V. TECHNICAL APPENDICES

EXISTING CONDITIONS AND ISSUES

Regional Stratigraphy. The stratigraphic and lithologic features of the major rock sequences within the Santa Paula planning area (Norris and Webb, 1990 and Dibblee, 1990 and 1992) are described by age group as follows:

Middle to Late Eocene, Matilija Sandstone (Tma, Tmaw, Tmasl, Tmash). Predominantly north-dipping (including overturned beds) sequence of resistant marine, thick-bedded, tan arkosic sandstone with thin partings of gray micaceous shale, and hard white sandstone and thin shale interbeds in the Santa Paula Peak area. This bedrock crops out in the northeast portion of the planning area.

Late Eocene, Cozy Dell Shale (Tcd, Tcdss). Predominantly north-dipping, marine, dark gray shale and light gray to tan arkosic sandstone. Outcrops exist at the northern tip of the planning area, adjacent to Santa Paula Creek.

Late Eocene, Coldwater Sandstone (Tcw, Tcwsh). Predominantly north-dipping and overturned beds of marine hard and tan sandstone, and greenish-gray and fossiliferous siltstone and shale. This bedrock crops out in the northern portion of the planning area, adjacent to Santa Paula Creek.

Oligocene, Sespe Formation (Tsp). Non-marine sandstone and conglomerate with outcrops restricted to south of the City of Santa Paula and the Santa Clara River.

Middle Miocene, Conejo Volcanics (Tcva). Volcanic rocks consisting of andesitic basalt. These rocks crop out in a thin strip near the peak of South Mountain, in the southern portion of the planning area.

Middle Miocene, Topanga Formation (Tts). Southern-dipping, marine, semi-friable sandstone that is time equivalent to the Conejo Volcanics. Crops out in a small area in the southwestern portion of the planning area.

Middle and Late Miocene, Monterey Formation (Tm). Described previously as the Modelo Formation (Weber, 1984), this unit is described as marine, biogenic, thinly-bedded to finely-laminated siliceous shales. This unit crops out in the northwestern portion of the planning area adjacent to Santa Paula Creek, and in the southwest portion of the planning area adjacent to Santa Clara River.

Pliocene and Pleistocene, Pico Formation (QTpm, Tp). Predominantly southern-dipping, marine, soft claystone or mudstone with some lenses or interbeds of semi-friable sandstone. A thick, coherent white tuff bed exists in the South Mountain area. This unit crops out over most of the planning area north of Santa Clara River, and in the southwest portion of the planning area adjacent to the river valley.

Late Pliocene and Early Pleistocene, Las Posas Sand (QTlp, QTlc). Southern-dipping, marine strata consisting of friable sandstone and sandy siltstone with some lenses of pebble-cobble conglomerate. This unit crops out in a thin zone adjacent to the west of Santa Paula Creek, in the northern section of the planning area.

Pleistocene, Saugus Formation (Qts). Southern-dipping, nonmarine, weakly-consolidated alluvial cobble-boulder conglomerate. This unit crops out along the northern border of the Santa Clara River Valley, in the central portion of the planning area.

Older Surficial Sediments (Qoa, Qog, Qof) . Dissected remnants of weakly-consolidated alluvial gravel, sand and silt. These sediments crop out primarily between Santa Paula Creek and Timber Canyon, north of the City of Santa Paula.

Surficial Sediments (Qg, Qf, Qa). Unconsolidated and generally undissected stream channel and alluvial deposits. These deposits lie within the boundaries of Santa Paula Creek, Timber Canyon, and in the Santa Clara River Valley floor.

Regional Seismicity and Earthquake History. Earthquakes occur along active faults. One of the tools used in the evaluation of seismic risk is the historical earthquake record. These records list when an earthquake occurred, its epicenter and depth below ground surface, and strength (Modified Mercalli Intensity or Magnitude). Seismic records in southern California date back about 200 years -- to the time of Spanish colonization. Earthquake recurrence along an individual fault can be on the order of thousands of years, so the historical record alone is not sufficient to fully determine the seismic risk that an area may experience. Despite these limitations, a review of historical seismicity has value in evaluating the seismicity that an area may undergo. The accuracy of the database increases with time; events before about 1940 are based on colloquial data and are not instrumentally recorded. These events, therefore, may not accurately locate the recorded event.

Historical Seismicity of the Santa Paula Area. The lower Santa Clara Valley has not had a large, damaging earthquake in 200 years of record keeping. According to the State of California, Department of Conservation, Earthquake Epicenter Map of California (1978), no earthquake epicenters, for earthquakes with a magnitude of 4.0 or greater, have been located within the City of Santa Paula planning area between 1900 through 1974. In addition, no large earthquakes are known to have occurred in the western Transverse Ranges during the historical record of the past 200 years (CDMG, 1996).

Several historical earthquakes with epicenters outside of the Santa Paula area have affected the Santa Clara Valley and the County of Ventura. An earthquake which occurred offshore, possibly on a continuation of the Oak Ridge Fault, in December 21, 1812 created tsunami-like waves along the Ventura coastline (Yeats, 1988). The great Fort Tejon earthquake of January 9, 1857, with its epicenter on the San Andreas Fault close to the northeast corner of Ventura County, caused significant damage in the southern portion of the County and cracks in the river bed six miles from the mouth of the Santa Clara River (City of Santa Paula, 1974). Two earthquake "shocks" occurred on June 6, 1925 and June 30, 1941, of magnitudes 6.3 and 5.9, respectively, which caused some damage in Ventura. The February 9, 1971 San Fernando (magnitude 6.5) earthquake caused severe damage to older buildings in Santa Susana, and small displacement along the Santa Susana Fault (the eastern extension of the Oak Ridge and possibly San Cayetano Fault zones).

The 1994 Northridge (magnitude 6.7) earthquake resulted in a maximum displacement of 3.5 meters along a south-dipping blind thrust fault. As stated above, the Northridge blind thrust fault is thought to be a continuation of the Oak Ridge Fault. The Oak Ridge Fault also continues offshore. More than 400 earthquakes between magnitude 0.5 to 4.0 occurred on this offshore segment of the Oak Ridge Fault in April of 1984 (CDMG, 1995).

Probable Future Seismicity for the Santa Paula Area. The slip rate on the Oak Ridge Fault at South Mountain is estimated at 4.9 ± 1.0 millimeters per year (mm/yr) since the late Pliocene/early Pleistocene time. A slip rate of 4.5 ± 1.5 mm/yr was determined for the San Cayetano Fault based on stratigraphic evidence from the oldest alluvial fans at Timber Canyon, fluvial terrace deposits, and alluvial fan surfaces at Sisar Creek, Bear Canyon, and Mud Creek (CDMG, 1995). Yeats (1988) assumed that the slip rates calculated for the San Cayetano Fault are in the same general range as those for the Oak Ridge Fault, and that average recurrence intervals for earthquakes on these faults are in the same range. However, the CDMG determined in their study of the 1994 Northridge earthquake (CDMG, 1995) that the slip rate on the San Cayetano Fault was greater than 10 mm/yr, and the slip rate on the Oak Ridge Fault was between 1 and greater than 5 mm/yr. The average recurrence interval documented for the Oak Ridge Fault (250 to 500 years), and surmised for the San Cayetano Fault, suggests that a damaging earthquake may strike the lower Santa Clara Valley in the near future (Yeats, 1988).

SEISMIC HAZARDS

Seismic Setting. The regular occurrence of earthquakes in the southern California area serves as ongoing evidence that the area is seismically active. Although nothing can be done to prevent the occurrence of earthquakes, through proper construction design and planning, their destructive effects can be reduced. Within the last several decades, there has been a recognition that structures should not be built over active fault traces. Ongoing earthquake research has resulted in improved construction standards for buildings, roadways, and other structures. Another approach to increasing awareness of seismic hazards has been the State requirement that local governments address seismic safety issues in their General Plans [Government Code Section 65302(g)]. This Safety Element meets the requirement to consider the goals, programs, and policies that are to be followed to reduce the danger of earthquakes.

Earthquake hazards are manifested in many ways, including ground rupture, ground shaking, landslides, tsunamis, liquefaction, and seiches. Secondary hazards that can be caused by earthquakes include flooding due to dam failure, urban fires, and toxic chemical releases.

Previous Work. A Seismic Hazard Analysis of Santa Paula was performed by Earth Technology Corporation of Long Beach, California, in February of 1985. Earth Technology Corporation concluded that the recurrence interval for the Western Transverse Ranges province (which includes the City of Santa Paula) for peak ground accelerations of 0.10 g, 0.14 g, 0.19 g, 0.24 g, and 0.28 g, was 50 years, 100 years, 200 years, 400 years, and 600 years, respectively. The recurrence intervals for peak ground accelerations expected to be generated from an earthquake along the San Andreas Fault were considered separately in Earth Technology's report. The recurrence interval along the San Andreas Fault, based on surface geomorphology, ranges from 140 to 300 years. The median peak ground acceleration in the City, based on a magnitude 8.25 event on the San Andreas Fault at a distance of 53 kilometers from the City, was calculated to be 0.15 g. Earth Technology recommended that a seismic design criteria of 0.2 g should be utilized in the analysis and redesign of unreinforced masonry buildings in the City.

Seismically-Induced Ground Shaking. Earthquake-generated ground shaking is the greatest cause of widespread damage in an earthquake. The California Seismic Safety Commission (1993, 1994) estimates that ground shaking causes 99% of the earthquake damage to residences and other structures in California. Local conditions can greatly influence the intensity of ground shaking. Types of soil, depth to bedrock, depth to groundwater, and orientation of the fault movement all influence the intensity of ground shaking.

Ground shaking is the shock wave produced when there is a sudden movement created by an earthquake rupture. As the shock wave travels away from the hypocenter (the point of rupture), energy is lost and the intensity of the wave diminishes. In general, ground shaking diminishes as the distance from the earthquake epicenter increases. This attenuation relationship has been studied by numerous scientists, resulting in several attenuation models. Distance from the hypocenter also affects the form of the ground shaking. For sites near (within about 10 miles) the hypocenter, one may feel a sharp, high-frequency shock wave. This type of shock wave tends to affect short (one to two story) structures. At greater distances, the high-frequency shock wave is attenuated and one feels a rolling motion. This rolling motion tends to affect higher structures (multi-story structures, towers, large tanks).

A common scale used to measure the magnitude of an earthquake is the Richter scale. Richter magnitude is a logarithmic measurement of the maximum motion of the earthquake event as recorded on a seismograph. Richter magnitude is defined as the logarithm of the maximum amplitude on a seismogram written by an instrument of a specified standard type calculated to be at a distance of 62 miles (100 km) from the epicenter. By definition, Richter magnitude is fixed to an event and does not vary with distance. Seismically-induced ground shaking can also be measured quantitatively as ground surface acceleration (acceleration with respect to the force of gravity-[g]), and qualitatively by the modified Mercalli scale (see Table S-A1). Because of the attenuation of ground shaking with distance, modified Mercalli intensities (MMIs) vary depending on distance from the earthquake, soil type, resonance of the underlying sediments, and other site specific phenomena.

Ground shaking caused by the magnitude 6.7 Northridge Earthquake of January 17, 1994 resulted in the single most costly natural disaster in U.S. History. Over 33 fatalities and 7,000 injuries were attributed to the earthquake. Damages were widespread and included six sections of collapsed highway structures, thousands of damaged or destroyed residential and commercial structures, widespread disruption of utilities and other lifeline facilities, and numerous landslides and soil embankment failures. In all, over 14,000 structures in 28 cities were damaged by the earthquake. In the City of Santa Paula, located about 35 miles from the epicenter, 22 buildings were damaged, but none were severely damaged (Earthquake Engineering Research Center, 1994).

TABLE S-A1 MODIFIED MERCALLI INTENSITY SCALE (ABRIDGED)[1]	
INTENSITY	**DESCRIPTION**
I	Not felt except by a very few under especially favorable circumstances.
II	Felt by only a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated.
IV	During the day, felt indoors by many, outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably.
V	Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	Felt by all; many are frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight.
VII	Everybody 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 motorcars.
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. Chimneys, factory stacks, columns, monuments, walls fall. Heavy furniture overturned. Disturbs persons driving motorcars.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed along with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.

Source: United States Geological Survey, 1985

As stated previously, ground shaking attenuates with distance, thus, active faults near the City of Santa Paula have the potential to produce the greatest ground accelerations. The 1994 Northridge earthquake resulted in accelerations (through bedrock and soil) of up to about 0.5 g near the epicenter and accelerations were extrapolated to be less than 0.2 g near the City of Santa Paula (Earthquake Engineering Research Center, 1994).

Proper design of new structures and strengthening of existing structures can reduce or prevent damage associated with ground shaking. Conformance with the Building Code in the building of new structures helps reduce the likelihood of damage. In residences, most of the damage caused by groundshaking is the result of:

- *Unbraced water heaters,*
- *Houses not adequately anchored to their foundations, and*
- *Houses that have weak cripple walls, or are on pier-and-post foundation.*

Much of the life-threatening earthquake damage to commercial property is caused by:

- *Walls that are poorly anchored to the roof or floors,*
- *Unreinforced masonry walls,*
- *Poorly reinforced concrete walls or columns.*

The majority of buildings in the City of Santa Paula area were constructed in the 1920s, 1950s and 1960s. A large portion of the downtown area is considered "historic". These historic buildings, and many of the other residential and commercial structures within the City, were constructed prior to the implementation of building codes. Many of the historic masonry buildings are unreinforced.

The California Seismic Safety Commission (1993, 1994) has published guidebooks that assist property owners with identifying structural weaknesses and provide recommendations for mitigating these problems. These guidebooks can be ordered directly through the Seismic Safety Commission (Sacramento) and are entitled:

- *The Homeowners Guide to Earthquake Safety*
- *The Commercial Property Owner's Guide to Earthquake Safety*

Fault Rupture. Ground rupture occurs when displacement along a fault reaches the ground surface. Ground rupture capable of causing several inches or greater displacement could have a catastrophic effect on the integrity of a structure. Thus, setbacks from active fault traces are incorporated into determining areas that are suitable to develop. A difficulty in determining the fault rupture hazard is predicting where future ground rupture will occur. Fault displacement often is within a fault zone and not necessarily along exact traces of previous breaks. Also, movement typically is along more than one fault break.

One way in which geologists classify faults is on their movement history. As defined by the California State Mining and Geology Board (Hart, 1994), faults that have had surface displacement within the last 11,000 years (Holocene age) are considered ***active*** faults. Faults are considered ***potentially active*** if they show evidence of surface displacement during Quaternary time (within the last 1.6 million years).

California's Alquist-Priolo Special Studies Zones Act of 1972 (Public Resources Code Section 2621 et. seq.) regulates the development and construction of structures in the state. The act assures that public buildings, and all other structures for human occupancy, are not built on active faults. This act is designed to reduce earthquake hazards to life and property. Active and potentially active faults are to be considered during construction within the state. Cities and counties affected by the zones must regulate certain development within the zones. For proposed development within one of the fault zones, a geologic study must be performed to demonstrate that the sites are not threatened by ground rupture from future faulting.

When designing a structure, it is important to consider the likely earthquake that a fault can produce. A ***maximum probable earthquake*** is the largest earthquake that is expected to be produced within a 100-200 year time frame. Because the life of most structures is on the order of this range, maximum probable earthquakes are commonly used as design criteria for a structure. A ***maximum credible earthquake*** is the largest event that can be produced by a particular fault, regardless of time span. For critical structures, such as dams, emergency operation centers, fire stations, nuclear power plants, and other similar buildings, the maximum credible earthquake is often used as the seismic design criteria.

The following is a brief description of the faults which may affect the Santa Paula planning area.

San Cayetano Fault. The San Cayetano Fault is an east-west trending **active** fault that traverses the Sulphur Mountain ranges in the north end of the Santa Paula planning area and extends eastward to the San Fernando Valley. The San Cayetano is a north-dipping reverse fault on the north side of the Ventura Basin. A slip rate of approximately 4.5 mm/yr has been adopted for the San Cayetano Fault based on displacement of fluvial terrace deposits and alluvial fan surfaces at Sisar Creek, Bear Canyon, and Timber Canyon. There has been no surface faulting event on this fault in at least the past 200 years (SCEC, 1995).

The San Cayetano Fault is modeled as having the potential to produce a MCE of magnitude 6.8 (CDMG, 1996). Such an event could produce ground shaking accelerations ranging from 0.26 g to 0.63 g and a MMI of IX-X in the Santa Paula area.

Santa Susana Fault. The Santa Susana Fault is an east-west trending **active** fault with dip-slip and strike-slip components. About 2,000 meters of vertical offset (the north side up) and 3,200 meters of left-lateral strike slip have been observed along the fault (Yerkes and Lee, 1981). In some places the fault cuts late Pleistocene fan deposits, and surface rupture occurred along the northeast portion of the fault during the 1971 San Fernando earthquake.

The Santa Susana Fault is modeled as having the potential to produce a MCE of magnitude 6.6 CDMG, 1996). Such an event could produce a ground shaking acceleration of 0.26 g and a MMI of IX-X in the Santa Paula area.

Blind Thrust Faults. Low-angle thrust faults, known as ***blind thrust faults***, have recently been recognized as a seismic risk in southern California. Blind thrust faults are low angle features that do not reach the ground surface but do have surface expressions in the form of overlying folds that grow during large earthquakes. The seismic hazard from blind thrust faults has been demonstrated by the Northridge (1994) and the Whittier Narrows (1987) earthquakes. The magnitude 6.7 Northridge earthquake was produced by a south dipping blind thrust fault extending northward from beneath the San Fernando Valley to the Santa Susana Mountains (Jackson, et. al., 1995). The blind thrust fault which caused the Northridge earthquake is believed to be an eastward extension of the Oak Ridge Fault Zone which lies in the southern portion of the Santa Paula planning area. The magnitude of an earthquake that a blind thrust can produce is dependent on the fault's area and characteristic displacement. Earthquakes ranging in size from magnitude 6.4 to magnitude 7.5 can be expected on individual blind thrust segments.

The Northridge Blind Thrust Fault is modeled as having the potential to produce a MCE of magnitude 6.9 (CDMG, 1996). Such an event could produce a ground shaking acceleration of 0.085 g and a MMI of VIII-IX in the Santa Paula area.

Ventura Fault. The Ventura Fault is an east-west trending **active** fault which extends from the east end of the City of Ventura near the Santa Clara River, into the Santa Barbara Channel to the west. The Ventura Fault is a north-dipping reverse fault which appears to cut Holocene strata (Yerkes and Lee, 1981).

The Ventura Fault is modeled as having the potential to produce a MCE of magnitude 6.8 (CDMG, 1996). Such an event could produce ground shaking accelerations ranging from 0.25 g to 0.38 g and a MMI of X-XI in the Santa Paula area.

San Andreas Fault. The San Andreas Fault is mapped by Jennings (1994) as a northwest-southeast trending **active** fault with a length of over 600 miles. This fault is a right-lateral strike-slip fault which forms the plate tectonic boundary between the Pacific plate to the west and the North American plate to the east. The San Andreas Fault has an estimated slip rate of 16-38 mm per year and a recurrence interval of 132 years for large earthquakes (Peterson and Wesnousky, 1994). Numerous earthquakes have been recorded along the San Andreas Fault. Of the faults discussed here, the San Andreas Fault has the highest possibility of future rupture. Because this fault is located about 70 miles east of Santa Paula, ground shaking from a San Andreas Fault event would be somewhat attenuated by the time it reached the City.

The San Andreas Fault is rated as being able to produce a MCE of magnitude 7.8. Such an earthquake could produce a peak ground acceleration of 0.18 g, or a MMI between X-XI in the Santa Paula planning area. Because of the distance between the City and the fault, the nature of ground shaking is expected to be a long period rolling movement.

Oak Ridge Fault. The Oak Ridge Fault is an east-west trending **potentially active** fault that traverses much of the Santa Clara River Valley, extending from the Santa Paula area to the San Fernando Valley. This fault is a steeply south-dipping reverse fault that has an onshore length of about 25 miles (SCEC, 1995). As described by Yeats and Huftile (1995), the 1994 Northridge earthquake may have occurred on a continuation of the Oak Ridge fault system. Because slip rates along the Oak Ridge fault (5 millimeters per year) are nearly three times greater than the Northridge blind thrust fault (the actual fault responsible for the Northridge earthquake), they speculate that there is a potential for a Northridge-size earthquake in the Ventura Basin area. The recurrence interval of this fault is estimated at 250 to 500 years (Yeats, 1988). The Oak Ridge Fault is located in the southern portion of the Santa Paula planning area.

The Oak Ridge Fault is modeled as having the potential to produce a MCE of magnitude 6.9 (CDMG, 1996). Such an event could produce ground shaking accelerations ranging from 0.26 g to 0.64 g and a MMI of X-XI in the Santa Paula area. The nature of the ground shaking would be a sharp, high-frequency wave if the earthquake occurs near Santa Paula, or a longer period, rolling wave if the rupture takes place away from the City.

GEOLOGIC HAZARDS

Liquefaction. Liquefaction is a phenomenon that occurs when loosely consolidated soils lose their load bearing capabilities during shaking and flow in a fluid-like manner. Liquefaction typically occurs in water-saturated, loosely compacted, fine- to medium-grained sand where the groundwater table is within about 40 feet below grade. When these materials are shaken, such as during an earthquake, pore pressure of the sediments increases, causing the sediment to behave as a liquid. Where the liquefied layer occurs near the ground surface, structures built on such a layer could sink into the ground. Other effects of liquefaction include lateral spread, flow failures, ground oscillations, and loss of bearing strength (Tinsley et. al., 1985). Because liquefaction occurs in sediments, areas of bedrock are not considered liquefiable.

Because of a tendency for young sediments to be poorly consolidated, recently deposited material, such as river and flood plain deposits, are more susceptible to liquefaction than other types of sedimentary deposits. The distribution of sediment grain size also influence the susceptibility of liquefaction. Silty sand deposits have the greatest potential for liquefaction. Gravelly sand or deposits containing less than 15 percent clay are less likely to liquefy, and bouldery and cobbly gravels or deposits containing more than 15 percent clay are not known to liquefy (Tinsley et. al., 1985).

Depth to groundwater influences the susceptibility for liquefaction. Where groundwater is within 10 feet from ground surface, the susceptibility is very high. For groundwater between 10 and 40 feet, the susceptibility is high. For groundwater at 40 to 50 feet below grade, the susceptibility is low, and for groundwater deeper than 50 feet, the susceptibility is very low.

The magnitude and duration of ground shaking also has an influence on the susceptibility of liquefaction. The larger the magnitude of an earthquake, the greater the distance at which liquefaction is observed. Similarly, the longer the duration of shaking, the greater the distance at which liquefaction is observed.

The Seismic Hazard Mapping Act was established in 1990 by the CDMG, following the devastating 1989 Loma Prieta earthquake. The purpose of the Seismic Hazard Mapping Act is to encourage land-use management policies and regulations that will reduce and mitigate earthquake hazards, and assist cities and counties in preparing their general plans. The Act calls for the delineation of seismic hazard zones that identify areas of high potential for ground failures such as amplified ground shaking and liquefaction. The purpose of the seismic hazard zones is to show local officials where geotechnical investigations should be required prior to the issuance of a construction permit. The liquefaction zone criteria, based on the Seismic Hazard Mapping Act, is shown in Table S-A2 (CDMG, 1995).

Table S-A2. Liquefaction Zone Criteria

Geologic Unit	Depth to Groundwater	
	Greater than 40 feet	Less than 40 feet
Qa, Qg	low	high
all other	low	low

Source: State of California, Department of Conservation, Division of Mines and Geology
Special Publication 116, The Northridge, California, Earthquake of 17 January 1994, 1995

Lateral spread is the movement of blocks of ground as a result of liquefaction in a subsurface layer. During liquefaction of a subsurface layer of sediment into a fluid mass, gravity can cause the mass to flow down slope. Examples of this include movement into a cut slope such as a river channel, irrigation channel, or a storm drain. Lateral spread typically occurs on gentle slopes ranging from 0.3° to 3°. Ground movement of several feet to tens of feet are possible. Lateral spread is particularly destructive for pipelines, utilities, bridge piers, and other structures having shallow foundations.

Ground oscillation may take place where liquefaction occurs at depth and where the ground slope is too gentle for lateral spreading. When deeper zones liquefy, overlying sediments that are not liquefied can decouple and differentially move. Manifestations of ground oscillation include a ground wave, ground settlement, and opening and closing of fissures.

Flow failure occurs when blocks of ground are decoupled from underlying sediment and move downslope. Flow failures occur on slopes greater than 3°. These blocks can be quite large, from tens of feet to several miles in length and width. Underwater flow failures can also generate tsunamis. Flow failures constitute the greatest hazard produced by liquefaction.

Loss of bearing strength can occur under a structure when the underlying soil liquefies. Large movement in the soil column is possible, allowing for structures to settle, tip, or float upwards.

The City of Santa Paula lies within the Santa Clara River Valley, and extends northward up Santa Paula Creek. The surficial sediments beneath the Santa Clara River Valley and Santa Paula Creek are recent valley and floodplain deposits consisting of silt, sand, and gravel. The Santa Paula planning area extends northward into the Sulphur Mountain and Santa Paula Peak areas, and southward into South Mountain, which are underlain by bedrock. The areas underlain by bedrock are not susceptible to liquefaction. However, the area of the City underlain by unconsolidated alluvial sediments within the Santa Clara River Valley may be susceptible to liquefaction.

According to the United Water Conservation District (Dal Pozzo, 1997), the depth to groundwater in two locations within the boundaries of the City of Santa Paula, and in the Santa Clara River Valley, is less than 40 feet below ground surface (bgs). The depth to groundwater in the two wells monitored by the United Water Conservation District, Well #-03N21W16H08S and Well #03N21W15G05S, was last measured on January 23, 1997 as 31.59 feet bgs and 23.87 feet bgs, respectively. According to the City of Santa Paula Department of Public Works (Wilkinson, 1997), groundwater levels in the Santa Clara River Valley within the planning area are generally less than 40 feet below ground surface. Based on the depth to groundwater beneath the Santa Clara River Valley within the planning area, and on the Seismic Hazard

Mapping Act criteria, the entire alluvial basin may be susceptible to liquefaction. In areas where the subsurface sediments have a high clay content (greater than 15%) or are very coarse grained (containing cobbles or boulders), the susceptibility to liquefaction would be decreased.

Slope Stability Hazards (Landslides, Mud and Debris Flows, and Rock Falls). Landslides, debris and mud flows, and rock falls all occur within the planning area. All are manifestations of gravity driven flows of earth materials due to slope instability. Hill slopes naturally have a tendency to fail. Unless engineered properly, development in hillside areas tends to increase the potential for slope failures. Slope modification by grading, changes in the infiltration of surface water, and undercutting slopes can create unstable hill slopes, resulting in landslides or debris flows.

Much of the City of Santa Paula is comprised of topographically pronounced areas. These hill slopes and mountains predominantly consist of sedimentary rock outcrops that are locally covered with soil. Slope instability is of greatest concern in these topographically pronounced areas. The majority of landslide and slope wash problems in the Santa Paula area occur in geologic terraces involving folded sequences of claystone, siltstone, and sandstone. Within the planning area, the majority of the mapped landslides (Dibblee, 1990 and 1992) occur in the Pico and Sespe Formations, and the Topanga Sandstone. Landslides and potentially unstable slopes are especially common in hillside areas underlain by sedimentary bedrock of the Pico Formation. This formation is generally soft and crumbly and contains abundant clay and silt strata (City of Santa Paula, 1974).

Landslides. Naturally-occurring landslides are associated with steep slopes which have been undercut by erosion or on slopes where the bedding planes of the bedrock are inclined down the slope. The presence of subsurface water also contributes to slope instability. Ground shaking, due to an earthquake, can trigger movement in terrain already prone to landslides.

Several landslides in the area are depicted on geologic quadrangle maps for Santa Paula and Santa Paula Peak (Dibblee, 1990 and 1992). The largest landslides mapped in the planning area are prominent along the major fault zones: San Cayetano and Oak Ridge Faults. According to the CDMG (Open File Report No. 95-07, 1995), the largest, most extensive, landslides in the planning area are ancient composite rotational failures along anti-dip slopes on the north side of South Mountain and Oak Ridge. On the north slope of South Mountain, large composite landslides have occurred in interbedded sandstone and claystone of the Sespe and Vaqueros Formations, below a ridge top formed by a volcanic andesite sill and silicified sandstone. Smaller dip slope landslides/earth flows are present in the south-dipping Pico siltstone and coarser-grained Saugus Formation in the hillsides north of the City.

The Seismic Hazard Mapping Act discussed above also calls for the delineation of seismic hazard zones that identify areas of high potential for ground failures such as earthquake-induced landslides. The landslide hazard zone criteria, based on the Seismic Hazard Mapping Act criteria, is shown in Table S-A3 (CDMG, 1995).

Table S-A3. Landslide Zone Criteria

Strength Category*	Slope Category			
	0 to 25% (0 - 4:1)	25% to 50% (4:1 - 2:1)	50% to 67% (2:1 - 1.5:1)	> 67% (> 1.5:1)
A (strong)	low	low	low	high
B (moderate)	low	low	high	high
C (weak)	low	high	high	high

Source: State of California, Department of Conservation, Division of Mines and Geology, Special Publication 116, The Northridge, California, Earthquake of 17 January 1994, 1995.
**The Strength Category is based on the lithology, past performance, and structural features of geologic units identified on source maps.*

The Seismic Hazard Maps for the Santa Paula or the Santa Paula Peak Quadrangles have not yet been published by the CDMG as of the date of this report, but should be acquired by the City of Santa Paula upon publication and incorporated by reference, herein. A breakdown of the hillside areas, within a portion of the Santa Paula planning area, into landslide susceptibility categories can be found in the CDMG Open File Report No. 95-07 (1995).

Debris and Mud Flows. Debris and mud flows often occur after periods of precipitation. Water soaked soil and rock are destabilized by the weight of the water. Often compounding the added weight is erosion of the base of a hill slope. Once this slope becomes destabilized, the water, soil, and mud mass is driven downhill by gravity. Numerous mud and debris flows occurred during the very heavy rains of January 1969, especially north of the Santa Clara River Valley, between Santa Paula and Piru Creeks (Weber, 1973). Inhabited building structures at the bases of slopes are especially prone to destruction due to mud flows.

Debris flows most frequently occur during intense rainstorms of the wet season, on steep slopes underlain by poorly indurated sand and silty units of granular soils, and on moderate slopes where loose debris has accumulated in swales and gullies. Debris flows are abundant on steep slopes underlain by the Pico Formation in the planning area (CDMG, 1995). Most of the hillside terrain within the planning area has been identified by the CDMG as being the most susceptible to debris flows because:

- *The evidence of previous debris flows is common;*
- *Source hollows and swales were observed;*
- *The slopes are steeply inclined; and*
- *The appropriate source material is widespread.*

In general, the areas most susceptible to debris and mud flows correspond to the areas with a high potential for earthquake-induced landslides.

Rock Falls. Rock falls occur in virtually all types of rocks and especially on slopes steeper than 40°. Areas of primary risk from rock falls are those located at the base of steep, high slopes where rock outcrops (usually Saugus Formation, Conejo Volcanics, or Sespe Formation) are susceptible to dislodgment of large cobbles or boulders. These conditions are locally present along the northern and southern margins of the Santa Clara River Valley within the planning area. Rock falls are usually triggered by seismically-induced ground shaking or by erosional destabilization of a hill slope.

SOIL HAZARDS

Expansive Soils. Expansive soils are those that are characterized as having a high shrink-swell potential (Edwards, et. al., 1970). The shrink-swell potential of a soil refers to the change in volume resulting from a change in moisture content. Soils with high shrink-swell potential generally have a high clay content and shrink when dry and swell when wet. Expansive soils can cause considerable damage to building foundations, roads, and other structures. Soils with low shrink-swell potential are generally suitable for building sites if other geologic factors are also favorable.

Soils with a high clay content, and a moderate to high shrink-swell potential, can be derived from weathering and erosion of many different rock types. The chemical breakdown of certain minerals through the weathering process can produce a clay soil in an area underlain with bedrock. In the planning area zones of soil with a high shrink-swell potential, as described in the Soil Survey of Ventura County (Edwards, et. al., 1970), generally correspond with mapped outcrops of claystone, siltstone, and shale as mapped by Dibblee (1990 and 1992).

Settlement. Settlement is the downward movement of a soil or of the structure which it supports, resulting from a reduction in the voids in the underlying strata. Settlement can result from natural consequences such as accumulation of sediments (addition of weight) over porous alluvial soils within a river valley. Settlement can also result from human activities which include: improperly placed artificial fill, and structures built on two different soil and/or bedrock materials with different settlement rates. In addition, settlement can result from seismic ground shaking and/or liquefaction in naturally-occurring soils. Liquefaction is discussed in its own section in this report.

Inadequately emplaced fill material, if not compacted properly, can subside when a structure is built on the fill. It is important that fills be engineered so that the density and moisture of the material can be controlled. Controlling the density, moisture, and compaction of the fill material will reduce the possibility that the material will settle after development on the fill. Structures which are constructed partially on a cut pad (into bedrock) and partially on a fill pad may result in settlement problems and should be addressed during engineering design.

Settlement hazards can occur in areas with permeable alluvial deposits, where fill is improperly placed, and in areas where construction occurs across a cut/fill boundary. Areas of poorly consolidated sediments should be engineered to support the weight of a structure that is to be built on the site. In areas of fill, the fill should be compacted to adequately support the proposed development, and structures should not be placed partially on cut and partially on fill unless specifically designed by civil and structural engineers.

Subsidence. Subsidence is the decrease in volume of a material as the result of an increase in the density of a material. It is generally related to the withdrawal of fluids such as water, oil, and gas from the subsurface. When fluids are removed from the subsurface, the overburden weight, which the water had previously helped support through buoyant forces, is transferred to the soil structure. Subsidence typically occurs over a long period of time and results in a number of structural impacts. Facilities most impacted by subsidence are long, surface infrastructure facilities such as canals, sewers and pipelines.

The extraction of groundwater from an aquifer beneath an alluvial valley can result in subsidence, or settlement, of the alluvial soils. The factors which influence the potential occurrence and severity of alluvial soil settlement due to groundwater withdrawal include: degrees of groundwater confinement; thickness of aquifer systems; individual and total thickness of fine-grained beds; compressibility of the fine-grained layers; probable future depth of wells; and probable future decline in groundwater levels (City of Santa Paula, 1974).

According to the Ventura County Department of Water Resources (Panaro, 1997), groundwater is withdrawn from the Santa Paula Groundwater Basin from an unconfined aquifer within Quaternary alluvial sediments and the San Pedro Formation. The Santa Paula Groundwater Basin services approximately 13,504 acres, and the groundwater is utilized for irrigation, municipal and domestic supply. The aquifer within the Santa Paula Groundwater Basin is approximately 2,000 feet thick based on oil well logs, can potentially hold up to 4,915,000 acre-feet of water, and currently has an agreed upon initial allocation yield of 30,500 acre-feet (Brommenschenkel, 1997). The water demand for the City of Santa Paula, and its general service area, for 1990 was 6,500 acre-feet. Based on the conservative safe yield made by Dr. Mann in 1959, Santa Paula has a water supply large enough to support its current population and future development.

Oil extraction sometimes also results in overlying soil settlement or differential subsidence. The Santa Paula area has not had significant subsidence problems despite historical oil drilling in the area. According to the State of California Division of Oil and Gas (Fields, 1997), State regulations require subsidence studies in coastal areas where sea water intrusion due to oil extraction is an issue. Subsidence studies are generally not performed in inland areas.

Hydrocompaction. Hydrocompaction occurs in relatively loose, open textured soils above the groundwater table. Once water is introduced, whether by heavy irrigation or a rise in the water table, the soil loses strength and consolidates under its own weight. Hydroconsolidation typically occurs in desert environments and has been noted in some semi-arid regions of southern California.

FLOOD HAZARDS

Historic Flooding. Table S-A4 provides a listing of major flood events that have occurred in Ventura County over the previous 25 years.

Heavy water flows occurred on Santa Paula Creek in 1938, 1943, 1969, 1973, 1978 and 1980. The 1938 and 1943 floods caused Congress to authorize a flood protection project on Santa Paula Creek in 1948. Work on the flood protection project began in 1974, but was halted due to a court order stating that an insufficient environmental study was performed. The Corps of Engineers began work on the flood protection project again in 1994 (City of Santa Paula, 1994).

Table S-A4. Major Flood Events in Ventura County

Date	Comments
1973	State declared disaster
Feb. 9-10, 1978	Presidentially declared disaster
February 16, 1980	Presidentially declared disaster; 4-day storm event
March 1, 1983	Presidentially declared disaster; peak flow on record in Zone III
February 10-12, 1992	Presidentially declared disaster; 50-year flood event
January 10, 1995 and March 10, 1995	Presidentially declared disaster; 10-13 million dollars in damage from the combined storms

Source: County of Ventura, Flood Control Department

The 1969 and 1978 floods presented major threats to the City, as rock and debris completely filled in the channel of Santa Paula Creek. Five inches of rain fell on the City of Santa Paula within six hours in 1980. Fagan Barranca escaped its banks and flooded about 80 homes and covered 11 miles of street with mud (City of Santa Paula, 1994).

Flood Control and Prevention. Flood hazards may be alleviated through a variety of measures, some corrective and some preventive. Corrective measures include warning and relief programs, flood-proofing of existing structures, and the construction of flood control works. Preventive measures include public acquisition of flood plain lands, public information programs, development policies and regulations.

Flood control prevention is the responsibility of the Ventura County Flood Control District. The Flood Control District has the authority to maintain and construct flood control facilities on all major channels, including Santa Clara River, Santa Paula Creek, Adams Barranca, Fagan Barranca, Todd Lane, and Peck Road. The network of tributary storm drain trunks and laterals that collect and convey surface water from the urban areas to the major channels is the responsibility of the City of Santa Paula Public Works Department (City of Santa Paula, 1994).

On the Federal level, the regulations of the National Flood Insurance Program (NFIP), which is administered by the Federal Insurance Administration (a component of the Federal Emergency Management Agency), require that communities adopt land use restrictions for the 100-year flood plain in order to qualify for Federally-subsidized flood insurance. The program requires that residential structures be elevated above the level of the 100-year flood and that other types of structures be floodproofed. The NFIP was established by Congress with the passage of the National Flood Insurance Act of 1968. The NFIP was broadened and modified with the passage of the Flood Disaster Protection Act of 1973 and other legislative measures.

To provide for early flood warning, the Ventura County Flood Control District has been operating an automated flood warning system since 1979. The system is known as "ALERT" (Automated Local Evaluation in Real Time) and was developed by the National Weather Service in Sacramento, California. The system is comprised of self reporting rain gages and stream gages that collect data and transmit signals to a flood warning center computer system located in the County Government Center Administration Building in Ventura. Operators of the system compare rainfall forecasts with the runoff forecasts from the hydrologic models and notify proper authorities in threatened areas to initiate evacuation warnings as appropriate. In the Santa Paula area, self reporting stations are located at Santa Paula Creek near Steckel Park (stream level and precipitation) and at Fagan Canyon near Main Street (stream level and precipitation) (Kane, 1997).

Potential Inundation Due to Dam Failure. The State of California has been responsible for supervising dams since August 14, 1929 for the purpose of safeguarding life and protecting property (California Department of Resources, 1995). The legislation was enacted following the failure of St. Francis Dam in March 1928. St. Francis Dam was located in San Francisquito Creek, a tributary to the Santa Clara River, located east of the City of Santa Paula and north of the City of Santa Clarita. In 1965, legislation was revised to include off stream storage reservoirs as a result of the failure of Baldwin Hills Reservoir in December of 1963. In March 1973, Senate Bill 896 was adopted by the State of California amending the Government Code. This law required dam owners, under the direction of the Office of Emergency Services, to show the possible inundation below their dam in the event of a failure.

FIRE HAZARDS

Causes and Origins of Wildland Brush Fires. The vegetation found within the City of Santa Paula boundaries include agricultural and riparian vegetation. In the hillside areas of the Santa Paula planning area, vegetation includes riparian, grassland, chaparral, oak woodland, and coastal sage shrub. The hillside vegetation, primarily the chaparral and coastal sage shrub, provides a major source of fire fuel. These vegetative associations contain many species of plants considered pyrophytic, plants which need the heat of the fire to germinate their seeds for reproduction. When these vegetation systems are burned over by a brush fire, the existing ground cover is destroyed, but in many cases the plant association survives and is actually improved by this means of natural selection.

The climate of the region is one of the critical factors influencing the occurrence and severity of brush fires. The hot dry summers leave the area hillsides susceptible to a major fire. During the early fall, periods of "Santa Ana" winds occur, caused by a local weather phenomenon of a low pressure system developing off the coast while a high pressure system settles over the inland desert areas. The result is the hot dry winds which pour over the mountain areas into the Santa Clara River Valley aggravating the potential fire threat in the high brush areas already dried out by the summer heat. Nearly 90 percent of the large Southern California fires documented over the last 73 years have occurred between September and December, during the Santa Ana season (Crosby, 1992).

Brush fires are often caused by man, either intentionally or unintentionally. Continued urbanization of the flat lands within the valleys has put increasing pressure on the development of hazardous brush covered hillsides. The longer a brush area goes without burning, the older dry, dead materials and the new plant growth constitute potentially a more volatile fuel source. These fuel sources are usually then ignited by man, either directly through arson or careless action, or indirectly through accidents such as sparks from engine exhaust, falling power lines, etc. Natural causes are now relatively minor causes of brush fires. Man is the primary agent in this natural cycle of fire.

Santa Paula Fire Department Response. The SPFD responded to 1,456 incidents in the City of Santa Paula in 1996. Emergency medical aid responses were 978, comprising 67% of the total incidents. Fire services consisted of that specified in Table S-A5.

Table S-A5. Fire Incident Activity Summary - 1996, Santa Paula

Fires/Incidents	Number of Incidents	Dollar Loss
Structures	19	$127,125
Vehicles	38	86,000
Smoke Checks	49	0
Vegetation	28	200
Refuse	28	1,150
Public Service	82	0
False Alarms	106	0
Hazmat/Spills	27	2,000
Aircraft	2	0
TOTAL FIRES	379	3,668
Emergency Medical	978	0
Vehicle Accidents	36	0
Other Calls	63	0
TOTAL INCIDENTS	1,456	$217,400

Source: Santa Paula Fire Department, April 14, 1997

Some cities within Ventura County have chosen to contract with the Ventura County Fire Protection District for fire protection services. The Ventura County Fire Department's Battalion 51 has two fire stations located in the Santa Paula area:

- *Summit Fire Station, 12727 Santa Paula-Ojai Road, Santa Paula, California 93060; and*
- *Saticoy Fire Station, 12391 West Telegraph Road, Santa Paula, California 93060.*

The SPFD has a number of mutual aid agreements with other fire departments and services agencies within Ventura County. If the resources of these departments/agencies are depleted, assistance can also be obtained through various state agencies including Office of Emergency Services, the Department of Forestry and Fire Protection, the State Fire Marshall, and the Department of Fish and Game; and various Federal agencies including the U.S. Forest Service, the National Park Service and Bureau of Land Management, and the Department of Defense. Urban fire hazard abatement is discussed in this section and Wildland fire hazard abatement is discussed in the following section.

Existing Fire Stations. The SPFD currently operates two fire stations. The SPFD maintains a 5-minute response goal for any incident within the City. Table S-A6 provides a summary of the local fire station's capabilities (personnel and equipment).

The Santa Paula Fire Department is a combination full time/part time department providing fire suppression and emergency medical services as well as fire prevention and business hazardous materials regulation functions within the City. There are eight full time personnel, consisting of a Fire Chief, Assistant Chief, three Captains and three Engineers, and 27 part time

Table S-A6. Santa Paula Fire Department Station Capabilities

Station No.	Year Built	Location	Personnel	Equipment
1	1935	114 South 10th Street	1 Captain* 1 Engineer* 1 part-time firefighter 20 part-time, paid/ call personnel	Engine #1 (1954 Mack Pumper) Engine #6 (1988 Ford Pierce Pumper) Truck (1986 Ford Pierce Pumper with 50 ft aerial ladder) One Utility Pick Up Truck
2	1988	536 West Main Street	7 part-time, paid/ call personnel	Engine #3 (1970 Ward LaFrance Pumper) One sedan car

Source: City of Santa Paula Fire Department, April 1997
** Three each full time, work on a 24-hour rotating shift system*

paid/call personnel, consisting of four Captains, four Engineers, and 19 firefighters. There are two volunteer Chaplains. Administration and Prevention offices are at the Community Development Building. Routine fire, medical and other calls are handled by the on-duty engine company, which consists of a Captain and an Engineer on a rotating 24-hour shift system. They are supplemented by the Chief and Assistant Chief during weekday business hours and during the evenings and weekends by a third crew member scheduled from among the part time personnel. All available part time personnel are dispatched to emergencies that require more than the duty engine company. According to the Fire Chief, the average number of part time, paid/call personnel responding to typical daytime fire emergencies in 1993 was between 14 to 20.

In 1995 six full-time firefighting positions were created and Fire Station 1 is now staffed 24-hours a day with one Captain, one Engineer, and (in the evenings, weekends and holidays) a part-time firefighter. This alleviated most of the problems related to part time, paid/call personnel response time to fire emergencies. It has also been suggested by the SPFD that another fire station be opened on Ojai Road above Mill Park to take advantage of the closer availability of firefighters who live in that area. In addition, funding and staffing a one 3- or 4-man engine company on a 24-hour basis using a combination of full time and part time personnel at Station 2 has been recommended (Skeels, 1997), particularly in the event of annexation and development of the Adams Canyon area. It may also be appropriate to locate and staff a fire station within Adams Canyon.

Station 1, referenced in Table S-A6, was constructed prior to the enactment of strict seismic structural codes and is of masonry construction. However, according to the SPFD (Skeels, 1997), the engine room of Station 1 was seismically upgraded in 1987, and has recently been remodeled to include upgraded office space and living quarters for firefighters. Fire stations are considered critical facilities that must be functional in the event of an earthquake or other disaster to minimize loss of life and property damage.

Historic Brush Fires. Table S-A7 provides a summary of brush fires which have occurred in the Santa Paula planning area since 1936. The 1985 Ferndale fire, and the 1993 Steckel fire, burned through all of Adams Canyon. Large uncontrolled fires occur on a regular basis in the South Mountain area (City of Santa Paula, 1994).

Effects of Brush Fires. The principal effects of brush fires include loss of vegetative ground cover, increased erosion, loss of building structures, loss of utilities, and loss of life. Loss of the vegetative ground cover results in damage to valuable recreational and open space area. Many of the plant and animal associations in the natural communities have adapted themselves to a fire-climax cycle, and will naturally generate themselves through fire. Hence, they themselves may not be permanently impacted.

Loss of vegetative cover results in secondary erosional impacts, especially in steeply sloped hillside areas. When a slope is burned over by a fire of intense heat, a chemical reaction in the soil takes place which makes it less porous. As the rains of winter come, rain water runs off and causes mudslides and mudflows. Properties not affected directly by the fire may be damaged or destroyed by the effects of increased runoff due to brush fire.

Table S-A7. Historic Brush Fires Near Santa Paula (1936-1993)

Name	Origin (Quadrangle)	Date Started	Acres Burned
Boosey	Santa Paula Peak	1/26/36	900
La Questa	Santa Paula Peak	11/23/38	1,682
Edwards	Santa Paula Peak	11/22/39	4,450
Mud Creek	Santa Paula Peak	12/10/51	500
Culbert	Santa Paula	12/4/62	5,525
Santa Paula Canyon	Santa Paula Peak	12/4/62	1,941
Sespe Ranch	Santa Paula	10/15/67	17,431
Timber Canyon	Santa Paula Peak	10/16/67	11,450
Sespe Ranch	Santa Paula	12/16/71	2,925
Sespe Ranch	Santa Paula	9/26/73	1,008
South Mountain	Santa Paula	11/13/75	6,500
South Mountain	Santa Paula	10/29/80	3,600
Loma	Santa Paula	6/15/81	1,331
Mupu	Santa Paula Peak	7/4/85	28
Ferndale	Santa Paula Peak	10/14/85	47,064
Ferndale	Santa Paula	10/21/85	45,710
Lloyd Butler RX Burn	Santa Paula	9/30/86	600
Bradley	Santa Paula	11/10/86	9,027
South Mountain	Santa Paula	10/8/90	714
Steckel	Santa Paula	10/27/93	26,500

Source: Ventura County Fire Department

The loss of man-made improvements in the brush covered areas constitute most of the dollar loss from fires. Losses along this line include homes, barns and sheds, utility lines and facilities. The loss of valuable watershed area combined with the actual suppression costs also are major determinants of the total dollar costs of any fire. The potential for loss of life is the most dangerous aspect of brush fires. Occasionally, trapped residents are injured or killed when there is no warning of the impending disaster, or when they simply refuse to evacuate their homes in the face of the fire. Unfortunately, the largest loss of life occurs to the professional fire fighters who are killed while fighting brush fires, which have a highly unpredictable nature, or in other accidents during the support operations necessary to suppress the fire. Fortunately, there have been no serious injuries or deaths in the brush fires that have come into Santa Paula.

As the population of California cities continue to grow, more and more people are encroaching on what firefighters call the urban/wildland interface, the perimeter of urban areas adjacent to wildlands. According to California Department of Forestry and Fire Protection (CDF) statistics, since 1980 more than 5,000 structures have been damaged in wildland fires, triple the amount of damage that occurred in the previous 15 year period. Some of the more recent devastating examples of this phenomenon include:

Santa Barbara: Painted Cave Fire of June 1990 which swept across almost 5,000 acres of coastal hillsides, destroying more than 600 houses.

Oakland/Berkeley: 1991 fire covering over 1,600 acres, decimated entire neighborhoods, killing 25 people, destroying 2,900 homes, and leaving more than $1.5 billion in property damage.

Malibu to Laguna Beach: a series of fires in the fall of 1993 which killed three people and destroyed over 1,000 homes.

Fire Hazard Reduction. Experienced firefighters believe they can no longer protect homes and lives as well as they did in the past with fuel loading causing such catastrophic fires (Gilmer, 1994). It is up to the homeowners living on the urban/wildland interface to establish defensible space. Defensible space describes a band of managed vegetation around a home which stops the movement of fire by denying fuel. The Fire Department does not recommend indiscriminate clearing of native chaparral and other vegetation. Natural vegetation plays an important role in erosion control. The goal is to obtain a balance between fire hazard reduction and erosion control. Defensible space also provides a place where fire fighters can do their jobs without unnecessary risk to themselves. According to the CDF, as many as 80 percent of the homes lost to wildfires in the past could have been saved if the owners had followed a few simple fire safe practices. Some of these fire safe practices include the following:

- *Use fire resistant landscaping. Fire resistant plants are those with low growth habit (generally less than 18 inches in height), low fuel volume, and high moisture content. Such plants offer far less fuel than upright woody shrubs.*

- *Irrigate and maintain landscaping. A fire resistant plant will lose this quality if allowed to dry out. Maintenance insures the effectiveness of the fire resistant landscape by retaining proper spacing between plants and removing dead/dry vegetation.*

- *Have a fire-retardant roof. Untreated wood shake roofs provide fuel for an advancing fire. Class A roofs provide the most protection. These include: clay tile, concrete tile, fibrous cement shake, metal tile, and fiberglass composition shingles.*

The County Fire Protection District has developed a Fire Hazard Reduction Program with the goal of preventing the loss of life and property due to uncontrolled wildfire in the urban/wildland interface through the cooperation of the property owners of Ventura County (Ventura County Fire Protection District). The stated objectives of the Fire Hazard Reduction Program are to:

1. *Reduce significantly the incidence of destructive fires in the urban/wildland interface areas, and the resulting loss of life and property.*
2. *Provide a defensive perimeter around urbanized areas of the Fire District.*
3. *Provide for the protection of structures in the urban/wildland interface by establishing and maintaining a 100 foot defensible perimeter around each structure.*
4. *Provide for the removal of annual fuels within the defensive perimeter.*
5. *Provide any fire suppression resource from any agency the opportunity to successfully protect structures and other valuable properties during a wildfire threat.*
6. *Protect the watershed fire areas from exposure to structure fires in the urban/wildland interface areas.*

The Fire Hazard Reduction Program strives to establish defensive barriers in the urban/wildland interface in preparation for the annual onslaught of wildfire. Hazardous vegetation is at its peak growth in the spring and fall seasons. An inspection program has been developed that targets hazard reduction in the spring and fall months. Within the 100 foot defensible perimeter, all brush, flammable vegetation, or combustible growth identified as a fire hazard by an inspecting officer is required to be mowed or cut to a stubble height not to exceed 3 inches. All cuttings are required to be removed from the property. Single specimens of trees, ornamental shrubbery or ground covers are permissible provided that they do not form a means of rapidly transmitting fire from the native growth to any structure. Other specific clearance requirements pertain to roof surfaces, chimneys, propane tanks, access roads, and vacant parcels and are specified within the Fire Hazard Reduction Program guidelines.

The Santa Paula Fire Department has its own Fire Hazard Reduction Program, and has required that the weed abatement and vegetation management programs be followed for new developments in high fire risk areas. However, some questions regarding the effectiveness of these programs, for new developments in canyons and on hillsides, in minimizing the risk of loss of life or property from wildland fires still need to be addressed. The Santa Paula Fire Department should be consulted when new development plans are being considered for canyon and hillside areas within the Santa Paula planning area.

The best defense against disastrous fires affecting the urban/wildland interface is a working partnership between developers, property owners, their neighbors, the Ventura County Fire

Department, and the Santa Paula Fire Department. More detailed information pertaining to defensible space strategies and other fire hazard reduction approaches can be obtained from the Santa Paula Fire Department.

HAZARDOUS MATERIALS

More than 60,000 chemicals are produced in the United States. Over 11,000 of these chemicals are used for commercial purposes. Within the County of Ventura, over 5,000 manufacturing and service industries use or store hazardous materials, including pesticides, acids, caustics, solvents, and heavy metals (County of Ventura, 1989). Because of the widespread use of hazardous materials in our communities, minor and major hazardous materials spills and incidents occur. Most of these incidents are related to the increasing transport of chemicals over roadways or through industrial accidents. SR 126 and SR 150 are major transportation corridors through Santa Paula.

In an effort to reduce impacts associated with a hazardous material incident, Ventura County has developed a Hazardous Materials Emergency Response Plan. The goal of the plan is to protect life, property, and the environment from the effects of a hazardous material release to air, land or water or a hazardous material fire. Procedures to be used in the event of an incident and specific agency responsibilities are identified within the plan. The Plan is activated by the designated Incident Commander at the scene. Depending on the nature of the incident, this could be either the appropriate law enforcement authority (City of Santa Paula Police Department, Ventura County Sheriff's Department or California Highway Patrol) or the SPFD.

The County Hazardous Materials Emergency Response Plan is supplemented by individual Business Plans for businesses/facilities that store or handle hazardous materials and wastes. Under Chapter 6.95, section 25503 of the California Health and Safety Code, Business Plans are required from California businesses that handle a hazardous material in quantities equal to or greater than the following:

- *55 gallons of a liquid;*
- *500 pounds of a solid;*
- *200 cubic feet of a compressed gas; or*
- *Extremely hazardous substances above Federal threshold reporting quantities*

As part of the Business Plan, emergency response plans and procedures must be developed and training sessions must be provided to employees. Businesses are periodically inspected by local administering agencies (Santa Paula Fire Prevention Bureau) to ensure that handling, storage, and waste disposal practices conform with appropriate laws and regulations.

According to the Santa Paula Fire Department (Araiza, 1997), 100 businesses use or store hazardous materials in the City of Santa Paula (Table S-A8). These businesses include gasoline stations, automotive repair facilities, dry cleaners, agricultural facilities, crude oil pipelines and facilities, and miscellaneous commercial and industrial facilities. Industrial use of hazardous materials is centered in the downtown Santa Paula area. Many of the commercial businesses that store or use hazardous materials are located on Main Street or Harvard Boulevard. Specific information regarding the location of businesses and types and quantities of hazardous substances used or stored can be obtained through the Santa Paula Fire Department.

Table S-A8. Number of Businesses and Facilities that Use/Store Hazardous Materials by Street Name

Street Name	Number of Businesses
10th Street	7
Corporation Street	7
Harvard Boulevard	20
Main Street	23
Quail Court	7
Santa Maria Street	6
Santa Paula Street	5
Streets with Five or Fewer Businesses	32
Total	107

Source: Santa Paula Fire Prevention Bureau, personal communication, Assistant Chief Rick Araiza, 1997

Only one facility uses or stores acutely hazardous materials within the City of Santa Paula: Baker Performance Chemicals located at 265 Quail Court. Extremely hazardous wastes (or materials) are defined by California HWCL as any hazardous waste or mixture of hazardous wastes which, if human exposure should occur, may likely result in death, disabling personal injury or serious injury because of its quantity, concentration, or chemical characteristics.

In addition to traffic related incidents, hazardous materials spills could be caused by ground shaking associated with a large earthquake or other soil related hazards (landslide, debris flow, liquefaction, etc.). As discussed in Section IIA, peak horizontal ground accelerations of 0.64 g and Modified Mercalli Intensities of VIII-IX could cause major structural damage to facilities using hazardous materials. Hazardous material containers not properly secured could be felled and/or ruptured. Improperly segregated materials could result in toxic or explosive reactions.

AIRCRAFT HAZARDS

Based upon the Airports Comprehensive Land Use Plan Update for Ventura County (VCTC, 1991), the Ventura County Transportation Commission is also the Airport Land Use Commission (ALUC) for the County, including Santa Paula Airport. The purpose of the ALUC is to "formulate a comprehensive plan that will provide for the orderly growth of each public airport and the area surrounding the airport within the jurisdiction of the commission" (Public Utilities Code Section 21675). The ALUC comprehensive plan includes protecting public health, safety, and welfare. The ALUC prepared an updated Airports Comprehensive Land Use Plan (CLUP) for the four airports in Ventura County, including Santa Paula Airport.

The California Department of Transportation (Caltrans) Division of Aeronautics maintains an Airport Land Use Planning Handbook that addresses airport land use compatibility issues such as aircraft accident characteristics and safety compatibility. Caltrans provides suggestions to the ALUC in forming local policies. The ALUP designated Airport Safety Areas, for Santa

Paula Airport, extending from the runway as a basis for determining land use compatibility. The Airport currently serves private passenger aircraft.

OIL WELLS AND OIL SUMPS

Existing Operations. The source for local oil regulations is the City of Santa Paula Municipal Code No. 5.40, *Santa Paula Oil Code*. The following is a brief overview of the procedures required to drill and abandon oil wells.

Permits. A permit from the County of Ventura must be obtained for drilling a new well or re-entering a well previously abandoned, prior to commencing said operation within the planning area.

Well Spacing. No well shall be located within 1090 feet of any building used for human occupancy, nor shall any such building be erected within 100 feet of any well not abandoned, except buildings incidental to the operation of the well. According to the City of Santa Paula Municipal Code Section 5.40.070, well location shall be in accordance with the requirements of the state and the zoning ordinance of the City.

Storage Tanks. Tanks shall be constructed and maintained so as to prevent leakage. Diversion walls or drains safely directing any escape of fluids to catchment basins, to impounding basins formed by impervious dikes around tanks or groups of tanks, or combinations thereof, shall be constructed. The net capacity of a catchment basin or dike impounding basin, shall be equal to the capacity of the largest tank, plus six inches of freeboard.

Any new crude petroleum storage facilities, incidental to a producing well, shall not exceed a storage capacity of 2,000 barrels per well. The minimum distances between aboveground tanks for storing flammable liquids other than crude petroleum, and for storing crude petroleum, to the line of adjoining property which may be built upon are specified in the City of Santa Paula Municipal Code Section 5.40.130.

Fire Prevention. The Uniform Fire Code and the City of Santa Paula Fire Code applies to all aspects of oil well operations. This includes, but is not limited to, no smoking within 50 feet of any well, tank, or area where hydrocarbons are present. The City of Santa Paula Fire Department should be notified when an oil drilling permit has been filed. The code requires that a minimum of two fire extinguishers be maintained at all oil well locations where drilling, servicing, or repair work is being conducted.

Abandonment Procedures. Abandonment of oil wells shall include the following procedures:

1. *A copy of the Division of Oil and Gas "Notice of Intention to Abandon" furnished by the Division of Oil and Gas is mailed to the City;*
2. *The well has been abandoned in accordance with the requirements of the Division of Oil and Gas;*

3. *The site has been cleared of all drilling or producing equipment and left in a clean condition, which shall include draining and backfilling of any sump used in connection with the well and removal of concrete, pipe and other foreign materials from the surface of the ground, and the surface of the land, insofar as practicable, left in a neat and orderly condition; and*
4. *The City shall have inspected and certified in writing that such well has been properly abandoned in accordance with the provisions of the Santa Paula Municipal Code, Chapter 5, Section 5.40.080.*

Hazardous Conditions. In the event that the City of Santa Paula and/or the State Supervisor of Oil, Gas and Geothermal Resources determines at any time that any well heretofore or hereafter drilled, or other operations covered by the ordinances, is endangering any fresh water body or strata, or that any oil field construction, improvement, or operation constitutes a safety hazard, or a substantial nuisance to the public, the City of Santa Paula and/or the State Supervisor of Oil, Gas and Geothermal Resources shall have the right to compel the operator to make such modifications as may be required to correct such condition.

Equipment and appurtenances hazardous to life or limb shall either be attended 24 hours a day, or enclosed, in all inhabited, urban, or common places of public use areas where there is a reasonable likelihood of potential danger to persons. Perimeter enclosures shall conform to the fencing requirements satisfactory to the City of Santa Paula. There shall be at least one gate which is of sufficient width to give access to fire vehicles. The gate shall be locked at all times when the property is unattended and a key or combination shall be made available to the City of Santa Paula.

Sumps. Most oil wells had associated oil sump areas where waste fluids and oil were deposited. In the past, these oil sumps were buried and not removed. Placement of structures over these areas could force the oil and waste fluids to the surface and will also contaminate the soil. As part of the discretionary review process, the City should require a Phase I Environmental Site Assessment for all properties that have the potential to contain an oil sump as defined as follows:

- *All sites that contain an existing or abandoned oil well;*
- *All sites within the area of known oil drilling operations as shown on the State of California Division of Oil, Gas and Geothermal Resources Maps.*

However, if a clearance letter from the State of California Division of Oil, Gas and Geothermal Resources and/or the State Regional Water Quality Control Board is provided, a Phase I Environmental Site Assessment should not be necessary unless further evidence of soil contamination is discovered.

The Phase I Environmental Site Assessment shall contain, at minimum, a description of the study area, a past and present land use analysis, and the general field observations of the site to determine the level of contamination on the site. If the Phase I Environmental Site Assessment indicates a presence of soil contamination or oil sumps, detailed soil testing should be conducted and a report should be prepared that identifies the extent of the contamination and the appropriate remediation techniques. The soils report shall be submitted prior to acceptance of applications as complete applications.

The City should require that all oil sumps or contaminated soil that is discovered be remediated in accordance with State and County procedures. The State Regional Water Quality Control Board has the primary responsibility for overseeing the remediation process.

Previous Operations. Prior to the enactment of the City of Santa Paula Municipal Code Section 5.40.080 in 1981, oil wells and associated facilities and sumps may not have been abandoned in accordance with current regulations. Improperly abandoned wells, improperly abandoned facilities, and improperly abandoned oil sumps all are potential sources of safety hazards.

CRITICAL FACILITIES

New hospitals are required to undergo stringent design and construction standards in conformance with the Hospital Act of 1972. This legislation was enacted following the 1971 San Fernando Earthquake of Southern California in which several hospitals in the vicinity of the epicenter were seriously damaged and unable to continue functioning during a critical period. These newer standards are considerably more stringent than standards in place prior to 1972.

LIFELINE FACILITIES

Electrical. The City of Santa Paula is supplied electrical power by Southern California Edison. Substations are the most vulnerable component of the electrical power delivery system. Transformers, switches, circuit breakers, control equipment, and high-voltage porcelain insulators are especially susceptible to high-frequency ground motions which can be generated in earthquakes. A substation can be disabled by seismic intensities as low as VII (Toppozada, 1988).

If damaged during an earthquake, sections of the City may be without power. Critical facilities such as hospitals, the Police Station and Fire Stations can function on backup generators. If only limited electrical service can be restored following a disaster, these facilities should be given priority.

Lack of electrical power can also impair designated evacuation centers, communication facilities, and water distribution systems. Evacuation centers that will most likely be used during a disaster and emergency communication facilities should be equipped with backup power systems. Much of the water supplied to the City of Santa Paula and to fire hydrants is pumped electrically from groundwater wells. A backup power source for groundwater pumps, or gravity-fed water distribution systems, should be incorporated into City-wide, fire suppression emergency programs.

Natural Gas and Oil. Natural gas is supplied to the City by Southern California Gas Company through major distribution lines (6" to 12"). Numerous crude oil pipelines traverse the Santa Paula planning area and within the City limits. The pipelines in the northern planning area are operated by Unocal, those within the City limits are operated by Unocal, Shell, Texaco, and Four Corners Pipe Line Company, and those in the southern portion of the planning area are operated by Unocal, Shell, and Texaco. Crude oil pipelines are typically buried within the upper 5 feet and are equipped with emergency shut off valves. These pipelines could potentially be damaged in an earthquake, resulting in disruption of service and contamination of surface waterways, soil, and underlying groundwater.

Water. The City of Santa Paula supplies water to the City through the pumping of groundwater from the Santa Paula Groundwater Basin. The groundwater is pumped electrically to water tanks and fed by gravity to the City for municipal supply. There are also private groundwater wells utilized for agriculture and domestic supply.

Water distribution lines could be damaged in an earthquake as a result of liquefaction. Breaks in water distribution pipelines could result in disruption of service, loss of pressure, and localized flooding and associated impacts (erosion, sinkholes, etc.). A lack of adequate water pressure could result in inadequate flow for fire suppression. In addition, if electrical service was terminated due to an earthquake, the electrically-operated pumps in the groundwater wells would not operate. The issue of an electrical outage is discussed in the electricity section above. Additional information pertaining to fire suppression is provided in the technical background in the appendix of this document.

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