Section 7: Earthquakes

Why Are Earthquakes a Threat to the Temple City?

The most recent significant earthquake event affecting Southern California was the January 17th 1994 Northridge Earthquake. At 4:31 A.M. on Monday, January 17, a moderate, but very damaging earthquake with a magnitude of 6.7 struck the San Fernando Valley. In the following days and weeks, thousands of aftershocks occurred, causing additional damage to affected structures.

Fifty-seven people were killed and more than 1,500 people seriously injured. For days afterward, thousands of homes and businesses were without electricity; tens of thousands had no gas; and nearly 50,000 had little or no water. Approximately 15,000 structures were moderately to severely damaged, which left thousands of people temporarily homeless. 66,500 buildings were inspected, nearly 4,000 were severely damaged, and over 11,000 were moderately damaged. Several collapsed bridges and overpasses created commuter havoc on the freeway system. Ground shaking caused extensive damage, but earthquake triggered liquefaction and dozens of fires also caused additional severe damage. The extremely strong ground motion in large portions of Los Angeles County resulted in record economic losses.

However, the earthquake occurred early in the morning on a holiday. This circumstance considerably reduced the potential effects. Many collapsed buildings were unoccupied, and most businesses were not yet open. The direct and indirect economic losses ran into the 10's of billions of dollars.

Historical and geological records show that California has a long history of seismic events. Southern California is probably best known for the San Andreas Fault, a 400-mile long fault running from the Mexican border to an offshore point west of San Francisco. “Geologic studies show that over the past 1,400 to 1,500 years large earthquakes have occurred at about 130 year intervals on the southern San Andreas fault. As the last large earthquake on the southern San Andreas occurred in 1857, that section of the fault is considered a likely location for an earthquake within the next few decades.”[c]

But San Andreas is only one of dozens of known earthquake faults that criss-cross Southern California. Some of the better-known faults include the Newport-Inglewood, Whittier, Chatsworth, Elsinore, Hollywood, Los Alamitos, and Palos Verdes faults. Beyond the known faults, there are a potentially large number of “blind” faults that underlie the surface of Southern California. One such blind fault was involved in the Whittier Narrows earthquake in October 1987.

Although the most famous of the faults, the San Andreas, is capable of producing an earthquake with a magnitude of 8+ on the Richter scale, some of the “lesser” faults have the potential to inflict greater damage on the urban core of the Los Angeles Basin. Seismologists believe that a 6.0 earthquake on the Newport-Inglewood would result in far more death and destruction than a “great” quake on the San Andreas, because the

San Andreas is relatively remote when compared to the urban centers of Southern California.

For decades, partnerships have flourished between the United States Geological Survey, California Institute of Technology, the California Geological Survey and universities to share research and educational efforts with Californians. Tremendous earthquake mapping and mitigation efforts have been made in California in the past two decades, and public awareness has risen remarkably during this time. Major federal, state, and local government agencies and private organizations support earthquake risk reduction, and have made significant contributions in reducing the adverse impacts of earthquakes. Despite the progress, the majority of California communities remain unprepared because there is a general lack of understanding regarding earthquake hazards among Californians.

To better understand the earthquake hazard, the scientific community has looked at historical records and accelerated research on those faults that are the sources of the earthquakes occurring in the Southern California region. Historical earthquake records can generally be divided into records of the pre-instrumental period and the instrumental period. In the absence of instrumentation, the detection of earthquakes is based on observations and felt reports, and is dependent upon population density and distribution.

Since California was sparsely populated in the 1800s, the detection of pre-instrumental earthquakes is relatively difficult. However, two very large earthquakes, the Fort Tejon in 1857 (7.9) and the Owens Valley in 1872 (7.6) are evidence of the tremendously damaging potential of earthquakes in Southern California. In more recent times two 7.3 earthquakes struck Southern California, in Kern County (1952) and Landers (1992).

The damage from these four large earthquakes was limited because they occurred in areas, which were sparsely populated at the time they happened. The seismic risk is much more severe today than in the past because the population at risk is in the millions, rather than a few hundred or a few thousand persons.

History of Earthquake Events in Southern California

Since seismologists started recording and measuring earthquakes, there have been tens of thousands of recorded earthquakes in Southern California, most with a magnitude below three. No community in Southern California is beyond the reach of a damaging earthquake. Table 7-1 describes the historical earthquake events that have affected Southern California.

Table 7-1. Earthquake Events in the Southern California Region

Southern California Region Earthquakes with a Magnitude 5.0 or Greater	
1769 Los Angeles Basin	1916 Tejon Pass Region
1800 San Diego Region	1918 San Jacinto
1812 Wrightwood	1923 San Bernardino Region
1812 Santa Barbara Channel	1925 Santa Barbara
1827 Los Angeles Region	1933 Long Beach
1855 Los Angeles Region	1941 Carpenteria
1857 Great Fort Tejon Earthquake	1952 Kern County
1858 San Bernardino Region	1954 W. of Wheeler Ridge
1862 San Diego Region	1971 San Fernando
1892 San Jacinto or Elsinore Fault	1973 Point Mugu
1893 Pico Canyon	1986 North Palm Springs
1894 Lytle Creek Region	1987 Whittier Narrows
1894 E. of San Diego	1992 Landers
1899 Lytle Creek Region	1992 Big Bear
1899 San Jacinto and Hemet	1994 Northridge
1907 San Bernardino Region	1999 Hector Mine
1910 Glen Ivy Hot Springs	

Source:http://geology.about.com/gi/dynamic/offsite.htm?site=http%3A%2F%2Fpasadena.wr.usgs.gov%2Finfo%2Fcahist_eqs.html

Causes and Characteristics of Earthquakes in Southern California

EARTHQUAKE FAULTS

A fault is a fracture along between blocks of the earth's crust where either side moves relative to the other along a parallel plane to the fracture.

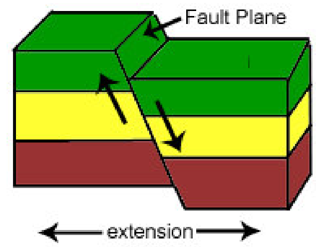


Figure 7-2. Earthquake Fault

STRIKE-SLIP

Strike-slip faults are vertical or almost vertical rifts where the earth's plates move mostly horizontally. From the observer's perspective, if the opposite block looking across the fault moves to the right, the slip style is called a right lateral fault; if the block moves left, the shift is called a left lateral fault.

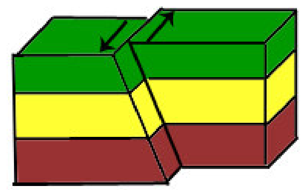


Figure 7-3. Strike-slip fault

DIP-SLIP

Dip-slip faults are slanted fractures where the blocks mostly shift vertically. If the earth above an inclined fault moves down, the fault is called a normal fault, but when the rock above the fault moves up, the fault is called a reverse fault. Thrust faults have a reverse fault with a dip of 45 ° or less.

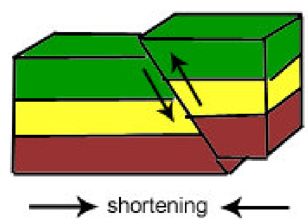


Figure 7-4. Dip-slip fault

OBLIQUE-SLIP

Oblique-slip faulting suggests both dip-slip faulting and strike-slip faulting. It is caused by a combination of shearing and tension of compress ional forces.

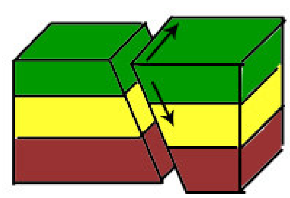


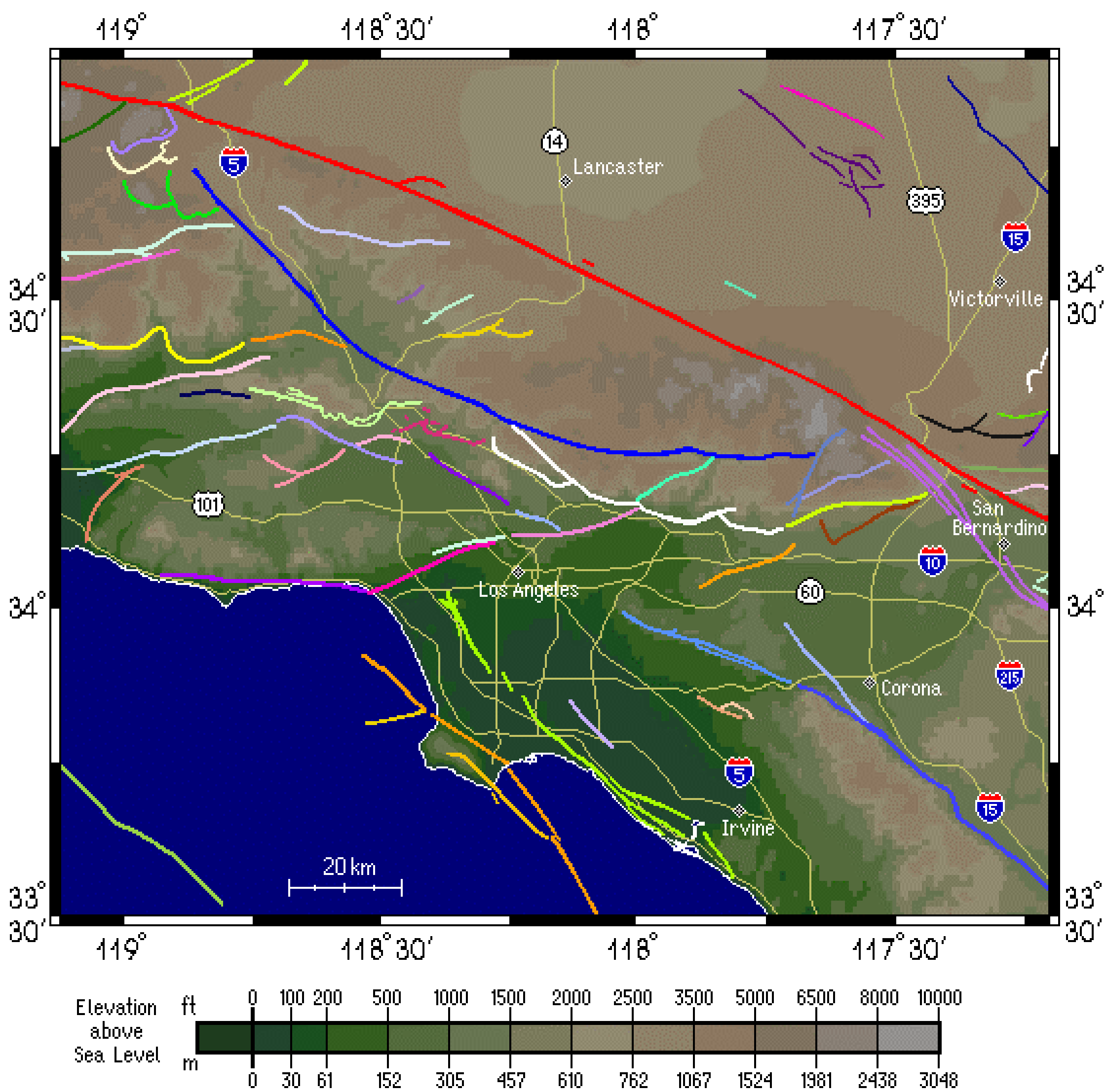
Figure 7-5. Oblique-slip fault

FAULTS OF SOUTHERN CALIFORNIA

Los Angeles Region

This map covers most of the Los Angeles metropolitan area. Within this map area, most every kind of fault type can be found. Indeed, since these maps show only surface traces of faults, some potentially damaging faults -- namely, blind thrust faults, like the one that caused the Northridge earthquake of 1994 -- are not shown. Some of the faults, which are shown may never rupture again.[d] For further documentation, please see the documents prepared by the California Geological Survey.

Figure 7-6: Faults Located in Southern California



Source: http://www.data.scec.org/faults/lafault.html

SAN ANDREAS FAULT ZONE[e]

TYPE OF FAULT: right-lateral strike-slip
LENGTH: 1200 km
550 km south from Parkfield; 650km northward
NEARBY COMMUNITY: Parkfield, Frazier Park, Palmdale, Wrightwood, San Bernardino, Banning, Indio
LAST MAJOR RUPTURE: January 9, 1857 (Mojave segment); April 18, 1906 (Northern segment)
SLIP RATE: about 20 to 35 mm per year
INTERVAL BETWEEN MAJOR RUPTURES: average of about 140 years on the Mojave segment;
recurrence interval varies greatly -- from under 20 years (at Parkfield only) to over 300 years
PROBABLE MAGNITUDES: M_W6.8 - 8.0

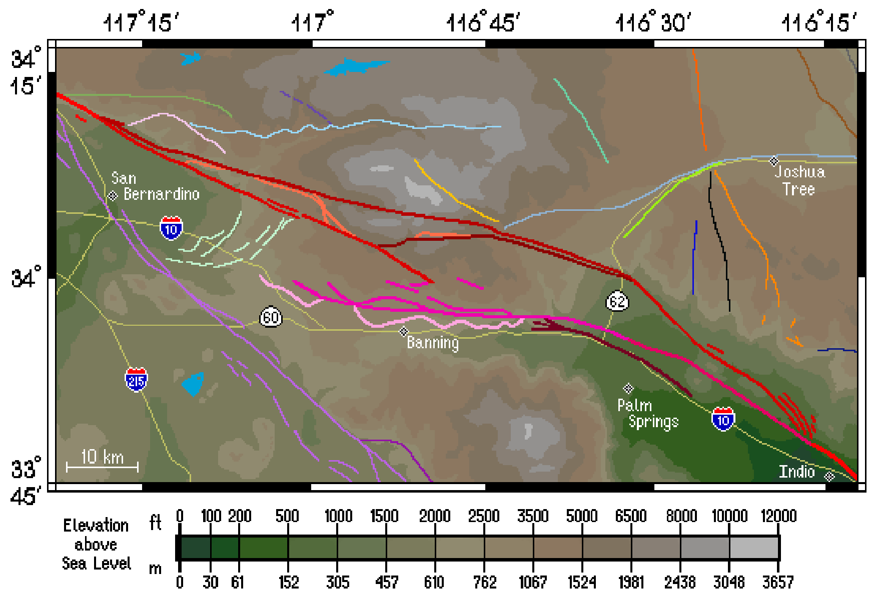
San Andreas Fault Zone -- San Gorgonio Pass Area:

The San Gorgonio Pass area is fairly complex, geologically speaking. Here the San Andreas fault interacts with other faults (most notably the San Jacinto fault zone and the Pinto Mountain fault) and thereby becomes somewhat fractured, over the distance extending from just north of San Bernardino to just north of Indio, some 110 kilometers (70 miles). Because this deformation has been going on for well over a million years, ancient and inactive strands of the San Andreas fault can be found here. Other faults in this area are have been "reawakened" recently after being dormant for hundreds of thousands of years. There is even evidence to suggest that there is no active, continuous main trace of the San Andreas fault going all the way through the pass, not even at depth -- implying that the San Andreas fault may currently be in the process of creating a new fault path through this area! This could also mean that a single, continuous rupture from Cajon Pass to the Salton Sea (a stretch of the San Andreas that has not ruptured in historical times) is unlikely to occur. Fault rupture mechanics are still not well understood, however, and the discontinuity could prove to have little effect on tempering a major earthquake on this southern stretch of the San Andreas fault zone.

Figure II.7 is a map of the San Gorgonio Pass area. Cities and towns are shown as diamonds, lakes are shown in light blue, and highways are shown in yellow. It should be noted that due to the complexity of this area, many researchers have used different nomenclature for the local faults, and placed the dividing lines between certain named fault segments in varying places. This naturally makes it difficult to decide upon one standard for labeling maps such as this. When possible, these differences will be noted within the fault files, but keep in mind that the system used here represents only one of many ways of characterizing this intriguing and complex geologic region.

Dr. Kerry Sieh of Cal Tech has investigated the San Andreas fault at Pallett Creek. “The record at Pallett Creek shows that rupture has recurred about every 130 years, on average, over the past 1500 years. But actual intervals have varied greatly, from less than 50 years to more than 300. The physical cause of such irregular recurrence remains unknown."[f] Damage from a great quake on the San Andreas would be widespread throughout Southern California.

Figure 7-7: San Gorgonio Pass area



Source: http://www.data.scec.org/fault_index/sanandre.html

<u>WHITTIER FAULT</u> [g]

TYPE OF FAULTING: right-lateral strike-slip with some reverse slip
LENGTH: about 40 km
NEARBY COMMUNITIES: Yorba Linda, Hacienda Heights, Whittier
MOST RECENT SURFACE RUPTURE: <u>Holocene</u>
SLIP RATE: between 2.5 and 3.0 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: unknown
PROBABLE MAGNITUDES: M_W6.0 - 7.2
OTHER NOTES: The Whittier fault dips toward the northeast.

<u>SAN JOSE FAULT</u> [h]

TYPE OF FAULTING: left-lateral strike-slip; minor reverse component possible
LENGTH: about 18 km
NEARBY COMMUNITIES: Claremont, La Verne, Pomona
LAST SIGNIFICANT QUAKE: <u>Feb. 28, 1990; M_L5.4</u>;
No surface rupture found
MOST RECENT SURFACE RUPTURE: <u>Late Quaternary</u>
SLIP RATE: between 0.2 and 2.0 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: unknown

PROBABLE MAGNITUDES: M_L6.0 - 6.5
OTHER NOTES: The San Jose fault dips steeply to the north.

NEWPORT-INGLEWOOD FAULT ZONE [i]

TYPE OF FAULTING: right-lateral; local reverse slip associated with fault steps
LENGTH: 75 km
NEAREST COMMUNITIES: Culver City, Inglewood, Gardena, Compton, Signal Hill, Long Beach, Seal Beach, Huntington Beach, Newport Beach, Costa Mesa
MOST RECENT MAJOR RUPTURE: March 10, 1933, M_W6.4 (but no surface rupture)
SLIP RATE: 0.6 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: unknown
PROBABLE MAGNITUDES: M_W6.0 - 7.4
OTHER NOTES: Surface trace is discontinuous in the Los Angeles Basin, but the fault zone can easily be noted there by the existence of a chain of low hills extending from Culver City to Signal Hill. South of Signal Hill, it roughly parallels the coastline until just south of Newport Bay, where it heads offshore, and becomes the Newport-Inglewood - Rose Canyon fault zone.

LOS ALAMITOS FAULT [i]

TYPE OF FAULT: uncertain
LENGTH: 11 km
NEARBY COMMUNITIES: Los Alamitos, Lakewood, Bellflower
MOST RECENT SURFACE RUPTURE: Late Quaternary
OTHER NOTES: Age uncertain; fault indistinct. May be part of a larger fault system -- the Compton-Los Alamitos fault.

SANTA MONICA FAULT [k]

TYPE OF FAULTING: left-reverse
LENGTH: 24 km
NEARBY COMMUNITIES: Pacific Palisades, Westwood, Beverly Hills, Santa Monica
MOST RECENT SURFACE RUPTURE: Late Quaternary
SLIP RATE: between 0.27 and 0.39 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: unknown
PROBABLE MAGNITUDES: M_W6.0 - 7.0 (?)
OTHER NOTES: This is a north-dipping fault. Its slip rate may be greatest at its western end.

RAYMOND FAULT [l]

TYPE OF FAULTING: left-lateral; only minor reverse slip
LENGTH: 26 km
NEAREST COMMUNITIES: San Marino, Arcadia, South Pasadena
MOST RECENT MAJOR RUPTURE: Holocene

SLIP RATE: between 0.10 and 0.22 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: roughly 4500 years (?)
PROBABLE MAGNITUDES: M_W6.0 - 7.0

This fault dips at about 75 degrees to the north. There is evidence that at least eight surface-rupturing events have occurred along this fault in the last 36,000 years.

The exact nature of the slip along the Raymond fault has been a subject of debate for quite some time. The fault produces a very obvious south-facing scarp along much of its length, and this has made many favor reverse-slip as the predominant sense of fault motion. However, there are also places along this scarp where left-lateral stream offsets of several hundred meters can be seen.

The matter will not be conclusively resolved until the Raymond fault ruptures at the surface, but some new light was shed on the debate in late 1988, when the Pasadena Earthquake occurred. Apparently located on the Raymond fault, the motion of this quake was predominantly left lateral, with a reverse component only about 1/15th the size of the lateral component. Curiously enough, this corresponds very well with a scarp height of about 30 meters (reverse slip) versus a left-lateral stream offset of about 400 meters (lateral slip), which are found along the scarp of the Raymond fault south of Pasadena.

If the Raymond fault is indeed primarily a left-lateral fault, it could be responsible for transferring slip southward from the Sierra Madre fault zone to other fault systems.

SIERRA MADRE FAULT ZONE [m]

TYPE OF FAULTING: reverse - ANIMATION
LENGTH: the zone is about 55 km long;
total length of main fault segments is about 75 km, with each segment measuring roughly 15 km long
NEARBY COMMUNITIES: Sunland, Altadena, Sierra Madre, Monrovia, Duarte, Glendora
MOST RECENT SURFACE RUPTURE: Holocene
SLIP RATE: between 0.36 and 4 mm/yr
INTERVAL BETWEEN SURFACE RUPTURES: several thousand years (?)
PROBABLE MAGNITUDES: M_W6.0 - 7.0 (?)
OTHER NOTES: This fault zone dips to the north. It was not the fault responsible for the 1991 Sierra Madre earthquake.

The Sierra Madre fault zone is often divided into five main segments, labeled with the letters A through E, to more easily characterize this fairly complex system. The map to the right shows these segments.

Figure II-8: Local Fault Locations

These five divisions, while simpler than the entire fault zone, should not be thought of as individual faults, however -- some of these segments are themselves complex systems of parallel and branching faults. It has been suggested that differing fault geometries in this zone keep each lettered segment separate during rupture events -- thus, neighboring segments should not rupture simultaneously. Others, however, suggest that the fault zone may rupture both in single-segment and multiple-segment breaks.

The most recent surface ruptures are seen on the B and D segments. The least active segment, at least in surface appearance, is the A segment, also known as the Vasquez Creek fault, which runs between the San Gabriel fault and the intersection of the B and C segments of the Sierra Madre fault zone. At the junction of the C and D segments, the Clamshell - Sawpit Canyon fault splays off from the fault zone, toward the northeast (shown in sea green on the map above). It was this fault, not the Sierra Madre fault zone itself, that ruptured to produce the Sierra Madre earthquake of 1991 (named for the nearby community of Sierra Madre).

One of the strands that make up segment D is known as the Duarte fault, because of its location near that community. Segment E represents the easternmost part of this fault zone, and at its eastern end, it meets up with several other faults in a complex zone northwest of the town of Upland, near the epicenter of the 1990 Upland earthquake. The general trend of the Sierra Madre fault zone continues eastward from this point along the base of the San Gabriel Mountains, but this eastern continuation is known as the Cucamonga fault zone. The Cucamonga fault zone seems to be more active (has a higher slip rate) than the Sierra Madre fault zone.

While rupture on the Sierra Madre fault zone (theoretically) could be limited to one segment at a time, it has recently been suggested that a large event on the San Andreas fault to the north (like that of 1857) could cause simultaneous rupture on reverse faults south of the San Gabriel Mountains -- the Sierra Madre fault zone being a prime example of such. Whether this could rupture multiple Sierra Madre fault zone segments simultaneously is unknown.

SAN GABRIEL FAULT ZONE [n]

TYPE OF FAULTING: primarily right-lateral strike-slip
LENGTH: roughly 140 km
NEARBY COMMUNITIES: Castaic, Saugus, Sunland
MOST RECENT SURFACE RUPTURE: Late Quaternary west of intersection with the Sierra Madre fault zone; Quaternary east of that intersection; Holocene only between Saugus and Castaic
SLIP RATE: 1 mm/yr to 5 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: unknown
OTHER NOTES: Slip rate and recurrence interval probably vary significantly along the length of the San Gabriel fault zone. The western half is probably much more active than the eastern half. Dip is generally steep and to the north.

CLAMSHELL-SAWPIT CANYON FAULT [o]

TYPE OF FAULT: reverse
LENGTH: 18 km
NEAREST COMMUNITIES: Sierra Madre, Monrovia
MOST RECENT SURFACE RUPTURE: Late Quaternary
OTHER NOTES: This fault dips to the north at about 40 (at the surface) to 50 (at depth) degrees.

The Sierra Madre earthquake of 1991 probably originated on the Clamshell - Sawpit Canyon fault. Though a sizable earthquake, the depth of this quake prevented the rupture from reaching the surface.

CUCAMONGA FAULT ZONE [p]

TYPE OF FAULTING: thrust - ANIMATION
LENGTH: about 30 km
NEAREST COMMUNITIES: Claremont, Upland, Cucamonga
SLIP RATE: between 5 and 14 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: estimated at roughly 600-700 years
PROBABLE MAGNITUDES: M_W6.0 - 7.0
MOST RECENT RUPTURE: very recent Holocene
OTHER NOTES: Typical ground rupture per major event estimated at 2 meters. Slip rate (and thus recurrence interval) is somewhat disputed. If fastest slip rate is assumed, surface rupture interval may be as short as 150-200 years. This zone of faulting dips to the north.

The Cucamonga fault zone is part of the same fault system, marking the southern boundary of the San Gabriel Mountains, as the Sierra Madre fault zone. Sometimes it is included as part of the Sierra Madre fault zone, as is the San Fernando fault zone far to the west; here we refer to each as separate fault zones, as it is not clear that rupture may progress from one to another. Perhaps the best way to rectify the difference in nomenclature is to refer to the Cucamonga fault zone, Sierra Madre fault zone, and the San Fernando fault zone as the *Sierra Madre fault* ***system***.

SAN FERNANDO FAULT ZONE [q]

TYPE OF FAULTING: thrust
LENGTH: 17 km
NEAREST COMMUNITIES: San Fernando, Sunland
LAST MAJOR RUPTURE: February 9, 1971, M_w6.6
SLIP RATE: 5 mm/yr (?)
INTERVAL BETWEEN MAJOR RUPTURES: roughly 200 years
PROBABLE MAGNITUDES: M_W6.0 - 6.8
OTHER NOTES: Dip is to the north. The slip rate is not well known, but trenching studies indicate recurrence interval as between 100 and 300 years.

SANTA SUSANA FAULT ZONE [r]

TYPE OF FAULTING: thrust
LENGTH: 38 km
NEARBY COMMUNITIES: Piru, Sylmar, San Fernando
MOST RECENT SURFACE RUPTURE: Late Quaternary, except for a short segment which ruptured slightly during the 1971 San Fernando earthquake
SLIP RATE: between 5 and 7 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: uncertain
PROBABLE MAGNITUDES: M_W6.5 - 7.3
OTHER NOTES: The faults in this complex zone primarily dip to the north.

PALOS VERDES FAULT ZONE [s]

TYPE OF FAULT: right-reverse (?)
LENGTH: roughly 80 km
NEARBY COMMUNITIES: San Pedro, Palos Verdes Estates, Torrance, Redondo Beach
MOST RECENT SURFACE RUPTURE: Holocene, offshore; Late Quaternary, onshore
SLIP RATE: between 0.1 and 3.0 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: unknown
PROBABLE MAGNITUDES: M_W6.0 - 7.0 (or greater?); fault geometries may allow only partial rupture at any one time
OTHER NOTES: Has two main branches (see below). Continues southward as the Palos Verdes - Coronado Bank fault zone.

PALOS VERDES-CORONADO BANK FAULT ZONE [t]

TYPE OF FAULTING: right-lateral and normal faulting (?) - ANIMATION
LENGTH: at least 90 km;
with the Palos Verdes - Coronado Bank Fault Zone: at least 180 km;
NEAREST COMMUNITY: San Diego (20 km offshore)
MOST RECENT SURFACE RUPTURE: Holocene
SLIP RATE: roughly 2.0 mm/yr
OTHER NOTES: Essentially continuous with the Palos Verdes fault zone. Rupture extending from one named section across to another section might be possible.

CABRILLO FAULT [u]

TYPE OF FAULT: right-normal (?)
LENGTH: 20 km
NEARBY COMMUNITIES: Rancho Palos Verdes, Rolling Hills Estates, San Pedro
MOST RECENT SURFACE RUPTURE: Holocene, offshore; Late Quaternary, onshore
SLIP RATE: uncertain
INTERVAL BETWEEN MAJOR RUPTURES: unknown
PROBABLE MAGNITUDES: M_W6.0 - 6.8
OTHER NOTES: Dips to the north.

<u>REDONDO CANYON FAULT</u> [v]

TYPE OF FAULT: right-reverse (?)
LENGTH: 11 km
NEARBY COMMUNITIES: Palos Verdes Estates, Redondo Beach
MOST RECENT SURFACE RUPTURE: <u>Holocene</u>
SLIP RATE: uncertain
INTERVAL BETWEEN MAJOR RUPTURES: unknown
PROBABLE MAGNITUDES: M_W5.8 - 6.5

<u>MALIBU COAST FAULT ZONE</u> [w]

TYPE OF FAULT: reverse
LENGTH: 34 km; has several parallel strands
NEAREST COMMUNITIES: Malibu, Pacific Palisades
MOST RECENT SURFACE RUPTURE: <u>Holocene</u>, in part; otherwise <u>Late Quaternary</u>
SLIP RATE: roughly 0.3 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: uncertain
OTHER NOTES: This is a north-dipping fault. The slip rate may be higher at its eastern end, where it meets the <u>Santa Monica fault</u>, and develops left-reverse motion.

<u>CHINO FAULT</u> [x]

TYPE OF FAULT: right-reverse
LENGTH: 21 km
NEAREST COMMUNITIES: Corona, Chino
MOST RECENT SURFACE RUPTURE: <u>Late Quaternary</u>
SLIP RATE: about 1.0 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: unknown
PROBABLE MAGNITUDES: M_W6.0 - 7.0
OTHER NOTES: The dip of this fault is to the southwest.

<u>LOS ALAMITOS FAULT</u> [y]

TYPE OF FAULT: uncertain
LENGTH: 11 km
NEARBY COMMUNITIES: Los Alamitos, Lakewood, Bellflower
MOST RECENT SURFACE RUPTURE: <u>Late Quaternary</u>
OTHER NOTES: Age uncertain; fault indistinct. May be part of a larger fault system -- the Compton-Los Alamitos fault.

<u>RED HILL FAULT (ALSO ETIWANDA AVENUE FAULT)</u> [z]

TYPE OF FAULTING: <u>thrust</u> - ANIMATION
LENGTH: about 25 km (see below)
NEAREST COMMUNITIES: Etiwanda, Alta Loma, Upland

SLIP RATE: uncertain
INTERVAL BETWEEN MAJOR RUPTURES: unknown
PROBABLE MAGNITUDES: M_W6.0 - 7.0
MOST RECENT SURFACE RUPTURE: Holocene at eastern end; otherwise, Late Quaternary
OTHER NOTES: This fault dips to the north. The eastern 9 kilometers of the Red Hill-Etiwanda Avenue fault is often considered to be a part of the Cucamonga fault zone, as it shows surface rupture more similar to that of the Cucamonga fault zone than to that of the rest of the Red Hill fault.

HOLLYWOOD FAULT [aa]

TYPE OF FAULT: left-reverse
LENGTH: 15 km
NEARBY COMMUNITIES: Hollywood, Beverly Hills, Glendale
MOST RECENT SURFACE RUPTURE: Holocene
SLIP RATE: between 0.33 mm/yr and 0.75 mm/yr
INTERVAL BETWEEN MAJOR RUPTURES: 1600 years (?)
PROBABLE MAGNITUDES: M_W5.8 - 6.5, alone;
larger if rupture is simultaneous with an adjacent fault
OTHER NOTES: Could be considered a westward extension of the Raymond fault. Roughly parallel to the Santa Monica fault.

SAN ANTONIO FAULT [bb]

TYPE OF FAULTING: left-lateral strike-slip - ANIMATION
LENGTH: 20 km
NEARBY COMMUNITIES: Mt. Baldy, Alta Loma
MOST RECENT SURFACE RUPTURE: Late Quaternary
OTHER NOTES: The small branch to the west near the southern end of the San Antonio fault is known as the **Evey Canyon fault**. The San Antonio fault probably cuts and offsets the Stoddard Canyon fault.

STODDARD CANYON FAULT [cc]

TYPE OF FAULTING: left-lateral strike-slip
LENGTH: 18 km
NEARBY COMMUNITIES: Alta Loma, Lytle Creek
MOST RECENT SURFACE RUPTURE: Quaternary
OTHER NOTES: Also called the South San Antonio fault, this north-dipping fault is one of many in a complex system of branching faults north of the Cucamonga fault zone, none of which appear to have been active in Holocene times. The largest of these is the **Icehouse Canyon fault**, which branches off to the north of the Stoddard Canyon fault. The Stoddard Canyon fault is probably cut and offset by the San Antonio fault to the west, but the intersection of these two faults is buried, and the exact relation is unclear.

SAN JACINTO FAULT ZONE [dd]

TYPE OF FAULTING : right-lateral strike-slip; minor right-reverse
LENGTH: 210 km, including Coyote Creek fault
NEARBY COMMUNITIES: Lytle Creek, San Bernardino, Loma Linda, San Jacinto, Hemet, Anza, Borrego Springs, Ocotillo Wells
MOST RECENT SURFACE RUPTURE: within the last few centuries; April 9, 1968, M_w6.5 on Coyote Creek segment
SLIP RATE: typically between 7 and 17 mm/yr
INTERVAL BETWEEN SURFACE RUPTURES: between 100 and 300 years, per segment
PROBABLE MAGNITUDES: M_w6.5 - 7.5

Earthquake Related Hazards

Ground shaking, landslides, liquefaction, and amplification are the specific hazards associated with earthquakes. The severity of these hazards depends on several factors, including soil and slope conditions, proximity to the fault, earthquake magnitude, and the type of earthquake.

Ground Shaking

Ground shaking is the motion felt on the earth's surface caused by seismic waves generated by the earthquake. It is the primary cause of earthquake damage. The strength of ground shaking depends on the magnitude of the earthquake, the type of fault, and distance from the epicenter (where the earthquake originates). Buildings on poorly consolidated and thick soils will typically see more damage than buildings on consolidated soils and bedrock.

Earthquake Induced Landslides

Earthquake induced landslides are secondary earthquake hazards that occur from ground shaking. They can destroy the roads, buildings, utilities, and other critical facilities necessary to respond and recover from an earthquake. Many communities in Southern California have a high likelihood of encountering such risks, especially in areas with steep slopes.

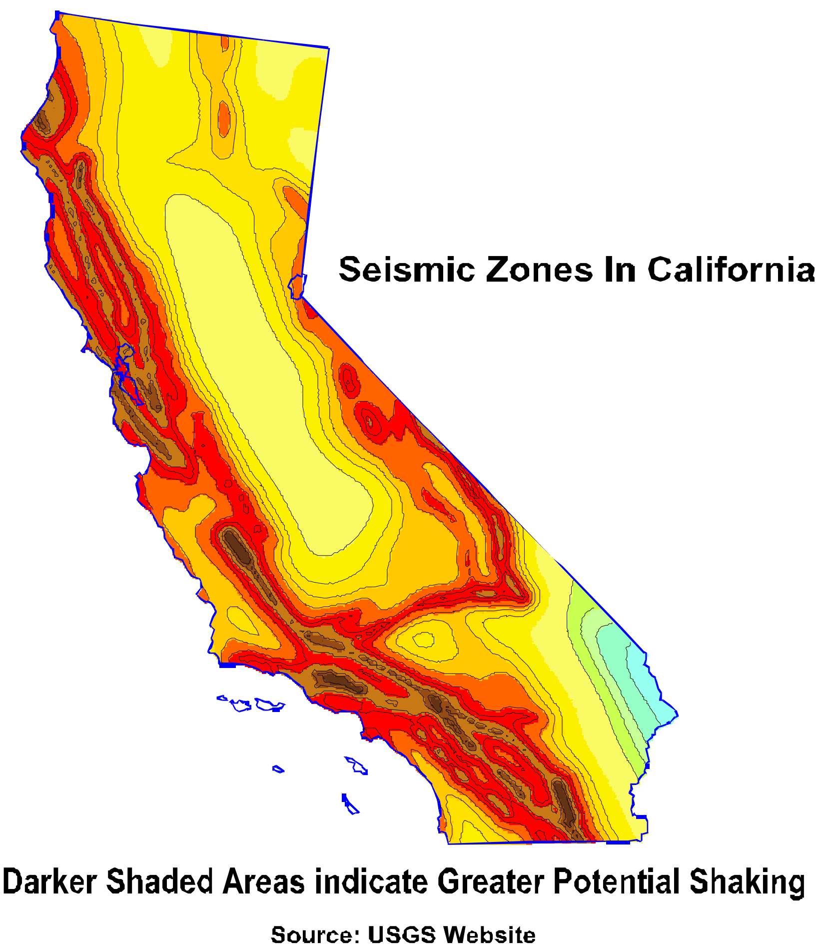
Liquefaction

Liquefaction occurs when ground-shaking causes wet granular soils to change from a solid state to a liquid state. This results in the loss of soil strength and the soil's ability to support weight. Buildings and their occupants are at risk when the ground can no longer support these buildings and structures. Many communities in Southern California are built on ancient river bottoms and have sandy soil. In some cases this ground may be subject to liquefaction, depending on the depth of the water table.

Amplification

Soils and soft sedimentary rocks near the earth's surface can modify ground shaking caused by earthquakes. One of these modifications is amplification. Amplification increases the magnitude of the seismic waves generated by the earthquake. The amount of amplification is influenced by the thickness of geologic materials and their physical properties. Buildings and structures built on soft and unconsolidated soils can face greater risk.[ee] Amplification can also occur in areas with deep sediment filled basins and on ridge tops.

Figure 7-8. Seismic Zones in California



Earthquake Hazard Assessment

Hazard Identification

In California, many agencies are focused on seismic safety issues: the State's Seismic Safety Commission, the Applied Technology Council, Governor's Office of Emergency Services, United States Geological Survey, Cal Tech, the California Geological Survey, as well as numerous universities and private foundations.

These organizations, in partnership with other state and federal agencies, have undertaken a rigorous program in California to identify seismic hazards and risks including active fault identification, bedrock shaking, tsunami inundation zones, ground motion amplification, liquefaction, and earthquake induced landslides. Seismic hazard maps have been published and are available for many communities in California through the State Division of Mines and Geology.

In California, each earthquake is followed by revisions and improvements in the Building Codes. The 1933 Long Beach resulted in the Field Act, affecting school construction. The 1971 Sylmar earthquake brought another set of increased structural standards. Similar re-evaluations occurred after the 1989 Loma Prieta and 1994 Northridge earthquakes. These code changes have resulted in stronger and more earthquake resistant structures.

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting regarding structures for human occupancy. This state law was a direct result of the 1971 San Fernando Earthquake, which was associated with extensive surface fault ruptures that damaged numerous homes, commercial buildings, and other structures. Surface rupture is the most easily avoided seismic hazard.[ff]

The Seismic Hazards Mapping Act, passed in 1990, addresses non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides.[gg] The State Department of Conservation operates the Seismic Mapping Program for California. Extensive information is available at their website: http://gmw.consrv.ca.gov/shmp/index.htm

Vulnerability Assessment

The effects of earthquakes span a large area, and large earthquakes occurring in many parts of the Southern California region would probably be felt throughout the region. However, the degree to which the earthquakes are felt, and the damages associated with them may vary. At risk from earthquake damage are large stocks of old buildings and bridges: many high tech and hazardous materials facilities: extensive sewer, water, and natural gas pipelines; earth dams; petroleum pipelines; and other critical facilities and private property located in the county. The relative or secondary earthquake hazards, which are liquefaction, ground shaking, amplification, and earthquake-induced landslides, can be just as devastating as the earthquake.

The California Geological Survey has identified areas most vulnerable to liquefaction. Liquefaction occurs when ground-shaking causes wet granular soils to change from a solid state to a liquid state. This results in the loss of soil strength and the soil's ability to support weight. Buildings and their occupants are at risk when the ground can no longer support these buildings and structures. Map 6 on page 160, illustrates historic epicenters, major fault areas, and areas vulnerable to damage from shaking. Map 7 on page 161, is a Seismic Hazard Zone map from the State of California that identifies areas (shaded in green) in the El Monte Quadrangle, which are soils vulnerable to liquefaction. Map 8 on page 162, is an enlarged map illustrating areas that are vulnerable to liquefaction in the City.

Risk Analysis

Risk analysis is the third phase of a hazard assessment. Risk analysis involves estimating the damage and costs likely to be experienced in a geographic area over a period of time. Factors included in assessing earthquake risk include population and property distribution in the hazard area, the frequency of earthquake events, landslide susceptibility, buildings, infrastructure, and disaster preparedness of the region. This type of analysis can generate estimates of the damages to the region due to an earthquake event in a specific location. FEMA's software program, HAZUS, uses mathematical formulas and information about building stock, local geology and the location and size of potential earthquakes, economic data, and other information to estimate losses from a potential earthquake. The HAZUS software is available from FEMA at no cost.

For greater Southern California there are multiple worst case scenarios, depending on which fault might rupture, and which communities are in proximity to the fault. But damage will not necessarily be limited to immediately adjoining communities. Depending on the hypocenter of the earthquake, seismic waves may be transmitted through the ground to unsuspecting communities. In the Northridge 1994 earthquake, Santa Monica suffered extensive damage, even though there was a range of mountains between it and the origin of the earthquake.

Damages for a large earthquake almost anywhere in Southern California are likely to run into the billions of dollars. Although building codes are some of the most stringent in the world, ten's of thousands of older existing buildings were built under much less rigid codes. California has laws affecting unreinforced masonry buildings (URM's) and although many building owners have retrofitted their buildings, hundreds of pre-1933 buildings still have not been brought up to current standards. The City has no unreinforced masonry buildings.

Non-structural bracing of equipment and contents is often the most cost-effective type of seismic mitigation. Inexpensive bracing and anchoring may be the most cost effective way to protect expensive equipment. Non-structural bracing of equipment and furnishings will also reduce the chance of injury for the occupants of a building.

Community Earthquake Issues

Earthquake damage occurs because humans have built structures that cannot withstand severe shaking. Buildings, airports, schools, and lifelines (highways and utility lines) suffer damage in earthquakes and can cause death or injury to humans. The welfare of homes, major businesses, and public infrastructure is very important. Addressing the reliability of buildings, critical facilities, and infrastructure, and understanding the potential costs to government, businesses, and individuals as a result of an earthquake, are challenges faced by the city.

Dams

There are a total of 103 dams in Los Angeles County, owned by 23 different agencies or organizations, ranging from the federal government to home owner associations. These dams hold billions of gallons of water in reservoirs. Releases of water from the major reservoirs are designed to protect Southern California from flood waters and to store domestic water. Seismic activity can compromise the dam structures, and the resultant flooding could cause catastrophic flooding. Following the 1971 Sylmar earthquake the Lower Van Norman Dam showed signs of structural compromise, and tens of thousands of persons had to be evacuated until the dam could be drained. The dam has never been refilled.

Buildings

The built environment is susceptible to damage from earthquakes. Buildings that collapse can trap and bury people. Lives are at risk and the cost to clean up the damages is great. In most California communities, including Temple City, many buildings were built before 1993 when building codes were not as strict. In addition, retrofitting is not required except under certain conditions and can be expensive. Therefore, the number of buildings at risk remains high. The California Seismic Safety Commission makes annual reports on the progress of the retrofitting of unreinforced masonry buildings. All of the commercial unreinforced masonry buildings located in Temple City have been retrofitted.

Infrastructure and Communication

Residents in the City of Temple City commute frequently by automobile and public transportation, such as buses and commuter rail. An earthquake can greatly damage bridges and roads, hampering emergency response efforts and the normal movement of people and goods. Damaged infrastructure strongly affects the economy of the community because it disconnects people from work, school, food, and leisure, and separates businesses from their customers and suppliers,

Bridge Damage

Even modern bridges can sustain damage during earthquakes, leaving them unsafe for use. Some bridges have failed completely due to strong ground motion. Bridges are a vital transportation link - with even minor damages making some areas inaccessible. Because bridges vary in size, materials, location and design, any given earthquake will affect them differently. Bridges built before the mid-1970' s have a significantly higher risk of suffering structural damage during a moderate to large earthquake compared with those built after 1980 when design improvements were made. The bridges in the City of Temple City are owned by state or county agencies (including railroad bridges and bridges over flood control channels). See map 1 on page 155, which illustrates the bridge locations throughout the City.

Damage to Lifelines

Lifelines are the connections between communities and outside services. They include water and gas lines, transportation systems, electricity and communication networks. Ground shaking and amplification can cause pipes to break open, power lines to fall, roads and railways to crack or move, and radio and telephone communication to cease. Disruption to transportation makes it especially difficult to bring in supplies or services. Lifelines need to be usable after earthquake to allow for rescue, recovery, and rebuilding efforts and to relay important information to the public.

Disruption of Critical Services

Critical facilities include police stations, fire stations, hospitals, shelters, and other facilities that provide important services to the community. These facilities and their services need to be functional after an earthquake event. See map 2 on page 156 for the location of these facilities.

Businesses/Private Sector

Seismic activity can cause great loss to businesses, both large-scale corporations and small retail shops. When a company is forced to stop production for just a day, the economic loss can be tremendous, especially when its market is at a national or global level. Seismic activity can create economic loss that presents a burden to large and small shop owners who may have difficulty recovering from their losses.

Forty percent of businesses do not reopen after a disaster and another twenty-five percent fail within one year, according to the Federal Emergency Management Agency (FEMA). Similar statistics from the United States Small Business Administration indicate that over ninety percent of businesses fail within two years after being struck by a disaster.

The Institute of Business and Home Safety has developed “Open for Business”, which is a disaster planning toolkit to help guide businesses in preparing for and dealing with the adverse affects of natural hazards. The kit integrates protection from natural disasters into the company's risk reduction measures to safeguard employees, customers, and the investment itself. The guide helps businesses secure human and physical resources during disasters, and helps to develop strategies to maintain business continuity before, during, and after a natural disaster occurs.

Individual Preparedness

Because the potential for earthquake occurrences and potential earthquake related property damage is relatively high in the City, increasing individual preparedness is a significant need. Strapping down heavy furniture, water heaters, and expensive personal property, as well as being earthquake insured, and anchoring buildings to foundations are just a few steps individuals can take to prepare for an earthquake.

Death and Injury

Death and injury can occur both inside and outside of buildings due to collapsed buildings falling equipment, furniture, debris, and structural materials. Downed power lines and broken water and gas lines can also endanger human life,

Fire

Downed power lines or broken gas mains can trigger fires. When fire stations suffer building or lifeline damage, quick response to extinguish fires is less likely. Furthermore, major incidents will demand a larger share of resources, and initially smaller fires and problems will receive little or insufficient resources in the initial hours after a major earthquake event. Loss of electricity may cause a loss of water pressure in some communities, further hampering fire fighting ability.

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations.

City of Temple City Codes

Implementation of earthquake mitigation policy most often takes place at the local government level. The City of Temple City contracts all building and safety services with the Los Angeles County Building and Safety, and that agency enforces all building codes pertaining to earthquake hazards.

The 2001 triennial edition of California Code of Regulations, Title 24 consists of the following 11 parts:

- Part 1 - California Building Standards Administrative Code
- Part 2 - California Building Code
- Part 3 - California Electrical Code
- Part 4 - California Mechanical Code
- Part 5 - California Plumbing Code
- Part 6 - California Energy Code
- Part 7 - California Elevator Safety Construction Code

- Part 8 - California Historical Building Code
- Part 9 - California Fire Code
- Part 10 - California Code for Building Conservation
- Part 11 - Not used
- Part 12 - California Reference Standards Code

The following sections of the UBC address the earthquake hazard:
1605.1 (Distribution of Horizontal Sheer);
1605.2 (Stability against Overturning);
1626 (Seismic);
1605.3 (Anchorage); and
1632 , 1633,1633.9 deal with specific earthquake hazards.

The City's Community Development Department and Public Works Department (Public Safety/Code Enforcement) enforce the zoning and land use regulations relating to earthquake hazards.

Generally, these codes seek to discourage development in areas that could be prone to flooding, landslide, wildfire and/or seismic hazards; and where development is permitted, and that the applicable construction standards are met. Developers in hazard-prone areas may be required to retain a qualified professional engineer to evaluate level of risk on the site and recommend appropriate mitigation measures.

Coordination among Building Officials

Building Codes set the minimum design and construction standards for new buildings and for building retrofitting. Los Angeles County has adopted the most recent seismic standards in its building code, which requires that new buildings be built at a higher seismic standard.

The City also requires that site-specific seismic hazard investigations be performed for new essential facilities, major structures, hazardous facilities, and special occupancy structures, such as schools, hospitals, and emergency response facilities.

Hospitals

"The Alfred E. Alquist Hospital Seismic Safety Act ("Hospital Act") was enacted in 1973 in response to the moderate Magnitude 6.6 Sylmar Earthquake in 1971 when four major hospital campuses were severely damaged and evacuated. Two hospital buildings collapsed, killing forty-seven people. Three others were killed in another hospital that nearly collapsed.

With approval of the Hospital Act, the California Legislature noted that: Hospitals, that house patients who have less than the capacity of normally healthy persons to protect themselves, and that must be reasonably capable of providing services to the public after a disaster, shall be designed and constructed to resist, insofar as practical, the forces generated by earthquakes, gravity and winds. *(Health and Safety Code Section 129680)*

When the Hospital Act was passed in 1973, the State anticipated that based on the regular and timely replacement of aging hospital facilities, the majority of hospital buildings would be in compliance with the Hospital Act's standards within 25 years. However, hospital buildings were not, and are not, being replaced at that anticipated rate. In fact, the great majority of the State's urgent care facilities are now more than 40 years old.

The moderate Magnitude 6.7 Northridge Earthquake in 1994 caused $3 billion in hospital-related damage and evacuations. Twelve hospital buildings constructed before the Act were cited (red tagged) as unsafe for occupancy after the earthquake. Those hospitals that had been built in accordance with the 1973 Hospital Act were very successful in resisting structural damage. However, nonstructural damage (for example, plumbing and ceiling systems) was still extensive in those post-1973 buildings

Senate Bill 1953 ("SB 1953"), enacted in 1994 after the Northridge Earthquake, expanded the scope of the 1973 Hospital Act. Under SB 1953, all hospitals are required, as of January 1, 2008, to survive earthquakes without collapsing or posing the threat of significant loss of life. The 1994 Act further mandates that all existing hospitals shall be seismically evaluated, and retrofitted, if needed. By 2030, the buildings are to be in substantial compliance with the Act (which requires that the hospital buildings be reasonably capable of providing services to the public after disasters). SB 1953 applies to all urgent care facilities (including those built prior to the 1973 Hospital Act) and affects approximately 2,500 buildings on 475 campuses.

SB 1953 directed the Office of Statewide Health Planning and Development (OSHPD), in consultation with the Hospital Building Safety Board, to develop emergency regulations including earthquake performance categories with subgradations for risk to life, structural soundness, building contents, and nonstructural systems that are critical to providing basic services to hospital inpatients and the public after a disaster. (Health and Safety Code Section 130005)

The Seismic Safety Commission Evaluation of the State's Hospital Seismic Safety Policies

In 2001, recognizing the continuing need to assess the adequacy of policies, and the application of advances in technical knowledge and understanding, the California Seismic Safety Commission created an Ad Hoc Committee to re-examine the compliance with the Alquist Hospital Seismic Safety Act. The formation of the Committee was also prompted by the recent evaluations of hospital buildings reported to OSHPD that revealed that a large percentage (40%) of California's operating hospitals are in the highest category of collapse risk.

CALIFORNIA EARTHQUAKE MITIGATION LEGISLATION

California is painfully aware of the threats it faces from earthquakes. Dating back to the 19th century, Californians have been killed, injured, and lost property as a result of earthquakes. As the State's population continues to grow, and urban areas become even more densely built up, the risk will continue to increase. For decades the Legislature has passed laws to strengthen the built environment and protect the citizens. Table II-9 provides a sampling of some of the 200 plus laws in the State's codes.

Table II-9. Partial List of the Over 200 California Laws on Earthquake Safety

Government Code Section 8870-8870.95	Creates Seismic Safety Commission.
Government Code Section 8876.1-8876.10	Established the California Center for Earthquake Engineering Research.
Public Resources Code Section 2800-2804.6	Authorized a prototype earthquake prediction system along the central San Andreas fault near the City of Parkfield.
Public Resources Code Section 2810-2815	Continued the Southern California Earthquake Preparedness Project and the Bay Area Regional Earthquake Preparedness Project.
Health and Safety Code Section 16100-16110	The Seismic Safety Commission and State Architect, will develop a state policy on acceptable levels of earthquake risk for new and existing state-owned buildings.
Government Code Section 8871-8871.5	Established the California Earthquake Hazards Reduction Act of 1986.
Health and Safety Code Section 130000-130025	Defined earthquake performance standards for hospitals.
Public Resources Code Section 2805-2808	Established the California Earthquake Education Project.
Government Code Section 8899.10-8899.16	Established the Earthquake Research Evaluation Conference.
Public Resources Code Section 2621-2630 2621.	Established the Alquist-Priolo Earthquake Fault Zoning Act.
Government Code Section 8878.50-8878.52 8878.50.	Created the Earthquake Safety and Public Buildings Rehabilitation Bond Act of 1990.
Education Code Section 35295-35297 35295.	Established emergency procedure systems in kindergarten through grade 12 in all the public or private schools.
Health and Safety Code Section 19160-19169	Established standards for seismic retrofitting of unreinforced masonry buildings.
Health and Safety Code Section 1596.80-1596.879	Required all child day care facilities to include an Earthquake Preparedness Checklist as an attachment to their disaster plan.
Source: http://www.leginfo.ca.gov/calaw.html	

Earthquake Education

Earthquake research and education activities are conducted at several major universities in the Southern California region, including the California Institute of Technology, the University of Southern California, the University of California Los Angeles, the University of California Santa Barbara, and the University of California Irvine. The local clearinghouse for earthquake information is the Southern California Earthquake Center (SCEC) located at the University of Southern California, Los Angeles, CA 90089, telephone: (213) 740-5843, fax: (213) 740-0011, email: SCEinfo@usc.edu, website: http://www.scec.org. The Southern California Earthquake Center (SCEC) is a community of scientists and specialists who actively coordinate research on earthquake hazards at nine core institutions, and communicate earthquake information to the public. The SCEC is a National Science Foundation (NSF) Science and Technology Center and is co-funded by the United States Geological Survey (USGS).

In addition, Los Angeles County, along with other Southern California counties, sponsors the Emergency Survival Program (ESP), an educational program for learning how to prepare for earthquakes and other disasters. Many local organizations have very active emergency preparedness programs that include earthquake drills and periodic disaster response team exercises.

Earthquake Mitigation Action Items

The earthquake mitigation action items provide guidance on suggesting specific activities that the City can undertake to reduce risk and prevent loss from earthquake events. Each action item is followed by ideas for implementation, which can be used by the NHMP committee and City Administration in pursuing strategies for implementation.

Mitigation Goal # 1*:* Identify funding sources for structural and nonstructural retrofitting of structures that are identified as seismically vulnerable.

Ideas for Implementation:

- Provide information for property owners, small businesses, and organizations on sources of funds (loans, grants, etc.)

- Explore options for including seismic retrofitting in existing programs, such as low-income housing, insurance reimbursements, and pre and post disaster repairs

Coordinating Organization: Community Development Department, Finance Department
Timeline: 2 years
Plan Goals Addressed: Partnerships and Implementation , Public Awareness

Constraints:	Staff to maintain and provide research for this action item.

Mitigation Goal # 2*:* Encourage purchase of earthquake hazard insurance.

Ideas for Implementation:

- Provide earthquake insurance information to Temple City residents and property owners

- Coordinate with insurance companies to produce and distribute earthquake insurance information

Coordinating Organization:	Community Development Department, local real estate offices
Timeline:	2 years
Plan Goals Addressed:	Protect Life and Property, Public Awareness
Constraints:	Staff to maintain and provide research for this action item.

Mitigation Goal # 3*:* Encourage seismic strength evaluations of critical facilities in the City to identify vulnerabilities for mitigation in City facilities, local agencies, public infrastructure, and critical facilities to meet current seismic standards.

Ideas for Implementation:

- Develop an inventory of City buildings, schools, and critical facilities that do not meet current seismic standards

- Encourage owners of non-retrofitted structures to upgrade them to meet seismic standards

- Encourage water providers to replace old cast iron pipes with more ductile iron, and identify partnership opportunities with other agencies for pipe replacement,

Coordinating Organization:	Public Works, Community Development Department
Timeline:	5 years
Plan Goals Addressed:	Protect Life and Property, Public Awareness
Constraints:	Staff to maintain and provide research for this action item.

Mitigation Goal # 4*:* Encourage reduction of nonstructural and structural earthquake hazards in homes, schools, businesses, and government offices.

Ideas for Implementation:

- Provide information to City staff, business owners, school facility managers and residents on securing bookcases, filing cabinets, light fixtures, and other objects that can cause injuries and block exits
- Encourage City staff, business owners, school facility managers, and residents to refer to FEMA's practical guidebook: "Reducing the Risks Nonstructural Earthquake Damage"
- Encourage homeowners and renters to use "Is Your Home Protected from Earthquake Disaster? A Homeowner's Guide to Earthquake Retrofit" (IBHS) for economic and efficient mitigation techniques
- Explore partnerships to provide retrofitting classes for homeowners, renters, building professionals, and contractors
- Target development located in potential fault zones or in unstable soils for intensive education and retrofitting resources

Coordinating Organization: Community Development Department
Timeline: Ongoing
Plan Goals Addressed: Protect Life and Property, Public Awareness
Constraints: Staff to maintain and provide research for this action item.

IDENTIFIED HAZARD # 1	Unsecured contents may fall off shelves used to store chemicals.
WHAT COULD HAPPEN	• Contents could strike nearby occupants. • Contents could release dangerous chemicals or cause a hazardous reaction to occur.
ACTION TO BE TAKEN	• Install wood or Plexiglas strips across open face of shelves. • Shelves must be secured. • Install shelf with a lip to prevent objects from falling. • Relocate heavy items or volatile chemicals to floor mounted cabinets when possible.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 2	Unsecured wall-mounted cabinets, lockers and metal storage cabinets.
WHAT COULD HAPPEN	• Contents could strike nearby occupants. • Contents could block hallways and exit areas.
ACTION TO BE TAKEN	• For single unit, secure each unit to wall studs or blocking with screws. • For multiple units, fasten each unit to a clip angle with metal screws. Fasten clip angle to wall studs or blocking with screws. • Relocate cabinets, lockers, or metal storage cabinets away from hallways and exit ways.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 3	Unsecured aquariums or terrariums.
WHAT COULD HAPPEN	• Aquariums or terrariums could fall striking nearby occupants. • Aquariums or terrariums could fall and block hallways and exit areas.
ACTION TO BE TAKEN	• Fasten clip angle to tabletop against each side of the unit. • Locate these units away from doors and exit ways.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 4	Unsecured ceiling-height interior walls.
WHAT COULD HAPPEN	• Damage pipes and electrical wiring. • Wall may fall and could strike nearby occupants. • Wall may fall and could block hallways and exit areas.
ACTION TO BE TAKEN	• Secure ceiling-height walls with diagonal bracing. • Consult a qualified architect or structural engineer for seismic requirements. • Walls are usually not fire-rated.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 5	Unsecured TV monitors or speakers.
WHAT COULD HAPPEN	• Units may fall off the mounting brackets, striking occupants below. • Units could block exit ways for evacuation during an emergency. • A fallen unit may damage electrical wirings, exposing nearby occupants to electrical shock or start a fire.
ACTION TO BE TAKEN	• Secure each TV or monitor to mounting bracket with adjustable straps. • Follow the recommendation provided by the manufacturer for mounting bracket for TV, monitors or speakers. • Locate units mounting brackets away from doors or exit ways. • Consider using a pre-approved mounting bracket from the Office of Statewide Health Planning and Development (OSHPD). • Consult a qualified architect or structural engineer for seismic bracing requirements.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 6	Unsecured wall hung items such as pictures, decorations or signs.
WHAT COULD HAPPEN	• Contents could strike nearby occupants. • Contents could block hallways and exit areas.
ACTION TO BE TAKEN	• Install hook into wall stud. Close hook with pliers after hanging item. • Alternatively, use hook with closed loop or spring-back retention bar. • Use specialized earthquake hooks (ook™ brand) that retain wire hung items. • Do not hang an item that weighs more than recommended by the hook manufacturer.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 7	Unsecured fire extinguishers.
WHAT COULD HAPPEN	• Unit may fall off wall and damage the shut-off valve or hose, releasing its content. • Unit could strike nearby occupants. • A damaged fire extinguisher may not be functional in an emergency.
ACTION TO BE TAKEN	• Secure fire extinguisher mounting bracket or cabinet to wall framing. • Retention straps can be used for further security. • Cabinets must be accessible either through breakable glass or latched door.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 8	Glass windows and doors at entryways.
WHAT COULD HAPPEN	• Glass may fall or shatter injuring nearby occupants. • Fallen glass could block doors and exits during an emergency.
ACTION TO BE TAKEN	• Replace glass on door and glass surrounding the door with safety glazing (glass) or safety film. • Safety glass has permanent identification label etched or ceramic fired on the glass and readable from the inside of the building.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 9	Unsecured free standing and cubical partitions.
WHAT COULD HAPPEN	• Cubical partitions could strike nearby occupants. • Fallen cubical partitions could block hallways and exit areas.
ACTION TO BE TAKEN	• Screw clip angle to intermediate and end panels at each end. • Secure clip angle to concrete floor with concrete drill-in anchor bolt at each leg. Lag bolt must be installed into floor joists or blocking. • Clip angle must be screwed into the metal frame portion of the cubical partition. • Maximum distance between intermediate or end panels is 10 feet. • Panel joint must be rigid. • If panels are hinged together or joints were not rigid, reinforce the top with steel flat plate across the joint and secure the bottom with clip angle.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 10	Unsecured file cabinets.
WHAT COULD HAPPEN	• File cabinets could fall over striking nearby occupants. • Contents could block hallways and exit areas.
ACTION TO BE TAKEN	• When the cabinet depth or width is less than two-thirds the height, the cabinet should be secured to an adjacent wall, or fastened to adjacent cabinets. • Cabinets should have latching drawers. • Heavier contents should be stored in lower drawers of a file cabinet. • Locate cabinets away from exits and hallways. • Metal clips should be provided for attachments at cabinets and at walls. • Metal clip attachments at the wall should utilize screws that are properly installed into wall studs or blocking.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 11	Unsecured bookcases 6 feet or more in height.
WHAT COULD HAPPEN	• Bookcases could fall over striking nearby occupants. • Bookcases could block hallways and exit areas.
ACTION TO BE TAKEN	• Install cross bracing in back of bookcases. Use cable or metal strap for bracing. • If bookcases were located back-to-back, tie them together with steel plates. • Secure bookcases to wall or floor using clip angles. • Alternatively, secure bookcases with anti-tip struts at top. • For bookcases standing next to a wall, secure them to wall framing with clip angles. • Relocate heavy books to lower levels.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 12	Unsecured bookcases less than 6 feet in height.
WHAT COULD HAPPEN	• Bookcases could fall over striking nearby occupants. • Bookcases could block hallways and exit areas.
ACTION TO BE TAKEN	• Tie back-to-back bookcases together with clips and bolts or screws. • Fasten bookcases to floor if the length or combined width is less than two-thirds the height to prevent tipping over. • Fasten isolated bookcases to floor or wall. • Relocate heavy books to lower levels.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 13	Unsecured desktop/countertop equipment.
WHAT COULD HAPPEN	• Equipment could fall off desk or countertop striking nearby occupants. • Fallen desktop equipment may damage electric wiring, causing power interruption, electrical shock to nearby occupants or fire.
ACTION TO BE TAKEN	• Secure with heavy-duty hook-and-loop fasteners. Attach self adhering hook-and- loop pads to base of desktop equipment case and the matting pads to desktop. • Secure with cable with self-adhering anchor pads to equipment and desktop. • Relocate desktop or heavy equipment away from doors and exit ways. • Consult a qualified structural engineer or architect for heavy countertop equipment.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 14	Unsecured equipment on carts.
WHAT COULD HAPPEN	• Equipment may fall off cart or topple cart striking nearby occupants.
ACTION TO BE TAKEN	• Secure equipment to cart with adjustable straps. Tighten strap to remove any slack. • Relocate carts away from doors and exit ways. • Cart should have locking wheels or casters. • If the height of the cart exceeds two-thirds the depth or width of the cart, secure the cart to the wall with rope, chain or cable. Rope, chain or cable should be attached to eyebolts or other closed loop fasteners, which should be installed into wall studs or blocking.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 15	Unsecured display cases/art objects.
WHAT COULD HAPPEN	• School awards, trophies and art objects could fall striking nearby occupants. • School awards, trophies and art objects could fall and block hallways and exit areas.
ACTION TO BE TAKEN	• Secure display case to floor. Shelves in display case must also be secured. • Use angle bracket if needed. • Secure contents to shelves using hook-and-loop or museum wax or a combination of both. • Consult a qualified structural engineer or architect for heavy countertop equipment.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 16	Unsecured equipment on wheels.
WHAT COULD HAPPEN	• Wheel-mounted furniture may roll or fall striking nearby occupants. • Wheel-mounted furniture may roll or fall blocking doors and exit ways for evacuation during an emergency.
ACTION TO BE TAKEN	• Install eyescrews to wall and secure furniture to eyescrews with cable, chain or rope. • Replace free rolling wheels with lockable wheels. • If wheels are not lockable, install eyescrews to floor and secure furniture to eyescrews with cable, chain or rope. • Eyescrews must be installed into wall studs or blocking.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 17	Unsecured office equipment.
WHAT COULD HAPPEN	• Office equipment may fall striking nearby occupants. • Fallen office equipment may damage electric wiring, exposing occupants to electrical shock or start a fire.
ACTION TO BE TAKEN	• Secure office equipment to the floor. • Use concrete drill-in anchor bolts for concrete floor. • Use lag bolts for wood floor. Install them into floor beams or blocking. • Bolts must be installed through metal framing of office equipment. Do not install through thin gauge housing panels • If clip angles are used, attach clip angle to metal framing of the equipment. Do not attach to thin gauge housing panels.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 18	Unsecured refrigerators and vending machines.
WHAT COULD HAPPEN	• Refrigerators and vending machines may fall striking nearby occupants. • Refrigerators and vending machines may damage electric wiring, exposing occupants to electrical shock or start a fire. • Refrigerators and vending machines could fall and block hallways and exit areas.
ACTION TO BE TAKEN	• Secure refrigerators and vending machines to floor with slotted z-clips or clip angles. • Slotted z-clip must have a minimum of two bolts to the floor. • Relocate refrigerators and vending machines away from doors and exit ways.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 19	Unsecured shop/gym equipment.
WHAT COULD HAPPEN	• Shop or gym equipment may fall striking nearby occupants. • Shop or gym equipment could fall and block hallways and exit areas.
ACTION TO BE TAKEN	• Secure shop or gym equipment to concrete floor with concrete drill-in anchor bolt at each leg. • Secure shop or gym equipment to wood floor with a lag bolt at each leg. Lag bolt must be installed into floor joists or blocking. • When clip angle is required, screw angle to equipment and fasten to floor with either concrete drill-in anchor or lag bolts.
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 20	Unsecured gas cylinders/tanks.
WHAT COULD HAPPEN	• Gas cylinders or tanks may fall over and damage the shut-off valve, releasing hazardous or flammable contents. • A cylinder with a damaged shut-off valve may result in the tank or valve becoming a projectile. • Cylinders may fall over, striking or rolling and striking nearby occupants.
ACTION TO BE TAKEN	• Secure each cylinder or tank to a wall with two restraints. • Alternatively, to providing wall restraints, cylinders or tanks may be kept within a storage rack or compartment that is secured to a wall or floor. • Store gas cylinders or tanks in non-occupied areas, and away from exit routes or exit doors. • Chain, cable or rope restraints must be attached to eyebolts or other closed hook structural fasteners. • Eyebolts or other fasteners must be attached to wall framing (studs or blocking.)
TIMELINE	• Ongoing

IDENTIFIED HAZARD # 21	Unsecured water heaters.
WHAT COULD HAPPEN	• Plumbing equipment or water heaters may slide or fall striking nearby occupants. • Plumbing equipment or water heaters may slide or fall spilling hot water on floor or nearby occupants, or rupture gas lines.
ACTION TO BE TAKEN	• Secure base of water heater by bolting to floor. • Secure water heater to wall with plumber's tapes, or other methods recommended by the Department of General Services – Division of the State Architect (DSA). • Use concrete drill-in anchor bolts for concrete floor and wall. • Use lag bolts for wood floor and wall. Lag bolts must be installed into floor beams, wall studs or blocking. • When clip angle is required, screw angle to equipment and fasten to floor with either concrete drill-in anchor or lag bolts. • Space between wall and water heater must be shimmed tight with non-combustible material at the locations of the plumber's tape. • Consult a qualified architect or professional engineer for seismic anchorage requirements.
TIMELINE	• Completed at all sites

IDENTIFIED HAZARD # 22	Gas Shut-off Valves.
WHAT COULD HAPPEN	• When an earthquake of significant magnitude occurs, gas lines may rupture, release natural gas and ignite to cause fires and explosions.
ACTION TO BE TAKEN	• Require the installation of natural gas earthquake automatic shut-off valves at all City sites.
TIMELINE	• Require home owners to provide installation of device within 2 years