2.2.3 Geology/Soils/Seismic/Topography

This section evaluates potential impacts to geology and seismic hazards that could result from operation of the Tier I and Tier II projects. Geology and seismic hazard impacts that could occur during project construction are discussed in Section 2.4, and cumulative impacts are discussed in Section 2.5.

Regulatory Setting

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

This section also discusses geology, soils, and seismic concerns as they relate to public safety and project design. Earthquakes are prime considerations in the design and retrofit of structures. Caltrans’ Office of Earthquake Engineering is responsible for assessing the seismic hazard for Caltrans projects. Structures are designed using the Caltrans Seismic Design Criteria. The Seismic Design Criteria provides the minimum seismic requirements for highway bridges designed in California. A bridge’s category and classification will determine its seismic performance level and which methods are used for estimating the seismic demands and structural capabilities. For more information, please see the Caltrans Division of Engineering Services, Office of Earthquake Engineering, Seismic Design Criteria.

Affected Environment

The information in this section is summarized from the Preliminary Geotechnical Report (2007).

Tier I Corridor Alternatives

The proposed project is located entirely within the Monterey Bay area of Santa Cruz County. Monterey Bay is underlain by water-bearing unconsolidated alluvium, stream channels, and basin sediments. The area has been cut by a complex series of high-angle thrust and strike slip northwest-trending faults, which has produced the northwest-trending ridge and valley systems. These areas are filled with Pleistocene to Holocene alluvium. The region consists of marine and non-marine sedimentary strata. There are no important natural landmarks or major geologic features in the area.

The underlying native soil units and their drainage and permeability characteristics are shown in Table 2.2.3-1 below. Table 2.2.3-1 shows that the soils in the project area are poorly drained to excessively drained, with loam to sandy loam surface textures. Sedimentary rock is found on most of the creek banks and gulches. Permeability or hydraulic conductivity of the area is moderately high to high, and runoff is very low to high, as shown in Table 2.2.3-1.

Table 2.2.3-1: Underlying Native Soil Units, Drainage Characteristics, and Permeability

Soil Unit	Map Unit Name	Surface Texture	Permeability	Slope (%)	Drainage	Runoff	Erosion Hazard
105	Baywood loamy sand	Loamy sand	High	2-15	Excessively drained	High	High
106	Baywood loamy sand	Loamy sand	High	15-30	Excessively drained	High	High
114	Ben Lomond – Felton	Loamy sand	High	30-50	Well drained	Moderately slow	Moderately low
116	Bonny Doon loam	Loam	Moderately high	5-30	Excessively drained	Slow	Low
124	Danville loam	Loam	High	0-2	Well drained	Slow	Low
129	Elder sandy loam	Sandy loam	Moderately high	0-2	Well drained	Moderately slow	Moderately low
130	Elder sandy loam	Sandy loam	Moderately high	2-9	Well drained	Moderately slow	Moderately low
133	Elkhorn sandy loam	Sandy loam	High	2-9	Well drained	Moderately slow	Moderately low
134	Elkhorn sandy loam	Sandy loam	High	9-15	Well drained	Moderately slow	Moderately low
135	Elkhorn sandy loam	Sandy loam	High	15-30	Well drained	Moderately slow	Moderately low
136	Elkhorn-Pfeiffer complex	Sandy loam	High	30-50	Well drained	Moderately slow	Moderately low
143	Lompico-Felton complex	Loam	High	30-50	Well drained	Moderately slow	Moderately low
161	Pinto loam	Loam	Moderately high	0-2	Moderately well drained	Slow	Low
162	Pinto loam	Loam	Moderately high	2-9	Moderately well drained	Slow	Low
170	Soquel loam	Loam	Moderately high	0-2	Moderately well drained	Moderately slow	Moderately low
171	Soquel loam	Loam	Moderately high	2-9	Moderately well drained	Moderately slow	Moderately low
174	Tierra Watsonville complex	Sandy loam	Moderately high	15-30	Moderately well drained	Very slow	Moderately low
176	Watsonville loam	Loam	Moderately high	2-9	Poorly drained	Very slow	Moderately low
177	Watsonville loam	Loam	Moderately high	9-15	Poorly drained	Very slow	Moderately low
178	Watsonville loam	Loam	Moderately high	15-30	Poorly drained	Very slow	Moderately low
179	Watsonville loam	Loam	Moderately high	30-50	Poorly drained	Very slow	Moderately low
182	Zayante coarse sand	Coarse sand	High	9-15	Excessively drained	High	Low

Source: Preliminary Geotechnical Report, 2007.

Erosion hazard is moderately low to high, but the improved areas within the project corridor that are protected by erosion control measures should have a low erosion potential. Table 2.2.3-1 demonstrates that the study area could be susceptible to erosion if runoff is high and drainage is excessive. The erosion hazard potential decreases as runoff and drainage decreases.

Seismic Activity

The project is located in a seismically active area of California. Many of the faults in the project area are capable of producing earthquakes that may cause strong ground shaking at the bridge locations. The maximum credible earthquake represents the largest magnitude earthquake that could occur on a given fault, based on the current understanding of the regional tectonic structure. The maximum credible earthquake is used to determine the safety evaluation for freeway design. The peak bedrock acceleration is the greatest distance at which the bedrock moves during an earthquake. The maximum credible earthquake for the Zayante-Vergales Fault, which is 2.2 miles away from the project area and is a controlling fault for the project vicinity, is 7.25 on the Richter scale. Another controlling fault for the project vicinity is the San Andreas Fault, which has a maximum credible earthquake of 8.0 on the Richter scale and is 6.25 miles away from the project area. See Table 2.2.3-2 for locations of the fault systems relative to the project site.

Table 2.2.3-2: Locations of the Fault Systems Relative to the Project Site

Fault Name	Estimated Closest Distance to the Middle* of the Project Area (miles)	Maximum Credible Earthquake	Peak Bedrock Acceleration
Zayante-Vergales	2.20	7.25	0.60
San Andreas	6.25	8.00	0.50
Sargent	8.15	6.75	0.30
Monterey Bay Zone	8.15	6.50	0.25
Calaveras-Pacines-San Benito	19.4	7.50	0.20

*Nearest perpendicular distance to the possible bridge location is taken to calculate peak bedrock acceleration.
Source: Preliminary Geotechnical Report, 2007.

The general terrain along the project corridor consists of gentle slopes presenting little or no potential for the formation of slumps, landslides, or earth flows; however, there is some potential for these conditions along the stream banks and terrace margins, defined by the distribution of surficial deposits. Additionally, the hillside slopes several hundred feet to the east and west of the corridor and has minor landslide potential.

Liquefaction

Liquefaction during an earthquake typically occurs in loose, cohesionless, saturated, and granular soils below the groundwater table. Submerged cohesionless sands and silts of low relative density are the type of soils that usually are susceptible to liquefaction. Clays are generally not susceptible to liquefaction. Within the study area, the majority of the submerged cohesionless subsoils are primarily medium dense to very dense. However, loose sands were encountered at some locations, such as the Park Avenue and Bay Avenue undercrossings.

Tier II Auxiliary Lane Alternative

The geology of the Tier II Auxiliary Lane Alternative project area is predominantly composed of marine terrace deposits from the Pleistocene era with small amounts of alluvium from the Pleistocene era and sedimentary rock from the Pliocene era. The primary soil types within the study area include Watsonville loam, which is poorly drained and has moderately high permeability, and Elkhorn sandy loam, which is well drained and has high permeability. Due to these soil conditions, the liquefaction potential for the study area is considered very low. The closest fault to the study area is the Zayante–Vergales Fault, which is 3.5 miles away. The maximum credible earthquake for this fault is 7.25 on the Richter scale.

Environmental Consequences

Tier I Corridor Alternatives

The developed areas within the project corridor are expected to have a low erosion potential. It is anticipated that no new embankments will be required for construction of the Tier I Corridor HOV Lane Alternative or Tier I Corridor TSM Alternative. In addition, the project area is not expected to have any significant amount of expansive soils.

Seismic Activity

The principal seismic hazard in the proposed project area is the potential for moderate to severe ground shaking from earthquakes occurring on one or more regional active faults. The Zayante-Vergales Fault is the controlling fault for this project and is likely to induce strong ground shaking within the project vicinity. The San Andreas Fault system also has displayed considerable activity in the past and is likely to do so in the future.

Based on the available data, liquefaction potential in the project corridor is generally relatively low; however, the potential is very high near the Park Avenue undercrossing and its vicinity (characterized by 8.5 foot level depth to groundwater) and at the Bay Avenue undercrossing (13 foot level depth to groundwater). Because groundwater levels affect soil cohesion and may vary with the passage of time, the levels would be verified during the final design phase for the preferred alternative.

Lateral spreading is a phenomenon associated with liquefaction where lateral movement of a soil embankment occurs along a free face. Impacts of liquefaction on improvements may vary and would depend on the type of structure. There is a possibility that lateral spreading may occur at any of the major creek channel crossings. The consequences could be potential failure of the bridge abutments, exceeding the lateral capacities of the bridge pile supports, and blockage of creek flows with soil deposits.

The project area has relatively low potential for landslides; however, slopes located along the creeks in the project corridor may pose local slump or landslide risk.

Risk to the General Public and Workers

The majority of surface drainage in the project area is well to moderately drained, indicating a moderately low erosion hazard throughout the project area. This means that the project would not expose construction workers, highway users, or structures to potential substantial adverse effects from soil erosion and/or surface drainage. Highway workers and users may be exposed to adverse effects from seismic activity due to the proximity of the Zayante-Vergales Fault. The San Andreas, Sargent, Monterey Bay Zone, and Calaveras-Pacines-San Benito faults also pose a potential danger.

Tier II Auxiliary Lane Alternative

The improved areas within the project corridor are expected to have a low erosion potential. It is anticipated that no new embankments would be required for this alternative. In addition, the Tier II project area is not expected to have any significant amount of expansive soils.

The project area has relatively low potential for landslides. Slopes located along the Rodeo Creek Gulch may pose local slump or landslide risk.

The majority of surface drainage in the project area is well to moderately drained, indicating a moderately low erosion hazard throughout the project area. This means that the project would not expose construction workers, highway users, or structures to potential substantial adverse effects from soil erosion and/or surface drainage. Highway workers and users may be exposed to adverse effects from seismic activity due to the proximity of the Zayante-Vergales Fault. The San Andreas, Sargent, Monterey Bay Zone, and Calaveras-Pacines-San Benito faults also pose a potential danger.

No Build Alternatives

Under the Tier I and Tier II No Build Alternatives, no major improvements would be made to Route 1. Geologic and seismic issues related to construction would not occur.

Avoidance, Minimization, and/or Mitigation Measures

Tier I Corridor Alternatives and Tier II Auxiliary Lane Alternative

The measures discussed below are applicable to the Tier II Auxiliary Lane Alternative and are anticipated to be applicable to future construction projects tiered from either of the Tier I Corridor Alternatives, which would be subject to separate environmental review. The selection of a Tier I Corridor Alternative would not result in actual construction; therefore, no avoidance, minimization, and/or mitigation measures are required at this time.

The proposed Tier II Auxiliary Lane Alternative and all future projects tiered from either of the proposed Tier I Corridor Alternatives would be designed to meet all Caltrans seismic engineering requirements. Caltrans Guidelines for Geotechnical Foundation Investigations and Reports would be used for the site-specific investigations. Specifications for construction would conform to Caltrans Standard Specifications; therefore, the following avoidance measures would be incorporated into project design for this and any future build alternative:

- A site-specific seismic hazard engineering analysis will be conducted during final design, which will include engineering recommendations for retaining walls, expansive soil treatment, cuts and fills, and bridge foundation elements.
- The specific seismic hazard engineering analysis will include design measures to address surface drainage, slope maintenance, and surface protection/erosion control. In addition, the seismic hazard engineering analysis will include design measures to minimize the potential damage from ground shaking, fault rupture, liquefaction, lateral spreading, and slope instability. The following requirements will be incorporated as part of the seismic hazard engineering analysis:
  - Replanting will be incorporated into project plans to protect any new slopes.
  - Permanent erosion control measures, such as infiltration devices, media filters, and detention devices, will be applied to all new and/or exposed slopes. Ditches, berms, dikes, swales, overside drains, flared end sections, and outlet protection/velocity dissipation devices will be designed to handle concentration flows.
  - Slope/surface protection systems with vegetated surfaces and hard surfaces will be employed to minimize erosion.
- To minimize potential damage from ground shaking, structures associated with this project will meet maximum credible earthquake standards, as established by the Caltrans Office of Earthquake Engineering. Caltrans has established Seismic Design Criteria for incorporating seismic loads in the design of structures. Structure design, including bridges, will reflect these design guidelines. Impacts from ground shaking and fault rupture are to be mitigated using appropriate Caltrans design methods, such as the use of stone columns, subexcavation, dynamic compaction, or dewatering methods.

- For foundation design of structures having concentrated loads (e.g., bridges), design will address the additional loads generated by the liquefaction conditions. The most suitable method(s) will be selected based on site-specific subsurface investigations conducted as part of the seismic hazard engineering analysis.
- Site-specific engineering recommendations to minimize impacts from lateral spreading will be incorporated into the final design plans and construction contract documents. Angled piles may be needed to lessen lateral pressures of creek banks to resist lateral spreading.
- Localized movements along creek banks will be controlled by incorporating in the project design appropriate permanent slope protection, including rock riprap or revetment. Structures, such as retaining walls, will be required to mitigate specific conditions. Site-specific engineering recommendations to minimize long-term impacts due to landsliding will be defined based upon field testing during the final design phase and incorporated in the final design.

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