CALIFORNIA HIGH-SPEED TRAIN

Program Environmental Impact Report/Environmental Impact Statement

Los Angeles to San Diego via Inland Empire

Geology and Soils Technical Evaluation

January 2004

Prepared for:

California High-Speed Rail Authority

CALIFORNIA HIGH-SPEED RAIL AUTHORITY

U.S. Department of Transportation
Federal Railroad Administration

U.S. Department of Transportation
Federal Railroad Administration

CALIFORNIA HIGH-SPEED TRAIN PROGRAM EIR/EIS

Task 2.4

Los Angeles to San Diego
via
Inland Empire

Geology and Soils
Technical Evaluation

Prepared by:

HNTB

in association with

CH2MHILL

JANUARY 2004

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

A-P	Alquist-Priolo
ARB	Air Reserve Base
Authority	California High-Speed Rail Authority
CDC	California Department of Conservation
CEQA	California Environmental Quality Act
CGS	California Geological Survey
CNDDB	California Natural Diversity Database
CPT	cone penetration test
DEM	Digital Elevation Model
DWR	Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Environmental Site Assessment
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
HST	high-speed train
I-	Interstate
km/h	kilometers per hour
MCE	maximum credible earthquake
M_m	moment magnitude
mph	miles per hour
mya	million years ago
NCEER	National Center for Earthquake Engineering Research
NEPA	National Environmental Policy Act
NRCS	National Resource Conservation Service
NWI	National Wetlands Inventory Database

ppm	parts per million
PSHA	Probabilistic Seismic Hazards Analysis
RTP	Regional Transportation Plans
SPT	standard penetration test
SR	State Route
STIP	State Transportation Improvement Program
TBM	tunnel boring machine
TDR	time domain reflectometer
U.S.	United States
UBE	Upper Bound Event
UP	Union Pacific
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1.0 INTRODUCTION

The California High-Speed Rail Authority (Authority) was created by the Legislature in 1996 to develop a plan for the construction, operation, and financing of a statewide, intercity high-speed passenger train system.[1] After completing a number of initial studies over the past 6 years to assess the feasibility of a high-speed train system in California and to evaluate the potential ridership for a variety of alternative corridors and station areas, the Authority recommended the evaluation of a proposed high-speed train system as the logical next step in the development of transportation infrastructure in California. The Authority does not have responsibility for other intercity transportation systems or facilities, such as expanded highways, or improvements to airports or passenger rail or transit used for intercity trips.

The Authority adopted a Final Business Plan in June 2000, which reviewed the economic feasibility of a 1,127-kilometer-long (700-mile-long) high-speed train system. This system would be capable of speeds in excess of 321.8 kilometers per hour (200 miles per hour [mph]) on a dedicated, fully grade-separated track with state-of-the-art safety, signaling, and automated train control systems. The system described would connect and serve the major metropolitan areas of California, extending from Sacramento and the San Francisco Bay Area, through the Central Valley, to Los Angeles and San Diego. The high-speed train system is projected to carry a minimum of 42 million passengers annually (32 million intercity trips and 10 million commuter trips) by the year 2020.

Following the adoption of the Business Plan, the appropriate next step for the Authority to take in the pursuit of a high-speed train system is to satisfy the environmental review process required by federal and state laws, which in turn will enable public agencies to select and approve a high-speed rail system, define mitigation strategies, obtain necessary approvals, and obtain financial assistance necessary to implement a high-speed rail system. For example, the Federal Railroad Administration (FRA) may be requested by the Authority to issue a Rule of Particular Applicability, which establishes safety standards for the high-speed train system for speeds over 200 mph and for the potential shared use of rail corridors.

The Authority is the project sponsor and the lead agency for purposes of the California Environmental Quality Act (CEQA) requirements. The Authority has determined that a Program Environmental Impact Report (EIR) is the appropriate CEQA document for the project at this conceptual stage of planning and decisionmaking, which would include selecting a preferred corridor and station locations for future right-of-way preservation and identifying potential phasing options. No permits are being sought for this phase of environmental review. Later stages of project development would include project-specific detailed environmental documents to assess the impacts of the alternative alignments and stations in those segments of the system that are ready for implementation.

The decisions of federal agencies, particularly the FRA related to high-speed train systems, would constitute major federal actions regarding environmental review under the National Environmental Policy Act (NEPA). NEPA requires federal agencies to prepare an environmental impact statement (EIS) if the proposed action has the potential to cause significant environmental impacts. The proposed action in California warrants the preparation of a Tier 1 Program-level EIS under NEPA, due to the nature and scope of the comprehensive high-speed train system proposed by the Authority, the need to narrow the range of alternatives, and the need to protect/preserve right-of-way in the future. FRA is the federal lead agency for the preparation of the Program EIS, and the Federal Highway Administration (FHWA), the United Stated (U.S.) Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (USACE), the Federal Aviation Administration (FAA), the U.S. Fish and Wildlife Service (USFWS), and the Federal Transit Administration (FTA) are cooperating federal agencies for the EIS.

[1] Chapter 796 of the Statutes of 1996; SB 1420, Kopp and Costa

A combined Program EIR/EIS is to be prepared under the supervision and direction of the FRA and the Authority in conjunction with the federal cooperating agencies. It is intended that other federal, state, regional, and local agencies will use the Program EIR/EIS in reviewing the proposed program and developing feasible and practicable programmatic mitigation strategies and analysis expectations for the Tier 2 detailed environmental review process that would be expected to follow any approval of a high-speed train system.

The statewide high-speed train system has been divided into five regions for study: Bay Area-Merced, Sacramento-Bakersfield, Bakersfield-Los Angeles, Los Angeles-San Diego via the Inland Empire, and Los Angeles-Orange County-San Diego. This discipline-specific *Geology and Soils Technical Evaluation* for the Los Angeles to San Diego via the Inland Empire region is one of five such reports being prepared for each of the regions on the topic. It is 1 of 11 technical evaluations for this region. This evaluation will be summarized in the Program EIR/EIS, and it will be part of the administrative record supporting the environmental review of alternatives.

1.1 GEOLOGY AND SOILS METHODOLOGY

The geology and soils impact and resource analysis for this program-level EIR/EIS is focused on a broad comparison of the potential impacts of seismic hazards, active fault crossings, slope stability, and oil and gas fields. The influence of these conditions, the influence of difficult excavation on construction, and the impact of the alternative projects on mineral resources are also evaluated. Potential impacts of these conditions along the proposed High-Speed Train and Modal Alternatives are compared to the No-Project Alternative.

CEQA provides criteria for significant geologic, soils, and seismic impacts. The criteria specifically addresses the questions regarding exposure by the project to people or structures to potential substantially adverse effects, including the risk of loss, injury, or death involving:

- Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.
- Strong seismic ground shaking?
- Seismic-related ground failure, including liquefaction?
- Landslides?
- Result in substantial soil erosion or the loss of topsoil?
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or offsite landslides, lateral spreading, subsidence, liquefaction, or collapse?
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code, creating substantial risks to life or property?
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?
- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?

Each of these CEQA criteria is included in the baseline conditions and subsequent analysis of potential impacts.

In general, our methodology involved the acquisition and analysis of available statewide GIS layers pertinent to these impacts. Criteria for definition of hazards were identified based upon generally accepted statewide practices, and these hazards were compared as impacts to each project alternative. A numerical ranking system was developed to compare impacts between the alternatives. The summary tables for the region are then completed to identify geology, soils, and seismic hazards within the study area for each of the corridor segments and around station sites for the high-speed train alternative, and along highway corridors and around airports for the Modal Alternative.

1.2 ALTERNATIVES UNDER CONSIDERATION

1.2.1 No-Project Alternative

The No-Project Alternative serves as the baseline for the comparison of Modal and High-Speed Train Alternatives. The No-Project Alternative represents the state's transportation system (highway, air, and conventional rail) as it existed in 1999-2000, and as it would be after implementation of programs or projects currently programmed for implementation and projects that are expected to be funded by 2020 (Figure 1.2-1). The No-Project Alternative addresses the geographic area serving the same intercity travel market as the proposed high-speed train (generally from Sacramento and the San Francisco Bay Area, through the Central Valley, to Los Angeles and San Diego). The No-Project Alternative satisfies the statutory requirements under CEQA and NEPA for an alternative that does not include any new action or project beyond what is already committed.

The No-Project Alternative defines the existing and future statewide intercity transportation system based on programmed and funded (already in funded programs/financially constrained plans) improvements to the intercity transportation system through 2020, according to the following sources of information:

- State Transportation Improvement Program (STIP)
- Regional Transportation Plans (RTPs) for all modes of travel
- Airport plans
- Intercity passenger rail plans (California Rail Plan 2001-2010, Amtrak 5- and 20-Year Plans)

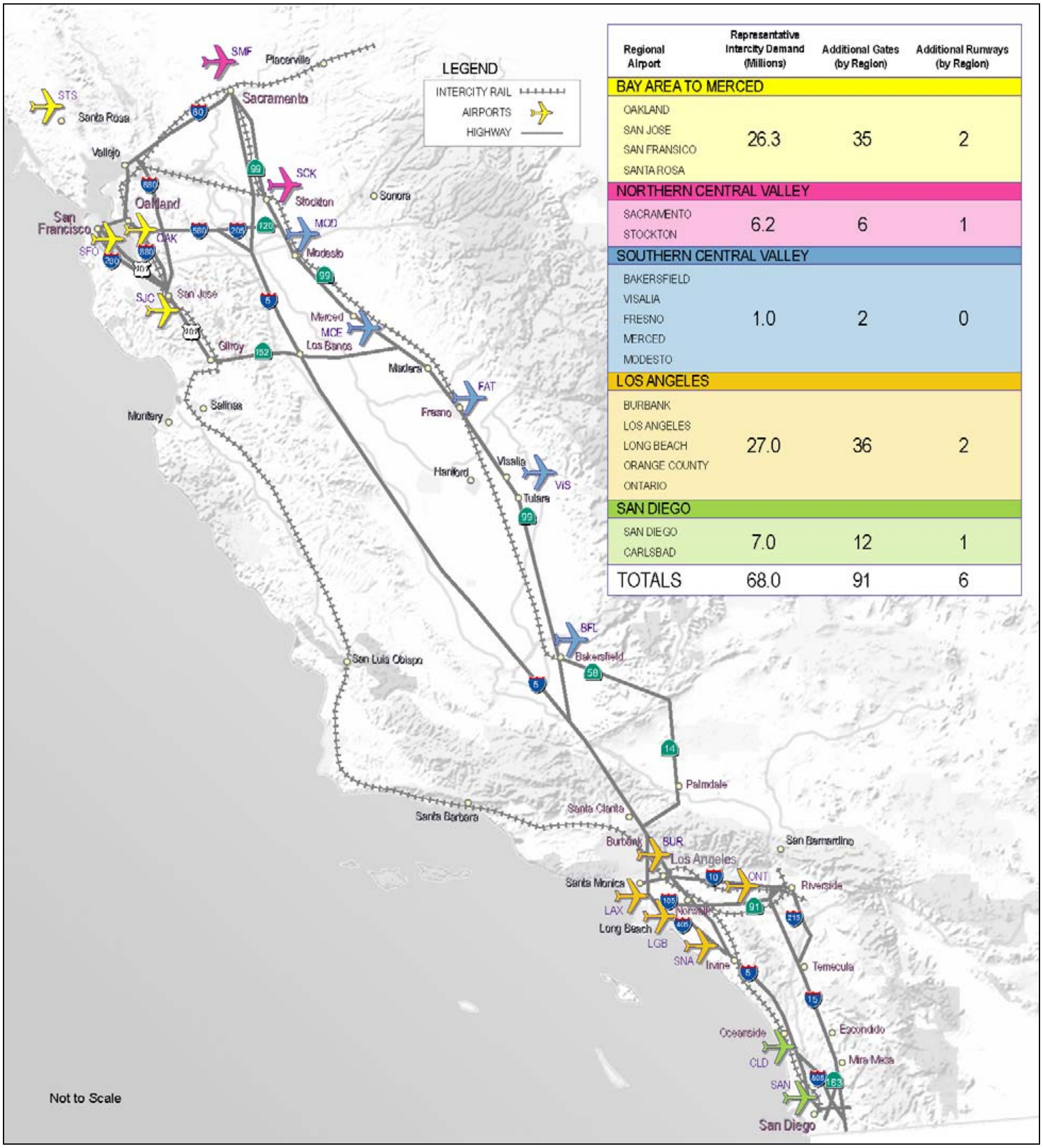
As with all of the alternatives, the No-Project Alternative will be assessed against the purpose and need topics/objectives for congestion, safety, air pollution, reliability, and travel times.

1.2.2 Modal Alternative

There are currently three main options for intercity travel between the major urban areas of San Diego, Los Angeles, the Central Valley, San Jose, Oakland/San Francisco, and Sacramento: vehicles on the interstate highway system and state highways, commercial airlines serving airports between San Diego and Sacramento and the Bay Area, and conventional passenger trains (Amtrak) on freight and/or commuter rail tracks. The Modal Alternative consists of expansion of highways, airports, and intercity and commuter rail systems serving the markets identified for the High-Speed Train Alternative (Figures 1.2-2 and 1.2-3). The Modal Alternative uses the same intercity travel demand (not capacity) assumed under the high-end sensitivity analysis completed for the high-speed train ridership in 2020. This same travel demand is assigned to the highways, airports, and passenger rail described under the No-Project Alternative.

Figure 1.2-1 No-Project Alternative – California Transportation System

Figure 1.2-2 Modal Alternative – Highway Component



Regional Airport	Representative Intercity Demand (Millions)	Additional Gates (by Region)	Additional Runways (by Region)
BAY AREA TO MERCED			
OAKLAND SAN JOSE SAN FRANSICO SANTA ROSA	26.3	35	2
NORTHERN CENTRAL VALLEY			
SACRAMENTO STOCKTON	6.2	6	1
SOUTHERN CENTRAL VALLEY			
BAKERSFIELD VISALIA FRESNO MERCED MODESTO	1.0	2	0
LOS ANGELES			
BURBANK LOS ANGELES LONG BEACH ORANGE COUNTY ONTARIO	27.0	36	2
SAN DIEGO			
SAN DIEGO CARLSBAD	7.0	12	1
TOTALS	68.0	91	6

Figure 1.2-3 Modal Alternative – Aviation Component

The additional improvements or expansion of facilities are assumed to meet the demand, regardless of funding potential and without high-speed train service as part of the system.

The Modal Alternative for the Los Angeles to San Diego via the Inland Empire region consists of two major proposed improvements:

- Improvements to Highways: Consisting of additional highway lanes to provide sufficient highway capacity and associated interchange reconfiguration, crossing bridge widening, ramp widening, cross street and intersection widening (Figure 1.2-2). Within the study area corridor, these improvements, therefore, would occur along proposed portions of Interstates (I-) 10, 215, 15, and State Route (SR) 163. Table 1.2-1 lists the proposed highway improvements along the Los Angeles to San Diego via the Inland Empire corridor.

Table 1.2-1 Proposed Modal Alternative Highway Improvements Los Angeles to San Diego via the Inland Empire

Highway Corridor	Segment (From – To)	No. of Additional Lanes[1] (Total – Both Directions)	No. of Existing Lanes (Total- both directions)	Type of Improvement
I-10	I-5 to East San Gabriel Valley	2	10	widening
I-10	East San Gabriel Airport to Ontario Airport	2	8	widening
I-10	Ontario Airport to I-15	2	8	widening
I-10	I-15 to I-215	2	8	widening
I-15	I-10-I-215	2	8	widening
I-215	Riverside to I-15	2	4	widening
I-215	I-10 to Riverside	2	6	widening
I-15	I-215 to Temecula	2	10	widening
I-15	Temecula to Escondido	2	8	widening
I-15	Escondido to Mira Mesa	2	10	widening
I-15	Mira Mesa to SR-163	2	10	widening
SR-163	I-15 to I-8	2	8	widening

[1] Represents the number of through lanes in addition to the total number of existing lanes that approximate an equivalent level of capacity to serve the representative demand

- Improvements to Airports: Primarily consisting of improvements to terminal gates and runways to provide sufficient landside and airside capacity and associated taxiways, ground access, parking, terminal and support facilities and airports that can serve the same geographic area and demand as the proposed High-Speed Train (HST) Alternative. Within the study area corridor, these proposed improvements would occur at Ontario International Airport (ONT) and the San Diego International Airport (SAN) (Figure 1.2-3). Table 1.2-2 lists the airport improvements associated with the Ontario and San Diego airports.

Table 1.2-2 Proposed Modal Alternative Airport Improvements – Year 2020 Los Angeles to San Diego via the Inland Empire

Airport Name	Additional Gates	Additional runways
Ontario Airport	8	1
San Diego	12	1

Source: Parsons Brinckerhoff, November 2002

1.2.3 High-Speed Train Alternative

The Authority has defined a statewide high-speed train system capable of speeds in excess of 200 miles per hour (mph) (320 kilometers per hour [km/h]) on dedicated, fully grade-separated tracks, with state-of-the-art safety, signaling, and automated train control systems. State-of-the-art, high-speed, steel-wheel-on-steel-rail technology is being considered for the system that would serve the major metropolitan centers of California, extending from Sacramento and the San Francisco Bay Area, through the Central Valley, to Los Angeles and San Diego (Figure 1.2-4).

The High-Speed Train Alternative includes several corridor and station options. A steel-wheel-on-steel-rail, electrified train, primarily on exclusive right-of-way with small portions of the route on shared track with other rail is planned. Conventional "nonelectric" improvements are also being considered along the existing rail corridor from Los Angeles to San Diego through Orange County (LOSSAN). The train track would be at grade, in an open trench or tunnel, or on an elevated guideway, depending on terrain and physical constraints.

For purposes of comparative analysis the high-speed train corridors will be described from station to station within each region, except where a bypass option is considered when the point of departure from the corridor will define the end of the corridor segment.

As described in the introduction, the study area is broadly defined by the Los Angeles to San Diego via Inland Empire corridor segment, which may be broadly divided into three regional segments. Each segment has several alternative alignments for all or a portion of the length of the segment. For example, Segment 1 has three alternative alignments, listed as 1A, 1B, and 1C. Each segment is further subdivided into subsegments for analyzing and reporting potential impacts. The various segment options and subsegments, along with station locations, are described below.

1.2.3.1 Regional Segment 1 – Union Station to March Air Reserve Base Segment

<u>Segment 1A</u>

Subsegment 1A1: Union Station to Pomona
Subsegment 1A2: Pomona to Ontario (beginning of Segment 1C)
Subsegment 1A3: Ontario (beginning of Segment 1C) to Colton (end of Segment 1C)
Subsegment 1A4: Colton to March Air Reserve Base (ARB)

<u>Segment 1B</u>

Subsegment 1B1: Union Station to Pomona

<u>Segment 1C</u>

Subsegment 1C1: Ontario (beginning of Segment 1C) to Colton (end of Segment 1C)

Station Locations: El Monte (1A1), Pomona (1A2), Ontario (1A2), Colton (1A3), University of California at Riverside (1A4), South El Monte (1B1), City of Industry (1B1), and San Bernardino (1C1)

1.2.3.2 Regional Segment 2 – March ARB to Mira Mesa Segment

<u>Segment 2A</u>

Subsegment 2A1: March ARB to Escondido (beginning of Segment 2B)
Subsegment 2A2: Within Escondido (beginning to end of Segment 2B)
Subsegment 2A3: Escondido to Mira Mesa

**Figure 1.2-4 High-Speed Train Alternative –
Corridors and Stations for Continued Investigation**

Segment 2B

Subsegment 2B1: Within Escondido (Beginning to end of Segment 2B)

Station Locations: March ARB (2A1), Temecula (2A2), Escondido (2A2), and Escondido Transit Center(2B1)

1.2.3.3 Regional Segment 3 – Mira Mesa to San Diego Segment

Segment 3A

Subsegment 3A1: Mira Mesa to Qualcomm Stadium

Segment 3B

Subsegment 3B1: Within Mira Mesa (beginning and end of Segment 3C)
Subsegment 3B2: Mira Mesa (end of Segment 3C) to Downtown San Diego

Segment 3C

Subsegment 3C1: Within Mira Mesa (end of Segment 3C)

Station Locations: Mira Mesa (3A1), Qualcomm Stadium (3A1), Transit Center (3B2), San Diego International Airport (3B2), and Downtown San Diego (3B2)

2.0 BASELINE/AFFECTED ENVIRONMENT

2.1 STUDY AREA

Geology and soil impacts on the proposed Modal and High-Speed Train Alternatives were evaluated in this study. The proposed HST alignment has been divided into 3 major segments, which have been split into subsegments. The proposed alignment is shown in Figure 2.1-1.

The specific study area for geology and soil for the proposed Modal and HST Alternatives is defined as 200 feet from corridors and around stations. This area incorporates all cross sections with the exception of deep cuts and fills. Comparisons of segments were made for this technical evaluation based generally on length of the segments in the various geologic conditions. Though a 200-foot boundary from the corridors and stations has been defined as the specific geologic and soil study area, an implied site-specific evaluation was not conducted in the geologic and soil evaluation of the proposed Los Angeles to San Diego via Inland Empire corridor. That level of detail is beyond the scope of this study and, to complete, will require detailed site-specific field investigations in the future. Generalized geologic and soil types defined in numerous publications including, but not limited to, information from the California Geologic Survey were reviewed and evaluated to determine the following information.

2.2 GEOLOGY AND SOIL

The generalized geologic and soil conditions for the proposed Los Angeles to San Diego via Inland Empire corridor consist of two major formations, as described below.

- Marine and nonmarine sedimentary rocks formed during the Cenozoic Era (65 million years ago [mya] to present). Sandstones, shale, siltstone, conglomerate, and breccia, moderately to well consolidated. Soil generally consists of unconsolidated and semiconsolidated alluvium deposits that are mostly nonmarine but does include marine deposits near the coast.
- Plutonic rocks, such as granite and various quartz formations, formed during the Mesozoic Era (230 to 65 mya).

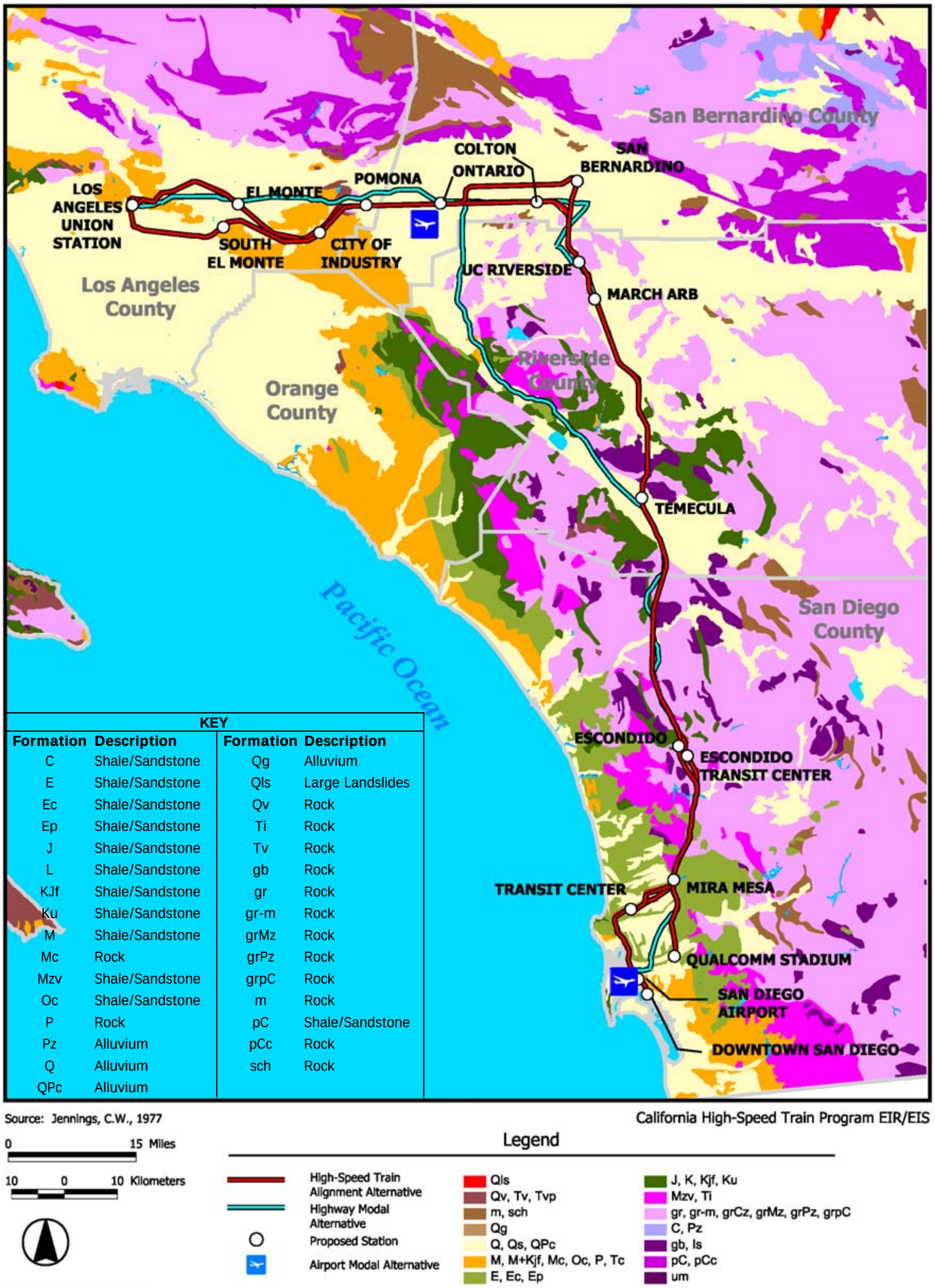
Sedimentary rocks and alluvium dominate the area where the proposed alignments traverse north of Temecula and near the coast in San Diego. Plutonic rock formations are dominant along the subsegments between Temecula and San Diego. Surficial geology and soil units are shown in Figure 2.2-1.

2.2.1 Regional Geologic Setting

The proposed corridor for the Modal and HST Alternatives is located within two major geologic regions, the Los Angeles Basin and the Peninsular Ranges province of California. Most of Segment 1 falls within the Los Angeles Basin, which includes all of downtown Los Angeles and extends east to just west of Ontario. The remaining subsegments of Segment 1, all of Segment 2 and Segment 3 traverse through the Peninsular Ranges province of California.

The Los Angeles Basin is a northwest-trending alluviated lowland plain about 50 miles long and 20 miles wide on the coast of Southern California (Yerkes et al., 1965). The lowland plain is bounded on the north by the Santa Monica Mountains and the Elysian, Repetto, and Puente Hills and on the east and southeast by the Santa Ana Mountains and San Joaquin Hills. These mountains and hills expose Mesozoic or older basement rocks and sedimentary and igneous rocks of late Cretaceous to late Pleistocene age. The Los Angeles physiographic basin is underlain by a structure depression, parts of which have been the sites of discontinuous deposition since late Cretaceous time and of continuous subsidence and chiefly marine deposition since middle Miocene time.

Figure 2.1-1 Modal and High-Speed Train Alternatives
Los Angeles to San Diego via Inland Empire



KEY

Formation	Description	Formation	Description
C	Shale/Sandstone	Qg	Alluvium
E	Shale/Sandstone	Qls	Large Landslides
Ec	Shale/Sandstone	Qv	Rock
Ep	Shale/Sandstone	Ti	Rock
J	Shale/Sandstone	Tv	Rock
L	Shale/Sandstone	gb	Rock
KJf	Shale/Sandstone	gr	Rock
Ku	Shale/Sandstone	gr-m	Rock
M	Shale/Sandstone	grMz	Rock
Mc	Rock	grPz	Rock
Mzv	Shale/Sandstone	grpC	Rock
Oc	Shale/Sandstone	m	Rock
P	Rock	pC	Shale/Sandstone
Pz	Alluvium	pCc	Rock
Q	Alluvium	sch	Rock
QPc	Alluvium		

Figure 2.2-1 Surficial Geology and Soil Units

The Peninsular Ranges province is an elongate series of mountainous ridges and peaks rising in places to elevations of more than 9,800 feet. It extends southeastward about 900 miles from the Los Angeles Basin to the tip of Baja California (Yerkes et al., 1965). Elongate northwest-trending mountain ridges separated by straight-sided, sediment-floored valleys characterize both the submerged and exposed parts of the province. Marine and nonmarine clastic strata of late Cretaceous or Cenozoic age overlie basement rocks. The Peninsular Ranges province includes the Southern California batholith.

The dominant structural features of the Peninsular Ranges province are northwest- to west-northwest-trending fault zones (Yerkes et al., 1965); these zones separate large elongate blocks that stand at different structural elevations. Most of the faults die out to the northwest or merge with or are terminated by the east-trending steep reverse faults that form the southern margin of the Transverse Ranges province. In the northern part of the province, the major faults appear to be late Cenozoic in age, and many are seismically active. Large folds are few in the exposed part of the province; these have west- to northwest-trending axes.

2.2.2 Topographic Setting

The topography within the Los Angeles Basin is generally flat except certain localized areas formed by sandstone/shale hills. The topography within the northern part of Segment 2 from UCR Station to approximately the Temecula Station is generally flat except certain localized areas formed by granitic highs. The southern part of Segment 2 from Temecula Station to Mira Mesa Station is generally characterized by outcrops of rounded granitic highs. Tunnels may be required in the major mountain areas. The topography within Segment 3 is generally composed of rolling mountain hills with some sloping areas greater than 33 percent. Flat valleys generally separate the mountain hills.

2.2.3 Geologic Units

The geologic units encountered in the Los Angeles Basin, which includes all of Segment 1, are primarily alluvium, with localized sandstone/shale/siltstone/conglomerate encountered at the middle of the basin based on the *Geologic Map of California* (Jennings, 1997). The alluvium deposits encountered in the basin are mostly nonmarine deposits and generally unconsolidated and/or semiconsolidated. The sandstone/shale/siltstone/conglomerate deposits encountered are moderately to well consolidated.

The geologic units encountered in the Peninsular Ranges province, which includes parts of Segment 1 and all of Segments 2 and 3, are primarily Mesozoic granite, Gabbro dark dioritic rocks, and sandstone/shale/conglomerate, based on the *Geologic Map of California* (Jennings, 1997). Straight-sided, sediment-floored valleys consisting of alluvium deposits mostly separate the mountain ridges. The granitic rocks encountered in the Peninsular Ranges province are generally moderately hard to hard. The sandstone/shale/conglomerate deposits are moderately to well consolidated.

2.2.4 Soil Units

The soils encountered in the Los Angeles Basin and in the valleys separating the mountain ridges in the Peninsular Ranges province are primarily alluvium-derived soils consisting of sands, silts, and clays. This is also true in the coastal San Diego and surrounding areas. Near-surface or exposed rock is present along the high ridges of the province.

2.2.4.1 Corrosive Soils

Corrosive soil and geologic materials have great impacts on the design and construction of the project. Chemicals such as sulfate present in the soil, rock mass, or groundwater have a detrimental effect on concrete. Large concentrations of chlorides will adversely affect any ferrous materials, such as iron and steel. When soluble sulfate concentrations are greater than 2,000 parts per million (ppm) in soil, mitigation measures must be taken to protect any concrete structures in contact with the soils. If the soil is not removed, appropriate cement types must be used in concrete mix designs. Soils are generally considered corrosive and deleterious to ferrous materials when chloride concentrations exceed

10,000 ppm. Since no corrosion data are available at this time, corrosion potential should be evaluated during future phases of the project with additional field explorations. It is our opinion that if corrosion potential exists, it can be mitigated regardless of the alternative chosen and will not be a controlling factor for alternative selection.

2.2.4.2 Erodible Soils

Highly erodible soils would include alluvial deposits such as fine sands, silts, and soft clays. Structure foundations adjacent to or located in flowing water must be located at a depth such that erosion or scour does not undercut the soil and cause a failure. Foundations may also require embedment into bedrock. For the purpose of this document, it is our opinion that the alternative selection will not be dependent on the erosion potential along the proposed segments.

2.2.4.3 Expansive Soils

Many clay soils and shales expand upon wetting and shrink when dried. The expansion can result in a volume increase in the wetted-soil state many times greater than in the dry-soil state. These changes in soil volume can cause major structural damage if not considered in the design. Because no erosion/ shrink/ swell data is available at this time, shrink/swell potentials should be evaluated during future phases of the project with additional detailed explorations. For the purpose of this document, it is our opinion that the alternative selection will not be dependent on the shrink/swell potential. In most cases, this condition can be mitigated with relative ease and, therefore, is not expected to be a controlling factor for the alternative selection.

2.3 Regional Groundwater Conditions

Groundwater is addressed here in a very preliminary and regional manner. No attempt was made to contour or discern groundwater levels throughout the project area; however, groundwater generally occurs in two distinct regions throughout the study area. Relatively uniform, unconfined aquifers and associated water tables are expected in the Los Angeles Basin, which includes all of downtown Los Angeles and extends east to just west of Ontario. Groundwater in the mountainous regions (the Peninsular Ranges province), from the Los Angeles Basin to the tip of Baja California is expected to be highly variable controlled by fracture permeability in rock units and local alluviated valleys that are relatively restricted in their extent.

Because no detailed, site-specific investigations have been performed during this study, groundwater table information along the proposed the Modal and HST Alternatives is not available. As such, it is not possible to ascertain site specific impacts to design or construction due to the presence of groundwater. However, for the purpose of this study, we have assumed shallow groundwater is present throughout the site. The geological hazard evaluation is based on this assumption and is presented in subsequent sections. We recommend that groundwater levels be investigated during future field exploration phases and the corresponding hazards be reevaluated based on actual conditions encountered.

2.4 Oil and Gas Fields

Oil and gas fields that may impact the proposed segments are found principally in the Los Angeles Basin. The Los Angeles Basin is notable for its great structural relief and complexity in relation to its geologic youth, small size, abundant oil production, and presence of subsurface gasses. The Los Angeles Basin is the most prolific of California’s oil-producing districts (Yerkes et al., 1965). Segment 1 will traverse across or near oil fields. No known gas fields are present in the Los Angeles Basin or other locations of the proposed segments. Oil and gas fields in the Los Angeles Basin may have impacts on the proposed project, and the impacts are discussed and evaluated in Sections 4.0 and 5.0.

2.5 MINERAL RESOURCES

Various mineral resources are currently produced in California. For the purpose of this document, only sand and gravel resources were reviewed and considered for potential impacts on the proposed project. The *Map of California Principal Mineral-Producing Localities, 1990 – 2000*, was reviewed for the potential mineral fields that are located in the vicinity of the proposed project. The results are presented in subsequent sections.

2.6 SEISMIC HAZARDS

Three primary seismic hazards occur as a result of the presence of faults capable of generating earthquakes. These include ground rupture potential, strong ground motion, and liquefaction and other seismically related ground movements. Ground rupture occurs when a fault ruptures at depth and movement along the fault propagates to the ground surface. Large differential ground surface movements both laterally and vertically can occur. Ground motion occurs when faults rupture at depth where pressures are high and result in earthquakes. Liquefaction and other ground movements are the result of ground motions where localized subsurface rock or soil conditions are susceptible to collapse or flow. Each of these hazards is described more thoroughly below along with a description of their potential occurrence.

2.6.1 Regional Faulting and Historic Seismicity

Faulting is prevalent throughout California, resulting in intense seismicity when compared to other parts of the country. Faulting within the study area has been evaluated on the basis of the most recent documented fault activity. Three sources were compiled to evaluate faulting, including the Fault Activity Map of California (Jennings, 1994), Alquist-Priolo (A-P) Earthquake Fault Zones of California (California Geological Survey [CGS], 2000), and fault source information used by the California Department of Transportation (Mualchin, 1996). The potential faults within the project study area are shown in Figure 2.6-1. These sources were used to compile Plate 10, Quaternary Faults and Alquist-Priolo Earthquake Fault Zones. It should be noted that faults mapped by Mualchin contain valuable fault names and parameters but are mapped irrespective of frequency of movement. A-P mapping represents those zones where the CGS considers faults to be present, requiring further site specific fault studies and recommendations for development. These zones generally include faults with known movements within the past 10,000 years (i.e., Holocene).

2.6.2 Ground Rupture Potential

The potential for ground rupture typically is estimated based upon the presence of faults with known displacement during recent geologic time. California generally categorizes faults as capable of future movement if there is evidence that the fault has moved within the past 10,000 years (i.e., Holocene) and defines this category of faults as “Active.” Faults with movement within the past 1.6 million years (i.e., Quaternary) and no known Holocene displacement are considered moderately capable of rupture and are categorized as “Potentially Active.” Faults older than 1.6 million years are treated with the least concern and are called “Inactive.” Essential or critical facilities to human health and safety are required to recognize the potential for ground rupture on or immediately adjacent to both Active and Potentially Active Faults. For purposes of this project, Quaternary fault crossing zones are defined as areas where Quaternary faults transect any portion of the segment including a 200-foot buffer allowing for other improvements associated with the project that would be influenced by ground rupture potential.

California is a seismically active region when compared to other parts of the country. The Los Angeles to San Diego via Inland Empire study area occurs within a region of extensive faulting and folding, much of which has occurred during recent geologic time. As a result, seismicity within this segment study area is relatively frequent and often result in moderate to large earthquakes.

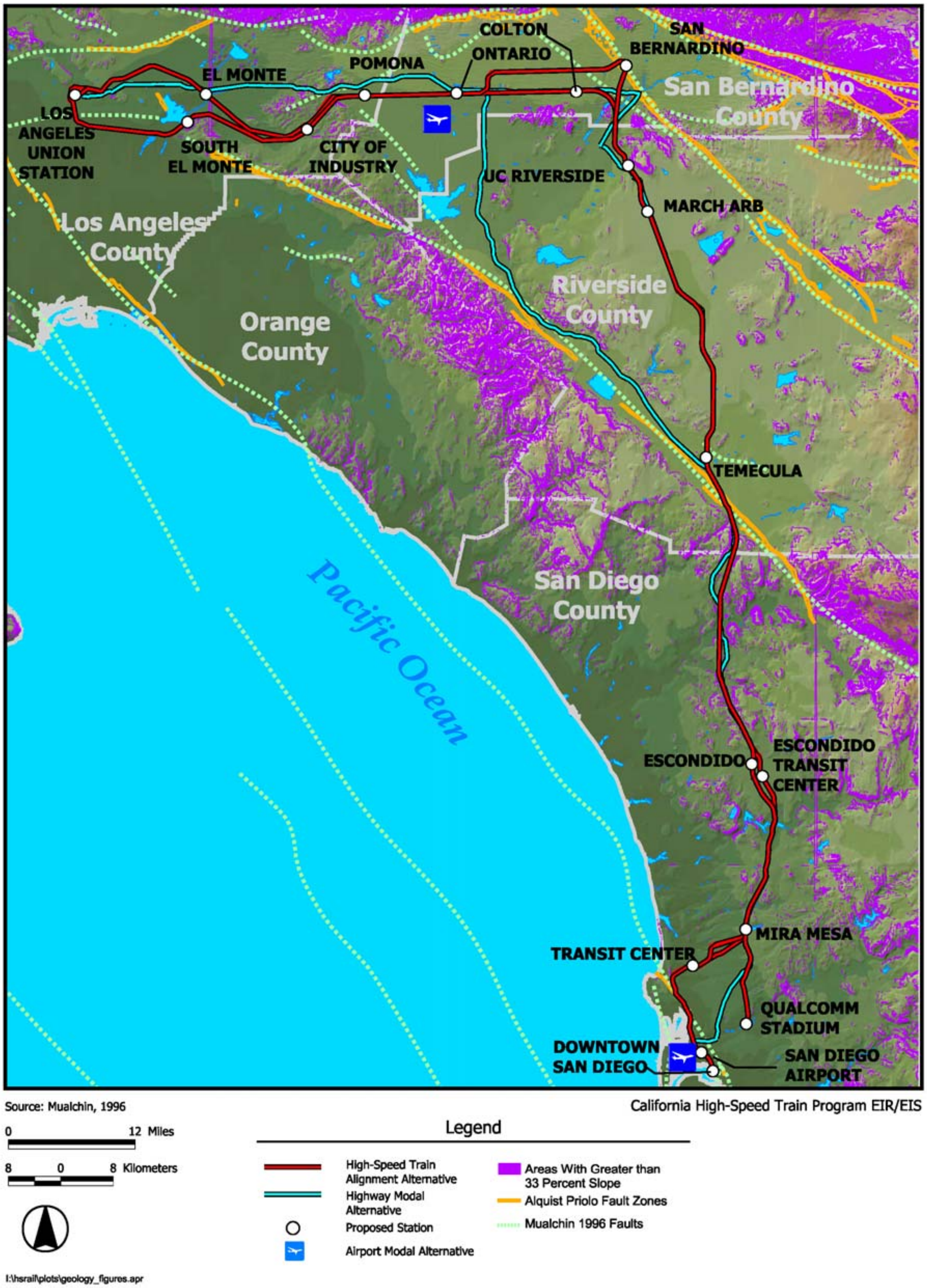


Figure 2.6-1 Percent of Slopes and Potentially Active Faults

2.6.3 Ground Motion Potential

The future potential for seismicity within the project area will be controlled by the behavior of faults within and adjacent to this region. The CGS and USGS have generated maps that indicate potential seismic ground motion (Jennings, 1994 and 1997). These maps are the result of running computer models that consider the fault frequency of movement and slip rate as well as documented (historic) seismicity defining future ground motions on the basis of probability of occurrence. Generally speaking, this model relates each of the recognized faults considered capable of generating earthquakes during the near future and decreases, or attenuates, the ground shaking with distance away from the fault. The probability of occurrence is provided in three probability scenarios including the Design Basis Event (10 percent probability of exceedance in 50 years), the Upper Bound Event (10 percent probability in 100 years), and the Maximum Conceivable Event (10 percent in 250 years). The state requires that essential and critical public facilities design to accommodate against catastrophic failure for the Upper Bound Event, or UBE. For purposes of this project, areas of potentially strong ground motion have been defined as areas where peak horizontal earthquake ground motion accelerations may exceed 50 percent (i.e., 0.50) g.

2.6.4 Liquefaction and Other Seismic Ground Movement

Liquefaction is a seismic phenomenon in which loose, saturated fine-grained granular soils behave like a fluid when subjected to high-intensity ground shaking. Liquefaction occurs when three general conditions exist: shallow groundwater, low-density sandy soils, and high-intensity ground motion. Studies indicate that saturated, loose and medium-dense, near-surface, cohesionless soils exhibit the highest liquefaction potential, while dry, dense, cohesionless soils and cohesive soils exhibit low to negligible liquefaction potential. Effects of liquefaction on level ground include sand boils, settlement, and bearing capacity failures below structural foundations. For purposes of this project, potentially liquefiable zones have been identified as those areas where ground motions exceed 40 percent (i.e., 0.40) g but excluding areas mapped as underlain by rock.

2.7 POTENTIALLY UNSTABLE SLOPES

Slope instability can require stabilization planning, design, and construction costs and, if not adequately characterized and mitigated during construction, can cause severe damage to surface and near-surface improvements. Typically, site-specific studies are undertaken to address subsurface conditions and perform quantitative analysis of slope stability and design of mitigation measures where necessary. Since this evaluation precedes the availability of a design or site specific studies, a more general approach was taken. Each of the geologic formations mapped (Jennings, 1997) was assigned a formational rating for slope stability (low, meaning comparably stable formational characteristics relative to potential for slope failure). The potentially unstable formations were then compared to the Digital Elevation Model (DEM) that has been queried for slope areas flatter than and steeper than 33 percent slope gradient. Areas that have slopes greater than 33 percent are shown in Figure 2.7-1. For purposes of this project, the criteria for mapping potentially unstable slopes was all areas in which slope gradients exceed 33 percent and are not underlain by rock units having high strength characteristics (i.e., low instability ratings). A 200-foot-wide buffer zone around these potentially unstable areas was created to take into consideration other site improvements that may be influenced as well.

2.8 DIFFICULT EXCAVATION AREAS

Difficult excavation areas have been addressed relative to surface excavation characteristics and tunneling methods. Surface excavation (i.e., earthwork methods) methods differ significantly from deeper tunnel boring machine (TBM) excavation. Whereas hard rock at the surface may be difficult to excavate by bulldozers and other heavy, surface earthmoving equipment, TBM excavation typically prefers these conditions. Conversely, fractures and faults result in crushed rock, along which groundwater is prevalent, is difficult to excavate using TBM, and yet those are the preferred conditions for surface excavation methods. For this reason, we have used hardness characteristics of the rock for portions of the segment where aerial and at-grade track is proposed. We have used fault zone information for areas where tunneling is proposed. Each of the geologic formations mapped were assigned a formational rating for hardness and thus excavatability using surface methods (Jennings, 1997). Faults that include Quaternary and pre-Quaternary faults were digitized into zones identified as difficult to excavate using tunneling methods.

2.9 SECONDARY HAZARDS

There are a number of secondary hazards, though uncommon in occurrence, that deserve mentioning. These include hydroconsolidation, expansive rock, sinkholes, and tsunamis.

Hydroconsolidation is the phenomenon of collapsible soils, that may be present along the proposed segments. Hydroconsolidation is a condition where soils are dry and strong in their natural state and appear to provide good support for foundations. However, if they become wet, these soils quickly consolidate generating settlements that can become quite large.

Expansive rock may be present along the segment. Like expansive soil, some rock formations, when presented with changing overburden pressures or moisture contents, may rebound or expand. This may cause significant distress to pavements or structures founded on this type of formation.

Sinkholes, though geologically rare in Southern California geology, are possible and could present impacts such as foundation settlements. Sinkholes generally are related to subterranean washouts from flowing groundwater and not related to karst activity.

Impacts from tsunamis could be possible, especially in a subaqueous seismically active region such as Southern California. A tsunami could form as a result of an offshore earthquake and have significant damaging effects, especially along the proposed shoreline or near shoreline segments in the San Diego region. Damage could include but not be limited to severe flooding, erosion, scour, and foundation settlements.

3.0 EVALUATION METHOD

3.1 GEOLOGY AND SOILS METHODOLOGY

The geology and soils impact and resource analysis for this program-level EIR/EIS is focused on a broad comparison of the potential impacts of seismic hazards, active fault crossings, slope stability, and oil and gas fields. The influence of these conditions, the influence of difficult excavation on construction, and the impact of the alternative projects on mineral resources are also evaluated. Potential impacts of these conditions along the proposed High-Speed Train and Modal Alternatives are compared to the No-Project Alternative.

CEQA provides criteria for significant geologic, soils, and seismic impacts. The criteria specifically addresses the questions regarding exposure by the project to people or structures to potential substantially adverse effects, including the risk of loss, injury, or death involving:

- Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.
- Strong seismic ground shaking?
- Seismic-related ground failure, including liquefaction?
- Landslides?
- Result in substantial soil erosion or the loss of topsoil?
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or offsite landslides, lateral spreading, subsidence, liquefaction, or collapse?
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code, creating substantial risks to life or property?
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of waste water?
- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?

Each of these CEQA criteria is included in the baseline conditions and subsequent analysis of potential impacts.

As described in Section 2.0, soil conditions include expansive, erosive, and corrosive soils. Soil conditions were not included in our methodology. Similarly, secondary hazards discussed in Section 2.9 were not considered significant to the project and were not included in our ranking methodology. The methodology used to compare alternative projects, alignments, and stations is outlined below. The results of these comparisons are summarized in Section 4.0.

In general, our methodology involved the acquisition and analysis of available statewide GIS layers pertinent to these impacts. Criteria for definition of hazards were identified based upon generally accepted statewide practices, and these hazards were compared as impacts to each project alternative. A numerical ranking system was developed to compare impacts between the alternatives. The summary tables for the region are then completed to identify geology, soils, and seismic hazards within the study area for each of the corridor segments and around station sites for the high-speed train alternative, and along highway corridors and around airports for the Modal Alternative.

3.2 SEISMIC HAZARDS

Seismic hazards have been evaluated by combining the influences of strong ground motion and liquefaction potential. These potential hazards are discussed previously in Sections 2.6.3 and 2.6.4. Zones of strong ground motion have been defined previously as areas where peak horizontal earthquake ground motion accelerations may exceed 50 percent (i.e., 0.50) g. Liquefaction potential has been previously defined as those areas where ground motions exceed 40 percent (i.e., 0.40) g but excluding areas mapped as underlain by rock. To compare alternative projects (i.e., Modal versus HST), segments, and stations, a ranking system was developed. This ranking system consists of the combination of the percentage of portions of the segment within the strong ground motion zones and the percentage of segment within the potentially liquefiable zones.

Seismic Hazard = % segment in Strong Ground Motion + % in Potentially Liquefiable Zones

Overlapping liquefaction/ground motion hazards are not considered duplicative in that they require unique mitigation effort. Stations were compared by determining whether any portion of the proposed station occurs within the ground rupture zone and a yes or no ranking. Results of calculations using this methodology are contained in Sections 4.0 and 5.0, where mitigation options also are discussed conceptually.

3.2.1 Active Fault Crossings

A fault is a fracture or zone of fractures in the earth's crust along which there has been displacement of the sides relative to one another. An active fault is one that has moved in geologically recent times (within the last 11,000 years). When the earth's crust moves along a fault, an offset develops between the landscapes and surface features on opposite sides of the fault. Some faults move at a slow but steady pace (a few centimeters per year) without generating earthquakes; this type of movement is called "creep." Other faults do not move for long periods then move all at once, causing an earthquake along with sudden displacement along the fault (called "stick-slip" movement). Portions of highways and railways crossing active faults may be subject to offset and local disruption when either type of movement occurs.

The teams referred to the published fault maps produced by the California Geological Survey (CGS, 2003); specifically maps of the Alquist-Priolo Special Studies Zones (A-P maps) defined around active faults in California. The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. As a result of the act, active faults were identified and mapped, and a 50-foot buffer zone was established around each identified active fault segment. The Alquist-Priolo map series serves as a consistent guide for the regional teams, but it may not represent the complete hazard due to active fault crossings. While these maps identify most of the major faults in California, other unmapped active faults may exist or may be created during an earthquake in the future.

For the purposes of analysis and comparison, the teams referred to the A-P maps described above, the fault map for fault names and ages (Jennings, 1994), and to the California Department of Transportation seismic hazard map (Mualchin, 1996). Seismic hazards (percent of length), the analysis includes the segment length that crosses a 500-foot zone around active faults in the overall tally of seismic hazards. This 500-foot zone is assumed to be a shear zone with the potential for fault rupture and displacement either with an earthquake event or as a result of slow creep. In specific locations, the size of the shear zone was increased based on local knowledge.

Major fault crossings are described in Section 4.1. These faults are shown in Figure 2.6-1.

3.2.2 Strong Ground Motion

To be provided by PMT.

3.2.3 Liquefaction

Liquefaction is a seismic phenomenon in which loose, saturated, fine-grained soils behave like a fluid when subjected to high-intensity ground shaking. Liquefaction occurs when three general conditions exist: shallow groundwater, low-density sandy soils, and high-intensity ground motion. Studies indicate that saturated, loose and medium-dense, near-surface cohesionless soils exhibit the highest liquefaction potential, while dry, dense, cohesionless soils and cohesive soils exhibit low to negligible liquefaction potential. Effects of liquefaction on level ground include sand boils, settlement, and bearing capacity failures below structural foundations.

The liquefaction potential in the High-Speed Rail project was evaluated based on the potential seismic hazards and the subsurface soil conditions encountered along the proposed Modal Alternative highway improvements, along the HST segments, and at the proposed HST stations. Based on the available information, Jennings' *Fault Map of California* was reviewed for the potential seismic hazards. The USGS 1996 UBE Ground Motion shape-file was used to determine the 0.3 g and 0.5 g ground acceleration contours. The geology was reviewed to identify the surface geology and the subsurface soil conditions for the top 5 feet of soil (Jennings, 1997). Liquefaction potential was evaluated based on the following simplified criteria in this project:

- Potential for Liquefaction: ground acceleration is greater than 0.3 g and weak to moderate
- Low Potential for Liquefaction: ground acceleration is less than 0.3 g and soil is hard

These criteria assume shallow groundwater is present. If a portion of the proposed segment falls in the 0.3 g-plus ground acceleration contour and the subsurface soil is classified as alluvium or colluvium by the Jennings 1997 geology, this portion of the segment is considered to have a potential for liquefaction. The lengths of subsegments having liquefaction potential are added for each segment to compare the total length of the segment as the percentage having liquefaction potential. For HST stations, if the station is located on alluvium or colluvium soil and falls in the 0.3 g-plus ground acceleration contour, potential for liquefaction is considered for the station. Again, shallow groundwater levels are assumed.

The liquefaction potential evaluated in this report can be considered only preliminary because of the simplified evaluation methodology used. In current geotechnical practice, the liquefaction potential is evaluated using the procedures outlined in SPT-Based Analysis of Cyclic Pore Pressure Generation and *Undrained Residual Strength* by Seed and Harder (1990) as modified by the National Center for Earthquake Engineering Research (NCEER) Workshop on Evaluation of Liquefaction Resistance of Soils (NCEER, 1997). To perform a realistic liquefaction evaluation by using this methodology, site-specific soil borings with standard penetration tests (SPTs) advanced to a depth of at least 50 feet are necessary. The liquefaction potential concluded in this report will be verified in future investigations.

3.3 SLOPE STABILITY

Potentially unstable slope areas have been defined previously as areas where slopes have a gradient steeper than 33 percent slope gradient but are not underlain by strong geologic rock formations. A 200 foot wide buffer zone was added to consider the influences of other improvements. To compare alternative projects (i.e., Modal versus HST), segments, and stations, a ranking system was developed in which the percentage of segment within the potentially unstable zones are computed and compared. This ranking system is described as follows:

Unstable Slopes = percent of segment within 200-foot buffer of potentially unstable zones

Stations were compared by determining whether any portion of the proposed station occurs within the potentially unstable slope areas within the 200-foot buffer and a yes or no ranking. Results of calculations using this methodology are contained in Sections 4.0 and 5.0 and mitigation options are discussed conceptually in Section 6.0.

3.4 DIFFICULT EXCAVATION

Areas of difficult excavation zones have been identified using both geologic formation characteristics as well as the existence of faults of any age, as described previously in Section 2.6. These zones consist of fault zones that may influence subsurface tunneling methods and also hard rock zones that may influence surface excavation methods. To compare alternative projects (i.e., Modal versus HST), segments, and stations, a ranking system was developed in which the percentage of segments within the areas of difficult excavation applied to the corresponding track profile (i.e., at-grade/aerial versus tunnel) was computed and compared, or:

> Difficult Excavation = percent of at-grade/aerial segments within hard rock units and percent of tunnel segments within fault zones

Stations were compared by determining whether any portion of the proposed station occurs within the difficult excavation areas defined by hard rock formations. Results of calculations using this methodology are presented in the potential impacts and mitigation Sections 4.0 and 5.0. Mitigation and subsequent analysis requirements are discussed conceptually in Section 6.0.

3.5 OIL AND GAS FIELDS

The major issue associated with oil, gas, and geothermal resources is the exclusion of future resource availability caused by the location of facilities such as railroad tracks, roadways, and parking areas. Potential impacts on oil, gas, or geothermal resource availability were evaluated based on a comparison of known resource location versus facility location. Potential resources were identified from published resource maps produced by the California Department of Conservation – Division of Oil, Gas, and Geothermal Resources (CDC, 2001a and 2001b). Where project facilities and resources collocate, the distance and percent length of the crossing was calculated in Section 4.1.

Sources of information for both mineral resources and oil/gas resources are those available through the California Geological Survey. Maps and publications are available through their website: http://www.consrv.ca.gov/cgs/information/publications/counties.

3.6 MINERAL RESOURCES

The major issue associated with mineral resources is the exclusion or restriction of current or future extraction caused by location of facilities such as railroad tracks, roadways, and parking areas. Potential impacts on mineral extraction were evaluated based on a comparison of known resource location versus facility location. Potential resources were identified from published resource maps produced by the California Department of Conservation – California Geological Survey (CGS, 2000). Where project facilities and resources collocate, "yes" was entered in Section 4.1.

4.0 POTENTIAL GEOLOGICAL IMPACTS – OPERATIONS

4.1 IMPACTS

Geologic impacts to the proposed alternatives may greatly influence final segment decisions and construction costs especially related to mitigation of undesirable geologic conditions. These impacts are described in the following discussions and presented in Table 4.1-1.

4.1.1 No-Project Alternative

The No-Project Alternative does not require any additional operations and, therefore, is not considered unique to the Modal Alternative. Potential impacts for the Modal Alternative are thus considered applicable to this alternative as well.

4.1.2 Modal Alternative

4.1.2.1 Seismic Hazards

The major potential impacts on the Modal Alternatives include potential seismic hazards such as strong ground shaking, liquefaction, seismically induced settlement and landslides, ground surface rupture, and potential impacts of shallow groundwater table.

The Modal Alternative improvements are located within a seismically active region. Several active faults that could produce significant ground shaking are in the immediate vicinity of the site or cross the segments. Based on the Mualchin 1996 Fault Map, the San Jose Fault (moment of magnitude [M_m] is 6.75) crosses I-10 in Pomona. Strong ground shaking and severe ground surface rupture at this location are anticipated if the San Jose Fault slips in this area.

Based on the A-P Maps, two A-P fault zones are identified crossing the Modal Alternatives segments. The San Bernardino South A-P zone crosses I-10 in San Bernardino and the Temecula A-P zone crosses I-15 in Temecula. Table 4.1-1 summarizes the seismic hazards in terms of strong ground motion and liquefaction potential for the Modal Alternatives. The numbers of active fault crossings identified by the fault map are listed in Table 4.1-1 (Jennings, 1994).

The segments of the Modal Alternatives have a moderate to high potential for possible seismic hazards such as liquefaction. Seismically induced settlement and landslides may occur locally depending on the subsurface soil conditions and slope ratio of the surrounding mountains and hills. The sites with active fault crossings may rupture if earthquakes occur.

4.1.2.2 Slope Stability

Less than 0.5 percent of the proposed segment traverses areas with slope ratios greater than 33 percent. Therefore, significant impacts due to unstable slopes are expected to be low. Localized unstable slopes may exist and will require future detailed investigation and possible mitigation.

4.1.2.3 Difficult Excavation

No excavations during operations are expected. Therefore, difficult excavation during operations is not a concern for all segments.

4.1.2.4 Oil and Gas Fields

No oil and gas fields were identified along the Modal Alternatives. Therefore, their potential for impacts to the Modal Alternative operations is considered low.

4.1.2.5 Mineral Resources

A sand and gravel pit is present near the vicinity of I-15. Therefore, based on the ranking system, the potential for a mineral resource impact to the I-15 Modal corridor is high. This may be in the form of increased truck traffic during operations. Other corridors in the Modal Alternative are ranked as low.

4.1.3 High-Speed Train Alternative

4.1.3.1 Seismic Hazards

The major potential impacts on the High-Speed Train Alternative include potential seismic hazards such as strong ground shaking, liquefaction, seismic induced settlement and landslides, and ground surface rupture, long-term settlement on the existing oil and gas fields, and potential impacts of shallow groundwater table.

The proposed HST segments and the HST stations are located within a seismically active region. Several active faults that could produce significant ground shaking are in the immediate vicinity of the site or cross the proposed segments and stations. Based on the Mualchin 1996 Fault Map, significant faults include:

- Elysian Park (maximum credible earthquake [MCE] M_m = 7.00) crossing Subsegment 1B1 in Los Angeles
- Rialto-Colton-Claremont (M_m = 6.75) and San Jacinto (M_m = 7.50) crossing Subsegment 1C1 in San Bernardino
- Murrieta Hot Springs (M_m = 6.00) crossing Subsegment 2A1 in Murrieta
- Whittier-Elsinore (M_m = 7.50) crossing Subsegment 2A1 in Temecula
- Newport-Inglewood-Rose Canyon (M_m = 7.00) crossing Subsegment 3B2 in San Diego

Strong ground shaking and severe ground surface rupture at these locations are anticipated if a fault slip occurs in these areas. These faults can generate estimated peak bedrock accelerations from 0.3 g to 0.7 g on the project site.

Based on the A-P Maps, three A-P fault zones are identified crossing the proposed HST segments. The San Bernardino South A-P zone crosses Subsegment 1C1 in San Bernardino, Temecula A-P zone crosses Subsegment 2A1 in Temecula, and La Jolla A-P zone crosses Subsegment 3B2 in San Diego. The total numbers of active fault crossings identified by the fault map are summarized in Table 4.1-1.

The peak ground accelerations generated by the active faults were reviewed by the UBE map contours, and the strong ground motions are determined based on criteria of ground accelerations greater than 0.5 g. The liquefaction hazard was evaluated based on criteria of ground accelerations greater than 0.3 g plus weak to moderate soils encountered. Since no specific soil borings have been done at this time, we assume that all alluvium has the potential to liquefy if the ground acceleration is greater than 0.3 g. Table 4.1-1 summarizes the seismic hazards in terms of strong ground motion and liquefaction potential for the proposed HST segments and the HST stations.

Except Subsegments 2A2, 2A3, 2B1, and 3A1, which have a low potential for seismic hazard (liquefaction), the remaining segments of the proposed HST segments have a medium to high potential for seismic hazards. Liquefaction potential for the proposed HST stations is included in Table 4.1-1 as part of the seismic hazard ranking. Seismically induced settlement and landslides may occur locally, depending on subsurface soil conditions and slope ratio of the surrounding mountains and hills. The potential for ground surface rupture is high at sites that have active fault crossings. Seismic impacts on the proposed Temecula Station are significant because of an active fault crossing the site.

Table 4.1-1 Geology and Soils Impacts Comparison

Category	Seismic Hazards[a] (percent)	Active Fault Crossings[b]	Slope Stability[c] (percent)	Difficult Excavation[d] (percent)	Oil and Gas Fields[e] (percent)	Mineral Resources[f]
Modal Alternative						
I-10	100	8	0.2	10	0	None
I-15	66	4	0	52	0	SG
I-215	100	4	0	15	0	None
I-8	20	1	0	80	0	None
SR-163	69	0	0	31	0	None
HST Alternative						
Subsegment 1A1	100	3	0.4	7	4	SG
Subsegment 1A2	100	0	0	0	0	SG
Subsegment 1A3	100	0	0	0	0	None
Subsegment 1A4	100	0	0	22	0	None
Subsegment 1B1	100	0	0	22	18	SG
Subsegment 1C1	100	6	0	0	0	None
Subsegment 2A1	79	5	0.05	43	0	None
Subsegment 2A2	0	0	0	98	0	None
Subsegment 2A3	0	0	0	98	0	None
Subsegment 2B1	0	0	0	0	0	None
Subsegment 3A1	17	1	0	83	0	None
Subsegment 3B1	79	0	0	21	0	None
Subsegment 3B2	93	2	0	41	0	None
Subsegment 3C1	81	0	0	19	0	None
HST Stations						
El Monte	Yes	None	None	None	None	None
Pomona	Yes	None	None	None	None	None
Ontario	Yes	None	None	None	None	SG
Colton	Yes	None	None	None	None	None
South El Monte	Yes	None	None	Yes	Yes	None
City Of Industry	Yes	None	None	None	None	None
San Bernardino	Yes	None	None	None	None	None
UCR	Yes	None	None	Yes	None	None
March ARB	Yes	None	None	None	None	None
Temecula	Yes	1	None	None	None	None
Escondido	No	None	None	Yes	None	None
Escondido Transit Center	No	None	None	Yes	None	None
Mira Mesa	No	None	None	Yes	None	SPS
Qualcomm	Yes	None	None	Yes	None	None

Table 4.1-1 Geology and Soils Impacts Comparison

Category	Seismic Hazards[a] (percent)	Active Fault Crossings[b]	Slope Stability[c] (percent)	Difficult Excavation[d] (percent)	Oil and Gas Fields[e] (percent)	Mineral Resources[f]
Transit Center	Yes	None	None	Yes	None	None
San Diego Airport	Yes	None	None	None	None	None
Downtown San Diego	Yes	None	None	None	None	None

[a] Includes strong ground motion and liquefaction as follows:

1. Strong ground motion from UBE map contours > 0.5 g – High
   < 0.5 g – Low
2. Liquefaction similar to above – > 0.3 g and weak to moderate soils – potential
   < 0.3 g and hard soils – low potential

[b] Number of crossings is separate column

[c] Two categories for slopes:
More likely – more than 33 percent slope and weak or moderate soils
Less likely – less than 33 percent slope
Note landslide potential is included here, because mapping of landslides not available statewide.

[d] Difficult excavations: Percent of alignment in strong formations (and section requires cut or tunnel). For tunnel sections, jointed/faulted rock also considered difficult excavation, to be evaluated based on fault crossings (of all ages).

[e] Percent of length in mapped oil and gas fields

[f] Mineral Resources
SG Sand and Gravel
SPS Specialty Sand

4.1.3.2 Slope Stability

Less than 0.5 percent of the proposed segment traverses areas with slope ratios greater than 33 percent. No HST stations are projected in areas of slopes greater than 33 percent. Therefore, significant impacts due to unstable slopes are expected to be low. Localized unstable slopes may exist and will require future detailed investigation and possible mitigation.

4.1.3.3 Difficult Excavation

No excavations during operations are expected. Therefore, difficult excavation during operations is not a concern for all segments.

4.1.3.4 Oil and Gas Fields

The *Map of Oil, Gas, and Geothermal Fields in California, 2001* was reviewed for the potential oil and gas fields (CDC, 2001a). No gas fields were found for the proposed HST segments and the HST stations. Oil fields were found only within Subsegment 1A1, Subsegment 1B1, and at the South El Monte Station. The percentage of the segment length crossing the oilfields in Subsegments 1A1 and 1B1 are approximately 4 percent and 18 percent ranking as low and high impact potential, respectively. The oil field encountered at the South El Monte Station is abandoned. Long-term settlement of these proposed segments located along the oil fields needs to be monitored. Odors may have an impact on some segments and on the proposed station locations. Therefore, environmental protection measurements may be required during operations in these areas.

4.1.3.5 Mineral Resources

In the vicinity of Subsegments 1A1, 1A2, and 1B1 (near Ontario Station), sand and gravel pits were encountered. A specialty sand pit is found near the vicinity of the Mira Mesa Station. Therefore, these areas have a high potential for impacts to mineral resources based on the evaluation system ranking methodology. This may be in the form of increased truck traffic during operations.

5.0 POTENTIAL GEOLOGICAL IMPACTS – CONSTRUCTION

5.1 IMPACTS

Geologic impacts to the proposed alternatives may greatly influence final segment decisions and construction costs especially related to mitigation of undesirable geologic conditions. These impacts are described in the following discussions and presented in Table 4.1-1.

5.1.1 No-Project Alternative

The No-Project Alternative does not require any additional operations and, therefore, is not considered unique to the Modal Alternative. Potential impacts for the Modal Alternative are thus considered applicable to this alternative as well.

5.1.2 Modal Alternative

5.1.2.1 Seismic Hazards

Impacts of seismic hazards on the Modal Alternative during construction are same as those described in Section 4.1.2.1 for impacts during operations. Therefore, they are not repeated in this section. Seismic design normally is not incorporated into construction methods. Seismic impacts during construction are considered low because of the temporary duration of the construction process. Therefore, seismic impacts during construction are considered low.

5.1.2.2 Slope Stability

Less than 0.5 percent of the proposed segments traverse areas with slope ratios greater than 33 percent. Therefore, significant impacts due to unstable slopes during construction are expected to be small. Localized unstable slopes may exist and will require future detailed investigation and possible mitigation.

5.1.2.3 Difficult Excavation

Difficult excavation during construction is expected for Segments I-15, I-8, and SR 163 due to moderate to hard granitic rocks in these segments. At the locations with shallow groundwater tables, dewatering may be required during excavation. Selected large landslides are not identified along the Modal Alternative based on the Jennings 1997 geology map; however, localized landslides may occur. Mitigation measurements would be required if potential landslides are identified in future investigations.

5.1.2.4 Oil and Gas Fields

No oil and gas fields were identified along the Modal Alternative.

5.1.2.5 Mineral Resources

A sand and gravel pit is present near the vicinity of I-15. A specialty sand pit is found near the vicinity of the Mira Mesa Station.

5.1.3 High-Speed Train Alternative

5.1.3.1 Seismic Hazards

Impacts of seismic hazards on the High-Speed Train Alternative during construction are the same as those described in Section 4.1.3.1 for impacts during operations and, therefore, are not repeated in this section. However, since the construction period is of limited duration, the probability of occurrence of such an event is considered to be low.

5.1.3.2 Slope Stability

Less than 0.5 percent of the proposed segments traverse areas with slope ratios greater than 33 percent. Therefore, significant impacts due to unstable slopes during construction are expected to be small. Localized unstable slopes may exist and will require future detailed investigation and possible mitigation.

5.1.3.3 Difficult Excavation

Difficult excavation during construction is expected for Segments 1A4 and 1B1; Segments 2A1, 2A2, and 2A3; and Segments 3A1, 3B1, 3B2, and 3C1 due to moderate to hard shale/sandstone and granitic rocks presented in these segments. Proposed tunnels in Segment 2 are expected to have easy excavations due to relatively intact rock conditions and no active fault crossings. At the locations with shallow groundwater tables, dewatering may be required during excavation. Selected large landslides are not identified along the proposed alignments based on the Jennings 1997 geology map; however, localized landslides may occur. Mitigation measurements would be required if potential landslides are identified in future investigations.

5.1.3.4 Oil and Gas Fields

No gas fields were found for the proposed HST segments and stations. However, oil fields were found in Subsegment 1A1 and Subsegment 1B1 and at the South El Monte Station. The percentages of the segment lengths crossing the oil fields in Subsegments 1A1 and 1B1 are approximately 4 percent and 18 percent, respectively. The oil field encountered at the South El Monte Station is abandoned. Contaminated soil and groundwater may be encountered during excavation on the existing oil fields. Therefore, environmental protection measurements and dewatering in these areas may be required during excavations and construction dewatering operations. In such areas, appropriate disposal of soils and groundwater should be addressed during detailed investigations.

5.1.3.5 Mineral Resources

In the vicinity of Subsegments 1A1, 1A2, and 1B1 (near Ontario Station), sand and gravel pits were encountered. A specialty sand pit is near the vicinity of the Mira Mesa Station.

6.0 REFERENCES

California Department of Conservation, California Geological Survey (CGS). *Map of California, Principal Mineral-Producing Localities--1990*. 2000.

California Department of Conservation, Division of Oil, Gas, and Geothermal Resources. *Oil, Gas, and Geothermal Fields in California*. Map S-1. 2001a.

California Department of Conservation, Division of Oil, Gas, and Geothermal Resources. *District 1 Oil Fields Map*. April 16, 2001b.

California Division of Mines and Geology. *Digital Images of Official Maps of Alquist-Priola Earthquake Fault Zones of California, Southern Region, CD 2000-003*. 2000.

California Division of Mines and Geology. *GIS Shape-Files of Official Maps of Alquist-Priolo Earthquake Fault Zones of California*. 2000.

California, State; Governor's Office of Planning and Research. *CEQA Guidelines*. Appendix G, Section VI. Revised October 26, 1998.

Division of Mines and Geology (DMG), Department of Conservation. Internet website. Http://www.consrv.ca.gov/dmg/ . Accessed January 2003.

Hunt, R.E. *Geotechnical Engineering Investigation Manual*. 1983.

Jennings, C.W. *Fault Activity Map of California and Adjacent Areas with Locations and Ages of Recent Volcanic Eruptions*. Geologic Data Map No. 6. Prepared for California Division of Mines and Geology. 1994.

Jennings, C.W. *Geologic Map of California*. Prepared for California Division of Mines and Geology. 1997.

Mualchin, L. *California Seismic Hazard Map*. Prepared for California Department of Transportation. 1996.

Parsons Brinckerhoff. *Final Draft Environmental Analysis Methodologies.* . Prepared for California High-Speed Rail Authority. November 7, 2002.

Parsons Brinckerhoff. *Plans and Profiles*. Prepared for California High-Speed Rail Authority. November 2002.

Parsons Brinckerhoff. *Screening Report*. Prepared for California High-Speed Rail Authority. April 2002.

Seed and Harder. "SPT-Based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength." 1990. Modified in *Workshop on Evaluation of Liquefaction Resistance of Soils*. National Center for Earthquake Engineering Research (NCEER). 1997.

Yerkes, R.F., T.H. McCulloh, J.E. Schoellhamer, and J.G. Vedder. *Geology of the Los Angeles Basin, California—An Introduction.* Geological Survey Professional Paper 420-A. 1965.

7.0 PREPARERS

7.1 HNTB CORPORATION

Linda Bohlinger
Vice President
HNTB Corporation

Doctoral course work, Public Administration, University of Southern California; M.P.A., Public Administration, University of Southern California; B.A., Spanish, University of California, Santa Barbara. 25 years of experience in the transportation industry. Currently a National Vice President, Rail Services, with the HNTB Corporation. Most recent position was as the Executive Director of South Florida's Tri-County Commuter Rail Authority (Tri-Rail). Held previous positions as the CEO for the Los Angeles County Metropolitan Transportation Authority and other positions in California state and regional government.

- Project Principal

John S. Kulpa
Chief Transportation Planner
HNTB Corporation

Ph.D., Business Management, LaSalle University; M.S., Urban and Environmental Studies, Rensselaer Polytechnic Institute; B.A., Political Science, New York University. 22 years of experience in transportation planning and engineering.

- Project Manager

7.2 CH2M HILL

Brian Hausknecht
Senior Planner
CH2M HILL

M.S., Environmental Engineering, University of Florida; B.A., Biology, Jacksonville University. 20 years of experience in hazardous materials management and environmental analysis.

- Project Manager

Richard Burke
Transportation
Environmental Specialist
CH2M HILL

M.S., Technology Policy, Washington University; B.S., Architecture, Stanford University. More than 25 years of national and international experience in directing environmental projects that comply with requirements of NEPA, CEQA, and other governmental regulations.

- Senior Reviewer

Ping Tian, Ph.D., P.E.
Geotechnical Engineer
CH2M HILL

Ph.D., Geotechnical Engineering, University of Oklahoma; M.S., Coastal and Ocean Engineering, Hohai University, Nanjing, China; B.S., Engineering Mechanics, Hohai University, Nanjing, China. Over 10 years of experience in geotechnical field investigation, foundation design, and analysis. Experience in pavement analysis and design and in slope stability, settlement, liquefaction, vertical and lateral pile capacity, and seepage analyses.

- Task Lead

Yoga Chandran, Ph.D., G.E. Geotechnical Project Manager CH2M HILL	Ph.D., Civil Engineering, University of California at Davis; M.S., Civil Engineering, University of California at Davis; B.S., Civil Engineering, University of Peradeniyo, Sri Lanka. Over 19 years of experience specializing in geotechnical investigation and soil characterization, making foundation recommendations, pollutant transport in saturated soil, laboratory and *in situ* soil testing, soil dynamics, and earthquake engineering. • Senior Reviewer
Curtis R. Basnett, G.E. Geotechnical Engineer CH2M HILL	M.C.E., Civil Engineering, University of Florida; B.S., Civil Engineering, University of Florida. More than 15 years of experience in field and laboratory soil testing, field explorations, *in situ* soil testing and sampling, landfill siting and design, embankment and foundation design, slope stability evaluations for earth dikes, and deep foundation designs for highway projects. • Primary Reviewer