DRAFT 3

BACKGROUND REPORT #16

Geology/Geologic Hazards

City of Goleta
March 19, 2004

INTRODUCTION

The purpose of this planning background report section is to describe the existing geologic environment within the City of Goleta as it has been characterized by various agencies and other sources. The content of this report was prepared for the City of Goleta by RBF Consulting with edits by the City. The sections of this report relating to geologic hazards will be addressed in the City's safety element.

Topographically, the Goleta Valley is a broad, flat alluvial plain bordered on the south by the bluffs of the Pacific coastline and on the north by foothills and terraces that lie in the foreland of the Santa Ynez Mountains. The Goleta alluvial plain covers an area approximately eight miles long and up to three miles in width. It generally slopes gently from all directions into the Goleta Slough, which is located roughly in the south central portion of the area. The foothills consist of steep, dissected highlands along the northern boundary that merge towards the south with the more gently sloping Goleta plain. The dissected highlands generally occupy elevations ranging from 140 feet above mean sea level (msl) to 400 feet msl and are characterized by slopes greater than 30 percent.

An elevated and broadly dissected coastal plain is present over much of the southern one-half to two-thirds of the valley. Much of the coastline consists of a flat terrace ranging from 50 to 150 feet msl. The cliff line is broken in the central portion of the study area at the Goleta Beach County Park by a number of creeks which empty into the ocean at this point, and at the west and east end of the City where two other creeks drain into the ocean.

REGIONAL GEOLOGY

The rocks and sediments exposed in the Goleta Valley are Tertiary and Quaternary in age. Together, these deposits aggregate about 16,000 feet in thickness with approximately 1,500 feet being exposed in the Goleta Valley. These units lie along an east-west trend that roughly parallels the coast. The following descriptions are taken from the Goleta Watershed Comprehensive Soil and Water Conservation Planning Project (Santa Barbara Soil Conservation District, et al., 1968).

Tertiary Rocks

- Undifferentiated Eocene Strata. Eocene strata, which outcrop near the study area, include the Matilija sandstone, the Cozy Dell shale, and the Coldwater Formation. At the present it appears that these units do not crop out in the study area.

- Sespe Formation. The Sespe Formation is of Oligocene Age and consists of a series of continental shales, siltstones, sandstones and conglomerates, which average about 2,600 feet thick. Red and green shales alternate with coarse red, greenish and tan sandstones. The sandstone becomes coarser grained and more prominent in the lower part of the formation. A prominent red pebble conglomerate forms the basal unit in the Goleta area.

- Vaqueros Formation. The Vaqueros sandstone consists of a massive, dirty-white to buff, medium- to coarse-grained sandstone that contains a fossiliferous basal conglomerate in some areas. This Oligocene Age unit is locally glauconitic and considered of marine origin.

- Rincon Formation. The Rincon Formation consists of a series of uniform, greenish-brown, fissile marine mudstones and shales with irregular, limy, ferric-stained concretions and beds. It is considered to be of Early Miocene and Early Middle Miocene Age. The unit averages about 1,700 feet in thickness in the Goleta Basin.

  The Rincon Formation is one of Santa Barbara County's most troublesome rock units. It is typically exposed along an east-west band at the northern end of the City, although isolated outcrops also appear in other areas. This geologic unit is known for shallow landslides that are typically restricted to depths of 15 feet or less. The slope failures tend to occur along the weathered-unlettered interface where water has penetrated after a period of rainfall or from the downward percolation of irrigation water. Many slope failures in the area are the result of a combination of pore pressure conditions and exceedance of the shear strength of clay weathered from mudstone and claystone that typifies the formation. Where flat topography is present, structures constructed on the Rincon Formation have been damaged by the constant expansion and shrinkage of the soil; where slopes occur, these effects are augmented by the tendency for soil creep slumps and landslides to occur.

  The Rincon Formation is also known for its high uranium content which decays and releases radon, a radioactive gas. Radon is recognized as a health hazard by the Environmental Protection Agency (EPA) and is known to cause lung cancer. Potential impacts to human health could be incurred by improper construction practices, which allow for the buildup of radon gas within a particular structure. Thus, this geologic unit poses a potential health hazard.

- Monterey Formation. The Monterey Formation is of Middle and Late Miocene Age. The geologic unit typically consists of a hard, splintery, silicified shale. However, in many places it consists of a soft diatomaceous shale or contains thin beds of volcanic ash, is tightly folded or crumpled, and is shattered or extensively fractured. This formation averages over 1,000 feet in thickness and is impregnated with tar. In surface exposures the beds are normally white and locally stained with limonite, whereas fresh material is usually bluish-gray. The Monterey Formation occurs along the sea cliff and in a discontinuous belt along the northerly side of the Goleta alluvial plain. The weaker portions of the Monterey Formation are easily eroded by both marine and non-marine processes including wave action, wind erosion and erosion due to rainfall.

The Monterey Formation accounts for most of the rocks exposed along the sea cliffs within the Goleta area and the weaker portions of this formation are easily eroded. In addition to wave action, wind erosion and erosion due to rainfall, erosion of cliffs can also be caused or enhanced by surface water runoff, saturated soil conditions resulting from septic tank systems and over watering of vegetation, chemical erosion, foot trails and animal burrows.

- <u>Sisquoc Formation</u>. The Pliocene Age Sisquoc Formation consists of a series of consolidated thin bedded to massive, locally limy and fossiliferous, gray to brown marine mudstones and claystones which average over 1,400 feet in thickness. This unit only occurs along the sea cliffs in the Goleta Basin.

Quaternary Rocks

Pleistocene and Recent Age deposits are composed of the Santa Barbara Formation, several different deposits of alluvium and terrace deposits, both marine and fluvial and minor amounts of wind-blown material. Together they total more than 1,000 feet of section and occur throughout the Goleta Basin.

- <u>Santa Barbara Formation</u>. The Early Pleistocene Age Santa Barbara Formation consists of approximately 1,000 feet of unconsolidated sands, silts and clays. The formation is usually composed of a yellowish-buff, medium- to fine-grained quartzose sand with interlayered silts and clays. The Santa Barbara Formation is locally concretionary and fossiliferous and generally occurs in the central and southeast portion of Goleta Valley.

- <u>Terrace Deposits</u>. Late Plesitocene terrace deposits comprise a relatively thin cap of unconsolidated clastic sediments resting uncomformably on marine terraces. The typical thickness of these deposits is less than 100 feet. The deposits also contain a basal boulder-cobble conglomerate overlain by poorly sorted detrital pebbles, sand, silts and clays.

- <u>Older Alluvium</u>. The Older Alluvium varies in thickness form 0 feet to over 200 feet. This Pleistocene Aged material unconformably overlies older consolidated rocks and consists of reddish-brown to tan, unconsolidated detrital materials. Several bodies of mixed boulders, cobbles, pebbles, sands, silts and clays are included within this unit.

- <u>Younger Alluvium</u>. The Recent Age Younger Alluvium underlies the Goleta Plain and extends as valley fill up the canyon bottoms, which drain into the basin. Thickness of this unit varies from very thin on the north to nearly 225 feet in the southerly portion of the valley. Generally, the alluvium consists of mud, silt, sand and discontinuous basal gravels.

The geologic structure of the Goleta Valley and adjacent foothills generally consists of a southerly-dipping east-west trending homocline, similar in character to the structure of the Santa Ynez Mountains. The detailed geologic structure in this area is actually more complex and consists of a series of northwest trending synclinal and anticlinal folds that meet and are truncated by a series of generally east-west trending faults. Oil and gas are produced by wells on these folds where closed structural traps have been formed by faulting and folding.

SOILS

Based on the U.S. Department of Agriculture, Soil Conservation Service (SCS) Soil Survey (1988), there are three soil associations in Goleta (refer to Exhibit 1, *Soils*). A soil association is defined as a landscape that has a distinctive soils pattern. It normally consists of one or more major soils and at least one minor soil and is named for the major soils.

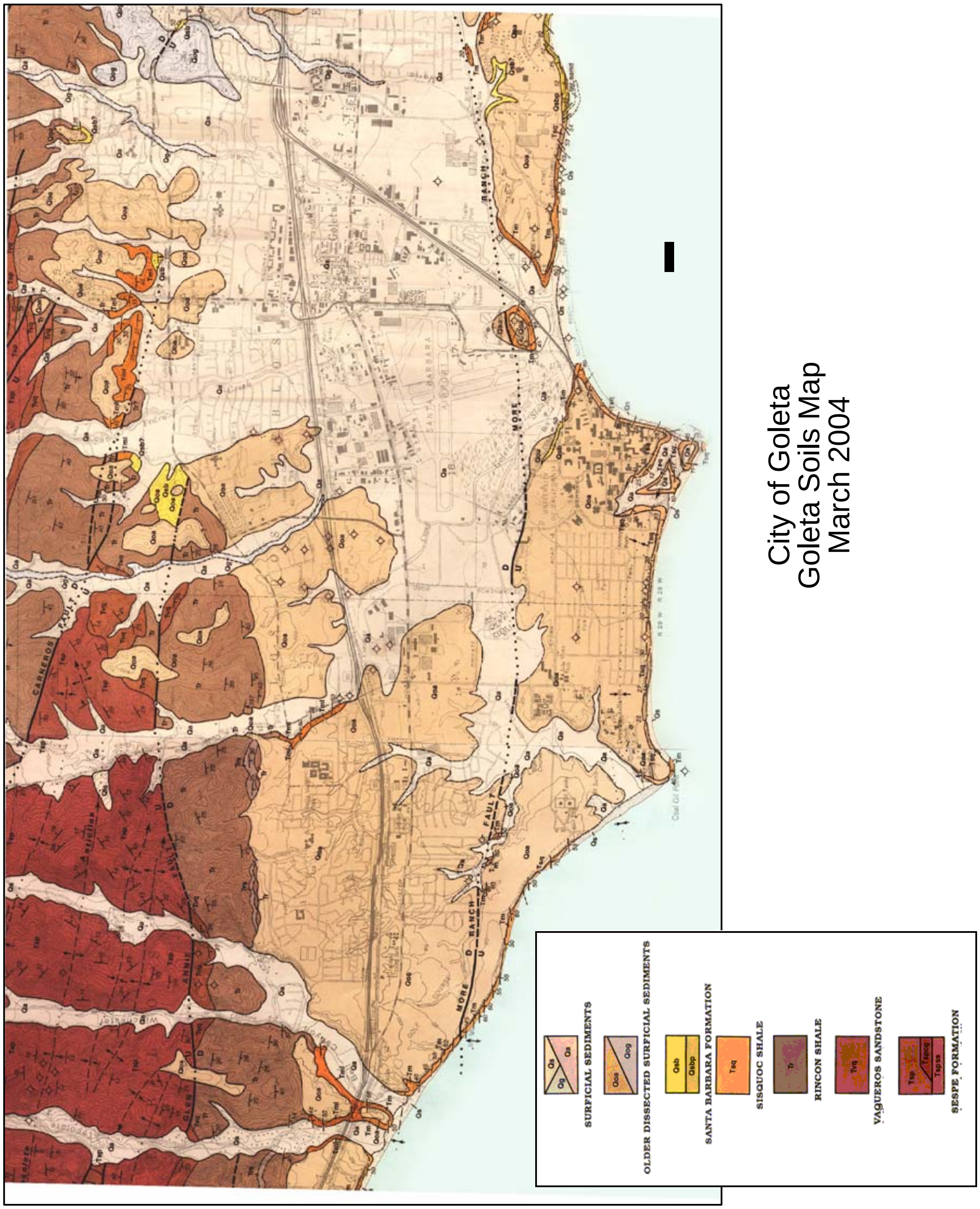
The first, Goleta-Elder-Agueda association, consists of nearly level to moderately sloping, well-drained sandy loams, and silty clay loams on flood plains and alluvial fans in valleys. The second is the Camarillo-Aquents flooded association, which is nearly level, poorly drained and very poorly drained fine sandy loams on low flood plains and tidal flats. The Milipitas-Positas-Conception association consists of nearly level to steep, moderately well drained fine sandy loams on terraces.

Soil types present in Goleta Valley that represent a moderate constraint to development include: the Aquepts Series, which are highly prone to flooding and ponding; the Argizerolls series, which consists of landslide material; and the Ayers Series, which are highly prone to landslides. The soils of the Arnold, Camarillo, Conception, Diablo, Lodd, Milipitas, San Andreas and Zaca series also represent a minor constraint to development due to typically high expansive potential and their occurrence on steeper slopes. A soil with high expansive potential contains clayey substrata that swells or expands when wet and shrinks when dries. Repeated shrinking and swelling of the soil can lead to damage to foundations, fill slopes and other associated facilities.

Geologic impacts could occur as a result of new development on existing hazards (e.g., bluff retreat, seismic hazards and exposure to Radon gas) and the creation of impacts by new development (e.g., increased erosion, slope failure, etc).

Two potential hazards are related to development on steep slopes (slopes greater than 20 percent): erosion effects and slope instability. Typical impacts associated with urban development would involve increased erosion and downstream sedimentation and possible slope failure from vegetation clearance, grading of roads, driveways and building pads and installation of retaining walls and drainage structures. Impacts resulting from agricultural development would be more extensive than for rural or ranchette development because vegetation clearance is typically more complete, until cover cropping is attained.

Exhibit 1, Soils

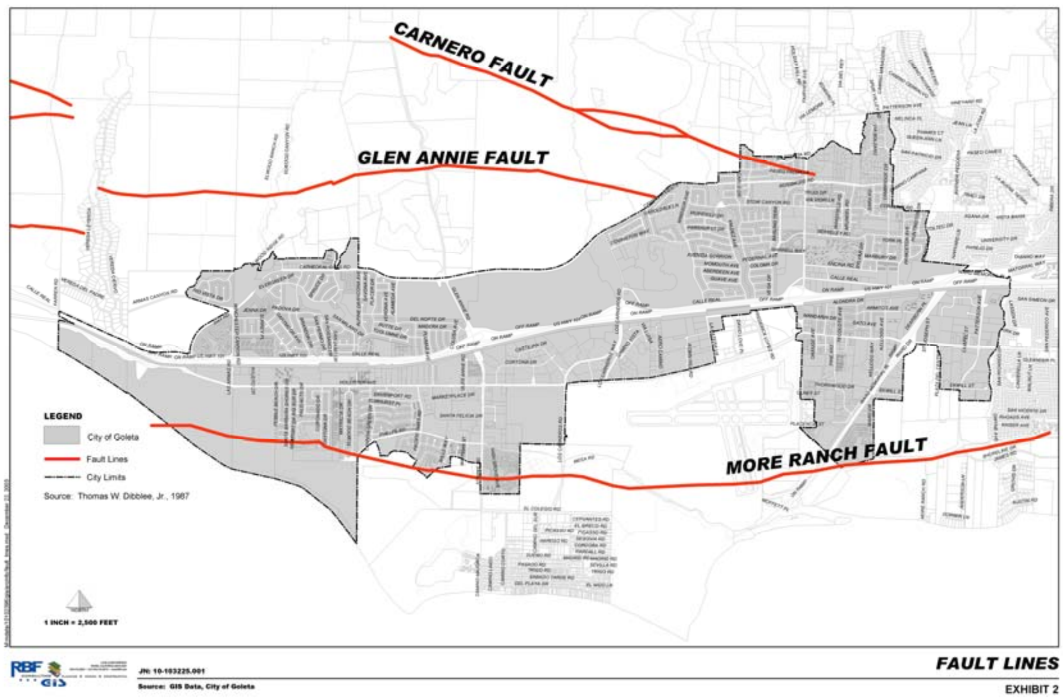


City of Goleta
Goleta Soils Map
March 2004

SEISMICITY

Two or more possible sets of faults occur in the area; evident in aerial photographs, they exist in part as strong linear features in the more competent bedrock. Exhibit 2, *Fault Lines*, illustrates the faults in the area; none of the faults shown on Exhibit 2 have been designated as active through the creation of an Alquist-Priolo special studies zone. However, several faults are considered active or potentially active based on criteria outlined in the Seismic Safety and Safety Element (SSSE)(County of Santa Barbara, 1979) of the Comprehensive Plan and by the California division of Mines and Geology (CDMG). Faults that are considered active (those which exhibit historic seismicity or displace Holocene deposits) include the More Ranch (5.8 maximum credible earthquake Richter scale) and Mesa faults (5.0 maximum credible earthquake Richter scale).

Insert Exhibit 2, Fault Lines



San Jose and Goleta faults are considered potentially active (having no historic seismic record and displace Pleistocene but not Holocene strata).

The SSSE considered the following faults in the Goleta area as inactive (having no record of displacement for more than 2,000,000 years): the Carneros, Dos Pueblos, Eagle, Glen Annie, Las Varas, Lavigia, Modoc, San Antonio, San Pedro and Ygnacio. Major active or potentially active regional faults, which could have an effect on the Goleta Valley, include the San Andreas, Santa Ynez, Rinconada, Nacimiento, Big Pine, Pine Mountain, White Wolf and Garlock (County of Santa Barbara, 1979).

Additionally, the City of Goleta may be subject to earthquakes occurring along unknown faults. On August 13, 1978, an earthquake occurred southwest of the City of Santa Barbara approximately 5.5 miles below the Santa Barbara Channel. The most intense ground motion occurred between Turnpike Road and Winchester Canyon Road, including the University of California Santa Barbara (UCSB). The earthquake resulted in window damage to businesses and residences, several mobile homes being displaced from their pedestals, significant structural damage to ten permanent UCSB buildings and a freight train derailment as a result of movement in the track.

Major potential hazards occurring in the project area from seismic activity involve ground shaking and related effects from earthquakes on local and major regional faults. Seismic hazards include ground rupture, ground acceleration, liquefaction and tsunamis.

Ground Rupture

Seismically-induced ground rupture is defined as the physical displacement of surface deposits in response to earthquake-generated seismic waves. Ground rupture is confined to the trace of the fault, and is a response to the movement of blocks of material on either side of the fault. Displacement or rupture of the ground surface due to faulting can cause damage to property and structures as well as potential loss of life. Ground rupture is a potential problem in the project area due to known active faults systems.

Developments near the More Ranch and Mesa faults (both considered active) would be expected to have the most significant potential to be affected by ground rupture.

Ground Acceleration

Ground acceleration is an estimation of the peak bedrock or ground motion associated with a specific earthquake event. It is expressed in terms of "g" forces, where g equals the acceleration due to gravity. Acceleration can be measured directly from seismic events or derived from magnitude and fault distance data. Ground shaking is not confined to the trace of a fault, but rather propagates into the surrounding areas during an earthquake, with the intensity diminishing with distance from the fault.

Large earthquakes along the more extensive of these faults can produce ground accelerations with longer wavelengths and durations than smaller faults, although with the latter, structures may be closer and thus generate greater peak acceleration values. Both the wavelength and duration of seismic waves can contribute to the destructive potential of individual earthquake events. Ground acceleration parameters associated with maximum credible earthquakes along selected faults are given in Table 1, *Major*

Faults and Seismicity Data. Estimated modified Mercalli Scale intensities (derived from ground acceleration values) associated with these earthquake events are also listed on Table 1. Severe or extended ground accelerations can produce a variety of adverse structural effects, as described in Table 2, *Modified Mercalli Intensity Scale*.

Table 1
MAJOR FAULTS AND SEISMICITY DATA

Fault	Approximate Minimum Distance From Site (Miles)	Maximum Credible[1] Earthquake (In Richter Magnitude)[2]	Approximate Peak Ground Acceleration[3]	Repeatable High Ground Acceleration[4]	Estimated Mercalli Scale Intensity[5]
Active:					
Big Pine	18.0	7.1-7.2	0.24	0.16	VII-VIII
Mesa	1.0	5.0+	~0.34	0.22	VII-VIII
More Ranch	0.0	5.8+	0.51	0.33	VIII-X
Nacimiento	24.0	7.6+	0.24	0.24	VII-VIII
San Andreas	45.0	8.25	0.16	0.16	VII
Santa Ynez	9.0	7.2	0.42	0.27	VII-VIII
Potentially Active:					
Goleta	0.0	4.5	~0.30	0.20	VI-VIII
San Jose	0.0	5.8	0.51	0.33	VIII-IX

Source: Goleta Community Plan Final EIR, August 1992.

[1]Defined as the maximum estimated earthquake capable of occurring
[2]Richter magnitude, from Santa Barbara County SSSE
[3]From Greensfeeder 1974
[4]From Plessel & Slosson 1974
[5]From USGS (1980)

Liquefaction

Liquefaction is the loss of shearing strength in a saturated sandy soil due to some kind of vibration such as that caused by an earthquake. The vibration due to an earthquake can cause an increase in pore pressure within the saturated soils. If the pore pressure is raised to be equivalent to the load pressure, this causes a temporary loss of shear strength, allowing the material to flow as a fluid. This temporary condition can result in the severe settlement of foundations and in slope failure.

There is no historic evidence of liquefaction in Santa Barbara County. However, the potential exists for liquefaction to impact structures overlying sandy soils and a shallow water table. The majority of the Goleta area is comprised of alluvial deposits, which are susceptible to the effects of liquefaction. The coastal plain and valley bottom areas (such as found in the majority of Goleta) generally have a moderate potential for liquefaction. Loose, granular soils are most susceptible to these effects, while the stability of silty clay and clay materials is generally not as affected by vibratory motion.

Liquefaction is generally restricted to saturated or near saturated materials at depths of less then 100.

Table 2
MODIFIED MERCALLI INTENSITY SCALE

Richter Magnitude Scale	Modified Mercalli Intensity Scale	Damage Created
< 2	I.	Tremor not felt.
2	II.	Tremor felt by persons at rest or in upper floors of a building.
3	III.	Tremor felt indoors. Vibrations feel like a light truck passing by; may not be recognized as an earthquake. Hanging objects swing.
3 – 4	IV.	Hanging objects swing. Vibrations feel like a heavy truck passing by, and the jolt feels like a heavy ball striking the walls. Standing cars rock. Windows, dishes and doors rattle. Glasses clink and crockery clashes.
4	V.	Earthquake felt outdoors, and its direction can be estimated. Sleepers are awakened. Liquids are disturbed, some spilled. Small unstable objects are displaced or upset. Doors swing, closing and opening. Shutters and pictures move. Pendulum clocks stop, start or change rate. Wooden walls and frames crack in the upper range of scale 4.
4 – 5	VI.	Earthquake felt by everybody. Many are frightened and run outdoors. Persons walk unsteadily. Window, dishes and glassware are broken. Knick-knacks and books fall off shelves; pictures off walls. Furniture moved or is overturned. Weak plaster and adobe masonry crack. Small bells in churches and schools ring. Trees and bushes are shaken.
5	VII.	Difficult to stand. Earthquake noticed by drivers of motorcars. Hanging objects quiver. Furniture is broken. Damage to adobe masonry, including fallen plaster, loose bricks and stones, cracks in tiles and cornices. Weak chimneys break at roofline. Some cracks in other masonry. Waves form in ponds, disturbing mud at the bottom. Slides and caving in sand and gravel banks. Large bells ring. Concrete irrigation ditches are damaged.
6	VIII.	Steering of motorcars is affected. Partial collapse of some masonry structures. Some damage to reinforced masonry. Fall of stucco and some masonry walls. Twisting and falling of chimneys, factory stacks, monuments, towers and elevated tanks. Frame structures, if not bolted to foundations, shift. Loose panel walls are thrown out; decayed pilings break off. Branches break off trees. Changes in flow or in temperature of springs or wells. Cracks in wet ground and on steep slopes.
6 – 7	IX.	General panic. Adobe structures destroyed; unreinforced masonry heavily damaged, sometimes completely collapsed. General damage to foundations. Frame structures, if not bolted, shift off their foundations. Serious damage to reservoirs. Underground pipes are broken. Conspicuous

		cracks in the ground. In alluvial areas, sand and mud are ejected, forming sand craters.
7	X.	Most masonry and frame structures are destroyed. Most foundations destroyed. Some well-built wooden structures and bridges are destroyed. Serious damage to dams, dikes and embankments. Underground pipelines are seriously damaged. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and in flatlands. Rails bent slightly.
8 +	XI.	Rails bent greatly. Underground pipelines completely out of service. Many and widespread disturbances of the ground, including broad fissures, earth slumps and land strips in soft, wet ground. Sand- and mud-charged water ejected from fissures in the ground. Sea waves (tidal waves or tsunamis) of significant magnitude. Severe damage to dams, dikes and embankments. Few, if any, masonry structures remain standing. Large, well-constructed bridges destroyed due to damage to their supporting piers or pillars. Wooden bridges are affected less.
	XII.	Damage is nearly total. Lines of sight and level are distorted. Objects are thrown into the air. Great and varied disturbances of the ground, including numerous shearing cracks, landslides, large rock falls, and numerous widespread slumping of river banks. Fault slips in firm rock with notable horizontal and vertical offset. Water channels, both at the surface and underground are disturbed and modified. Lakes are dammed, rivers are deflected, waterfalls occur. The rolling effect of the seismic waves is actually seen at the ground surface.
Source: Leighton & Associates.		

Tsunamis

Offshore (underwater) earthquake-induced tsunamis are the result of seismic energy producing massive wavelike or oscillatory movement in large bodies of water. These waves are relatively low and harmless in the open ocean, but can reach substantial heights when they approach shallow water depths near shore. However, tsunamis have a very low frequency of occurrence and most of the time there is time to warn residents to evacuate.

A seismic event on any moderate offshore fault could result in a tsunami, which would affect the project area. No reliable historic records are present which substantiate the occurrence of a tsunami in Goleta. However, on November 4, 1927, a major earthquake off the coast of Point Arguello initiated the occurrence of a true tsunami. It was recorded on tide gages as far away as Hawaii and reached heights of six feet msl on the coasts of Santa Barbara and San Luis Obispo counties (County of Santa Barbara 1979). Under certain tidal and storm conditions, a tsunami could affect lands up to 20 to 25 foot elevations and potentially impact areas as high as 40 feet msl (County of Santa Barbara 1991). The areas most subject to the effects of a tsunami would be along the oceanfront.

Tsunamis can reach heights of 50-100 feet in some areas of the world, although a wave of this size would not be expected to occur in the Goleta area. The SSSE considers a 10-foot high sea wave as being more probable in the area and recommends that a contour elevation of 40 feet be used in planning as the tsunami risk limit (Goleta Community Plan Final EIR, August 1992).

PLANNING IMPLICATIONS FOR THE CITY OF GOLETA

A number of issues can be considered in the subsequent General Plan work efforts, including: 1) protection in the event of a seismic event; 2) protection from hazards due to development on the Rincon Formation; 3) protection from erosion and slope instability due to slope development.

Protection in the Event of a Seismic Event

The City of Goleta is located in a seismically active area, and thus will need to consider adequate protection from natural disaster, such as earthquakes and related seismic hazards (i.e., liquefaction, ground acceleration, ground rupture), and ensure that the City is adequately prepared in the event of such an emergency.

Protection from Hazards due to development on the Rincon Formation

Radon present in the Rincon Formation is recognized as a health hazard by the Environmental Protection Agency (EPA). In addition, development on the Rincon Formation could result in slope instability. The City of Goleta will need to consider adequate measures to protect future development from exposure to radon gas and possible slope failure.

Protection from Erosion and Slope Instability due to Slope Development

Development on steep slopes (slopes greater than 20 percent) within the City of Goleta could result in hazards involving erosion and slope instability. The general plan should consider appropriate measures to protect development from these hazards.

REFERENCE MATERIALS

Goleta Community Plan, prepared by the County of Santa Barbara Resource Management Department, August 1993.

Goleta Community Plan Final Environmental Impact Report, prepared by the County of Santa Barbara, August 1992.

Goleta Old Town Revitalization Plan, Proposed Final Environmental Impact Report, prepared by the County of Santa Barbara Planning & Development, Comprehensive Planning Division, June 1997.

Goleta Old Town Revitalization Plan, Proposed Final Environmental Impact Report, prepared by the County of Santa Barbara Planning & Development, Comprehensive Planning Division, June 1998.

Phase II Environmental Site Assessment Goleta Old Town Brownfields Project, prepared by Padre Associates Inc. for County of Santa Barbara Planning and Development Department, November 2000.

The Goleta Valley Outlook, prepared by the Santa Barbara County Planning & Development, May 1998.