# 4.4 Geology, Soils, and Seismicity

This section presents a discussion of geologic, soils, and seismic hazards and impacts on development associated with implementation of the 2007 Monterey General Plan. The topics discussed in this section overlap those discussed in other sections of this EIR, including the erosion and groundwater quality discussion in Section 4.3, Water Resources.

## 4.4.1 Abstract

Monterey County is located in one of the most seismically active regions in the world. The San Andreas Fault traverses the eastern portion of the County, and many areas therein are susceptible to seismic hazards such as strong ground shaking, liquefaction, and earthquake-induced landslides. In addition, erosion hazards are present in the agricultural areas of the Salinas and Pajaro Valleys. Implementation of the 2007 General Plan would result in development and land use activities on individual lots of record and agricultural areas throughout the County. However, all impacts related to geology, soils, and seismicity would be less than significant with mitigation and compliance with federal, state, and local regulations.

## 4.4.2 Existing Conditions

### 4.4.2.1 Regional Geology

Much of the unique landscape and resources of Monterey County have their origins in the County's geologic history. Monterey County lies within the California Coast Ranges geomorphic and physiographic province, a region dominated by active tectonics astride the margin between the Pacific and North American tectonic plates. Regional tectonic forces generate an estimated relative motion between the North American and Pacific plates of approximately 2 inches per year. Over time, these forces have created the varied mountainous, valley, and fault-bound blocks seen in Monterey County today. Present-day plate motion is dominantly right-lateral strike slip, with a minor component of convergence or compression, especially along the Big Sur coastline. "Right-lateral strike slip motion" refers to a rightward shift along the fault boundary when viewing toward the fault.

One hundred million years ago, motion was dominantly convergent when the Pacific Plate was being subducted beneath the North American Plate. This subducted oceanic crustal material was metamorphosed under high pressure to become the Franciscan Complex, one of the oldest rock types underlying Monterey County. Another even older block of rocks, known as the Salinian block, has been rafted northward along the San Andreas Fault. These rocks originated as marine bed on the continental shelf hundreds of miles to the south of their present location, probably west of the Mojave Desert in southern California. During the Miocene Epoch (5 to 24 million years ago), the Pacific and North American plates shifted the direction of their major movement relative to one another, and instead of a convergent margin, the plate boundary became a transform boundary with lateral movement similar to that occurring along the present-day San Andreas Fault system. Movement along the ancient fault system caused the Salinian rocks to be carried northward—after undergoing folding and intrusion by granitic rocks. Thus, the two major rock types underlying Monterey County, the Salinian and Franciscan, both were created as a result of interaction between the Pacific and North American plates.

Plate motion continues today and is manifested along the County's various fault systems. Two faults considered active with evidence of historic or recent movement are the San Andreas and San Gregorio Faults, which form the eastern and western boundaries of the Salinian block. Tectonic movement in the region has resulted in a variety of active fault types. Uplift along faults is largely responsible for the formation of the Coast Ranges, including the Santa Lucia and Gabilan Ranges. In Monterey County, the uplift that formed the Coast Ranges was much more rapid than in other parts of the state. The dramatic cliffs of the Big Sur Coast and steep slopes of the Santa Lucia Mountains are products of this rapid uplift during the Pliocene epoch, more than a million years ago.

The rapid uplift stimulated by active faulting accelerated other physiographic processes that formed major geologic features evident today. Rapid erosion and deposition of soil from the uplifted mountains formed broad alluvial fans of well-drained, nutrient-rich soil. This process occurred over several tens of millions of years. During the Pleistocene era, the sea level fluctuated repeatedly in response to climate changes that formed glaciers in other parts of the world. As the sea level changed, marine sediments were deposited beneath what later became the floor of the Salinas Valley. The interplay of two fundamentally different depositional processes—the erosion and deposition of alluvial material when the sea level retreated, and the deposition of marine layers when the sea advanced—created a complexity of soils and substrate materials. These processes are responsible for what we now consider the valuable agricultural soils of the Salinas Valley. They also formed the sandy stream terrace deposits along both sides of the Salinas Valley.

The changes in sea level created the 180- and 400-foot aquifers and intervening clay layers that separate them beneath the Salinas Valley. Marine deposits constitute the impermeable clay layer that confines the aquifer in the northern Salinas Valley and is the reason the groundwater table is not recharged from the Salinas River north of Chualar.

It was during this same era of fluctuating sea levels and accelerated erosion that Monterey Canyon was formed. Millions of years ago, when the sea had retreated, streams from the ancestral Gabilan Mountains carved the deep canyon. The sea later returned to submerge the canyon in Monterey Bay. The deep submarine canyon is largely responsible for the extraordinary biodiversity of Monterey Bay. Other submerged features in Monterey Bay are the gravel ledges and rock bars known to fishermen as Italian Ledge and Portuguese Ledge, which are renowned for their abundance of sea life. These features formed as gravel beds and were uplifted by the Monterey Bay Fault zone, which extends from Monterey Bay into upper Carmel Valley.

Uplift resulting from convergence of the Pacific and North America plates has occurred several times in geologic history, but the uplift of the Santa Lucia and Gabilan Mountains to their present position probably occurred during the last 400,000 years. A series of wave-cut, marine terraces around the Monterey Peninsula and south along Highway 1, together with a series of fluvial terraces that flank the Carmel River, record the uplift of the Santa Lucia Range in the last million years.

Active geologic processes are still modifying the land throughout the County. These processes include rivers eroding and depositing sediment, the formation of dunes by wind-borne sand, and landslides in the mountains and hills.

### 4.4.2.2 Seismicity

#### Faulting

Faults form in rocks when stresses overcome the internal strength of the rock, resulting in a fracture. Large faults develop in response to large regional stresses operating over a long time, such as those stresses caused by the relative displacement between the North American and Pacific tectonic plates. According to the elastic rebound theory, these stresses cause strain to build up in the earth’s crust until enough strain has built up to exceed the strength along a fault and cause a brittle failure. The slip between the two stuck plates or coherent blocks generates an earthquake. Following an earthquake, strain will build again until another earthquake. The magnitude of slip is related to the maximum allowable strain that can be built up along a particular fault segment. The greatest buildup in strain due to the largest relative motion between tectonic plates or fault blocks over the longest time will generally produce the largest earthquakes. The distribution of these earthquakes is a study of much interest for both hazard prediction and the study of active deformation of the earth’s crust. Deformation is a complex process and strain due to tectonic forces is not only accommodated through faulting but also through folding, uplift, and subsidence, which can be gradual or in direct response to earthquakes.

Faults are mapped to determine earthquake hazards since they are where earthquakes tend to recur. A historical plane of weakness is more likely to fail under stress and strain than a previously unbroken block of crust. Faults are therefore a prime indicator of past seismic activity, and faults with recent activity are presumed to be the best candidates for future earthquakes. However, since slip is not always accommodated by faults that intersect the surface along traces, and since the orientation of stresses and strains in the crust can shift, predicting the location of future earthquakes is complicated. Earthquakes sometimes occur in areas with previously undetected faults or along faults previously thought inactive.

In California, a system has been developed by the California Geological Survey and U.S. Geological Survey (USGS) to assess the activity of faults. Under this system, faults are classified active if they have ruptured in the last 11,000 years or within the Holocene period. Other faults are considered inactive.

There are several fault maps for Monterey County. The Fault Activity Map of California shows nearly all faults that are considered active, potentially active, or inactive (Exhibit 4.4.1). The Alquist-Priolo Earthquake Fault Zones Maps show faults that are considered active. In Monterey County, all of the mapped onshore active fault traces lie along the main San Andreas Fault. The southeast County is an active earthquake area with a regular cycle of moderately large earthquakes. Five earthquakes of magnitude 6.0 or greater on the Richter scale have occurred on this segment of the fault since 1901. Fortunately, this area has only a small population, with only the small town of Parkfield containing land within the Earthquake Fault Zone (EFZ).

Other onshore faults in Monterey County include the Berwick, Seaside-Chupines, Cypress Point, Gabilan Creek, Garrapata, Harper, Hatton Canyon, Jolon, Nacimiento, Navy-Tularcitos, Palo Colorado, Reliz, Rinconada, Rocky Creek, San Gregorio, Sylvan, Tularcitos, and Zayante-Vergeles. No major earthquakes have occurred on these faults during the past 100 years.

A final class of faults is those mapped offshore. Since these faults are offshore, they are not a risk for causing a land rupture but could cause seismic shaking and possibly trigger a tsunami. A tsunami may be triggered by an underwater landslide in response to seafloor deformation or may occur from the actual fault rupture motion. This component of risk is separate from the risk of a tsunami generated elsewhere around the Pacific Rim from a large earthquake, such as the earthquake that caused the devastating 2004 tsunami in Sumatra, but the impact could be similar.

In Monterey County, two earthquakes have caused recorded tsunami run-up heights that exceeded 1 meter. The 1960 Chilean Earthquake of estimated magnitude 9.5 (largest ever recorded) caused a 1.1-meter run-up-and killed one person, while the slightly smaller but nearer 1964 Alaska earthquake of magnitude 9.2 caused a 1.4-meter run up and significant boat damage at harbors in the Monterey Bay area. According to the State of California Seismic Safety Commission Report released in December 2005, the maximum estimated run-up height in Monterey Bay is 1 to 2 meters, while 2 to 5 meters is anticipated along the Big Sur Coast. Perhaps the most likely source for a significant tsunami exceeding 1 meter in run-up height would be from a rupture along the Cascadia Subduction zone in the Pacific Northwest, which evidence indicates has not had a major rupture since 1700 and could produce an earthquake in the Richter magnitude 9.0 range. Various tsunami-generating scenarios have been examined by the USGS, the California Geologic Survey (CGS), the California Seismic

Safety Commission, and universities—including the University of Southern California Tsunami Research Center. This research is being used to update the current warning system. The Monterey County Office of Emergency Services is currently examining the updated tsunami research, particularly that completed by USGS and the University of Southern California, to establish an effective community notification or alert system for evacuation. This would be implemented in coordination with the West Coast and Alaska tsunami warning system, which is the primary alert system in the region. Targeted study areas are those that lie below 5 and 10 meters above mean sea level, since these are considered most at risk from inundation by a major tsunami.

## Earthquakes

The entire California Coast and Coast Ranges area is prone to earthquakes, including Monterey County. A Richter magnitude 6.0 earthquake that struck near the Town of Parkfield in 2004 caused only minor damage; however, a magnitude 6.5 earthquake near the more populous area of San Simeon in 2003 in neighboring San Luis Obispo County caused major damage to unreinforced masonry structures and killed two people in Paso Robles. Based on history, the probability of such an earthquake occurring in the next few decades that is equal or larger in magnitude in Monterey County is quite likely.

Table 4.4-1 summarizes the year, epicenter, and magnitude of major historical quakes that have affected Monterey County since 1900. Earthquake damage from some of these historical quakes has been significant. The Preliminary Report of the State Earthquake Commission, dated May 31, 1906, described the damage that occurred in Monterey County from the April 1906 San Francisco quake:

> Along the banks of the Salinas River and extending from Salinas to the vicinity of Gonzales, so far as our reports at present show, the bottom lands were more severely ruptured, fissured, and otherwise deformed than in any other portion of the State. The Spreckels Sugar Mill, situated on the banks of the river, suffered more severely probably than any other steel structure in the State.

Other damage from the 1906 earthquake included destruction of the wharf at Moss Landing and destruction of the Hotel Del Monte in Monterey.

**Table 4.4-1.** Major Historical Earthquakes in the Region

| Year | Epicenter | Richter Magnitude at Epicenter |
|---|---|---|
| 1901 | Parkfield | 6.4 |
| 1906 | San Francisco | 8.3 |
| 1922 | Parkfield | 6.3 |
| 1934 | Parkfield | 6.0 |
| 1966 | Parkfield | 6.6 |
| 1983 | Coalinga | 6.5 |
| 1984 | Morgan Hill | 6.1 |
| 1989 | Loma Prieta | 7.1 |
| 2003 | San Simeon | 6.5 |
| 2004 | Parkfield | 6.0 |

Source: U.S. Geological Survey 2006.

While Richter magnitude provides a useful measure of comparison between earthquakes, the Moment magnitude is more widely used for scientific comparison since it accounts for the actual slip that generated the earthquake. Actual damage is due to the propagation of seismic or ground waves from initial failure, and the intensity of shaking is as much related to earthquake magnitude as the condition of underlying materials. Loose materials tend to amplify ground waves, while hard rock can quickly attenuate them, causing little damage to overlying structures. For this reason, the Modified Mercalli Intensity (MMI) Scale provides a useful qualitative assessment of earthquake intensity. The MMI Scale is shown in Table 4.4-2.

## Future Earthquake Probability

Both the USGS and CGS are conducting active research on earthquake probabilities throughout California. While much effort has been focused on the San Francisco Bay Area, there are several active projects in Monterey County, such as the San Andreas Fault Observatory at Depth (SAFOD) project near Parkfield, in the southeastern portion of the County. In 2005, a borehole penetrated to a depth of over 13,000 feet in order to install sensitive monitoring equipment used to record the future pattern and slip from earthquakes at depth.

**Table 4.4-2.** Modified Mercalli Intensity of Earthquakes

| Richter Scale Magnitude | Modified Mercalli Intensity | Effects of Intensity |
|---|---|---|
| 0.1–0.9 | I | Not felt except by a very few under especially favorable circumstances. |
| 1.0–2.9 | II | Felt by only a few persons at rest, especially on upper floors of building. Delicately suspended objects may swing. |
| 3.0–3.9 | III | Felt quite noticeable in doors, especially on upper floors of building, but many people do not recognize it as an earthquake. Standing cars may rock slightly. Vibration like passing a truck. Duration estimated. |
| 4.0–4.5 | IV | During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensations like heavy truck striking building. Standing cars rocked noticeably. |
| 4.6–4.9 | V | Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. |
| 5.0–5.5 | VI | Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of faller plaster and damaged chimneys. Damage slight. |
| 5.6–6.4 | VII | Everyone runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars. |
| 6.5–6.9 | VIII | Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monument walls, and heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving in cars disturbed. |
| 7.0–7.4 | IX | Damage considerable in specially designed structures; well-designed frame strictures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. |
| 7.5–7.9 | X | Some well-built structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Railway lines bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks. |
| 8.0–8.4 | XI | Few, if any masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and landslips in soft ground. Rails bent gently. |
| 8.5 ≤ | XII | Total damage. Waves seen on ground. Lines of sight and level distorted. Objects thrown into the air. |

Source: Abridged from *The Severity of an Earthquake, USGS General Interest Publication.* Available online from the U.S. Geological Service at: http://pubs.usgs.gov/gip/earthq4/severitygip.html (U.S. Government Printing Office Number 1989-288-913).

The most commonly cited document for earthquake planning is the Probabilistic Seismic Hazard Assessment, which addresses the probability of seismic shaking since that is the primary hazard from earthquakes.

Several seismic sources are present in the County, including several that are not considered at risk from fault rupture under the Alquist-Priolo Earthquake Fault Zoning Act (A-P Act). Documented seismic sources are the Rinconada, San Gregorio (Palo Colorado), Monterey Bay-Tularcitos, Hosgri, and San Andreas Faults.

The present analysis of seismic data indicates that the highest-magnitude earthquakes that would generate the strongest seismic shaking are expected to occur on the San Andreas Fault since this has the highest slip rates and rupture lengths. Other faults with high slip and rupture lengths are the southern segment of the San Gregorio and Hosgri Faults. Both the Rinconada and Monterey Bay-Tularcitos Faults have much lower slip rates and are therefore not expected to produce as large an earthquake as the other faults. Evidence indicates that the San Andreas Fault is the dominant seismic source in the region. Based on this assessment, the strongest peak ground accelerations with a 10%probability of being exceeded in 50 years that are greater than 80% of the acceleration due to gravity are along the San Andreas Fault in the Parkfield area. Such ground acceleration would likely generate shaking of a Mercalli Intensity level of at least IX. Peak ground accelerations are predicted to be less elsewhere, with the strongest peak ground accelerations in the more populous North County between Salinas and San Juan Bautista, where peak ground acceleration as high as 70% of gravity is predicted. While these areas are predicted to have the strongest ground shaking, this assessment does not consider the amplification of seismic waves by shallow surface materials, which could be considerable in looser liquefiable materials far from an earthquake. This hazard is addressed separately under the topics of unstable geologic materials, liquefaction, and other secondary seismic hazards.

## 4.4.2.3 Geologic Hazards

Geologic hazards pose a substantial danger to property and human safety, and are present due to the risk of naturally occurring geologic events and processes impacting human development. Therefore, the hazard is influenced by the conditions of human development as much as by the frequency and distribution of major geologic events. From a planning point of view, these hazards are potential constraints on the intended use of the land. By analyzing these constraints, the risks can be assessed and may be mitigated to an acceptable level.

Billions of dollars and hundreds of lives have been lost due to geologic hazards in California, many of which are present in Monterey County. Common geologic hazards present in Monterey County include ground rupture along faults, strong seismic shaking, liquefaction, and slope failure.

## Fault Rupture

Fault rupture is a seismic hazard that affects structures sited above an active fault. The hazard from fault rupture is the movement of the ground surface along a fault during an earthquake. Typically, this movement takes place during the short time of an earthquake but can also occur slowly over many years in a process known as "creep." The only known creeping fault in the County is the part of the San Andreas between San Juan Bautista and Parkfield. Most structures and underground utilities cannot accommodate the surface displacements of several inches to several feet commonly associated with fault rupture or creep.

In response to the severe fault rupture damage of structures by the 1971 San Fernando earthquake, the State of California enacted the Alquist-Priolo Earthquake Fault Zoning Act in 1972. This act required the State Geologist to delineate EFZs along known active faults with a relatively high potential for ground rupture. Faults that are zoned under the A-P Act must meet the strict definition of being sufficiently active and well-defined for inclusion as an EFZ. Properties within EFZs are subject to state regulations that include prohibiting structures for human occupancy being sited within 50 feet of an active fault, requiring geologic reports addressing surface fault hazard, and geologic review of fault reports, among other provisions. Based on fault investigations and evidence of past rupture, the only state-designated EFZs in the County are along the San Andreas Fault.

Ground rupture or cracking outside a mapped active fault trace that is caused from seismic shaking, settlement, or other motion triggered by earthquakes is common. Following the 1989 Loma Prieta earthquake, major ground cracking occurred in the Santa Cruz Mountains, especially along ridgetops; this phenomenon was due to the propagation of seismic waves and probably to differential settlement and lurch cracking.

## Ground Shaking

As previously mentioned, strong ground or seismic shaking is a major hazard in the County. Exhibit 4.4.2 depicts predicted peak seismic shaking intensity throughout the County (shaking in percent gravity = "g"). Monterey County is subject to very strong (0.3–0.6 g) to severe (greater than 0.6 g) shaking from the San Andreas, San Gregorio, and Reliz/Rinconada Faults. The entire County is within Seismic Zone 4, considered the most seismically active zone in the United States based on the 2001 California Building Code (adopted by Monterey County) and the 1997 Uniform Building Code. The severity of ground shaking depends on several variables, such as earthquake magnitude, epicenter distance, local geology, thickness and seismic wave-propagation properties of unconsolidated materials, groundwater conditions, and topographic setting. Consequently, the hazard from ground shaking is most severe in areas near the San Andreas Fault and in the unconsolidated alluvial areas of the County such as the Salinas and Carmel Valleys.

The most common type of damage from ground shaking is structural damage to buildings, which can range from cosmetic stucco cracks to total collapse. The overall level of structural damage from a nearby large earthquake would likely be moderate to heavy, depending on the characteristics of the earthquake, the type of ground, and the condition of the building. Besides damage to buildings, strong ground shaking can cause severe damage by falling objects such as bookcases or water heaters, or broken water or gas pipes. In industrial settings, chemical spills are a serious potential hazard. Fire and explosions resulting from ruptured gas pipes are also major hazards associated with strong ground shaking.

The ability to predict which areas will shake the strongest is vital to building design, emergency management, and analysis of related hazards such as liquefaction and earthquake-induced landslides. Although it is not possible to predict the exact level of shaking at a site, it is feasible to assess what level of ground shaking is likely to occur in a given time period.

The most common level of ground shaking used in designing residential and commercial buildings is the design basis ground motion, which has a seismic shaking level (peak ground acceleration) with a 10% chance of being exceeded in 50 years. Expressed another way, this level of ground motion has a 1 in 475 chance of being exceeded each year. Public schools, hospitals, and essential services buildings are designed to resist the upper-bound earthquake, which has a 10% chance of being exceeded in 100 years or a 1 in 949 chance of being exceeded each year.

## Liquefaction

Liquefaction is a process in which sediments below the water table temporarily lose strength during an earthquake and behave as a viscous liquid rather than a solid. Liquefaction is restricted to certain geologic and hydrologic environments, primarily recently deposited sand and silt in areas with high groundwater levels. The process of liquefaction involves seismic waves passing through saturated granular layers, distorting the granular structure and causing the particles to collapse. This causes the granular layer to behave temporarily as a viscous liquid rather than a solid, resulting in liquefaction.

Liquefaction can cause the soil beneath a structure to lose strength, which may result in the loss of foundation-bearing capacity. This loss of strength commonly causes the structure to settle or tip. Loss of bearing strength can also cause light buildings with basements, buried tanks, and foundation piles to rise buoyantly through the liquefied soil.

Large ground motions resulting from liquefaction, especially lateral spreading, can cause damage to buried pipelines. Most pipe breaks during the Loma Prieta earthquake were in areas with significant thickness of liquefiable soil (greater than 3 feet). Broken pipelines represent a serious public safety issue as demonstrated by burning natural gas lines in the 1994 Northridge earthquake and broken water mains in San Francisco in the 1906 earthquake.

Ground shaking levels that are strong enough to cause liquefaction are present in all of the alluvial basins in Monterey County. Liquefaction potential is shown in Exhibit 4.4.3. Areas in Monterey County most susceptible to liquefaction include the Salinas River and floodplain, the Moss Landing and Elkhorn Slough areas, the Carmel River and floodplain, the San Antonio and Lockwood Valleys, and the Peachtree and Cholame Valleys.

## Slope Instability and Landslides

Landslides are common in Monterey County due to the combination of the rapidly uplifting mountains, locally fractured and weak rocks, and sometimes intense rainfall along the coast. Many ancient landslides formed during the Pliocene or Pleistocene, between 11,000 and 2 million years before the present. Younger landslides formed during the Holocene, or past 11,000 years, are commonly divided into recent or historic deposits and old landslides. Very young landslides have fresh scarps, disrupted drainages, closed depressions, and disturbed vegetation. Older landslides are modified by erosion, resulting in subdued scarps, reestablished vegetation, and new drainage paths. Soils have formed on some older landslide deposits; however, most soils are poorly developed or absent because of high erosion rates and steep slopes.

### Causes of Landslides

There are many causes for landslides, but for geologic hazard evaluation, they can be divided into two main groups: human activity and natural causes. Humans can cause landslides by improperly designing or constructing roads, buildings, and septic systems; excavating the toe of a slope or loading the upper slope; vegetation removal; mining; and human-introduced water sources (lawn watering, leach fields, storm drains, and water lines). Natural causes include steep slopes, weak rock, unfavorably inclined planes of weakness (bedding, joints, and faults), undercutting by streams and waves, intense rainfall, vegetation removal by fire, and earthquakes.

Regardless of whether they are caused by human or by nature, all landslides share some common causes. The first is that slopes become unstable as a result of a decrease in the resisting forces that hold the earth mass in place or an increase in the driving forces that facilitate its movement. The second is that water is a key factor in nearly all landslides because it increases the weight of the soil, thereby increasing the driving forces. Water also acts as a lubricant and serves to decrease the resisting forces. An understanding of water and its effect on slope equilibrium is essential to mitigating landslide hazards.

Most landslides are generated by intense rainfall. Other initiating causes include fires and earthquakes. The temporal pattern of high-intensity, short-duration rainfall is a more important factor in triggering landslides than annual or monthly precipitation totals. Antecedent moisture conditions determine whether large amounts of rainfall will successfully trigger a landslide. If earth materials already contain significant moisture from prior rainfall, the severity of precipitation from a new storm can be less yet can still trigger a landslide. If other factors are equal, magnitude, intensity, and duration of the storm are important factors that can contribute to hillslope instability.

Landslides are one of the most costly geologic hazards to affect the County and are responsible for millions of dollars in damage to houses and roads. As population growth increases, there is increased development pressure to build on unstable slopes. Proper planning can significantly reduce the risks associated with landslides.

### Types of Landslides

Landslides and other forms of slope failure form in response to the long-term geologic cycle of uplift, mass wasting, and disturbance of slopes. Mass wasting refers to a variety of erosional processes from gradual downhill soil creep to mudslides, debris flows, landslides, and rock fall—processes that are commonly triggered by intense precipitation that varies according to climactic shifts. Often various forms of mass wasting are grouped together as “landslides,” the term generally used to describe the downhill movement of rock and soil.

Geologists classify landslides into several different types that reflect differences in the type of material and type of movement. The four most common types of landslides are translational, rotational, earth flow, and rock fall. Debris flows are another common type of landslide that is similar to earth flows, except that the soil and rock particles are coarser. “Mudslide” is a term that appears in non-technical literature to describe a variety of shallow, rapidly moving earth flows. All of these types of landslides are abundant in Monterey County.

Deep-seated rotational and translational slides are common in several types of geologic units, especially in the Franciscan Complex rocks. The Franciscan rocks and associated serpentinite are relatively unstable because of their numerous discontinuities (faults, joints, and shear zones) and tend to fail as multiple, nested landslides. Granitic and metamorphic basement rocks also have rotational slides, although to a lesser degree than the Franciscan rocks. Debris flows may be more common. Coastal terrace deposits are susceptible to shallow-seated rotational slides.

Landslides occur in all the geologic units, but translational slides are most common in the Monterey Formation. The Monterey Formation is especially prone to translational slides along clay beds. Good examples of translational landslides in the Monterey Formation are along Carmel Valley Road near Arroyo Seco, where the beds are inclined in the same direction as the slope and are sliding in what geologists refer to as “dip-slope conditions.” Under these conditions, slip can occur between the beds. This is most common in clay or shale beds where moisture between the beds can cause expansion of highly plastic clays, such as smectite, and form a zone of weakness where downslope shear stress can exceed the strength of the material and trigger a landslide.

Rock falls along road cuts and steep slopes are widespread in the igneous, metamorphic, and volcanic rocks, especially on high ridges and peaks. Many rock falls are a result of failure along closely spaced intersecting discontinuities, especially where undercut by roads or streams. Localized areas of rock fall are present throughout the Arroyo Seco watershed. Rocks deposited on hillslopes are subject to rolling or sliding where fire has removed the groundcover that stabilized them. Rock falls typically occur shortly after periods of intense rainfall and during earthquakes. The risk of earthquake-triggered landslides in the County that was tabulated from various geological data mostly provided by the USGS and CGS is included as Exhibit 4.4.4.

Relative susceptibility to landslides can be described according to the following geologic conditions:

- **Low**: Flatlands and low relief terrain, includes mainly Quaternary deposits. In steep terrain, includes mainly crystalline basement rock, volcanic rock, and Cretaceous sandstone. Approximately 5% of the area is likely to fail in a major earthquake.
- **Moderate**: Moderately steep terrain underlain by mainly unconsolidated and weakly cemented sandstone, shale, and Franciscan Complex. Approximately 15% of the area is likely to fail in a major earthquake.
- **High**: Steep terrain underlain by mainly unconsolidated and weakly cemented sandstone, shale, Franciscan Complex, and existing landslides. Approximately 25% of the area is likely to fail in a major earthquake.

## Land Subsidence

Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials. The principal causes of land subsidence in the region are groundwater mining, which can cause collapse of aquifer sediments and compaction, drainage of organic soils, underground mining, hydrocompaction, and sinkholes. There is little documentation of widespread subsidence in Monterey County.

Aquifer-system compaction (groundwater mining) results from pumping ground water out of the aquifer faster than it is able to recover through recharge. This has caused considerable subsidence—as much as 15 to 25 feet in parts of the Santa Clara and San Joaquin Valleys. It is less common in the Salinas Valley, perhaps due to relatively less diversion of the Salinas River and lower evapotranspiration rates, particularly near the coastal margin. Subsidence can also result from pumping oil and gas, although this is less common than pumping of groundwater. No significant subsidence was reported for the San Ardo oil field or any other oil fields in the County.

There is little evidence of widespread land subsidence from drainage of organic soils, underground mining, or hydrocompaction in Monterey County. Another form of local subsidence is from sinkholes. These most commonly form when the roof of an underground tunnel or cavity collapses. Sometimes when a water main bursts, the ground above will collapse since the subsurface fill was washed out. Sinkholes also occur where rapid runoff erodes subsurface strata above rock or another hard layer and eventually causes the surface soils to collapse. This process is sometimes related to gullying of erosive surface soils or very soft rock.

### 4.4.2.4 Soil Hazards

Soil hazards can be considered a subset of geologic hazards that, due to their complexity, are often considered separately. Soils are directly impacted by land use change and climate patterns since they lie at the surface, where development impacts are concentrated. They are therefore a primary consideration of any geotechnical investigation or soils report for a development. Soil characteristics directly impact land use. Soil ideal for agriculture may not be suitable for building foundations or roadways, while certain erosive or expansive soils are entirely unsuitable to use as engineered fill. Important soil characteristics include the properties related to agricultural and natural habitat resources, as well as those properties related to land development projects. Once site-specific soil properties are known, potential impacts on particular land use projects should be evaluated and necessary mitigations implemented. Improper design for specific soil conditions can cause significant financial losses and can influence the performance and safety of civil works. Similarly, soils often have important agricultural or habitat properties that should be considered in planning decisions. To put the importance of soil characterization in perspective, the State of California has estimated that statewide losses[1] caused by damage from expansive soils from 1970 through 2000 exceeded $150 million and losses from erosion during the same period totaled $565 million.

The complexity of the County's geology is reflected in the 25 major soil associations found in the County. These associations represent hundreds of soil series, which were mapped and analyzed in great detail by the U.S. Department of Agriculture Soil Conservation Service in 1978. The variety of soils is due to the variability of the five major soil-forming factors within the County. These are parent material, climate, topography, biological factors, and time. Coastal soils that formed upon the same parent materials as interior soils may vary widely due to the contrast between the cool and damp maritime climate versus the hot and dry climate of the interior. Common soils associations include the Cieneba-Sur-Junipero (CSJ), Sheridan-McCoy, Santa Lucia Reliz (SLR), Oceano, Garey-Greenfield (OGG), Arnold-Santa Ynez, Shedd (ASS)-Los Osos-Nacimiento (LN) and Lithic Xerothents-Gaviota-Plaskett (LXGP).

The Natural Resources Conservation Service has interpreted the behavior of the soils they mapped under various circumstances and examined their suitability for particular land uses. The soil interpretations most useful for planning and land use decisions are runoff potential; erosion hazard; shrinking and swelling behavior; and suitability for agriculture, shallow excavations, sanitary landfills, septic tank absorption fields, roads and streets, dwellings and small commercial buildings. Soil interpretations for farmlands have particular importance in Monterey County, which contains over 300,000 acres of productive farmlands.

[1] The estimate assumes that agricultural and engineering practices are consistent through the 30-year period.

The classifications used for the farmlands inventory, in order of decreasing productivity, are Prime Farmland, Farmland of Statewide Importance, Unique Farmland, and Farmland of Local Importance. Prime Farmlands occur in scattered acreages throughout the County, but the most extensive acreages occur on the deep, rich soils of the Salinas Valley, sometimes referred to as the "nation's salad bowl." Soil, climate, and a third component—water—combine to help make Monterey County one of the most agriculturally productive areas in the world. Monterey County does not have any designated Farmland of Local Importance.

## Erosion

Erosion can be defined as the wearing away of the land surface by flowing water, waves, or wind, or by such process as mass wasting and corrosion. Erosion not only leads to soil loss but also results in degraded water quality, unwanted soil deposition leading to property damage, and increased danger from flooding. In Monterey County, erosion is a significant force that affects three distinct types of land use: agricultural land, residential development, and coastal bluffs.

Soils can sometimes be quantitatively rated as to their erosion hazard potential. The relative erosion hazard is depicted at a County-wide scale in Exhibit 4.4.5.

### Agricultural Erosion

Soil loss or soil erosion is most common in the North County, especially where strawberries are grown on moderately steep hillsides in the Aromas Sand Formation. Loamy sand soils developed on top of sandy dunes or slopes are highly erosive; moderately steep slopes greater than 15% that would not normally be considered erosive if underlain by more cohesive soil or rock are particularly susceptible to scour from wind or from being washed away through runoff, especially when bare. In the Salinas Valley, erosion and deposition are directly related through flooding, where sediment is picked up in one area, transported, and deposited in another. This includes sediment eroded from stream banks due to scouring flow. There is also general erosion on terrace surfaces and wind erosion of bare soils, especially those with low cohesion that have formed from sandy deposits. Due to grading and terracing on unstable slopes, erosion is sometimes triggered on even moderately steep slopes, especially in unvegetated or unplanted areas. Outside the Salinas Valley, there are wide-open undeveloped areas such as in the South County and Diablo Range. In these areas, a substantial proportion of soil erosion may be attributed to livestock grazing, where soil that is bare from compaction and trampling may concentrate runoff and lead to rilling or gullying of the ground. This problem often can be controlled through careful management of rangeland and avoidance of overgrazing. It is also important to consider the benefits of grazing, such as the reduction of overgrown vegetation that raises the fire hazard.

### Hillside Development Erosion

Erosion is commonly concentrated on steep slopes; therefore, soil disturbance or grading on steep slopes is likely to trigger erosion unless controlled. Common causes of erosion are (1) site grading and disturbance of soil and rock during construction, where runoff and improper drainage can trigger erosion and improper drainage; and (2) post-construction drainage. Problems during construction include gullying across freshly graded slopes that have not been seeded or mulched for the winter, slumping of loose soils, and soils or rock fall over steeply cut banks. Poorly graded roads also may allow water to concentrate, resulting in erosion and deposition; in extreme cases, ruts can channel water, creating washouts that can trigger minor debris flows or landslides. Post-construction erosion is mainly a result of poorly designed and maintained drainage structures such as culverts, pipe down-drains, and ditches. Concentrated runoff may erode soil simply by the large impact force that can be generated from high-velocity flows, while sediment-laden water from turbid runoff often can cause drainageways to become clogged and may trigger further erosion by redirecting flow into areas unable to handle the concentrated runoff.

### Coastal Erosion

Coastal erosion of dunes, cliffs, and bluffs is a serious problem in Monterey County. Coastal erosion of cliffs is concentrated along the Big Sur Coast due to very steep terrain; but there are locally severe erosion problems in the south Monterey Bay area, mainly due to highly erosive windblown sand and particularly in the incorporated and unincorporated areas around Marina, Sand City, Monterey, and Fort Ord. In this area, the coastline is one of low relief, with sand dunes present from the Pajaro River southward to Carmel, and much erosion is due to movement of unstable windblown sand—especially where vegetation has not been established. Much beachfront property is also lost from high surf and wave action that is concentrated during winter storms. This sand may be redistributed along the coast in a process known as long-shore or littoral drift. When sand is depleted or cut off by an obstruction, the result is often severe; with no new sand to reform the beach, a major retreat of the coastline occurs. This problem is forecast to get worse based on some projections of global warming causing the sea level to rise.

In the Marina State Beach area, bluffs and dunes retreated at an average rate of 5 to 7 feet per year from 1937 to 1983. For example, Stilwell Hall at the former Fort Ord Officer’s Club was originally built 300 feet from the beachfront in 1943, but by 2000 was already being threatened by beach waves and has since been demolished. The sewer outfall at Fort Ord also experienced major erosion since construction in 1962, where the beach retreated 175 feet in 21 years. As much as 40 feet of retreat occurred during the storms of 1982 and 1983 when there was an El Niño climatic pattern. Major retreat of the beach has also occurred in the Sand City area, where the beach has retreated 6 to 8 feet per year on average between 1956 and 1975. Some of this is due to sand mining operations.

South of Carmel, the coastline steepens and bluffs are the dominant landform due to the high rates of tectonic uplift. In contrast to the uniformly high erosion rates of the sand dunes along southern Monterey Bay, the erosion rates on the Big Sur Coast differ depending on the type of bedrock, degree of fracturing and weathering, ground water seepage, and exposure to waves. Generally, the granitic and metamorphic rocks are relatively resistant to erosion, except near faults and other areas of intense fracturing and weathering. Some rocks of the Franciscan complex are intrinsically weak and more readily eroded compared to granitic and metamorphic rocks. In addition, several landslides along State Highway 1 are caused by erosion from violent wave action.

The least resistant units to erosion are the coastal terrace deposits. The terrace deposits are typically far enough above sea level that they are not subject to direct wave action. However, they are subject to erosion from surface water and seepage. Because of their relatively porous texture, large quantities of water can infiltrate into terrace deposits. Groundwater is a major influence in cliff erosion. Erosion takes place through a process known as “spring sapping,” in which bluffs are undermined by flowing water loosening rock particles and chemically dissolving the cement that binds the particles. A similar process is “piping,” in which water flows through open channels such as burrows, eroding and enlarging them. Non-natural sources of water such as irrigation, septic effluent, and urban runoff add significant amounts of water that could contribute to sapping and piping. Lawn and garden watering contributes the equivalent of 70 to 80 inches per year of rain and 500 to 800 gallons per day of septic effluent. Under certain hydrogeologic conditions, some of this water could contribute to erosion in the form of mass wasting (or even landslides) by groundwater.

Other influences on coastal erosion include changes in climate. Both short-term events such as El Niño storm cycles and long-term events such as rising sea level will increase erosion rates along the coast. Therefore, structures sited along the coast must account for these extreme events.

## Unstable Geologic Units

Unstable geologic units are those that lack the integrity to support human-made improvements such as buildings and roadways. This may be due to lack of strength, lack of compaction or low density, or unsuitability of material for a particular foundation. Unstable geologic units may also be initially stable and lose stability due to improper drainage or buildup of pore pressure that causes a reduction in strength. Major problems include settlement, lurch cracking, differential settlement, and expansion. Instability is often due to a range of factors that may be difficult to quantify but can be collectively attributed to unstable native materials and unstable fill soils. Unstable geologic units include soft marshy soils that are prone to subsidence, sandy soils with shallow groundwater prone to liquefaction, and friable or poorly indurated rock such as the Monterey Formation or alluvium that can fail on slopes. Particularly unstable are fill soils or debris placed over marshes and wetlands to create new land. This includes a variety of heterogeneous mixtures of loose to very well consolidated gravel, sand, silt, clay, rock fragments, organic matter, and human-made debris.

### Expansive Soils

Expansive soils shrink and swell depending on moisture level as the clay minerals in these soils expand and contract. Soils with moderate or high expansion potential are susceptible to shrinking and swelling due to fluctuations in moisture content and are a common cause of foundation deterioration, pavement damage, cracking of concrete slabs, and shifting of underground utilities. According to the California Building Code, soils with an expansion index exceeding 91 are considered highly expansive; such soils would typically have a liquid limit of 40 or more and plasticity index exceeding 15. These soils are undesirable for use as engineered fill or subgrade directly underneath foundations or pavement, and must be replaced with non-expansive engineered fill or require treatment to mitigate their expansion potential.

## 4.4.2.5 Other Hazards

### Tsunami

Tsunamis are ocean waves caused by large earthquakes and landslides that occur near or under the ocean. When tsunamis approach shore, they behave like a very fast-moving tide that extends far inland. Powerful tsunamis, such as the one that struck Southeast Asia in December 2004, can level structures and result in significant loss of human life. Tsunami waves can persist for many hours because of complex interactions with the coast. The most recent tsunami to strike California occurred in Crescent City in 1964. Currently, efforts are underway to map tsunami inundation zones along the California coast.

### Seiche

Seiches are standing waves set up on rivers, reservoirs, ponds, and lakes when seismic waves from an earthquake pass through the area. Effects of seiches are similar to those of a tsunami.

### Mudflow

A mudflow (used interchangeably with “debris flow” or “lahar”) is a flowing mixture of water-saturated debris that moves downslope under the force of gravity. Mudflows consist of material varying in size from clay to blocks several tens of meters in maximum dimension. When moving, they resemble masses of wet concrete and tend to flow downslope along channels or stream valleys. Mudflows are formed when loose masses of unconsolidated wet debris become unstable.

The major hazard to human life from mudflows is from burial or impact by boulders and other debris. Buildings and other property in the path of a mudflow can be buried, smashed, or carried away. Because of their relatively high density and viscosity, mudflows can move and even carry away vehicles and other objects as large as bridges.

# 4.4.3 Regulatory Framework

## 4.4.3.1 Federal Regulations

### Uniform Building Code

The Uniform Building Code (UBC) defines different regions of the United States and ranks them according to their seismic potential. There are four types of these regions—Seismic Zones 1 through 4, with Zone 1 having the least seismic potential and Zone 4 having the highest. Monterey County is located in Seismic Zone 4; accordingly, any future development would be required to comply with all design standards applicable to Seismic Zone 4.

### Disaster Mitigation Act of 2000

The Federal Disaster Mitigation Act (DMA) of 2000 (Public Law 106-390) emphasizes the need for state, tribal, and local entities to closely coordinate disaster mitigation planning and implementation efforts.

Section 322 of the DMA requires adoption of a state mitigation plan as a condition of disaster assistance, adding incentives for increased coordination and integration of mitigation activities at the state level through the establishment of requirements for two different levels of state plans: standard and enhanced. States that demonstrate an increased commitment to comprehensive mitigation planning and implementation through development of an approved Enhanced State Plan can increase the amount of funding available through the Hazard Mitigation Grant Program (HMGP). Section 322 also establishes a new requirement for local mitigation plans and authorizes up to 7% of HMGP funds available to a state to be used for development of state, tribal, and local mitigation plans.

Provisions of the DMA 2000 include:

- funding for disaster planning and mitigation;
- development of experimental multi-hazard maps to better understand risk;
- establishment of state and local government infrastructure mitigation planning requirements (Advance Infrastructure Mitigation [AIM]);
- defining how states can assume more responsibility in managing the HMGP;
- adjusting ways in which management costs for projects are funded; and

- establishment of performance-based standards for mitigation plans and requiring states to have a program (AIM) to develop County government plans. Should counties fail to develop an infrastructure mitigation plan, their federal share of damage assistance would be reduced from 75 to 25% if there was recurrent damage to the same facility or structure in response to the same type of disaster.

To maintain compliance with DMA 2000 and receive full federal funding, Monterey County and its cities prepared the Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) that was adopted in September 2007 by those jurisdictions. This detailed plan identifies potential natural and man-made hazards, assesses their likely risk, and includes mitigation methods to reduce risks. The potential hazards identified in the MJHMP include coastal erosion, dam failure, earthquake, flood, hazardous materials event, landslide, tsunami, wildland fire, and windstorm. Mitigation measures proposed to address these risks Countyincluded preventative actions, property protection techniques, natural resource protection strategies, structural projects, emergency services, and public information and awareness activities.

## 4.4.3.2 State Regulations

### Alquist-Priolo Earthquake Fault Zoning Act

The primary purpose of the A-P Act is to mitigate the hazard of fault rupture by prohibiting the location of structures for human occupancy across the trace of an active fault. The A-P Act addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards.

The A-P Act requires the State Geologist (Chief of the California Geologic Survey) to delineate EFZs along faults that are sufficiently active and well defined. “Sufficiently active faults” show evidence of Holocene surface displacement along one or more or their segments. “Well-defined faults” are clearly detectable by a trained geologist as a physical feature at or just below the ground surface. The boundary of an EFZ is generally about 500 feet from major active faults, and 200 to 300 feet from well-defined minor faults. The A-P Act dictates that cities and counties withhold development permits for sites within an Alquist-Priolo (A-P) Zone, until geologic investigations demonstrate that the sites are not threatened by surface displacements from future faulting.

A-P Zone mapping has been completed by the State Geologist for all of the quadrangles in Monterey County. The maps have been distributed to all affected cities, counties, and state agencies for their use in developing planning policies and controlling renovation or new construction. Local agencies must regulate most development projects within the A-P Zones. Projects include all land divisions and some structures constructed for human occupancy. While state law exempts single-family wood-frame dwellings and steel-frame dwellings that are less than three stories and are not part of a development of four units or more, local regulations may be more restrictive than state law.

Before a project can be permitted within an identified EFZ, cities and counties require a geologic investigation to demonstrate that proposed buildings would not be constructed across active faults. This requires that a site-specific evaluation and written report prepared by a state-licensed geologist document the occurrence or absence of an active fault. This commonly requires trenching to identify any offset strata but also may be completed through simple observation of surface fault expression. If an active fault is identified, a structure intended for human occupancy cannot be placed over the trace of the fault and must be set back, generally no closer than 50 feet from the fault.

## Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act (SHMA) addresses non-surface fault rupture earthquake hazards, including strong ground shaking, liquefaction, and seismically induced landslides. The CGS is the principal state agency charged with implementing the SHMA. Pursuant to the SHMA, the CGS is directed to provide local governments with seismic hazard zone maps that identify areas susceptible to amplified shaking, liquefaction, earthquake-induced landslides, and other ground failures. The goal is to minimize loss of life and property by identifying and mitigating seismic hazards. The seismic hazard zones delineated by the CGS are referred to as “zones of required investigation.” Site-specific geotechnical hazard investigations are required by SHMA when construction projects fall within these areas. Seismic hazard maps covering Monterey County for both liquefaction risk and earthquake-induced landslides are presented as Exhibits 4.4.3 and 4.4.4.

## California Building Standards Code

Title 24 of the California Code of Regulations, also known as the California Building Standards Code, sets forth minimum requirements for building design and construction. The California Building Standards Code is a compilation of three types of building standards from three different origins:

a) Building standards that have been adopted by state agencies without change from building standards contained in national model codes;

b) Building standards that have been adopted and adapted from the national model code standards to meet California conditions; and

c) Building standards, authorized by the California legislature, constituting extensive additions not covered by the model codes that have been adopted to address particular California concerns.

In the context of earthquake hazards, the California Building Standards Code design standards have a primary objective of ensuring public safety and a secondary goal of minimizing property damage and maintaining function during and following seismic event. Recognizing that the risk of severe seismic ground motion varies from place to place, the California Building Standards Code seismic code provisions vary depending on location (Seismic Zones 0, 1, 2, 3, and 4—with 0 being the least stringent and 4 being the most stringent). Monterey County is located in Seismic Zone 4.

### California Department of Transportation Seismic Safety Retrofit Program

The California Department of Transportation (Caltrans) Seismic Safety Retrofit Program was established by emergency legislation (SB 36X) after the October 17, 1989, Loma Prieta earthquake. The purpose of this program is to evaluate all publicly owned bridges in California and to take actions necessary to prevent their collapse due to earthquakes. The local component of the Seismic Safety Retrofit Program provides funding and other assistance to cities and counties for evaluating bridges and improving their resistance to seismic shaking.

## 4.4.3.3 Local Regulations

### Monterey County Grading and Erosion Control Ordinances

Chapters 16.08 and 16.20 of the Monterey County Code regulate grading and erosion control, respectively. These ordinances supplement the regulations from the California Building Standards Code, which addresses standards for all grading construction. These ordinances help to maintain safe grading conditions and erosion control in order to avoid potentially harmful impacts related to property, the public, and environmental health. Slope failure or bank collapses due to improper grading and erosion of sediment into waterways are two critical hazards.

#### Monterey County Grading Ordinance

The County grading ordinance generally regulates grading involving more than 100 cubic yards of excavation and filling. Minor fills and excavations (cuts) of less than 100 yards that are not intended to provide foundation for structures, or that are very shallow and nearly flat, are typically exempt from the ordinance, as are shallow footings for small structures. Submittal requirements for a County grading permit include site plans, existing and proposed contour changes, an estimate of the volume of earth to be moved, and geotechnical (soils) reports. Projects involving grading activities over 5,000 cubic yards must include detailed plans signed by a state-licensed civil engineer.

Grading is not allowed to obstruct storm drainage or cause siltation of a waterway. All grading requires that temporary and permanent erosion control measures be implemented. Grading within 50 feet of a watercourse, or within 200 feet of a river, is regulated in the Zoning Code Floodplain regulations. Work in the Salinas River and Arroyo Seco River channels is exempted if it is covered by a U.S. Army Corps of Engineers 5-year regional 404 permit, approved by the

California Department of Fish and Game, and approved by the Monterey County Water Resources Agency.

In addition to grading ordinance provisions, the Zoning Code (Chapter 1.64.230) details specific regulations for development on slopes in excess of 30%, including conformance with the grading ordinance and erosion control requirements. Specific geotechnical or engineering geologic investigation requirements include the following:

1) Presentation of data regarding the nature, distribution, and strength of existing soils.
2) Recommended grading procedures and design criteria for corrective measures when necessary, including buttress fills.
3) Examination and recommendations to maintain slope stability.
4) Description of the site geology of the site and the effect of geologic conditions on the proposed development.
5) Incorporation of approved report recommendations in the grading plans and specifications. (Ord. 2535 110, 1979.).
6) Completion of a liquefaction study, where applicable and the potential for liquefaction, should there be:
   a) Shallow ground water at 50 feet (15.24 meters) or less,
   b) Unconsolidated sandy alluvium,
   c) Site within Seismic Zone 4.

Design standards in the ordinance include requirements for fill slopes, cut slopes, and drainage controls.

### Monterey County Erosion Control Ordinance

The County Erosion Control Ordinance generally prohibits development on slopes greater than 30%, requiring completion of an Erosion Control Plan, control of runoff, avoiding creek disturbance, regulating land clearing, and prohibiting grading activities during the winter. Enforcement of the Erosion Control Ordinance is by the County Director of Building Inspection.

## Monterey County Local Coastal Program

The California Coastal Act requires all development within the coastal zone to comply with policies and regulations enacted by the state and the California Coastal Commission (CCC) for the protection of the coast and its resources. Under the Coastal Act, the CCC delegates land use regulation to cities and counties for which a Local Coastal Program (LCP) has been certified. Regulation within the coastal zone is covered under Title 20 of the Monterey County Code, which embodies the Commission-certified Monterey County LCP. Coastal regulations are established by several local coastal land use plans under the LCP.

To carry out the Coastal Act policies relating to coastal hazards, the Monterey County LCP has provisions to address shoreline hazards, steep slopes and unstable areas, wildland fire, and coastal flooding.  The LCP identifies high hazard areas specific to each coastal planning area.  Monterey County's LCP consists of four planning areas:  North County–Coastal, Del Monte Forest, Carmel Area, and Big Sur Coast.

The *North County Land Use Plan* identifies seismic and geologic high hazard areas as:

a) zones ⅛-mile wide on each side of active or potentially active faults;

b) areas of Tsunami Hazard;

c) areas indicated as "Underlain by Recent Alluvium" and "Relatively Unstable Upland Areas" in the County Seismic Safety Element;

d) Geotechnical Evaluation Zones IV, V, and VI on the County Seismic Safety Element maps;

e) Geotechnical Evaluation Zones V and VI on the Monterey Peninsula Map of the County; and

f) the 100-Year Floodplain and areas classified as having a high to extreme fire hazard through application of the California Department of Forestry and Fire Protection criteria.

The Carmel Area Land Use Plan reflects this list except that it also includes existing landslides and adds consideration of the Fire Hazard Severity Scale in determining fire hazards.  The Del Monte Forest Land Use Plan identifies high hazard areas related to seismic and fire risk.  Slopes over 30% in combination with unstable bedrock or soils are noted as potentially hazardous, and the Cypress Point fault (potentially active) and minor faulting in the Pescadero Canyon area are the most significant local hazards.  Most forested areas of the Del Monte Forest are considered high fire hazard areas.  While not specifically identified as a high flood hazard area, the Del Monte Forest Land Use Plan policies address areas subject to potential wave run-up and prohibition of development on bluff faces.  The Big Sur Coast Land Use Plan notes that the entire area presents a high degree of hazards, including seismic, geologic, flood, and fire hazards.

## Monterey County Health and Safety Element

California Planning Law (Government Code Section 65300 et seq.) requires the County to adopt a Safety Element as an integral part of its General Plan.  Safety elements address evacuation routes, traffic congestion, and peak occupant and traffic loads for structures; water supply requirements; and minimum road widths and clearance around structures—as those items relate to identified fire and geologic hazards.  The intent of the state-mandated Safety Element is to ensure that local governments develop the regulatory tools necessary to protect public health, safety, and welfare against disasters and hazards.

The Safety Element is expected to establish objectives and policies that will protect the community from any unreasonable risks associated with the effects of seismically induced surface rupture, ground shaking, ground failure, tsunami, seiche, dam failure, slope instability leading to mudslides and landslides, subsidence, liquefaction, and other seismic and geologic hazards; flooding; and wildland and urban fires.

The current Monterey County Health and Safety Element was updated in 2004 and again in 2006. This element incorporates two of the seven state-mandated General Plan elements—the Safety Element and the Noise Element. The Safety Element is included in the 2007 General Plan update and incorporates the state requirements for contents of both the safety and noise elements.

## 4.4.4 Project Impacts

### 4.4.4.1 Methodology

Widely available industry sources were examined to document regional and local geology. Information regarding regional geology and seismically induced hazards was taken from various sources of the California Department of Conservation, California Geological Survey (CDC, CGS). Information about soil characteristics was derived from the Soil Conservation Service's Soil Survey of Monterey County. In addition, information related to other seismic hazards, such as landslide and liquefaction zoning, was taken from CDC, CGS maps as well as the existing 2006 Monterey County General Plan and General Plan EIR. Where potential geological hazards are identified for a particular planning area within Monterey County, such hazards are expected to affect any potential development in that planning area.

### 4.4.4.2 Thresholds of Significance

Implementation of the 2007 General Plan would result in a potentially significant impact relative to geology, soils, and seismicity if it would:

a) expose persons or structures to geologic hazards such as fault rupture, ground shaking, liquefaction, or landslides;

b) result in substantial soil erosion or loss of topsoil;

c) permit development on unstable geologic units or soils;

d) permit development on expansive soils;

e) permit the use of septic or alternative wastewater systems in areas where soils are incapable of supporting such systems; or

f) expose persons or structures to inundation by tsunami, seiche, or mudflow.

### 4.4.4.3 Impact Analysis

Buildout of the 2007 General Plan to the 2030 and 2092 planning horizons could result in impacts related to the following geologic hazards: fault rupture, ground shaking, liquefaction, landslides, erosion, expansive soils, septic tanks, and tsunami/seiche/mudflow. Adverse impacts on geology, soils, and seismicity associated with implementation of the 2007 General Plan are detailed in this section in the discussions for Impacts GEO-1 through GEO-8. Buildout of the General Plan through 2092 would involve development of all available lots now known (41,000 plus units) based on the dwellings per year from the 2030 AMBAG growth estimate. As geologic impacts are location-oriented and buildout to 2092 proposes growth for the same locations as under the 2030 planning horizon, buildout to 2092 would potentially result in similar adverse impacts on geology, soils, and seismicity as those described in this section for 2030 planning horizon impacts. The 2007 General Plan and Area Plans policies set forth comprehensive measures to avoid and minimize adverse impacts related to geology, soils, and seismicity, to the maximum extent practicable. The 2007 General Plan and Area Plans policies summarized below in this section identify seismically sensitive areas and mitigation measures to reduce impacts related to potential impacts. It is anticipated that building codes, grading ordinances, and seismic measures to reduce the potential for geologic hazards would evolve and become more effective over time.

It should also be noted that one of the expected effects of global climate change is rising sea levels. This would expand inland the coastal areas potentially affected by tsunami. Climate change impacts are addressed in the Climate Change section of this EIR.

#### Fault Rupture

**Impact GEO-1: Implementation of the 2007 General Plan could expose persons and property to fault rupture hazards. (Less-Than-Significant Impact.)**

##### 2030 Planning Horizon

**<u>Impact of Development with Policies</u>**

Implementation of the 2007 General Plan to the 2030 planning horizon would result in new urban and agricultural development in undeveloped areas. As a result, more persons and structures could be exposed to geological hazards such as fault rupture. Fault rupture as a result of seismic shaking would be harmful because it could cause structural failure and collapse of poorly built structures and cause nonstructural building elements to fall. This could result in utility lines (electrical and natural gas) breaking presenting a hazard to occupants and nearby persons, and damage to contents.

Faults considered recently active by the CGS are the San Andreas and Palo Colorado-San Gregorio Fault systems. Since the Palo Colorado-San Gregorio Fault is mapped underneath the Monterey Bay, only the San Andreas Fault has mapped active traces onshore at risk for fault rupture. These fault traces are included in A-P Zones. However, the 2007 General Plan would not result in more persons and structures proximate to the San Andreas fault or its respective A-P Earthquake Fault Zones (refer to Exhibit 4.4.1). Finally, unexpected ground rupture from a previously unmapped active fault is possible but unlikely, due to the considerable mapping and fault research completed throughout the County.

2007 General Plan Policies

The 2007 General Plan and Area Plan policies summarized below set forth comprehensive measures to minimize adverse fault rupture impacts.

***Safety Element***

Safety Element Policies S-1.1, S-1.2, S-1.4, S-1.5, and S-1.8 (consider fault rupture hazards, restrict development in mapped hazard areas, and enforce the A-P Act) direct future growth away from areas of potential fault rupture such as A-P Earthquake Fault Zones for the purpose of avoiding or minimizing geologic hazards. Policies S-1.3, S-1.6, and S-1.7 (establish conditions/standards for geotechnical studies) would help to avoid fault rupture hazard exposure risks in future development by implementing geotechnical study recommendations.

Area Plan Policies

There are no additional Area Plan policies related to fault rupture hazards.

Master Plan Policies

***Fort Ord Master Plan***

Supplemental policies in the Fort Ord Master Plan address fault rupture hazards. Seismic and Geologic Hazards Policies A-1 and A-2 (Countydevelop standards for minimizing seismic risk and use development review process) would help to avoid fault rupture hazard exposure risks with future development by implementing standards and geotechnical study recommendations. Seismic and Geologic Hazards Policy A-3 (Countyidentify areas of high seismic risk) would help to avoid fault rupture hazard by restricting new development in such high seismic risk areas.

**<u>Significance Determination</u>**

Implementation of the 2007 General Plan within the 2030 planning horizon could potentially result in adverse impacts related to fault rupture. However, the 2007 General Plan would not result in more persons and structures proximate to the San Andreas fault or its respective A-P Earthquake Fault Zones, and much of the proposed development within the planning areas near other County faults would be agricultural (wine-industry-related). Risks to agricultural development from ground rupture are minimal compared to risks to denser urban development. Most notably, structures (e.g., winery structures containing wine barrels) would not be permitted within 50 feet of an active fault. In addition to not locating structures or development across a known or suspected active fault trace, a primary mitigation for reducing risk would be requiring that new construction in Monterey County comply with California Building Code (CBC) Zone 4 seismic building criteria standards. These standards are designed to reduce ground rupture risks to acceptable levels, and contain construction requirements to minimize potential loss of life during an earthquake. Development in accordance with the 2007 General Plan, adherence to the A-P Act, and enforcement of the CBC would ensure that impacts related to potential fault rupture would be less than significant.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan policies and Area Plan policies is necessary.

**<u>Significance Conclusion</u>**

Implementation of the 2007 General Plan policies and respective Area Plan policies as well as adherence to CBC standards would reduce impacts related to potential fault rupture to a less-than-significant level.

### Buildout

**<u>Impact of Development with Policies</u>**

Buildout under the 2007 General Plan to 2092 would result in new urban and agricultural development in undeveloped areas beyond 2030 levels. New development could expose more persons and structures to geological hazards such as fault rupture.

<u>2007 General Plan Policies</u>

The 2007 General Plan and Area Plan policies summarized above identify high seismic risk areas and place restrictions on future development in those areas to minimize adverse fault rupture impacts.

**Significance Determination**

Buildout under the 2007 General Plan to 2092 could potentially result in adverse impacts related to fault rupture. However, the 2007 General Plan would not result in more persons and structures proximate to the San Andreas fault or its respective Alquist-Priolo Earthquake Fault Zones. Nonetheless, new structures would not be permitted within 50 feet of an active fault, and new construction throughout the County would comply with CBC Zone 4 seismic building criteria standards that are designed to reduce ground rupture risks to acceptable levels. Development in accordance with the 2007 General Plan, adherence to the Alquist-Priolo Act, and enforcement of the CBC would ensure that impacts related to potential fault rupture would be less than significant.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan policies and Area Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan policies and respective Area Plan policies as well as adherence to the Alquist-Priolo Act and CBC standards would reduce impacts related to potential fault rupture to a less-than-significant level.

## Ground Shaking

**Impact GEO-2: Land uses and development consistent with the 2007 General Plan could expose people or structures to substantial adverse seismic effects, including the risk of loss, injury, or death involving strong seismic ground shaking. (Less-Than-Significant Impact.)**

### 2030 Planning Horizon

**Impact of Development with Policies**

Implementation of the 2007 General Plan within the 2030 planning horizon would result in new urban and agricultural development in undeveloped areas. As a result, more persons and structures would be exposed to geological hazards such as ground shaking. Strong seismic ground shaking can be harmful, because it could cause structural failure and collapse of poorly built structures and could cause nonstructural building elements to fall, presenting a hazard to occupants and damage to contents.

Specifically, the 2007 General Plan would result in more persons and structures in and near areas of high probability for strong ground shaking in Pajaro and areas of high probability for moderate ground shaking throughout the Salinas Valley stretching from Castroville to Bradley (refer to Exhibit 4.4.2). While strong ground shaking is *probable* in these areas, it is *possible* throughout the County from several seismic sources.

2007 General Plan Policies

The 2007 General Plan policies summarized below establish comprehensive measures to minimize adverse ground shaking impacts.

***Safety Element***

Safety Element Policies S-1.1, S-1.2, S-1.5, and S-1.8 (restrict siting of land uses in identified hazard areas and limit approval of development that does not consider geologic hazards) direct future growth away from areas of high seismic ground shaking for the purpose of avoiding or minimizing geologic hazards. Policies S-1.3 and S-1.7 (establish conditions/standards for geotechnical studies) would help to avoid ground shaking hazard exposure risks with future development through implementation of geotechnical study recommendations.

Area Plan Policies

There are no additional Area Plan policies related to ground shaking hazards.

**Significance Determination**

Implementation of the 2007 General Plan within the 2030 planning horizon could potentially result in adverse impacts related to ground shaking. The majority of new development proposed under the 2007 General Plan would not occur in areas of high probability for strong seismic ground shaking; rather, much of the proposed planning area development would be in areas of high probability for moderate ground shaking, mostly agricultural (wine-industry-related). Risks to agricultural development from ground shaking are minimal compared to risks to denser urban development. Nonetheless, primary mitigation for reducing risk would require new construction (including winery structures containing wine barrels) in Monterey County to comply with CBC Zone 4 seismic building criteria standards. These are designed to reduce ground shaking risks to acceptable levels by making new structures more resistant to seismic shaking damage, and they contain construction requirements that minimize the potential loss of life from an earthquake. Development in accordance with the 2007 General Plan and enforcement of the CBC would ensure that impacts related to potential ground shaking would be less than significant.

### Mitigation Measures

No mitigation beyond the 2007 General Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan policies as well as adherence to CBC standards would reduce impacts related to potential ground shaking to a less-than-significant level.

### Buildout

**Impact of Development with Policies**

Buildout under the 2007 General Plan to 2092 would result in new urban and agricultural development in undeveloped areas beyond 2030 levels. New development could expose more persons and structures to geological hazards such as seismic ground shaking.

2007 General Plan Policies

The 2007 General Plan policies summarized above identify high seismic risk areas and place restrictions on future development in those areas to minimize adverse seismic ground shaking impacts.

**Significance Determination**

Buildout under the 2007 General Plan to 2092 could potentially result in adverse impacts related to fault rupture. The 2007 General Plan would result in more persons and structures in areas of high probability for strong and moderate ground shaking. However, new construction throughout the County will comply with CBC Zone 4 seismic building criteria standards that are designed to reduce ground shaking risks to acceptable levels. Development in accordance with the 2007 General Plan and enforcement of the CBC would ensure that impacts related to potential ground shaking would be less than significant.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan policies as well as adherence to CBC standards would reduce impacts related to potential fault rupture to a less-than-significant level.

## Liquefaction

**Impact GEO-3: Land uses and development consistent with the 2007 General Plan could expose property and structures to the damaging effects of ground subsidence hazards. This kind of geologic hazard**

**can be seismically triggered (e.g., liquefaction), caused by seasonal saturation of the soils and rock materials, or related to grading activities. (Less-Than-Significant Impact.)**

### 2030 Planning Horizon

**Impact of Development with Policies**

Implementation of the 2007 General Plan within the 2030 planning horizon would result in new urban and agricultural development in undeveloped areas. As a result, more persons and structures would be exposed to geological hazards such as liquefaction and ground subsidence. Liquefaction would be harmful because it could cause collapse or overturning of structures, collapse of pavements, and in some cases lateral spreading.

The 2007 General Plan would result in more persons and structures in areas of shallow groundwater in the Salinas River floodplain and near Elkhorn Slough, which have moderate to high susceptibility to liquefaction hazards. Thus, liquefaction could be of concern in the Community Plan Areas of Castroville, Chualar, and Pajaro; and in the Rural Centers of Bradley, Lockwood, Pine Canyon (King City), San Lucas, and San Ardo (refer to Exhibit 4.4.3).

2007 General Plan Policies

The 2007 General Plan policies summarized below set forth comprehensive measures to minimize adverse liquefaction impacts.

***Safety Element***

Safety Element Policies S-1.1, S-1.2, S-1.5, S-1.6, and S-1.8 (restrict siting of land uses in identified hazard areas and limit approval of development that does not consider geologic hazards) direct future growth away from areas of high liquefaction risk for the purpose of avoiding or minimizing geologic hazards. Policies S-1.3 and S-1.7 (establish conditions/standards for geotechnical studies) would help to avoid liquefaction hazard exposure risks with future development through implementation of geotechnical study recommendations.

Area Plan Policies

There are no supplemental Area Plan policies that address liquefaction.

**Significance Determination**

Implementation of the 2007 General Plan within the 2030 planning horizon could potentially result in adverse impacts related to liquefaction. However, no new structures would be permitted without development of a site-specific geotechnical report and adherence to the recommendations outlined therein for development on soils of potential liquefaction and subsidence. Specifically, Chapter 16.08 of the Monterey County Code requires that grading permit applications include soils engineering and engineering geology reports that provide "recommendations for grading procedures and design criteria for corrective measures when necessary, and opinions and recommendations covering adequacy of sites to be developed by the proposed grading" (Section 16.08.110). Standard geotechnical engineering procedures and soil testing, proper design, and quality control over construction can identify and mitigate liquefiable soils during site development. Modern soil engineering practices have improved substantially due to increased knowledge of soil types, their strengths, and groundwater conditions, as well as through the proper design and construction of fills and foundations. By using the best, most up-to-date standards, potential hazards related to subsidence and settlement damage—including liquefaction—can be reduced to levels that are generally considered acceptable. Thus, this requirement will identify problem soils and require mitigation when they are present. In addition, all new development would be built to CBC Zone 4 seismic building criteria standards, designed to reduce liquefaction risks to acceptable levels.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan policies, adherence to the CBC standards, and enforcement of the Monterey County Grading Ordinance would reduce impacts associated with liquefaction to a less-than-significant level.

### Buildout

**Impact of Development with Policies**

Buildout under the 2007 General Plan to 2092 would result in new urban and agricultural development in undeveloped areas beyond 2030 levels. New development could expose more persons and structures to geological hazards such as liquefaction.

2007 General Plan Policies

The 2007 General Plan policies summarized above identify high seismic risk areas and place restrictions on future development in those areas to minimize adverse liquefaction impacts.

**Significance Determination**

Buildout under the 2007 General Plan to 2092 could potentially result in adverse impacts related to liquefaction. The 2007 General Plan would result in more persons and structures in areas of high and moderate probability for liquefaction. However, new construction throughout the County will comply with CBC Zone 4 seismic building criteria standards that are designed to reduce liquefaction risks to acceptable levels. Development in accordance with the 2007 General Plan and enforcement of the CBC would ensure that impacts related to potential liquefaction would be less than significant.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan policies as well as adherence to the Monterey County Grading Ordinance and CBC standards would reduce impacts related to potential liquefaction to a less-than-significant level.

## Slope Instability and Landslides

**Impact GEO-4: Land uses and development consistent with the 2007 General Plan could expose people and structures to substantial damaging effects of landslides, including the risk of loss, injury, or death from downslope earth movement that may be slow or rapidly occurring. This kind of geologic hazard is commonly caused by earthquakes, seasonal saturation of soils and rock, erosion, or grading activities. (Less-Than-Significant Impact.)**

### 2030 Planning Horizon

**Impact of Development with Policies**

Implementation of the 2007 General Plan within the 2030 planning horizon would result in new urban and agricultural development in undeveloped areas. As a result, more persons and structures could be exposed to geological hazards such as downslope earth movement if new development was located on or near slopes. Landslides resulting in earth and debris flow could result in structural damage or complete loss of structures, as well as injuries or death to persons.

According to the 2007 General Plan, development would be predominantly located in areas of flat relief where there is little or no risk of slope instability. However, there is some proposed residential and agricultural development in and near hilly areas that could be susceptible to landslides, particularly in the Rural Centers of Bradley, Lockwood, Pleyto, and Pine Canyon (King City) (refer to Exhibit 4.4.4).

2007 General Plan Policies

The 2007 General Plan and Area Plan policies summarized below set forth comprehensive measures to minimize slope instability and landslide impacts.

***Safety Element***

Safety Element Policies S-1.1, S-1.2, S-1.5, S-1.6, and S-1.8 (restrict siting of land uses in identified hazard areas and limit approval of development that does not consider geologic hazards) direct future growth away from areas of high landslide risk for the purpose of avoiding or minimizing geologic hazards. Policies S-1.3 and S-1.7 (establish conditions/standards for geotechnical studies) would help to avoid landslide hazard exposure risks with future development through implementation of geotechnical study recommendations.

***Conservation and Open Space Element***

Conservation and Open Space Element Policies OS-1.3 through OS-1.6 restrict ridgeline development. These policies would reduce the potential for slope instability resulting from construction and the risks to homes and persons that would otherwise be built on ridgelines.

Area Plan Policies

The following supplemental policies in the Area Plans address potential impacts from unstable slopes and landslides.

***North County Area Plan***

Policy NC-1.3 (encourage preservation of large acreages in higher elevations and on steeper slopes) would help to avoid landslide hazard exposure risks with future development by directing larger swaths of growth to occur at lower elevations and on flatter terrain.

***Greater Salinas Area Plan***

Policy GS-3.1 (promote preservation of land exceeding 25% slope) would help to avoid landslide hazard exposure risks with future development by directing growth away from areas with greater than 25% slope.

***Greater Monterey Peninsula Area Plan***

Policy GMP-4.1 (encourage preservation of redwood forest and chaparral habitat exceeding 25% slope) would help to avoid landslide hazard exposure risks with future development by directing growth away from areas with greater than 25% slope.

***Carmel Valley Master Plan***

Policy CV-3.4 (promote sensitive siting and landscaping on hillsides and natural landforms altered by cutting, filling, grading, or vegetation removal) would help to avoid landslide hazard exposure risks with future development by directing careful growth on altered landforms and hillsides.

***Toro Area Plan***

Policy T-3.6 (encourage preservation of large acreages in higher elevations and on steeper slopes) would help to avoid landslide hazard exposure risks with future development by directing larger swaths of growth to occur at lower elevations and on flatter terrain.

***Cachagua Area Plan***

Policy CACH-3.2 (promote sensitive siting and landscaping on hillsides and natural landforms altered by cutting, filling, grading, or vegetation removal) would help to avoid landslide hazard exposure risks with future development by directing careful growth on altered landforms and hillsides.

**Significance Determination**

Implementation of the 2007 General Plan within the 2030 planning horizon could potentially result in adverse impacts related to landslides. However, no new structures would be permitted without development of a site-specific geotechnical report and adherence to the recommendations therein for development in areas susceptible to landslide. Specifically, Chapter 16.12 of the Monterey County Code (which comprises the County's Erosion Control Ordinance) prohibits construction activities that would lead to soil erosion or that would result in a permanent change to existing site on slopes greater than or equal to 25% (greater than 25% for development in the North County Land Use Plan) with exceptions being made only for special circumstances (Section 16.12.040). Section 21.66.010 of the Monterey County Code requires a conditional use permit for any development proposed on ridgelines. In addition, all new development would be built to CBC Zone 4 seismic building criteria standards, designed to reduce landslide risks to acceptable levels.

### Mitigation Measures

No mitigation beyond the 2007 General Plan and Area Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan policies and respective Area Plan policies in addition to enforcement of the Monterey County Erosion Control Ordinance and the CBC would ensure that potential impacts related to slope instability and landslides would be less than significant.

### Buildout

**Impact of Development with Policies**

Buildout under the 2007 General Plan to 2092 would result in new urban and agricultural development in undeveloped areas beyond 2030 levels. New development could expose more persons and structures to geological hazards such as landslides.

2007 General Plan Policies

The 2007 General Plan policies summarized above identify landslide susceptibility areas and place restrictions on future development in those areas to minimize adverse downward earth movement impacts.

**Significance Determination**

Buildout under the 2007 General Plan to 2092 could potentially result in adverse impacts related to landslides. The 2007 General Plan would result in more persons and structures in areas susceptible to landslide. However, new construction throughout the County will comply with CBC Zone 4 seismic building criteria standards designed to reduce slope stability and landslide risks to acceptable levels. Development in accordance with the 2007 General Plan and enforcement of the CBC would ensure that impacts related to potential landsliding would be less than significant.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan policies as well as adherence to the Monterey County Grading Ordinance and CBC standards would reduce impacts related to potential landslides to a less-than-significant level.

## Soil Erosion Hazards

**Impact GEO-5: Erosion from activities and land uses consistent with the 2007 General Plan could result in erosion hazards. (Less-Than-Significant Impact with Mitigation.)**

### 2030 Planning Horizon

#### Impact of Development with Policies

Implementation of the 2007 General Plan within the 2030 planning horizon would result in new urban and agricultural development in undeveloped areas. As a result, more persons and structures could be exposed to geological hazards such as erosion. Erosion results in the loss of topsoil that may reduce yield of crops or forage and cause sedimentation (siltation) problems downstream. Extreme cases of erosion can lead to landslides.

The 2007 General Plan would result in more persons and structures in areas of potential erosion hazard in the hilly and mountainous areas of Fort Ord/East Garrison and Pine Canyon (King City) Community Plan Areas and the Lockwood Rural Center (refer to Exhibit 4.4.5). In addition, agricultural development could occur on the uncultivated slopes in the Salinas Valley (particularly in portions of the Central/Arroyo Seco/River Road Segment and Jolon Road Segment Wine Corridors) that could put persons and winery structures in areas of potential erosion hazards.

2007 General Plan Policies

The 2007 General Plan and Area Plan policies summarized below set forth comprehensive measures to minimize adverse erosion impacts.

***Conservation and Open Space Element***

Conservation and Open Space Element Policies OS-3.1, OS-3.2, and OS-3.5 (require Best Management Practices be implemented and encourage continuance of federal, state, and local erosion control programs) would help to control erosion with future development through compliance with best management practices and all levels of government regulation regarding erosion prevention practices. Policies OS-3.3 and OS-3.7 (establish criteria for erosion-related surveys and promote preparation of watershed plans for state-designated impaired waterways) would help to avoid erosion risks with future development through implementation of erosion-related survey and watershed plan recommendations. Policies OS-3.4 and OS-3.6 (map areas of steep slopes and establish criteria for residential development in such areas) direct future growth away from areas of steep slopes for the purpose of avoiding or minimizing erosion hazards. Policy OS-3.5 (sets forth requirements for a ministerial permitting system for existing lots of record) would help to avoid erosion hazards with future development through implementation of ministerial permit erosion control standards.

***Agriculture Element***

Agriculture Element Policy AG-5.1 (promote soil conservation programs) would help to avoid erosion hazard exposure risks with future development through implementation of soil conservation program measures that reduce soil erosion and increase soil productivity. Policy AG-5.4 (encourage policies and programs to protect and enhance surface water and groundwater resources) would help to avoid erosion hazard exposure risk with future development through compliance with policies and programs that limit sedimentation of surface and groundwater resources.

***Safety Element***

Safety Element Policies S-1.1, S-1.2, S-1.5, S-1.6, and S-1.8 (restrict siting of land uses in identified hazard areas and limit approval of development that does not consider geologic hazards) direct future growth away from areas of high erosion risk for the purpose of avoiding or minimizing geologic hazards. Policies S-1.3 and S-1.7 (establish conditions/standards for geotechnical studies) would help to avoid erosion hazard exposure risks with future development through implementation of geotechnical study recommendations. In addition, Policy S-1.9 (prepare erosion control plan measures to reduce moderate and high erosion hazards) would help to avoid erosion hazard exposure risks with future development through implementation of erosion control plan recommendations that would be put forth by a California-licensed civil engineer or a California-licensed landscape architect.

<u>Area Plan Policies</u>

The following supplemental policies in the Area Plans address potential erosion impacts.

***North County Area Plan***

Policy NC-1.3 (encourage preservation of large acreages in higher elevations and on steeper slopes) would help to avoid erosion hazard exposure risks with future development by directing larger swaths of growth to occur at lower elevations and on flatter terrain. Policy NC-5.3 (encourage conjoint soil, water, and resource protection programs) would help to avoid or minimize erosion with future development through participation in cooperative soil conservation, water quality protection, and resource restoration programs with neighboring jurisdictions.

***Central Salinas Valley Area Plan***

Central Salinas Area Plan Policy CSV-5.2 (prohibit new recreation and visitor-serving commercial uses that would produce runoff) would direct growth of runoff producing land uses away from areas that would result in erosion. Policy GS-3.1 (promote preservation of land exceeding 25% slope) would help to avoid erosion hazard exposure risks with future development by directing growth away from areas with greater than 25% slope.

***Greater Monterey Peninsula Area Plan***

Policy GMP-4.1 (encourage preservation of redwood forest and chaparral habitat exceeding 25% slope) would help to avoid erosion hazard exposure risks with future development by directing growth away from areas with greater than 25% slope.

***Carmel Valley Master Plan***

Policy CV-3.4 (promote sensitive siting and landscaping on hillsides and natural landforms altered by cutting, filling, grading, or vegetation removal) would help to avoid erosion hazard exposure risks with future development by directing careful growth on altered landforms and hillsides. Policies CV-3.8 and CV-3.9 (require retention of riparian vegetation and willow cover along the Carmel River) would help to avoid erosion along the Carmel River with future development through plantings along the river banks. Policy CV-4.1 also establishes specific standards to reduce erosion and runoff potential associated with future development.

***Toro Area Plan***

Policy T-3.6 (encourage preservation of large acreages in higher elevations and on steeper slopes) would help to avoid erosion hazard exposure risks with future development by directing larger swaths of growth to occur at lower elevations and on flatter terrain. Policy T-4.1 (prohibit practices that contribute to siltation and flooding of Toro Creek) would help to avoid erosion into and sedimentation of Toro Creek with future development.

***Cachagua Area Plan***

Policy CACH-3.2 (promote sensitive siting and landscaping on hillsides and natural landforms altered by cutting, filling, grading, or vegetation removal) would help to avoid erosion hazard exposure risks with future development by directing careful growth on altered landforms and hillsides.

***South County Area Plan***

Policy SC-5.2 (encourage conjoint soil, water, and resource protection programs) would help to avoid or minimize erosion with future development through participation in cooperative soil conservation, water quality protection, and resource restoration programs with neighboring jurisdictions.

<u>Master Plan Policies</u>

***Fort Ord Master Plan***

Fort Ord Master Plan Soils and Geology Policies A-2, A-3, and A-4 (prepare and monitor erosion control plans that meet requirements of a Stormwater Pollution Prevention Plan) would help to avoid or minimize erosion with future development through implementation and monitoring of Stormwater Pollution Prevention Plan erosion control requirements.

***Significance Determination***

Implementation of the 2007 General Plan within the 2030 planning horizon could potentially result in adverse impacts related to erosion. Accelerated erosion is a widespread impact that may be reduced but not entirely eliminated in areas of moderate to steep topography in Monterey County. Causes include vegetation removal, improper farming practices, grading for roadways and construction, and improper diversion and discharge of water. However, no new structures would be permitted on slopes greater than 25 to 30%, with limited, mitigated exceptions. Specifically, the County Erosion Control Ordinance (Chapter 16.12 of the County Code) prohibits development on slopes greater than 30%, requires implementation of an Erosion Control Plan, regulates the control of runoff, requires that creek disturbance be avoided, regulates land clearing, and prohibits grading activities during winter.

Implementation of the AWCP could induce property owners to change crop cover to vineyards or to plant vineyards on uncultivated slopes, thereby increasing the potential for soil erosion. The potential for soil erosion is particularly acute if property owners cultivate slopes so that rows are parallel to the slope gradient. However, an agricultural permit process would need to be established prior to allowing any conversion of slopes greater than 25% to agricultural lands.

The NPDES program governs water quality, including discharge of sediments into navigable water bodies. In Monterey County, the Central Coast RWQCB is charged with enforcing NPDES requirements, including runoff management programs that include

Best Management Practices to control erosion and sedimentation. Future development proposed in the 2007 General Plan would be required to apply and comply with Central Coast RWQCB NPDES erosion control permits. Phase I of the permit process would cover sites with construction disturbance greater than 1 acre, which includes most residential subdivisions and commercial developments. In addition, Phase II of the permit process would cover sites with construction disturbance less than 1 acre. Thus, 2007 General Plan implementation projects of all sizes would be covered by some phase of NPDES permit.

General Plan implementation activities would be subject to federal, state, and local erosion control programs, as well as the policies of the 2007 General Plan and Area Plans. In addition, by incorporating modern erosion control practices such as the use of biotechnical bank stabilization and geotextile fabrics to hold soil in place as well as various types of planting, soil erosion on most disturbed slopes can be greatly reduced. However, the development and implementation of erosion control measures on steep slopes and areas of highly erodible soils can be challenging and often are only partially successful, and high erosion hazards are widespread throughout the County. Therefore, the potential remains for significant erosion hazards to occur from development on individual lots of record and new hillside agricultural cultivation projects. The 2007 General Plan policies and the existing federal, state, and local erosion control requirements do not adequately mitigate this potentially significant impact to a less-than-significant level. Mitigation Measure BIO-2.1 (see Section 4.9, Biological Resources) would reduce the significance of this impact.

### Mitigation Measures

**BIO-2.1:** Stream Setback Ordinance.

No additional mitigation beyond the General Plan and Area Plan goals and policies is necessary.

**Significance Conclusion**

Mitigation Measure BIO-2.1 would reduce this potentially significant impact to a less-than-significant level by restricting development near streams and thereby reducing the risk for construction and other activities related to development to cause bank failure or erosion. This measure also ensures that erosion from other activities will not directly flow into creeks and streams. Thus, with compliance with 2007 General Plan and respective Area Plans policies; adherence to federal, state, and local erosion control regulations (i.e., County Grading Ordinance and NPDES program); implementation of the 2007 General Plan would result in a less-than-significant impact related to erosion hazards.

## Buildout

**Impact of Development with Policies**

Buildout under the 2007 General Plan to 2092 would result in new urban and agricultural development in undeveloped areas beyond 2030 levels. New development could expose more persons and structures to geological hazards such as erosion.

2007 General Plan Policies

The 2007 General Plan policies summarized above identify erosion susceptibility areas and place restrictions on future development in those areas to minimize adverse erosion impacts.

**Significance Determination**

Buildout under the 2007 General Plan to 2092 could potentially result in adverse impacts related to erosion. The 2007 General Plan would result in more persons and structures in areas susceptible to erosion. General Plan implementation activities would be subject to federal, state, and local erosion control programs, as well as the policies of the 2007 General Plan and Area Plans. However the potential remains for significant erosion hazards to occur from development on individual lots of record and new hillside agricultural cultivation projects. The 2007 General Plan policies and the existing federal, state, and local erosion control requirements do not adequately mitigate this potentially significant impact to a less-than-significant level. Mitigation Measure BIO-2.1 (see Section 4.9, Biological Resources) would be in place to reduce the significance of this impact.

### Mitigation Measures

**BIO-2.1:** Stream Setback Ordinance.

No additional mitigation beyond the General Plan and Area Plan goals and policies is necessary.

**Significance Conclusion**

Mitigation Measure BIO2.1 would reduce this potentially significant impact to a less-than-significant level. Thus, with compliance with 2007 General Plan and respective Area Plan and Area Plan policies; adherence to federal, state, and local erosion control regulations (i.e., County Grading Ordinance and NPDES program, buildout of the 2007 General Plan would result in a less-than significant impact related to erosion hazards.

## Expansive Soils and Unstable Geologic Units

**Impact GEO-6: Land uses and development consistent with the 2007 General Plan could expose property improvements to potential adverse effects from expansive soils. Expansive soils can damage improvements, especially structures such as residential buildings, small commercial buildings, and pavements. (Less-Than-Significant Impact.)**

### 2030 Planning Horizon

**Impact of Development with Policies**

Implementation of the 2007 General Plan within the 2030 planning horizon would result in new urban and agricultural development in undeveloped areas. As a result, more persons and structures would be exposed to geological hazards such as the effects from expansive soils. Newly constructed buildings, pavements, and utilities could be damaged by differential settlement due to soil expansion and contraction. Movements may cause foundations to crack, various structural portions of the building to be distorted, and doors and windows to warp so that they do not function properly. Utilities also may be affected. These variations in ground settlement may ultimately lead to structural failure and damage to infrastructure.

Soil surveys provide general information about soils in an area. They are available from the Natural Resources Conservation Service, U.S. Department of Agriculture. However, maps provide only generalized locations. Only geotechnical tests can determine the existence of and corresponding swell potential of expansive soils at a site and, thus, the probability for structural damage.

2007 General Plan Policies

The 2007 General Plan policies summarized below set forth comprehensive measures to minimize adverse expansive soil and unstable geologic unit impacts.

***Safety Element***

Safety Element Policies S-1.1, S-1.2, S-1.5, and S-1.8 (restrict siting of land uses in identified hazard areas and limit approval of development that does not consider geologic hazards) direct future growth away from areas of expansive soil risk for the purpose of avoiding or minimizing geologic hazards. Policies S-1.3 and S-1.7 (establish conditions/standards for geotechnical studies) would help to avoid unstable geologic unit and expansive soil hazard exposure risks with future development through implementation of geotechnical study recommendations.

Area Plan Policies

No supplemental Area Plan policies address expansive soils or unstable geologic units.

**Significance Determination**

New development in accordance with the 2007 General Plan could result in construction activities overlying expansive or unstable soils. However, no new structures would be permitted without development of a site-specific soil sampling and laboratory soils testing report and adherence to the recommendations outlined therein, such as the proper subsoil preparation, drainage, and foundation design for constructing on more unstable soils. Procedures used in expansive soils testing are found in the 2001 CBC, adopted by Monterey County. According to the CBC, foundations for structures resting on soil with an expansion index greater than 20 require special design consideration. In addition, the Monterey County Grading Ordinance (Chapter 16.08 of the County Code) requires special treatment for grading sites with difficult soils. These limit the potential for development to occur without design features to mitigate the risk.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan policies is necessary.

**Significance Conclusion**

Implementation of 2007 General Plan policies as well as enforcement of the CBC would reduce potential expansive soil impacts. CBC requirements ensure that design and construction conform to recommendations from a geotechnical or soils investigation. This includes procedures for handling expansive soils through such techniques as replacement of expansive soils with non-expansive engineered fill, lime treatment, moisture conditioning, and other techniques. Consequently, potential expansive soil impacts would be less than significant.

### Buildout

**Impact of Development with Policies**

Buildout under the 2007 General Plan to 2092 would result in new urban and agricultural development in undeveloped areas beyond 2030 levels. New development could expose more persons and structures to geological hazards such as expansive soils.

<u>2007 General Plan Policies</u>

The 2007 General Plan policies summarized above identify high seismic risk areas and place restrictions on future development in those areas to minimize adverse expansive soil impacts.

**<u>Significance Determination</u>**

Buildout under the 2007 General Plan to 2092 could potentially result in adverse impacts related to expansive soils. The 2007 General Plan could result in more persons and structures in areas of expansive soils. However, new construction throughout the County will comply with CBC Zone 4 seismic building criteria standards designed to reduce expansive soil and unstable geologic unit risks to acceptable levels. Development in accordance with the 2007 General Plan and enforcement of the CBC would ensure that impacts related to potential expansive soils would be less than significant.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan policies is necessary.

**<u>Significance Conclusion</u>**

Implementation of the 2007 General Plan policies as well as adherence to CBC standards would reduce impacts related to potential expansive soils to a less-than-significant level.

## Septic Systems and Alternative Wastewater Systems

**Impact GEO-7: Construction of septic tanks or alternative wastewater disposal systems on soils incapable of adequately supporting such systems could damage improvements and adversely affect groundwater resources. (Less-Than-Significant Impact.)**

### 2030 Planning Horizon

**<u>Impact of Development with Policies</u>**

Implementation of the 2007 General Plan to the 2030 planning horizon would result in new urban and agricultural development in undeveloped areas. As a result, more persons and structures would be exposed to hazards related to construction of septic tanks on soils incapable or adequately supporting such systems. This may result in contaminated surface water or groundwater.

Septic tanks could be associated with development in the Salinas Valley, particularly within the Central/Arroyo Seco/River Road Segment, Metz Road

Segment, and Jolon Road Segment wine corridors and the River Road, Pine Canyon (Kings City), San Lucas, and San Ardo Rural Centers.

<u>2007 General Plan Policies</u>

The 2007 General Plan and Area Plan policies summarized below set forth comprehensive measures to avoid and minimize adverse impacts associated with septic tank systems.

***Public Services Element***

Public Services Element Policies PS-4.1, PS-4.2, PS-4.3, and PS-4.5 (promote use of wastewater collection and treatment systems for new development) would help avoid the adverse impacts of impaired surface and groundwater quality that could potentially occur with installation of septic tank systems through determent of the use of septic and alternative wastewater systems. Policy PS-4.8 (require County to establish septic system and alternative wastewater system criteria) would direct future development to comply with septic tank criteria such as minimum lot size, location of wells, the capacity of the system, and other factors related to soil suitability in order to minimize risks to groundwater resources.

<u>Area Plan Policies</u>

The following supplemental Area Plan policies address impacts related to on-site septic systems.

***Carmel Valley Master Plan***

Carmel Valley Master Plan Policy CV-5.5 (require geologic and soils surveys if including on-site septic system) would help to ensure that future development with proposed septic systems would not contaminate the groundwater aquifer through implementation of geologic and soil survey recommendations. This policy would specifically require review for proper siting and design in accordance with the standards of the *Carmel Valley Wastewater Study*.

***Central Salinas Area Plan***

Central Salinas Area Plan Policy CSV-5.2 (require recreation and visitor-serving commercial use septic systems to meet RWQCB Basin Plan requirements) would help to minimize potential impairment of groundwater quality from septic systems through implementation of RWQCB Basin Plan measures related to septic systems.

**Significance Determination**

New development in accordance with the 2007 General Plan could result in installation of septic tank systems for wastewater disposal, especially in more rural areas of the County containing wine-related facilities. However, most General Plan development is not anticipated to be on septic, as population growth and respective new development is anticipated to occur primarily within the community planning areas rather than the rural or winery corridor areas. Nonetheless, no septic tanks would be permitted without development of a site-specific geotechnical report and adherence to the recommendations outlined therein related to installation of septic tanks systems. Finally, any alternative system management program must be consistent with RWQCB requirements, which would ensure that disposal does not degrade surface waters.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan and Area Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan policies would promote the use of wastewater collection and treatment systems rather than septic tanks and would establish comprehensive standards for septic and alternative wastewater systems. Consequently, potential septic system impacts would be less than significant.

### Buildout

**Impact of Development with Policies**

Buildout under the 2007 General Plan to 2092 would result in new urban and agricultural development in undeveloped areas beyond 2030 levels. New development could expose more persons and structures to geological hazards associated with use of septic tanks.

2007 General Plan Policies

The 2007 General Plan policies summarized above place restrictions on future development in terms of installation of septic tank systems.

**Significance Determination**

Buildout under the 2007 General Plan to 2092 could potentially result in adverse impacts related to septic tanks. However, new construction throughout the County would comply with 2007 General Plan and Area Plan policies that would ensure that impacts related to septic tanks would be less than significant.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan and Area Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan and Area Plan policies would reduce impacts related to septic tanks to a less-than-significant level.

## Tsunami, Seiche, and Mudflow Hazards

### Impact GEO-8: Land use activities and development consistent with the 2007 General Plan could expose persons and property to tsunami, seiche, or mudflow hazards. (Less-Than-Significant Impact.)

#### 2030 Planning Horizon

**Impact of Development with Policies**

Implementation of the 2007 General Plan within the 2030 planning horizon would result in new urban and agricultural development in undeveloped areas. As a result, more persons and structures would be exposed to hazards related to tsunami, seiche, or mudflow.

Development is not proposed for the immediate coastal areas or proximate to Lakes Nacimiento and Lake San Antonio (two large inland water bodies). Development is proposed for areas of the Bradley, Lockwood, Pleyto, and Pine Canyon (King City) rural areas.

2007 General Plan Policies

The 2007 General Plan contains policies that address development in areas prone to slope hazards such as landslides and mudflows. These policies are summarized in the discussion for Impact GEO-4.

Area Plan Policies

No Area Plan policies address the topics of tsunami, seiche, or mudflow hazards.

**Significance Determination**

The probability of seiche and mudflow are low in Monterey County. The areas with the greatest possibility of such hazards are not populated. Portions of the coast could be subject to inundation in the case of a tsunami. However, this risk has been identified in the certified Local Coastal Program, and protective policies have been put in place to minimize risk to new development. Therefore, there would be no increase in tsunami or seiche hazards over existing levels.

Mudflows have occurred in recent geologic time in the coastal areas near Big Sur, which contain numerous steep slopes. Mudflows are extremely rare outside of that area, particularly in the inland portions of the County. Nonetheless, there is a remote possibility that mudflows could inundate inland areas where significant slopes are located. However, in terms of mudflow, no development would be permitted on slopes greater than 30% without mitigated exception. In addition, new development would be required to meet all applicable standards of the CBC, which includes standards related to slope stability. Therefore, adherence to 2007 General Plan policies and the CBC would ensure that no additional exposure to mudflow hazards would be created.

#### Mitigation Measures

No mitigation beyond the 2007 General Plan policies is necessary.

**Significance Conclusion**

With adherence to 2007 General Plan policies and compliance with the CBC, impacts related to tsunami, seiche, and mudflow hazards would be less than significant.

### Buildout

**Impact of Development with Policies**

Buildout under the 2007 General Plan to 2092 would result in new urban and agricultural development in undeveloped areas beyond 2030 levels. New development could expose more persons and structures to geological hazards associated with tsunami, seiche, and mudflow.

2007 General Plan Policies

The 2007 General Plan policies summarized above set forth comprehensive measures to minimize adverse mudflow and landslide impacts.

**Significance Determination**

Buildout under the 2007 General Plan to 2092 could potentially result in adverse impacts related to tsunami, seiche, and mudflow. However, new construction throughout the County would comply with 2007 General Plan and Area Plan policies that would ensure that impacts related to tsunami, seiche, and mudflow would be less than significant.

**Mitigation Measures**

No mitigation beyond the 2007 General Plan and Area Plan policies is necessary.

**Significance Conclusion**

Implementation of the 2007 General Plan and Area Plan policies would reduce impacts related to tsunami, seiche, and mudflow to a less-than-significant level.

## 4.4.5 Level of Significance after Mitigation

All impacts related to geology, soils, and seismicity would be less than significant with mitigation and compliance with federal, state, and local regulations.