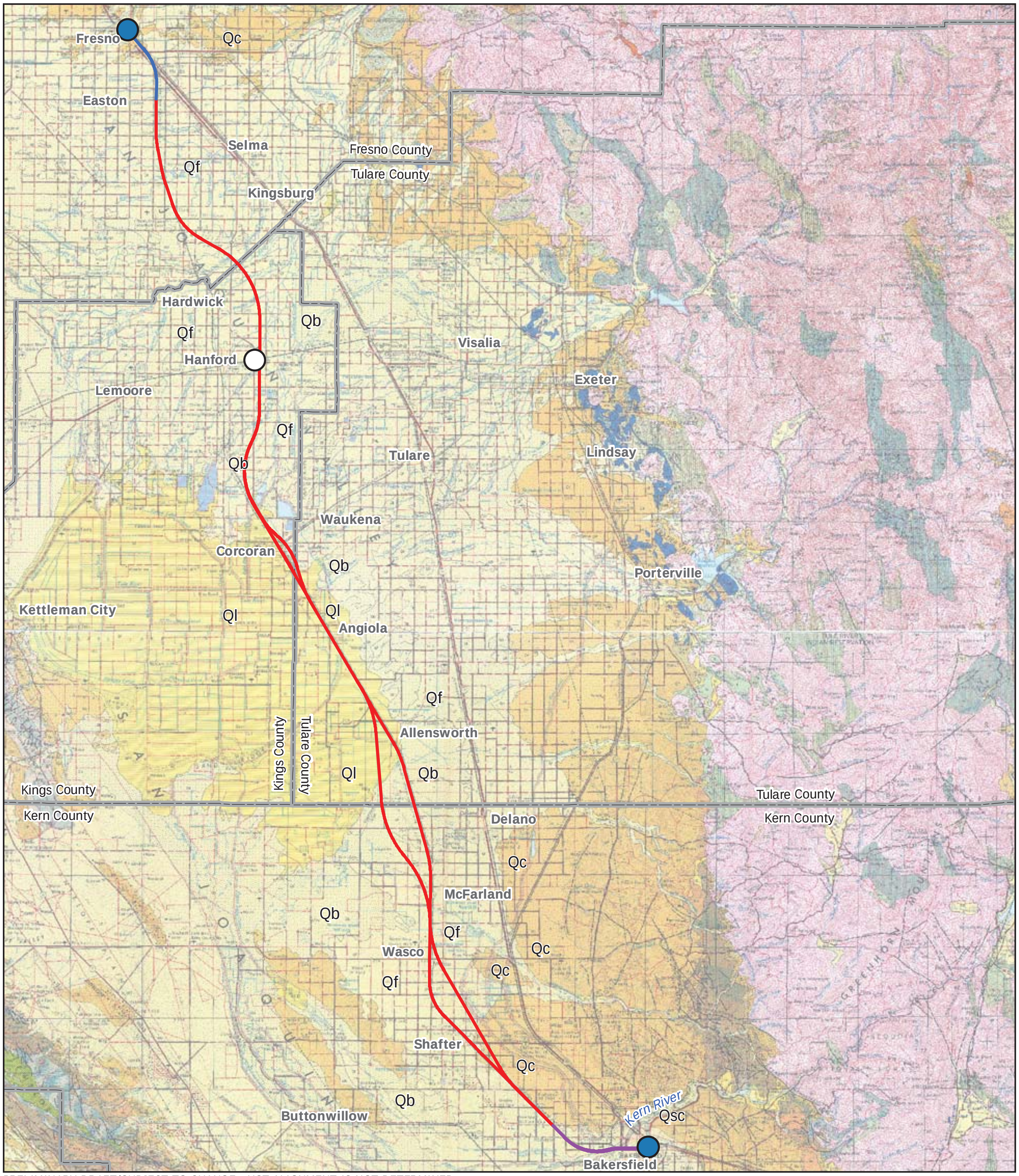
- Fresno – Begins at approximately Amador Street and continues south through downtown Fresno, terminating at East Jefferson Avenue just south of the Fresno city limits.
- Rural – Begins at East Jefferson Avenue and continues southeast for about 102 miles to approximately State Route (SR) 58 (Rosedale Highway) on the northern outskirts of Bakersfield.
- Bakersfield – Begins at SR 58 and continues east for about 9 miles to approximately Union Street.

### 4.1.1 Physiography and Regional Geologic Setting

All three segments of the Fresno to Bakersfield Section are in the Great Valley geomorphic province, which in the project region is characterized by relatively flat topography. The Great Valley is formed by the Great Valley geocline, which is a large, elongated, northwest-trending asymmetric structural trough (Figure 4.1-2). The northwest-trending axis of the geocline is closer to the western side of the valley, with the regional dip of the formations on the eastern side being less than that of the formations on the western side. The valley is bordered by the Coast Ranges to the west, the Klamath Mountains and Cascade Range to the north, the Sierra Nevada to the east, and the San Emigdio and Tehachapi Mountains on the south.

The structural trough has a long, stable eastern shelf supported by metamorphic and igneous rocks of the west-dipping Sierran slope. The basement rocks of the western edge of the structural trough are composed of Jurassic-aged metamorphic, ultramafic, and igneous rocks of the Franciscan complex (Hackel 1966). This structural trough began receiving sediments in the late Jurassic period (208 to 144 million years ago) (MA). It has been filled with sediments derived from both marine and continental sources. The thickness of the valley sediments ranges from thin veneers along the valley edges to greater than 40,000 feet in the central portion of the valley. These sedimentary deposits range in age from the Jurassic (202 to 145 MA) to Holocene (0 to 0.01 MA) epochs, with the older deposits (Jurassic to Eocene 55.8 to 33.9 MA) comprising the marine sequence, and the younger deposits (Eocene to Holocene age) comprising the continental sequence. The marine deposits were formed in offshore shallow ocean shelf and basin environments. Continental sediments were derived from mountain ranges surrounding the valley and were deposited in lacustrine, fluvial, and alluvial environments (Norris & Webb 1990).

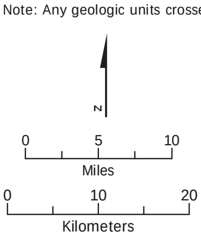
A schematic depicting a transverse cross section through the southern San Joaquin Valley is shown on Figure 4.1-3. At the latitude of the proposed Fresno and Bakersfield HST stations, the valley is approximately 54 and 45 miles wide, respectively. At the site of the potential Kings/Tulare Regional HST station, the valley is approximately 70 miles wide. The Great Valley can be divided into the Sacramento Valley to the north and the San Joaquin Valley to the south, with the dividing line between the two at approximately the Sacramento River-San Joaquin River Delta. The Fresno to Bakersfield Section is in the San Joaquin Valley.




PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

June 30, 2011

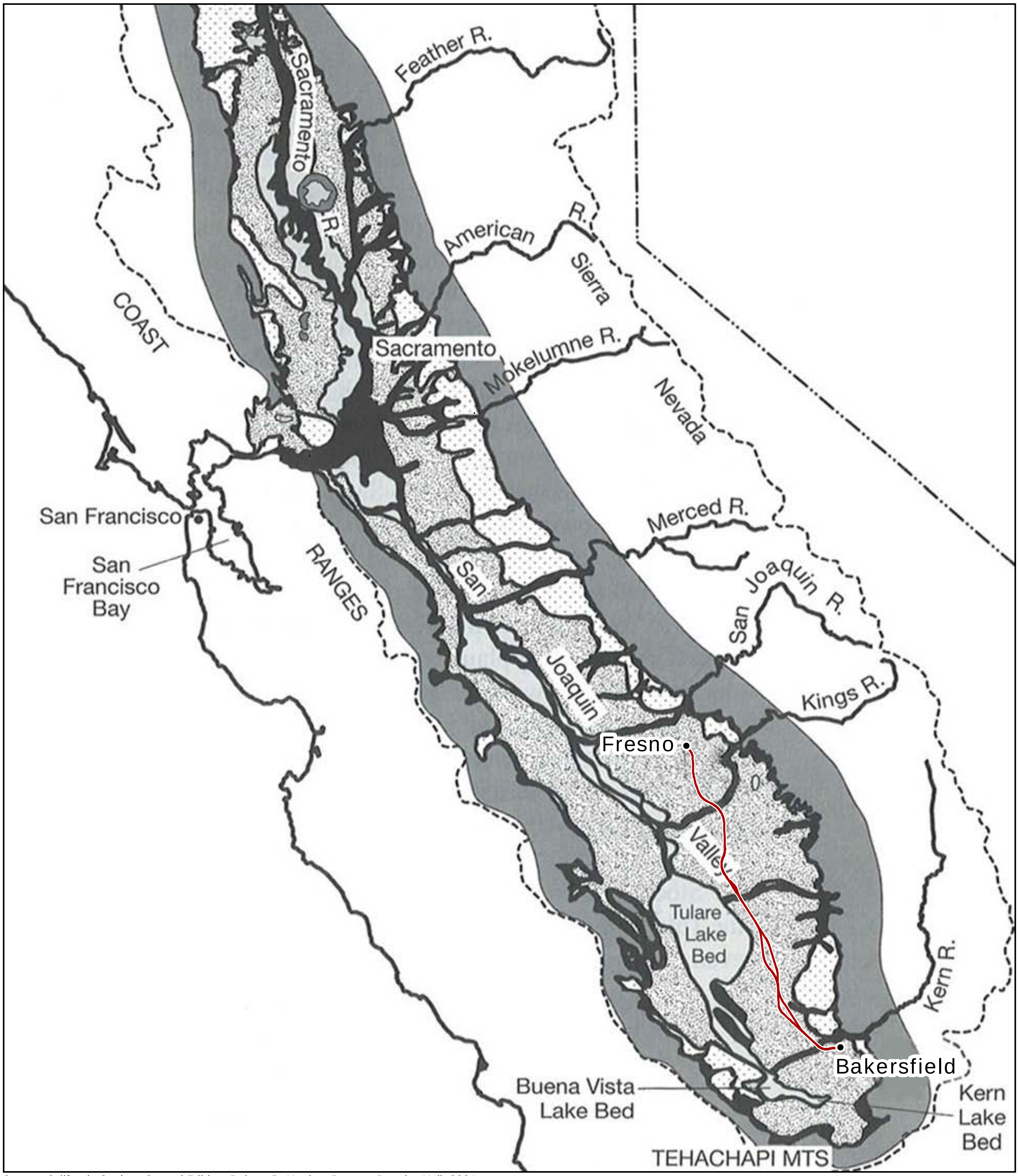
Data source: URS, 2011
Base map source: California Division of Mines and Geology, 1997
Note: Any geologic units crossed by HST alignment are included in legend




Preferred HST station
Potential Kings/Tulare Regional Station
Fresno segment of study area
Rural segment of study area
Bakersfield segment of study area

Qsc - Stream channel deposits
Qf - Fan deposits
Qb - Basin deposits
Ql - Quaternary lake deposits
Qc - Pleistocene nonmarine

**Figure 4.1-1**
Geology of the study area




Source: California Geology Second Edition, Debora R. Harden, Pearson Prentice Hall, 2004

July 1, 2011

Alternative alignments

Overflow lands and lake bottoms

River flood plains and channels

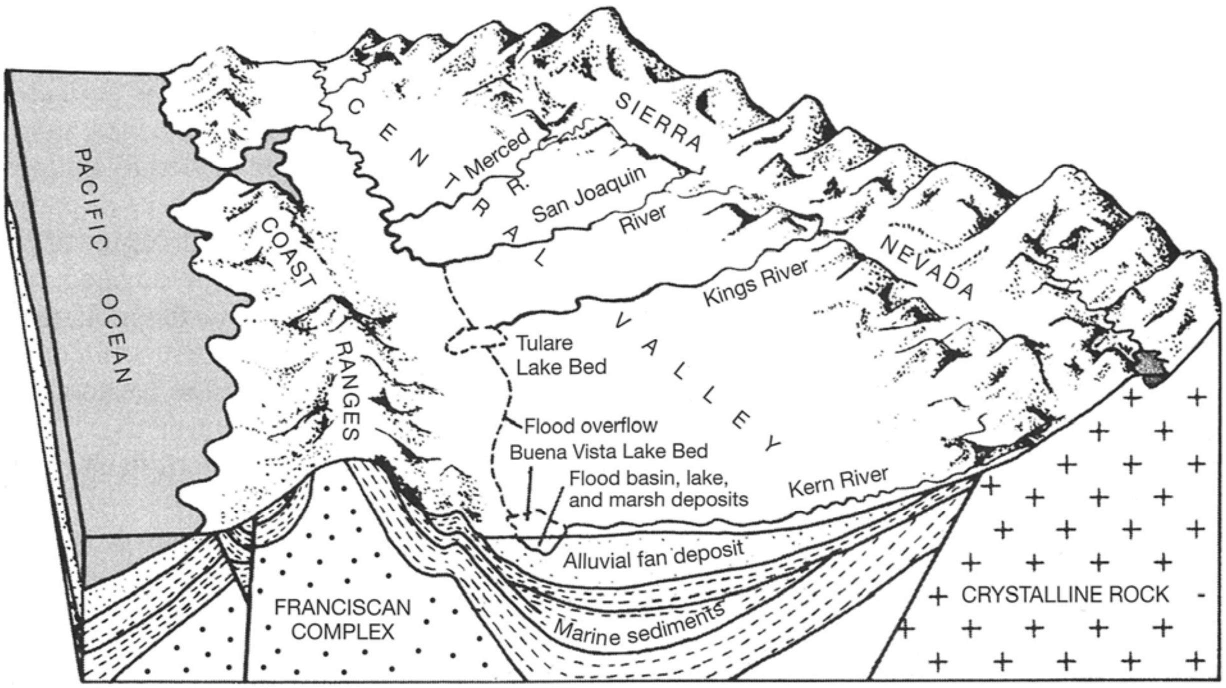
Low alluvial plains and fans

Older alluvium

Valley boundary

Map not to scale

Figure 4.1-2
Great Valley Geomorphic Province




Source: Harden, 2004

July 1, 2011

Figure 4.1-3
Schematic block diagram, southern San Joaquin Valley

### 4.1.2 Geology

In this section, the geologic conditions of the study area are discussed in further detail with reference to the project geologic map, which is presented on Figure 4.1-1. The project geologic map shows the locales of the various soil and rock units in the vicinity of the alternative HST alignments, as mapped by Jenkins, Geologic Map of California, Fresno and Bakersfield sheets, 1965 and 1966, respectively. Mineral Resource Zones (MRZs), as mapped by the California Division of Mines and Geology (CDMG 1966, 1988a, 1988b, 2009), are discussed in Section 4.5.1.

#### A. FRESNO

The Fresno segment of the project traverses recent alluvial fan deposits (Qf) and older Pleistocene nonmarine sedimentary deposits (Qc). These deposits originated from stream channels emanating from the foothills east of Fresno. The more recent alluvial fan deposits consist primarily of a mixture of clay, silt, and sand. The older nonmarine alluvium consists primarily of a mixture of slightly consolidated clay, silt, sand, and gravel. The older alluvium is usually situated at a higher elevation and typically exhibits dissected, channelized topography (CDMG 1965, 1973). These deposits may also form a succession of terraces that vary in age. Within the Fresno city limits, artificial fill of various compositions may exist in areas where the alternative HST alignments cross. Surface elevations along the proposed Fresno segment descend from approximately 290 feet mean sea level (msl) in the vicinity of the proposed Fresno station to 280 feet msl in the vicinity of Easton.

#### B. RURAL

The rural portion of the project traverses primarily through flat terrain underlain by thick sequences of sedimentary deposits. From the vicinity of Easton for about 10 miles, the HST passes over Quaternary alluvial fan deposits of the Great Valley. In this area, these deposits eroded from the Sierra Nevada and were deposited on floodplains and bottomlands from mountain streams associated primarily with the Kings River floodplain. These deposits consist of a mixture of clay, silt, and sand. Surface elevations along the alignment in this area vary from approximately 285 feet to 265 feet msl from north to south, respectively. To the south, the HST traverses Quaternary basin deposits (Qb) that were deposited during flood stages of the major streams in the area between natural stream levees and fans (CDMG 1965). These deposits extend to margins north of Laton and underlie small areas to the north and south of Guernsey, with surface elevations along this portion of the alignment ranging from approximately 260 feet to 220 feet msl from north to south, respectively.

To the south of Laton, the HST crosses primarily alluvial fan deposits, described above, to areas north of Corcoran. In the vicinity of Corcoran, the HST alternative alignments cross Quaternary lake deposits associated with Lake Corcoran, which occupied approximately the western half of the San Joaquin Valley about 600,000 years ago (Norris and Webb 1976). These lake deposits consist primarily of lake-bed-type clays, silt, and fine sand, and extend to south of Allensworth. From Allensworth to SR 58, the HST alternative alignments cross the deposits described above from north to south including:

- Quaternary Basin Deposits extending to the north of Pond.
- Fan deposits to the proximity of Shafter.
- Pleistocene nonmarine sediments (primarily along the eastern margin of the HST) to the vicinity of Greenacres. In the vicinity of Corcoran and extending to SR 58, surface elevations along the HST alignments generally rise from 210 feet to about 375 feet msl, respectively.

#### C. BAKERSFIELD

The Bakersfield portion of the HST alternative alignments traverse primarily basin deposits from the vicinity of Greenacres to downtown Bakersfield, with surface elevations along the HST alignments varying between 380 feet and 410 feet msl, respectively. In the vicinity of downtown Bakersfield, the HST alignments are underlain by stream channel deposits associated with the Kern River. These deposits likely consist of a mixture of clay, silt, sand, and gravels being deposited and reworked by the Kern River. The HST will be elevated across this river channel.

### 4.1.3 Site Soils

Soil type is one criterion used to evaluate potential impacts of development, as well as potential impacts of the environment on the project. Soils are typically considered for their resource value in agricultural production or for their potential development characteristics or constraints. Depending on type, some soils are susceptible to erosion and/or expansive behavior, while others are more suitable for construction. Soil type mapping, emphasizing a soil's agricultural and engineering properties, has been conducted by various government agencies and universities since the 1930s. Typically, the mapping is conducted on a county-wide (or geographic) basis using nomenclature that changes with time. Accordingly, soil descriptors can change at the county line and not be directly transferable from one county to another. Figure 4.1-4 illustrates soil associations along the Fresno to Bakersfield portions of the HST alignment, and represents a recent database compiled by the Natural Resources Conservation Service (NRCS), the successor to the Soil Conservation Service (SCS), an agency within the U.S. Department of Agriculture (USDA). The NRCS soil types presented on this figure are summarized in Table 4.1-1, which also indicates the susceptibility to various hazards.

#### A. FRESNO

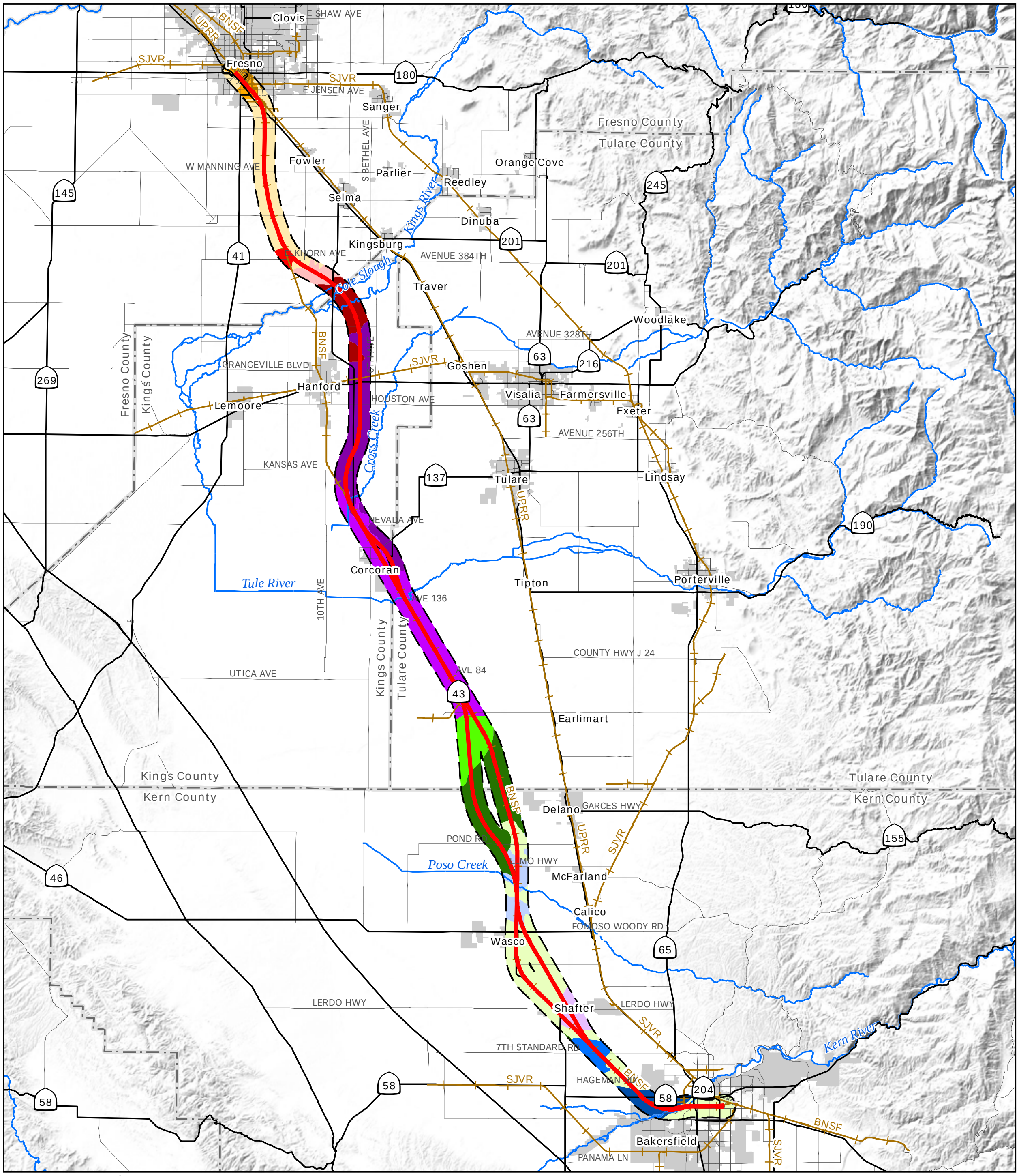
In the Fresno segment, the HST traverses soils of the San Joaquin-Madera-Cometa and Hanford-Delhi associations, formed on low alluvial terraces and young alluvial fans/alluvial benches, respectively.

#### B. RURAL

Most of the soil associations shown in Table 4.1-1 underlie the rural segment of the HST, as shown on Figure 4.1-4. The central portion of the alignment is centered on Corcoran, and from about 2.5 miles south of Kansas Avenue to the Allensworth Bypass is underlain by Lakeside-Kimberlina-Garces and Westcamp-Houser-Gepford-Armona associations formed on alluvial fans, basins, and floodplains. These soils are predominantly fine-grained to loamy in texture. Most of the soils in the vicinity of Wasco and Shafter belong to the Twisselman-Nahrub-Lethent association, consisting of fine-grained materials located on basin rims and fan remnant geomorphic features.

#### C. BAKERSFIELD

Over 50 percent of the Bakersfield HST segment is underlain by soils of the Wasco-Kimberlina association, well-drained materials formed on alluvial fans and plains, as well as fan skirts. Most of the remainder of the Bakersfield segment sits on soils of the Westhaven-Lerdo-Excelsior-Cajon association, which similarly is formed on alluvial fans and fan skirts.




PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

July 1, 2011

Source: U.S. Department of Agriculture, Natural Resources Conservation Service, 2006

- Alternative alignments
- Existing rail line
- Major road
- Hydrographic feature
- Community/Urban area
- NRCS general soil types with 1-mile buffer
- County boundary

N

0 5 10
Miles

0 10 20
Kilometers

- s742 - Lewis-Fresno-Dinuba
- s743 - Waukena-Temple-Pond
- s744 - Nord-Grangeville-Chino
- s745 - Hanford-Delhi
- s746 - San Joaquin-Madera-Cometa
- s774 - Panoche-Milham-Kimberlina
- s775 - Wasco-Kimberlina
- s778 - Twisselman-Nahrub-Lethent
- s779 - Panoche-Garces
- s780 - McFarland
- s781 - Milham
- s782 - Westhaven-Lerdo-Excelsior-Cajon
- s783 - Zerker-Premier-Delano-Chanac
- s807 - Westcamp-Houser-Gepford-Armona
- s810 - Lakeside-Kimberlina-Garces

Figure 4.1-4
General soils data

**Table 4.1-1**
Soil Types in the Study Area

| Soil Association | Map Symbol[1] | HST Segment | County(ies) of Occurrence | Landform Groups | Soil Hazards | Drainage Class | Particle Size |
|---|---|---|---|---|---|---|---|
| San Joaquin-Madera-Cometa | s746 | Fresno | Fresno | Low alluvial terraces | None to moderate erosion, low to high shrink-swell potential, high corrosivity potential | Moderately well drained | Fine |
| Hanford-Delhi | s745 | Fresno/Rural | Fresno | Young alluvial fans and alluvial benches | None to slight water erosion, slight to moderate wind erosion, low shrink-swell potential, low corrosivity potential | Well drained | Coarse-loamy |
| Waukena-Temple-Pond | s743 | Rural | Fresno | Basin floodplain | None to slight water erosion, slight wind erosion, low to moderate shrink-swell, low to high corrosivity potential | Moderately well drained | Fine-loamy |
| Lewis-Fresno-Dinuba | s742 | Rural | Fresno | Alluvial fans/ valley plains | None to slight erosion, low to moderate shrink-swell, high corrosivity potential | Moderately well drained | Fine-loamy |
| Nord-Grangeville-Chino | s744 | Rural | Fresno/Kings | Lower parts of recent alluvial fans and floodplains | None to slight erosion, low to moderate shrink-swell, low to high corrosivity potential | Well drained | Coarse-loamy |
| Lakeside-Kimberlina-Garces | s810 | Rural | Kings/Tulare | Alluvial fans | Slight water erosion, low to high shrink-swell, slight to moderate wind erosion | Well drained | Fine-loamy |
| Westcamp-Houser-Gepford-Armona | s807 | Rural | Kings/Tulare | Low alluvial fans, basins and floodplains | Slight wind erosion, moderate to high water erosion, low to high shrink-swell, high corrosivity | Poorly drained | Fine |
| Twisselman-Nahrub-Lethent | s778 | Rural | Tulare | Basin rims and fan remnants | Moderate to high erosion, moderate wind erosion, low to moderate shrink-swell, high corrosivity potential | Moderately well drained | Fine |

**Table 4.1-1**
Soil Types in the Study Area

| Soil Association | Map Symbol[1] | HST Segment | County(ies) of Occurrence | Landform Groups | Soil Hazards | Drainage Class | Particle Size |
|---|---|---|---|---|---|---|---|
| Panoche-Garces | s779 | Rural | Tulare/Kern | Alluvial fans and floodplains | Slight water erosion, slight to moderate wind erosion, low to moderate shrink/swell | Well drained | Fine-loamy |
| Wasco-Kimberlina | s775 | Rural | Kern | Alluvial fans, fan skirts and plains | Slight water erosion, low to moderate shrink-swell, low to high corrosivity | Well drained | Coarse-loamy |
| McFarland | s780 | Rural | Kern | Alluvial fans and floodplains | Slight water erosion, low to moderate shrink-swell low to high corrosivity | Well drained | Fine-loamy |
| Zerker-Premier-Delano-Chanac | s783 | Rural | Kern | Alluvial plains and terraces | Low shrink-swell, low wind erosion | Well drained | Fine-loamy |
| Milham | s781 | Rural | Kern | Alluvial fans | Low to moderate erodibility, low to moderate shrink-swell | Well drained | Fine-loamy |
| Westhaven-Lerdo-Excelsior-Cajon | s782 | Bakersfield | Kern | Alluvial fans and fan skirts | Moderate to high erodibility, slight wind erosion, low shrink-swell | Somewhat excessively drained | Not used |

Note:
[1] Refer to Figure 4.1-4 for correlation with map units.

## 4.2 Geologic Hazards

### 4.2.1 Landslide Hazards

Landslides occur as a result of the downward movement of masses of loosened soil and/or rock down a hillside or moderately steep slope. Fundamentally, landslides are the result of a hill slope materials' loss of strength, often due to an increase in pore-water pressures and the forces of gravity, causing a tendency to move downward. The high variability of landslides is caused by many factors—including, but not limited to—steepness of slope, type of material, water content of slope soils, amount of vegetation, areas subject or prone to soil loss due to manmade activities, and earthquake or strong ground motions. Landslide categories vary from fast-moving debris flows to slow-moving soil creep.

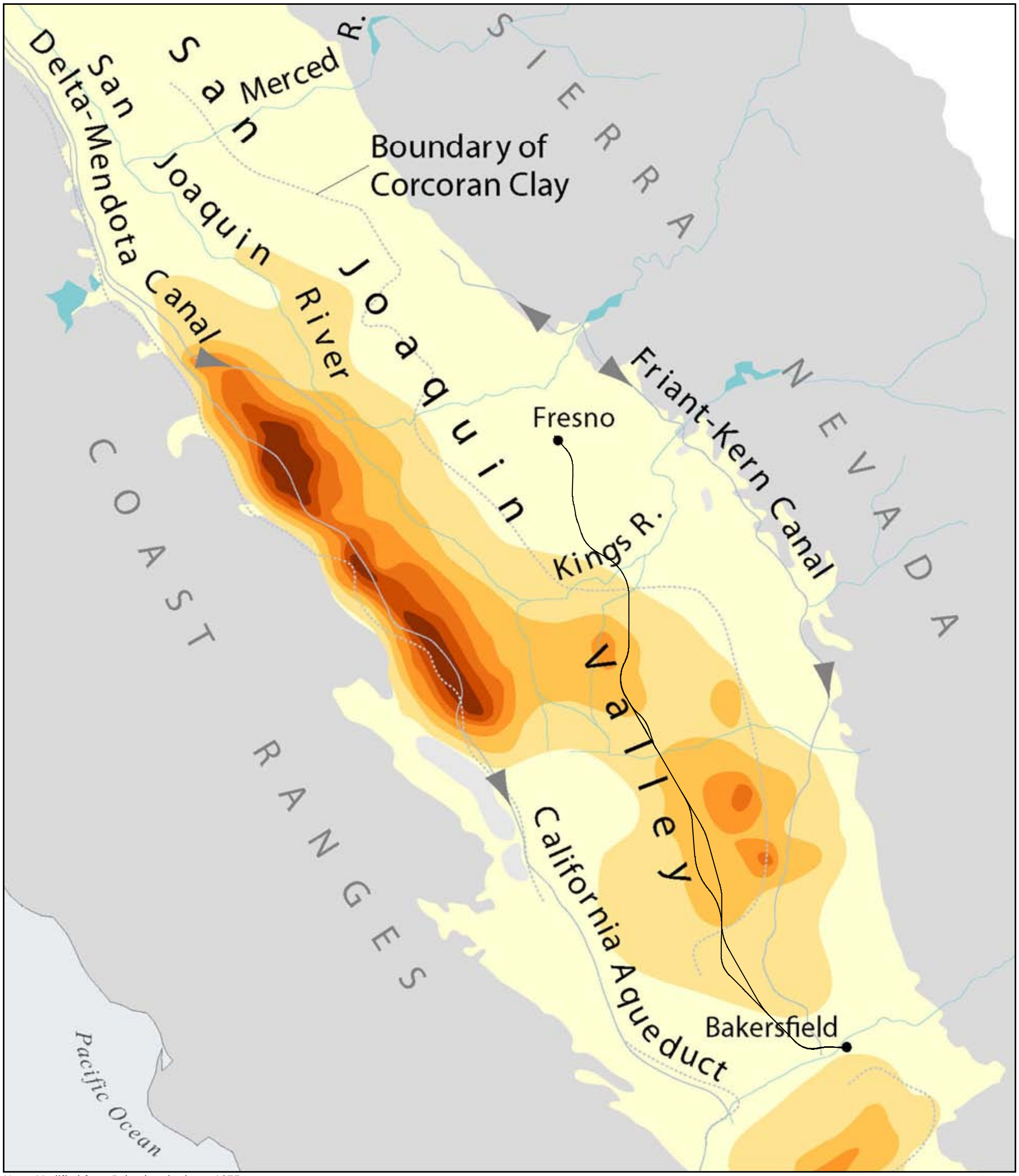
The San Joaquin Valley is generally a broad, featureless alluvial plain that is relatively flat in its geomorphic expression. The lack of significant slopes in the vicinity of the Fresno to Bakersfield Section indicates that the hazard from slope instability in the form of landslides and/or debris flows is considered low; however, potential may exist for localized small slides and minor slumps where the HST crosses steeper river banks and creeks.

### 4.2.2 Ground Subsidence

Ground subsidence is the result of fluid (water or petroleum) extraction from underlying formations that cause the collapse of pore spaces previously occupied by the removed fluid. This is a gradual drop in ground surface elevation, not like collapse over a mine shaft or tunnel. It is most often caused by the large volumetric withdrawals of fluids from underground reservoirs. In many cases, ground shaking caused by tectonic activity can exacerbate the vertical sinking of land in an area over the withdrawal site. If volumes of either water or petroleum, or mined minerals removed from the subsurface are sufficiently great, the resulting subsidence may damage engineered structures. Figure 4.2-1 shows a simplified summary of historic subsidence in the San Joaquin Valley relative to the alignment of the HST.

The San Joaquin Valley has a long history of subsidence due to groundwater pumping. Some areas in the Valley have sunk as much as 30 feet since the 1920s (Harden 2004). The primary cause of subsidence in the San Joaquin Valley is the consolidation of fine-grained sediments due to lowered groundwater levels in the vast aquifer system underlying the Valley, after long-term groundwater extraction in excess of recharge (Planert 1996). In Fresno County, areas along the Valley Trough in the western part of the county have experienced subsidence of land surfaces due to groundwater pumping. Since 2000, subsidence in the county has stabilized, except during drought periods (County of Fresno 2009). These areas of continued subsidence are located to the west of the HST alternative alignments.

The Health and Safety Element of the Kings County General Plan, 2009, has identified Kings County as having a minimal occurrence of ground subsidence. However, the county's Seismic Safety Map has identified areas susceptible to liquefaction and ground subsidence where the HST alternative alignments pass in the vicinity of Corcoran (Kings County 2009).




Note: Modified from Poland and others, 1975

June 30, 2011

Subsidence (feet)
- Less than 1
- 1 to 4
- 4 to 8
- 8 to 12
- 12 to 16
- 16 to 24
- Greater than 24

Alternative alignments

Map not to scale

Figure 4.2-1
Subsidence in the San Joaquin Valley

The Five-County Seismic/Geologic Hazard and Microzone Map (Envicom Corporation 1974) has identified areas in the Tulare-Wasco area, known as the Wasco-Tulare subsidence bowl, where significant amounts of subsidence occurred as measured between 1948 and 1954. The HST alternative alignments traverse the southwestern portion of Tulare County, where subsidence has occurred southeast of Corcoran. The area of recorded subsidence extends to the northern portions of Wasco, in Kern County. Subsidence in the Wasco area, first recognized in 1935, includes approximately 1,220 square miles (1,952 square kilometers) of land with more than 1 foot of recorded subsidence. As of 1970, approximately 300 acres of land were reported to have subsided more than 5 feet (Kern County Planning Department 2007).

The Kern County General Plan (2007) has identified four types of subsidence occurring in the county. These include subsidence due to tectonic activity, extraction of oil and gas, withdrawal of groundwater, and subsidence caused by hydrocompaction of moisture-deficient alluvial deposits. Ground-subsidence conditions near the HST alternative alignments are the result of over-producing groundwater in the area of Arvin-Maricopa, to the southeast of Bakersfield. Other known areas of subsidence in the vicinity are generally limited to areas south/southeast of Bakersfield, in the vicinity of the Kern Lake Bed, north of the Temblor Range front.

Oil-field-related subsidence is known to occur in small areas to the south and west of Bakersfield. This type of subsidence has historically accounted for approximately 1 foot or less of oil-extraction-related subsidence in the Bakersfield vicinity, and is localized in the area. Between August 1997 and September 1999, the National Aeronautics and Space Administration (NASA) and the U.S. Geological Survey (USGS) monitored subsidence in the vicinity of Bakersfield using satellite interferometric synthetic aperture radar (InSAR). InSAR is a radar technique used in remote sensing and geodesy to measure discrete subsidence displacements over time. The study has shown that up to 3.5 inches of subsidence was recorded over a 2-year period in areas up to 12 miles to the north and northwest of Bakersfield. In addition, in the vicinity of the Edison oil field east of the proposed Bakersfield station, subsidence due to production of the field may occur.

Cavities occur naturally in carbonate rocks such as limestone and dolomite due to solutioning. Materials underlying the Fresno to Bakersfield Section alignments are primarily Quaternary sedimentary deposits; therefore, the hazard of collapse of surface soils due to subsurface cavities is negligible.

### 4.2.3 Poor Soil Conditions

Soil conditions generally considered to have a negative impact on engineered facilities include: expansivity, corrosion potential, collapsible properties, and erosion potential. Each of these attributes, based on county soil surveys, and summarized in Table 4.1-1, is discussed below for the Fresno to Bakersfield Section of the HST.

#### A. EXPANSIVE SOILS

Expansive soils are those that undergo a significant increase in volume during wetting, and shrink in volume as they dry; e.g., decrease in water content. Expansive soils can cause significant damage to structures due to increases in uplift pressures. Soils are generally classified as having low, moderate, and high expansive potentials, where the type and percentage of clay particles present in the soil are indicative of the soil's expansion potential. Predominantly fine-grained soils containing a high percentage of clays are potentially expansive, whereas predominantly coarse-grained soils such as sands and gravels are generally non-expansive.

Table 4.1-1 summarizes the expansive potential of soils traversed by the HST alignment, and Figure 4.2-2 illustrates expansive soils in the study area. As shown on the figure, the potential for highly expansive soils along the alignment occur:

- Locally in the vicinity of Fresno
- North of Corcoran and in the vicinity of Cross Creek
- Between the Tule River and north of the Tulare County border

Moderately expansive soil potential exists along the HST alignment:

- Locally north of Kings River
- North and south of Corcoran
- North of Wasco extending to the Tulare County border
- South of Shafter
- East of Bakersfield

### B. SOIL CORROSIVITY

Soil corrosivity involves the measure of the potential of corrosion for steel and concrete caused by contact with some types of soil. Knowledge of potential soil corrosivity is often critical for the effective design parameters associated with cathodic protection of buried steel and concrete mix design for plain or reinforced concrete buried project elements. Factors—including soil composition, soil and pore water chemistry, moisture content, and pH—affect the response of steel and concrete to soil corrosion. Soils with high moisture content, high electrical conductivity, high acidity, and high dissolved salts content are most corrosive. In general, sandy soils have high resistivities and are the least corrosive. Clay soils, including those that contain interstitial salt water, can be highly corrosive. Soil types with the potential to cause corrosion to infrastructure related to the HST are shown in Table 4.1-1.

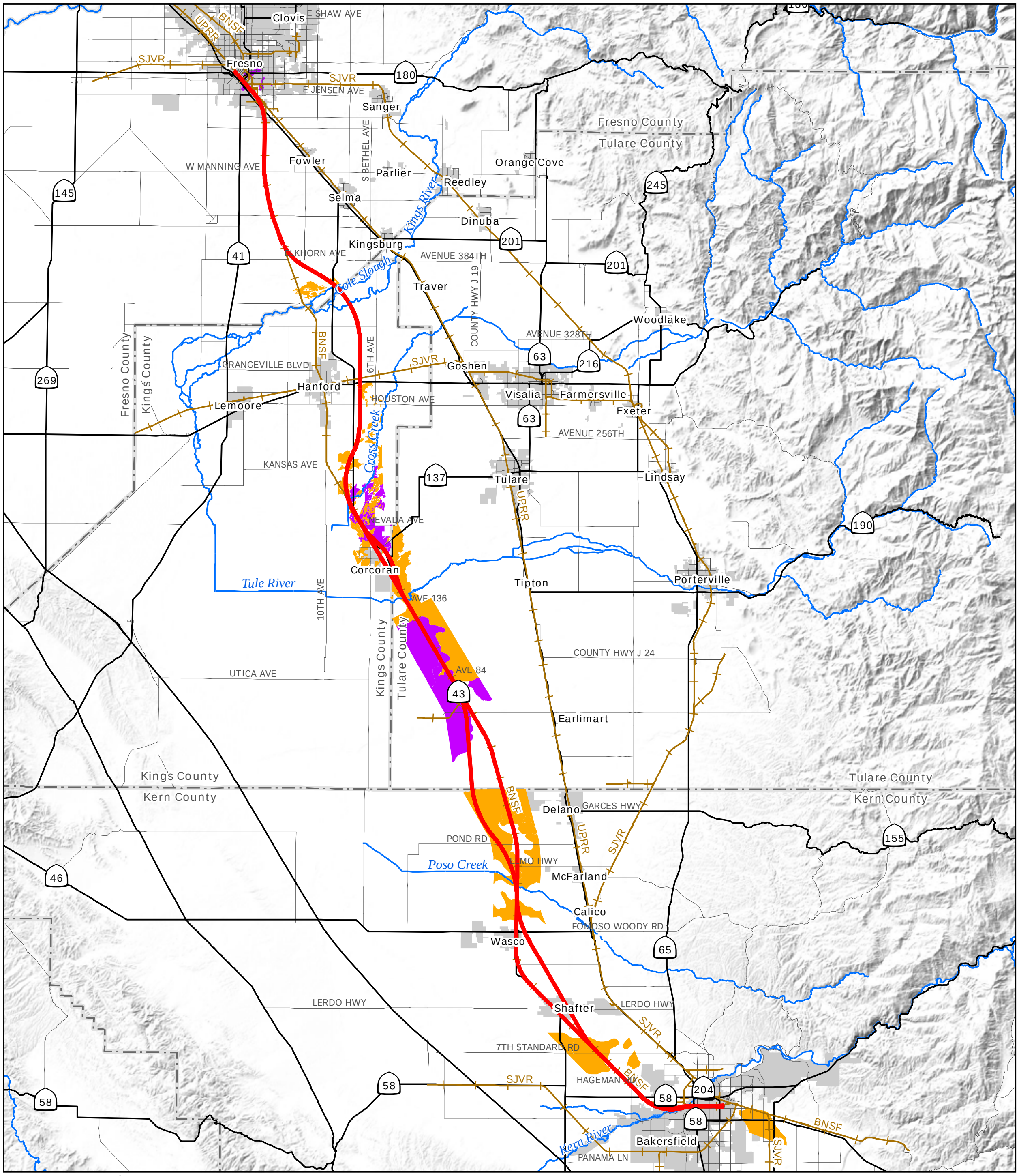
Figure 4.2-3 presents an illustration of the potential for corrosion to occur between native soil and buried concrete for the proposed HST alignment. The only portion of the alignment demonstrating a high potential is related to soils of the Lakeside-Kimberlina-Garces association and the Twisselman-Nahrub-Lethent association in the vicinity and south of the town of Corcoran.

Figure 4.2-4 is essentially the same as Figure 4.2-3, except it illustrates potential corrosivity between native soils along the HST alignment and buried, uncoated steel. In this case, all of the alignment exhibits a high potential for corrosivity except for the following:

- The vicinity of Fresno to about Elkhorn Avenue.
- A small area in the vicinity of Greenacres due west of downtown Bakersfield.

### C. COLLAPSIBLE SOILS

Collapsible soils are soils that undergo settlement upon the addition of water, which weakens or destroys soil particle bonds of loosely packed structure, reducing the bearing capacity of the soil. Other mechanisms for soil collapse include the sudden closure of voids in a soil, whereby the sudden decrease in volume results in loss of the soil's internal structure, causing the soil to collapse. Specific soil types, such as loess and other fine-grained aeolian soils, are most susceptible to collapse.




PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

June 30, 2011

Source: Expansive soils, USGS Soil Survey Geograpahic Database, 2007-2008

N

0 5 10 Miles

0 10 20 Kilometers

Alternative alignments

Existing rail line

Major road

Hydrographic feature

Community/Urban area

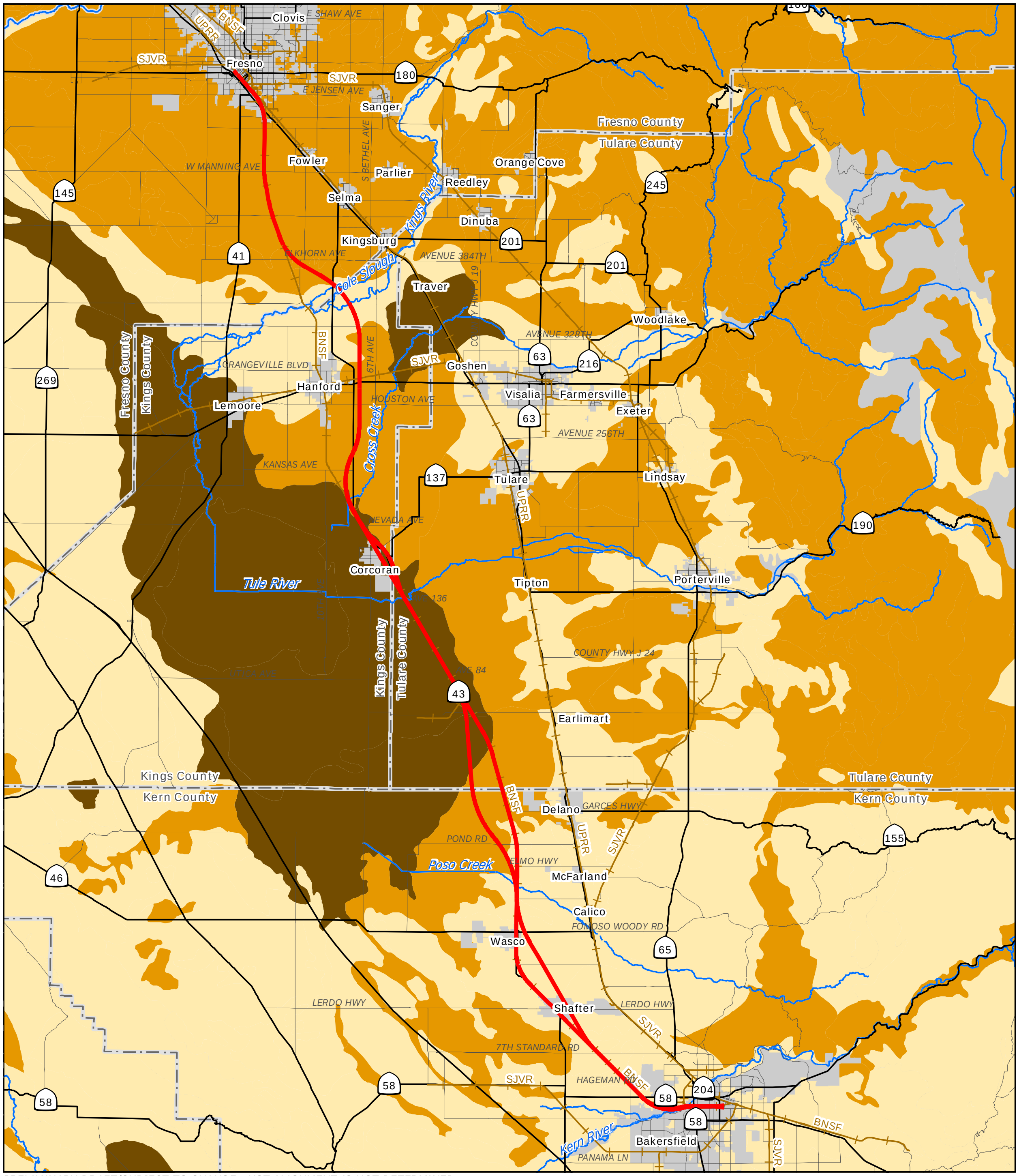
County boundary

Expansive potential

High

Moderate

Figure 4.2-2
Expansive soils in the study area




PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

Source: Corrosive soils, USGS Soil Survey Geograpahic Database, 2007-2008

July 1, 2011

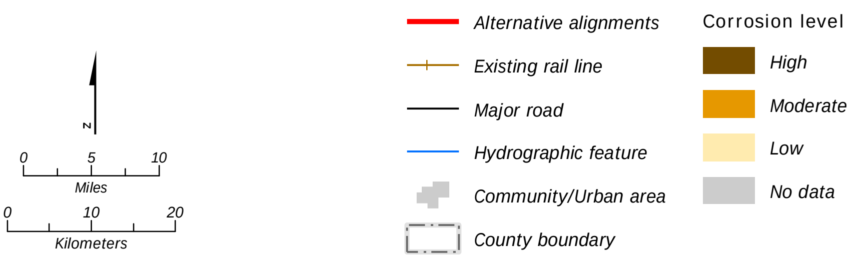
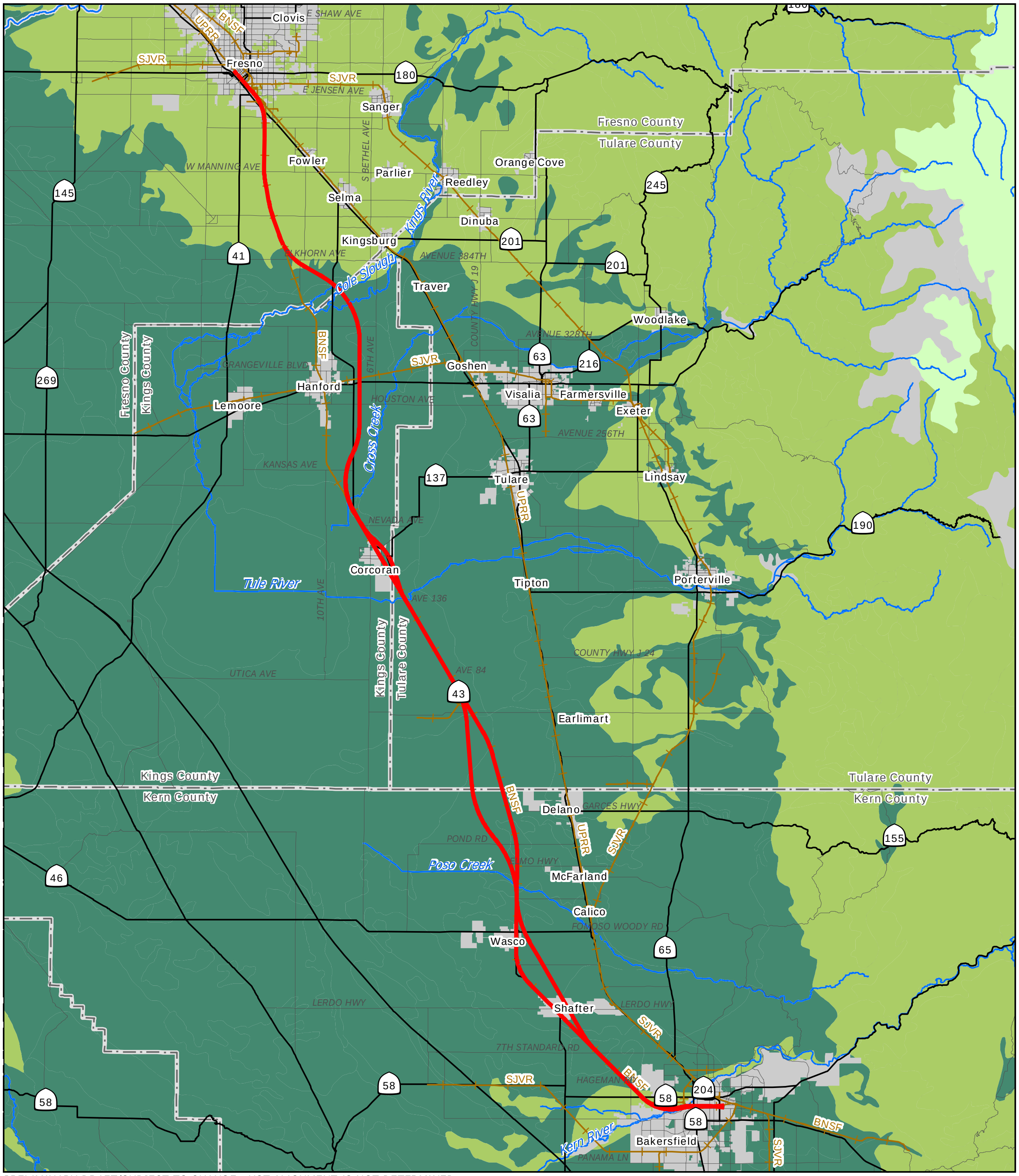


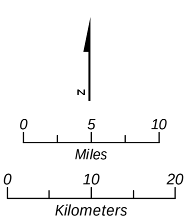

Figure 4.2-3
*Susceptibility of concrete to corrosion when in contact with the soil*




PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

July 1, 2011

Source: Corrosive soils, USGS Soil Survey Geographic Database, 2007-2008




*Alternative alignments*

*Existing rail line*

*Major road*

*Hydrographic feature*

*Community/Urban area*

*County boundary*

Corrosion level

*High*

*Moderate*

*Low*

*No data*

Figure 4.2-4

*Susceptibility of uncoated steel to corrosion when in contact with the soil*

Soils in the San Joaquin Valley have similar textures to that of loess, with classifications ranging from poorly graded silty sand to clay (predominantly montmorillonite) (Hunt 1984). Laboratory testing during the field investigation phases of the project would be required to identify soils susceptible to collapse. The dominant soil types subject to collapse upon the addition of water are along portions of the western edge of the San Joaquin Valley, where mudflows resulted in the deposition of alluvial fans emanating from the foothills to the west (CDMG 1973). Thus, these materials, which are distant to the HST alignment, are unlikely to be encountered along the Fresno to Bakersfield alignment alternatives.

#### D. ERODIBLE SOILS

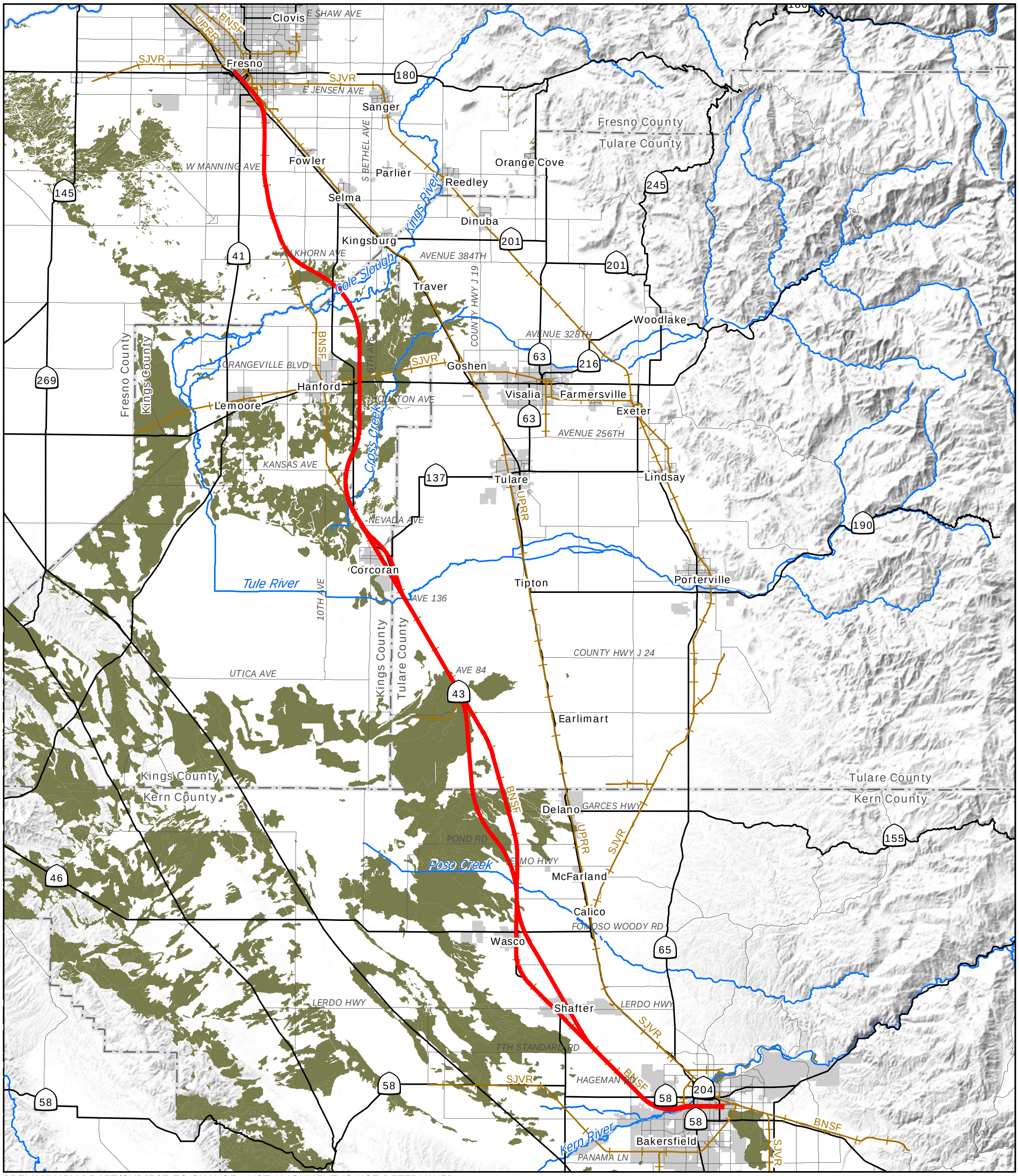
Certain soil types demonstrate a higher potential for erodibility due to the forces of flowing or impinging water (rainfall and runoff) than other soil types. This is expressed in the Revised Universal Soil Loss Equation by a factor designated K, the soil erodibility factor. Figure 4.2-5 presents the HST alignments compared to relative soil erodibility factors along their length. In this case, K is defined as a function of texture, organic matter content and cover, structure size class, and subsoil-saturated hydraulic conductivity. Soils with a relatively high silt content and low to negligible plasticity tend to be the most erodible; as a rule of thumb, values of K in excess of 0.4 are considered to be highly susceptible to erosion, as noted on Figure 4.2-5.

This figure indicates that most of the HST alternative alignments are not located in areas that are particularly susceptible to erosion; however, the following reaches show a K greater than 0.4:

- North of Laton
- In the vicinity of Hanford
- Locally north of Corcoran
- East of Alpaugh
- West of Delano
- In the southeastern portion of Bakersfield

### 4.2.4 Areas of Difficult Excavation

Due to the presence of predominantly uncemented Quaternary sediments in the San Joaquin Valley, areas of difficult excavation along the HST alignment (including drilled piers or driven piles) are not anticipated. However, some soils with zones of hardpan (those containing a layer commonly cemented by calcium carbonate or other mineral constituents) may locally pose excavation issues, depending on the thickness and degree of cementation. Difficult excavation is defined herein to mean requiring the use of excavation tools and equipment, such as rippers or rock core barrels, beyond those normally used for standard earthwork conditions. Figure 4.2-6 indicates soils along the HST alignment where difficult excavation conditions may be encountered. These include small portions of the San Joaquin-Madera-Cometa association in downtown Fresno; the Nord-Grangeville-Chino association north of E. Harlan Avenue and the town of Hanford, and the Westcamp-Houser-Gepford-Armona association south of the town of Corcoran.




PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

July 1, 2011

Source: Erodible soils, USGS Soil Survey Geograpahic Database, 2007-2008

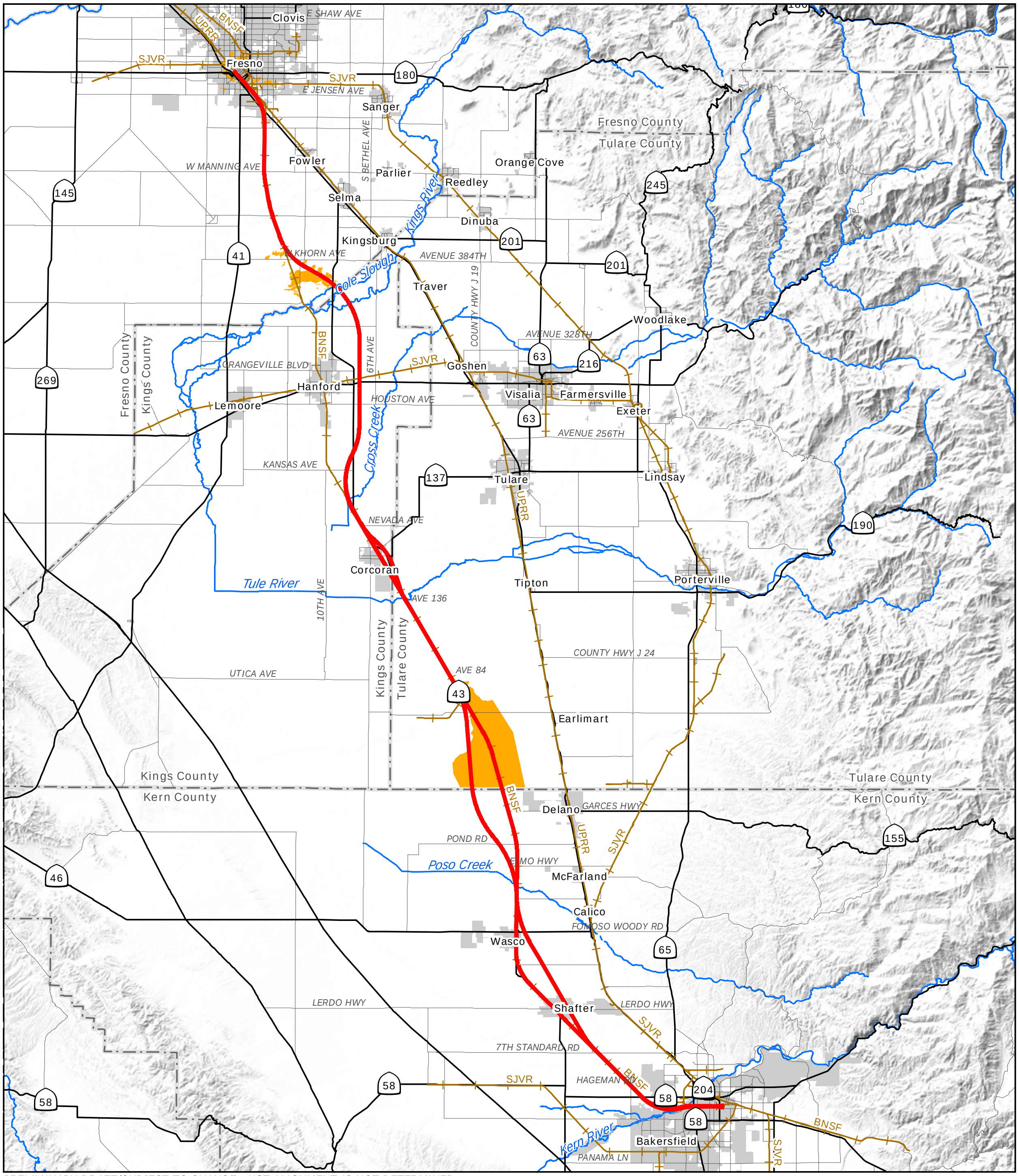
Alternative alignments
Existing rail line
Major road
Hydrographic feature
Highly erodible soils (K factor, rock free > 0.4)
Community/Urban area
County boundary

N

0 5 10 Miles

0 10 20 Kilometers

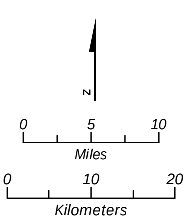
Figure 4.2-5
*Erodible soils in the study area*




*PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED*

*July 1, 2011*

*Source: Hardpan soils, USGS Soil Survey Geograpahic Database, 2007-2008*




*Alternative alignments*

*Existing rail line*

*Major road*

*Hydrographic feature*

*Community/Urban area*

*County boundary*

*Difficult to excavate soil*

Figure 4.2-6

*Difficult to excavate soils in the study area*

# 4.3 Primary Seismic Hazards

Primary seismic hazards are those hazards directly associated with earthquakes, and include ground surface fault rupture and strong ground shaking.

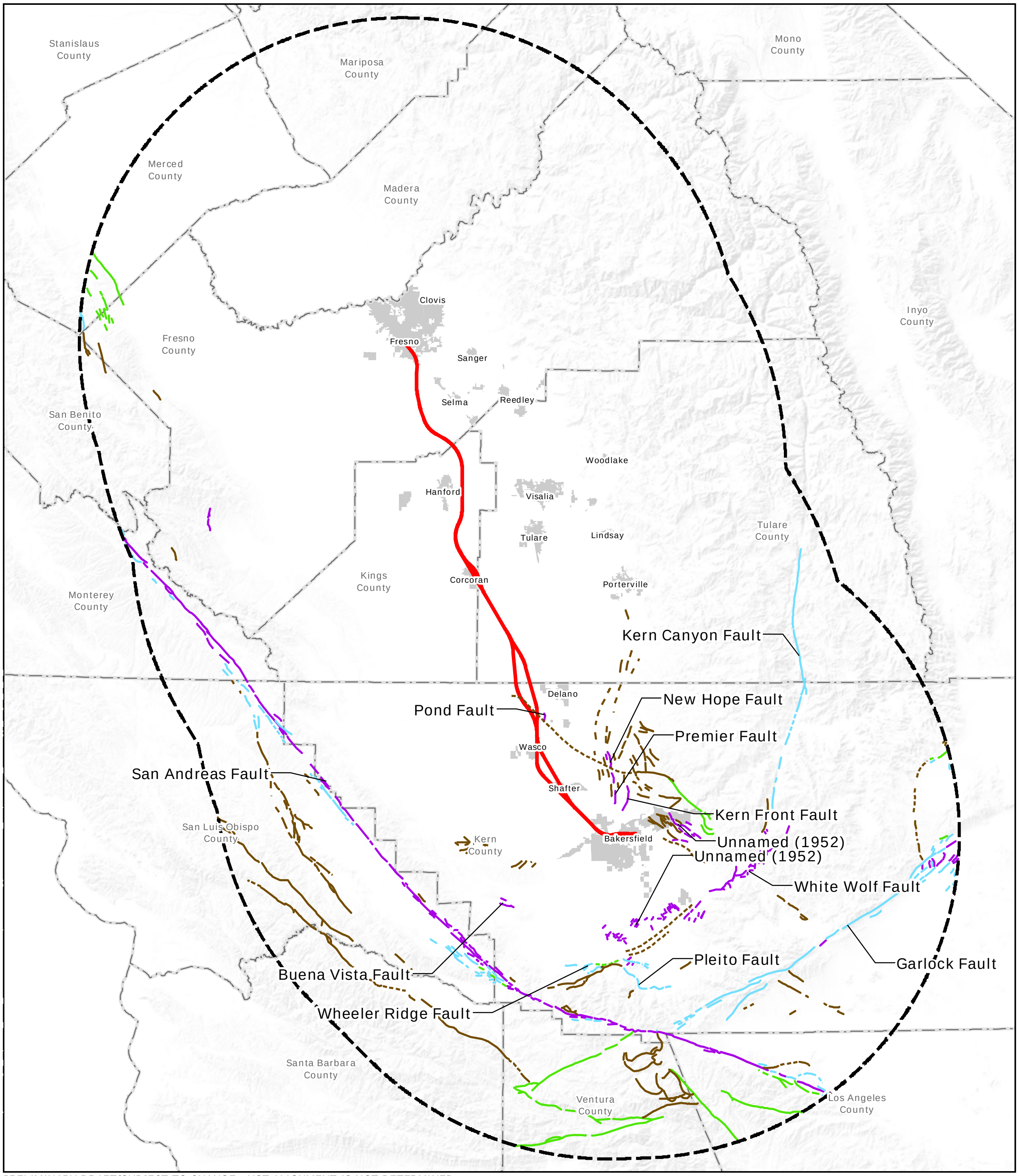
## 4.3.1 Surface Fault Rupture

Fault rupture refers to the extension of a fault to the ground surface by which the ground breaks, resulting in an abrupt relative ground displacement; for example, vertical or horizontal offset. Surface fault ruptures are the result of stresses relieved during an earthquake event, and often cause damage to structures astride the rupture zone.

To help identify and reduce the hazard of surface fault rupture, the “Alquist-Priolo Earthquake Fault Zoning Act” (AP Act) is a state law enacted to regulate certain development projects near active faults. The purpose of the act is to prohibit the location of most structures intended for human occupancy across the trace of an active fault. The act requires that development permits for projects in “Earthquake Fault Zones” be withheld until geologic investigations demonstrate that the sites are not threatened by surface displacement from future fault rupture. To be zoned under the AP Act, a fault must be considered active, or both sufficiently active and well-defined (CDMG 1997). The California Geological Survey (CGS) defines an active fault as one that has had surface displacement within Holocene time (about the last 11,000 years); and a sufficiently active fault as one that has evidence of Holocene surface displacement along one or more of its segments or branches (CDMG 1997). The CGS considers a fault to be well defined if its trace is clearly detectable as a physical feature at or just below the ground surface.

The Fresno to Bakersfield Section crosses the Pond Fault, which is mapped as a concealed fault in the area where it crosses the alignment. It should be noted that different names have been used for this structure, including Pond-Poso Creek in the concealed, longer, northwest-oriented portion of the fault (Jennings and Bryant 2010). The Pond Fault is situated to the east of Pond, California (Figure 4.3-1). It consists of a 2/3-mile-wide zone of northwesterly trending normal faults. The southernmost strand of the Pond Fault is approximately 3 miles to the south of the community of Pond, and 2 miles to the east of where the HST crosses the fault. It is interpreted to be an extension of the Poso Creek Fault, to the south. The fault segment was evaluated as part of a state-wide effort to evaluate faults for recent movement (Smith 1983), and was part of a Los Angeles Department of Water and Power (LADWP 1974) study for the siting of a nuclear power plant. Previous studies have shown that historic fault rupture (creep) has occurred on the fault, with repeated movement likely since Eocene and possibly Paleocene time (LADWP 1974, p. 2.5E 67A). The fault displacement is interpreted to be “normal,” downthrown to the southwest, and dipping approximately 50 to 70 degrees from horizontal. The amount of total displacement along the width of the zone decreases to the northwest. The westernmost portion of the fault is interpreted to have the largest displacements. This segment of the fault, if projected to the surface at this location, would be in the vicinity of Lytle Avenue, approximately 1.5 mile east of Pond and the HST alignment. During the LADWP study, the following observations were made:

- North-south-trending zone of cracks crossing Elmo Highway, approximately 1.5 miles east of the HST alignment.
- A sag, cracks, and a scarp in the Peterson Road pavement, approximately 1.5 miles east of the HST alignment.

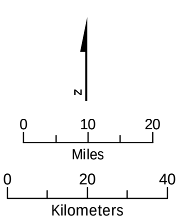



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

July 1, 2011

Source: C.W. Jennings and W.A. Bryant, *Fault Activity Map of California and Adjacent Area,* Geologic Data Map no. 6

Scale: 1:750,000 (California Geological Survey, 2010)




Active

Holocene faults

- Approximate location
- Concealed
- Well located

Historic faults

- Approximate location
- Concealed
- Well located

Potentially Active

Quaternary faults

- Approximate location
- Concealed
- Well located

Late Quaternary faults

- Approximate location
- Concealed
- Well located

- Alternative alignments
- 62-mile buffer from alignments
- Community/Urban area
- County boundary

Note: Faults with historic breaks are named but not necessarily discussed in text.

Figure 4.3-1
Active and potentially active faults within 62 miles of the HST alternatives

- An 8-foot-wide zone of cracked pavement, with an up to 2-inch-high scarp and broad sag across Lytle Road, approximately 1.5 miles east of the HST alignment.
- A wide zone of dips in pavement across Benner Road, approximately 1 mile east of the HST alignment.

The HST alternative alignments (BNSF Alternative Alignment and Allensworth Bypass) pass over the concealed portion of the Pond Fault. At the crossing, the fault is approximately 1 mile south of the community of Pond. From the HST/fault crossing, the Pond Poso Fault extends concealed in a northwesterly direction approximately 5 miles, where it curves to the west another 2 miles to its mapped terminus (Jennings and Bryant 2010). To the south of the HST/fault crossing, the fault extends concealed to the southeast approximately 22 miles, where it crosses Poso Creek. To the southeast of the creek, the fault continues unconcealed, where it meets the Kern Gorge Fault in the vicinity of Pine Mountain. In this region, the fault is downthrown to the south, and dips to the south (Jennings and Bryant 2010).

The conclusion of the fault evaluation study (Smith 1983) suggested that the Pond Fault was sufficiently well defined to warrant zoning, and the likely cause of the documented historic surface rupture may be the result of subsidence due to groundwater withdrawal rather than tectonics.

### 4.3.2 Seismic Sources

The Fresno to Bakersfield Section is in the San Joaquin Valley of California in a relatively seismically quiescent region between two areas of documented tectonic activity. The Pacific Coast Ranges to the west contain many active faults that are associated with the northwest-trending San Andreas Fault System (Jennings and Bryant 2010). The Coast Ranges-Sierran Block boundary zone, which follows the physiographic boundary between the Coast Ranges and Great Valley, contains potentially active blind thrust faults, which are thrust faults that do not rupture all the way to the ground surface (Unruh and Moores 1992). Based on the size of historical events and on the inferred segmentation of the boundary zone, these blind thrust faults are capable of producing moderate to large earthquakes. The San Andreas Fault, which parallels the Pacific Coast Ranges along the Fresno to Bakersfield Section, has a long history of movements and earthquakes, and is therefore considered a likely potential source of a damaging earthquake along the HST alignment. The San Andreas Fault, at its closest to the Fresno and Bakersfield HST Stations, is approximately 70 and 37 miles to the west, respectively.

Known active fault zones that would pose the most serious hazard to the Fresno to Bakersfield Section include the San Andreas Fault to the west, the Owens Valley Fault Group to the east, and the White Wolf Fault to the south. The Owens Valley system is too far away from the HST alignment to be shown on Figure 4.3-1, which shows fault systems within 62 miles (about 100 kilometers) from the alignment. These faults and the available data pertaining to them indicate that they too could be the source of strong ground shaking for the four-county study area.

The Owens Valley Fault Group consists of a series of faults that have been the source of numerous earthquakes in historic time. Along the base of the eastern slope of the Sierra Nevada, the Owens Valley Fault Group is divided into three sections: a northern active area, a central seismically “quiet” area, and a southern area. The northern active area of the Owens Valley Fault Group is approximately 90 miles to the east of Fresno.

The White Wolf Fault, near the Tehachapi range southeast of Bakersfield, is a mapped active fault that produced a damaging series of earthquakes in 1952. The White Wolf Fault is a left-lateral-reverse fault approximately 60 miles long. The seismicity of the area is limited to a single major event and its aftershocks. The White Wolf Fault is approximately 28 miles to the southeast of the Bakersfield Station.

The area surrounding the Fresno to Bakersfield Section has been classified by the most recent California Uniform Building Code (2007). The area from the northern terminus of the Bakersfield to Fresno HST Section to approximately the northern Kern County border has been designated as Seismic Zone 3 (1 in 10 chance that an earthquake with an active peak acceleration level of 0.30g (3/10 the acceleration of gravity) will occur in the next 50 years. The rest of the study area is designated as Seismic Zone 4, with a 1-in-10 chance that an earthquake with an active peak acceleration level of 0.40g (4/10 the acceleration of gravity) will occur in the next 50 years.

The faults and related magnitude of maximum probable earthquake and recurrence interval are listed in Table 4.3-1. Figure 4.3-1 presents these fault systems with respect to the Fresno to Bakersfield Section.

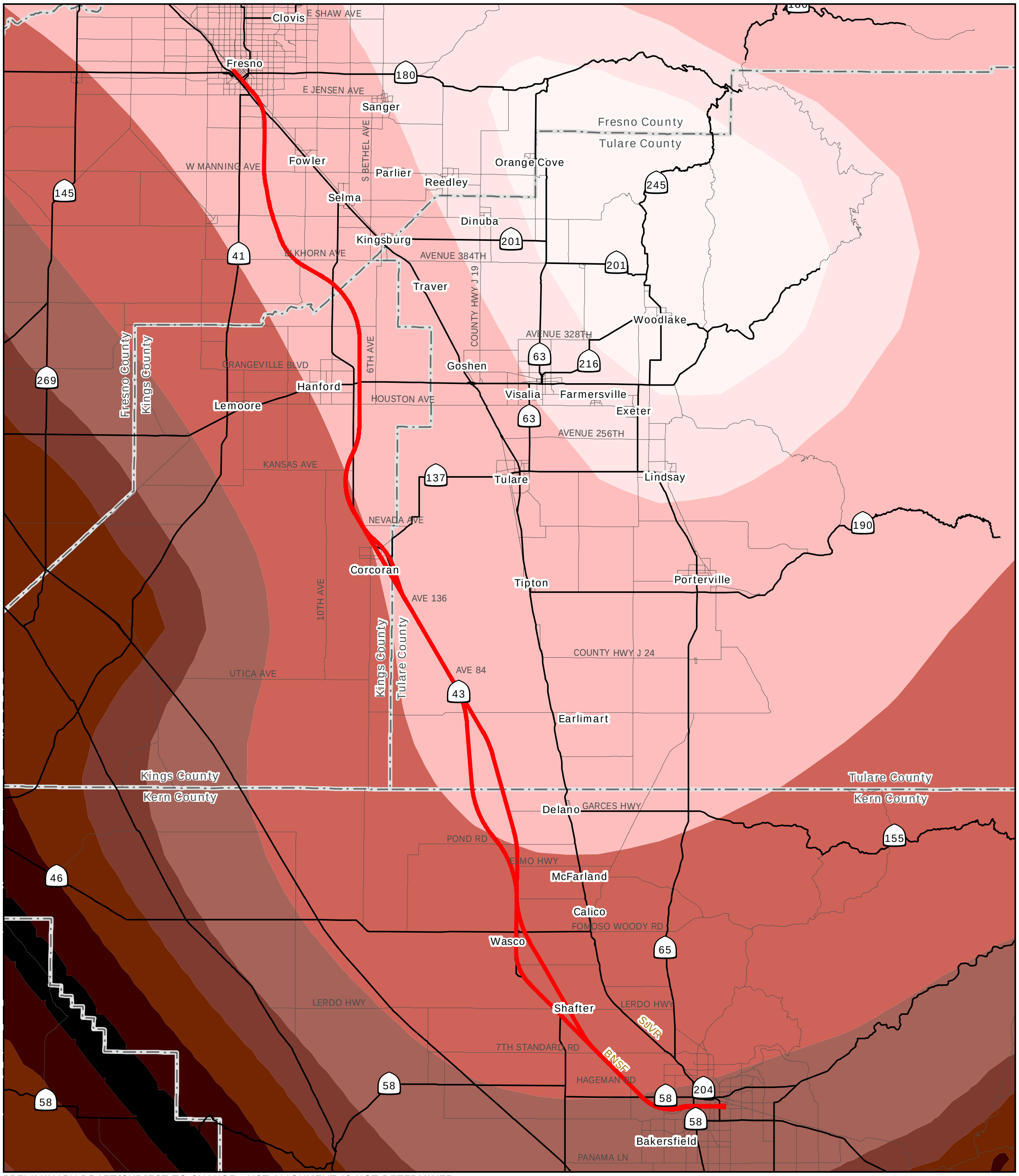
**Table 4.3-1**
Active Faults with the Highest Potential for Strong Ground Shaking

| Fault | Magnitude of Maximum Earthquake (Richter) | Recurrence Interval (years) |
|---|---|---|
| San Andreas Fault | | |
| 1857 Break | 8.3 - 8.5 | 160 |
| Owens Valley Fault Group | | |
| North Area | 7.0 | 125 |
| Central Area | 8.25 | 300 - 10,000 |
| South Area | 6.0 | 135 |
| White Wolf Fault | 7.0 | 1,000 - 5,000 |
| Kern Canyon | 7.1 | 800 - 3,700 |
| Source: Envicom Corporation 1974; Grant and Sieh 1994; URS 2010. | | |

## 4.3.3 Seismic Ground Motion

The Fresno to Bakersfield Section is susceptible to strong ground shaking generated during earthquakes on nearby faults. Strong ground motion occurs as energy is released during an earthquake. The intensity of ground motion depends on the distance to the fault rupture, the earthquake magnitude directivity effects, and the geologic conditions underlying and surrounding the site through which the seismic waves pass.

Ground motions induced by a seismic event are characterized by a value of horizontal peak ground acceleration (PGA) that is expressed as a percentage of the acceleration of gravity (g). Either deterministic or probabilistic methods are typically used to estimate the level of shaking that can be expected at a project site. The USGS has developed a probabilistic seismic hazard model for California (USGS 2008). Probabilistic estimates of ground motion corresponding to a 10% probability of exceedance in 50 years can be obtained from a USGS web site by inputting the latitude and longitude of the project site (USGS 2008). Figure 4.3-2 presents the calculated PGAs for the Fresno to Bakersfield Section for this particular level of activity. Estimates of PGAs for the proposed HST stations and a potential Heavy Maintenance Facility (HMF) are derived from this web site, and are provided in Table 4.3-2. The highest ground accelerations (>0.3g) are anticipated in Bakersfield.




PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

July 1, 2011

Source: U.S. Geological Survey, Peak Ground Acceleration, National Hazard Seismic Maps (2008)

Peak horizontal acceleration, 2% in 50 years (%g)

- 16-18
- 18-20
- 20-30
- 30-40
- 40-50
- 50-60
- 60-80
- 80-120
- 120-160

- Alternative alignments
- Major road
- County boundary

N

0 5 10
Miles

0 10 20
Kilometers

Note: Peak horizontal accelerations shown on this figure, from the USGS website, are for bedrock. Peak horizontal ground accelerations shown in Table 4.3-2 are derived by using the process described by Seed et al. 2002.

Figure 4.3-2
Calculated peak ground acceleration
(2% probability of exceedance in 50 years)

**Table 4.3-2**
Summary of Peak Ground Acceleration Values at Station Locations and Potential HMF Sites along the Fresno to Bakersfield Section

| Station/HMF Sites | Peak Ground Acceleration (%g) 10% Probability of Exceedance in 50 years | |
|---|---|---|
| | Rock[1] | Ground Surface[2] |
| Fresno Station | 0.13 | 0.25 |
| Kings/Tulare Regional Station | 0.14 | 0.26 |
| Bakersfield Station | 0.23 | 0.35 |
| (HMF) Fresno Works–Fresno | 0.13 | 0.25 |
| (HMF) Kings County–Hanford | 0.15 | 0.27 |
| (HMF) Kern Council of Governments–Wasco | 0.18 | 0.30 |
| (HMF) Kern Council of Governments–Shafter (East and West sites) | 0.21 | 0.32 |

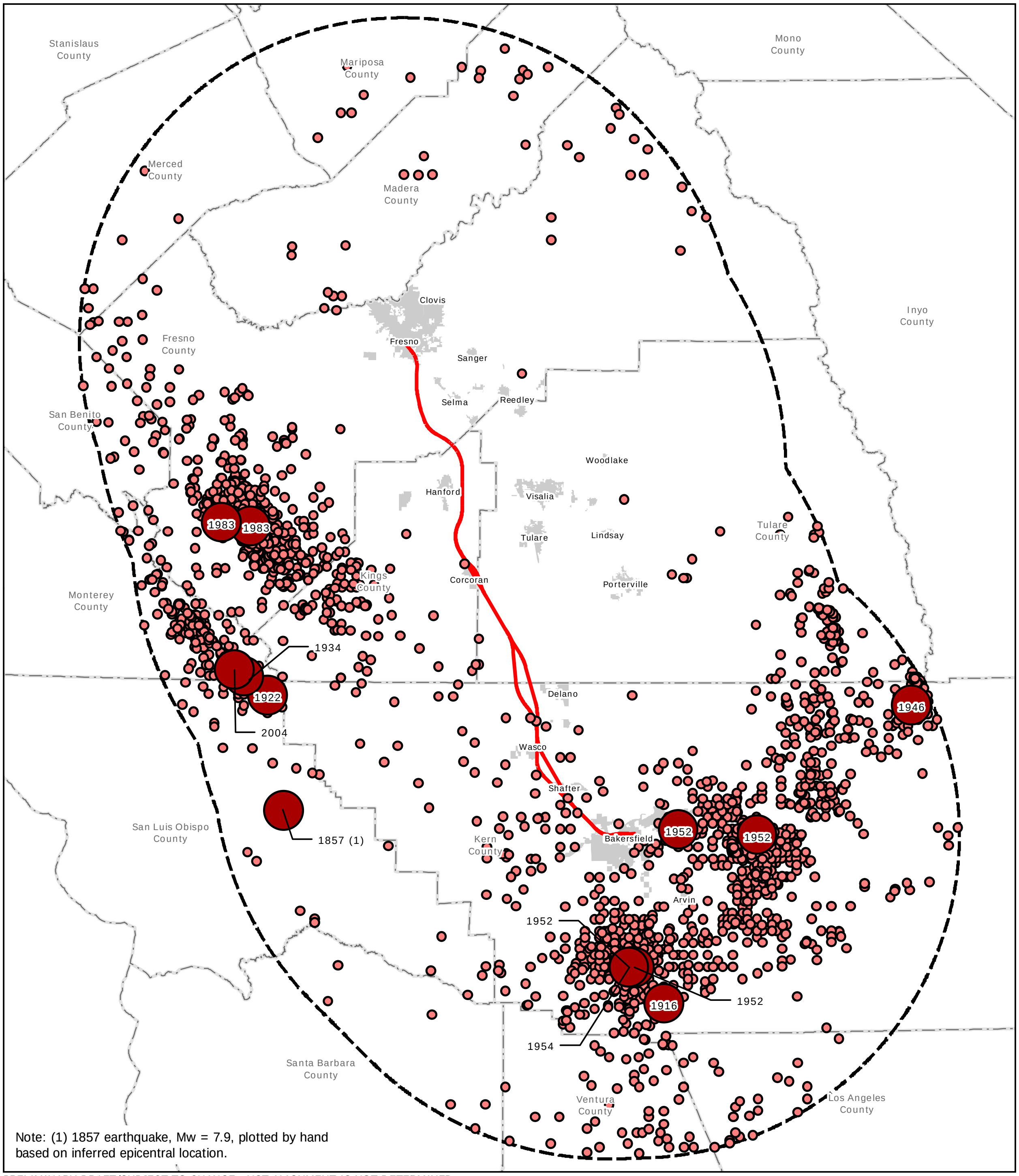
Source: USGS 2008.

[1] Bedrock acceleration, from USGS 2008; see also Figure 4.3-2.

[2] Converted to ground surface acceleration in accordance with Seed et al. (2002).

## 4.3.4 Historic Seismicity

The largest historic earthquake in the vicinity of the Fresno to Bakersfield Section occurred along the San Andreas Fault, which lies to the west of the project. The Fort Tejon earthquake (estimated Magnitude 7.9) on this fault occurred on January 9, 1857. Strong shaking caused by the earthquake was reported to have lasted for at least 1 minute. Historic earthquake activity in the region is shown on Figure 4.3-3.




PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

July 5, 2011

Source: Historic Earthquakes, USGS, 2010. California Historical Earthquake Online Database, 1769 - 1974.

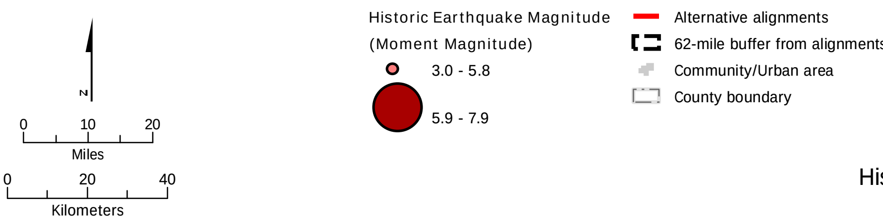



Figure 4.3-3
Historic earthquakes and magnitudes within 62 miles of the project area

Some of the major historic earthquakes in the vicinity of the project and their magnitudes and locations are listed in Table 4.3-3.

**Table 4.3-3**
Summary of Significant Historic Earthquakes in Southern California Region

| Date | Location/Fault | Moment Magnitude | Epicentral Latitude (degrees) | Epicentral Longitude (degrees) |
|---|---|---|---|---|
| 09 January 1857 | Ft. Tejon / San Andreas | 7.9 | 35.30 | -119.80 |
| 21 July 1952 | Kern County / White Wolf | 7.7 | 35.00 | -119.02 |
| 28 June 1992 | Landers / various | 7.3 | 34.20 | -116.44 |
| 26 March 1972 | Owens Valley / Owens Valley | 7.4 | 36.70 | -118.10 |
| 16 October 1999 | Hector Mine / (?) | 7.1 | 34.59 | -116.27 |
| 19 May 1940 | Imperial County / Imperial | 6.7 | 32.73 | -115.50 |
| 2 May 1983 | Coalinga / "Coalinga nose" | 6.4 | 36.32 | -120.31 |
| 4 August 1985 | Kettleman Hills / Blind Thrust | 6.1 | - | - |
| 22 October 1916 | Tejon Pass / San Andreas | 6.0 | - | - |
| Source: CGS 2003. | | | | |

# 4.4 Secondary Seismic Hazards

Secondary seismic hazards include phenomena that occur as a result of ground shaking, including liquefaction, lateral spreading, seismic settlement, seismically induced landsliding, and earthquake-induced flooding.

## 4.4.1 Liquefaction

Soil liquefaction is the process by which the shear strength of granular-saturated soils is reduced because of an increase in pore pressure during seismic shaking, or human-induced events. Requisite conditions for liquefaction to occur include saturated granular soils that are not free-draining, with a loose-packed grain structure capable of progressive rearrangement of grains during repeated cycles of seismic loading. When liquefaction occurs, the particles rearrange to a denser state, but excess pore pressure is not dissipated; therefore, the shear strength of the soil decreases, thus reducing the soil's ability to support foundations for buildings and bridges.

According to the Five-County Seismic Safety Element (Envicom Corporation 1974), soil types along the Fresno to Bakersfield Section of the HST alignment are not conducive to liquefaction because of the coarse soil textures typical of the eastern portion of the San Joaquin Valley.

Similarly, the groundwater table is quite deep (greater than 100 feet) over much of the alignment. The Geologic and Seismic Hazards Report (Authority and FRA 2011) includes figures and text that describe:

- The areas most likely to have a shallow enough water table to allow seismic liquefaction to occur relative to the HST alignment, which are to the south of Fresno and between Corcoran and the Tulare/Kern County line; and
- Areas in the vicinity of major stream crossings where recharge may be occurring.

### 4.4.2 Lateral Spreading

One of the consequences of seismic liquefaction in sloping ground areas is the phenomenon known as lateral spreading, which refers to the translation of land laterally after the loss of support due to liquefaction. For this to occur, the liquefied area must be relatively near a free face, a vertical or sloping face such as a road cut or stream/river bank. The Fresno to Bakersfield Section is relatively flat; therefore, lateral spreading in response to the liquefaction of subsurface soil is not expected. However, localized lateral spreading may occur in areas where the HST traverses creeks and river channels.

### 4.4.3 Seismically Induced Landslide Hazards

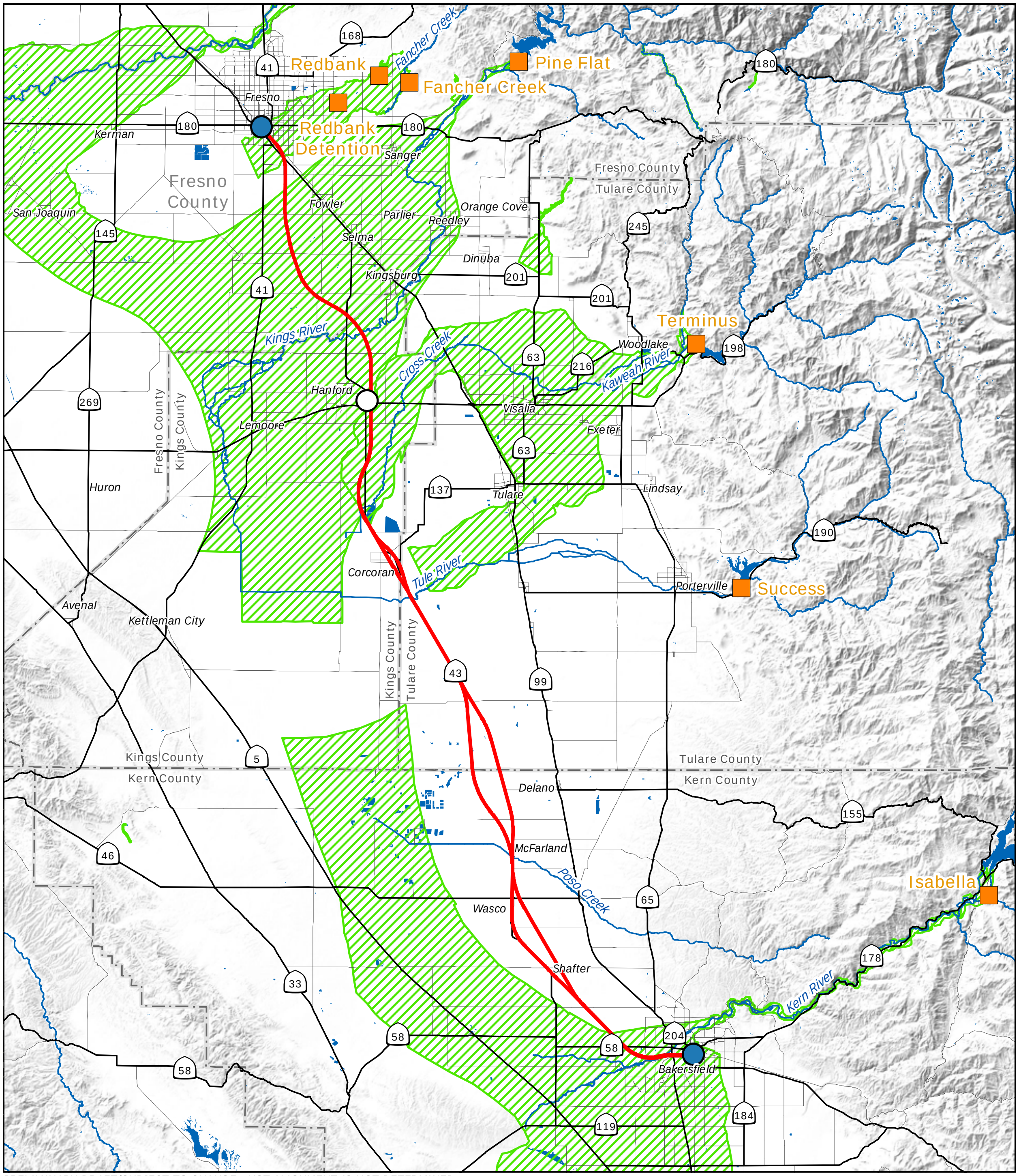
Landslides triggered by earthquakes historically have been a significant source of damage in California. Areas that are most susceptible to earthquake-induced landslides are steep slopes in poorly cemented or highly fractured rocks, areas underlain by loose, weak soils, and areas on or adjacent to existing landslide deposits. These types of geologic terrains do not exist in the relatively flat-lying areas that the Fresno to Bakersfield Section crosses. Accordingly, seismically induced landslide hazards for the Fresno to Bakersfield Section are judged to be very low.

### 4.4.4 Seismically Induced Flood Hazards

Seismically induced flooding is caused by failure of water-retaining structures such as a dam, levee, or storage tank during a seismic event. Seiche or tsunami waves are another type of seismically induced flooding. A seiche refers to the movement of an enclosed body of water such as a bay, lake, river, or reservoir due to periodic oscillation. Seiches commonly occur as a result of intense seismic shaking or catastrophic landslides displacing large amounts of water in a short period of time. The period of oscillation varies, and depends on the size of the water body. The period of a seiche can last for minutes to several hours, and depends on the magnitude of oscillations, as well as the geometry of the water body. Seiches have been recorded to cause significant damage to nearby structures, including dams, shoreline facilities, and levees or embankments. Because no large bodies of water are near the Fresno to Bakersfield Section, the risk of damage from seiches is considered to be low.

A tsunami is an ocean wave that develops as a result of the displacement of large amounts of water over a short period of time. Tsunamis are commonly associated with submarine faults that displace water in the ocean over long distances. The effect of a tsunami on a shoreline is closely associated with the bathymetric properties of an ocean basin. Tsunamis can also occur as a result of submarine, as well as land-based landslides, which displace large volumes of water over a short period of time. Due to the distance from the ocean (about 75 to 100 miles) tsunamis do not present a potential hazard to the Fresno to Bakersfield Section.

Review of the California Emergency Management Agency's dam inundation maps shows that the Fresno to Bakersfield Section of the HST crosses over potential inundation areas of several reservoirs. The inundation areas relative to this HST section are shown on Figure 4.4-1 and discussed below. The inundation areas shown are conservative scenarios, assuming that the retained bodies of water are at their maximum elevation, and assuming catastrophic failure of the retaining structures during seismic shaking. Potential flooding due to dam failure is discussed in more detail in Section 3.8, Hydrology and Water Resources.

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July 1, 2011

Source: California Office of Emergency Services, Dams and Dams Inundation Area; GIS Data (2000)

Dam

Area potentially subject to inundation due to catastrophic dam failure

Preferred HST station

Potential Kings/Tulare Regional Station

Alternative alignments

County boundary

0 5 10 Miles

0 10 20 Kilometers

Note: Inundation area due to failure of Success Dam not available.

Figure 4.4-1
*Inundation in the study area due to catastrophic dam failures*

Failure of the Redbank, Fancher Creek, and Redbank Detention dams approximately 8 miles east of the proposed Fresno Station would result in flood waters traveling westerly through Fancher Creek, which meanders to the northwest of Calwa City. Flood waters would likely inundate portions of the alternative alignments from the proposed Fresno Station south to Calwa City.

Pine Flat Reservoir is approximately 27 miles to the northeast of the Fresno to Bakersfield Section in the Kings River drainage area (Figure 4.4-1). The Pine Flat Dam, near Piedra, is a 440-foot concrete gravity dam operated by the U.S. Army Corps of Engineers (USACE). Forming Pine Flat Lake with a capacity of 1,000,000 acre-feet, its primary functions are flood control, irrigation, and recreation. Should Pine Flat Dam fail during an earthquake, flood waters would travel south and southwest through the Kings River drainage area, where they would first intercept the alternative alignments just south of the city of Fresno, and continue to spread to the south to an area east of Hanford, inundating the alternative alignments between Corcoran and Hanford (including the potential HST station site).

Terminus Reservoir (Lake Kaweah) is approximately 37 miles to the east of the potential Kings/Tulare Regional Station. The Terminus Dam is a dam on the Kaweah River that provides primarily irrigation and municipal water supply. Built by the USACE, the earthfill dam is 130 feet high and approximately 870 feet long, and impounds about 143,000 acre-feet of water. According to the Health and Safety Element of the Tulare County General Plan (Tulare County 2009), dam failure at full capacity is considered remote. In the unlikely event of dam failure, flood waters would be expected to reach portions of Kings County within 12 hours. These waters would cover an approximately 6-mile portion of BNSF Alternative Alignment and the Corcoran Bypass between Hanford and Corcoran.

Lake Success is approximately 37 miles to the east of Corcoran (Figure 4.4-1). The dam is a 156-foot-high earth dam and impounds approximately 62,000 acre-feet of water. The primary purpose of the dam is flood control. According to the Tulare County General Plan, failure of the Success Dam could cause substantial flooding in Tulare County; however, maps showing inundation due to the potential of dam failure are outdated, with new maps currently in development (USACE 2010).

Isabella Dam is approximately 37 miles to the northeast of Bakersfield, California (Figure 4.4-1). The dam consists of a main dam and an auxiliary dam built and operated by the USACE. The main dam is 185 feet high and the auxiliary dam is 98 feet high; both are of earthen construction, and serve primarily for flood control. The dam impounds about 568,000 acre-feet of water. The water impounded behind the main dam forms Isabella Lake. Water from the lake is released in two possible ways: release into the Lower Kern River through the main dam outlet works; or via a canal to a downstream powerhouse from the Auxiliary dam. In late April 2006, seepage problems were discovered in the Isabella Auxiliary Dam.

In 2007, the USACE found evidence of an active fault (Kern Canyon Fault) beneath the structure of the Isabella Auxiliary Dam. Upon discovery, the USACE reduced the fill capacity to no more than 66%, a level deemed safe and within acceptable safety parameters. Updated flood maps prepared by the USACE in 2008 show that the BNSF Alignment Alternative and the Bakersfield South Alternative could be inundated by as much as 20 feet of water if Isabella Dam were to fail.

## 4.5 Geological Resources

### 4.5.1 Mineral Resources

Information on the mineral resource potential in the study area was obtained from publications of the Department of Conservation, CGS. The Surface Mining and Reclamation Act of 1975 (SMARA) directs the State Geologist to classify the non-fuel mineral resource zones (MRZs) of the state to show where economically significant mineral deposits occur based on scientific data. According to the CGS, the major mining and mineral producers active in the San Joaquin Valley consist of sand and gravel extraction.

Land studied by the CGS is classified as Mineral Resource Zones 1 through 3:

- MRZ 1 – Areas where adequate information indicates that no significant mineral deposits are present, or where it is judged that little likelihood exists for their presence.
- MRZ 2 – Areas where adequate information indicates that significant mineral deposits are present, or where it is judged that a high likelihood exists for their presence.
- MRZ 3 – Areas containing mineral deposits, the significance of which cannot be evaluated from available data.

Information on the mineral resource potential in the Fresno portion of the study area was obtained from the California Department of Conservation—Division of Mines and Geology, Generalized Mineral Land Classification of Aggregate Resources in the Fresno Production-Consumption (P-C) Region (CDMG 1988b). In accordance with California's SMARA, the land in the Fresno P-C Region is classified according to "the presence, absence, or likely occurrence of significant mineral deposits in areas of the county subject to either urban expansion or other irreversible land uses incompatible with mining."

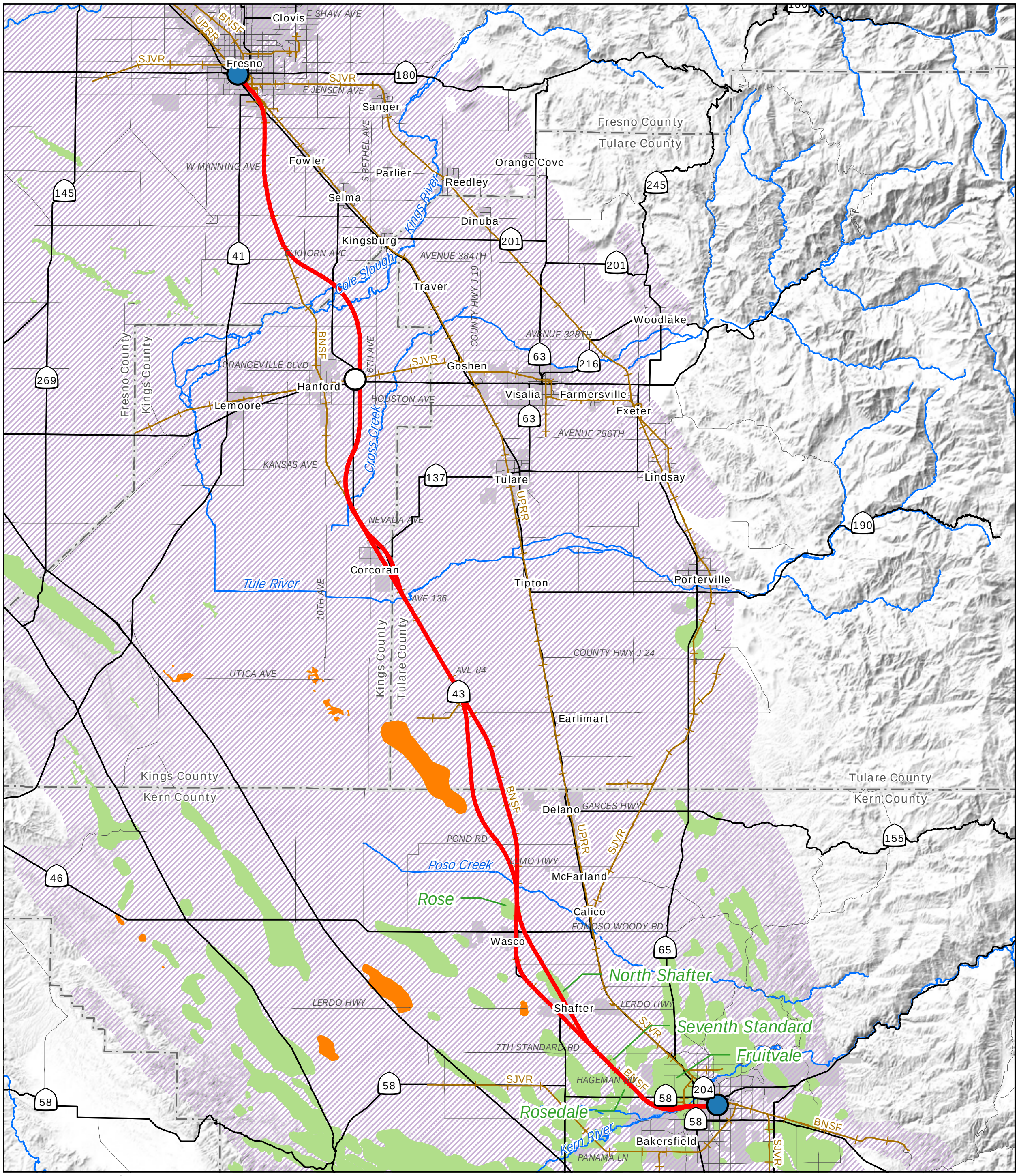
The San Joaquin River Resource Area and the Kings River Resource Area (about 1 mile and over 15 miles east of the Fresno to Bakersfield Section, respectively) are areas in the Fresno study area, which are mapped as MRZ 2.

The CDMG published Special Report 147 (SR 147) – Mineral Land Classification: Aggregate Materials in the Bakersfield Production-Consumption Region (CDMG 1988a). Special Report 210, published in October 2009 (CDMG 2009), reevaluates and updates SR 147. Sand and gravel deposits with material suitable for use as construction aggregate are classified in this updated report. Emphasis was placed on deposits of Portland Cement Concrete-grade (PCC-grade) aggregate; however, permitted deposits suitable for lower grades of aggregate use—such as asphaltic aggregate, base, subbase, and fill—were also included. Only PCC-grade deposits were placed in sectors for potential consideration for designation by the State Mining and Geology Board. A review of the Bakersfield study area relative to the published update indicates that MRZ 2 conditions apply to about a 4-mile-long segment of the alternative alignments between the intersection of Highways 99 and 178. All other portions of the alignment in the Bakersfield P-C area are designated MRZ 3.

### 4.5.2 Fossil Fuel Resources (Oil and Natural Gas)

The Great Valley has produced trillions of cubic feet of natural gas and millions of barrels of oil since the discovery of these resources more than 100 years ago. The Fresno to Bakersfield Section is in close proximity to numerous active and abandoned oil and gas fields. These fields are primarily in the northern and southern portion of the rural segment of the project and in Bakersfield. The Fresno to Bakersfield Section is situated in the Division of Oil, Gas, and Geothermal Resources (DOGGR) Districts 4 and 5. District 4 includes Kern and Tulare counties, and District 5 includes Fresno and Kings counties. Figure 4.5-1 shows the oil and gas fields in the project vicinity. The BNSF alternative crosses several oil fields:

- The Fruitvale Oil Field, approximately 1.5 miles to the west of Bakersfield.
- The Rosedale Oil Field, approximately 6 miles to the west of Bakersfield.
- The Seventh Standard Oil Field between Bakersfield and Shafter.
- The Rose Oil Field, north of Wasco.

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July 1, 2011

Source: California Department of Conservation, 2010

- Alternative alignments
- Existing rail line
- Major road
- Hydrographic feature
- Community/Urban area
- County boundary
- Preferred HST station
- Potential Kings/Tulare Regional Station
- Gas field
- Oil field (field labelled intersecting project footprint)
- Sedimentary basin with oil, gas, or geothermal production

N

0 5 10 Miles

0 10 20 Kilometers

Figure 4.5-1
*Oil, gas, and geothermal fields in the Fresno to Bakersfield Section*

In addition, the Wasco-Shafter Bypass passes through the North Shafter Oil Field. The BNSF Alternative Alignment would be elevated over the Fruitvale Oil Field. The alignments would be at-grade through the other oil fields listed above. Contractors would use safe and explosion-proof equipment during project construction in areas where explosion hazards exist, and would test for gases regularly.

Review of recent aerial photography shows a few oil wells within the project footprint. If any unidentified wells are encountered during construction, these wells would be demolished or abandoned according to city and county regulations.

Reportedly, on the order of seven active and four abandoned wells are within the footprint of the proposed project (Mitchell 2009). These, and potentially any additional unidentified wells, will have to be properly addressed during construction.

### 4.5.3 Geothermal Resources

Review of the DOGGR California Geothermal Map (DOGGR 2002) and CDMG Geothermal Resources Map (CDMG 1980) show that none of the alternative alignments are in or near a Geothermal Resource Area as classified by DOGGR. Additionally, no producing or abandoned geothermal wells or geothermal springs are along the alternative alignments.

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# Chapter 5.0

## Impact Analysis and Mitigation Strategies

# 5.0 Impact Analysis and Mitigation Strategies

## 5.1 Methodology for Impact Analysis

Impacts related to geology, soils, and seismicity have been analyzed qualitatively, based on a review of published soils and geologic information for the study area and on professional judgment, in accordance with the current standard of care for geotechnical engineering and engineering geology. The analysis focuses on the proposed project's potential to increase the risk of personal injury, loss of life, and damage to property, including new facilities, as a result of existing geologic conditions in the study area, and includes construction-related impacts.

## 5.2 Assumptions

Consistent with the general Program-wide design strategies identified in the Program EIR/EIS (PEIR/PEIS) prepared for the HST program (Authority and FRA 2005), the analysis assumes the following:

- A site-specific geotechnical and engineering geologic study will be conducted for the proposed project, covering the entire project vicinity, performed by appropriately state-licensed personnel with appropriate experience and skills; for example, in accordance with Caltrans and AASHTO standards, as applicable.
- Earthwork will be designed and conducted in accordance with all relevant requirements of Section 19 of the most current Caltrans Standard Specifications (Caltrans 2009).
- All structures will be designed consistent with Caltrans Seismic Design Criteria (Caltrans 2009) or equivalent standards.
- Passive or active gas venting systems and gas collection systems will be installed in areas of subsurface gas hazard, consistent with the section engineer's standard.
- Expansive soil hazards can be addressed through overexcavation and replacement with nonexpansive fill, or other mitigation measures such as amendment or modification consistent with Caltrans Standard Specifications (Caltrans 2009).
- Corrosive soil hazards can be addressed by overexcavation and replacement with noncorrosive fill; by use of corrosion-protected materials; or by other measures consistent with Caltrans Standard Specifications (Caltrans 2009).
- Construction will proceed in accordance with requirements of a Stormwater Pollution Prevention Plan (SWPPP), as discussed in hydrology/water resources.
- Post-construction soil erosion hazard will be addressed by overexcavation and replacement with non-erosive engineered fill, or by the use of geosynthetics, vegetation, riprap, or other suitable measures consistent with Caltrans Standard Specifications (Caltrans 2009).

## 5.3 Environmental Consequences

Evaluation of the potential environmental effects of a particular project necessarily involves an analysis of the project's impact on the environment, as well as the environment's impact on the project. This second aspect of analysis is particularly true when discussing geology and soils.

Similarly, the analysis must consider the short-term construction phase as well as the long-term post-construction or operational phase. The following paragraphs summarize potential environmental consequences (or impacts) related to the HST project expressed from a geology, soils, and seismicity standpoint. Fifteen potential impacts are identified. Table 5.3-1 illustrates that the majority of potential impacts are related to the long-term, operational-phase effects of the environment on the project, and a lesser number are due to short-term construction impacts. Both construction and operational impacts are discussed in the following paragraphs in order to reduce redundancy. Note that many potential hazards are unlikely to occur during the relatively short construction period. Nevertheless, they are included because they could theoretically be experienced during construction.

**Table 5.3-1**
Summary of Potential Impacts

| Potential Impact | Impacts of the HST Project on the Environment | | Impacts of the Environment on the HST Project | |
|---|---|---|---|---|
| | Construction Phase | Operational Phase | Construction Phase | Operational Phase |
| Surface fault rupture | N/A | N/A | N/A | N/A |
| Seismic ground shaking | N/A | N/A | [A] | X |
| Liquefaction/seismically induced ground failure | N/A | N/A | [A] | X |
| Slope failure hazards/cut or fill | X | X | N/A | N/A |
| Preexisting landslides | N/A | N/A | N/A | N/A |
| Tsunami and seiche | N/A | N/A | N/A | N/A |
| Seismically induced dam failure | N/A | N/A | [A] | X |
| Ground subsidence | N/A | N/A | X | X |
| Expansive soils | N/A | N/A | X | X |
| Corrosive soils | N/A | N/A | X | X |
| Collapsible soils | X | X | N/A | N/A |
| Soil erosion | [A] | X | X | X |
| Difficult excavation | N/A | N/A | X | [B] |
| Subsurface gas | N/A | N/A | X | X |
| Mineral resources | N/A | N/A | N/A | N/A |

Notes:
[A] Unlikely, due to relatively short construction period, but possible.
[B] Assumes no new construction in operational period.
X = Denotes a potential impact that will be reduced to a less than significant level by appropriate design studies.

## 5.3.1 Surface Fault Rupture

As indicated in Section 4.3.1, surface fault rupture is not anticipated to be a problem in the HST project vicinity. Accordingly, no mitigation measures are considered necessary.

### 5.3.2 Seismic Ground Shaking

Subsurface conditions will be characterized, as required for design, in accordance with accepted engineering guidelines and standards. Similarly, ground motions will be calculated for all project components in accordance with the latest procedures, and design/construction details will be developed appropriately. We therefore do not anticipate unacceptable ground-shaking impacts and associated mitigation measures.

### 5.3.3 Liquefaction and Other Types of Seismically Induced Ground Failure

Potential seismic liquefaction and lateral spreading are discussed in Sections 4.4.1 and 4.4.2, respectively. As noted, available information suggests that liquefaction in the project vicinity is not judged to be a problem. Likewise, lateral spreading is not anticipated, except possibly at selected stream crossings. This would be addressed by conventional engineering design consisting of ground improvement or a structural solution; thus, no particular adverse impacts are anticipated or mitigation measures required.

### 5.3.4 Slope Failure Hazards Associated with Cut or Fill Slopes

Cuts and fills for the construction and operation of various project components will be designed in accordance with commonly accepted geotechnical engineering procedures. Thus, adverse impacts are not anticipated, and mitigation measures would not be required.

### 5.3.5 Slope Failure Hazards Associated with Preexisting Landslides, Including Seismically Induced Landslides

Inasmuch as no landslides, either statically or seismically induced, have been identified in the HST project vicinity, this hazard is judged to be nonexistent for the project alignment and facilities.

### 5.3.6 Tsunami and Seiche Hazards

As noted in Section 4.4.4, large bodies of water are not located in close proximity to the Fresno-to-Bakersfield portion of the HST project vicinity, so no hazard due to seiches is anticipated. Similarly, the HST project vicinity is located a considerable distance away from the Pacific Ocean, so no tsunami hazard exists and no mitigation is proposed.

### 5.3.7 Seismically Induced Dam Failure Hazards

Section 4.4.4 discusses and illustrates potential inundation areas calculated from the unlikely catastrophic failure of identified dams located upstream of the HST project vicinity. Figure 4.4-1 shows the potential inundation areas in the study area. Identified potential dam failures resulting in inundation of the flat-lying areas that could affect portions of the HST alignment include, from north to south, the Redbank, Fancher Creek, Pine Flat Dam, Terminus Dam, Success Dam, and Isabella Dam. To date, an inundation area map for Success Dam has not been available for the HST corridor area.

### 5.3.8 Ground Subsidence

Ground subsidence is caused by the extraction of a fluid or minerals from the underlying geologic formation, resulting in the collapse of pore spaces previously occupied by the fluid or mined minerals zone. If materials are removed in great quantities, resulting subsidence can cause significant damage to engineered structures and infrastructure. As previously discussed in Section

4.2.2, the San Joaquin Valley has a long history of subsidence, primarily due to regional groundwater pumping and more locally due to oil and gas extraction. The HST alternative alignments traverse the southwestern portion of Tulare County, where subsidence has occurred southeast of Corcoran. The area of recorded subsidence extends to the northern portions of Wasco, in Kern County. Recent data using InSAR radar techniques has shown that areas in the vicinity of Bakersfield subsided 3.5 inches over a 2-year period. In addition, areas in the vicinity of the Edison oil field will likely experience future subsidence. It is expected that conventional engineering design; for example, periodic reballasting of the tracks, will be implemented to mitigate for areas susceptible to or experiencing ground subsidence.

### 5.3.9 Expansive Soils

Expansive soils include those types of soils that undergo a significant increase in volume during wetting, and shrink in volume with a decrease in water content (drying). Structures, including foundations built on expansive soil, can experience significant damage due to increases in uplift pressures if not designed properly. As discussed in Section 4.2.3, soils with expansive properties have been previously mapped in the vicinity of Hanford and Corcoran, extending into the southeastern portions of Tulare County. In Kern County, expansive soils have been identified in the southeastern part of Bakersfield.

The potential for shrinkage and/or swelling of native soils is considered low to moderate along the HST alignment. Special engineering or construction considerations where the HST alignment traverses these types of soils may be necessary. Standard geotechnical engineering practices can be applied to minimize the hazards related to expansive soils, including a subsurface drilling and laboratory testing program. Some of the engineering considerations that may be applied to mitigate expansive soils are as follows:

- Treating expansive soils with lime or other additives.
- Replacing expansive materials with non-expansive ones to a depth where seasonal moisture fluctuations remain constant.
- Stabilizing the moisture content of the soil by using a waterproof membrane (Caltrans 2009).
- Use of downturned curbs or post-tensioned slabs for structures founded at grade.
- Balancing potential expansion pressures by net applied foundation loadings.
- Extending foundation down below the zone of expansive soils.

### 5.3.10 Corrosive Soils

Soil corrosivity involves the measure of the potential for steel and concrete to corrode as a result of contact with some types of soils. Soils with high moisture content, high electrical conductivity, high acidity, and high dissolved salts content are most corrosive.

Buried steel or concrete portions of the project that are potentially susceptible to corrosion should be identified by standard geotechnical engineering testing and soil resistivity surveys to identify the extent of the problem, and mitigate the potential hazards. Mitigation usually includes designing the concrete mix for the potential hazard, increasing the amount of concrete cover for buried reinforced concrete structures, and protecting buried steel structures with special coatings, or cathodic protection.

### 5.3.11 Collapsible Soils

Collapsible soils are soils that undergo rapid settlement upon the addition of water. Soil types susceptible to collapse include loess and other fine-grained, windblown soils, both of which are common to the San Joaquin Valley. Special engineering or construction considerations where the HST alignment traverses these types of soils may be necessary. Standard geotechnical engineering practices such as pre-wetting can be applied to minimize the hazards related to collapsible soils, including a subsurface drilling and laboratory testing program.

### 5.3.12 Soil Erosion

Potential soil erosion is discussed in Section 4.2.3, and the areas particularly susceptible are illustrated on Figure 4.2-5. The potential for soil erosion (soils with a K value greater than 0.4) has been previously identified in areas north of Laton, in the vicinity of Hanford, locally north of Corcoran, east of Alpaugh, and west of Delano, and in the southeastern portion of Bakersfield. Standard methods of soil erosion control such as minimizing disturbed areas during construction, protecting disturbed areas with suitable erosion control measure or planting, use of berms and swales to dissipate sheet flow energy, and sealing of disturbed areas not actively worked. In addition, implementation of local and state regulations regarding soil erosion, such as stormwater best management practices and temporary soil erosion guidelines will be followed in the design and construction of the HST facility; therefore, no unusual impacts are anticipated, and no specific mitigation measures are anticipated or proposed.

### 5.3.13 Difficult Excavation

Due to the presence of predominantly unconsolidated Quaternary sediments in the San Joaquin Valley, areas of difficult excavation along the HST alignment are not anticipated. However, some soil associations along the alignment may have a hardpan, formed of harder layers that range in composition from dissolved silica to a matrix of iron oxides and calcium carbonate. Some of the construction considerations that may be applied to mitigate hardpan are as follows:

- Breaking the soil by mechanical means: digging, plowing, or in the extreme use of rippers.
- Using rock augers or core barrels to penetrate resistant hardpan zones for drilled shaft foundations construction.
- Pre-drilling hardpan zones where driven piling is proposed

### 5.3.14 Subsurface Gas Hazards

No portions of the HST study area are known to be located over areas likely to be affected by subsurface gas accumulations. Accordingly, no particular impacts are anticipated, and no mitigation measures are anticipated or proposed.

### 5.3.15 Mineral Resources

Potential mineral resources, including concrete aggregate; fossil fuels (oil and natural gas); and geothermal resources are discussed in Sections 4.5.1, 4.5.2, and 4.5.3, respectively; and oil and gas fields are shown on Figure 4.5-1. It is not expected that existing mineral resources would be adversely impacted by construction of the HST project, because standard design and construction protocols would be followed. Accordingly, no adverse impacts or special mitigation measures are anticipated or proposed.

## 5.4 Design Strategies

The Program EIR/EIS (Authority and FRA 2005) was reviewed to evaluate suggested design strategies relative to this Project EIR/EIS with respect to soils, geology, and seismicity issues. As noted in the Program EIR/EIS, mitigation for potential impacts related to geologic and soil conditions must be developed on a site-specific basis, following more detailed (design-level) engineering geologic and geotechnical studies, including seismic risk. The following paragraphs summarize design approaches as reflected in that document. Because the project design standards would minimize or eliminate potential geologic hazards, no mitigation measures would be required.

### 5.4.1 Fault Crossings

The potential for ground rupture along active faults is one of the few geologic hazards that can rarely be fully mitigated. However, known nearby active faults are typically monitored, and in some cases damage to existing infrastructure from fault creep is mitigated with routine maintenance, which could include repaving or minor realignment. Project design will provide for the installation of early warning systems, triggered by strong ground motion associated with ground rupture. Linear monitoring systems such as time domain reflectometers could be installed along major highways and rail lines in the zone of potential ground rupture. These devices emit electronic information that is processed in a centralized location and typically used to temporarily control traffic and trains, thus reducing accidents.

### 5.4.2 Ground Shaking

The potential for hazards related to ground shaking during a large earthquake cannot be eliminated completely. However, some strategies typically used to reduce hazards, include the following:

- The potential for collapse or toppling of superstructures such as bridges or retaining structures due to strong ground motion can be greatly reduce by designing structures to withstand the estimated loads resulting from anticipated ground motions. Designs typically include additional redundancy and ductility in the structure. Temporary facilities, such as shoring, would be designed considering a lower probability of seismic events.
- HST derailment during a peak event could be reduced by designing a track-wheel system capable of withstanding the potential ground motions in most of the project vicinity. In addition, a network of strong motion instruments has been installed throughout California, and additional monitoring stations are proposed as discussed above. These stations provide ground-motion data that could be used with the HST instrumentation and controls system to temporarily shut down the HST operations during and after an earthquake. The system would then be inspected for damage due to ground motion and/or ground deformation, and then returned to service when appropriate. This type of seismic protection is already used for many rapid transit systems in seismically active areas, and has proved effective.

### 5.4.3 Liquefaction, Seismically Induced Settlement, Poor Soils

Design strategies to address seismic hazards such as liquefaction, seismically induced settlement, and landslides, as well as long-term settlement, may include, but would not be limited to, the following:

- Design and engineer all structures for earthquake activity. Seismic design for the bridge structures would be based on the Caltrans Seismic Design Criteria, and facilities design would be in accordance with the Building Code.
- Design and install foundations resistant to soil liquefaction and settlement [structural solution].
- Apply the requirements of Section 19 (Earthwork) of the most current Caltrans Standard Specifications (Caltrans 2009) to ensure that geotechnically stable slopes are planned and created.

- Subsurface gases: Install passive or active gas venting systems and gas collection systems in areas where subsurface gases are identified.
- Remove corrosive soil, design buried structures for corrosive conditions, and use corrosion-protected materials in infrastructure.
- Address erosive soils through soil removal and replacement, geosynthetics, vegetation, and/or riprap, where warranted.
- Remove or moisture-condition; for example, pre-soak, potentially shrink-swell susceptible soils, where necessary.
- Use ground improvement techniques such as stone columns, compaction grouting, or deep dynamic compaction in areas of potential liquefaction [geotechnical solution].
- Use buttress berms, flattened slopes, drains, soil nails, and/or tiebacks in areas of slope instability.
- Avoid settlement with preloading, use of stone columns, deep dynamic compaction, grouting, and/or special foundation designs.

### 5.4.4 Cut/Fill Slope Instability

The potential for failure of natural and/or temporary construction slopes and retention structures can be mitigated through geotechnical investigation and review of proposed earthwork and foundation excavation plans and profiles. Based on investigation and review, recommendations would be provided for temporary and permanent slope reinforcement and protection, as needed.

Additionally, during construction, geotechnical inspections would be performed to verify that no new, unanticipated conditions are encountered, and to verify the proper incorporation of recommendations. Slope monitoring may also be incorporated in the final design, where warranted.

### 5.4.5 Oil and Gas Fields

Hazards related to potential migration of hazardous gases due to the presence of oil fields, gas fields, or other subsurface sources can be reduced or eliminated by following strict federal and state Occupational Safety & Health Administration (OSHA/Cal-OSHA) regulatory requirements for excavations, and by consulting with other agencies as appropriate, such as the Department of Conservation (Division of Oil and Gas) and the California Environmental Protection Agency, Department of Toxic Substances Control, regarding known areas of concern.

Practices would include using safe and explosion-proof equipment during construction and testing for gases regularly. Active monitoring systems and alarms would be required in underground construction areas and facilities where subsurface gases are present. Gas barrier systems have also been used effectively for subways in the Los Angeles area. Installing gas-detection systems can monitor the effectiveness of these systems.

## 5.5 Cumulative Impacts

The construction of one project does not alter the risk of geologic hazards to another project because all projects must be constructed in accordance with the Uniform Building Code. Therefore, no cumulative impact related to geologic hazards could cause damage to man-made structures.

However, seismically induced dam failure could result in flooding, with more than 20 feet of water in large areas of the south San Joaquin Valley (see Section 4.4.4). The present and reasonably foreseeable future projects would increase the number of people exposed to this flood risk. The construction of the Fresno to Bakersfield Section would expose people traveling on the train and HST operations personnel to this flood risk. The contribution of the Fresno to Bakersfield Section to the exposure of people and facilities to seismically induced flood risk would be negligible relative to the urban and rural population of the south San Joaquin Valley that is exposed to this risk.

# Chapter 6.0

## References

# 6.0 References

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# Section 7.0
## Preparer Qualifications

# 7.0 Preparer Qualifications

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