

4.7 GEOLOGICAL RESOURCES

4.7.1 Setting

The topography of the county can be divided into three general landform types: the Santa Cruz Mountains to the north and northeast, the coastal terraces along the bay, and the Pajaro Valley to the south and southeast. Of the county's 41 square miles, approximately 74 percent is privately owned and not urbanized (i.e., vacant, rural, agricultural, open space, or developed in parcels larger than five acres). Approximately 14 percent of the land area is urbanized and twelve percent is in public ownership.

Earthquake Groundshaking and Fault Rupture. The county is located in the vicinity of at least six major regional seismic fault systems, and is therefore located within an area of high seismic risk. However, no formally recognized faults are located within the Cities of Santa Cruz, Scotts Valley, Watsonville, or Capitola.

Faults in the county include the San Andreas, Zayante, Ben Lomond, San Gregorio, Butano, and the Monterey Bay Fault Zone. Based upon the major historic earthquakes that have occurred along these regional faults, each is considered active or potentially active (i.e., characterized by movement within the last 200 years), except the Ben Lomond Fault, for which insufficient data is available to determine its activity.

The San Andreas Fault Zone runs in a northwest/southeast direction, generally east of the county, although a portion of the fault zone extends into the southern portion of the county. The U.S. Geological Survey (USGS) has estimated that the San Andreas Fault could produce an earthquake of magnitude 8.5 on the Richter scale. The City of Santa Cruz was one of the hardest hit communities in the 7.1 magnitude Loma Prieta earthquake that occurred on October 17, 1989. Its epicenter was located approximately 10 miles east of the City, on the San Andreas Fault. In the downtown area, 34 commercial buildings were demolished and several more buildings were damaged. It is estimated that the maximum credible earthquake experienced in the City would equal a magnitude of 8.3, on the San Andreas Fault.

The Zayante Fault Zone is located approximately 1.5 miles north of the City of Scotts Valley, and the Butano Fault Zone is located approximately four miles north of the City of Scotts Valley. Both the Zayante Fault and Butano Fault are tied into the San Andreas Fault system and are capable of producing major earthquakes of magnitude 7.4 and 6.4 on the Richter Scale, respectively. These fault zones run in a north-south direction, generally east of the County, although the Zayante Fault Zone traverses the northeast portion of the Watsonville Planning Area.

The Ben Lomond Fault Zone is located between the Cities of Scotts Valley and Santa Cruz, approximately one mile southeast of the City of Scotts Valley Planning Area. The San Gregorio Fault Zone is located offshore to the west of the county. This fault is capable of producing an



earthquake greater than magnitude 7.4. The Corralitos Fault Zone is located in the Pajaro Valley, in the southern portion of the county, near the City of Watsonville.

The southern ends of the historically active Hayward and Calaveras Faults are located approximately 25 miles to the northeast and east of the City of Santa Cruz, respectively. The Hayward and Calaveras faults are capable of generating quakes greater than magnitude 7.4.

Liquefaction. The City of Santa Cruz General Plan 1990-2005 identifies large areas of moderate to high liquefaction potential through the central portion of the City. During the 1989 Loma Prieta earthquake, liquefaction-related ground failure was widespread from Santa Cruz to Salinas in the San Lorenzo, Pajaro, and Salinas River areas. These areas are distinguished geologically by the presence of silt and sand and by the presence of shallow ground water. The most widespread damage was to levees of the Pajaro and San Lorenzo Rivers, which suffered cracking due to differential settlements and small displacement at many locations of liquefaction.

The City of Scotts Valley General Plan identifies areas of moderate liquefaction potential throughout the City, generally within and adjacent to creeks and drainages. The majority of Scotts Valley Road and a substantial portion of Highway 17 through the City are located in areas of moderate liquefaction potential.

Liquefiable soil conditions occur along broad bands that follow the creeks, sloughs, rivers and lakes that drain the City of Watsonville Planning Area. Much of downtown Watsonville is located in a zone of moderately high liquefaction potential.

Slope Stability. Many hillside areas of the county are susceptible to landslides, especially in areas with steeper slopes, such as the San Lorenzo Valley area. In addition, several coastal bluff areas, such as the East Cliff and West Cliff Drive areas, have historically been subject to slope instability.

In the City of Santa Cruz, landslide deposits and soil creep occur primarily on slopes in the western side of the City near Moore Creek Canyon. Landslide deposits are also found in the upper portions of Arana Gulch and DeLaveaga Park and other isolated locations in the City. Cliff retreat, which is the result of hillside or coastal headland soil constraints by weathering, physical disturbance and, in the case of ocean cliffs, the continuous and forceful actions of waves and tides, is prevalent along North Pacific Avenue, Chestnut Street, and ocean cliffs and West Cliff Drive and Seabright Beach. For ocean cliffs in areas where wave action contacts Santa Cruz mudstone formations, there exists a low potential for cliff soil constraints; where wave action contacts the Purisima Formation, there exists a moderate potential for cliff soil constraints. Both situations occur along West Cliff Drive and East Cliff Drive from Natural Bridges State Park to Santa Cruz Yacht Harbor.

A large portion of the City of Scotts Valley Planning Area consists of sloping land with moderate to high landslide potential. Landslide deposits in the City are concentrated in the hillside areas in the near the western and eastern boundaries of the City.



Tsunami/Seiche. The county contains no lakes of sufficient size that would produce substantial seiche effects. However, coastal portions of the county are subject to potential tsunami hazards.

4.7.2 Impact Analysis

a. Methodology and Significance Thresholds. Implementation of the 2001 RTP, and projects pursuant to the RTP, would create a significant impact relative to geologic resources if any project contemplated under the RTP would result in any of the following conditions:

- *Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, strong seismic ground shaking, seismic-related ground failure, including liquefaction, or landslides;*
- *Result on substantial soil erosion or the loss of topsoil;*
- *Result in the loss of a unique geologic feature;*
- *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 off-site landslide, lateral spreading, subsidence, liquefaction, or collapse; or*
- *Be located on expansive soil, creating substantial risks to life or property.*

Because the location of each of the improvements is different in geologic character, determination of significance is based on an individual study at the time of the project permit application and environmental review. Therefore, for the purposes of this program EIR, transportation modifications that are located in areas of moderate to high geologic, soil or flood hazard shall be considered potentially significant.

b. Project Impacts and Mitigation Measures. This section describes generalized impacts associated with the projects anticipated under the RTP. Table 4.7-1 in Section 4.7.2.c. summarizes the specific projects that could result in the impacts discussed in this section.

Impact G-1 **Some RTP projects may be located on potential unstable soils, in areas of high liquefaction or erosion potential, or in areas subject to landslides. This is considered a Class II, *significant but mitigable* impact.**

Construction and operation of some roadways and bikeways included in the 2001 RTP could be prone to slope stability, soil and liquefaction hazards. Bridges are less susceptible to such hazards. These hazards could be exacerbated through grading associated with transportation projects, and construction of such projects on unconsolidated fill. The nature of these hazards, and their potential impacts, are described below.

Liquefaction. Liquefaction potential is widespread throughout the county, particularly in lower-lying valleys overlaid by alluvium. Such areas are also typically characterized by high



groundwater. This condition is most prevalent in the coastal areas of the county. Several of the county's major roadways and urban centers are located in such areas. Consequently, nearly all RTP projects involving structural change or new facilities could be subject to liquefaction and high groundwater hazards.

Expansive soils have a clay content and mineralogy that renders them susceptible to volume increase upon absorption of water and volume decrease upon desiccation. Repeated cycles of wetting and drying of expansive soils can cause damage to roadways, foundations, and concrete flatwork.

Compressible soils include soils with a high organic content, those with a low density and finegrained porous texture, and uncompacted or poorly compacted fill. Soil "collapse", also referred to as "hydroconsolidation", is a term descriptive of the relatively rapid settlement of certain soils upon saturation. Soils prone to collapse include low density, porous sands and silts deposited in an arid or semi-arid environment. The effect of soil compression or collapse is settlement of the ground surface with a resultant potential to damage foundations of structures and other improvements.

Potential impacts related to soil stability and collapsible/compressible soils for the majority of the projects are unlikely, as such geologic conditions are not prevalent in the county. However, impacts are considered potentially significant, and each project would require a more thorough evaluation as it would occur.

Landslide. Roadway projects in mountainous areas or along steeply sloped streambanks are subject to landslide, particularly adjacent to areas of unstabilized cut or fill. Landslides, including rockfalls, can damage the facility itself, or cars and bicycles using the facilities. Lives could also be at risk. Landslides can cause temporary road closures to allow clean up and repair, if necessary. Such closures would necessitate detours, which in turn may cause temporary congestion on detour routes. It should be noted that projects listed in the 2001 RTP would involve slope stabilization and repair that would reduce potential impacts related to landslides.

Soil Erosion. Soil erosion is the removal of soil by water and wind. The rate of erosion is estimated from four soil properties: texture, organic matter content, soil structure, and permeability data. Other factors that influence erosion potential include the amount of rainfall and wind, the length and steepness of the slope, and the amount and type of vegetative cover. Structures and facilities constructed on these soils, as well as users of the facilities, could be exposed to hazards related to erosion.

Mitigation Measures. The following programmatic measures would reduce potential impacts to the extent feasible.

- G-1(a)** If a particular RTP bridge or passenger station project is located in an area of moderate to high liquefaction potential, the local jurisdiction in



which this project is located shall ensure that these structures are designed based upon appropriate geology, soils and earthquake engineering studies. Possible design measures include deep foundations, removal of liquefiable materials and dewatering. This requirement can be accomplished through the placement of conditions on the project by the local jurisdiction during individual environmental review.

- G-1(b)** If a particular RTP road widening or bridge project involves cut slopes over 20 feet in height or is located in areas of bedded or jointed bedrock, the local jurisdiction in which the project is located shall ensure that specific slope stabilization studies are conducted. Possible stabilization methods include buttresses, retaining walls and soldier piles. This requirement can be accomplished through the placement of conditions on the project by the local jurisdiction during individual environmental review.
- G-1(c)** If a particular RTP bridge or passenger station project is located in an area of highly expansive, collapsible or compressible soils, the local jurisdiction in which the project is located shall ensure that a specific investigation and appropriate design factors are implemented. This requirement can be accomplished through the placement of conditions on the project by the local jurisdiction during individual environmental review.
- G-1(d)** If a particular RTP roadway or fixed facility project involving deep foundations or underground areas is located in an area of high groundwater potential, the local jurisdiction in which the project is located shall ensure that appropriate construction techniques (such as de-watering, special water proofing, and deeper foundations) are included. This requirement can be accomplished through the placement of conditions on the project by the local jurisdiction during individual environmental review.
- G-1(e)** If a particular RTP roadway or fixed facility project involving deep foundations or underground areas is located in an area of moderate or high erosion potential, the local jurisdiction in which the project is located shall ensure that a grading and erosion control plan that minimizes erosion and sedimentation shall be prepared and implemented by the project proponent, prior to issuance of Grading Permits. This requirement can be accomplished through the placement of conditions on the project by the local jurisdiction during individual environmental review. The grading and erosion control plan must include the following:



- a. Methods such as retention basins, drainage diversion structures, spot grading, silt fencing/coordinated sediment trapping, straw bales, and sand bags shall be used to minimize erosion on slopes and siltation into waterways during grading and construction activities.
- b. Graded areas shall be revegetated within four weeks of grading activities with deep-rooted, native, drought-tolerant species to minimize slope failure and erosion potential. Geotextile binding fabrics shall be used if necessary to hold slope soils until vegetation is established.
- c. Exposed areas shall be stabilized to prevent wind and water erosion, using methods approved by the P&B Grading Division and APCD. These methods may include importing of topsoil is to be imported and spread on the ground surface in areas having soils that can be transported by the wind, and/or the mixing of the highly erosive sand with finer-grained materials (silt or clay) in sufficient quantities to prevent its ability to be transported by wind. The topsoil or silt/clay mixture is to be used to stabilize the existing soil to prevent its ability to be transported by wind. As a minimum, six inches of topsoil or silt/clay/sand mixture is to be used to stabilize the wind-erodible soils.
- d. Landscaped areas adjacent to structures shall be graded so that drainage is away from structures.
- e. Grading on slopes steeper than 5:1 shall be designed to minimize surface water runoff.
- f. Fills placed on slopes steeper than 5:1 shall be properly benched prior to placement of fill.
- g. Brow ditches and/or berms shall be constructed and maintained above all cut and fill slopes, respectively.
- h. Cut and fill benches shall be constructed at regular intervals.
- i. Retaining walls shall be installed to stabilize slopes where there is a 10-foot or greater difference in elevation between buildable lots.
- j. Excavation and grading shall be limited to the dry season of the year (typically April 15 to November 1, allowing for variations in weather) unless an approved erosion control plan is in place and all measures therein are in effect.

Significance After Mitigation. Implementation of the above measures would reduce potential impacts of projects located in areas with liquefaction potential, unstable slopes, expansive, collapsible, compressible, or erosive soils, and/or high groundwater to a less than significant level.



Impact G-2 Some RTP projects could be subject to seismic hazards, including fault rupture and groundshaking. This is considered a Class II, *significant but mitigable* impact.

Fault rupture can occur along or immediately adjacent to faults during an earthquake. Fault rupture is characterized by ground cracks and displacement that could endanger life and property. Damage is typically limited to areas close to the moving fault.

Groundshaking effects are also the result of an earthquake, but the impacts can be much more widespread. Although a function of earthquake intensity, groundshaking effects can be greatly magnified by the underlying soils and geology, which may amplify shaking at great distances. It is difficult to predict the magnitude of groundshaking following an earthquake, as shaking can vary widely within a relatively small area.

Projects in the south coastal area are most susceptible to seismic hazards because of the large number of active faults in the region (for example, the San Andreas, Zayante, Ben Lomond, San Gregorio, Butano, and the Monterey Bay fault zones). Historically, very large earthquakes very near the area have produced substantial groundshaking (the 1989 Loma Prieta earthquake, for example).

Bridge-type structures are most susceptible to earthquake groundshaking and fault rupture; however, roadways may also be damaged by either phenomenon.

Mitigation Measures. The following measures are recommended to mitigate potential impacts relating to seismic activity.

G-2(a) The local jurisdiction in which a particular RTP bridge or passenger station project is located shall ensure that the structure is designed and constructed to the latest geotechnical standards. In most cases, this will necessitate site specific geologic and soils engineering investigations to exceed the code for high groundshaking zones. This can be accomplished through the placement of conditions on the project by the local jurisdiction during individual environmental review.

G-2(b) The local jurisdiction in which a particular RTP bridge or passenger station project is located shall ensure that these structures are placed in areas outside of fault rupture zones. If avoidance is not possible, detailed geologic and seismic studies must be conducted to locate active or potentially active fault traces. Structures shall then be placed outside of an appropriate setback distance. This requirement can be accomplished through the placement of conditions on the project by the local jurisdiction during individual environmental review.



Significance After Mitigation. Implementation of the above measures would reduce potential impacts to a less than significant level.

c. Specific RTP Projects That May Result in Impacts. Table 4.7-1 identifies those projects that may create impacts as discussed in Section 4.7.2.b above. The individual projects listed could create significant geologic or flooding impacts but would not necessarily do so. Additional specific analysis will need to be conducted as the individual projects are implemented in order to determine the actual magnitude of impact. Mitigation measures discussed above would apply to these specific projects.

Table 4.7-1 RTP Projects That May Result in Geologic Impacts

Project	Lead Agency	Location	Impact	Description of Impact
Many	All	All roadway extensions, new Class I bikeways, and roadway modifications in coastal areas	G-1	Projects are subject to potential soils constraints, and/or high groundwater impacts.
Many	All	All roadway extensions, new Class I bikeways, and roadway modifications, particularly in the northern and eastern portions of the County or near active faults	G-2	Projects are subject to potential groundshaking and fault rupture in the event of an earthquake
Constrained Projects				
AIR-P1	Airport	Lump Sum Watsonville Airport Projects	G-1, 2	Structures subject to potential soil constraints and seismic hazards
CT-18	Caltrans	Highway 1/Harkins Slough	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
CT-P34	Caltrans	Highway 1/San Lorenzo Bridge Widening	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
CT-P31	Caltrans	Highway 1 Vista Point Upgrade	G-1, 2	Facilities subject to potential soil constraints and seismic hazards
CT-P30	Caltrans	Lump Sum Other SHOPP Projects	G-1, 2	Bridge structures subject to potential soil constraints and seismic hazards
CT-P19	Caltrans	Pajaro Rail Station Design and Construct	G-1, 2	Structure subject to potential soils constraints and seismic hazards
CO 24	County	East Cliff Drive Bike/Pedestrian Path	G-1	Path subject to potential soil constraints
CO 3	County	East Cliff Drive Bike/Pedestrian Path	G-1	Path subject to potential soil constraints
CO-P16	County	Robertson Street Improvements	G-1	Roadway subject to potential soil constraints
CO 32	County	Sanctuary Scenic Trail	G-1	Path subject to potential soil



Table 4.7-1 RTP Projects That May Result in Geologic Impacts

Project	Lead Agency	Location	Impact	Description of Impact
				constraints
CO-P26s	County	Scott Creek Beach Improvements	G-1	Improvements subject to potential soil constraints
SC-P34	Santa Cruz	Branciforte Creek Bike/Pedestrian Crossing	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
SC 7	Santa Cruz	Broadway-Brommer Bike Path	G-1	Pathway subject to potential soil constraints
SC-P21	Santa Cruz	Brookwood Drive Bike Path	G-1	Pathway subject to potential soil constraints
SC-1	Santa Cruz	Multi-modal Station Development at Front Street, Near Beach Street	G-1, 2	Structure subject to potential soil constraints and seismic hazards
SC-P36	Santa Cruz	River Levee Connection	G-1, 2	Pathway subject to potential soil constraints and seismic hazards
SC-P35	Santa Cruz	River Levee - Southeast End	G-1, 2	Pathway subject to potential soil constraints and seismic hazards
SC-P37	Santa Cruz	River Pathway Connection/Highway 1 Undercrossing	G-1, 2	Pathway subject to potential soil constraints and seismic hazards
SC-3	Santa Cruz	San Lorenzo River Bike/Pedestrian Bridge	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
RTC 21	SCCRTC	Rail/Trail: Bike/Pedestrian Path Along Santa Cruz Branch Rail Line	G-1, 2	Pathway subject to potential soil constraints and seismic hazards
MTD-13	SCMTD	Metro Center Rehabilitation	G-1, 2	Structure subject to potential soil constraints and seismic hazards
UC-P4	UCSC	Jordan Gulch Bridge # 1	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
UC-P43	UCSC	UCSC - Bike Path Connection to Western Drive	G-1, 2	Pathway subject to potential soil constraints
WAT 29	Watsonville	Harkins Slough Road Reconstruction	G-1	Roadway subject to potential soil constraints
WAT-P7	Watsonville	Struve Slough Bridge (HBRR)	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
WAT-20	Watsonville	Transit Center Joint Daycare Facility	G-1, 2	Structure subject to potential soil constraints and seismic hazards
WAT-P9	Watsonville	Watsonville Slough Bridge (HBRR)	G-1, 2	Bridge structure subject to potential soil constraints and



Table 4.7-1 RTP Projects That May Result in Geologic Impacts

Project	Lead Agency	Location	Impact	Description of Impact
				seismic hazards
<i>Unconstrained Projects</i>				
CAP-P19	Capitola	Capitola-Santa Cruz Commuter Ferry Service	G-1, 2	Structures subject to potential soil constraints and seismic hazards
CAP-P5	Capitola	Cliff Drive Improvement Project	G-1, 2	Slope stabilization subject to potential soil constraints and seismic hazards
CAP-P24	Capitola	Pacific Cove Expansion for Park and Ride Lot	G-1, 2	Structure subject to potential soil constraints and seismic hazards
CO-P10	County	Empire Grade Improvements	G-1	Roadway subject to potential soil constraints
CO-P38	County	Pajaro River Bike Path	G-1, 2	Pathway subject to potential soil constraints and seismic hazards
CO-P46	County	San Lorenzo River Corridor Bike Path	G-1, 2	Pathway subject to potential soil constraints and seismic hazards
SC-P24	Santa Cruz	Harbor Connection	G-1, 2	Pathway subject to potential soil constraint
SC-P3	Santa Cruz	Highway 1 Sound Wall	G-1, 2	Structure subject to potential soil constraints and seismic hazards
SC-P27	Santa Cruz	Josephine Street Bridge	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
SC-P39	Santa Cruz	Soquel Avenue to Broadway-Brommer Bike Path	G-1, 2	Structure subject to potential soil constraints and seismic hazards
UC-P39	UCSC	College Nine/Communications Pedestrian Bridge	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
UC-P37	UCSC	College Nine/Crown College Pedestrian Bridge	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
UC-P6	UCSC	Heller Drive/Steinhart Way Transit Bikeway Bridge	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
UC-P5	UCSC	Jordan Gulch Bridge #2	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
UC-P35	UCSC	McHenry Library/Student Center	G-1, 2	Bridge structure subject to



Table 4.7-1 RTP Projects That May Result in Geologic Impacts

Project	Lead Agency	Location	Impact	Description of Impact
		Pedestrian Bridge		potential soil constraints and seismic hazards
UC-P36	UCSC	Porter Street/Performing Arts Pedestrian Bridge	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
UC-P40	UCSC	Science Hill /Colleges 11&12 Pedestrian Bridge	G-1, 2	Bridge structure subject to potential soil constraints and seismic hazards
UC-P3	UCSC	Steinhart Way Multi-modal Improvements	G-1	Roadway subject to potential soil constraints
WAT-P23	Watsonville	Ohlone Parkway	G-1	Roadway subject to potential soil constraints

