CHAPTER 5 - EARTHQUAKES, FLOODS AND WILDFIRES: RISKS AND MITIGATION

CHAPTER CONTENT

5.1 STATEWIDE GIS HAZARD ANALYSIS

To determine appropriate hazard mitigation strategies and actions, California has undertaken a risk and vulnerability assessment for its primary hazards – earthquakes, floods and wildfires – and various secondary hazards – using Geographic Information System (GIS) analysis. GIS is helpful for analyzing spatial relationships between natural hazards and populations that live within areas affected by natural hazards.

Progress Summary 5.A: GIS Modeling and MyPlan Enhancement

Progress as of 2013: In the 2010 SHMP, three primary hazards and various secondary hazards were evaluated for impacts on California using Geographic Information System (GIS) software. Part of that effort included analyzing California's population density in relation to social vulnerability and creating a GIS dataset that visually displayed that vulnerability at a scale of approximately one square kilometer for the whole state. That dataset was then combined with hazard data for wildfire, flood and earthquake to identify areas most at risk.

In the 2013 SHMP, those basic hazard GIS datasets were again used, along with new and/or updated datasets, including those that identified vulnerability to hazards such as sea level rise and volcanic eruptions. During the intervening period Cal OES's MyPlan Internet Map Service (IMS) website became available through the joint efforts of Cal OES, the California Natural Resources Agency, the GIS Technical Advisory Working Committee (GIS TAWC), and contributing state agency partners. There are now many MyPlan data layers for use in local planning.

5.1.1 GIS ANALYSIS OF VULNERABILITY TO HAZARDS

For the 2010 SHMP, GIS modeling was developed to analyze vulnerability of California's population to disasters. Four maps were created: a population/social vulnerability base map and three hazard maps, earthquakes, floods, and wildfires. Population/social vulnerability data were combined with each GIS hazard dataset to show vulnerability for that hazard as it varies throughout the state. A map combining population/social vulnerability with all three hazards is used as a backdrop for a map showing all federal hazard mitigation projects from 1998 to 2008.

In the 2013 SHMP, the population/social vulnerability maps from the 2010 SHMP are again included. Although, updated hazard layer datasets have been obtained and new maps created, population data (from the 2000 census) are the same as those used for the 2010 SHMP maps because population changes reflected in the 2010 census data would be too small to be discernible at a statewide scale. Cal OES's MyPlan Internet Map Service (IMS) website was launched in fall 2011 through collaborative efforts of then-Cal EMA, the California Natural Resources Agency, the SHMP GIS Technical Advisory Working Committee (GIS TAWC), and other state agency partners. There are now many data layers available on MyPlan that can be turned on and off as needed to create community-scale hazard maps for use in Local Hazard Mitigation Plans, general plan safety elements (and all elements of a general plan, whether mandatory or optional, must be consistent with one another), and Local Coastal Programs.

For a full discussion of GIS modeling used to initially create the population/social vulnerability and related maps, see Appendix N, GIS Risk Exposure Methodology.

Earthquake Vulnerability Modeling

As noted in Chapter 4, while earthquakes occur less frequently than the other primary hazard events, they have accounted for the greatest combined losses (deaths, injuries, and damage costs) in disasters since 1950 and have the greatest catastrophic disaster potential. The earthquake hazard base map began with statewide vector (areas) data supplied by the California Geological Survey showing differing levels of expected relative intensity of ground shaking in California from anticipated future earthquakes.[38]

Flood Vulnerability Modeling

Flooding in California is widespread and the second most frequent disaster source. Since 1950, floods have accounted for the second highest combined losses and the largest number of deaths.

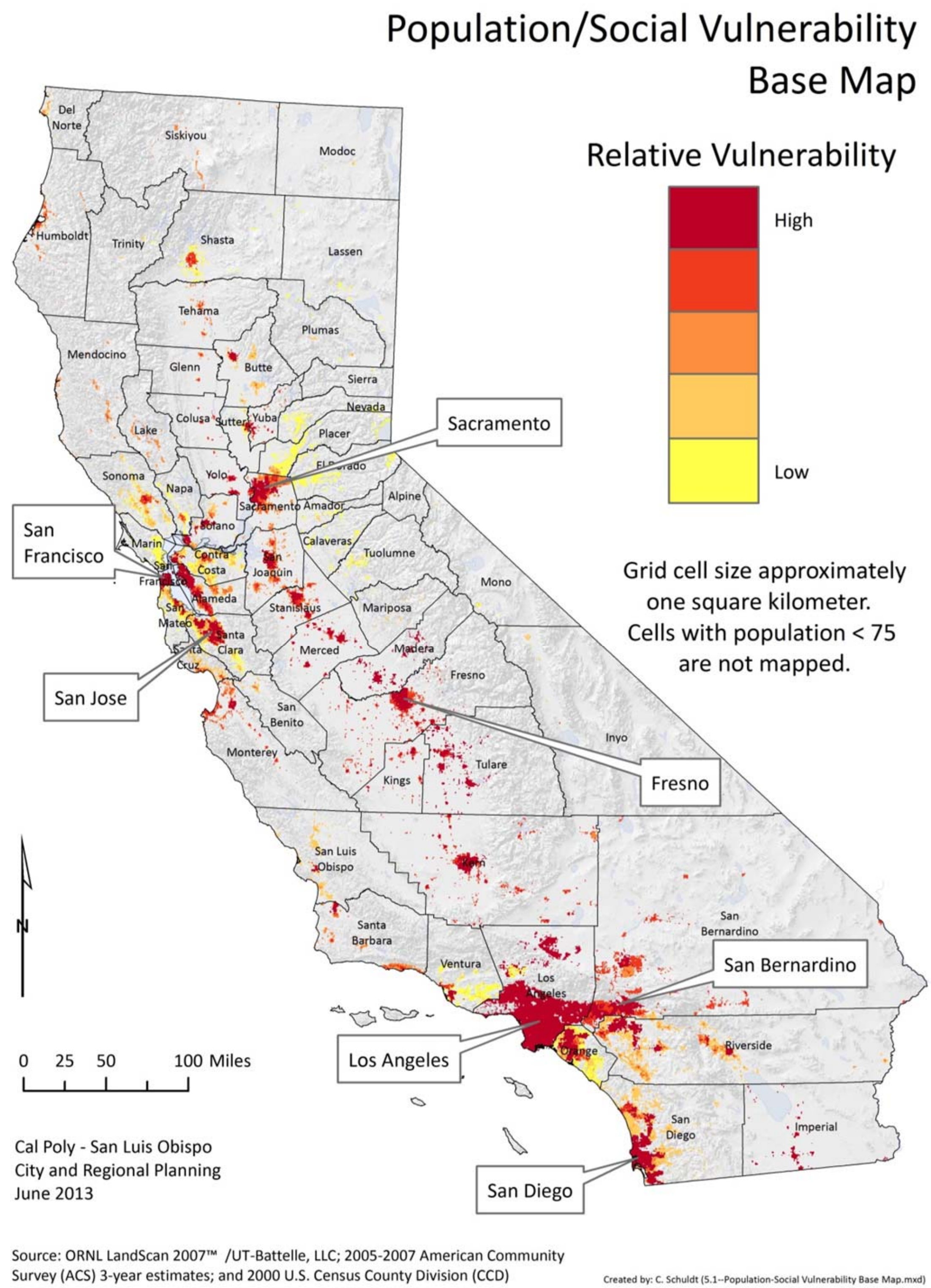
Wildfire Vulnerability Modeling

Wildfires are the most frequent source of declared disasters and account for the third highest combined losses. The Population/Social Vulnerability with Wildfire Hazard map uses data from the 2005 Wildfire Threat GIS map created by the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program (CAL FIRE/FRAP). Its original data take into account fuel loads and fire history, among other factors, to create five threat classes: extreme, very high, high, moderate, and little or no threat.

Wildfire vulnerability in California is found chiefly in wildland-urban-interface (WUI) communities, located largely on the periphery of suburban areas in Southern California, coastal mountains, and heavily wooded areas of the Sierra Nevada. Some areas burn frequently, particularly the hills surrounding Los Angeles, San Diego, and Big Sur, as well as more isolated mountains in the Coast Ranges and Sierra Nevada.

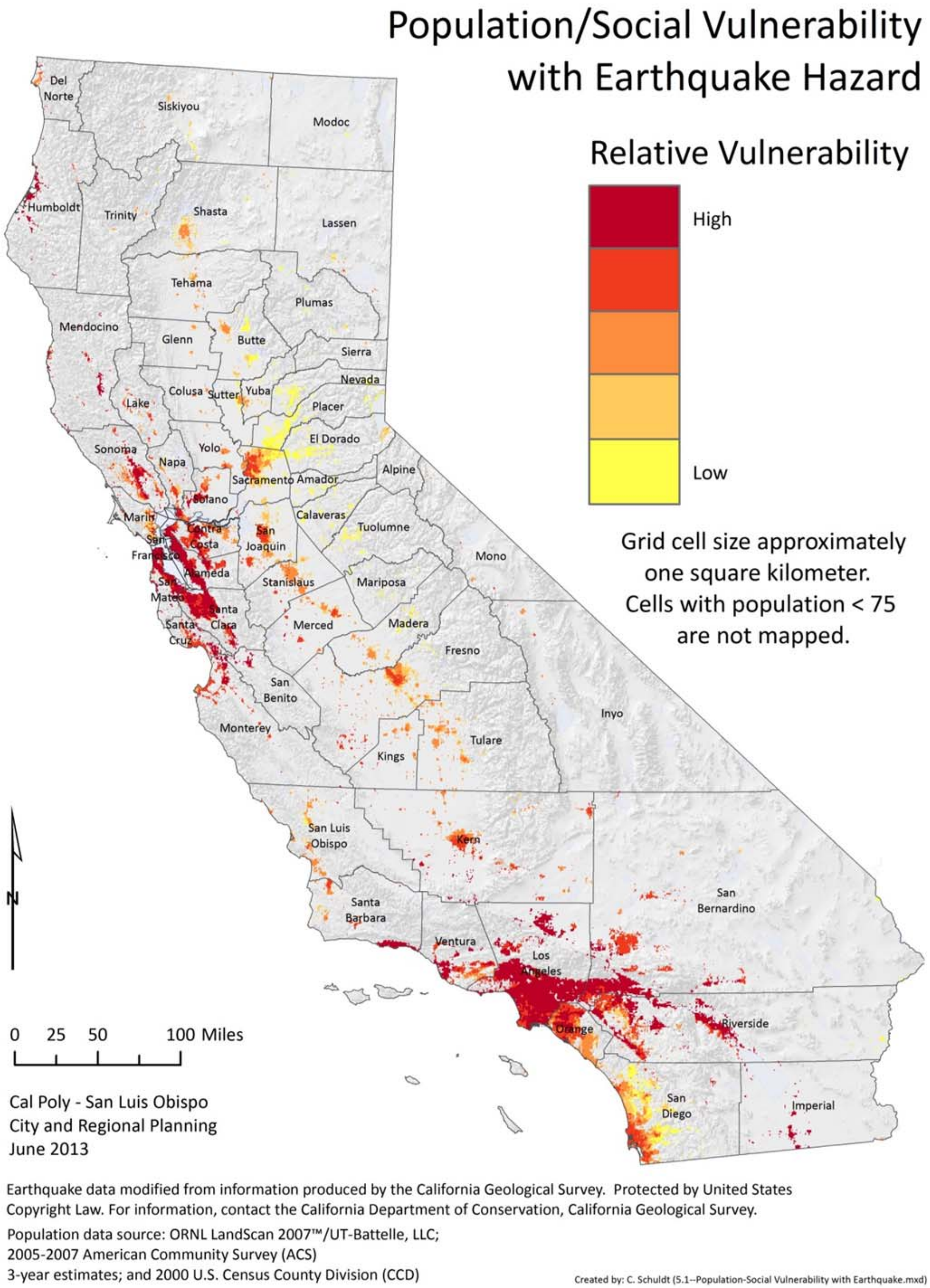
[38] 1.0 second spectral acceleration with 2-percent probability of exceedance in 50 years.

MAP 5.A: Population/Social Vulnerability Base Map



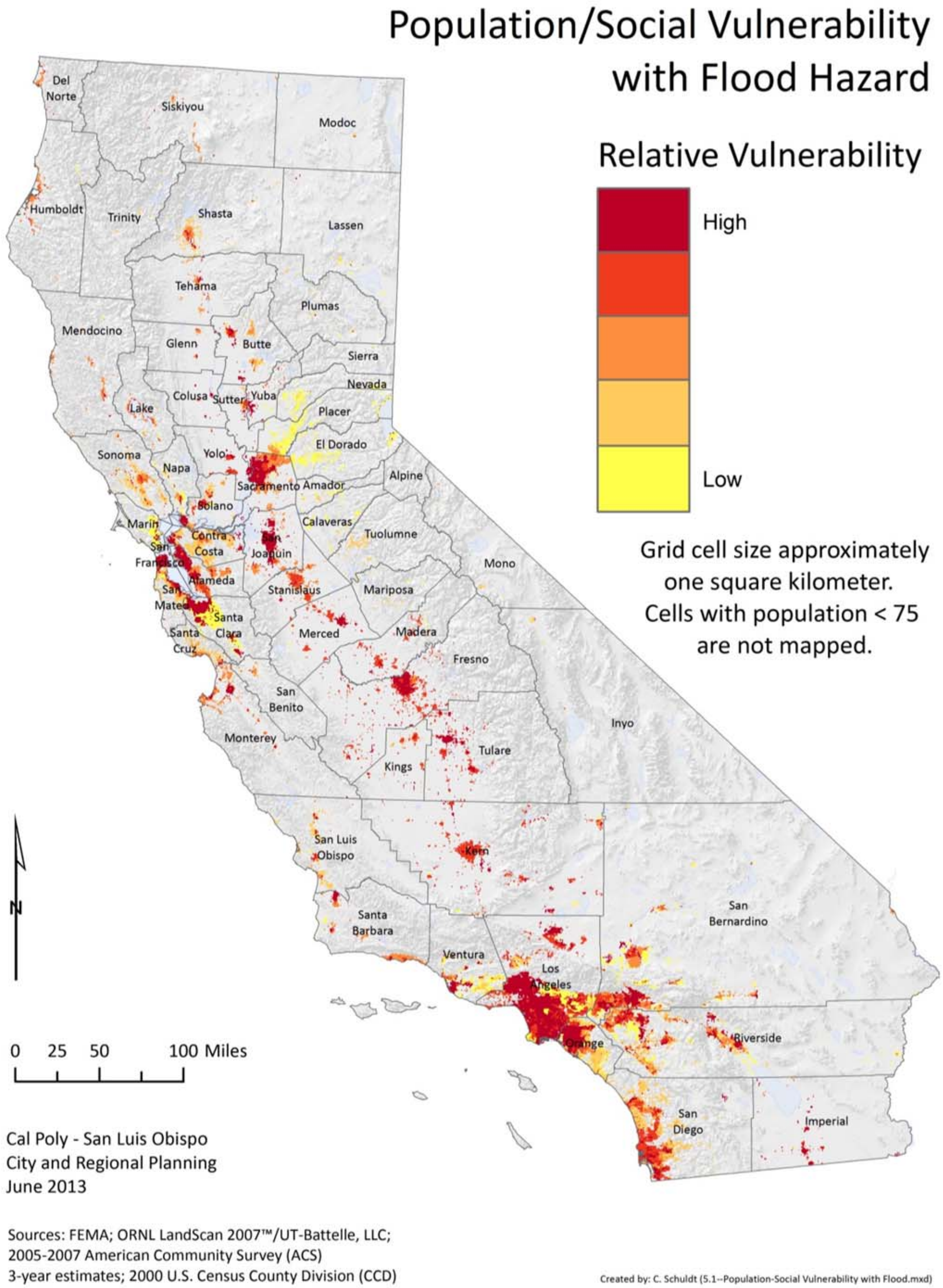
Map 5.A shows highest concentrations of combined population density and social vulnerability (based on the index described in Appendix N) in Southern California, the San Francisco Bay Area, and the Central Valley area. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

MAP 5.B: Population/Social Vulnerability with Earthquake Hazard



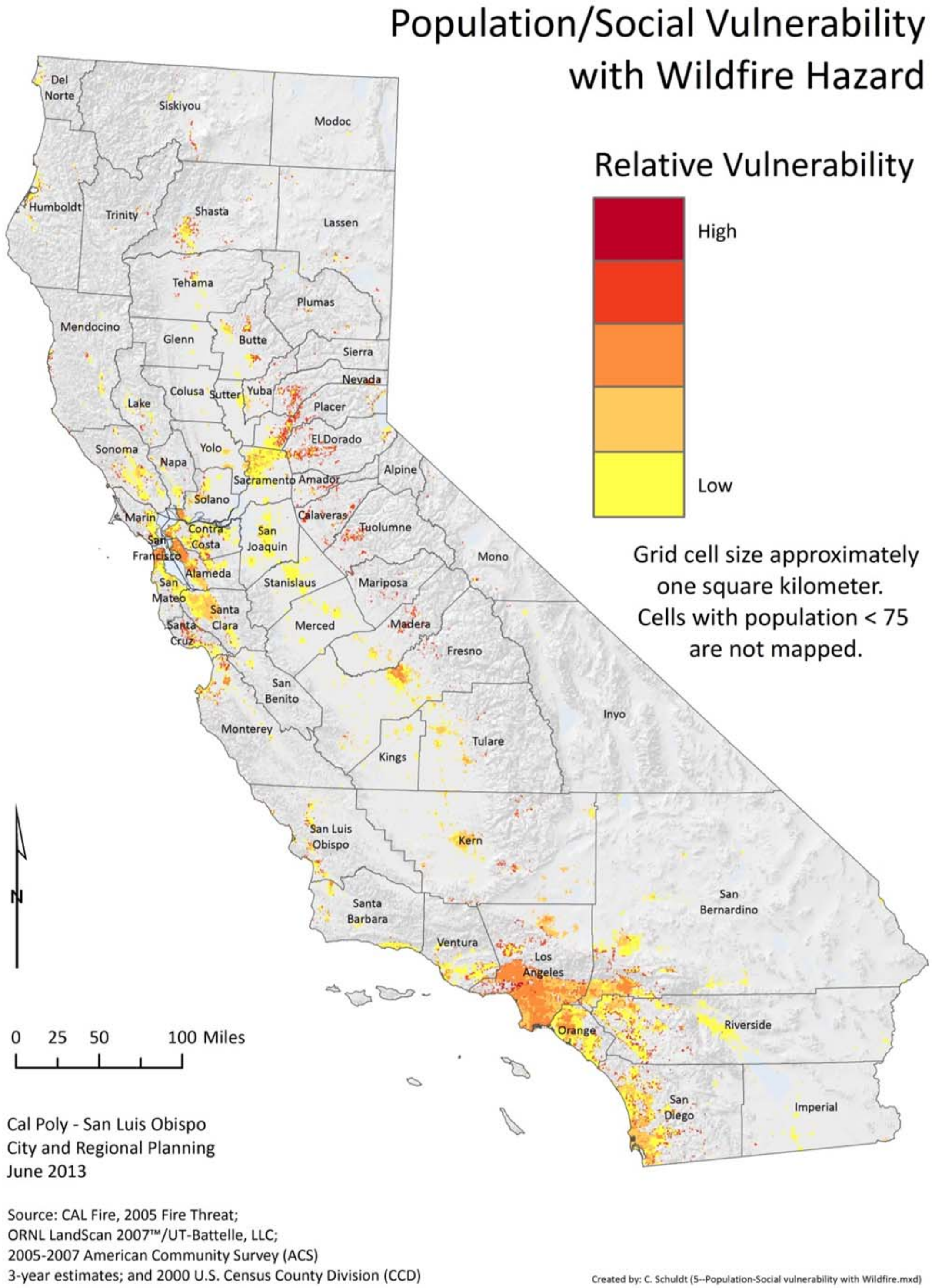
Map 5.B shows population/social vulnerability (based on the index described in Appendix N) in areas at high risk of earthquake hazards. Greatest concentrations are in Southern California and the San Francisco Bay Area. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

MAP 5.C: Population/Social Vulnerability with Flood Hazard



Map 5.C shows high concentrations of population/social vulnerability (based on the index described in Appendix N) in areas at high risk of flood hazards with low-lying areas spread across the state. Most heavily affected counties are in the San Francisco Bay Area, the Central Valley area, and Southern California. *(Online or download viewers can zoom in for a closer view of the information on this map.).*

MAP 5.D: Population/Social Vulnerability with Wildfire Hazard



Map 5.D shows moderate to high concentrations of population/social vulnerability (based on the index described in Appendix N) in areas at high risk of wildfire hazards. Most heavily affected areas are in the hilly and mountainous portions of the San Francisco Bay Area, Southern California, and the Sierra Nevada. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

Note: WUI areas tend to be less heavily populated than other parts of California. Therefore, the vulnerability patterns shown on a statewide map such as Map 5.D tend to be understated when viewed at a statewide scale. By zooming in on the online version of this map, readers can obtain a more accurate picture of these vulnerability patterns.

Future GIS Risk Assessment Plans

Although the one-kilometer grid cell size used in the preceding maps is appropriate for generalized statewide analysis, it is generally not useful for interpretation of hazards, risk, and vulnerability at the community level. However, the 2013 SHMP is being published both in print and on the web. The web version allows viewers to enlarge these maps to see more detailed information. Also, underlying base data, as well as the GIS model, will be made available.

ArcGIS ModelBuilder is a tool for designing and implementing geoprocessing of GIS layer data. It allows creation of a series of steps to manipulate GIS data that can be run repeatedly to test and refine the outcome. Because the 2013 SHMP risk analysis was created in ModelBuilder, as new base datasets become available, the model can be rerun and the vulnerability maps updated. A simplified user interface is being developed to easily allow relative weighting to be modified in the future.

MyPlan Website

Cal OES's MyPlan website (http://myplan.calema.ca.gov/) was released in late 2011 and since then has been available for creation of community-scale GIS hazard maps. It is aimed primarily at local planners and other professionals working for local communities. The intent is to provide support for preparation of Local Hazard Mitigation Plans, general plan safety elements (and all elements of a general plan, whether mandatory or optional, must be consistent with one another), and Local Coastal Programs (LCPs).

The MyPlan website provides a simple-to-use interface for viewing hazard and base data layers and creating user-specific maps. The GIS Technical Advisory Working Committee (GIS TAWC) continues to meet to provide updated GIS hazard datasets and to develop suggestions for improving MyPlan. The basic design of the website is also available to other states and agencies for use in their own specific applications of GIS web mapping.

5.1.2 PLANNING, POLICY AND ACTION IMPLICATIONS

These GIS multi-hazard risk exposure findings contain implications for priority-setting with respect to hazard mitigation strategies. When compared with the findings on population and construction growth presented in Chapter 4, additional implications are found:

1. When comparing population growth from 2000-2012 identified in Chapter 4 with risk exposure of socially vulnerable populations to various hazards, a substantial overlap is found among heavily populated areas, growth areas, and high risk exposure.

2. Historically, mitigation priority-setting has been done largely on an ad hoc basis in response to specific outcomes of particular disasters, including losses, damage locations, and scales.

3. The preceding multi-hazard risk analysis, together with historical analysis of declared disasters in California since 1950, reveals that earthquakes, floods, and wildfire hazards are pervasive, primary determinants of disaster losses.

4. The need is clear for an accelerated pre-disaster mitigation planning program that takes more directly into account the geographic patterns of hazards, vulnerability, and risk of earthquakes, floods, and wildfires.

5.2 EARTHQUAKE HAZARDS, VULNERABILITY AND RISK ASSESSMENT

This section addresses earthquakes as one of three primary hazards in the classification system introduced in Chapter 4 and includes information identifying the following dimensions of this hazard:

- Locations within the state (i.e., geographic area affected)
- Previous occurrences within the state
- The probability of future events (i.e., chances of recurrence)

5.2.1 IDENTIFYING EARTHQUAKE HAZARDS

Overview

Earthquakes represent the most destructive source of hazards, risk, and vulnerability, both in terms of recent state history and the probability of future destruction of greater magnitudes than previously recorded.

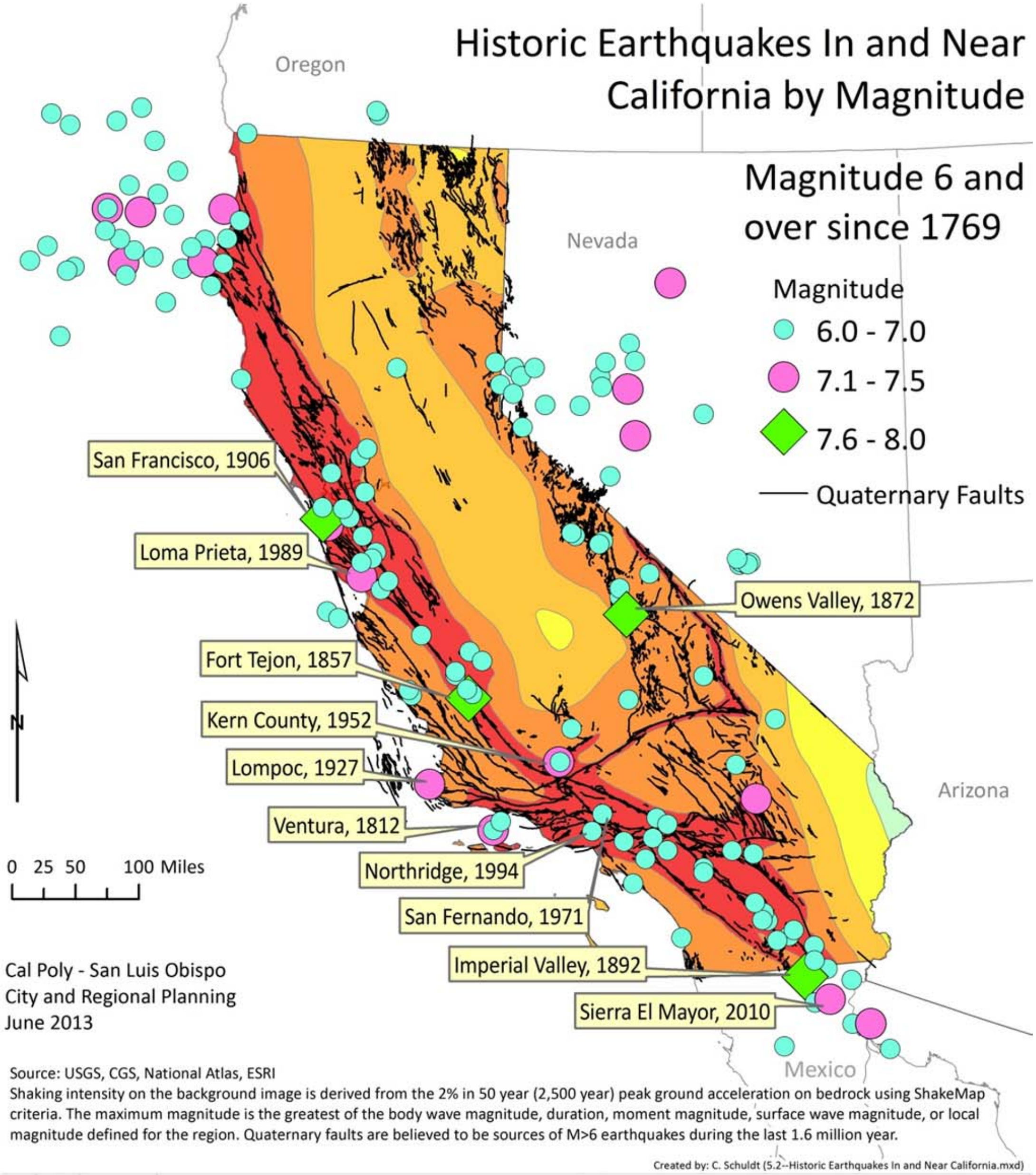
Earthquakes are a significant concern for California for several reasons. First, California has a chronic and destructive earthquake history. Since 1950, only 8 percent (12) of federally declared disasters in the state were the result of earthquakes. During this time, however, earthquake disasters have claimed 203 lives and resulted in 18,962 injuries and over $8 billion in Cal OES-administered disaster costs. Second, California has widespread earthquake vulnerability as indicated by California Geological Survey mapping of potential earthquake shaking intensity zones, with their common presence near many populated areas. Third, nearly all local governments that have submitted Local Hazard Mitigation Plans (LHMPs) have identified earthquakes as an important hazard.

Causes of Earthquakes: Plate Tectonics

California is seismically active because it sits on the boundary between two of the earth's tectonic plates. Most of the state – everything east of the San Andreas Fault – is on the North American Plate. The cities of Monterey, Santa Barbara, Los Angeles, and San Diego are on the Pacific Plate, which is constantly moving northwest past the North American Plate. The relative rate of movement is about two inches (50 millimeters) per year. The San Andreas Fault is considered the boundary between the two plates, although some of the motion (also known as slip) is taken up on faults as far away as central Utah.

In California, about 40 millimeters per year of the slip occur on the faults of the San Andreas system and about 10 millimeters per year occur in the Mojave Desert and in the Basin and Range area east of the Sierra Nevada on a fault system known as the eastern California shear zone.

MAP 5.E: Historic Earthquakes In and Near California by Magnitude (1769-2010)



	MMI	Damage	Effects
	X	Very Heavy	Some well-built, wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
	IX	Heavy	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.
	VIII	Moderate to Heavy	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
	VII	Moderate	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly-built or badly designed structures; some chimneys broken.
	VI	Light	Felt by all, many frightened. Some heavy furniture moved; a few instance of fallen plaster. Damage slight.
	V	Very Light	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

Map 5.E shows the pattern and selected dates of earthquakes in or near California during the past 240 years.

The constant motion of the plates causes stress in the brittle upper crust of the earth. These tectonic stresses build as the rocks are gradually deformed. The rock deformation, or strain, is stored in the rocks as elastic strain energy. When the strength of the rock is exceeded, rupture occurs along a fault. The rocks on opposite sides of the fault slide past each other as they spring back into a relaxed position. The strain energy is released partly as heat and partly as elastic waves called seismic waves. The passage of these seismic waves produces the ground shaking in earthquakes.

California has thousands of recognized faults. Only some are known to be active and only a subset of those pose significant hazards. The motion between the Pacific and North American plates occurs primarily on the faults of the San Andreas system and the eastern California shear zone. Faults are more likely to have future earthquakes on them if they have more rapid rates of movement, have had recent earthquakes along them, experience greater total displacements, and are aligned so that movement can relieve the accumulating tectonic stresses. Geologists classify faults by their recency of movement. “Active” faults represent the highest hazard and have ruptured to the ground surface during the Holocene period (about the last 11,000 years). “Potentially active” faults are those that displaced layers of rock from the Quaternary period (the last 1,800,000 years). Nearly all movement between the two plates is on active faults.

The San Andreas Fault is not the only significant fault/plate boundary in California. The seismicity north of the Cape Mendocino is controlled by faults associated with the Cascadia Subduction Zone, a large fault system offshore that separates the Juan de Fuca Plate to the west and the North America Plate to the east. This area is the most seismically active in the state. The Cascadia Subduction Zone is capable of producing great earthquakes (+8 magnitude) and last ruptured in the year 1700, causing what was likely an earthquake in the Magnitude 9 range. The subduction zone is also capable of generating a large tsunami.

Earthquake Hazards: Shaking

Damage due to ground shaking produces over 98 percent of all building losses in typical earthquakes. Building damage can be both structural and/or non-structural (contents) and both types of damage can cause injury or loss of life. In addition, buildings are also vulnerable to ground displacements associated with primary fault rupture, liquefaction, differential settlement, and landslides. Inundations from tsunamis, seiches, and dam failures can also be major sources of loss to buildings.

The amount of energy released during an earthquake is usually expressed as a magnitude and is measured directly from the earthquake as recorded on seismometers. An earthquake’s magnitude is expressed in whole numbers and decimals (e.g., 6.8). Seismologists have developed several magnitude scales. One of the first was the Richter Scale, developed in 1932 by the late Dr. Charles F. Richter of the California Institute of Technology. The most commonly used scale today is the Moment Magnitude (Mw) Scale, which is related to the total area of the fault that ruptured as well as the amount of offset (displacement) across the fault. It is a more uniform measure of the energy released.

The other commonly used measure of earthquake severity is “intensity.” Intensity is an expression of the amount of shaking at any given location on the ground surface. While an earthquake has only one magnitude, it may have many intensity values, which will generally decrease with distance from the epicenter. The Modified Mercalli Intensity (MMI) Scale has been used historically to describe earthquake shaking in terms related to observable effects (see Table 5.A). While more scientifically exact methods have been identified to describe earthquake shaking, the MMI can be useful in reconstructing shaking levels of earthquakes recorded prior to scientific instrumentation. With the advent of strong-motion recording instruments, shaking intensity measures have become more quantitative.

Table 5.A: Abbreviated Modified Mercalli Intensity (MMI) Scale

Intensity	Effects
I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
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.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: U.S. Geological Survey. http://earthquake.usgs.gov/learning/topics/mag_vs_int.php

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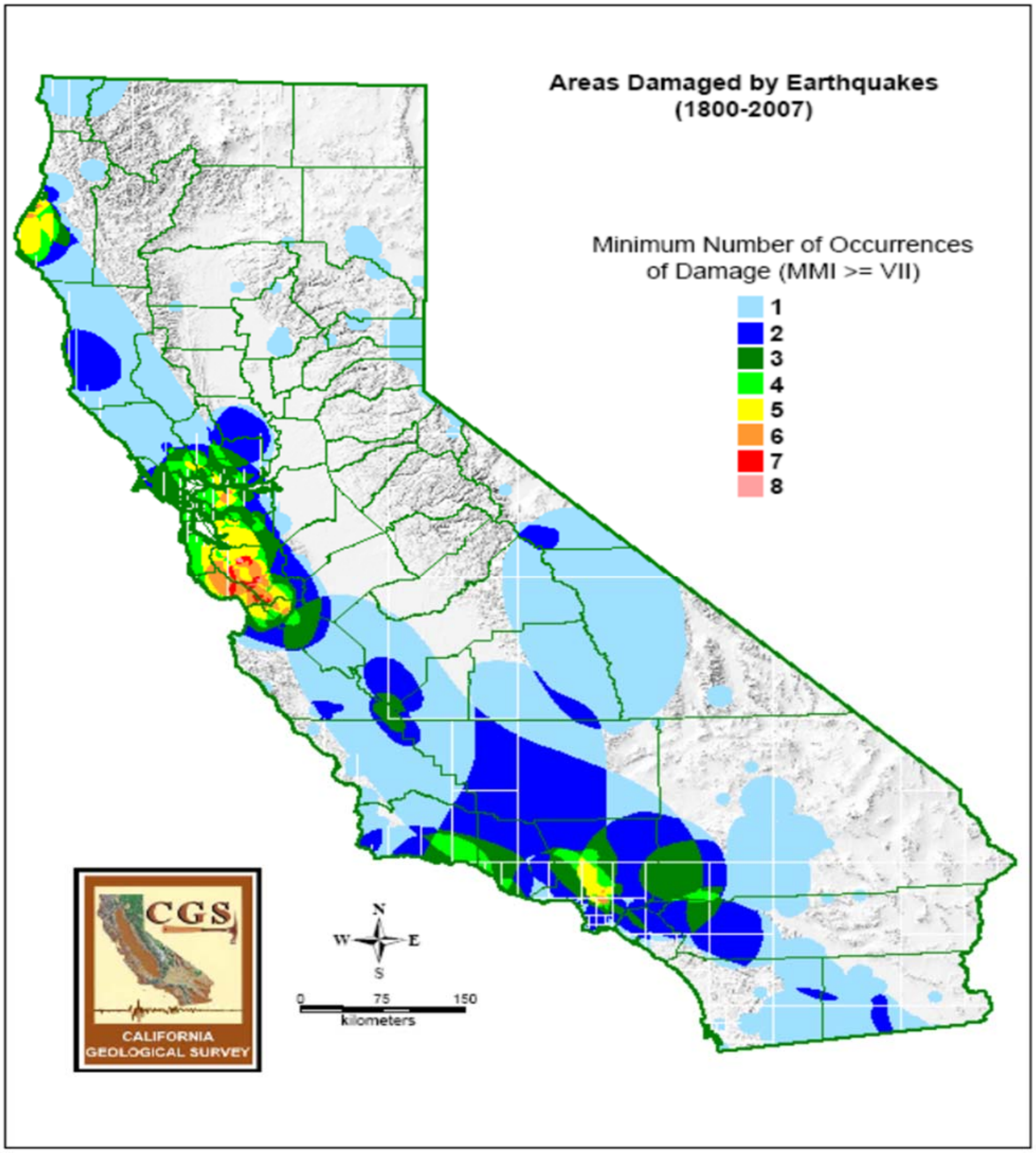
MAP 5.F: Areas Damaged by Earthquakes, 1800-2007

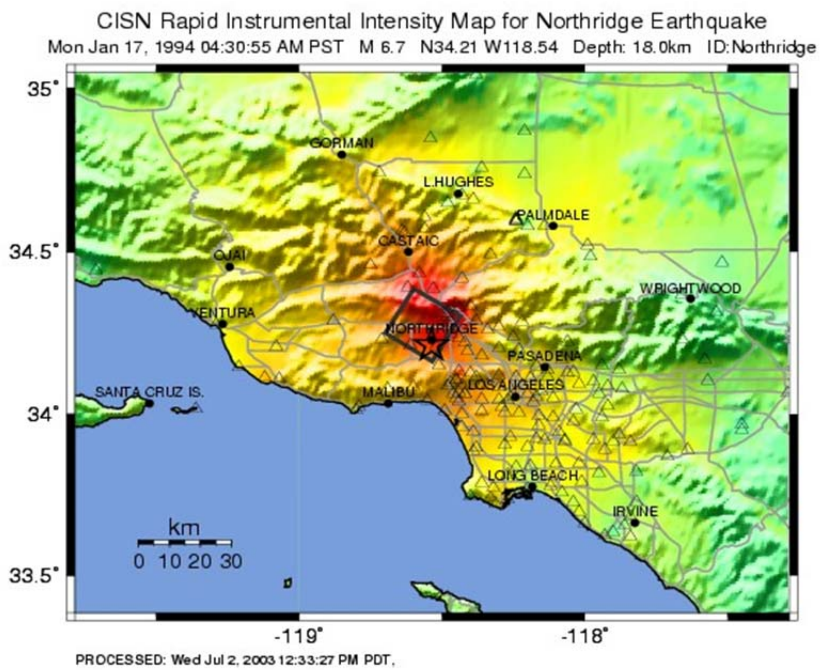


Map 5.F shows the numbers of historical occurrences of events described as MMI Scale VII or greater from 1800 to 2007. Such events notably have been concentrated along the San Andreas Fault system, particularly in the San Francisco Bay, Monterey Bay, and Humboldt County areas. However, a significant earthquake is expected in Southern California in the near future. Such an event would change this map accordingly showing larger areas of damage in Southern California.

Earthquake "ShakeMaps"

Earthquake shaking is measured by instruments called accelerometers that are triggered by the onset of shaking and record levels of ground motion at strong motion stations throughout the state operated by the California Geological Survey (CGS), U.S. Geological Survey (USGS), California Institute of Technology, and University of California, Berkeley. USGS rapidly converts the data from the accelerometers into ShakeMaps that show the distribution of earthquake shaking in terms of peak ground acceleration and peak ground velocity. These measures are used to infer shaking intensity expressed as Modified Mercalli Intensity (MMI). Based on actual measured motions, ShakeMaps, such as Map 5.G for the 1994 Northridge Earthquake, are a major step forward in guiding emergency response to earthquakes. They are used by emergency responders to evaluate the extent and variation of shaking within the area affected by an earthquake and to send resources to the areas that most likely sustained heavy damage. Simulated ShakeMaps are also generated for specific future earthquake scenarios based on intensity models.

MAP 5.G: ShakeMap



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

In addition, more sophisticated models of earthquake shaking for a given place consider the potential for all future earthquakes on surrounding faults and their related ground motion affecting that place. Integrating all of the potential for ground motion statewide produces maps that show the long-term probabilistic seismic hazard anywhere in the state. Such maps help identify areas that are particularly vulnerable, which is useful in pre-disaster mitigation planning as well as post-disaster performance evaluations of prior mitigation projects.

Amplification of Seismic Shaking

Although seismic waves radiate from their source like ripples on a pond, the radiation is not uniform due to the complex nature of an earthquake rupture, different paths the waves follow through the earth, and different rock and soil layers near the earth's surface. Large earthquakes begin to rupture at their hypocenter deep in the earth and the fault ruptures outward from that point. Because the speed of an earthquake rupture on a fault is similar to the speed of seismic waves, waves closer to the epicenter can be compounded by waves from farther along the rupture, creating a pulse of very strong seismic waves that move along the fault in the direction of the fault rupture. Seismic waves may also be modified as they travel through the earth's crust. Shaking from the 1989 Loma Prieta Earthquake was concentrated to the north, toward San Francisco and Oakland, possibly due to the reflection of seismic waves off the base of the earth's crust.

Loma Prieta Earthquake Damage, San Francisco, 1989

Source: U.S .Geological Survey

As seismic waves approach the ground surface, they commonly enter areas of loose soils where the waves travel more slowly. As the waves slow down, their amplitude increases, resulting in larger waves with frequencies that are more likely to damage structures. Waves can also be trapped within soft sediments between the ground surface and deep, hard basement rocks, their destructive energy multiplying as they bounce back and forth producing much greater shaking at the ground surface. CGS and USGS recorded large ground waves at many locations during both the Loma Prieta Earthquake and the 1994 Northridge Earthquake.

Unexpectedly large ground waves and their resulting damage may be produced from a relatively distant earthquake. Shaking from the 1999 Hector Mine Earthquake in the Mojave Desert produced waves with amplitudes of up to 15 centimeters in the Los Angeles basin, more than 200 kilometers from the epicenter. While there was little damage from the Hector Mine Earthquake, other large earthquakes have caused damage in distant places. For example, Nevada's 1954 Dixie Valley Earthquake resulted in damage to critical facilities in Sacramento due to water sloshing.

Mitigation of Seismic Shaking Hazards

Seismic shaking, which caused over 98 percent of the losses in the Loma Prieta Earthquake, has long been recognized as the main threat to structures during earthquakes. To mitigate this hazard, building codes have been steadily improved over the past 80 years as understanding of seismic shaking has improved based on strong motion data gathered by CGS and USGS. Current California building codes include provisions for considering the potential shaking from earthquakes, including stronger shaking near faults and amplification by soft soils.

The building code has been the main mitigation tool for seismic shaking in most buildings, although hospitals, schools, and other critical facilities are subject to additional mitigation measures, as will be discussed below.

Earthquake Hazards: Ground Failure

Fissuring, settlement, and permanent horizontal and vertical shifting of the ground often accompany large earthquakes. Although not as pervasive or as costly as the shaking itself, these ground failures can significantly increase damage and under certain circumstances can be the dominant cause of damage. The majority of damage from the 1964 Alaskan Earthquake was attributed to the extensive ground failures that accompanied the event. Studies after the 1994 Northridge Earthquake showed that when ground failure was involved, damage to residential dwellings was three to four times greater than average shake damage. Because of their geographic extent, network infrastructures such as water, power, communication, and transportation lines are particularly vulnerable to ground failures.

Fault Surface Rupture, Landers Earthquake, 1992

Fault Rupture

The sudden sliding of one part of the earth's crust past another releases the vast store of elastic energy in the rocks as an earthquake. The resulting fracture is known as a fault, while the sliding movement of earth on either side of a fault is called fault rupture. Fault rupture begins below the ground surface at the earthquake hypocenter, typically between three and ten miles below the ground surface in California. If an earthquake is large enough, the fault rupture will actually travel all the way to the ground surface, wreaking havoc on structures built across its path. Large earthquakes in Turkey and Taiwan have shown that few structures built across the surface traces of faults can withstand the large displacements that occur during earthquakes.

Liquefaction

In addition to the primary fault rupture that occurs right along a fault during an earthquake, the ground many miles away can also fail during the intense shaking. One common type of failure occurs with liquefaction, when soft, water-saturated soil settles suddenly during earthquake shaking. Seismic soil liquefaction can be described as significant loss of strength due to increase in pore pressures, resulting in ground deformation potential. This phenomenon turns the soil into a fluid-like substance, causing it to lose the ability to support buildings and other structures. Areas susceptible to liquefaction include places where sandy sediments have been deposited by rivers along their course or by wave action along beaches. Alameda Naval Air Station runways and Port of Oakland equipment suffered damage from liquefaction during the 1989 Loma Prieta Earthquake.

Lateral Spreading occurs on liquefiable land that slopes toward bodies of water can lose strength during earthquakes and spread laterally down-slope. Damage to structures and infrastructure in areas experiencing lateral spreading can be far worse than nearby areas experiencing only liquefaction.

Landslides

Landslides are the result of the down-slope movement of unstable hillside materials under the influence of weathering and gravity over time. Strength of rock and soil, steepness of slope, and weight of the hillside material all play an important role in the stability of hillside areas. Weathering and absorption of water can weaken slopes, while the added weight of saturated materials or overlying construction can increase the chances of slope failure. Sudden failure can be triggered by earthquake shaking, excavation of weak slopes, and heavy rainfall, among other factors.

Because landslides occur often without earthquakes, landslide hazards are discussed in a separate section of this SHMP (see Section 6.2, Landslides and Other Earth Movements).

Mitigation of Ground Failure

Because the safety and stability of buildings, bridges, and other engineered structures depend on strong, stable foundations, catastrophic ground failures of the type discussed here must be avoided by choosing safe construction sites or by reducing risk through prudent civil engineering practice. The latter includes constructing appropriate foundation systems and modifying unstable ground to increase stability through grading, compacting, or reinforcing soils. Experience has repeatedly shown that use of these methods in design and construction can greatly reduce damage and loss during earthquakes.

The 1971 San Fernando Earthquake was caused by rupture along the San Fernando Fault that resulted in total loss to many structures built across its path. That event clearly demonstrated that active faults must be avoided when constructing new buildings and led to passage of the Alquist-Priolo Earthquake Fault Zoning Act of 1972. The Act prohibits the construction of buildings for human occupancy across active faults in California. Similarly, the extensive damage caused by secondary ground failures during the 1989 Loma Prieta Earthquake focused attention on landslides and liquefaction and led to the Seismic Hazards Mapping Act, which increases construction standards at sites where ground failures during earthquakes are likely.

Ground Failure Hazard Zones

Determining where and when to mitigate ground failure hazards is facilitated by seismic hazard zone maps and earthquake fault zone maps. These maps identify where such hazards are more likely to occur based on analyses of faults, soils, topography, groundwater, and the potential for earthquake shaking sufficiently strong to trigger landslide and liquefaction. Both types of maps are based on the concept of “special study zones” and are used to identify locations where specially adapted construction standards are necessary for public safety and welfare. Local planning and building departments must use such maps as a screening tool to identify when to undertake detailed geotechnical or fault investigations in order to validate the level of hazard suspected at proposed development sites. A city or county can only issue a construction permit in hazard areas when the developer agrees on an appropriate level of mitigation against landslides or liquefaction, or when selected building sites are offset from active fault traces (usually at least 50 feet).

California disclosure laws require that sellers inform buyers if a property for sale is located within an earthquake fault zone or a seismic hazard zone.

Earthquake Hazards: Tsunami

Tsunamis are large waves caused by sudden disturbances in the ocean, usually on the ocean floor. Tsunamis are commonly caused by fault rupture on the ocean floor or by underwater landslides. The Great East Japan (Tohuku) earthquake and tsunami of 2011 have given new visibility to this threat in California, especially in the northwestern corner of California where a geologic setting similar to the 2011 Japan event exists. A separate section of this SHMP addresses this hazard (see Section 6.3, Tsunami Hazards). A seiche is a very large wave in an enclosed or partially enclosed body of water such as lake or harbor and may be generated by an earthquake.

5.2.2 PROFILING EARTHQUAKE HAZARDS

Recent Earthquake Events

Earthquakes large enough to cause moderate damage to structures—those of Magnitude 5.5 or larger—occur three to four times a year in California. For example, the Magnitude 6.5 San Simeon Earthquake of December 22, 2003 caused 2 deaths, 47 injuries, and $263 million in damage. The Humboldt County earthquake on Magnitude 6.5 January 9, 2010, resulted in zero deaths, 35 injuries and $43 dollars in damage. The Magnitude 7.2 El Mayor Cucapah earthquake (also known as the Sierra El Mayor earthquake) of April 4, 2010 was located in Northern Baja California at the former mouth of the Colorado River. This event shook not only Mexicali and Tijuana but also a large part of Southern California and parts of southwestern Arizona and Nevada. There were two confirmed deaths in Mexicali and 100 persons were injured between Baja California and Imperial County California. The total estimated damage in Southern California was $91 million while the total estimated damage between southern California and Baja California was estimated to be $1 billion with most of the damage occurring to the agriculture industry and irrigation district in Baja California.

Strong earthquakes of Magnitude 6 to 6.9 strike on an average of once every two to three years. An earthquake of this size, such as the 1994 Northridge Earthquake (Magnitude 6.7) or the 1983 Coalinga Earthquake (Magnitude 6.5), is capable of causing major damage if the epicenter is near a densely populated area. The Northridge Earthquake caused over $40 billion of disaster losses, 57 deaths, and 11,846 injuries.

Major earthquakes (Magnitude 7 to 7.9) occur in California about once every ten years. Two recent major earthquakes, the 1992 Landers Earthquake (Magnitude 7.3) and the 1999 Hector Mine Earthquake (Magnitude 7.1) caused extensive surface fault rupture but relatively little damage because they occurred in lightly populated areas of the Mojave Desert. In contrast, earthquakes of smaller magnitude but in densely populated areas, such as the 1989 Loma Prieta Earthquake (Magnitude 6.9), have caused extensive damage over large areas.

California's Catastrophic Earthquake Potential

Two of the largest historic earthquakes in California, the 1857 Fort Tejon Earthquake and the famous 1906 San Francisco Earthquake, were similar in magnitude (Magnitude 7.9 and Magnitude 7.8) and resulted from movement along the San Andreas Fault. Earthquakes of this size (Magnitude 7.7 to Magnitude 7.9) can cause more extensive damage over a larger area than the Magnitude 7.1 to Magnitude 7.4 earthquakes that have struck California in recent decades.

Although a great earthquake (Magnitude 8 or greater) has never been officially recorded in California, evidence suggests that one occurred in the early 18th century. Native American oral histories, tree-ring studies, and geological studies that show the uplift or subsidence of large areas of coastal land and records of a tsunami that struck Japan that cannot be correlated with an earthquake anywhere else around the Pacific indicate that a Magnitude 9 earthquake occurred in January 1700 on the Cascadia Subduction Zone, extending north from Cape Mendocino in Northern California to British Columbia. An earthquake of this size is similar to the one that struck Alaska in 1964 and is capable of extensive damage over a very broad region.

A 2006 study (Kircher, et al.) points out that since the 1906 San Francisco Earthquake, the Bay Area region's population has increased about ten-fold. Losses in the 1906 earthquake included 3,000 deaths, $524 million in direct building losses in 1906 dollars (which would equal about $42 billion in 2006 dollars), and 28,000 destroyed buildings, many by fire following the earthquake. It was estimated that a repeat of the 1906 earthquake in 2006 would result in 800 to 3,400 deaths, $90 billion to $120 billion in losses, and 90,000 to 127,000 extensively or completely damaged buildings.[39] Table 5.B shows earthquake losses from 1971 to 2010.

Table 5.B: Recent Earthquake Losses

Earthquake	Date	Magnitude	Direct Losses[a]	Deaths[d]	Injuries[d]
San Fernando	February 9, 1971	6.6	$2,200[b]	58	2000
Imperial Valley	October 15, 1979	6.5	$70[b]	0	91
Coalinga	May 2, 1983	6.4	$18[b]	1	47
Whittier Narrows	October 1, 1987	6.0	$522[c]	9	200+
Loma Prieta	October 17 1989	6.9	$10,000[d]	63	3757
Cape Mendocino	April 25, 1992	7.0	$80[c]	0	356
Landers/Big Bear	June 28, 1992	7.3	$120[c]	1	402
Northridge	January 17, 1994	6.7	$46,000[b]	57	11,846
Hector Mine	October 16, 1999	7.1	minor	0	11
San Simeon	December 22, 2003	6.5	$263[e]	2	46
Eureka/Humboldt	January 9, 2010	6.5	$43	0	43
El Meyor Cucapah	April 4, 2010	7.2	$91	0	91

[a]*Estimate in millions of dollars*
[b]*FEMA, 1997; U.S. Office of Technology Assessment*
[c]*National Research Council, 1994*
[d]*Cal OES*
[e]*CSSC 2004-02, 2004*

Although California has reduced the potential for earthquake-related deaths with upgraded building codes, the rate of population and per capita wealth growth is still outstripping California's ability to cap growth in earthquake disaster dollar losses as well as numbers of damaged facilities. On average, growth generates a 2-percent increase in constructed environment annually, helping to replace older facilities built to lower standards. However, less than 1 percent of unreinforced masonry (URM) buildings are being strengthened or replaced annually. Overall, 13 percent of the current building stock was built prior to earthquake codes. There remains an urgent need to increase the pace of retrofitting or replacement of such buildings to reduce potential losses in the next catastrophic earthquake.

[39] Kircher, et al. "When the Big One Strikes Again – Estimated Losses due to a Repeat of the 1906 San Francisco Earthquake." EERI Spectra Vol. 22, No. 52. April 2006.

Progress Summary 5.B: Great California ShakeOut Earthquake Drill and Public Readiness Initiative

Progress as of 2013: The Great California ShakeOut earthquake drill is an annual initiative where the public is encouraged to practice self-protective measures and to take other actions that promote earthquake resiliency. In 2008, approximately 5.5 million southern Californians participated in the first Great Southern California Shakeout earthquake drill. In 2009, the drill became statewide in California. It has continued to garner increased public participation and interest, with 6.9 million registered participants in 2009, 7.9 million in 2010, 8.6 million in 2011, and 9.4 million in 2012. In addition, ShakeOut has spread to other states, territories and countries, with 19.4 million participants worldwide in 2012.

ShakeOut registration encourages not only drill participation, but also promotes mitigation and preparedness. Moreover, it leverages the broad public visibility of the drill day to get people talking about preparedness and mitigation with people they care about. This promotion of "social milling" is based on social science indicating that people are most likely to change behavior around earthquake preparedness and mitigation if they talk about it with people they know, and when they see people like themselves taking action. The "hook" for ShakeOut is a Drop Cover Hold On drill to encourage people to practice on how to protect themselves during strong shaking. The ShakeOut initiative is much more and features "The Seven Steps" to Earthquake Safety as well.

ShakeOut as Part of Earthquake Education Stakeholder Networking

ShakeOut would not be possible if "led" in a traditional way by a single organization. It is coordinated by a broad coalition of organizations across sectors. Government jurisdictions, agencies, organizations, schools, community groups and individuals are all encouraged to register and "create their own drill" that meets their organization's goals. Outreach for ShakeOut depends on the Earthquake Country Alliance (ECA), a collaboration among three regional coalitions as well as statewide organizations, each attracting a broad base of stakeholders.

ECA broadens the definition of earthquake mitigation/education stakeholders. It is a statewide public-private partnership of people, organizations, and regional alliances that work together to improve preparedness, mitigation and resiliency. ECA's goal is to create a culture of resiliency for all Californians; ECA therefore depends on leveraging efforts and sharing strengths. This network is an important platform to deliver preparedness and mitigation information to all sectors, but it is also an important method for coordinate and unifying messages across various regions and organizations that develop and deliver such messages.

ECA's regional partners include the Southern California Earthquake Alliance, the Bay Area Earthquake Alliance, and the Redwood Coast Tsunami Work Group. Strategic Partner Organizations include the California Governor's Office of Emergency Services, United States Geological Survey, California Earthquake Authority, Southern California Earthquake Center, California Geological Survey, Federal Emergency Management Agency, American Red Cross, State Farm Insurance, and many others.

Mitigation Outreach as Part of "Readiness"

The Great ShakeOut is not advertised specifically as a mitigation event – "Mitigation" is a technical term used more by professionals; it does not typically resonate with the public in the same way as other emergency management terms like "preparedness" or "recovery". ShakeOut does carry mitigation as an important part of its comprehensive public message. Mitigation information is presented as part of every ShakeOut, with "Secure Your Stuff" (non-structural mitigation) which was a special theme for the 2010 ShakeOut. The ShakeOut initiative and the underlying structure of the Earthquake Country Alliance will continue to offer potential value for future mitigation efforts. They have educated millions of people about their proximity to earthquake hazards. The hope is that the increased consciousness of risk will translate into interest in mitigation as well as preparedness. The Great California ShakeOut also has potential mitigation benefits as a result of the networks it has created. ShakeOut continues to seek partners with an interest in reducing disaster losses and building communities of concerned individuals. These individuals and communities can be called on in the future to review mitigation actions, suggest mitigation improvements, assist in collecting data, and implement mitigation measures.

As agencies prepare for ShakeOut 2013, participants are encouraged to include mitigation as part of their message. This can include providing additional mitigation information on the ShakeOut website. Central to the mission of the Earthquake Country Alliance is a broad approach to public and community readiness and resilience. This broad approach is designed to integrate mitigation into a comprehensive public message that will "shift the culture of readiness in California."

ShakeOut emphasizes actions the public can take to increase their earthquake readiness and their ability to recover. On drill day, businesses, organizations, and municipalities are encouraged to participate in the drill with additional activities beyond the Drop Cover Hold On drill, including "Hazard Hunts" for non-structural hazards. To further promote drill registration and participation, ShakeOut includes many pre-drill events across the state. Since 2011, the Structural Engineers Association of Southern California (SEAOSC) have coordinated with ShakeOut to sponsor a Buildings At Risk (BAR) conference on structural earthquake mitigation issues, bringing together engineers, building officials, academics, policy makers and building owners. Current plans are to expand BAR statewide in 2013.

ShakeOut Partners: CEA and Red Cross
In 2012, CEA and the American Red Cross (Red Cross) joined forces to send an urgent message: "Get Prepared, California!" This new programming institutionalized the first statewide auction to benefit Red Cross, which raised $180,000 during Earthquake Preparedness Month in April and created the *Traveling Red Table* for a statewide media tour to promote the ShakeOut in September and October.

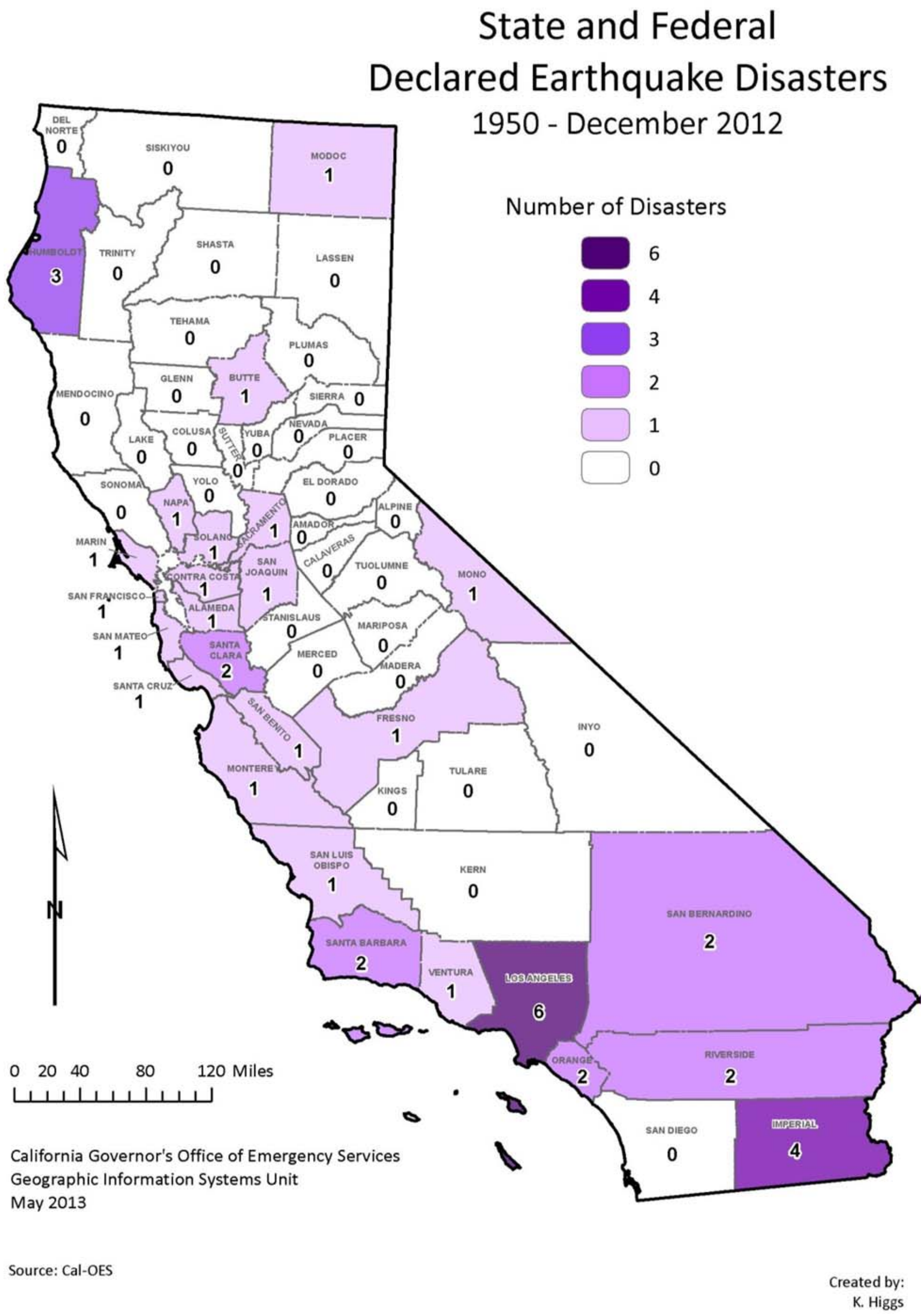
CEA will continue to develop communications programming that seeks to make earthquake preparedness a part of California culture and give the state's residents the strength to rebuild after the next damaging earthquake.

5.2.3 ASSESSMENT OF STATE EARTHQUAKE VULNERABILITY AND POTENTIAL LOSSES

Map 5.H illustrates the distribution of state earthquake disaster proclamations and declarations by county from 1950 to 2012 (representing 26 of California's 58 counties). Map 5.H shows the following numbers of such proclamations and disasters by county:

- Los Angeles County – 6
- Imperial County – 4
- Humboldt - 3
- Orange, Riverside, San Bernardino, Santa Barbara, and Santa Clara counties – 2
- Alameda, Butte, Contra Costa, Fresno, Marin, Modoc, Mono, Monterey, Napa, Sacramento, San Benito, San Francisco, San Joaquin, San Luis Obispo, San Mateo, Santa Cruz, Solano, and Ventura counties – 1

MAP 5.H: State and Federal Declared Earthquake Disasters, 1950-December 2012



Map 5.H shows the distribution within California of state-proclaimed and federally declared earthquake disasters from 1950 to 2012. The distribution of disasters can be generally related to potential future earthquake shaking hazards levels in California.

Vulnerable Areas and Populations

Earthquake vulnerability is primarily based upon population and the built environment. Urban areas in high hazard zones tend to be the most vulnerable, while uninhabited areas generally are less vulnerable. In the past, the CGS and USGS have done considerable work using GIS technology to identify populations in seismic hazard zones. Hurricane Katrina revealed the additional vulnerability of groups within the general population who may have fewer resources or less mobility than others. Map 5.C shows high concentrations of socially vulnerable populations throughout high earthquake hazard areas in the state's most heavily populated counties of Southern California, the Monterey Bay Area, and the San Francisco Bay Area. For a full description of social vulnerability and earthquake hazards, see Section 5.1.1.

Statewide Earthquake Loss Potential

Unfortunately, the number and variations of all potential earthquakes are so large that it is not possible to develop scenarios for all of them, nor would it be possible to rank them by importance if such scenarios were developed. To get an idea of the overall scope of the risk of losses from earthquakes and to determine which areas are most vulnerable, CGS uses an alternate approach based on probabilistic seismic hazard analysis (PSHA), which considers all possible earthquakes on all of the possible sources.

Potential Earthquakes

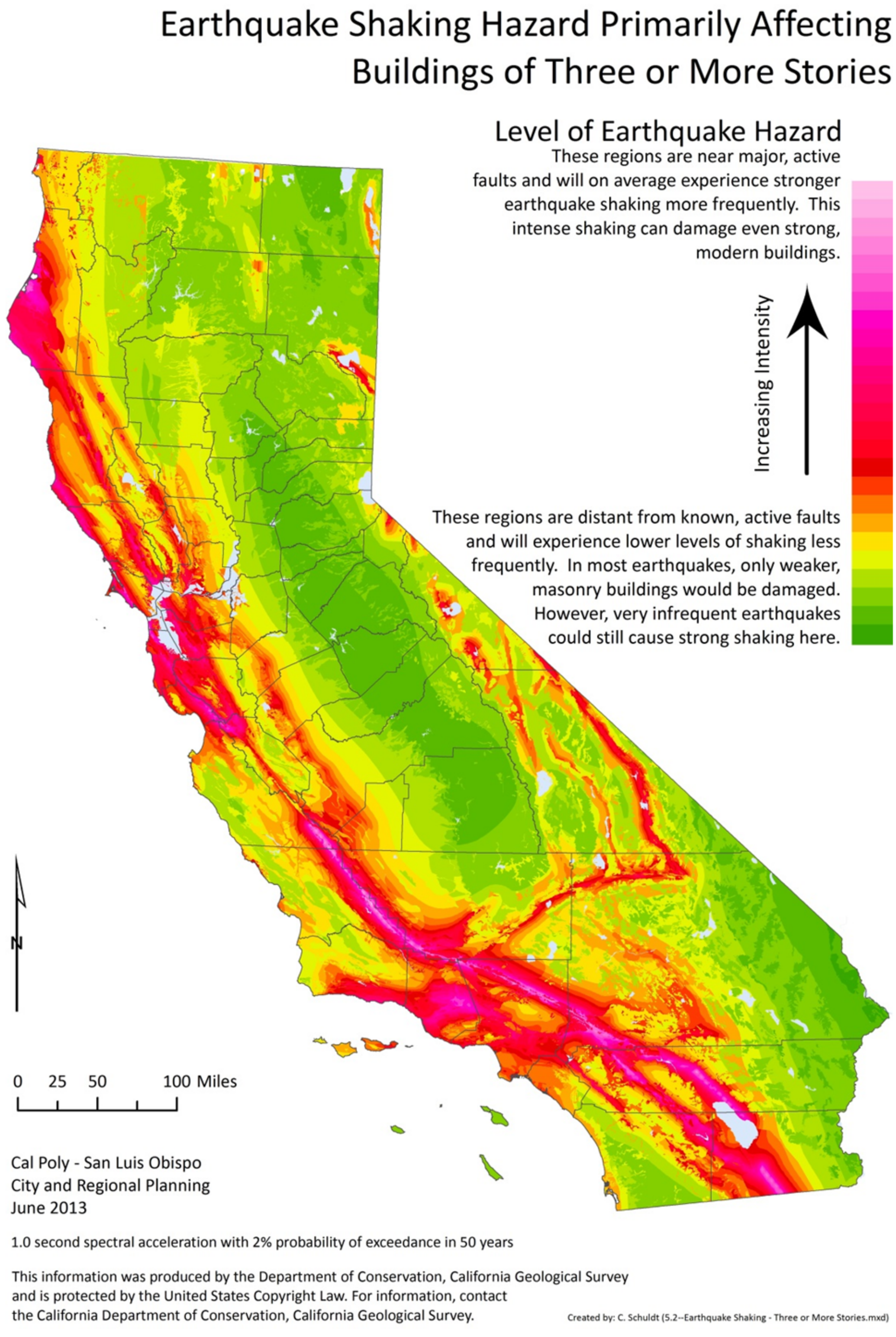
Past earthquakes may not provide a realistic estimate of future earthquakes' effects. Large earthquakes in lightly populated regions, such as Landers and Hector Mine, show the potential earthquake shaking from major earthquakes, while moderate earthquakes in populated areas, particularly Northridge, give a sense of California's vulnerability to earthquake shaking. A major earthquake near one of California's urban centers could cause unprecedented losses.

Current Views on Seismic Hazards Statewide

On the basis of research conducted following the 1989 Loma Prieta Earthquake, USGS and other scientists had estimated a 63-percent probability that at least one earthquake of Magnitude 6.7 or greater, capable of causing widespread damage, would strike the San Francisco Bay Area before 2032. Similarly, research coordinated by the Southern California Earthquake Center (SCEC) concluded that there was an 80- to 90-percent probability that an earthquake of Magnitude 7.0 or greater would hit Southern California before 2024.

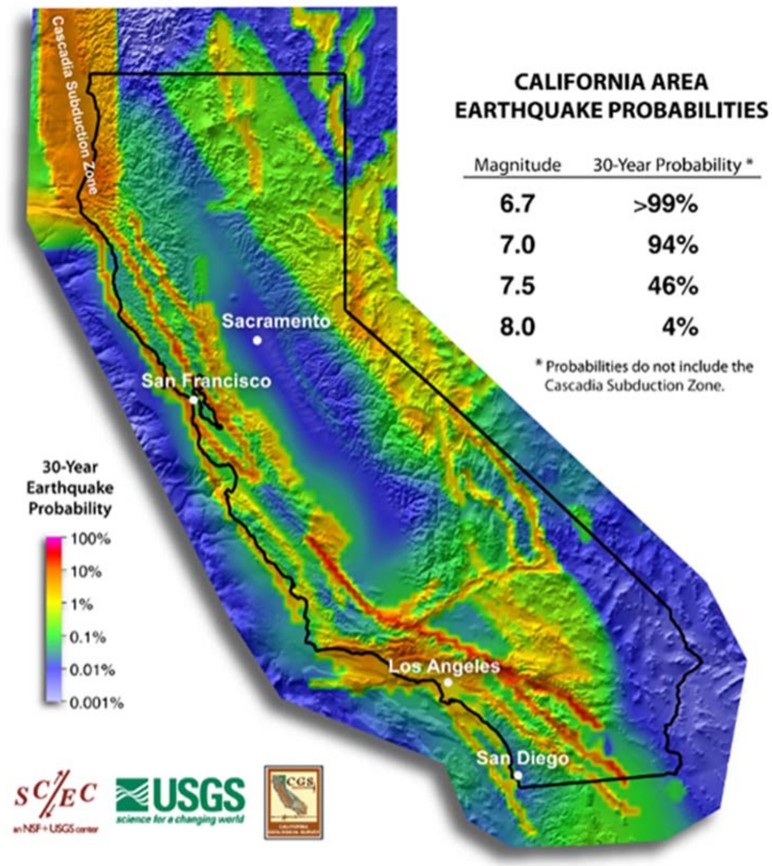
These probabilities were updated with the 2008 National Seismic Hazards Map, which included a time-independent version of an earthquake forecast map of California. The map was completed so that information on seismic hazards in California would be consistent with the level of knowledge throughout the rest of the country. In 2008, the USGS and CGS released the time-dependent and time-independent versions of the Uniform California Earthquake Rupture Forecast (UCERF II) model. These were the first statewide peer-reviewed forecasts and Next Generation Attenuation (NGA) ground motion prediction efforts undertaken.

MAP 5.I: Earthquake Shaking Hazard Affecting Buildings of Three or More Stories



Map 5.I shows the distribution of earthquake shaking hazards affecting buildings of three stories or more, according to CGS, USGS, and others. The most intense potential shaking areas parallel the coast between the borders with Mexico and Oregon.

MAP 5.J: Probability of Earthquake Magnitudes Occurring in 30-Year Time Frame



Source: United States Geological Survey Open File Report 2007-1437

Map 5.J depicts probabilities of various magnitude earthquakes greater than Magnitude 6.7 occurring in 30 years. These include >99 percent for a Magnitude 6.7 event, 94 percent for a Magnitude 7.0 event, 46 percent for a Magnitude 7.5 event, and 4 percent for a Magnitude 8.0 event. (http://www.scec.org/ucerf/) The Uniform California Earthquake Forecast Version II models (UCERF II) results have helped to reduce the uncertainty in estimated 30-year probabilities of strong ground motions in California. UCERF II also helped to reduce the uncertainty in the recurrence intervals of selected magnitude earthquakes. Success of the UCERF II project has led to the interest in the continued development of time-dependent earthquake forecasting.

The time independent UCERF III model, the first update to the State wide UCERF models, began development in 2010 and is scheduled to conclude by late 2013. Future products of the UCERF III project are considering aftershocks, clustering of earthquakes, and earthquakes being triggered by other earthquakes. A similar project for ground motion prediction equations has been developed. This is called the Next Generation Attenuation West-2 (NGA West-2). Both the UCERF II and the NGA results have been used to establish the range of estimated loss from various earthquake scenarios throughout the state. Both the time independent UCERF III and the NGA West-2 models and data have been combined by the USGS to use in developing the National Seismic Hazard Map update for California which is due to be released in April 2014. It is anticipated that the 2014 edition of the National Seismic Hazard Map and related documents will be incorporated into the 2016 update to the building code. The models are anticipated to be of great value in helping practitioners assess strong motion shaking throughout California on a regional basis for all classes of buildings and structures. For discussions by the California Earthquake Authority regarding the impacts of these projects to the residential building stock in California, see Section 5.2.4.1 (discussion under

Earthquake Vulnerability and Mitigation of Buildings). These models were important in reducing epistemic uncertainty in ground motion for seismic hazard assessment throughout California. The reduction of uncertainty in ground motion helps practitioners assess risk potential for new and existing buildings and infrastructure.

5.2.3.1 ESTIMATING LOSSES FROM FUTURE EARTHQUAKES

With HAZUS, a standardized methodology and GIS modeling software developed by FEMA, it has become possible in recent years to estimate possible losses from future earthquakes in California using ShakeMap scenarios. HAZUS is a regional loss estimation tool that uses population and building data aggregated at a census tract level. Building value and construction cost estimates are adjusted to reflect regional variations. By combining ShakeMaps with a statewide computerized inventory of population and buildings using HAZUS, Cal OES has estimated casualty and damage losses from various potential earthquakes for the two largest metropolitan regions of the state.

However, several qualifications on the probable accuracy of these estimates should be made:

1. Use of Decennial Census. Cal OES used the Decennial Census as the basis for estimating population and building inventory. Greater-than-expected growth, increased property values, and construction costs since that time may mean that losses are underestimated.

2. Losses to Critical Infrastructure. Due to lack of critical infrastructure data in the HAZUS model, Cal OES did not include these potential loss estimates.

3. Recovery Costs. HAZUS addresses some recovery issues but does not estimate additional potential losses that may be experienced as a result of a lengthy recovery and reconstruction process resulting from a catastrophic event in an urban area.

4. Instrumentation. The accuracy of ShakeMaps and the resulting HAZUS estimates is strongly dependent on recorded ground motion. Therefore, places with too few instruments have the potential for significant discrepancies in estimated shaking.

The California Integrated Seismic Network (CISN) and the Federal Advanced National Seismic System (ANSS) have been working together to fund and install additional seismic instruments. Both programs are funded at a level less than what is required to meet project objectives. Instrumentation is still sparse in some areas of the state, including the epicentral regions of the 2000 Napa and 2003 San Simeon earthquakes.

Progress Summary 5.C: HAZUS

California Geological Survey ran the USGS ShakeMap Scenarios as HAZUS level 1 and summarized the results in the report "HAZUS Annualized Earthquake Loss Estimation for California" published April 2011. More information in individual scenario results can be found at:
http://www.consrv.ca.gov/cgs/rghm/loss/Pages/2010_analysis.aspx. The report can be downloaded at:
ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/2011%20Annualized%20Losses/CGS_SR222_%20Losses_Final.pdf

Estimating Potential Earthquake Dollar Losses

Although multiple state databases exist for state-owned, -leased, and -operated facilities, there is no single statewide data source on these crucial resources. Given the size and complexity of California's economy and extent of its infrastructure, together with its inherent earthquake vulnerability, the problem of estimating potential dollar losses for state-owned and -operated facilities is an overwhelming economic modeling challenge.

A reasonable representation of a worst-case scenario for dollar losses for state-owned facilities might be reflected in a repeat of any of the great earthquakes experienced in the past two centuries. In light of California's catastrophic earthquake potential, a Magnitude 7.9 earthquake could be said to represent the worst-case dollar loss scenario for state-owned, -leased, or -operated facilities — far worse than dollar losses from disasters triggered by any other hazards including the other primary hazards, flooding and wildfires.

Table 5.C: Projected Earthquake Scenario Losses, Northern California

Potential Earthquake Scenarios	M_w[a]	Projected Building Damage[b]	Projected Range of Deaths	Projected Range of Injuries
San Andreas Fault: Repeat of the 1906 San Francisco Earthquake[c]	7.9	$94,000	800 - 1,600	22,000 - 32,000
San Andreas Fault: Santa Cruz, Peninsula, and North Coast Segments[c]	7.9	$122,000	1,800 - 3,400	39,000 - 59,000
San Andreas Fault: Santa Cruz and Peninsula Segments[d]	7.4	$30,000	2,100	105,000
San Andreas Fault: Santa Cruz Segment[d]	7.0	$5,900	--	--
San Andreas Fault: Peninsula Segment[d]	7.2	$24,000	1,300	66,000
Southern Hayward: Repeat of 1868 Earthquake[d]	6.7	$15,000	800	42,000
Northern Hayward[d]	6.5	$9,000	200	12,000
Southern Hayward and Northern Hayward[d]	6.9	$23,000	400	20,000
Rodgers Creek[d]	7.0	$8,000	150	10,000
Southern Calaveras and Central Calaveras[d]	6.4	$3,200	--	--
Northern Calaveras[d]	6.8	$10,000	200	15,000
Southern, Central, and Northern Calaveras[d]	6.9	$13,000	--	--
Concord[d]	6.2	$2,800	200	9,000
Green Valley[d]	6.5	$3,200	--	--
Concord and Green Valley[d]	6.7	$6,800	--	--
San Gregorio[d]	7.4	$15,000	350	19,000
Mount Diablo[d]	6.7	$7,000	40	3,000

[a] *Mw is an earthquake magnitude scale*
[b] *In millions of dollars*
[c] *Kircher, et al. "When the Big One Strikes Again – Estimated Losses due to a repeat of the 1906 San Francisco Earthquake." EERI Spectra Vol. 22, No. 52. April 2006.*
dMiller, 2007, CAL OES GIS Unit

Table 5.C and Table 5.D provide total building damage dollar loss estimates for 17 separate possible earthquake scenarios in Northern California and 14 in Southern California. Table 5.C reflects figures from the previously cited Charles Kircher study[40] in 2006, which modified HAZUS data with customized, more locally accurate data producing two scenarios, one for a repeat of the 1906 San Francisco Earthquake and the other for a projected alternative scenario Magnitude 7.9 earthquake in the San Francisco Bay region and surrounding counties.

[40] Kircher, et al. "When the Big One Strikes Again – Estimated Losses due to a Repeat of the 1906 San Francisco Earthquake." EERI Spectra Vol. 22, No. 52. April 2006.

This scenario portraying a repeat of the 1906 San Francisco Earthquake reflected an estimated total dollar loss of over $90 billion. The projected alternate scenario of a Magnitude 7.9 earthquake for the larger San Francisco Bay Area region and surrounding counties reflected an estimated total dollar loss of over $120 billion. That study estimated that there are approximately 3 million buildings in the larger scenario study region, representing roughly one-quarter of the estimated 14 million buildings in the state.

Table 5.D: Projected Earthquake Scenario Losses, Southern California

Potential Earthquake Scenarios	Mw[a]	Projected Building Damage[b]	Projected Range of Deaths	Projected Range of Injuries
ShakeOut Scenario 2008[e]	7.8	$32.7 billion[e] (in 2008 dollars)	1,782	50,750
San Andreas Fault: Repeat of 1857 Earthquake[c,d]	7.9	$150,000[d]	60-900	2,200-15,000
Puente Hills Fault[c]	7.1	$69,000	40-700	1,700-11,000
Newport-Inglewood[c]	6.9	$49,000	150-1,900	5,200-33,000
Palos Verdes[c]	7.1	$30,000	80-1,050	24,00-19,000
Whittier Fault[c]	6.8	$29,000	30-500	2,300-13,000
Verdugo Fault[c]	6.7	$24,000	100-1,300	3,150-18,700
San Andreas Fault: Southern Rupture[c]	7.4	$18,000	50-420	1,700-8,100
Santa Monica[c]	6.6	$17,000	40-190	2,000-13,000
Raymond Fault[c]	6.5	$17,000	60-520	2,150-11,700
San Joaquin Hills[c]	6.6	$15,000	60-920	2,200-15,500
Rose Canyon[c]	6.9	$14,000	40-600	1,300-9,000
San Jacinto[c]	6.7	$7,000	30-400	1,500-7,000
Elsinore Fault[c]	6.8	$4,000	40-70	450-2,000

[a] *Mw is an earthquake magnitude scale*
[b] *In millions of dollars*
[c] *Huls, 2007, Cal OES GIS unit, HAZUS scenario*
[d] *1857 Fort Tejon Earthquake Special Report, 2007, Risk Management Solutions*
[e] *Source: CGS Special Report 25/USGS Open File Report 2008-1150, The ShakeOut Scenario*

5.2.3.2 ESTIMATING EARTHQUAKE LOSSES TO STATE-OWNED AND LEASED BUILDINGS

The 2007 SHMP estimated maximum potential earthquake building damage loss to state-owned and leased facilities using best available data. Of the total 24,313 state-owned and -leased buildings, Table 5.E identifies total risk exposures of $48 billion for 15,255 buildings in areas potentially subject to Peak Ground Acceleration (PGA) of 31 to 175 percent (g) in an earthquake and $26 billion for buildings in areas subject to PGA of 11- to 30-percent (g).

Note that these figures overstate potential losses for two reasons: 1) earthquakes are centered within one region or another, and 2) only a portion of the inventory within a region affected by a large magnitude earthquake would suffer building collapse or substantial damage. However, since the science of earthquake prediction is in its infancy and the location and magnitude of damaging earthquakes are essentially unknown, this broad inventory provides an indication of maximum exposure, which should inform state policy-makers and managers on the scope of potential seismic upgrades needed for continuity of operations.

Table 5.E: Estimating Earthquake Dollar Loss for State Owned and Leased Buildings, as of 2007

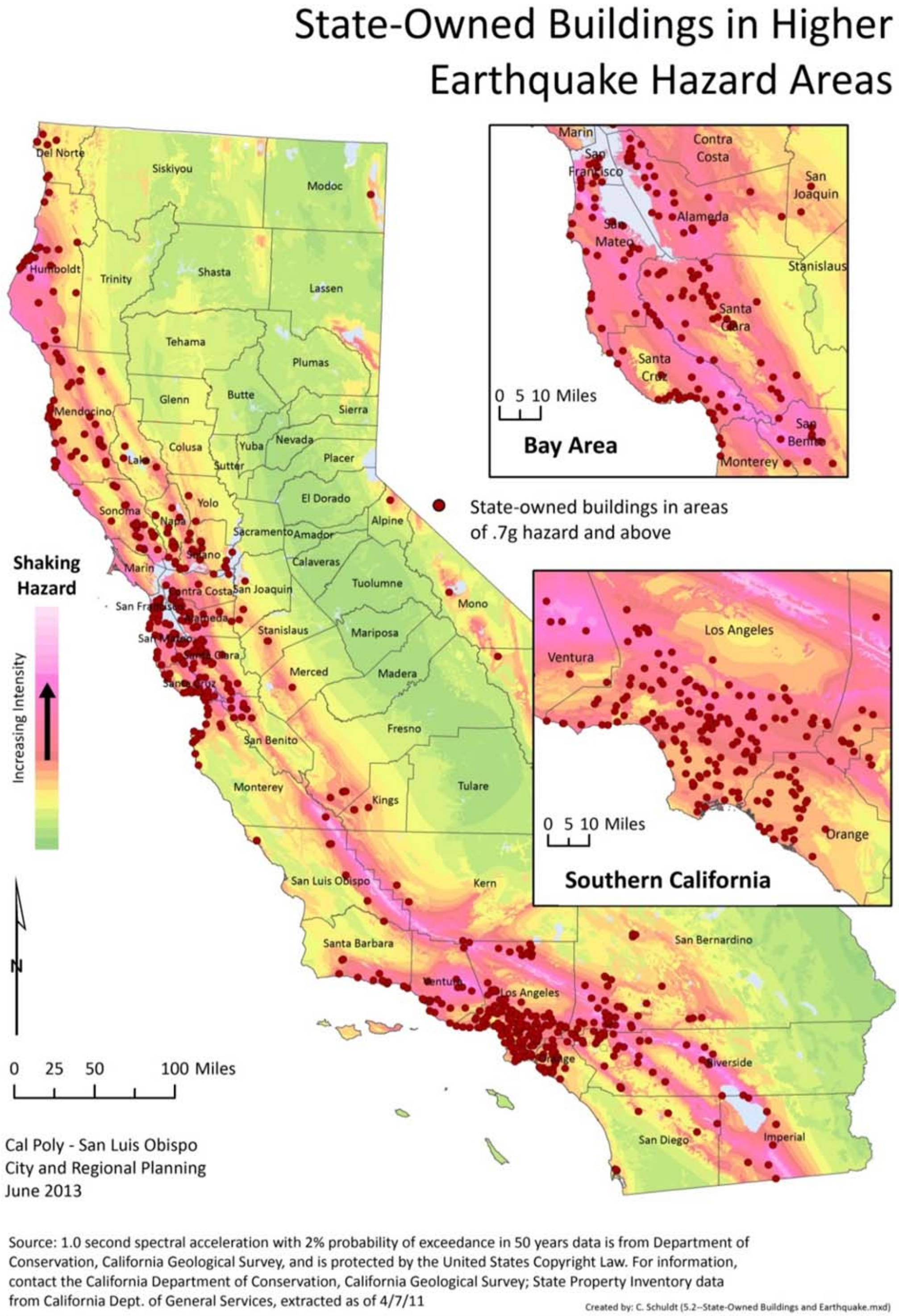
	State Ownership Status	No. of Buildings	Square Feet	$ Value at Risk (billions)
Low: 0-10%g Peak Ground Acceleration[a]	Own	2,821	8,467,822	2.96
	Lease	69	194,984	0.07
	Total	2,890	8,662,806	3.00[b]
Medium: 11-30%g Peak Ground Acceleration	Own	5,280	64,215,398	22.48
	Lease	888	9,495,449	3.32
	Total	6,168	73,710,847	26.00[b]
High: 31-175%g Peak Ground Acceleration	Own	14,167	131,178,132	45.91
	Lease	1,088	6,688,122	2.34
	Total	**15,255**	**137,866,254**	**48.00[b]**

[a] *Sources: Department of General Services, Cal OES, CGS*
[b] *number rounded*

This inventory includes structures with a wide range of vulnerability to earthquake risk. While some structures have been seismically upgraded under Proposition 122 (1990) bond funds and other funding sources, others remain vulnerable to damage and are in need of retrofitting.

The value of overall risk exposure to state owned buildings from earthquake shaking hazards is noted in Table 5.E as roughly $48 billion. This is far greater than the value of potential risk exposure of state owned buildings from flood and wildfire hazards which are on the order of approximately $2.0 billion each (see Tables 5.U and 5.AA). Therefore the seismic vulnerability of state owned buildings is of great concern to the State.

MAP 5.K: State-Owned Buildings in Higher Earthquake Hazard Areas



Map 5.K shows the location of state-owned buildings in potential high ground shaking areas.[41] Large concentrations are found in Southern California and the San Francisco Bay Area. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

[41] 1.0 second spectral acceleration with 2-percent probability of exceedance in 50 years.

California Vital Infrastructure Vulnerability Assessment (Cal VIVA)

The California Vital Infrastructure Vulnerability Assessment (Cal VIVA) project got under way with preparation of the 2010 SHMP. Its purpose is to develop and test a methodology for assessing the vulnerability of state-owned building stock to seismic and other hazards and determine minimum retrofit measures to protect its occupants from harm during a disaster and facilitate recovery by making it quickly operable after a disaster.

The vision for Cal VIVA is to 1) create an infrastructure resiliency planning and evaluation system that includes the long-term systematic screening of the state-owned building inventory, 2) determine potential vulnerabilities within that inventory, 3) systematically plan and set priorities for vulnerable building strengthening, and 4) execute initial building retrofit assessments, subject to project funding, design, and development.

By knowing the number, type, importance, and strength of California's state-owned buildings, the state will more effectively set priorities for infrastructure investments based on continuity of operations and other key criteria. This information will also enable the state to identify critical infrastructure that is especially weak or vulnerable to both natural and human-made disasters. With this knowledge, the state can ensure that the ability to respond to a disaster and maintain functionality exists even during extreme disasters.

Cal VIVA focused on establishing methods for assessing seismic vulnerability of state-owned buildings and recommending retrofit actions. The analysis and retrofit for each building has been relatively general in nature and focused on primary vulnerabilities, generic seismic upgrade approaches, and order-of-magnitude cost estimates, leaving more detailed cost estimates to a later phase when retrofit funding can be secured.

The Cal VIVA project has used the ASCE 31 Tier 1 or 2 analysis procedures for the seismic assessment. ASCE 31 is titled Seismic Evaluation of Existing Buildings and is a widely used, building-specific, industry standard document.

The 2010 SHMP notes that critical infrastructure is essential to the state's ability to provide assistance to the people of California. Infrastructure such as transportation routes, utilities, government facilities, and hospitals provide the state with the capacity to respond to disasters. The resiliency (ability to survive and recover from a disaster) of the state strongly depends on its capacity to maintain or restore infrastructure operations in disasters. Systematically assessing the condition of infrastructure is an important step toward mitigation.

Progress Summary 5.D: Cal VIVA

Progress as of 2013: The 2013 SHMP adds assessments of specific aspects of Cal VIVA in various sections of Chapters 5 and 6.

Three increments of Cal VIVA have been initiated to date, of which two have been completed. The first increment, Cal VIVA I, had three primary activities: 1) develop a standardized methodology to identify necessary mitigations of seismic vulnerabilities in buildings that are critical to response and recovery efforts after an earthquake, 2) test the methodology and 3) improve the methodology based on lessons learned. A sample of critical structures was investigated by Cal Poly personnel. Based on field investigation and review of existing documentation, seismic evaluations were prepared and upgrade concepts developed for these selected buildings. The results of these field investigations and evaluations were reviewed as a means of refining the prioritization process and assessment methodology. The final report was issued in March 2013.

Cal VIVA II, the second project used the seismic vulnerability assessment methodology developed in Cal VIVA I to examine two areas: 1) the conceptual development of a prototypical department plan for mitigation of seismic vulnerabilities in critical state-owned buildings, and 2) determination of the seismic vulnerability with resultant mitigation of selected state-owned, high-occupancy office buildings housing state employees critically needed for post-earthquake response and recovery operations. The final report was issued in March 2013.

The third project, Cal VIVA III, is testing and refining the Cal VIVA II prototypical department plan with an individual user department and producing a template that can be used by departments and agencies within state government to systematically address critical building vulnerability and potential retrofits on a long-term basis.

Cal VIVA III proposes establishment of a State Reporting Plan that includes a State-managed repository for data from individual state agencies and departments regarding seismic vulnerability of their state-owned buildings. Using the State Emergency Plan (SEP) and State Multi-Hazard Mitigation Plan (SHMP) as a combined foundation, the State Reporting Plan repository will identify departments responsible for seismically vulnerable building stock deemed necessary for post-disaster response and recovery operation, and monitor their systematic upgrades over time.

The State Reporting Plan will coordinate information gathered from Cal VIVA, the Proposition 122 State Seismic Program, CSU, UC programs, and other seismic upgrade programs, providing a basis for timely further seismic upgrade actions. Cal VIVA III is being prepared in association with EERI and is scheduled for completion in November 2013.

5.2.4 ASSESSMENT OF LOCAL EARTHQUAKE VULNERABILITY AND POTENTIAL LOSSES

This section addresses local earthquake hazard vulnerability and potential losses based on estimates provided in local risk assessments, comparing those with findings of the state risk exposure findings presented in the GIS analysis in Section 5.1.1 of this chapter.

5.2.4.1 EARTHQUAKE VULNERABILITY AND MITIGATION FOR BUILDINGS

This section discusses statewide and local vulnerability of buildings susceptible to earthquake damage, the greatest single factor contributing to California's potential future losses from earthquakes. It provides an overview of building vulnerability and mitigation, including mitigation of structural deficiencies and potential structural losses from fires following earthquakes. It then reviews vulnerability and mitigation progress with respect to a series of building sub-inventories, including private structures as well as state-owned and -leased buildings. The section is organized to provide the link between vulnerabilities of key building inventories by function and structural type with progress made in dealing with their potential losses.

Building Vulnerability to Earthquake Damage

Compared to other earthquake vulnerabilities, buildings pose the largest risk to life, injury, property, and economic welfare. California has approximately 14 million buildings, with an average of 2.7 occupants per building. Approximately 95 percent are low-rise (one to three stories), 5 percent are medium-rise (four to seven stories), and 0.03 percent are high-rise buildings (eight or more stories).[42] Observations after earthquakes indicate that building safety is most often compromised by poor quality in design and construction, inadequate maintenance, lack of code enforcement at the time of original construction, and improper alterations to the original building.[43]

A less common cause of damage is the poor performance of older buildings built to earlier seismic codes. Approximately 13 percent of California's buildings were constructed before 1933, when explicit

[42] Jones, et al. ATC 13.
[43] California Seismic Safety Commission, "Turning Loss to Gain," CSSC 95-01.

requirements for earthquakes first began to be incorporated into building codes and the state first required local governments to create building departments and issue permits. About 18 percent of California's buildings were constructed before 1940, when the first significant strong motion recording was made in El Centro. About 40 percent of the state's buildings were constructed before the Structural Engineers Association of California's first statewide consensus on recommended earthquake provisions were published in 1960. About 60 percent were built before the mid- to late-1970s, when significant improvements to lateral force requirements began to be enforced throughout the state. California did not have uniform adoption of the same edition of model codes in every jurisdiction until the early 1990s. Thus, well over half of all existing buildings in California are built to earlier standards that, in many cases, can result in inadequate earthquake performance.

Mitigation of Potential Building Losses

The most effective single element in mitigating earthquake losses to buildings is the consistent application of a modern set of design and construction standards, such as those incorporated in modern building codes. The codes are updated regularly to include the most effective design and construction measures that have been found by testing and research or observed in recent earthquakes to reduce building damage and losses. Local government building departments currently use the 2010 California Building Code (the 2013 California Building Code will take effect January 2014) with local amendments to regulate the vast majority of buildings. Acute care hospitals, public K-12 schools, and state-owned buildings, are regulated by the California Building Code (CBC) and more stringent amendments prepared by applicable state agencies.

For new buildings, state and local governments will enforce the 2013 California Building Standards Code (CBSC) that includes earthquake safety provisions from the 2012 International Building Code with enhancements for hospitals, public schools, and essential services buildings.

A small percentage of older buildings have been strengthened or "retrofitted" to improve their resistance to earthquake shaking. Observations after recent earthquakes suggest that retrofitted buildings on the whole perform noticeably better than similar buildings that have not been retrofitted (ATC 31, 1992, CSSC 94-06, WJE 1994). However, in many respects their performance has been mixed.

Fewer than five percent of California's existing buildings have been structurally retrofitted; the actual number has not been determined. California has adopted, with some amendments, a national standard, ASCE 41-06, Seismic Rehabilitation of Existing Buildings (scheduled to be re-issued in late 2013 as ASCE/SEI 41-13, Seismic Evaluation and Retrofit of Existing Buildings), as a retrofit regulation for acute care hospitals, public schools and state-owned buildings effective January 1, 2011. California has also adopted retrofit regulations for hospitals and unreinforced masonry (URM) buildings (see Chapter 34 of the 2013 CBC and Title 24 Part 10 of the CBSC). The CBC generally allows retrofits of any nature provided that they make existing buildings no less safe. These regulations and the 2012 International Existing Building Code are available for use at the discretion of all state and local regulatory agencies. They include a compilation of seismic evaluation and retrofit provisions for unreinforced masonry, tilt-up, wood-frame dwellings, and older concrete buildings. A separate California Historical Building Code contains provisions for evaluating, rehabilitating, and altering historical buildings.

National standards for building seismic evaluations and retrofits are published by the American Society of Civil Engineers as ASCE 31-03 "Seismic Evaluation of Existing Buildings" and ASCE 41-06 "Seismic Rehabilitation of Existing Buildings" (www.asce.org). They are scheduled to be superseded by ASCE/SEI 41-13, Seismic Evaluation and Retrofit of Existing Buildings in late 2013.

Mitigation measures for ground displacement include strengthening foundations, locating new facilities to avoid sites with the potential for large displacements during earthquakes, and modifying soils below foundations. Refer to CGS Special Publication 117, "Guidelines for Evaluating and Mitigating Seismic Hazards in California. (http://www.consrv.ca.gov/cgs/shzp/webdocs/Documents/sp117.pdf)

Mitigation of Losses in Non-Structural Systems

California did not begin to regulate the earthquake safety of non-structural systems in buildings, such as water heaters, ceilings, light fixtures, and heating equipment, until the 1970s. Buildings built before the 1970s and newer buildings that were not regulated and that have unbraced systems can be made safer with retrofit or replacement projects. FEMA offers guidelines for the evaluation and retrofit of building contents and non-structural building systems (FEMA 74). These retrofits can significantly reduce the risks of injuries and business interruption from earthquakes and are often feasible at very low costs.

Cal OES offers guidelines for evaluating and retrofitting nonstructural falling hazards common to schools at: www.caloes.ca.gov. The Homeowner's Guide to Earthquake Safety and the Commercial Property Owner's Guide to Earthquake Safety also contain recommendations on how to identify and retrofit contents and non-structural systems in buildings that are vulnerable to earthquakes. In addition the "Dare to Prepare" campaign of the Earthquake Country Alliance (http://www.daretoprepare.org/) has information for securing non-structural items. Water heater bracing kits that are certified for use by the State Architect are available at most hardware stores. The State Architect also offers strapping instructions online. (www.dgs.ca.gov/dsa/Resources/pubs.aspx)

Bracing can prevent fires and serious water damage caused by toppled water heaters. State law requires all replacement water heaters to be braced and all existing residential water heaters to be braced upon sale of buildings (Health and Safety Code 19210, et seq. at: www.leginfo.ca.gov).

Fires Following Earthquake

While ground shaking may be the predominant agent of damage in most earthquakes, fires following earthquakes can also lead to catastrophic damage depending on the combination of building characteristics and density, meteorological conditions, and other factors. Fires following the 1906 San Francisco Earthquake, 1923 Tokyo Earthquake, and 1995 Kobe Earthquake caused extensive damage and killed thousands.

Fires following the 1906 San Francisco Earthquake led to more damage than that due to ground shaking. Most recently, fires in the Marina District of San Francisco following the 1989 Loma Prieta Earthquake and in Los Angeles following the 1994 Northridge Earthquake demonstrate that fires following earthquakes pose a significant hazard, especially in densely populated urban areas, and a potentially serious problem due to severe strain on the fire departments that must respond to multiple simultaneous ignitions. Fire department response is often affected by impaired communications, water supply, and transportation, together with other emergency demands such as structural collapses, hazardous materials releases, and emergency medical aid.

Fires following earthquakes may result from multiple causes (e.g., overturned burning candles, electrical sparking from downed power lines, and broken natural gas pipelines.[44]). Numerous instances of serious fires following earthquakes have occurred in major urban areas. Fires following earthquakes can occur immediately after an earthquake or may be delayed. Causes of fires occurring immediately after include power lines that are fused or broken, with the resulting arcing coming into contact with combustible fuel; water heaters, stoves, and lighting fixtures/lamps that are dislodged and come into contact with combustible fuel; natural gas mains, lines and service that are severed, with the released gas finding a source of ignition; and combustible liquids that leak and find a source of ignition.

Fires that are delayed are generally human-caused or preventable (for example, fire caused by the restoration of electricity to an area not properly checked and secured). When power is restored, heating of electrical appliances can occur followed by ignition. Inexperienced people can start fires by trying to relight

[44] A complete list may be found in Fire Following Earthquake, Edited by Charles Scawthorn, John Eidinger, and Anshel Schiff. Technical Council on Lifeline Earthquake Engineering, Monograph No. 26. Published by the American Society of Civil Engineers. January 2005.

gas pilots. Vulnerability to fires following earthquake can be assessed for communities by well-established simulation models. Several computer programs (e.g., HAZUS, EQEFIRE, URAMP, SERA, RiskLink) are available to assess the fire following earthquake vulnerability of a community in future earthquakes. Details of various computer modeling techniques are described in the book Fire Following Earthquake.[45]

Mitigation of Fires Following Earthquakes

A general framework for fire mitigation includes the following components provided in advance of an earthquake disaster: 1) reduction in damage through advance planning and preparation; 2) presence of functioning automatic sprinklers or other suppression systems; 3) citizens able to extinguish the fire if water is available or to call the fire department; 4) functioning communications (i.e., telephone) required to contact fire departments; 5) available fire department personnel and their assets (i.e., apparatus); 6) functioning transportation networks (i.e., roads); 7) an adequate water supply; and 8) advance provision of firebreaks, via the urban planning process.

In addition, mitigation for the prevention of natural gas system leakage has included localized upgrading of natural gas pipelines and automatic seismic shut-off switches that cut off natural gas to customers. It is critical that restoration of gas service following an earthquake be coordinated through the local gas utility and the fire department to ensure that service is not restored until leak detection and minimum safety requirements are met on the distribution side of the gas meter. Restoration of gas and electrical services for areas known or suspected to have sustained damage may not be restored until the utilities and the fire department are prepared to have service restored.

An additional mitigation technique is the use of seismic pressure wave-triggered automatic garage door openers and alarms at fire stations. These devices help ensure that firefighters and fire equipment are not trapped in damaged fire stations following earthquakes.

Mitigation of Vulnerabilities by Building Sub-Inventories

The building types listed below, representing a mix of structural type, ownership, and function, are discussed in the following subsection:

1. State-Owned and -Leased Structures
2. Locally Regulated Unreinforced Masonry (URM) Buildings
3. Hospitals
4. Locally Regulated Essential Services Facilities
5. State-Regulated Essential Services Buildings
6. Other State-Owned Normal Occupancy Facilities
7. State Criminal Justice Buildings
8. State-Owned Health Services
9. K-12 Public Schools
10. Community Colleges
11. Public Universities
12. Tilt-Up Buildings
13. Single-Family Wood-Frame Dwellings
14. Multi-Unit Wood-Frame Residential Buildings
15. Mitigation for “Soft-Story” Buildings.
16. Locally Regulated Non-Ductile Concrete Buildings
17. Steel-Frame Buildings
18. High-Rise Buildings
19. Mobile Homes
20. Natural Gas Systems in Buildings

[45] Scawthorn, et al. January 2005.

This discussion provides a current assessment of vulnerability and mitigation progress for the preceding list of building inventories. The scale of the task of assessing, tracking, and mitigating structural vulnerabilities among California's millions of buildings is larger than that of any other state in the nation. For example, there are 12 million privately owned buildings, including most of the state's 2,673 hospitals; 86,000 K-12 public schools; 3,264 public university buildings; and 17,282 other state buildings**.**

Among the more vulnerable structures susceptible to potential loss in earthquakes are 25,945 unreinforced masonry (URM) buildings in high seismicity regions (now 70 percent retrofitted or replaced), and approximately 4,000 URM buildings in moderate seismicity regions, as well as approximately 57,000 tilt-up buildings, 17,000 non-ductile concrete structures, 46,000 soft-story apartments, 1.5 million vulnerable single-family dwellings and 473,000 mobile homes, in varying stages of retrofit.

For a summary of overall retrofit progress, see Appendix O, Overall Progress Toward Earthquake Mitigation of Key Building Inventories.

1. *Mitigation for State-Owned and -Leased Structures*

Cutting across the preceding sub-inventories of vulnerable buildings and mitigation progress by function and type are the state-owned and -leased buildings. There are over 20,000 state-owned structures, including over 3,000 university buildings. In addition, there are several thousand state-leased buildings, with lease terms varying in length.

Section 5.2.3 discusses the numbers, distribution, square footage, and value of state-owned and -leased properties in high earthquake shaking hazard areas. Section 5.2.3 also contains a substantial discussion regarding potential earthquake losses for state-owned and -leased structures and the need for a systematic assessment and retrofit of these structures, together with a preliminary description of the California Vital Infrastructure Vulnerability Assessment (Cal VIVA) project. Cal VIVA is designed to address this need on a long-term basis through a study that identifies the most efficient procedures for conducting ongoing assessments, setting priorities for retrofit recommendations, and carrying out actions as funding permits.

2. *Mitigation for Locally Regulated Unreinforced Masonry Buildings*

Unreinforced masonry (URM) buildings are made of brick, stone, or other types of masonry and have no reinforcing steel to keep them from falling down in earthquakes. Most URM buildings have features that can threaten lives during earthquakes. These include parapets, walls, and roofs that are poorly connected to each other. When earthquakes occur, inadequate connections in these buildings can allow masonry to fall placing occupants and passersby in harm's way. Floors and roofs can also collapse.

The risk to life from URM buildings can be significantly reduced by the regulation of alterations to existing buildings and seismic retrofits. California has prohibited the construction of new URM buildings since 1933. However, over 22,000 URM buildings still remain in use today in California's older commercial and industrial districts in high seismic hazard regions.

In 1986, California passed a law requiring local governments in high seismic regions nearest active faults to inventory their URM buildings, establish a risk reduction program, and report to the CSSC. Ninety-three percent of the jurisdictions affected by the URM law comply with its provisions. State government buildings are exempt from the URM law but are partially addressed by other laws and regulations.

Table 5.F: Status of Unreinforced Buildings in Seismic Zone 4

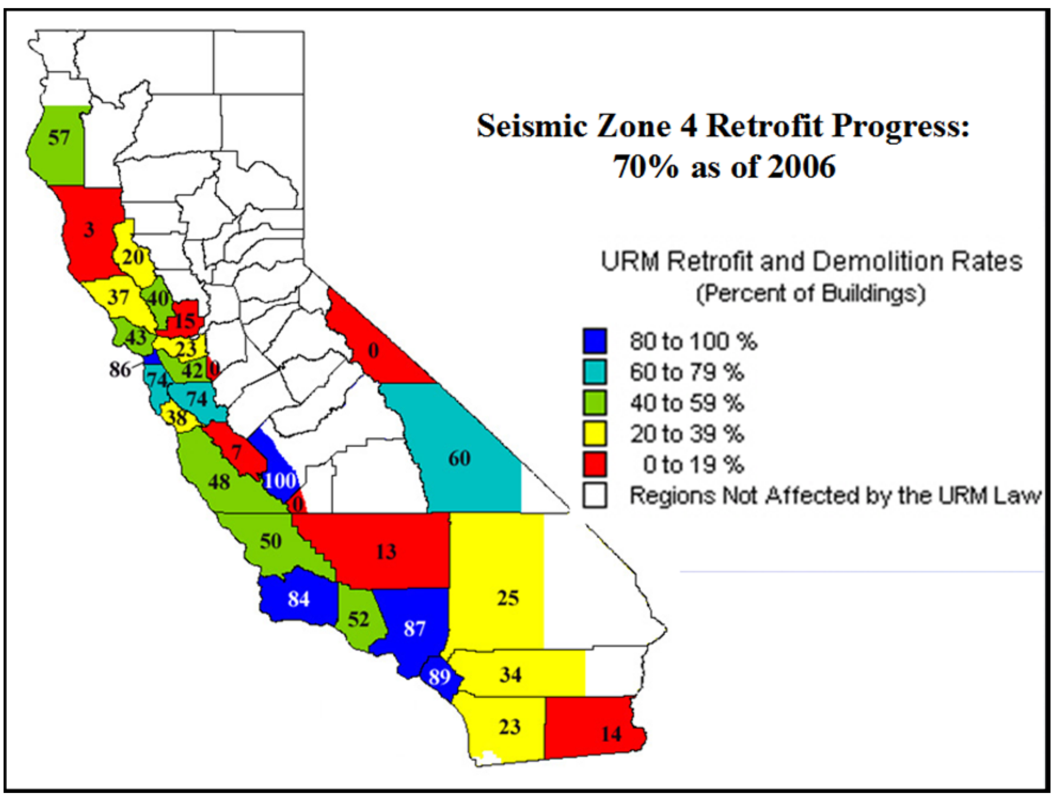
Number	Status	Percent Complete
18,144	Mitigated (e.g., Retrofitted, Replaced or Demolished)	70
14,203	Retrofitted to various standards	55
10,762	Retrofitted to the UCBC	41
3,441	Retrofitted to other standards	13
3,941	Demolished	15
7,801	Unretrofitted	30

Source: California Seismic Safety Commission. "SSC 2006-04." 2006. www.seismic.ca.gov/

In 1990, there were an estimated 30,000 URM buildings statewide; approximately 26,000 were located in Seismic Zone 4 (now called high seismicity regions) with the remainder in Seismic Zone 3 (now called moderate seismicity regions). Ninety-eight percent of the URM buildings in Seismic Zone 4 (high seismicity regions) (283 jurisdictions) have been inventoried and over 70 percent had been retrofitted, demolished, and/or replaced by 2006.

Statewide, URM buildings average 10,000 square feet of floor area. Retrofit costs average $60 per square foot with a range of $10 to $150 per square foot. Table 5.F shows the numbers and percent completions of seismic retrofits of URM buildings in high seismicity regions.

MAP 5.L: Unreinforced Masonry Retrofit Progress in Seismic Zone 4 (High Seismicity Regions)



Source: California Seismic Safety Commission

Map 5.L depicts the geographic distribution in 2006 of URM retrofit progress in high seismicity regions (formerly called Seismic Zone 4), which covers the most seismically active areas. Note that highest percentages tend to be in coastal counties near the San Andreas Fault zone.

The state adopted retrofit standards for URM buildings in Title 24, Part 10 of the 2013 California Building Standards Code. These reference the 2012 International Existing Building Code Appendix Chapter A1. Of California's cities and counties, 169 have adopted some form of these standards. See "Status of the Unreinforced Masonry Building Law" (SSC 2006-04) for the mitigation status of each jurisdiction affected by the state's URM law.

Retrofitted URM Building in San Luis Obispo

Best Practices Highlight 5.A: URM Retrofit Program Success in San Luis Obispo

What does it take to make significant hazard mitigation progress? For San Luis Obispo, California, it took the reality of an earthquake 40 miles away and the cooperation of businesses and property owners to make their downtown more resilient. More than 100 unreinforced masonry buildings have been retrofitted against earthquake forces, largely during the past decade, saving historic buildings, creating downtown vitality, and increasing public safety

Initial Challenge

Following adoption of the Unreinforced Masonry Building Law (Alquist) of 1986, City of San Luis Obispo building officials identified 126 hazardous unreinforced masonry buildings (URMs) – 76 in the downtown core. In 1997 the city's first seismic retrofit ordinance required full strengthening by 2017. By 2004, only 27 of the 127 hazardous buildings had addressed the seismic retrofit requirements.

San Simeon Earthquake – A Wake-Up Call

On December 22, 2003, the need for strengthening took on renewed urgency with the magnitude 6.5 San Simeon Earthquake. The San Simeon Earthquake resulted in two deaths due to unreinforced masonry building collapse and a range of building damage in northern San Luis Obispo County as well as chimney collapses in San Luis Obispo. Recognizing the risk posed to the city's vulnerable buildings, the San Luis Obispo City Council resolved to reassess the effectiveness of the unreinforced masonry ordinance. The San Luis Obispo Chamber of Commerce, tasked with enhancing the economic health of the area, was eager to collaborate with city officials and reconvened its Seismic Task Force, a group including building owners, business owners and city staff.

New Ordinance
In 2004 the 1997 seismic retrofit ordinance was revised to shorten the 2017 deadline to 2010 for completion of all seismic retrofits to hazardous URMs within the City. The Chamber of Commerce pushed for a seismic coordinator who could help its members facilitate plans, engineering and permits in short order. As part of the 1997 incentive program update, a seismic coordinator was hired who reported to the Economic Development Department overseen by the City Manager. The seismic coordinator had individual contact with every building owner, and was responsible for communicating rules and resources via presentations at outreach events and via periodic publications.

Monitoring Progress
In 2007 the Council reviewed progress under the ordinance and gave buildings still on the inventory new completion deadlines of 2008, 2009 or 2010. Although penalties were among the tools necessary to motivate action, the approach mostly emphasized incentives.

By 2010 San Luis Obispo was seeing major URM retrofit progress. One of the unintended consequences was an upswing in façade improvements and property consolidation for mixed use project proposals. This resulted in a downtown that now sports a revival of its historic charm and attendant economic vitality. As of late 2012 all but 14 of the original 126 buildings had been strengthened. Of these, five retrofit projects were in construction, and eight were scheduled to begin construction in 2013, subject to a new deadline of July 1, 2015.

Lessons Learned
Four key lessons were learned by the City of San Luis Obispo through this process:

- *Internal Advocate* - having an internal advocate, the seismic coordinator, made a difference in connecting the people with the law
- *Willing Players* - having a few property owners who understood the requirement and made the first step to bring their building into compliance got the ball rolling for other building owners
- *Buy-In from Building Owners* - working with building owners to achieve understanding and buy-in was essential
- *Reasonable Deadlines* - setting a deadline not too far into the future provided an incentive for work to get done without creating a timeline that was impossible to meet.

Source: Claire Clark and Monica Fiscalini

3. *Mitigation for Hospitals*

Since 1973, hospitals have been required to be built to higher standards than other buildings so they can be reoccupied after major earthquakes. However, most hospitals built before 1973 still remain in service, and some of them pose risks to life or are not expected to be available for occupation after future earthquakes. The 1973 Alquist Hospital Facilities Seismic Safety Act (HFSSA) designated the Office of Statewide Health Planning and Development (OSHPD) as the enforcement agency of the HFSSA mandates. OSHPD's primary objective is to safeguard the public health, safety, and general welfare through regulation of the design and construction of healthcare facilities, to ensure they are capable of providing sustained services to the public.

Senate Bill 1953 (SB 1953), enacted in 1994 after the Northridge Earthquake, expanded the scope of the 1973 Alquist Hospital Seismic Safety Act. The law as amended required that: 1) hospital owners survey the earthquake vulnerability of their buildings and submit to OSHPD their seismic evaluations reports as well as their compliance plans no later than January 1, 2001, 2) by 2013 all hospital buildings built before 1973 that pose threat to life be replaced or retrofitted so they can reliably survive earthquakes without collapsing or posing threats of significant loss of life, and 3) by 2030 all hospital buildings be reasonably capable of providing services to the public after disasters. Furthermore, hospitals were required to have the necessary nonstructural components and systems (emergency generator[s], oxygen tanks, etc.) strengthened by 2002 in order to be able to administer adequate and orderly evacuation of patient and staff, if needed.

Senate Bills SB 1661, SB 499, and SB 90 which were amendments to the HFSSA allow hospitals that pose a significant risk of collapse classified as SPC-1, an extension on the timelines for seismic compliance which could vary from two to up to seven years if progress toward seismic compliance is being made. By 2020 all SPC-1 hospital buildings must be either upgraded to SPC-2 (buildings that do not significantly jeopardize life, but may not be repairable or functional after a strong ground motion) or be removed from General Acute Care service.

SB 1953 applies to all acute care facilities (including those built after 1973) and affects approximately 2,750 buildings across 427 hospital facilities. State-owned hospitals are exempt from the seismic compliance requirements of HFSSA (SB 1953).

OSHPD has adopted and enforces regulations for the seismic evaluation and retrofit of existing hospital buildings (see Chapter 6 of the 2010 California Administrative Code and Chapter 34A of the 2010 California Building Code) that are applicable to all existing acute care hospitals.

Table 5.G: Hospital Structural Performance

Type	Category	Number of Buildings	Percent
Structural Performance Category (SPC)	SPC-1[a]	477	17.3
	SPC-2	509	18.5
	SPC-3/3s	380	13.8
	SPC-4/4s	805	29.2
	SPC-5/5s	564	20.4
Other Support Structures (SPC not assigned)	--	21	0.8
		2,756	100
Non-Structural Performance Category (NPC)	NPC-1	601	21.8
(Including Tunnels)	NPC-2	1835	66.6
	NPC-3	55	2.0
	NPC-4	125	4.5
	Not Assigned	140	5.1
		2,756	100

Source: OSHPD www.oshpd.ca.gov
[a] *SPC and NPC are on a scale where 1 is the most vulnerable and 5 is the least vulnerable*
[b] *3s, 4s, and 5s indicate seismic performance ratings self-reported by the hospital and not verified by OSHPD*

Table 5.G summarizes the seismic (structural/nonstructural) performance for hospitals. Structural Performance Category (SPC) 1 is the most vulnerable ranking for buildings. Many SPC-1 hospitals pose significant collapse risks. SPC-5 hospitals pose the least structural risk. Similarly, rankings for Non-Structural Performance Categories (NPC) range from 1 (most vulnerable) to 5 (least vulnerable).

4. *Mitigation for Locally Regulated Essential Services Facilities*

California has no statewide inventory of locally regulated essential services facilities, including fire, police, ambulance, and emergency communication facilities. Most of these facilities were built prior to 1986, before state standards began to require enhanced seismic safety, and are not expected to be reliably functional after severe earthquakes, delaying emergency response and in some cases posing significant risks to life. The Department of General Services (DGS) estimates there are approximately 450 fire stations, 400 emergency operations centers, and 450 police stations throughout California.

To mitigate the impact of earthquakes on locally regulated essential services facilities, California enacted the Essential Services Buildings Seismic Safety Act in 1986. Pursuant to the Act, the Division of the State Architect (DSA) within DGS adopted regulations that apply to the construction of all new essential services buildings (California Code of Regulations, Title 24, Part 1, Sections 4-201 to 4-249). There are no statewide regulations for evaluating and retrofitting locally regulated essential services buildings that existed prior to 1986 except for unreinforced masonry buildings in some jurisdictions. Some local governments and state agencies have voluntarily retrofitted or replaced their vulnerable buildings.

5. *Mitigation for State-Regulated Essential Services Buildings*

California has no statewide inventory of state-regulated essential services facilities, including fire, police, ambulance, and emergency communication facilities. Most of these facilities were built before state standards began to require enhanced seismic safety and are not expected to be reliably functional after earthquakes, delaying emergency response and in some cases posing significant risks to life. Key state agencies owning essential services facilities include:

- The California Department of Forestry and Fire Protection
- Caltrans
- The California Highway Patrol
- The Department of Water Resources

California enacted the Essential Services Buildings Seismic Safety Act of 1986 and DSA adopted regulations that apply to all new construction (Title 24, Part 1). For existing essential services buildings owned by the state, the California Building Standards Commission adopted regulations in Chapter 34 of the 2013 California Building Code that apply to building seismic evaluations and retrofits. California has also adopted a national standard, ASCE 41-06, Seismic Rehabilitation of Existing Buildings (scheduled to be re-issued in late 2013 as ASCE/SEI 41-13, Seismic Evaluation and Retrofit of Existing Buildings), as a retrofit standard for state-owned essential services buildings (effective January 1, 2008).

6. *Mitigation for Other State-Owned Normal Occupancy Facilities*

California has an asset management program for non-university buildings that maintains an inventory of over 17,000 buildings with a total of almost 90 million square feet of space Proposition 122 (1990) authorized $250 million for the identification and seismic retrofit of deficient state-owned buildings.

Progress Summary 5.E: State Building Retrofits

Progress as of 2013: In 1990, the state passed the Earthquake Safety and Public Buildings Rehabilitation Bond Act (Proposition 122). According to a Proposition 122 progress report issued in December 2008 by the Department of General Services (DGS), program funds had benefited 85 projects, with 55 completed, 1 under construction, 26 in various preparatory stages of design, and only 3 cancelled. According to DGS, the Proposition 122 program will ultimately result in the retrofit of over 145 buildings, totaling over five million square feet. Most importantly, the retrofits will protect a population of more than 70,000 employees and individuals in institutions.[46]

The Cal VIVA project builds on Proposition 122 by leading towards a process of evaluation and retrofit of state-owned seismically vulnerable buildings needed for response and recovery

In 1999, the DGS Real Estate Services Division estimated the cost for retrofitting all state buildings as $0.84 to $1.7 billion. In 2002, the state began a program to transfer facility funding and operations for county

[46] California Department of General Services. "State-Owned Buildings Bond Act Expenditures Status Report." December 2008.

courthouses to the Judicial Council. Seismic evaluations are required as part of the negotiation between the counties and the state.

For existing buildings owned by the state, the California Building Standards Commission adopted regulations now in Chapter 34 of the 2013 California Building Code that apply to seismic evaluations and retrofits.

7. *Mitigation for State Criminal Justice Buildings*

A 1979-1980 renovation and planning study funded by the Department of Corrections included seismic evaluations and identification of remedial actions for major state prison buildings. Since then, some prisons have been retrofitted in conjunction with other planned modernization projects. Together the Department of Corrections, Department of Justice, and California Youth Authority own:

- 33 prisons
- 38 correctional conservation camps
- 11 youthful offender institutions
- 12 crime laboratories

The California Building Standards Commission has adopted regulations now in Chapter 34 of the California Building Code for the seismic evaluation and retrofit of state criminal justice buildings. California has also adopted a national standard, ASCE 41-06, Seismic Rehabilitation of Existing Buildings, as a retrofit standard for state-owned criminal justice buildings that has been effective since January 1, 2008.

8. *Mitigation for State-Owned Health Services*

The state manages seismic risk in its health care facilities through the Department of General Services (DGS), CDHS, and DDS. The state owns:

- Four mental health hospitals with 4 million square feet of space
- Five developmental centers with 5 million square feet of space
- Two public health laboratories

The state’s acute care hospitals are exempt from the Alquist Hospital Seismic Safety Act. However, the state remains responsible for the public’s seismic safety in these facilities. For state-owned buildings, the California Building Standards Commission has adopted regulations (see Chapter 34 of the 2013 California Building Code) that are applicable to seismic evaluations and retrofits. California has also adopted a national standard, ASCE 41-06, Seismic Rehabilitation of Existing Buildings (scheduled to be re-issued in late 2013 as ASCE/SEI 41-13, Seismic Evaluation and Retrofit of Existing Buildings), as a retrofit standard for state-owned buildings.

9. *Mitigation for K-12 Public Schools*

Since 1933, public schools have been constructed in accordance with the Field Act, which requires thorough reviews of construction plans, strict inspections, and quality control. By 1977, nearly all public schools that were built before the Field Act had either been retrofitted or were no longer being used for instructional purposes. The Field Act did not begin to regulate non-structural systems and building contents in schools until the 1970s. Many schools, particularly older public schools, contain falling hazards that can injure occupants.

In 2002, the Department of General Services (DGS) released a report on a survey of early Field Act buildings that were constructed to regulations that, for certain types of construction are no longer considered to provide reliable life safety[47]. Survey results include the following:

- 42,000 Field Act building construction projects were submitted to DSA before the major building code changes effective in 1978.
- Buildings built before 1933 were either removed from use or retrofitted by 1976.
- 9,659 buildings (92 million square feet of space) with non-wood construction were constructed prior to 1978 when major changes were made to the Field Act regulations. Of these, 2,122 Category 1 buildings are expected to perform well and achieve life safety and 7,537 Category 2 buildings are not expected to perform as well as Category 1 buildings and will require more seismic evaluations.
- DGS anticipates needing $4.7 billion to evaluate and retrofit Category 2 buildings to meet a damage control and life safety performance objectives.

In November 2006, Proposition 1D authorized up to $199.5 million for purposes of seismic repair, reconstruction or replacement of kindergarten through twelfth grade school facilities.

California has adopted the Field Act and its regulations for new construction in the California Building Standards Code. For existing K-12 public schools and community colleges, DSA in 2003 adopted emergency seismic evaluation and retrofit regulations (see Chapter 34 of the 2007 California Building Code) that are applicable to public school buildings and conversions of non-Field Act buildings to public school use. California has also adopted a national standard, ASCE 41-06, Seismic Rehabilitation of Existing Buildings, (scheduled to be re-issued in late 2013 as ASCE/SEI 41-13, Seismic Evaluation and Retrofit of Existing Buildings), as a retrofit standard for public school buildings. Several older school districts throughout the state have or are currently retrofitting early Field Act schools.

The HMGP identified non-structural mitigation as a priority for schools and essential facilities following the 1994 Northridge Earthquake. Cal OES offers guidelines for the retrofit of building contents and non-structural building systems such as ceilings, light fixtures and mechanical equipment (Guide and Checklist for Nonstructural Earthquake Hazards in California Schools, available at: www.caloes.ca.gov

10. *Mitigation for Community Colleges*

In 2000, the community colleges chancellor's office funded a rapid seismic evaluation of buildings constructed to early Field Act standards. The survey found that the community college system has 20 district offices, 108 campuses, 54 off-campus centers, 4,366 buildings overall, and 52.2 million square feet of space. Of the total buildings, 1,600 were given a rapid seismic evaluation to identify retrofit needs that are now integrated into future capital outlay plans.

Up until June 30, 2006, community colleges also had to comply with the Field Act. On and after July 1, 2006, community colleges can choose not to comply with the seismic safety provisions of the Field Act. This change in law was triggered by the passage of Proposition 1D on the November 2006 ballot pursuant to Assembly Bill AB 127 (Nunez, Section 81052 Education Code) which provided funds for Field Act seismic upgrades.

At this time, no information is available regarding efforts to mitigate known vulnerable community college buildings.

[47] California Department of General Services, Division of the State Architect. "Seismic Safety Inventory of California Public Schools." November 15, 2002.

11. *Mitigation for Public Universities*

The University of California (UC) and California State University (CSU) systems together have 192 primary and satellite campuses and 10,000 buildings with 138 million square feet of space. Since the early 1970s, UC has been evaluating and retrofitting buildings on its campuses. The system has ranked the seismic safety of its major buildings from "good" to "very poor" and has embarked on capital outlay programs to retrofit those that are ranked "poor" or "very poor." In the early 1990s, CSU initiated a similar program. As of 2003, CSU had evaluated 1,364 major facilities, identified 145 as potentially hazardous and required further evaluation and retrofits in many cases.

As discussed further below, most facilities identified as hazardous now have retrofit projects undergoing design or construction or completed. The greatest vulnerability aspects of public universities are the potential for loss of life, research, and educational functions and damage to state property.

For existing public university buildings owned by the CSU and UC systems, the California Building Standards Commission has adopted regulations (see Chapter 34 of the 2013 California Building Code) that are applicable to their seismic evaluations and retrofits. Both university systems have active seismic safety programs with major long-term capital programs including billions of dollars in mitigation investments.

CSU Seismic Peer Review Board. Since 1993, CSU has had a vigorous program of reducing the unacceptable seismic risk of existing buildings and managing current construction programs to limit future seismic risk to acceptable levels. Seismic peer review is a mandatory part of the construction process of CSU. Consistent with Title 24, CSU has adopted minimum seismic parameters. These campus-specific coefficients seek to provide more accurate guidance for structural calculations. Site-specific soil conditions are determined by a geotechnical engineer as part of the development of each project.

CSU has a seismic emergency response protocol that was adopted in 2000 based on efforts of the Seismic Peer Review Board established in 1992. CSU Seismic Safety Requirements strive to build and maintain facilities "that provide an acceptable level of earthquake safety for students, employees and the public." The Seismic Review Board is comprised of seven independent engineers (six structural and one geotechnical) who review and advise CSU of existing policy and code requirements. The six structural engineers are assigned specific campuses and have developed a base of knowledge about each campus, site-specific soil issues, and fault proximity.

The Seismic Policy includes provisions for emergency response by the Seismic Review Board in the event of a significant seismic event. The Chairman of the Seismic Review Board acts as the Designated Building Official for the purposes of safety determination of structures. When an earthquake occurs, the Designated Building Official evaluates the safety of buildings on campus and indicates recommendations for engineering investigations to determine the condition of individual buildings.

The CSU Risk Management Authority (CSURMA) performs a tri-annual appraisal of approximately 3,000 buildings ($14 billion approximate value). The appraisal methodology identifies buildings in flood plains and with earthquake exposure.

In 2006, CSU obtained FEMA Pre-Disaster Mitigation Grant Program (PDM) supplemental funding for three planned projects that included a seismic retrofit as a part of their overall construction program. This federal program was designed to help fund projects that could help reduce the severity of loss in potential disaster scenarios such as flooding or seismic events. The Cal Poly Pomona and CSU San Bernardino campuses were awarded $2.17 million and $1.71 million, respectively, in supplemental funding.

CSU has funded and implemented $22.48 million in system-wide seismic retrofit projects between 2005-2006 and 2009-2010. The Seismic Retrofit Program has another $503.6 million in projects in the budget for 2010-2011 through 2014-2015.

University of California System-Wide Seismic Safety Program. The University of California (UC) Seismic Safety Program was initiated following the 1971 San Fernando Earthquake, with the governing Board of Regents adopting policies in 1975 calling for acceptable levels of seismic safety. Structural reviews to identify and set priorities for hazard mitigation were initiated in 1978 and continue on an ongoing basis. Each campus is presently working toward completing corrections on all remaining buildings with a seismic rating of "Poor" and "Very Poor," which generally corresponds to the Department of General Services ratings of V and VI.

From 1979 to 2008, seismic retrofit corrective and mitigation work was completed in more than 230 structures (67 percent of buildings needing seismic work), involving 16 million gross square feet. The cost of this work has been approximately $1 billion (not adjusted for inflation and excluding FEMA funding).

In addition to its academic facilities, UC operates five major medical centers and is the largest public health care provider in the nation besides the federal Veterans Administration. All hospital facilities are being seismically retrofitted in accordance with the Alquist Hospital Seismic Safety Act as part of the seismic retrofit and replacement program.

Progress Summary 5.F: UC Retrofits

Progress as of 2013: In recognition and response to the magnitude of the threat/risk posed by a potential catastrophic earthquake, the University of California (UC) began its system-wide structural seismic safety retrofit capital program in 1979. During the period 1979-2012, seismic retrofit corrective work was completed in 288 structures, comprising more than 19.5 million gross square feet (GSF). The cost of this work totaled approximately $7.8 billion in today's dollars, excluding Federal Emergency Management Agency (FEMA) funding, mainly for the replacement of the UCLA medical centers. This represents 99 percent of all UC investment in hazard mitigation, commensurate with the degree of catastrophic risk. The University of California expects that remaining seismic retrofit/mitigation work will require at least another 7 to 10 years, assuming adequate funding.

UC Berkeley SAFER and Disaster Resistant University (DRU) Programs.

The Seismic Action Plan for Facilities Enhancement and Renewal (SAFER) was created in 1997 to improve campus seismic safety, with highest priority on life safety, as well as to ensure sustained campus operations in the aftermath of a major earthquake on the Hayward Fault that runs through campus. SAFER also seeks to set priorities for seismic structural abatement retrofit projects, upgrade campus utilities, and provide non-structural seismic mitigation for campus buildings. SAFER implementation is estimated to cost UC Berkeley over $1 billion over the next 30 years with funding from multiple federal, state, university, corporate, and donor sources. (www.berkeley.edu/news/extras/1997/SAFER/index.html)

In 1998, in conjunction with the SAFER program, the FEMA Disaster Resistant Universities (DRU) program was initiated as a pilot project to develop a loss estimation tool and a risk management plan for UC Berkeley with broader application to universities and colleges nationwide. The DRU program has five major components:

- Assess natural hazard vulnerability and estimate loss
- Evaluate economic impacts of campus shutdown
- Develop and implement a strategic risk management plan
- Develop a model program for university disaster resistance
- Facilitate national funding support for hazard mitigation in research universities

Building A Disaster Resistant University was published by FEMA in 2003 and is both a how-to guide and a distillation of the experiences of UC Berkeley (which initially drafted the program guidance) and five other universities and colleges across the country that were also initially participating in the DRU program. The guide provides basic information designed for institutions just getting started as well as concrete suggestions for institutions that have already begun to take steps toward becoming more disaster-resistant. The guide can be downloaded from: http://www.fema.gov/library/viewRecord.do?id=1565

Best Practices Highlight 5.B: University of California Seismic Mitigation

The University of California is committed to reducing, preventing or eliminating potential risks and impacts of natural and human-caused disasters and keeping campus communities as safe and disaster-resilient as possible. The system-wide Hazard Vulnerability Assessment (HVA) initiative completed in 2005 identified catastrophic earthquake as the highest risk threat for most UC campuses and provides the UC system with a road map on how to most effectively rank and manage a wide range of catastrophic risks.

The University's Seismic Safety Program is an ongoing system-wide structural retrofit program overseen by each campus. Proposed seismic correctional work is coordinated with fire protection, health and safety upgrades, and rehabilitation or renovations for functional and programmatic improvements, and integrated into the University's Capital Improvement Program.

Following are project highlights from the University's Seismic Safety Program:

Santa Monica Hospital Seismic Replacement Project (opened January 2012): $574 million cost
The UCLA Santa Monica Hospital rebuilding project was launched in response to damage caused by the 1994 Northridge earthquake. The new hospital was built to meet the latest seismic safety standards and can withstand an earthquake of up to magnitude 8.4, while redundant power sources will allow the hospital to operate for at least 100 hours after an earthquake without receiving any outside help. Funding for the $574 million project was provided by multiple sources including FEMA grants, bond initiatives, and donations from individuals and corporations.

UCSF Mount Zion Medical Center Structural Seismic Retrofit Project (2011): $3 million HMGP Grant
FEMA just recently approved a seismic retrofit project at the Mount Zion Medical Center. The project is partially funded by FEMA's Hazard Mitigation Grant Program (HMGP). The targeted medical buildings were built of reinforced concrete in phases between 1948 and 1962. They have been identified as being out of compliance with current state building codes and requiring retrofit pursuant to Senate Bill 1953. This seismic retrofit project incorporates new concrete shear walls, reinforced concrete slabs, and "shotcrete" concrete infill at windows and structural steel.

UC Berkeley Student Union Seismic Retrofit Project (2010) $3 million FEMA PDM Grant
In June 2010, FEMA released $3,000,000 in Pre-Disaster Mitigation (PDM) funds to UC Berkeley to perform structural seismic retrofits to the Martin Luther King Jr. Student Union building. The funded project consists of strengthening existing structures in the Tilden Room and Pauley Ballroom, including installing a structural brace, adding and reinforcing concrete walls, and replacing plate glass windows with tempered or laminated glass. The FEMA PDM funds provide approximately 35 percent of the project's costs, which total $8,674,000. UC will fund the remaining balance of this project ($5,674,000).

Systemwide Building Seismic Gas Shutoff Valve Program
The UC Office of the President Risk Services created a campus reimbursement program funded by a policy holder insurance rebate to install seismic gas shutoff valves on natural gas mains outside campus buildings to prevent the possibility of an uncontrolled release of gas into buildings that could lead to catastrophic fire loss. Property loss prevention building evaluations were conducted in 2007-2009 by the insurer's engineering personnel on all University buildings with total property value of at least $10 million.

As part of this engineering assessment, a prioritized list of campus buildings needing shutoff valves was developed based on the likelihood of a gas main leak/break and the severity of impact should that occur. Likelihood was based on seismicity (earthquake zones), whereas the assessment of severity was based on building fire protection (sprinkler systems). Gas main size was also taken into account for both likelihood and severity, as larger gas mains are inherently less flexible and therefore more likely to break during an earthquake, releasing larger volumes of gas into buildings resulting in more severe fire conditions. The gas shutoff valve program account has a total budget of $320,677. To date, approximately 13 high-priority buildings at UC Irvine, UC San Francisco, and UCOP have had shutoff valves installed, at an actual total cost of $31,492. At this time, $289,186 remains in the account, which is estimated to be sufficient to install shutoff valves in all of the University's 86 highest priority buildings.

Related University of California mitigation programs include the following:

UC Berkeley Wildland Fire Hazard Mitigation Program: UC Berkeley campus lands include approximately 800 acres of wildland in the East Bay hills that border on residential neighborhoods in Berkeley and Oakland. The combination of an accumulation of dense non-native vegetation and increased urbanization has created a wildland-urban interface (WUI) condition posing an extreme threat to lives and property. From 1923 to 1991, 14 major fires have occurred in this area, including the 1991 Tunnel Fire that destroyed more than 2,800 buildings and claimed 25 lives.

In response to the 1991 Tunnel Fire, the university established a Campus Fire Mitigation Committee to develop and oversee a program to manage wildfire risk. The goal is to manage vegetation to ensure that the vulnerable areas are wildfire-defensible by improving accessibility for fire crews, creating and maintaining escape routes, and lessening the rate of spread of an ignition and/or reducing the potential for embers to ignite adjacent neighborhoods. From 2000 to 2009, the university has spent $1.35 million on the program.

UC San Francisco Pre-Disaster Mitigation (PDM) Grant Projects: Since 2005, UCSF has secured two competitive PDM gr ants for seismic mitigation projects. Grants totaling $6 million involved a structural separation and upgrade of the UCSF Medical Sciences Building and Moffitt Hospital and non-structural retrofits of the Moffitt and Long hospitals. Another $340,000 was obtained to mitigate wildfire hazards on the Mount Sutro Open Space Reserve, operated by UCSF.

UC Santa Barbara "Tsunami Ready" Program: UC Santa Barbara has earned the National Oceanic and Atmospheric Administration (NOAA) National Weather Service "Tsunami Ready" and "Storm Ready" status in recognition of its disaster preparedness and severe weather educational activities. In addition to an early warning system, the campus has established a "move to higher ground" procedure in the event of a tsunami.

12. *Tilt-Up Buildings*

Tilt-up buildings are typically one- or two-story buildings constructed of concrete walls that are poured horizontally, tilted into vertical positions, and connected to each other and to roofs. If the connections between the walls and roofs are weak, the walls can pull away from roofs and collapse during ground shaking. There is no statewide inventory of tilt-up buildings. However, a 1991 estimate suggested that there were approximately 57,000 throughout the state (EQE, 1991). Forty percent of these were built prior to 1976, after which building codes began to require stronger wall-to-roof connections. Many tilt-up buildings have been constructed in the past decade, generally to more current construction standards. Additional enhancements to the building code for new tilt-up construction were adopted in 1997.

The average building size for older tilt-up buildings is 30,000 square feet. Average retrofit costs are $5 per square foot in 2007 dollars. Many of California's light industrial and commercial properties contain tilt-up buildings or buildings with reinforced masonry or concrete walls with vulnerabilities in connections between walls, roofs, and floors. These buildings pose significant risks of casualties and losses in business continuity and California's market share from earthquake damage.

Table 5.H: Mitigation of Tilt-Ups and Similar Buildings

Jurisdiction	Number of Buildings	Program Type
Burbank	--	Mandatory Retrofit
Los Angeles	2,618	Mandatory Retrofit
Los Angeles County & Contract Cities	--	Mandatory Retrofit
Fullerton	220	Mandatory Retrofit
Hayward	130	Voluntary Retrofit
La Palma	--	Mandatory Retrofit
Brisbane	--	Voluntary Retrofit
Santa Monica	--	Mandatory Retrofit
Berkeley	75	Inventory Only
Fremont	--	Mandatory Retrofit

Source: California Seismic Safety Commission

Current retrofit provisions are available in Appendix Chapter A2 of the International Existing Building Code or ASCE 41-06 (scheduled to be re-issued in late 2013 as ASCE/SEI 41-13, Seismic Evaluation and Retrofit of Existing Buildings). The state also encourages sellers of tilt-up buildings and other vulnerable commercial buildings to disclose to buyers any typical earthquake weaknesses defined in the Commercial Property Owner's Guide to Earthquake Safety. State law encourages the disclosure of earthquake weaknesses in commercial properties at the time of sale.

13. *Mitigation for Single-Family Wood-Frame Dwellings*

Approximately 1.5 million single-family dwellings were built in California before 1960, when jurisdictions began to require adequately braced walls. Homes can slide or fall off their foundations if not adequately anchored and braced.

The primary risk posed by single-family wood-frame buildings is the potential for loss of housing and property after earthquakes. In addition, poorly braced homes on steep hillsides can slide down hills and present significant threats to life. Falling chimneys can also cause casualties and damage.
A 1999 survey by the Association of Bay Area Governments (ABAG) determined that from 2 percent to 38 percent of Bay Area homes were retrofitted depending upon jurisdiction, with an average retrofit rate well below 10 percent. Similarly, the California Earthquake Authority has found that about 6 percent of policyholders have retrofitted their homes.

The following cities have voluntary dwelling retrofit programs:

- Los Angeles – 6,000 dwellings retrofitted as of February 2006 (also adopted a voluntary hillside dwelling retrofit ordinance)
- Berkeley
- San Leandro
- Oakland
- Santa Barbara
- Santa Monica

The most current retrofit provisions are available in Appendix Chapter 3 of the International Existing Building Code. Local governments in the San Francisco Bay region have adopted more stringent retrofit provisions called Standard Plan Set A. (www.abag.ca.gov/bayarea/eqmaps/fixit/plansets.html)

The state also requires sellers of dwelling buildings to disclose to buyers any typical earthquake weaknesses defined in the Homeowner's Guide to Earthquake Safety

Best Practices Highlight 5.C: Addressing Seismic Vulnerability of California's Housing Stock

Residential Hazard, Vulnerability, Risk and Mitigation Assessment
Role of California Earthquake Authority (CEA)

Seismic Vulnerability of Statewide Housing Stock

Approximately 38 million people reside in California in approximately 13.4 million residential units (see Table 5.I). Housing represents the largest class of occupied buildings in the state. The majority of Californians live south of the Tehachapi Mountains or in the San Francisco Bay Area. Both areas have numerous extensive faults running through and near them and are subject to high levels of earthquake shaking potential. It is generally acknowledged that inadequately constructed and/or maintained buildings, situated on poorly performing soils, tend not to perform well during earthquakes. A statewide study of the performance of the California residential building stock has never been conducted. Studies of residential units, in general, have been localized and completed only after earthquakes have occurred.

Several studies of earthquake effects on housing have been completed, including those associated with the San Francisco Bay Area and the Los Angeles metropolitan area in 2007 and 2008 through the Community Action Plan for Seismic Safety (CAPSS) program in the San Francisco Bay Area and the Great California ShakeOut drills in 2008 and 2009. For a detailed discussion of the Great ShakeOut, see Section 5.2.3.

Residential construction increasingly has been influenced by natural hazard issues in California. Faulty performance of building stock during earthquakes has required numerous changes in building codes affecting subsequent construction, design, practices, and materials used. To date, neither a statewide assessment of California residential building stock nor statewide tracking of completed seismic retrofitting of housing has been funded or completed in California. Therefore, calculation/determination of the losses that could be avoided by the seismic retrofitting of residential units is unknown. The availability of this information would be useful in the development of future earthquake mitigation activities and could be an area of ongoing surveillance and study should FEMA decide to pursue it.

Table 5.I identifies the numbers and percent of housing units in California by type. It indicates that a majority of units (58.3 percent) are single-family detached.

Table 5.I: California Housing Units by Type, 2011

Units in Structure	Number of Units	Percent of total	Percent Change from 2008
1 unit detached	7,955,970	58%	2%
1 unit attached	957,678	7.0%	3%
2 units	349,851	2.5%	1%
3 or 4 units	749,821	5.5%	-2%
5-9 units	843,623	6.1%	2%
10-19 units	731,031	5.3%	4%
20 or more units	1,593,276	11.6%	8%
Mobile home	523,207	3.8%	1%
Boat, RV, van, etc.	16,730	0.1%	13%
Total housing units	13,721,187	100.0%*	2%

Source: 2011 American Community Survey 1-Year Estimates, Selected Housing Characteristics: 2011.
** Percentage s do not add to 100% due to rounding*

Impediments to Seismic Hazard Mitigation for Housing

The following are potential impediments to seismic hazard mitigation for residential units, along with actions being taken or needed to overcome these impediments:

1. *Lack of Standardization.* Seismic retrofits standards, specifications, and plans have generally not been standardized and included in the California Existing Building Code (CEBC). The CEA recently worked with the Office of the Governor, Department of Housing and Community Development, California Seismic Safety Commission, and California Building Standards Commission to adopt (on August 16, 2010) the first California Existing Building Code for the seismic retrofitting of wood frame dwellings: 2009 International Existing Building Code Appendix Chapter A3—Prescriptive Provisions for the Seismic Strengthening of Cripple Walls and Sill Plate Anchorage of Light, Wood-Frame Residential Buildings—by amending the 2010 and 2013 California Existing Building Code) for existing residential structures. The CEA has initiated research seeking to determine the percentage of damage that may be reduced if the seismic structural retrofitting of a house is done correctly. The CBC may need further revisions to prevent a seismic retrofit of a 1- to 4-family residence from triggering other code upgrade requirements.

The CEA has since joined forces with the Federal Emergency Management Agency (FEMA) to develop comprehensive guidelines for evaluating and seismically retrofitting single-family dwellings. These guidelines will include additional prescriptive provisions for certain earthquake deficiencies in single-family dwellings (such as cripple walls greater than 4 feet in height and dwellings with a living space over a garage) as well as detailed provisions for use by registered design professionals. The CEA has also begun a research program seeking to determine the percentage of damage that may be reduced if the seismic/structural retrofitting of a house is done correctly. Considering its present form, the CBC may require revisions to determine whether a seismic retrofit of a 1- to 4-family residence should also trigger other, unrelated code-upgrade requirements.

2. *Need for Training*. Building officials need to be trained to identify and evaluate seismic retrofit standards, specifications, and plans. Building contractors and related craftspeople also need to be trained to understand standards, specifications, and plans in order to successfully install the seismic retrofits into existing 1- to 4-family residences. The CEA is requesting that the Federal Emergency Management Agency and the International Code Council update their respective training materials to incorporate the new California Existing Building Code adopted on August 16, 2010 for the seismic retrofitting of residential structures.

Statewide Initiatives for Mitigating the Effects of Seismic Hazards on Housing

At present, aside from the state's property tax reappraisal exclusion and tax credits for Nationally-registered historical homes, the only other statewide seismic hazard mitigation incentives for residences are related to those offered by residential earthquake insurance providers.

The CEA currently is the largest provider of earthquake insurance in California and has about $10.2 billion in claim-paying capacity. The CEA is privately financed through insurance premiums and is a publicly managed instrumentality of the state. Private insurers that write residential property insurance in California may, at their option, and upon meeting participation requirements, participate in the CEA. Once they become CEA participants, insurers no longer write residential property earthquake insurance coverage and instead satisfy their legal obligation to offer earthquake insurance to their residential property policyholders by offering a CEA policy. Insurers that participate in the CEA are referred to as "Participating Insurers."
The CEA has maintained an A.M. Best Company financial-strength rating of "A minus (Excellent)" since 2002. The CEA is working with Cal OES to distribute financial incentives to homeowners to help offset the cost of residential structural retrofits.

Under California law, the CEA is required to offer a mitigation discount on an insured's CEA earthquake insurance annual premium if an insured has met certain mitigation criteria. Not all houses qualify for this discount. Section 10089.40(d) of the California Insurance Code describes the minimum effort needed for a CEA policyholder of a residential dwelling to qualify for a five-percent premium discount.

Current requirements for qualifying for the premium discount are:

- Dwelling was built prior to 1979
- Dwelling is tied to its foundation
- Dwelling has cripple walls braced with plywood or its equivalent
- Water heater is secured to the building frame

The same code section states, "The CEA Governing Board may approve a premium discount or credit above 5 percent, as long as the discount or credit is determined actuarially sound by the authority."
At present, the CEA does not have a seismic retrofit mitigation discount scale that allows policyholders to qualify for mitigation discounts other than that listed above. The CEA enabling legislation calls for other mitigation activities, including research, development, and consumer education, as well as contents mitigation and structural retrofitting. The CEA is continuing to work with stakeholders to determine how to specifically approach the seismic retrofitting of residential structures. For a discussion of this initiative, see Progress Summary 5.H.

Residential Earthquake Insurance as a Loss Reduction Tool

Depending on the homeowner's earthquake insurance provider, the successful utilization of the seismic retrofit standards and general plans may be considered when awarding discount points to homeowners to lower their earthquake insurance premiums. It is anticipated that the resiliency added to correctly retrofitted homes will help lower the potential for loss of life, injury, and structural and non-structural damage as well as contents damage resulting from earthquakes. The impact on mitigation activity levels and the benefits gained from incentives such as lowering residential earthquake insurance premiums for seismically retrofitted housing units are unknown.

Non-Structural Mitigation Items Provided to Californians by the CEA

The CEA has provided funding to help the U.S. Geological Survey and other agencies jointly develop and publish several guides on earthquake safety and preparedness, including "Putting Down Roots in Earthquake Country," which covers Southern California and the Bay Area, and "Living on Shaky Ground," which covers the North Coast Region. Other guides on home earthquake safety and preparedness include the California Seismic Safety Commission's Homeowner's Guide to Earthquake Safety, and Improving Natural Gas Safety in Earthquakes.

The CEA also has an ongoing hazard mitigation funding program. The CEA's commitment to mitigation is reflected in its Strategic Plan adopted by the CEA Governing Board in 2003. The plan calls for the CEA to "educate residents about their earthquake risk and motivate them to protect themselves and their property." The CEA board sets aside funding each calendar year (equal to 5 percent of its investment income, up to $5 million annually) for funding mitigation. This annual allocation requirement is set forth in California Insurance Code Section 10089.37.

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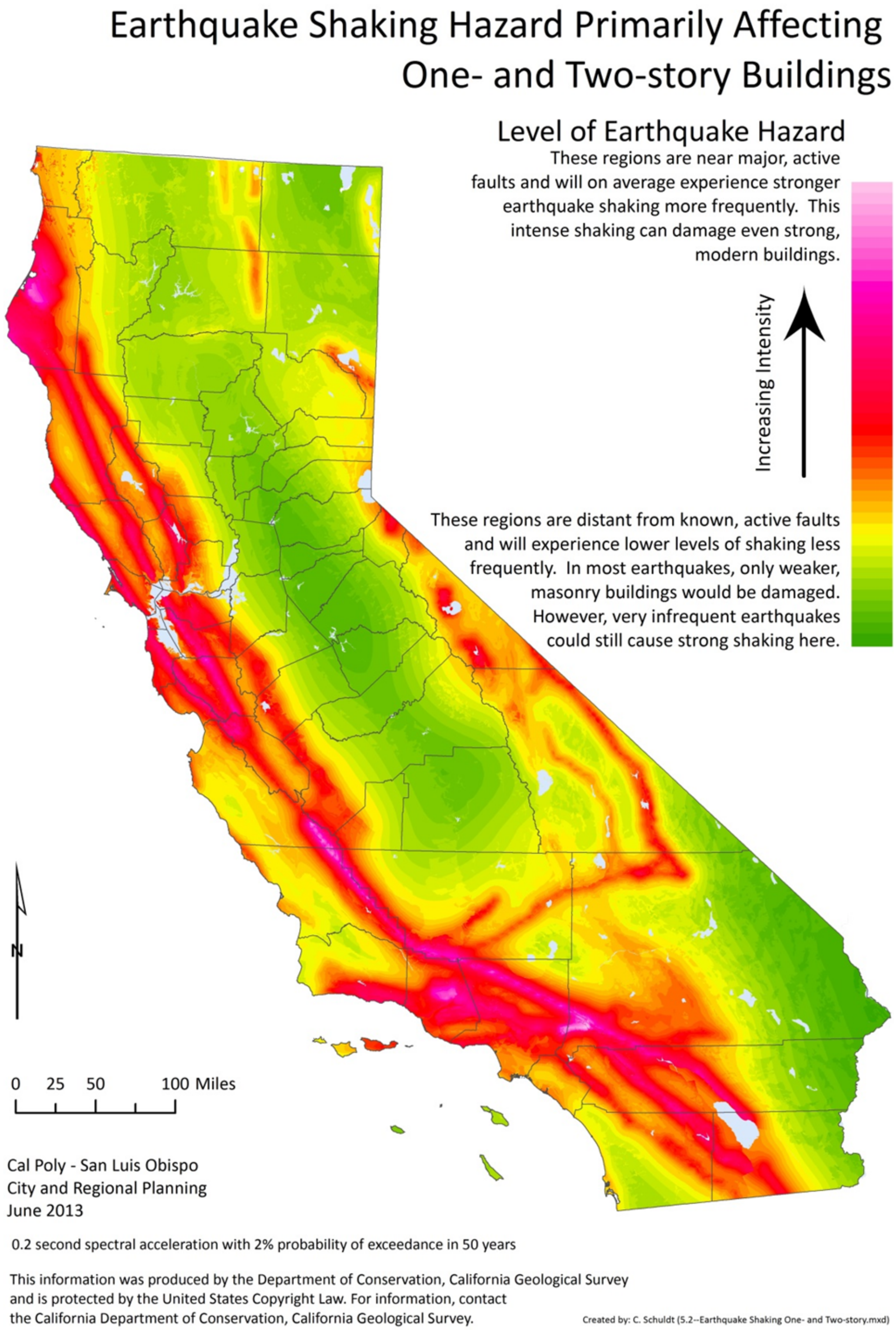
MAP 5.M: Earthquake Shaking Hazard Affecting One- and Two-Story Buildings



Map 5.M shows patterns of high potential earthquake shaking hazards affecting one- and two-story buildings. The pattern is similar but not identical to the pattern affecting taller buildings shown previously (Map 5. I).

Progress Summary 5.G: Seismic Evaluation of Single-Family Dwellings

Progress as of 2013: The CEA has since joined forces with the Federal Emergency Management Agency (FEMA) to develop comprehensive guidelines for evaluating and seismically retrofitting single-family dwellings. These guidelines will include additional prescriptive provisions for certain earthquake deficiencies in single-family dwellings (such as cripple walls greater than 4 feet in height and dwellings with a living space over a garage) as well as detailed provisions for use by registered design professionals. The CEA has also begun a research program seeking to determine the percentage of damage that may be reduced if the seismic/structural retrofitting of a house is done correctly. Considering its present form, the CBC may require revisions to determine whether a seismic retrofit of a 1 to 4-family residence should also trigger other, unrelated code-upgrade requirements.

14. *Mitigation for Multi-Unit Wood-Frame Residential Buildings*

There is no statewide inventory of multi-unit wood-frame residential buildings. However, the approximate number of buildings can be inferred from local inventories available from select cities as summarized below.[48] A significant number (perhaps one-third) of all apartments and condominiums have parking at the lower levels, which can create earthquake vulnerabilities. These buildings can collapse and cause casualties and property loss and be rendered uninhabitable after earthquakes. Up to 84 percent of the loss of housing in a Hayward Fault earthquake scenario is expected to occur in multi-family residential buildings (ABAG, 1999).

California contains a total of 160,000 apartment buildings with five or more units, according to the California Department of Finance. Approximately 130,000 apartment buildings are in regions of high seismicity including 46,000 soft-story buildings. The statewide average is 16 units per building.

Progress Summary 5.H: California Residential Mitigation Program Financial Incentives

Progress as of 2013: In the fall of 2009, the CEA held scoping sessions in Sacramento, Los Angeles, and Oakland to collect informed recommendations from related experts on future opportunities for the seismic retrofitting of residential structures in California. Stakeholders for the CEA mitigation program include California homeowners and renters, the California residential construction industry, Cal OES, the Association of Bay Area Governments, and the Southern California Association of Governments as well as the California Seismic Safety Commission (CSSC), Earthquake Country Alliance, and others. The participants at the scoping sessions suggested that a statewide standard was needed. The CEA subsequently worked together with the Office of the Governor, Department of Housing and Community Development, California Seismic Safety Commission, and California Building Standards Commission to facilitate the August 16, 2010 adoption of the first California Building Code for existing residential structures (Appendix A3 of the 2009 International Building Code -- "Prescriptive Provisions for the Seismic Strengthening of Cripple Walls and Sill Plate Anchorage of Light Wood-Frame Residential Buildings" -- with amendment of the 2007 and 2010 California Existing Building Code).

In August 2011 the CEA and CalEMA (now Cal OES) entered into a joint powers agreement to create the California Residential Mitigation Program (CRMP) to carry out a joint mitigation program. The board of directors of the Cal-EMA/California Earthquake Authority (“CEA”) Joint Powers Agreement (JPA) manages the CRMP which has been designed to provide financial incentives to homeowners who complete seismic retrofit projects on their dwellings. The program will be limited to funding dwelling retrofit expenses that:

- Strengthen cripple walls to enable them to function as shear members, significantly protecting the dwelling from collapsing;
- Bolt sill plates to the foundation, enabling the dwelling to remain in place, rather than sliding off the foundation during an earthquake; and

[48] California Department of Finance Demographics Unit (www.dof.ca.gov); Vukazich, Selvaduray & Tran, Santa Clara County Survey, EERI Spectra Vol. 22, No 4, November 2006.

- Properly strap the water heater to reduce the likelihood of water and fire damage, and to protect the water supply.

The CRMP's initial pilot project is scheduled to roll out in late 2013. This program will provide $3,000 per residential unit for seismic retrofit improvements as listed above. The program is funded from a CEA 5% of invested profits fund earmarked for seismic residential upgrading. Selected groups of homeowners in a northern California community and in a southern California community will use a web portal to submit applications for the retrofit program. The pilot project is intended to test all aspects of the program, leading to an early 2014 rollout statewide. Participation in CRMP programming will be open to all California homeowners whose dwellings meet program rules and the requirements of Chapter A3 of the California Existing Building Code (raised floor with cripple walls less than 4 feet tall, etc.).

Mitigation Research

The CEA invited earthquake engineering research professionals to the "Workshop for Development of an Experimental and Numerical Modeling Program to Evaluate the Effectiveness of Selected Seismic-Mitigation Measures for Single-Family Dwellings" held on January 24 and 25, 2013. The purpose of the workshop was to discuss research requirements and expectations. The workshop sought to develop a roadmap for a multi-year research program to evaluate the effectiveness of selected seismic-mitigation measures for wood-framed single family dwellings. The resulting research program will be designed to calculate appropriate mitigation-related insurance-premium discounts, support the guideline-development process, and inform other strategic CEA and CEA earthquake-loss-mitigation endeavors.

15. *Mitigation for "Soft-Story" Buildings*

Multi-unit residential structures with soft, weak, or open fronts are commonly referred to as "soft-story" buildings. Soft-story residential buildings are multi-story wood-frame structures with inadequately braced lower stories that may not be able to resist earthquake motion.

Soft-story buildings are an important component of the state's housing stock and are in jeopardy of being lost in the event of severe shaking. For example, the Association of Bay Area Governments (ABAG) has estimated that soft-story residential buildings will be responsible for 66 percent of the uninhabitable housing following an event on the Hayward Fault. The failure of soft-story residential buildings is estimated by ABAG to be the source of a disproportionate share of the public shelter population because such structures tend to be occupied by the very poor, very old, and very young.

In 2005, the state legislature passed AB 304, which encourages cities and counties to address the seismic safety of soft-story residential buildings and encourages local governments to initiate efforts to reduce the seismic risk in vulnerable soft-story residential buildings. AB 304 requires the seismic retrofit of these buildings to comply with a nationally recognized model code relating to the retrofit of existing buildings or substantially equivalent standards. It replaces the word "reconstruction" with "seismic retrofit" in provisions governing earthquake hazardous building reconstruction and defines seismic retrofit for purposes of provisions governing earthquake protection. "Seismic retrofit" means either structural strengthening or providing the means necessary to modify the seismic response that would otherwise be expected by an existing building during an earthquake, to significantly reduce hazards to life and safety.

The following are hazard mitigation strategies recently undertaken locally for "soft-story" buildings in California.

Soft-Story Building Inventories

The cities of Alameda, Berkeley, Fremont, San Francisco, San Leandro, and San Jose, as well as other Santa Clara County cities, in addition to Santa Rosa, Los Angeles, Concord, Rohnert Park, Burbank, Pasadena, Santa Monica, and Santa Barbara all have either undertaken or are in the process of beginning a soft-story building inventory.

Soft-story inventories in California range from those mandated by ordinance (Alameda) to those that are voluntary (Los Angeles). Since 2006, hundreds of soft-story buildings have been retrofitted. For example, Los Angeles went from 90 retrofitted buildings in 2006 to over 800 retrofitted soft-story buildings by 2009. There is still work to do, though, as most cities with inventories report thousands to tens of thousands of soft-story units.

San Francisco CAPSS Report
In 2009, the Community Action Plan for Seismic Safety (CAPSS) in the City and County of San Francisco published Here Today – Here Tomorrow: Earthquake Safety for Soft-Story Buildings.

Recommendations in the report pertain to "multi-unit soft-story buildings," defined as," Wood-frame structures, 3 stories or more, with 5 or more residential units, built before May 1973, and having a 'soft-story' condition on the ground floor."

Key recommendations included:

- The Department of Building Inspection should establish a program that requires owners of wood-frame buildings built before May 21, 1973 with three or more stories and five or more residential units to evaluate the seismic safety of their buildings and to retrofit them if they are found to be seismically deficient.
- Buildings should be retrofitted to a standard that will allow many of them to be occupied after a large earthquake.
- The City should immediately offer incentives to encourage voluntary retrofits. To get owners moving on making their buildings safer, the City should offer incentives to owners who retrofit, including expediting plan review, rebating permit fees, offering planning incentives, and seeking voter approval of a City-funded loan program.
- The Department of Building Inspection should form a working group to develop a detailed plan to implement the recommended program.

Best Practices Highlight 5.D: SF CAPSS and San Francisco's Soft Story Ordinance April 2013

Soft Story Ordinance
On the 107th anniversary of the 1906 Great Earthquake San Francisco Mayor Edwin Lee signed into law the Mandatory Seismic Retrofit Program for Soft Story Wood Frame Buildings which will lead to seismic strengthening of several thousand buildings in San Francisco. The new ordinance was approved unanimously by the Board of Supervisors with an 11-0 vote following years of work among City officials, property owners, tenants, and community members to reach a retrofitting plan.

Currently more than 58,000 San Francisco residents live in the estimated 3,000 or more wood-frame soft story buildings that are targeted for seismic retrofit by the soft story ordinance. These same buildings also house approximately 2,000 businesses with an estimated 7,000 employees. The primary goal of the soft story ordinance is to protect San Franciscans and the city's housing stock thus ensuring more rapid recovery from future earthquakes. The CAPSS study showed that the retrofitting of soft story buildings, as required by the new ordinance, would result in a reduction of earthquake collapse hazards and allow the city to retain significant amounts of housing stock following a moderate earthquake event (7.2 magnitude) and shorten the recovery time from such an earthquake. Thus the ordinance promotes the resiliency goals identified in the Community Safety Element of the San Francisco General Plan. The retrofits will also greatly increase the likelihood that these buildings will remain useable (or "safe enough to stay") for their residents following a major earthquake (SPUR Safe Enough to Stay/Shelter in Place). Allowing San Franciscans to remain in the city will also greatly ensure and quicken recovery.

The soft story ordinance expanded the reach of the CAPSS report to apply to wood-frame buildings built before January 1, 1978. These buildings consist of at least two stories over a weak ground floor level or garage with five or more residential units. The Soft Story Retrofit Program mandated by the new ordinance will occur over the next seven years.
After a mandatory noticing, building evaluations will begin late fall 2013 resulting in classification of all soft story buildings within the city into one of four compliance tiers. Phased requirements for completion of required retrofit upgrades vary according to compliance tier with all retrofit work to be completed by December 31, 2020.

There is also currently an incentive program in place. AB-094 was passed, and the Earthquake Safety Working Group (with many subcommittees) was formed in December 2012 to help guide the implementation of the ESIP program in public and technical advisory capacities. For more information regarding the soft story ordinance visit the CAPSS website: www.sfcapss.org

The most current retrofit provisions for soft-story buildings are available in Appendix Chapter A4 of the International Existing Building Code 2012 Edition or ASCE 41-06 (scheduled to be re-issued in late 2013 as ASCE/SEI 41-13*, Seismic Evaluation and Retrofit of Existing Buildings*). Local jurisdictions including the cities of San Francisco and Berkeley have enacted voluntary and mandatory retrofit ordinances. The CBC allows these references as acceptable alternatives to existing regulations.

16. *Locally Regulated Non-Ductile Concrete Buildings*

There is no statewide inventory of concrete buildings. However, an approximate figure of 16,000 to 17,000 buildings can be inferred from local inventories (See Progress Summary 5.I below). These buildings, particularly older ones with high numbers of occupants, can collapse and kill hundreds. This type of building is the fastest growing cause of earthquake losses around the world (Coburn, 2002). California instituted changes in building codes in the mid-1970s that were intended to stem losses in newer buildings constructed to later standards. However, the great majority of these buildings constructed before the mid-1970s have not been evaluated or retrofitted.

Two specific types of non-ductile concrete construction are flat slabs and lift slabs. With lift slab construction, concrete slabs are cast on the ground, lifted into place and then connected to columns. Flat slabs are cast-in-place, and connect to columns without beams. Historically, both types of construction were often designed without adequately accounting for the full movement a building will experience during an earthquake and older such buildings can therefore be prone to slab failure during a large earthquake.

In 2006 the Pacific Earthquake Engineering Research Center (PEER) was awarded a $3.6 million grant from the National Earthquake Engineering Simulation Center to assess these buildings' collapse risks and develop enhanced risk management methods (http://peer.berkeley.edu/).

The Pacific Earthquake Engineering Research Center administers the Network for Earthquake Engineering Simulation Grand Challenge project on existing hazardous concrete buildings (NSF Award# CMMI-0402490). The project team completed an inventory of older non-ductile concrete buildings in the City of Los Angeles in 2013, including detailed information on building location, age, configuration, and occupancy.

Prior to this project, this critical information was not available to policy makers, engineers, and researchers in an organized single source. The immediate impact of this inventory was demonstrated as it served as the backbone for earthquake scenario loss studies to help inform the City on the extent and character of its vulnerability. Laboratory studies have identified critical building components, and earthquake simulation studies have extended those findings to identify building characteristics that make a building most susceptible to collapse. The project is leveraging its work with the Concrete Coalition, FEMA, and NIST-funded companion projects to help practicing engineers identify those buildings with highest risk by developing guidelines for assessing vulnerability and methodologies to effectively strengthen the most critical elements that will prevent collapse and save lives.

Progress Summary 5.I: The Concrete Coalition

Progress as of 2013: In 2010, a statewide volunteer effort coordinated by the Earthquake Engineering Research Institute (EERI), through its Concrete Coalition Project canvassed cities throughout the state to determine how many pre-1980 non-ductile concrete buildings they may have within their jurisdictions.

Under a Hazard Mitigation Grant Program (HMGP) grant, the Concrete Coalition — a network of individuals, governments, institutions, and agencies — has been assessing risks associated with dangerous non-ductile concrete buildings and developing strategies for fixing them. Since 2008, the Concrete Coalition has prepared estimates of the number of pre-1980 concrete buildings in the 22 high-seismic-risk counties in the state. More accurate estimates than previously available have been assembled through 1) use of volunteers to count or estimate the numbers of these buildings in individual jurisdictions, 2) use of available field counts, 3) development of a regression model based on U.S. Census-based parameters, and 4) acquisition of statewide databases for school, university, and government buildings. This process has so far yielded an estimated range of 12,000 to 15,000 pre-1980 non-ductile buildings in the 22 high-risk counties, not all of which are necessarily dangerous or at risk of collapse. The final report from this phase is available at: https://www.eeri.org/2011/09/concrete-coalition-california-inventory-project-report-now-available/

The next step is to gain a better understanding of which of these represent the highest risk. This is a serious issue for the older, larger cities. San Francisco, for example, has over 3,000 non-ductile buildings. Although many of these will perform adequately in an earthquake, it is important to understand which ones will not and why. The collapse of even one large, high-occupancy building could have devastating consequences for a single community. In 2012/13, a new phase of the Concrete Coalition work, also supported by an HMGP grant, is focusing on developing tools that help decision-makers understand the dimensions of the problem, as well as help engineers develop techniques to categorize which of these buildings are most vulnerable.

The most current retrofit provisions are available in ASCE 41-06 (scheduled to be re-issued in late 2013 as ASCE/SEI 41-13, Seismic Evaluation and Retrofit of Existing Buildings) and Appendix Chapter A5 of the International Existing Building Code.

17. *Repair of Steel-Frame Buildings*

After the Northridge Earthquake, the City of Los Angeles enacted an ordinance that required the repair of existing damaged steel-frame buildings. Many of these buildings were restored to their pre-earthquake conditions and are likely to suffer similar or worse damage in future earthquakes. Elsewhere in the state no surveys of such buildings exist, although several similarly damaged buildings were discovered in the Bay Area years after the 1989 Loma Prieta Earthquake. The state has since changed its building code for constructing new buildings with this type of framing. There are no efforts in the state to require retrofits or enact post-disaster repair provisions.

The cities of Los Angeles and Santa Monica have post-earthquake repair ordinances. Los Angeles required owners to remove the finishes from joints in 242 buildings and repair the ones that were cracked. The most current recommended evaluation and retrofit provisions are in AISC 41-06 (scheduled to be re-issued as ASCE/SEI 41-13, Seismic Evaluation and Retrofit of Existing Buildings), FEMA 350 to FEMA 353 and the American Institute of Steel Construction Seismic Provisions (AISC 341). See www.aisc.org for more information. As of February 2006, the City of Los Angeles has reported cracks repaired in welds in 500 buildings in the region of strongest Northridge Earthquake shaking.

18. *Mitigation for High-Rise Buildings*

There is no statewide inventory of high-rise buildings. Only approximately 0.03 percent of all buildings in the state have eight or more stories. However, much of California's corporate, finance, legal, and insurance commerce takes place in these buildings. The potential for loss of market share in the economy from the closure of these buildings after earthquakes due to non-structural damage is significant. The Council on Tall Buildings and Urban Habitat maintains an inventory of high-rise buildings at: www.ctbuh.org

Guidelines are available for the retrofit of building contents and non-structural building systems, such as ceilings, light fixtures, and mechanical equipment (FEMA 74). Structural retrofits can be accomplished using ASCE 41-06 (scheduled to be re-issued in late 2013 as ASCE/SEI 41-13, Seismic Evaluation and Retrofit of Existing Buildings) or the International Existing Building Code. A Tall Buildings Initiative has been launched by the cities of Los Angeles and San Francisco to develop performance-based engineering for future new tall buildings. (http://peer.berkeley.edu/tbi/)

19. *Mitigation for Mobile Homes*

California has approximately 473,000 mobile homes. The Department of Housing and Community Development (HCD) regulates installations and alterations to mobile homes in approximately 3,600 of the state's 5,800 mobile home parks. Local governments have enforcement jurisdiction over the remaining parks, as well as overall manufactured home installations outside of parks. In 1974, HCD began to require engineered tie-down devices for wind loads in excess of 15 pounds per square foot for single-wide homes. However, most mobile homes installed from 1974 to 1994 were multi-wide or were installed in regions with lower wind speed and were exempt from this requirement. Therefore, most homes installed prior to 1994 are not attached to their foundations or otherwise braced to resist earthquake loads.

Numerous studies have determined that the performance of pre-1994 mobile homes in California earthquakes is significantly worse than that of conventional wood-frame dwellings. The primary earthquake weaknesses are the temporary foundations on which such homes are commonly placed. Homes on inadequate foundations can shift and fall several feet in earthquakes, severing gas lines. Doors can become stuck, trapping occupants and creating serious threats to life in events with fires (SSC 95-01, Turning Loss to Gain).

In 1981, the state began to regulate the design and construction of optional Earthquake-Resistant Bracing Systems that can be installed under existing mobile homes at the owners' discretion. Since 1994, the state has required that new or relocated mobile homes be braced to resist earthquakes in one of three ways:

- Conventional foundation systems similar to wood-frame dwellings
- Engineered tie-down systems
- Earthquake-Resistant Bracing Systems

Progress Summary 5.J: Mobile Homes

Progress as of 2013: Regulations that became effective April 1, 2013, now apply the current California Residential Code structural standards to any alteration of a manufactured home built after 1958. Previously, there were no structural requirements for mobile homes built between 1958 and 1971. This will add to the structural and lateral stability of manufactured housing.

20. *Mitigation of Natural Gas Systems in Buildings*

The CSSC has developed guidance for local governments for mitigating natural gas systems in buildings, titled Improving Natural Gas Safety in Earthquakes (SSC 02-03). The most cost-effective mitigation method is training the public to know when and how to manually shut off existing gas valves. Table 5.J shows local governments that have adopted mandatory seismic gas shutoff valve ordinances.

Table 5.J: Seismic Gas Shutoff Valves Ordinances

Jurisdiction	Ordinance Number(s)	Year(s)
Los Angeles[a]	171874, 174343	1995, 1998, 2002
Martinez	1269	1999
Contra Costa County	2000-11	2000
Richmond	32-00	2000
Alameda County	02001-54, 0-2001-55	2001
Marin County	322	2001
Hercules	9-2.09	2001
West Hollywood	01-592	2001
Brentwood	715	2002
Concord	02.9	2002
Danville	2007-08	2007

Source: California Seismic Safety Commission
[a] Los Angeles installed 168,000 valves as of February 2006
http://www.inspectaproperty.com/RetrofitOrdinances.html
http://www.seismic.ca.gov/pub/CSSC_2002-03_Natural%20Gas%20Safety.pdf

5.2.4.2 EARTHQUAKE VULNERABILITY AND MITIGATION FOR LIFELINE INFRASTRUCTURE

Lifeline infrastructure is any continuously engineered system providing transportation, communication, water, power or other distributed services. See Annex 3 for a detailed discussion on lifeline infrastructure. California's lifeline infrastructure is extensive. This subsection discusses the following:

1. Electrical utilities
2. Pipeline networks – natural gas, oil and water
3. Water supply, wastewater treatment and disposal systems
4. Dams, reservoirs, aqueducts, canals and levees
5. Petrochemical facilities
6. Solid waste disposal systems
7. Transportation systems
8. Ports and harbors
9. Communication systems

Table 5.K summarizes the overall progress toward earthquake mitigation of key utilities and transportation systems.

Table 5.K: Mitigation of Utilities and Transportation Infrastructure

Inventory Category	Numbers/ Miles	Mitigation program	Seismic Evaluation	Mitigation Progress	Responsible State Agencies
Utilities	31,720 miles	◒	◒	◒	California Energy Commission, Public Utilities Commission, Cal EPA, California Independent System Operator, Department of Water Resources
Ports and Harbors	10	◒	◒	◒	State Lands Commission, Coastal Commission
Highways	50,000 miles	◕	◕	◕	Caltrans
Railways	7,000 miles	○	○	○	Public Utilities Commission
Bridges (State)	2,194	●	◕	◕	Caltrans
Bridges (Local)	1,211	◒	◔	○	Caltrans
Dams	1200+	●	●	◕	Department of Water Resources

○ Begun
◔ Partially completed
◒ Halfway completed
◕ Nearly completed
● Most nearly completed

Source: California Seismic Safety Commission

General Observations on Lifelines Infrastructure

In addition to various laws, ordinances, regulations, standards, and guidelines, construction activities for utilities and transportation systems must abide by the California Environmental Quality Act (CEQA). If a utility or transportation activity is considered a "project" under CEQA, then the owner of the proposed project must either obtain an exemption from the requirements or use CEQA guidelines to see if the project may create an impact on the environment. This includes following a checklist to determine if there may be an impact on the environment from a seismic hazard. If the answer is yes, then the owner is required to address questions about seismic hazard assessment and possible mitigation. If the answer is no, then the owner is not required under CEQA to address seismic hazard assessment or mitigation, but may be required by a local ordinance, law, or standard, or their insurance company to address seismic hazard issues.

There is no comprehensive database for seismic hazard assessment or mitigation of utilities as a group or as just a particular type of utility. However, various groups have collected data on the performance of utilities and transportation systems during and after earthquakes in California and elsewhere. The data collection and analysis effort has been applied on an irregular level to various utility components. This is primarily due to the fact that a great deal of California's utility infrastructure has been in existence since before the 1971 San Fernando Earthquake. As new standards and guidelines have been developed, utilities have been using new data and design techniques to assess seismic hazards for power plants, electrical transmission and distribution systems, natural gas pipelines, water supply lines (including canals and aqueducts), and dams for new projects and seismic retrofit projects.

Caltrans and local governments have also been retrofitting bridges using new design techniques and new standards and guidelines. Data regarding locally owned transportation retrofit activities are not monitored in California. However, several facilities are known to have taken action for seismic hazard mitigation including ports and airports.

Experience gained after assessing earthquake performance of utilities and transportation systems points to the following:

1. Various degrees of damage affect the functionality of utilities, roads, bridges, ports, or airports. The extent of damage is related to the severity of the seismic hazard at the facilities in question, quality of the soils or rock at and adjacent to the site, design criteria used in building the facilities, and age and condition of the facilities. Those facilities of high-quality construction and built on good-performing soil or rock tend to perform better than those built on poorly performing soils.

2. Typical building codes for utilities and transportation systems focus on preventing the loss of lives and reducing property damage but do not guarantee that the facility will remain functional after an earthquake.

3. Fault rupture has caused breakage of pipes and offsets in the foundations of electrical power towers, roads, and buildings.

Other Lifeline Vulnerabilities

Observations of damage from California earthquakes have also shown that ground shaking may be locally attenuated but then be amplified farther away due to differential soil conditions and structural response. Such was the case in the 1999 Hector Mine Earthquake when an oil storage tank near Wilmington (over 100 miles away) was damaged while minimal or no damage was observed in cities between the epicenter and the tank. Ground shaking may also damage aboveground pipelines and their support framing.

1. Electrical Utilities

California has 31,721 miles of electric transmission lines and up to double that amount for the electric distribution system. In addition, California has 188 operational power plants varying in size from 50 megawatts to over 2,000 megawatts, generating a total of up to 53,700 megawatts.[49] California also imports, to various degrees throughout the year, electric power from outside of the state. No complete seismic hazard mitigation inventory for electrical power generation, transmission, and distribution exists in California. This is due to the lack of a requirement and funding for such a task and the fact that either private companies or investor-owned utilities own the majority of electric power generation and transmission. However, several assessments of electric power generation, transmission, and distribution systems have been performed following California earthquakes as well as earthquakes in Japan and elsewhere.[50] See Map 6.K for an overview of the State electrical grid.

Vulnerabilities

The greatest vulnerability is from strong ground shaking. High-voltage substations or switchyards are particularly vulnerable for two reasons: 1) substations and switchyards tend to be key facilities in the ability of a distribution or transmission system to reroute power around or to areas affected by earthquakes, and 2) some high voltage substation and switchyard equipment is relatively brittle.

[49] California Energy Commission (CEC) Power Plant Data Base, Summer 2003.
[50] Schiff 1999.

The amounts of recorded substation and switchyard damage after the 1971 San Fernando Earthquake, 1986 Palm Springs Earthquake, and 1994 Northridge Earthquake highlight these two vulnerabilities. The ground motion hazard is generally the greatest hazard overall. In regions struck by earthquakes, it is likely that vulnerable electric power equipment is in the area of strong ground shaking. Earthquake shaking can cause electrical lines to slap together, causing the lines to catch fire. In California, significant seismic hazard mitigation research has been conducted by electric utilities and researchers through organizations such as the Pacific Earthquake Engineering Research Center. Mitigation research products and results are making their way into new construction, purchasing, and siting decisions for all aspects of the electric utility industry in California.

Other vulnerable aspects of electrical transmission distribution and generation facilities include:

- Landslides that can damage electric transmission or distribution towers, substations, or switchyards.
- Ground deformation such as subsidence or liquefaction that can cause a misalignment in the power train of an electric power plant. Typically such problems can be mitigated by careful assessment of the potential for on-site liquefaction or subsidence and the proper design of foundations.

Interdependency on Electric Power

A key aspect of vulnerability is the potential for loss of electrical power in:

- Natural gas pipelines, including compressor and pumping stations
- Oil transmission pipelines and pumping stations
- Oil, natural gas, or water storage facilities
- Water supply systems and pumping stations
- Wastewater treatment and disposal systems

All of these systems rely on electric power; so when power is disrupted the services are interrupted. In some cases automatic shut-off valves and emergency power systems such as diesel generators have reduced this risk. Ground waves move at the speed of sound while electronic signals travel at the speed of light providing an opportunity for smart valve intervention.

2. Pipeline Networks - Natural Gas, Oil and Water

California is reported to have 12,414 miles of natural gas transmission pipeline (see Section 6.6.6 in Chapter 6 and Map 6.P showing California's natural gas pipelines). No complete seismic hazard mitigation inventory for pipeline networks exists in California. However, several regional utilities have assessed their natural gas pipe works with respect to seismic hazard. The incomplete seismic hazard inventory is due to the lack of a requirement and funding for such a task, and because utilities and private companies own most of the pipeline systems. Municipalities, special jurisdictions, and the state also own pipelines.

A significant contributor to pipeline failure after an earthquake is liquefaction. When soil liquefies it can lose all shear strength or shear resistance, essentially becoming a fluid with the density of soil. If a pipeline or any other underground structure has a density less than the liquefied soil, it is then subjected to buoyant forces and thrust to the surface. This happens with underground pipes, tanks, and other low-density structural and non-structural components.

Pipelines subjected to significant displacement may develop leaks or breaks. These may be caused by ground deformation or by strong ground shaking. Ground deformation may include fault rupture as well as landslides, liquefaction, or subsidence. Typical mitigation measures to offset this vulnerability include assessing siting requirements, flexible couplings, and aboveground fault crossings. Mitigation for fault crossings may also be accomplished by making pipes flexible enough and pipe supports big enough to allow pipelines to move to accommodate the anticipated ground displacements without rupture. Mitigation of areas prone to landslides prior to installation or rerouting of pipelines is possible. Ground deformation can cause significant damage to older pipe works made of cast iron or clay. For more discussion of natural gas pipeline hazards, see Chapter 6.

In recent years, several natural major water supply pipeline replacement projects have been undertaken in California. These projects tend to focus on replacing older pipes, valves, and pumps in an effort to maintain the reliability and modernize systems. For example, the East Bay Municipal Utility District recently completed a $662 million Seismic Improvement Program.[51] The San Francisco Public Utilities Commission is in process on a water system improvement program to be completed in 2016 (www.SFWater.org). This program includes a Bay Tunnel project to improve reliability of water delivery against earthquake hazards. See Best Practices Highlight 5.E on the following page.

In the larger view, severe disruptive impacts of a catastrophic earthquake could occur in California due to inadequate design and/or deteriorating conditions of aging gas and water transmission pipelines. This is especially true for Southern California, where much of the water supply is transported from long distances, through 900 miles of canals and tunnels (see Map 5.Q). The 2008 Great ShakeOut scenario in Southern California identified fires and serious long-term disruptions to imported water delivery as potential consequences from severed gas and water transmission pipelines in a Magnitude 7.8 earthquake, particularly for pipelines crossing the San Andreas Fault. Scawthorn's 2003 Earthquake Engineering Handbook documented the need for greater attention in urban areas to potential fires following earthquakes and disruption of water supply for fire-fighting response where water systems are damaged or destroyed by earthquakes.[52]

[51] Mitigation Success Stories, CSSC 99-05 (www.seismic.ca.gov)
[52] Scawthorn, et al. January 2005.

Best Practices Highlight 5.E: San Francisco PUC's Water System Improvement Program (WSIP)

A large portion of the damage in San Francisco during the Great Quake of 1906 resulted from subsequent fires burning unchecked across the City due to broken water mains preventing firefighters from extinguishing fires. Today it is understood that keeping critical water supplies and other utilities functional following a major earthquake is essential to preventing cascading hazards, such as fire, from causing additional damage.

San Francisco's Public Utility Commission (SFPUC) manages over 1,200 miles of pipes which deliver Hetch Hetchy water to San Francisco City and County; serving more than 2.6 million Bay Area residents. Since 2003, SFPUC has been at work on a $4.6-billion program to renovate the aging Hetch Hetchy Water System, following approval of a bond measure approved by San Francisco voters in November 2002. The project, called the Water System Improvement Program (WSIP) will be paid for by retail customers in San Francisco, as well as 26 wholesale customers serving Alameda, San Mateo and Santa Clara Counties.

The objectives of the Water System Improvement Program (WSIP) include:

- Improve the system to provide high-quality water that reliably meets all current and foreseeable local, State, and Federal requirements.
- Reduce vulnerability of the water system to damage from earthquakes.
- Increase system reliability to deliver water by providing the redundancy needed to accommodate outages.
- Provide improvements related to water supply/drought protection.
- Enhance sustainability through improvements that optimize protection of the natural and human environment.

WSIP reached the peak of construction in 2012 with 18 projects valued at $2.6B in construction and all major projects launched. Currently, more than two-thirds of the 81 WSIP projects have completed construction between California's Central Valley and San Francisco along the Hetch Hetchy Regional Water System.

Some major WSIP projects currently underway include:

- *Bay Tunnel Reliability Upgrade*: This upgrade project consists of a five-mile long tunnel under the San Francisco Bay, passing through environmentally sensitive marshlands and mudflats. There are vertical shafts at the end of each tunnel.
- *Calaveras Dam Replacement*: This project consists of building a new 220-foot earth and rock fill dam immediately downstream of the existing dam. This replacement work will restore the Calaveras Reservoir to its historic capacity.
- *Pipeline Replacement:* As part the pipeline replacement SFPUC will install new earthquake-proof water lines which have been used successfully in Japan for the last 40 years. The City will start installing the new pipes in a one-to two mile pilot project over the next couple of years

The program is expected to be completed in 2016. For more information about the program can be found at: http://www.sfwater.org/index.aspx?page=114 See Annex 4, Section 4.4.3 for more information on the WSIP.

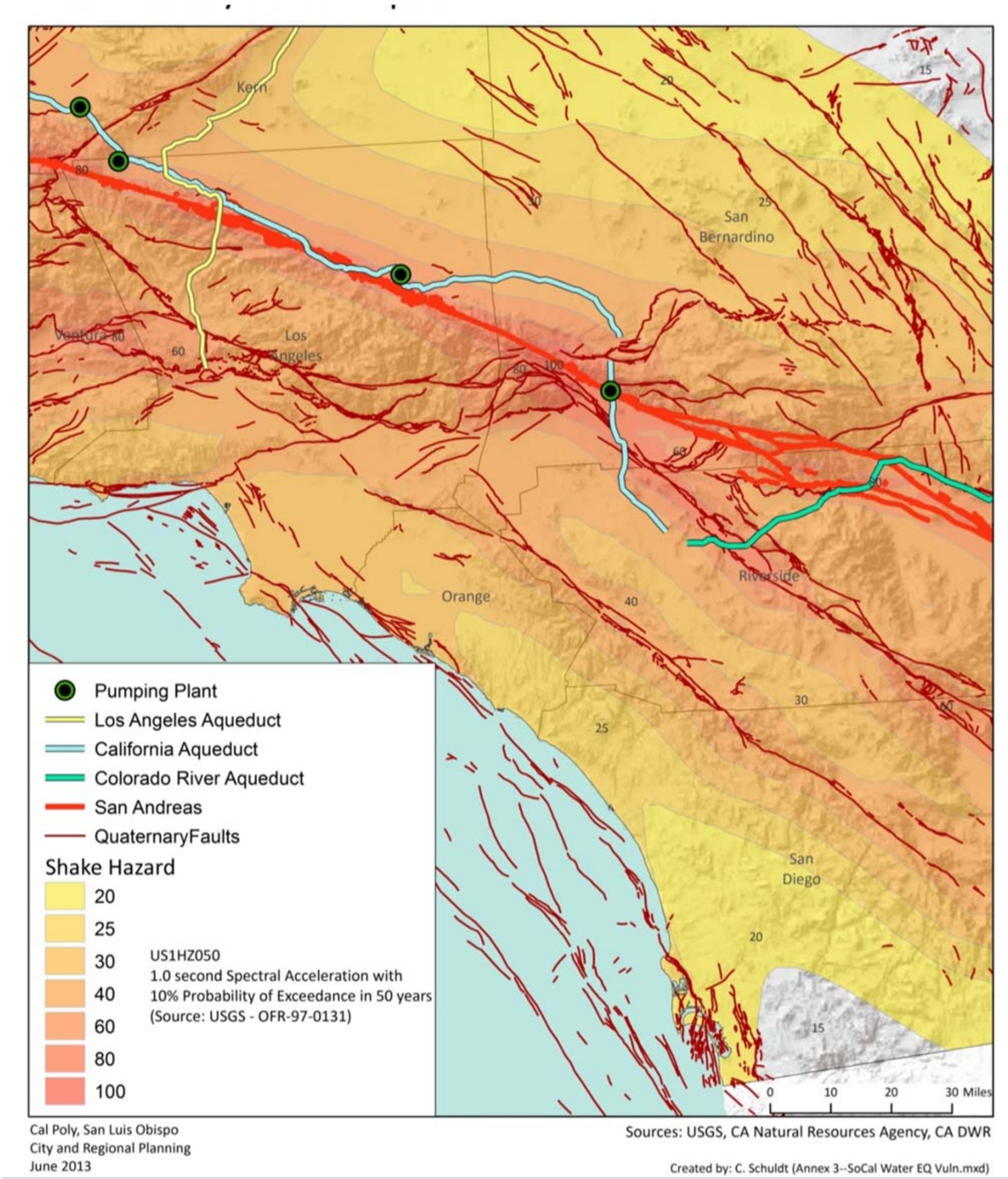
MAP 5.N: California Aqueducts, Canals and Natural Hydrologic Regions

Map 5.N shows the massive, complex system of state, federal, and locally sponsored dams, canals, pipelines, and tunnels by which water is stored and transferred within the 10 hydrologic regions of California. The three major aqueducts transporting water to Southern California together traverse nearly 1,000 miles.

3. Water Supply, Wastewater Treatment and Disposal Systems

Water filtration plants and wastewater treatment facilities are often located in areas subject to severe ground shaking and liquefaction, flooding, or tsunami inundation. Damage to water filtration plants can result in disruptions of clean water supplies. Damage to wastewater treatment facilities or their intake pipe works or effluent disposal systems can result in immediate serious public health hazards. Loss of power can also lead to discharges of partially treated or untreated effluent into waterways or the ocean. One mitigation technique to prevent an effluent discharge due to the loss of power is to include back up power at such plants to keep facilities operational. See Annex 3 for detailed discussion on lifelines infrastructure and hazard mitigation planning, including water supply infrastructure, as illustrated in Map 5.O.

MAP 5.O: Southern California Water Resources Vulnerability to Earthquakes



4. *Dams, Reservoirs, Aqueducts, Canals and Levees*

California uses over 1,200 dams and thousands of miles of levees to meet its water supply, conveyance, and flood protection demands. Although two-thirds of California's water supply generally originates in the northern third of the state, two-thirds of the population resides in the southern third. Southern California is heavily dependent upon water brought by the canals and tunnels comprising the Los Angeles Aqueduct, Colorado River Aqueduct, and State Water Project. The greatest weakness of this system is liquefaction-induced failures caused by strong ground shaking.[53]

Dams are a major component of this water collection and delivery system. Earthquake instrumentation of dams was begun after the 1971 Sylmar Earthquake, and though the effort continues with strong motion instrumentation projects conducted by the California Geological Survey and Department of Water Resources, fewer than 45 dams currently have adequate instrumentation. Modern adequate instrumentation can provide the data to assist rapid assessment of the health of a dam after significant earthquakes.

During the 1971 Sylmar Earthquake, the Lower San Fernando Dam, which is upstream from a heavily populated area, was severely damaged from liquefaction. Though heavily damaged, the dam was not breached and no dam failure induced flooding occurred. Later, another dam and a reservoir were built upstream from the Lower San Fernando Dam. The San Fernando Dam, which was being used only for flood control purposes, was damaged again during the 1994 Northridge Earthquake. Several other dams have experienced damage during earthquakes. The Department of Water Resources (DWR) Division of Safety of Dams has been working with dam owners to periodically assess the safety of dams in their jurisdictions, and several dam owners have rehabilitated their dams.

Three major seismic hazard mitigation efforts include the East Side Reservoir Project in Riverside County, the Olivehain Dam in San Diego County and the Calaveras Dam Replacement Project (See Highlight 5.F). The East Side Reservoir Project includes canals, pipeworks, a new dam, and a reservoir intended to provide water to a large portion of the Los Angeles metropolitan region for up to six months should an earthquake take the California Aqueduct out of service. The Olivehain Dam and reservoir are intended to provide San Diego with water should there be interruptions of water from the Colorado River after earthquakes. For full discussion of dam failure hazards and current mitigation efforts, see Chapter 6, Section 6.5.1, Dam Failure.

The San Francisco Bay-San Joaquin-Sacramento Delta region contains levees critical for delivering irrigation water to 3 million acres and drinking water to over 23 million people. A failure in one of the Delta levees in 1972 interrupted the state and federal water supply systems and required approximately 500,000 acre-feet of fresh water to restore export water to acceptable quality, according to Senate Hearings on the 1972 Levee Failure at Andrus-Brannan Islands. Recent studies indicate the levees in the Delta are susceptible to significant damage in a near-field seismic event. For full discussion on levees, see Chapter 6, Section 6.1, Levee Failure.

5. *Petrochemical Facilities: Oil Refineries and Liquefied Natural Gas Facilities*

California has major petrochemical facilities that include:

- Oil refineries
- Oil storage facilities
- Gasoline storage facilities
- Liquefied natural gas facilities
- Marine oil terminals

[53] Torres, et al., 2000

There is no statewide inventory of seismic hazard mitigation activities of petrochemical facilities.
There is a seismic hazard guideline for petrochemical facilities and a state building code for a segment of those petrochemical facilities, as follows:

- Guidelines for Seismic Evaluation and Design of Petrochemical Facilities by the American Society of Civil Engineers
- Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS) by the California State Lands Commission (CSLC) Marine Facilities Division, which is codified as California Code of Regulations Title 24, Part 2, California Building Code, Chapter 31F – Marine Oil Terminals

Both documents contain general seismic hazard assessment and mitigation for design information. The Guidelines for Seismic Evaluation and Design of Petrochemical Facilities provides information for engineers to develop project-specific seismic hazard mitigation designs and also contains information for emergency contingency planning, post-earthquake damage assessment and seismic retrofit design.

Application of MOTEMS

Since the completion of Title 24, CCR, Part 2, California Buildings Code, Chapter 31 F - Marine Oil Terminals, CSLC has continued to improve its understanding of structural issues associated with these marine facilities in California's ports. In 2005, a tsunami study for San Francisco Bay Area was completed. A project has been completed with the U.S Naval Academy, to more accurately assess forces on moored vessels from passing vessels nearby. These and other studies are available at www.slc.ca.gov.

The seismic portions of the MOTEMS have been inserted into a recognized international reference entitled "Seismic Design Guidelines for Port Structures" (2001) by the Working Group No. 34 of the Maritime Navigation Commission of the International Navigation Association (PIANC). In addition, the MOTEMS is now included as a guidance document in the National Earthquake Hazard Reduction Program (NEHRP) reference (FEMA - 450), published in 2003. The MOTEMS is also recognized as the seismic analysis/design resource for the U.S. military "Unified Facilities Criteria, Design: Piers and Wharves," July 28, 2005.

Progress Summary 5.K: MOTEMS – Building Code

Progress as of 2013: The results of recent studies and audits of onshore marine oil terminals in California have been reflected in the recently adopted Revision 2 to this building code, to be published in January 2014, as 2013 Title 24, CCR, Part, 2, CBC, Chapter 31 F- Marine Oil Terminals. The California State Lands Commission (CSLC) currently has a contract in place to simplify and more accurately determine the seismic capacity and demand of wharf / pier types of structures using a displacement ductility approach. The work is in progress and is expected to be completed by the second quarter of 2013.

All operators of marine oil terminals have submitted their initial engineering audits of hardware with a section on seismic vulnerability. Of the 12 "high-risk" terminals, most will require substantial rehabilitation to meet the seismic demand (475-year return period earthquake) of the building code requirement. Action plans have been submitted with scheduled completion dates and CSLC will monitor progress until completion. The six "moderate risk" terminals have similar structural issues, even though seismic demands are reduced from the "high" risk values.

To complete all of the seismic upgrades will require years and in many cases substantial structural rehabilitation, both for the structure and the soil slopes, subject to liquefaction. Understanding that in a marine environment, structures continue to deteriorate over time, the MOTEMS process will continue to monitor the structural health of these terminals with engineering audits required every 3 to 6 years for the remaining life of the structures. One issue that is quite common is that the piping and seismic displacement of the wharf/trestle may not be compatible. This may require additional engineering, in terms of pipeline stress analyses and modifications to existing lateral or vertical pipeline supports. In some cases liquefaction has now been identified as a critical issue and was not considered in the original design. Additionally, any new construction at a terminal will be subject to the MOTEMS and, in most cases, the construction will be subject to the "new" criteria, instead of being treated as "existing."

Criteria for LNG Receiving Terminals

In the last decade, a number of Liquid Natural Gas receiving terminals were proposed off shore of the California coast. None of these proposed projects were constructed. The current MOTEMS buildings code does not specify any distinctly different requirements for LNG terminals. However, the California State Lands Commission (CSLC) acknowledges that there should be significant differences in the design criteria of LNG terminals because of the hazards involved in handling and transferring LNG between shore and ships. Since 2010, there has been a considerable discussion of LNG exports instead of imports as the oil industry is considering possibilities for LMG extraction from shale gas. The CSLC will address the issue of managing LNG hazards as the national policy on LNG export becomes clearer.

Prior to publication of the 2010 SHMP, at a time when LNG receiving terminals were being proposed for California, the development of draft LNG Terminal Engineering and Maintenance Standards (LNGTEMS) was initiated under the direction of the CSLC Marine Facilities Division (MFD). As of November 2011, there were no proposals contemplated for any new LNG terminals in California, and further development of the draft was terminated. The draft set of regulations was not expected to be carried forward because it appeared to be unneeded in California at that time. However, recognizing that the fundamental work may be of value for other states or in other areas of the world where LNG terminal construction is still likely, the CSLC staff released the last draft of LNGTEMS to the public, to serve as a resource for state/federal agencies, terminal operators and consultants. See www.slc.ca.gov/division_pages/MFD/.../LNGTEMS-FINAL112811.pdf

6. *Solid Waste Disposal Systems (Municipal and Hazardous Waste Landfills)*

There are more than 200 municipal and hazardous waste landfills in California. There is no inventory of municipal or hazardous waste landfill seismic hazard mitigation activities. During the siting, permitting, or closure process, a landfill owner may be required to submit a stability analysis for the liner and/or final cover systems. The purpose of the liners and the final cover is to prevent the uncontrolled release of leachate or landfill gas (a gas that is made up mainly of methane) from the landfill. This may vary from a simple analysis for flat slopes to a sophisticated seismic hazard assessment and slope stability analysis.

In general, the greatest vulnerability for landfills with respect to seismic hazards may be the damage to the final cover or the landfill gas collection and control system caused by ground deformation (in this case the deformation of the landfill). Another significant vulnerability of landfills is the loss of electrical power to run leachate collection and control systems and landfill gas collection and control systems.

7. *Transportation Systems*

Transportation systems are generally categorized as follows:

- Highways (including freeways)
- Bridges
- County or City roadways
- Railways
- Ports and harbors (including airports)

California has approximately 50,000 lane miles of highways. Since there is no single database including all roadways in the state, the total lane miles of county and city roadways are unknown.

Progress Summary 5.L: Highway Bridge Retrofits

Progress as of 2013: Since the 1989 Loma Prieta Earthquake, approximately $14 billion in state highway earthquake retrofit improvement funds have been committed and largely completed. The following is a brief statewide synopsis of California state transportation system mitigation outcomes as of January 2013.

State and Local Bridge Improvements
There are over 12,800 state and 12,300 local bridges in California. Of the 2,194 state bridges previously determined to need seismic retrofitting, all but three have been retrofitted as of January 2013. Of the 1,243 local bridges determined to need seismic retrofitting, 906 have been retrofitted as of January 2013.

Toll Bridge Improvements
There are also nine state-owned toll bridges that have been determined to require seismic hazard mitigation. As of January 2013, the retrofitting of eight bridges had been completed. In addition, there is one local-owned toll bridge (Golden Gate Bridge) that is in the process of being retrofitted. The investment in these bridge upgrades totals more than $12.2 billion on Caltrans bridges and nearly $1.2 billion for local government bridges. In addition, Caltrans has funded another $90 million in research.

San Francisco-Oakland Bay Bridge
Among the toll bridges being retrofitted, the new separately funded $6 billion Bay Bridge, straddling two major faults and connecting San Francisco and Oakland, will be the largest and most expensive single-tower, self-anchored suspension bridge in the world. While the project was initiated after the 1989 earthquake, the groundbreaking took place 13 years later in 2002, at twice the cost originally estimated. The first approved design met seismic safety objectives but was rejected by the public in 1997 because it did not do justice to the bridge's prominence — symbolically, physically, or economically.

The ensuing public process illustrates how competing values can affect mitigation efforts, including the risk inherent in delay. The new structure is being built to "lifeline" criteria — designed to handle a very large earthquake, be put back immediately for emergency services, and then re-opened in short order. Its first-of-a-kind design innovations allow it to move with the motion of the quake, take the brunt of the force even to the point of breaking, while leaving the rest of the bridge intact. Its most important feature cannot be seen: a strong foundation of steel pipes pounded 300 feet below the bay floor. Completion is expected in 2013.

Other Caltrans transportation system mitigation actions include:

- The Highway Bridge Program to replace or rehabilitate public highway bridges over waterways, other highways or railroads when the state and the Federal Highway Administration determine that a bridge is significantly important and is unsafe because of structural deficiencies, physical deterioration or functional obsolescence. Approximately $240 million in federal funds are made available to local agencies annually under the Transportation Equity Act for the 21st Century (TEA21).

- The Culvert Inspection Program intended to preserve and upgrade the state's investment in highway drainage infrastructure. The inspections identify drainage and structural deficiencies to be addressed by major maintenance and capital rehabilitation/replacement contracts.

MAP 5.P: Transportation Infrastructure

Map 5.P shows major transportation infrastructure in California including freeways, other highways, railroads, international airports, and ports. Major north-south travel corridors include Interstates 5 and 99 and U.S. 101. Major east-west travel corridors include Interstates 80, 15, 10, and 8. Major ports include San Francisco, Oakland, Los Angeles-Long Beach, and San Diego.

8. Ports and Harbors

There is no systematic integrated database or inventory on seismic hazard assessment or mitigation for ports and harbors in California. However, most of the large ports and harbors have initiated some sort of seismic hazard study for various projects in recent years.

Ground deformation is a significant vulnerability in various ports and harbors since significant piers and quays are built out of dredge tailings or fill. Landfills do not typically perform well in large earthquakes, as evidenced by damage to human-made ground in the Marina District of San Francisco and in Kobe, Japan. Ground deformation on landfills at ports and harbors can affect harbors and ports by changing the alignments of tracks for large cranes used to load or off-load cargo ships. Such deformation may occur from lateral spreading, liquefaction, dynamic compaction, or secondary ground rupture. After the 1989 Loma Prieta Earthquake, some of the Oakland Airport's runways experienced severe ground deformation. This damage affected airport operations.

Depending on the location, geometry, and depth of the port or harbor, it may be susceptible to a tsunami or seiche. To date, California has had only one series of tsunamis that significantly damaged a port or harbor. That event was a series of tsunamis that hit the Port of Crescent City after the Magnitude 9.2 earthquake in Alaska on March 26, 1964.

Since 1946, California has had many tsunamis that have caused minor to major damage to many ports and harbors in California. For more information, see Section 6.3. Tsunami Hazards.

The American Society of Civil Engineers has created Seismic Guidelines for Ports. The guidelines provide generalized information for assessing seismic hazards for use in developing seismic hazard mitigation design criteria. The guidelines are based on observations of the performance of ports and harbors after earthquakes around the world. Several ports and harbors have also conducted seismic hazard mitigation projects.

9. Communication Systems

California has no seismic hazard inventory for its communication systems. However, there is a guideline for the improvement of performance during earthquakes titled Methods of Achieving Improved Seismic Performance of Communications Systems (Tang and Schiff, 1996).

The greatest vulnerability of communication systems depends on what communications aspects are under consideration. For example, switches and other aboveground components tend to be more affected by strong ground shaking than by liquefaction, while below-ground conduits may be more affected by liquefaction than by shaking. In prior strong urban earthquakes, there has been little damage to cellular telephone or internet systems. However, their use has grown exponentially since the 1994 Northridge Earthquake. Their typical vulnerabilities stem from the loss of electrical power and from surges in customer use potentially swamping the capacity of the systems.

The seismic vulnerability of radio and television communication systems is typically from the loss of power and shaking damage to unsecured equipment.

5.2.4.3 LOCAL HAZARD MITIGATION PLAN HAZARD RATINGS

An important source of local perceptions regarding vulnerability to earthquake threats is found in the collection of nearly 400 FEMA-approved Local Hazard Mitigation Plans (LHMPs) adopted by cities, counties, and special districts as of May 2013. The most significant hazards reported in this review are earthquakes, floods, and wildfires—the three primary hazards also identified on a statewide basis by the 2010 SHMP. Including these three primary hazards, LHMPs identified a total of 58 distinct local hazards.

Map 5.Q summarizes relative ratings of earthquake hazards in the 2010 review of LHMPs. Displayed are predominant earthquake hazard ratings shown as high (red), medium (orange), and low (yellow) rankings reflecting ratings given by at least 51 percent of the jurisdictions with LHMPs within each county. Counties shown without color represent either jurisdictions not having FEMA-approved LHMPs or counties where data are missing or problematic.

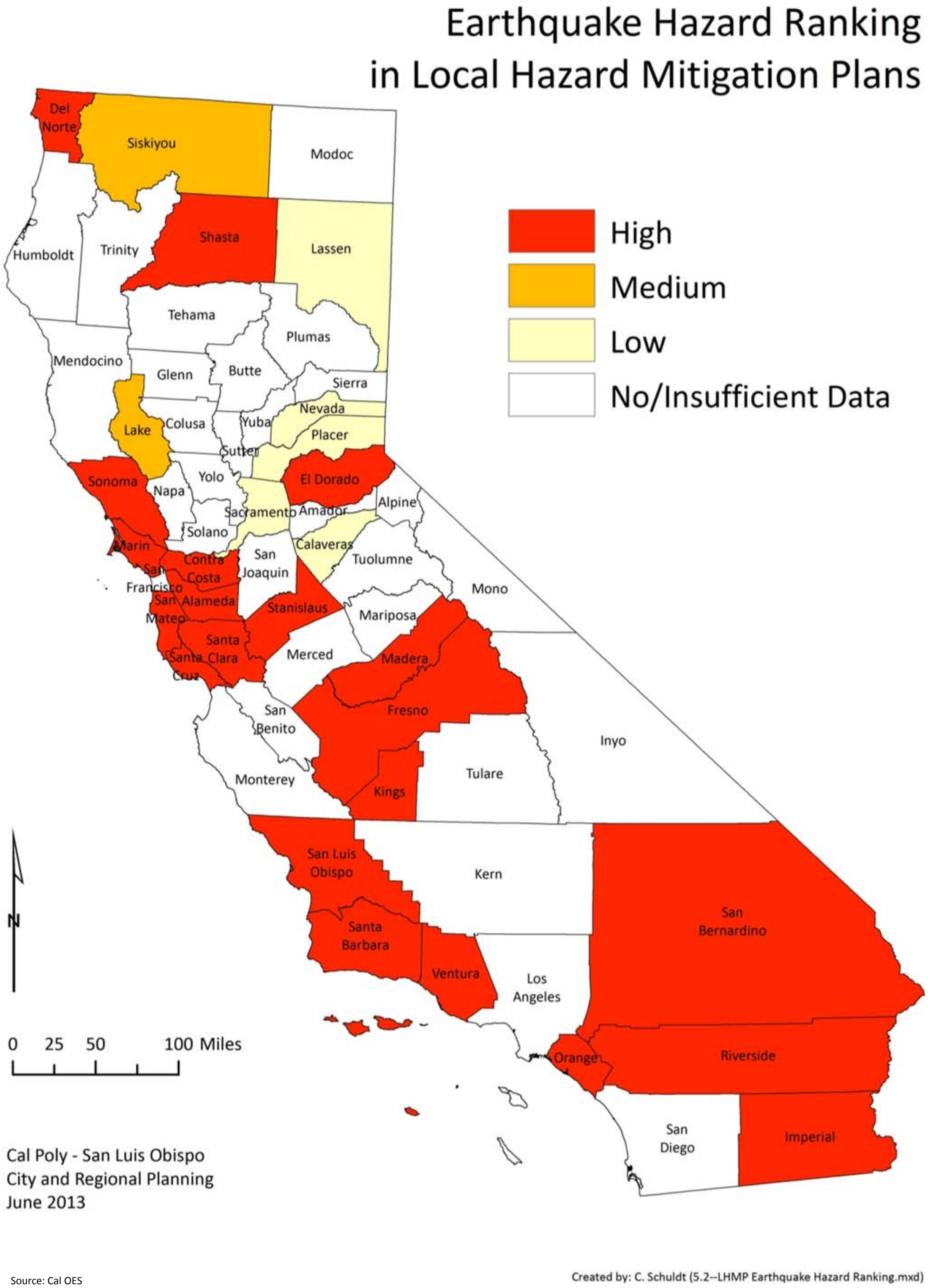
For a detailed evaluation of LHMPs approved as of May 2013, see Annex 5, California Local Hazard Mitigation Plan Status Report.

Implications for Local Loss Potential

Local hazard rankings are highly variable, responding to a wide variety of very specific local conditions. Each county and city has its own set of variables conditioning earthquake loss potential within its cities and unincorporated area. Descriptions of loss potential are very specific within individual LHMPs and are not consistently drawn up between plans, nor is there even coverage of all cities and unincorporated areas. Such variability will diminish as more cities and counties prepare LHMPs and greater standardization enables comparability of local data with statewide data.

The majority of LHMPs reviewed in 2010 in all Southern California and nearly all San Francisco Bay Area counties rated earthquakes high in their hazard rankings. Additionally, most Central Coast and North Coast counties and two eastern Sierra counties also rated earthquakes high. This is consistent overall with the patterns of earthquake hazards and population/social vulnerability patterns identified previously in Section 5.1.1.

MAP 5.Q: Earthquake Hazard Ranking in Local Hazard Mitigation Plans



Map 5.Q identifies earthquake hazards as being a predominant concern in the 2013 LHMP review for all Southern California counties with approved LHMPs, as well as most San Francisco Bay Area counties.

5.2.5 CURRENT EARTHQUAKE HAZARD MITIGATION EFFORTS

The preceding discussion included a description of most recent and current earthquake hazard mitigation efforts classified by type of buildings, infrastructure, and transportation. In recent decades California has invested significant funds in seismic mitigation efforts. From 1990 through June 2003, Californians spent in excess of $19 billion on seismic hazard mitigation activities (CSSC, 2003). This is an indicator of the level of effort to mitigate seismic hazards and reduce life and property loss after earthquakes.

Seismic Hazards Mapping Projects

As a catalyst to hazard mitigation, the Seismic Hazards Mapping Act and the Alquist-Priolo Earthquake Fault Zoning Act require evaluation of the potential for earthquake-related ground failure caused by surface faulting, liquefaction, and landslides, and have established regulatory zones of required investigation over the state's most populated areas and most hazardous faults. From the time of issuance and continuing into the future, permits for proposed development within the official zones are subject to approved geotechnical site investigations that document hazard potential at the project site and adjust development plans accordingly to the satisfaction of building officials, resulting in safer construction.

Funding has been about $3.5 million annually through 2006 from a special-fund levy on statewide building permit fees supplemented by a $20 million Post-Northridge Earthquake Stafford Act Hazard Mitigation Grant and the State General Fund. Cessation of grant funds in 2004 and California's economic downturn and associated decline in construction permit revenues, have resulted in a sharp decline in map production. From an all-time high of $2.5 million annually in 2006, special fund revenues have since plummeted to about $1.2 million annually since 2010. Having completed seismic hazard zoning for about half the high-risk areas in the state over the past 15 years, the current annual program budget is estimated to be capable of supporting completion of the remaining high-risk areas over the next 25 years.

Progress Summary 5.M: Seismic Hazards Mapping Projects

Progress as of 2013: Despite reduced funding, progress has continued in the State-mandated mapping programs for which the California Geological Survey (CGS) is responsible. Since 2010, three Official Seismic Hazard Zone Maps have been issued by CGS: four in Riverside County and one in Santa Clara County. This brings the total number of Seismic Hazard Zone Maps issued since the program's inception to 121 by the end of 2013 affecting 161 cities and 9 counties. A byproduct of the hazard zoning program is a new landslide inventory map series. These products are discussed in more detail in Chapter 6, Section 6.2.

Thirteen new and revised Alquist-Priolo Earthquake Fault Zone Maps have been issued: five in Riverside County, six in Imperial County, one in Ventura County, and one in Alameda County. This brings the total number of maps issued since the program's inception in 1972 to 553, affecting 104 cities and 36 counties. Progress in fault zoning is continuing in southern California along the San Andreas Fault and related faults, the Sierra Madre Fault, and the Whittier Fault, and along the West Napa Fault in northern California. Seismic hazard zoning for earthquake-induced liquefaction and landslides has resumed in the San Francisco Bay region, with five quadrangle maps underway in San Mateo County and seven underway in Contra Costa County, covering portions of Richmond and the Sacramento-San Joaquin Delta region.

The Seismic Hazards Mapping Act and Alquist-Priolo Earthquake Fault Zoning Act require cities and counties to take into account the official hazard zones when preparing the safety elements of their general plans, adopting and revising land use planning and permitting ordinances, and reviewing building permits. To help local government meet these requirements, CGS published an update of Special Publication 117A, "Guidelines for Evaluating and Mitigating Seismic Hazards in California." The guidelines establish the standard of practice for geotechnical hazard investigations for construction projects that are located in seismic hazard zones. This guide is being kept up-to-date online.

Other earthquake hazard zoning activities have been undertaken to provide additional resources to stakeholders affected by the regulatory zone hazard maps. Thousands of geotechnical and fault site investigation reports triggered by development within hazard zones are being scanned and converted to portable document file format (PDF) and made available over the California Geological Survey website. These reports represent "ground truth" measurements of hazard conditions at specific locations that can be used to revise the official hazard zone boundaries and be used by consultants performing geotechnical hazard investigations at nearby locations.

Access to official hazard zones and related map products including digital map images and GIS data has been improved by the new CGS Information Warehouse: (http://www.quake.ca.gov/gmaps/WH/index.htm, and through Cal OES and CNRA's new collaborative MyPlan web portal:
(http://hazardmitigation.calema.ca.gov/myplan).

Both seismic hazard zones and earthquake fault zones are now combined on a single map available as a single image PDF or a composite layer GeoPDF. The latter provides the map content on many separate layers that can be turned on or off for convenient viewing.

The official zones are also disseminated through the new MyPlan web service, providing a convenient one-stop shop for all stakeholders. http://www.calema.ca.gov/HazardMitigation/Pages/Hazard-Mitigation.aspx. Finally, an evaluation is underway to assess the feasibility of issuing new Official Tsunami Hazard Zones under authority of the Seismic Hazards Mapping Act. This activity is discussed in more detail in Chapter 6, Section 6.3, Tsunami Hazards.

Maps 5.R and 5.S show progress of long-term program goals for California, high-risk areas targeted for seismic hazard mapping, and active earthquake faults identified and zoned as of 2013.

FEMA-Funded Hazard Mitigation Projects

During the past ten years, local government and state agencies requested $97.5 million in earthquake mitigation projects from the Hazard Mitigation Grant Program (HMGP) under the Stafford Act and received a total of $67.2 million.

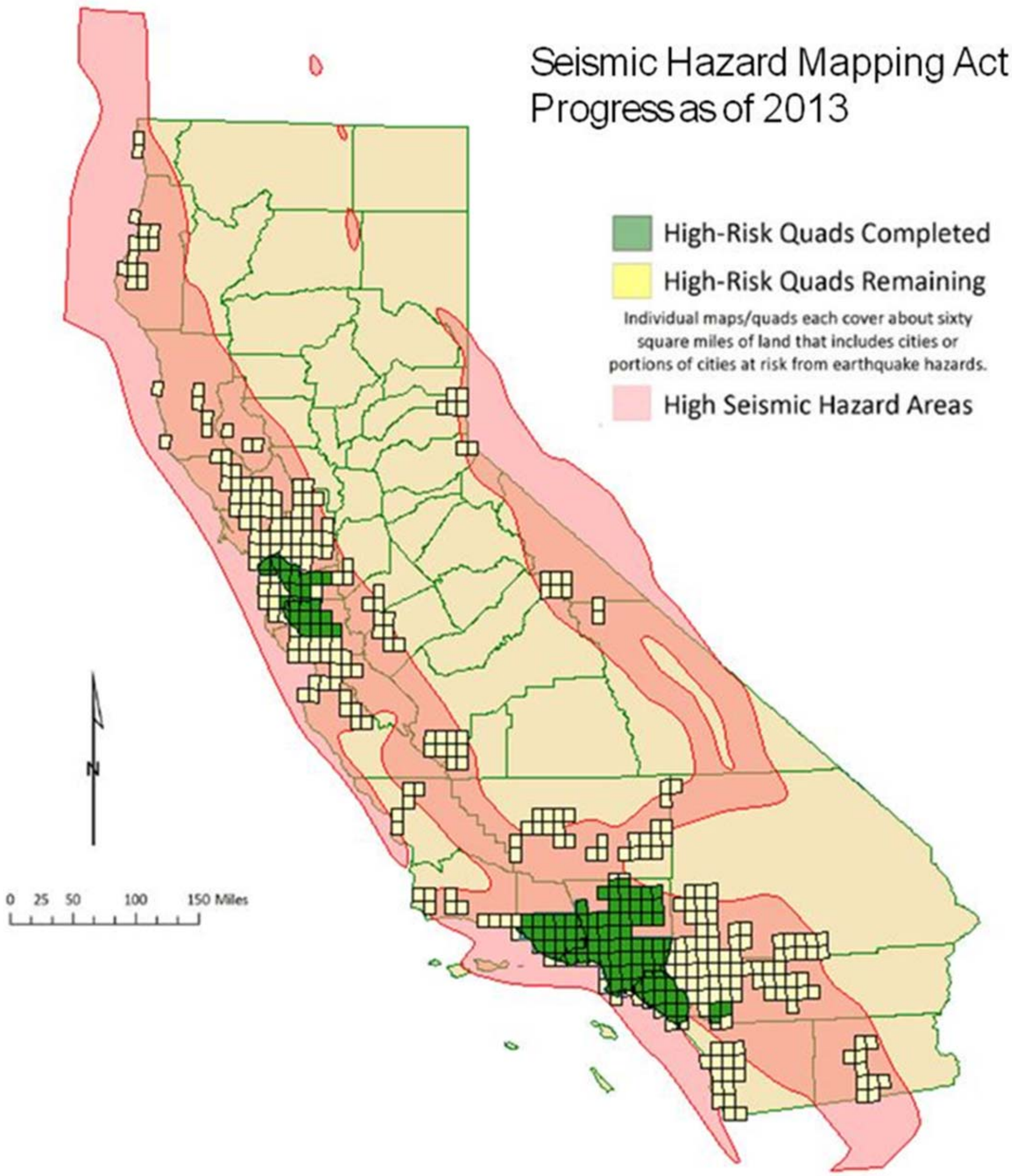
For specific mitigation ideas related to earthquakes, see "Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards" January 2013, prepared by FEMA, available on the FEMA website:
http://www.fema.gov/library/viewRecord.do?id=6938

Damage Assessment Monitoring System

The California Earthquake Clearinghouse, a voluntary group designed to share knowledge among the scientific and engineering communities after an earthquake, is testing a new damage assessment tool known as Unified Incident Command and Decision Support (UICDS), developed through the U.S. Department of Homeland Security's Science and Technology Directorate. Through UICDS, the clearinghouse uses a map that shows users where they are in relation to buildings that have been destroyed, provides models to anticipate where there could be potential damage and directions for how to get there, and includes updated incident reports. Within minutes, an engineer can be reporting on structural damage, the possibility of landslide, and how to rebuild a stronger building.

The mobile application SpotOnResponse gives clearinghouse members a sense of what's happening before they step out the door — where the damage is and where each member's talents can be most useful. History of the structure, information about a building's site plan, plus any pictures of the damage can be shared and discussed immediately. The technology can be useful in most situations where two or more agencies need to share information. For more information visit:
http://www.emergencymgmt.com/disaster/Decision-Support-Tool-Information-Sharing.html

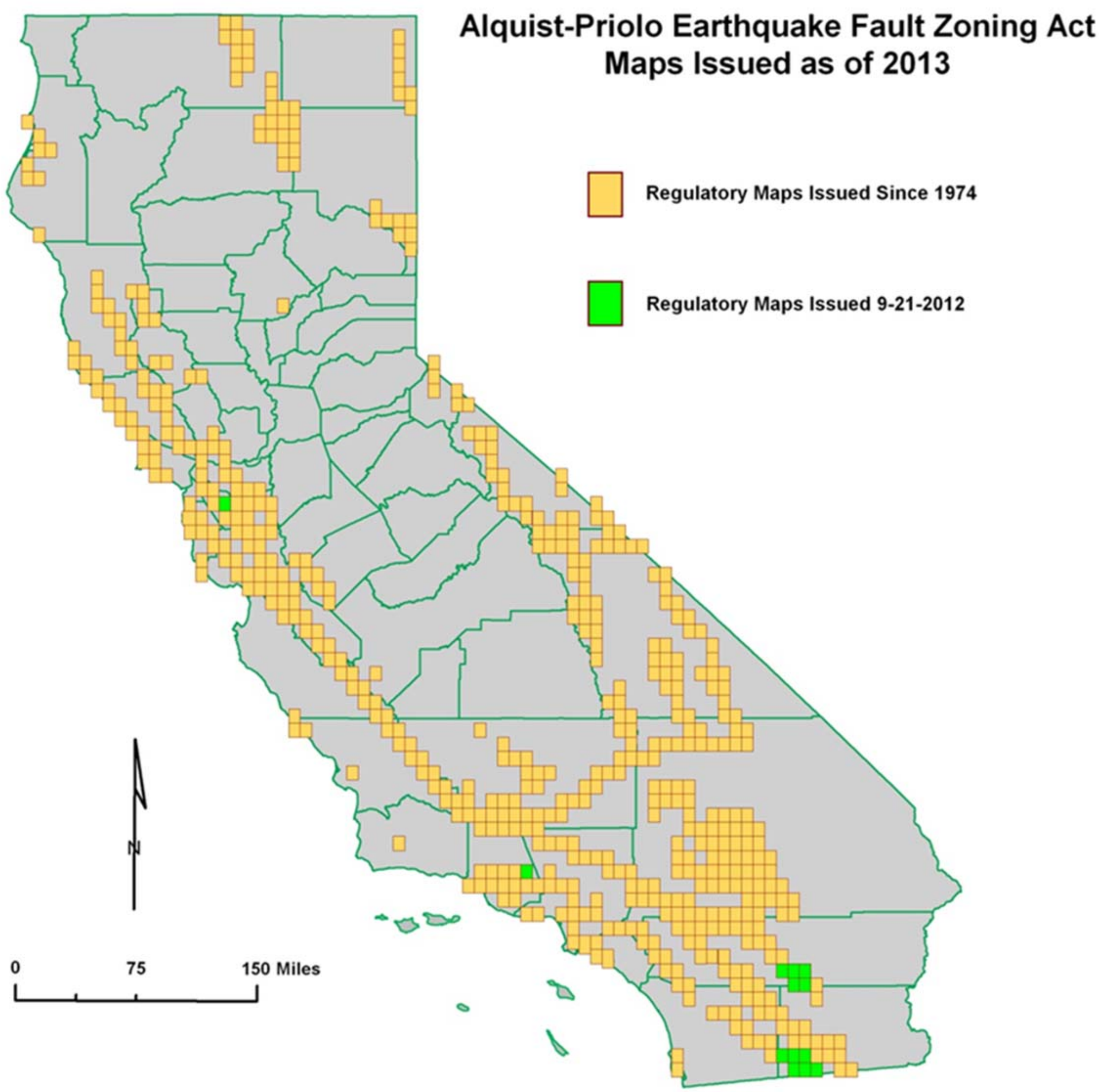
MAP 5.R: Seismic Hazards Mapping Act Progress as of 2013



Source: California Geological Survey

Map 5.R shows completion of Seismic Hazards Mapping Act mapping in areas of high seismic risk, primarily in Southern California and the San Francisco Bay Area.

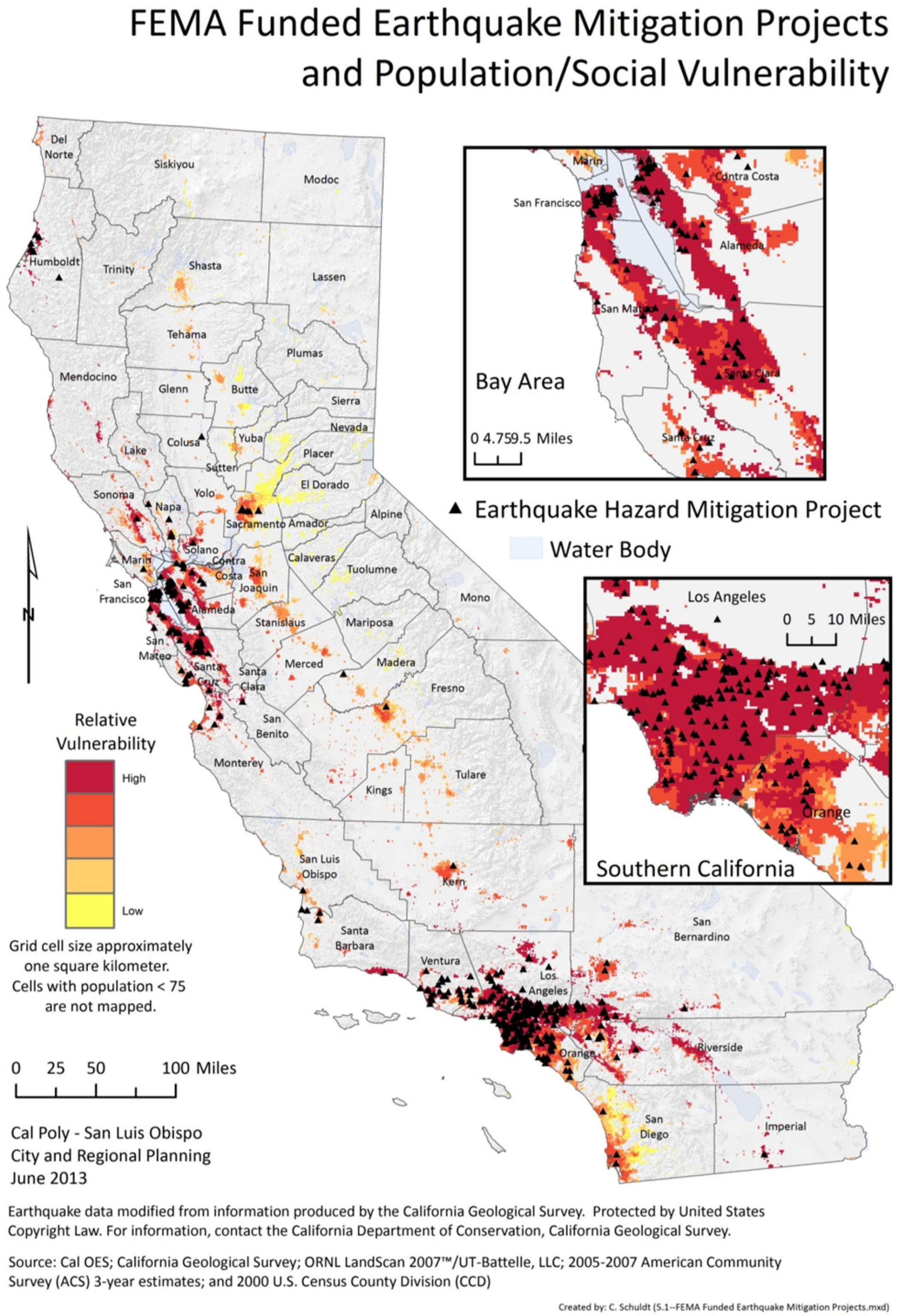
MAP 5.S: Alquist-Priolo Earthquake Fault Zoning Map as of 2013



Source: California Geological Survey

Map 5.S shows completion of Alquist-Priolo Earthquake Fault Zoning Act maps issued as of late 2012. Most recent maps completed have been primarily for Southern California areas.

MAP 5.T: FEMA Funded Earthquake Mitigation Projects and Population/Social Vulnerability



Map 5.T shows the distribution of earthquake-related FEMA-funded hazard mitigation projects in relation to vulnerable populations (based on the index described in Appendix N) in high earthquake hazard areas. More projects are in Southern California and the San Francisco Bay Area than in other parts of the state. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

5.2.6 OPPORTUNITIES FOR ENHANCED EARTHQUAKE HAZARD MITIGATION

California's mitigation plan for seismic hazards, the California Earthquake Loss Reduction Plan, has evolved since first being published in the 1980s. It was previously updated several times and was last signed by the Governor in 2002.

Earthquake Loss Reduction Plan

The most recent update, the California Earthquake Loss Reduction Plan, 2007-2011, was published by the Seismic Safety Commission in 2007. The plan articulates in considerable detail the state's priorities for earthquake hazard mitigation (See http://www.seismic.ca.gov/pub/CSSC_13-03_Loss_Reduction_Plan.pdf). It contains three overarching goals, eleven elements, and 148 initiatives, of which half are designed to continue indefinitely.

Key parts of the California Earthquake Loss Reduction Plan include:

- Goals for 2011 (see Table 5.L)
- Critically Important Initiatives (see Table 5.M)
- Cost Estimates for Seismic Hazard Mitigation (see Table 5.O)

Table 5.L: Earthquake Loss Reduction Plan Goals

Goal	Description
Advancement in Learning About Earthquakes	Applicable and effective research in geoscience, engineering, and social sciences about earthquakes, including techniques for mitigating their effects, are the basis of California's mitigation strategies. The Plan is committed to learning more about why earthquakes happen, where and when the next earthquakes are most likely and what the nature and pattern of future ground shaking are likely to be.
Advancement in Building for Earthquakes	Public policies that result in constructing earthquake resistant new buildings and retrofitting the most vulnerable existing structures save lives and reduce property damage. New structures built to higher performance standards contribute to the continued strength of the California economy directly by reducing earthquake losses and indirectly by allowing the State to deliver its products to the rest of the nation without interruption.
Advancement in Living with Earthquakes	Heightened preparedness and better emergency response systems minimize the pain and suffering from potentially disastrous earthquakes. Both short- and long-term efforts to accomplish personal and economic recovery significantly reduce their impacts. Californians need to be better prepared to understand, respond to, and recover from future earthquakes.

Source: California Seismic Safety Commission, 2007, California Earthquake Loss Reduction Plan 2007-2011, p.6 (www.seismic.ca.gov/pub/CSSC_2007-02_CELRP.pdf)

Eleven Elements of California Earthquake Loss Reduction Plan

The California Earthquake Loss Reduction Plan has eleven elements: Geosciences, Research and Technology, Education and Information, Economics, Land Use, Existing Buildings, New Buildings, Utilities and Transportation, Preparedness, Emergency Response, and Recovery. Each element of the California Earthquake Loss Reduction Plan has a series of related initiatives, which are divided into three categories: critically important, very important, and important. Table 5.M describes the critically important initiatives. The 2003 edition of the plan is subtitled "Post-earthquake Economic Recovery" and has an emphasis on recovery and agricultural issues while carrying forward initiatives from the 2007 plan (CSSC 2013-02).

Table 5.M: Critically Important Initiatives

Initiative	Description	Time to Accomplish
1.1.1	Geosciences: Ensure efficient, accurate, and reliable completion of the statewide Seismic Hazard Mapping Program for California's high-risk developed and developing areas. Utilize independent review and acceptance of appropriate procedures to compile the data and construct the maps. Include end users and others affected as part of the independent review.	*10 years*
2.1.1	Research & Technology: Support and co-fund California-based seismic research programs funded by federal agencies or the private sector.	*Ongoing*
3.2.1	Education & Information: Develop educational approaches and tools in seismic hazard mitigation including earthquake fundamentals, seismic hazards identification, safety information about potentially hazardous building contents, workplace safety, emergency plans, and risk assessment techniques and tools for those responsible for facilities operation and management.	*5 years*
4.1.1	Economics: Develop economic models and real case studies that demonstrate the cost-effectiveness of specific design, construction, and retrofit methods based on increased levels of property, contents, functionality, and tax base protection. Make those findings available to policy makers and to lending, insuring, and taxing agencies.	*3-5 Years*
5.1.1	Land Use: Require geotechnical and geological reports addressing seismic hazards for all subdivisions pending completion and adoption of mapping under the Seismic Hazards Mapping Act for any jurisdictional area.	*2 Years*
6.1.1	Existing Buildings: Encourage economic incentives, such as improved mortgage terms, reduced insurance rates, and positive tax benefits, for upgrading structural and non-structural elements in buildings.	*10 Years*
6.4.3	Existing Buildings: Identify and prioritize all seismically vulnerable public and private buildings. Establish a mitigation plan to reduce the risk posed by those buildings, including structural and non-structural elements, equipment and contents. The most vulnerable and the most essential buildings should be addressed as the highest priority.	*10 Years*
7.3.1	New Buildings: Amend statute to allow California to adopt seismic-specific amendments to international and/or national model building codes that meet the specific needs of the state and that apply to all state and local jurisdictions.	*2 Years*
8.4.3	Utilities & Transportation: Identify potentially vulnerable public and private utility systems including electric, gas, oil, water, and communication. Upgrade vulnerable systems to ensure the operation and timely restoration of essential systems to reasonable levels of service.	*5 Years*
9.4.1	Preparedness: Require compliance with the Standardized Emergency Management System (SEMS). Ensure school and district boards and administrators develop and implement school emergency plans and staff training as required by the Education Code.	*3-5 Years*
10.1.1	Emergency Response: Provide interoperable upgraded regional and local emergency communications including: 1) mutual-aid channels for police, fire, and emergency medical services; 2) regional emergency communications councils with authority to establish regional standards for emergency communication; and 3) response and recovery public broadcast channels for the public.	*3 Years*

11.2.1	Recovery: Establish plans for accommodating large displaced populations on an interim basis by using military facilities, publicly owned parks and recreational facilities, manufactured housing, and other appropriate options.	*5 Years*

Source: California Seismic Safety Commission, 2007 (www.seismic.ca.gov/pub/CSSC_2007-02_CELRP.pdf)

Table 5.N identifies mitigation activities classified as important or very important in the Geosciences Element, Economics Element, and Existing Buildings Element of the California Earthquake Loss Reduction Plan, 2007-2011, that are particularly supported by CEA because they affect residential units.

Table 5.N: Residential Initiatives of Special Interest to California Earthquake Authority

Initiative	Description	Importance Level
1.4.2	Geosciences: Support geosciences research that can be used to reduce earthquake risk and losses. Accomplished through the funding of the Pacific Earthquake Engineering Research Center (PEER). PEER is conducting applied research that develops effective mitigation practices for bridge retrofitting, seismic qualification of electrical equipment, and understanding of earthquake hazards and the risk of the residential damage from earthquakes. Some of this research has been co-funded by the federal government and non-governmental funding partners, which is in alignment with Initiative 2.1.1 Support and co-fund California-based seismic research programs by federal agencies and private sector. An example of such a funding project for Initiative 2.1.1 was the Uniform California Earthquake Rupture Forecast Version 2.0 project that was co-funded by the National Science Foundation, United States Geological Survey, Southern California Earthquake Center and California Earthquake Authority.	Important
4.2.3	Economics: Work with the insurance industry to establish objective criteria in which increased seismic performance of structures is incorporated into mortgages and underwriting practices. Development of a mitigation program by the CEA that will align with Initiative 4.2.3 to establish objective criteria in which seismic performance of structures is incorporated into insurance and underwriting practices.	Very Important
6.2.2	Existing Buildings: Develop and implement plans to increase the building owner's general knowledge of and appreciation for the value of seismic upgrading of the building's structural and nonstructural elements. Development of policies and local ordinances for the seismic retrofitting of soft-story residential buildings in San Francisco. This is in alignment with the Association of Bay Area Governments which is developing local regulations and standard plans for mitigating residential buildings	Very Important
6.4.7	Existing Buildings: Encourage building occupants, lease holders, mortgage providers, and insurers to require building owners to disclose seismic risks and the options to mitigate them prior to executing new or continuing financial commitments in connection with the building use. The state requires home sellers to disclose to homebuyers any known seismic hazards, but does not include options for mitigating seismic risks when the house is sold	Important

Source: California Seismic Safety Commission, 2007; California Earthquake Authority

Cost Estimates for Seismic Hazard Mitigation

Table 5.O summarizes the dollar amount spent on selected earthquake mitigation projects from 1990 through 2009. For a description of progress related to strengthening of buildings, see Appendix O.

Table 5.O: Estimated Expenditures on Earthquake Mitigation

Program or Project	Expenditures (in millions)
AB 300 Public School Survey	$.5
Alquist Act Hospital Evaluation and Retrofit Program	$11
BART Retrofit Program	$28
Bridge Retrofit by Local Governments	$1,196
Cal OES Hazard Mitigation Program (HMGP)	$70
CAL OES New State Operations Center	$26.5
Cal OES/DSA Nonstructural Pamphlet for Schools	$.05
Caltrans Bridge Retrofit, Replacement and Toll Bridge Program	$11,120
Caltrans Earthquake Research	$90
CEA Mitigation Program	$5
CGS Seismic Hazard Mapping Program	$39.6
City of Los Angeles ATC 50 Residential Grading Plan	$1
Community College Seismic Evaluation Survey	$.9
CSSC	$10
CSU Seismic Retrofit Program	$100
Department of Insurance Retrofit Grants Program	$6.4
Division of Safety of Dams (DWR)	$5
Division of the State Architect K-12 School Seismic Hazard and Retrofit/Design*	$1,550
DWR Levee Study in the Delta	$2.3
East Side Reservoir Project (Los Angeles)	$2,000
Hospital Seismic Hazard mitigation 1989-2002 (all California hospitals)	$7,120
Local Government Essential Services Building Retrofits	$45.4
Local Match for FEMA Post-Northridge Earthquake Seismic Hazard Mitigation	$249.7
Los Angeles Historic Property Contracts Retrofit Program	2.5
OPR	$225
Pacific Earthquake Engineering Research Center	$20
Proposition 122 State Building Retrofits	$223.5
PUC	$.6
PUC/CEC Earthquake Research	$5.5
San Francisco Bond Measure for URM Retrofits	$350
San Francisco Community Action Plan for Seismic Safety	$7
Seismic Instrument Operation (DWR)	$6
Seismic Upgrade of Schools and Public Buildings (Berkeley)	$374.5
State Lands Commission Marine Oil Terminal Project	$.1
Strong Motion Instrument Program	$52.3
Technology Development	$3
TriNet/CISN	$13.8
UC Berkeley SAFER Program	$250
UC Seismic Retrofit Program	$2,600
UC Seismographic Station and Research Center	$23
URM Building Seismic Retrofits	$1,730
Water Project Review (DWR)	$7
Total	$29,196.65

*NOTE: Includes possible errors due to rounding. * 1990-2002 only*

Table 5.P summarizes some of California's future mitigation funding commitments through 2030. All of these projects are currently being developed or are under construction.

Table 5.P: Selected Future State Seismic Hazard Mitigation Commitments

Projects Underway or Obligated	Funds Obligated (millions)
SB 1953 Hospitals Seismic Hazard Compliance (to be paid by hospital owners)	$23,800*
Proposition 47 School Construction and Modernization Seismic Hazard Assessment and Retrofit	$735
Proposition 1D Seismic Hazards Assessment and Retrofit	$400
PG&E Projects	$2,175
San Diego County Water Authority	$827
San Francisco PUC	$3,600
EBMUD Retrofit Program	$189
East Bay Bridge Span Replacement Project	$6,416 billion [a]
State Water Project	$30
Antioch Bridge	$195
Dumbarton Bridge	$275
Total	**$37,913**

**Denotes projected expenses from 2002 through 2030*
[a] Source: CalTrans, note this amount does not include program contingencies

Table 5.Q identifies the amount of federal funding supplied to the state for earthquake mitigation since 1990. One of the major mitigation successes funded in cooperation with the federal government has been the California Geological Survey Seismic Hazard Mapping Program. This effort has been ongoing since the passage of the Seismic Hazards Mapping Act in 1990.

Table 5.Q: Selected Federal Seismic Hazard Mitigation Investments in California 1990-Present

Principal Funding Sources	Expenditures (Millions)
FEMA Post-Northridge Earthquake (includes $11 million in Seismic Hazard Mapping funds)	$760
USGS	$300
National Science Foundation	$75
Federal Highway Funds (Seismic hazard mitigation)	$3,314
Total	**$4,449**

Future Updates

This portion of the SHMP was compiled with existing resources through the cooperative efforts of CGS and CSSC. The following are recommended for future updates to this SHMP:

- Develop and maintain a Living Earthquake Risk Model with enhanced samples of inventories or actual inventories reflecting their specific vulnerabilities
- Expand efforts to track statewide mitigation progress by governments and the private sector, particularly local government regulatory efforts to identify and mitigate geologic hazards

5.3 FLOOD HAZARDS, VULNERABILITY AND RISK ASSESSMENT

Floods represent the second most destructive source of hazard, vulnerability and risk, both in terms of recent state history and the probability of future destruction at greater magnitudes than previously recorded.

5.3.1 IDENTIFYING FLOOD HAZARDS

This section addresses floods as one of three primary hazards in the classification system introduced in Chapter 4 and includes information identifying the following dimensions of this hazard:

- Its location within the state (i.e., geographic area affected)
- Previous occurrences within the state
- The probability of future events (i.e., chances of recurrence)

Floods represent a significant concern for the state of California for several reasons. First, California has a chronic and destructive flooding history. From February 1954 to April 2011, 63 percent of federally declared major disasters in the state involved flooding. These disasters have claimed 292 lives, resulting in 759 injuries and over $4.8 billion in Cal OES-administered disaster costs. Second, California has widespread flooding vulnerability as indicated by FEMA Flood Insurance Rate Map (FIRM) designations, with their common presence in populated areas. Third, most local governments that have FEMA-approved Local Hazard Mitigation Plans (LHMPs) have identified flooding as an important hazard.

5.3.2 PROFILING FLOOD HAZARDS

Every county in the state experiences floods, although the nature of these events varies due to the state's diverse climatology and geography. Disparate climatological patterns present challenges to flood mitigation planning in California. These patterns include:

- El Nino conditions
- La Nina conditions
- Desert monsoons
- Northwest coastal conditions
- Tropical storms
- Gulf of Alaska storms
- "Pineapple Express" patterns

In addition, California's geographic diversity represents a difficult challenge to planning for flood mitigation. As pointed out in Chapter 4, California has a 1,100-mile-long coastline; prominent coastal and inland mountain ranges, including the Sierra Nevada; and extensive and highly varied deserts. These geographical factors combine to create various types of floods: alluvial fan, coastal, flash, fluvial, lake, levee, mudslide, riverine, seiche, and tsunami.

Flooding, erosion and debris flows can also occur in California in the months and years following large hot fires. Wildfires greatly reduce the amount of vegetation, which in turn reduces the amount of rainwater absorption, allowing excessive water runoff that often includes large amounts of debris. Structures located anywhere near a burn area are susceptible to flooding. Periods of high intensity rainfall are of particular concern, but post-fire flooding can also occur during a normal rainy season.

For more information, see:
www.usgs.gov/newsroom/leads_result.asp?ID=1530 , http://pubs.usgs.gov/fs/2005/3106/

Hydrologic Regions

California's ten natural hydrologic regions present disparate flood mitigation planning challenges. The following is a brief description of the ten regions, shown on Map 5.U.

North Coast Region

The North Coast hydrologic region runs along the Pacific Coast from the California-Oregon border to the mouth of the Russian River. This region is sparsely populated, with the majority of settlement in the Humboldt Bay area. The area receives larger rain totals than any other region and experiences some of the state's most spectacular and devastating flood events.

San Francisco Bay Region

The San Francisco Bay hydrologic region extends along the north central coast and encompasses most of the Bay Area counties. It reaches to just north of Ukiah in Mendocino County, south to the Coyote Creek watershed in Santa Clara County, and inland to just east of the Sacramento-San Joaquin Delta. The area around San Francisco Bay is heavily populated, and the entire region is marked by hills, river valleys such as those along the Russian River, and marshlands. The region is most vulnerable to classic stream flooding, landslides, and some urban flooding. Flooding along the coastal and bay shorelines can be severe when winter storms coincide with high tides. Sonoma County, most of which is located in this region, records the most National Flood Insurance program (NFIP) repetitive losses of any area in California.

Central Coast Region

The Central Coast hydrologic region reaches from Ano Nuevo Point in San Mateo County down the Pacific Coast to near the crest of the coast range in Santa Barbara County. The region is mountainous with very narrow strips of flat coastal plain. Generally, the mountain streams and rivers in this area run directly into the Pacific Ocean and lack significant delta areas. This region includes major agricultural areas and urban centers and is characterized by stream flooding and slides.

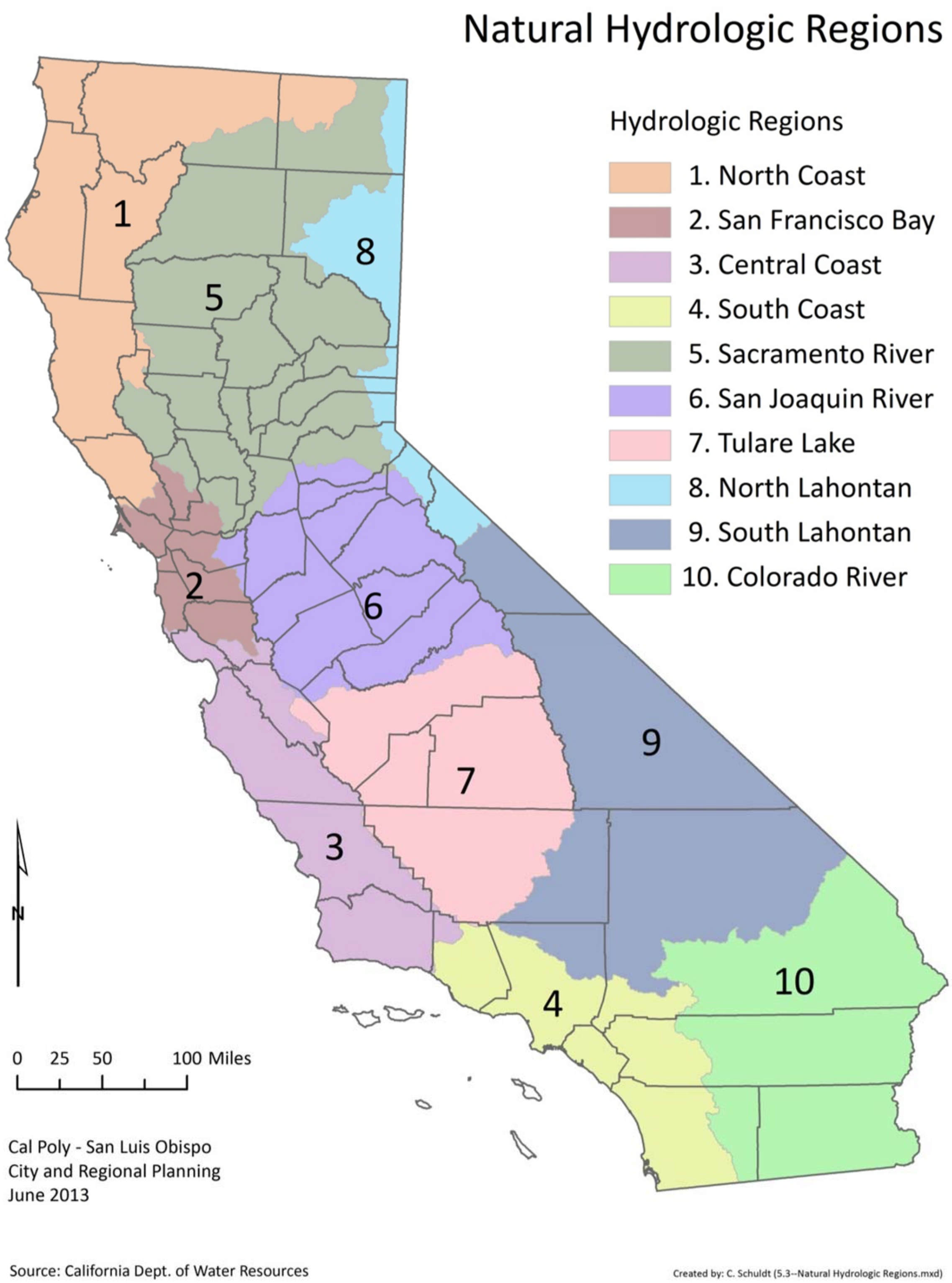
South Coast Region

The South Coast hydrologic region extends up from the U.S.-Mexico border to the Tehachapi, San Bernardino, San Gabriel, and San Jacinto mountains. Nearly one-third of the area is coastal plain. This region contains major urban centers, including the counties of Los Angeles, Orange, and San Diego. Much of the flooding is sudden and severe, resulting in massive slides, debris flows, and mudflows. Typical of the flooding that occurs in this area are the 1969 winter storms that killed 47 and resulted in $300 million in property damage. During these storms, an alluvial flood and debris flow on Deer Creek in San Bernardino County killed 11.

Sacramento River Region

The Sacramento River hydrologic region includes the northern half of the Central Valley. The Sacramento River drains through the Sacramento-San Joaquin Delta. The region is bounded by the Sierra-Nevada Mountains, Coast Range, Cascade Range, and Trinity Mountains. This is a major agricultural area, with the Sacramento metropolitan area comprising the largest concentration of population. Flooding in this region is predominantly caused by runoff from either major winter storm events or snowmelt. While massive dams and levee systems have significantly reduced this region's historic flood problems, the area remains vulnerable to flooding along small streams due to levee failures and in urban drain areas dependent upon pumping stations. This region includes portions of the Sacramento-San Joaquin Delta (see Chapter 6, Section 6.1).

MAP 5.U: Natural Hydrologic Regions



San Joaquin River Region

The San Joaquin hydrologic region encompasses the middle portion of the Central Valley bounded by the Sierra Nevada Mountains, Coast Range, divided between the American and Consumnes river watersheds, and divided between the San Joaquin and Kings river watersheds. The region also includes portions of the Sacramento-San Joaquin Delta, although that area is described separately in this SHMP. Although predominantly agricultural, this region has experienced increased urbanization in recent years and is subject to flooding from winter storm events and snowmelt.

Tulare Lake Region

The Tulare Lake hydrologic region comprises the extreme southern portion of the Central Valley. It is defined by the Sierra Nevada Mountains; divide between the San Joaquin and Kings rivers, the Coast Range, and the Tehachapi Mountains. The Kaweah, Tule, Kern, and Kings rivers all historically drained into the Tulare Lakebed. Through the late 1800s, Tulare Lake was of substantial size during wet periods, although its level fluctuated. A number of small reclamation districts were established in the area in the early 1900s that, over the years, built levees and reclaimed the more-than-200,000-acre lakebed for agriculture. Though now predominantly agricultural, this region contains the urban centers of Fresno, Bakersfield, Visalia and Hanford. It is subject to flooding from winter storms and snow runoff.

North Lahontan Region

The North Lahontan hydrologic region lies in the extreme northeast portion of the state. It is bounded by the Sierra Nevada, Cascade, and Warner mountain ranges on the west and the Nevada border on the east and runs south to Bridgeport in Mono County. Lake Tahoe is located in the center of the region. All streams in the region terminate in lakes or playas because they have no outlet to the ocean. This region is sparsely settled with the exceptions of the communities around Lake Tahoe and the City of Susanville. It experiences flooding from winter rainstorms, snowmelt, and intense late spring and early fall thunderstorms.

South Lahontan Region

The South Lahontan hydrologic region is nestled between the Sierra Nevada, San Bernardino, and San Gabriel Mountains, Nevada state line, Mono Lake Valley, and Northern Colorado Desert. Despite its generally dry conditions, this sparsely populated region experiences periodic winter storms and thunderstorms that often result in flash floods. Under storm conditions, the region's generally dry stream systems pose a significant threat. The Mojave River runs through three growing San Bernardino county communities: Hesperia, Victorville, and Barstow. The desert community of Hesperia is located at the base of an alluvial fan that forms the headwaters for the Mojave River. This area experiences significant flood damage during both winter storms and summer monsoon events.

Colorado River-Desert Region

The dominant hydrologic features of this region are the Colorado River, which forms its eastern boundary, and the Salton Sea, which lies just shy of its western boundary. The region is marked by the San Bernardino and San Jacinto mountains. The region is also bounded by the U.S.-Mexico border to the south and the South Lahontan region to the north. This is a mostly sparsely populated agricultural region that experiences irregular flooding. However, both common winter storm events and tropical flows from Mexico's Pacific Coast can bring massive rainstorms and flash floods. During the summer months, monsoonal flows come up over the mainland of Mexico.

5.3.2.1 PAST FLOOD DISASTERS

From February 1954 to April 2011 the state has had 32 state-proclaimed flood emergencies and 49 federally declared flood disasters. Since 1992, every county in California was declared a federal disaster area at least once for a flooding event (see Table 5.R).

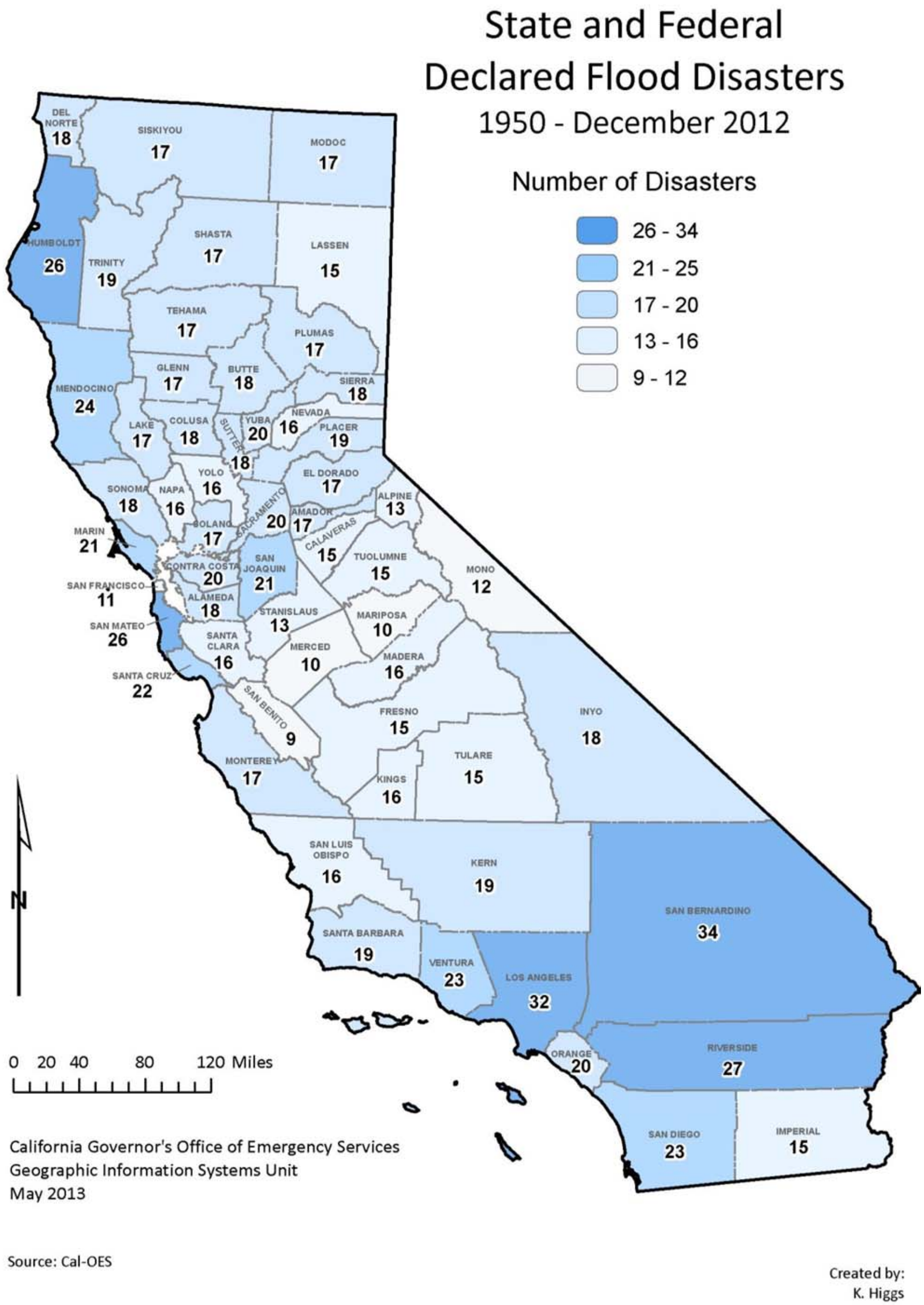
Table 5.R: Flood Disasters Since 1992 (as of July 2010)

Disaster #	Date	Scope (# of Counties)	# of Deaths	Damage in $
935-DR-CA	Feb-92	6	5	$123.2 million
979-DR-CA	Jan-93	25	20	$600 million
1044-DR-CA	Jan-95	45	11	$741.4 million
1046-DR-CA	Feb-95	57	17	$1.1 billion
1155-DR-CA	Jan-97	48	8	$1.8 billion
1203-DR-CA	Feb-98	40	17	$550 million
1498-DR-CA	Jun-03	2	16	--[a]
1529-DR-CA	Jun-04	1	0	$57 million
1577-DR-CA	Feb-05	8	24	$573.1 million
1585-DR-CA	Apr-05	7	0	$198.7 million
1628-DR-CA	Feb-06	40	5	$327.8 million
1646-DR-CA	Jun-06	16	1	$129.5 million
1884-DR-CA	Mar-10	6	0	Preliminary Damage Estimate: $50 million
1952-DR-CA	Dec-10	12	**	**

Source: Cal OES Origins and Development - A Chronology 1917-2010; Cal OES After Action Reports; FEMA: California Disaster History (http://www.fema.gov/disasters/grid/state-tribal-government/77?field_disaster_type_term_tid_1=All)
[a]DR-1428, 2003 Southern California Fires, caused the elimination of vegetation securing soils to the hillsides. In December 2003, mild flooding caused mudflows and landslides killing 16 people. The costs of the flood damages were not segregated from the fire damages.
*** Figures pending*

Continued on next page

MAP 5.V: State and Federal Declared Flood Disasters, 1950-December 2012



Map 5.V shows the distribution of floods leading to disaster declarations from 1950 to 2009. Counties with 21 or more declared disasters during this period include Los Angeles, Riverside, San Bernardino, and San Diego in Southern California; Contra Costa, San Mateo, and Santa Cruz in the San Francisco Bay Area; and Humboldt and Mendocino counties in Northern California.

5.3.3 ASSESSMENT OF STATE FLOOD VULNERABILITY AND POTENTIAL LOSSES

This section discusses statewide vulnerability of areas susceptible to flooding. It provides an overview of state vulnerability and potential losses to flood hazards and reviews progress with respect to Repetitive Loss Communities, as well as state-owned and -leased buildings.

The assessment of state vulnerability to floods uses counties as the primary unit of analysis. Included are several methods available for assessing the areas of the state that are the most vulnerable to flood hazards:

- GIS risk modeling
- Analysis of population in Flood Insurance rate Map (FIRM) floodplains
- Analysis of damage from historic flood events

Collectively, the results of analyses can be used to establish current and future vulnerability and potential loss with measures of space and magnitude.

5.3.3.1 ESTIMATING LOSES FROM FUTURE FLOODS

The following section identifies flood zones, affect population and potential losses.

Population in Flood Insurance Rate Map (FIRM) Floodplains

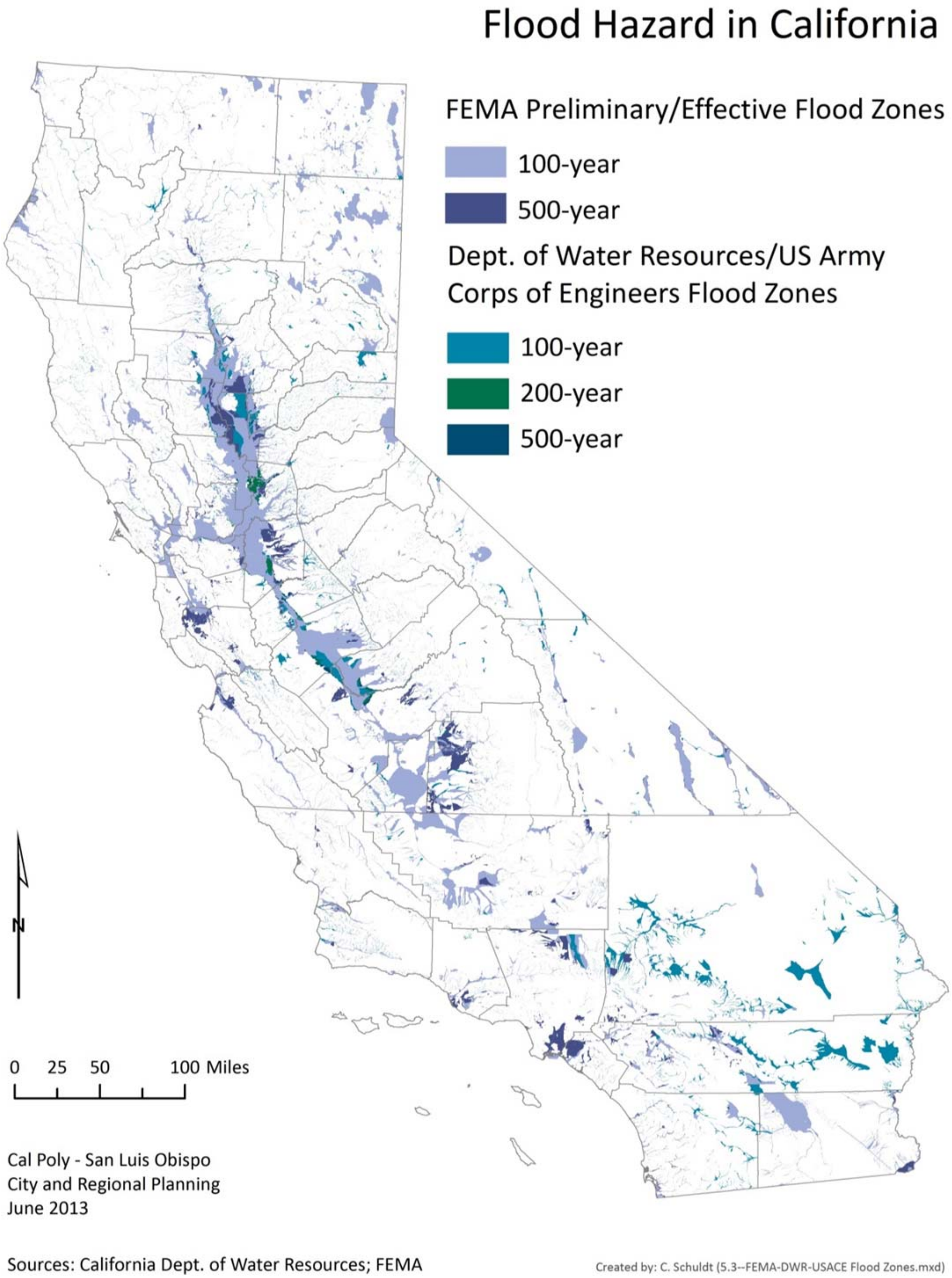
The standard references for establishing the location of flood hazards are the Flood Insurance Rate Map (FIRM) floodplains, part of a national insurance system maintained under the National Flood Insurance Program (NFIP), as described in Chapter 3, Section 3.1.1 and Annex 2. The FIRM maps not only identify the flood hazard zones for insurance and floodplain management purposes, but also provide a statement of probability of future occurrence. Map 5.W shows FEMA 100-year and 500-year flood zones and DWR 100-year, 200-year and 500-year flood zones.

For example, a 500-year flood has a 0.2-percent chance of occurring in any given year; a 100-year flood has a 1-percent chance, a 50-year flood has a 2-percent chance, and a 10-year flood has a 10-percent chance of occurrence. Although the recurrence interval represents the long-term average period between floods of specific magnitude, significant floods could occur at shorter intervals or even within the same year. The FIRM maps typically identify components of the 500-year and 100-year floodplains.

Map 5.X shows FEMA 100-year floodplains or areas with a 1-percent chance of a flood that size in any given year. High concentrations of 1-percent annual chance flood hazard areas are shown throughout the Central Valley, especially in the Sacramento-San Joaquin Delta region, as well as in selected other inland regions. (Online or download viewers can zoom in for a closer view of the information on this map.)

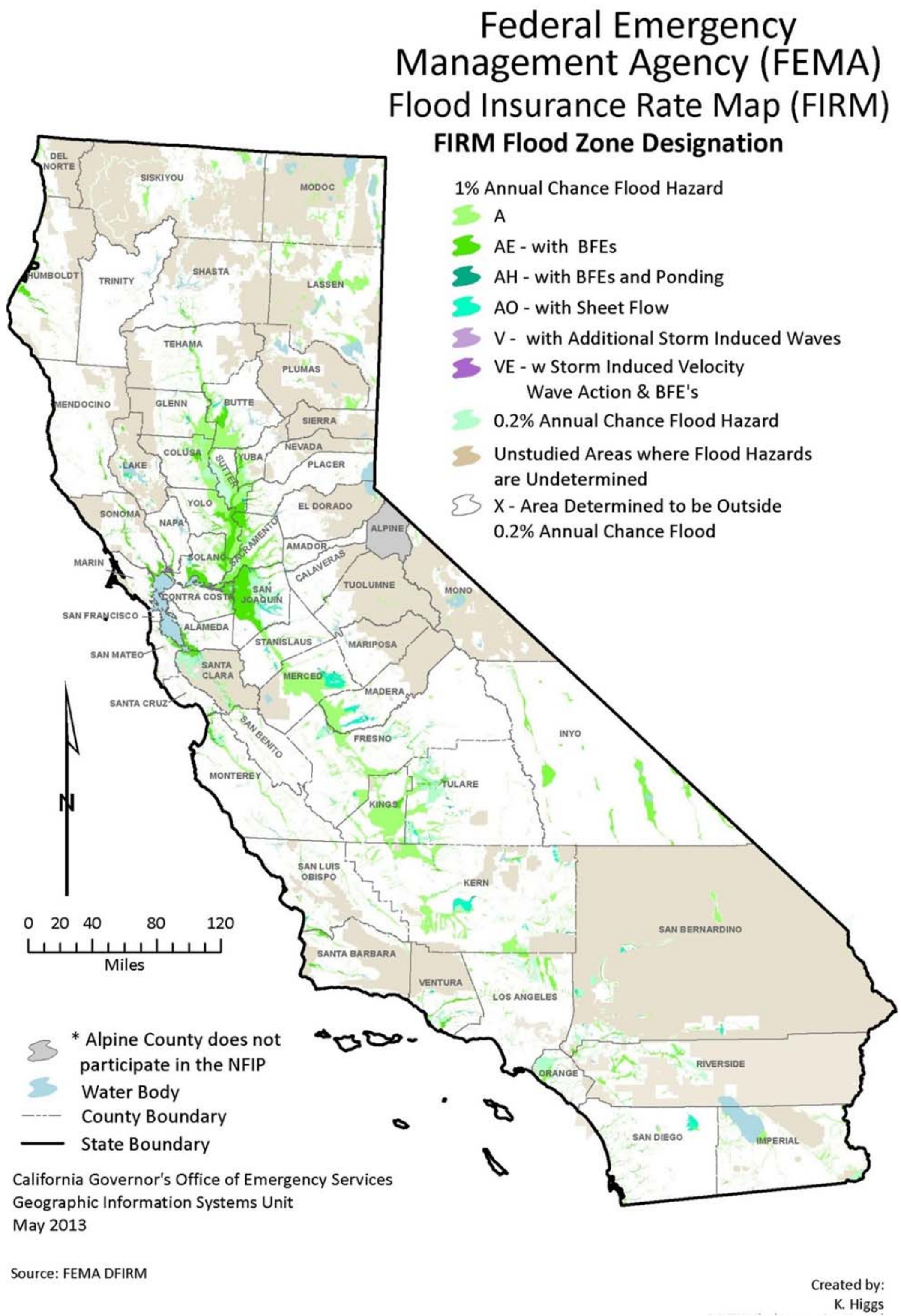
Flood zones are areas depicted on a FIRM map defined by FEMA according to levels of risk. Zones with a 1-percent annual chance of flooding are part of the Special Flood Hazard Area (SFHA) and considered to have high risk. In communities that participate in the NFIP, mandatory flood insurance purchase requirements apply to these zones: A, AE, A1-30, AH, AO, AR, A99, V, and VE or V1 through 30 (see Table 5.S).

MAP 5.W: Flood Hazard Areas in California



(Online or download viewers can zoom in for a closer view of the information on this map.)

MAP 5.X: FEMA Flood Insurance Rate Map



(Online or download viewers can zoom in for a closer view of the information on this map.)

Table 5.S: FIRM Flood Zones

ZONE	DESCRIPTION
A	Area with a 1% annual chance of flooding. No depths or Base Flood Elevations (BFEs) are shown.
AE	Base floodplain where BFEs are provided. AE Zones are now used on digital FIRMs instead of A1-A30 Zones.
A1 through 30	Known as numbered A Zones, these are the base floodplains in the old FIRM format where a BFE is shown.
AH	Area with a 1% annual chance of shallow flooding with an average depth ranging from 1 to 3 feet. BFEs are shown at selected intervals.
AO	River or stream flood hazard area, or area with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow with an average depth ranging from 1 to 3 feet. Average flood depths derived from detailed analyses are shown.
AR	Area with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam).
A99	Area with a 1% annual chance of flooding protected by a federal flood control system where construction has reached specified legal requirements. No depths or BFEs are shown.
V	Coastal area with a 1% or greater chance of flooding and an additional hazard associated with storm waves. No BFEs are shown within these zones.
VE or V1 through 30	Coastal area with a 1% or greater chance of flooding and an additional hazard associated with storm waves. BFEs are shown at selected intervals.
B, C, X	Zones considered to have moderate to low risk of flooding, although flood insurance is available to property owners and renters in communities that participate in the NFIP.
D	Area with possible but undetermined flood hazards, where no flood hazard analysis has been conducted.

Source: http://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1

Studies comparing 2000 U.S. Census data with NFIP FIRM maps found that over 5 million Californians (15 percent of total population) lived in a FIRM floodplain and nearly 2 million (5.8 percent of total population) lived in the 100-year floodplain. Based on these studies, California would normally expect approximately 20,000 people per year to be affected by 1 percent and 0.2 percent annual flooding; however, the state's flood risk is not evenly distributed. Approximately 84 percent of the 5 million Californians living in a FIRM floodplain were in 13 counties having 100,000 or more people within 100-year and 500-year FIRM floodplains (see Table 5.T). In 2000, the leader by far was Orange County, with close to 1.4 million people at risk. These numbers may shift somewhat with the 2010 Census.

Table 5.T: Counties with 100,000+ People Living in FIRM Floodplains, 2000

County	Total Population in FIRM Zone
Orange	1,384,403
Sacramento	490,014
Los Angeles	390,305
Santa Clara	304,511
Riverside	295,081
San Joaquin	287,742
Fresno	205,235
Monterey	198,283
San Bernardino	196,945
Ventura	187,179
San Diego	181,757
Tulare	154,184
Alameda	103,162

Source: U.S. Census; FEMA

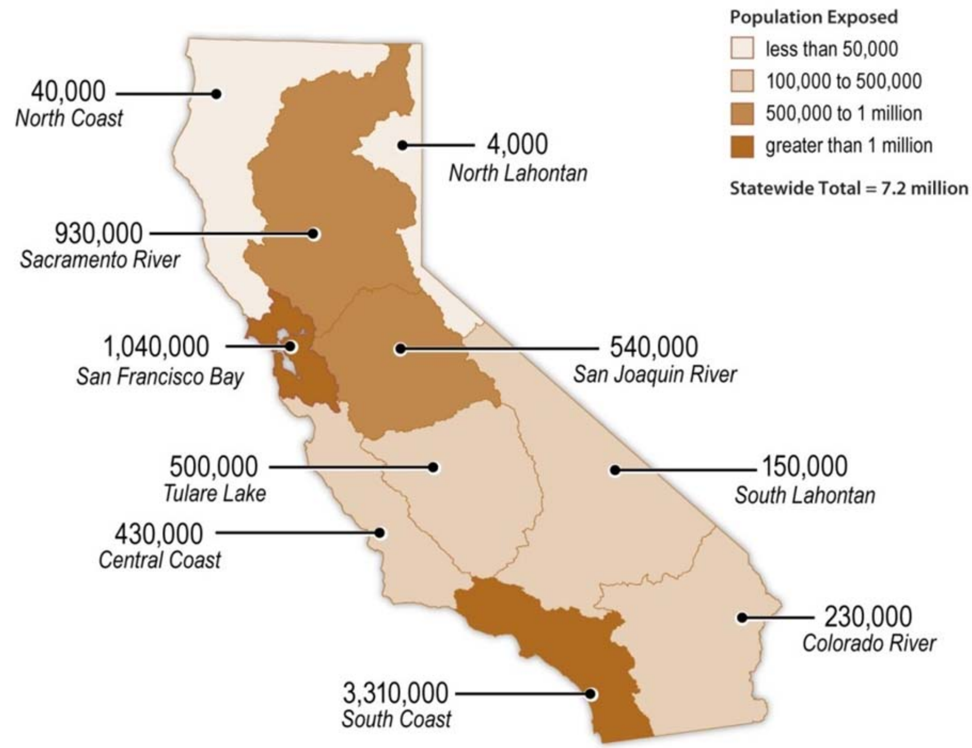
It should be noted that FIRM maps do not provide full coverage of the state and contain inaccuracies due to changes in development and infrastructure since the original surveying. The federal government started regulatory floodplain mapping on a nationwide basis in the late 1960s. FEMA has mapped a portion of California, but has substantial areas yet to map, subject to growth. Meanwhile, efforts have been under way to update some FIRM maps in the state through FEMA's new Risk MAP (Mapping, Assessment and Planning) Strategy. http://www.fema.gov/plan/ffmm.shtm

Cal OES swift water rescue crews are activated

Source: Cal OES

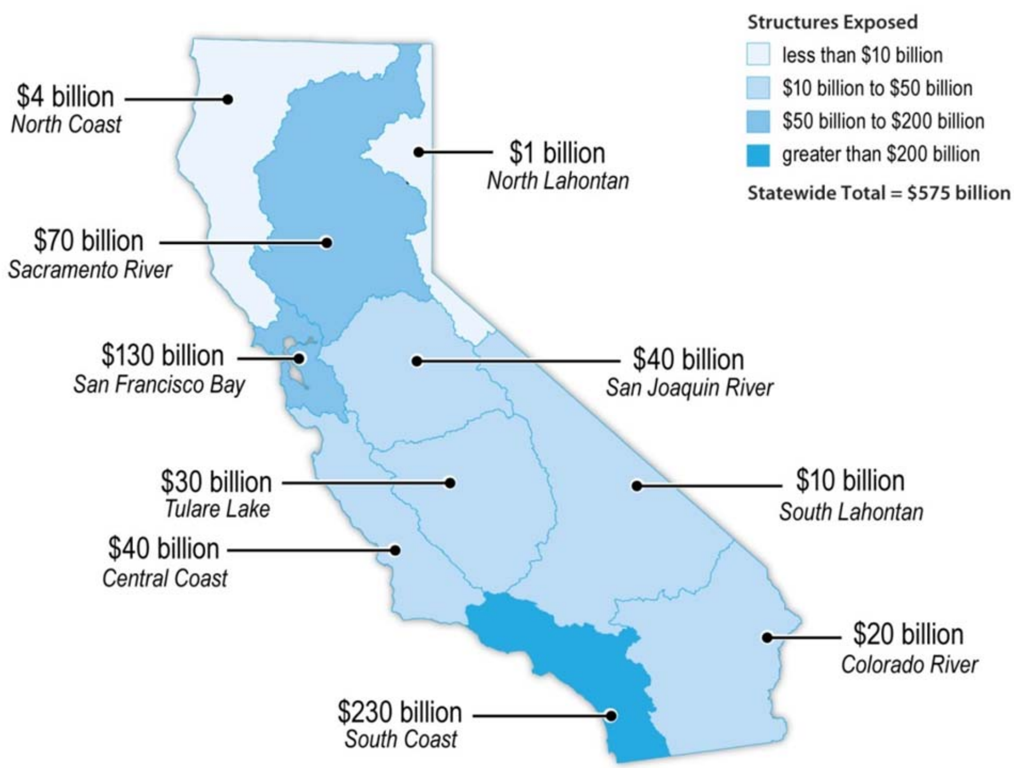
The maps on the following page were produced as part of the California Flood Futures Report (discussed in more detail in Section 5.3.5.5). One of five Californians lives in a floodplain (500-year flood). All counties have populations exposed to flooding (See Map 5.Y). The Statewide value of structures and contents at-risk from a 500-year flood event is more than $575 billion, distributed over all regions. Los Angeles, Orange and Santa Clara Counties lead the statistics with more than 500,000 persons and structures and contents worth more than $70 billion exposed to flooding (see Map 5.Z).

MAP 5.Y: Population Exposed to 500-Year Flooding in California by Hydrogeologic Region



Source: California's Flood Future, public review draft March 2013)

MAP 5.Z: Structures Exposed to 500-Year Flooding In California by Hydrogeologic Region



Source: California's Flood Future, public review draft March 2013)

5.3.3.2 ESTIMATING FLOOD LOSSES TO STATE-OWNED AND LEASED BUILDINGS

Given the size and complexity of California's economy and infrastructure, the challenge of estimating potential dollar losses for state-owned facilities is substantial. As discussed in Section 5.2.3, there are over 20,000 state-owned structures in California, plus several thousand state-leased buildings, with lease terms varying in length. Table 5.U identifies a total risk exposure of $11.62 billion for buildings in areas potentially subject to the 100-Year Flood (Zone A). These figures tend to overstate potential losses from this hazard for two fundamental reasons: 1) flood events are centered within one region or another, and 2) only a very small portion of the inventory within a region affected by heavy flooding would suffer substantial permanent damage.

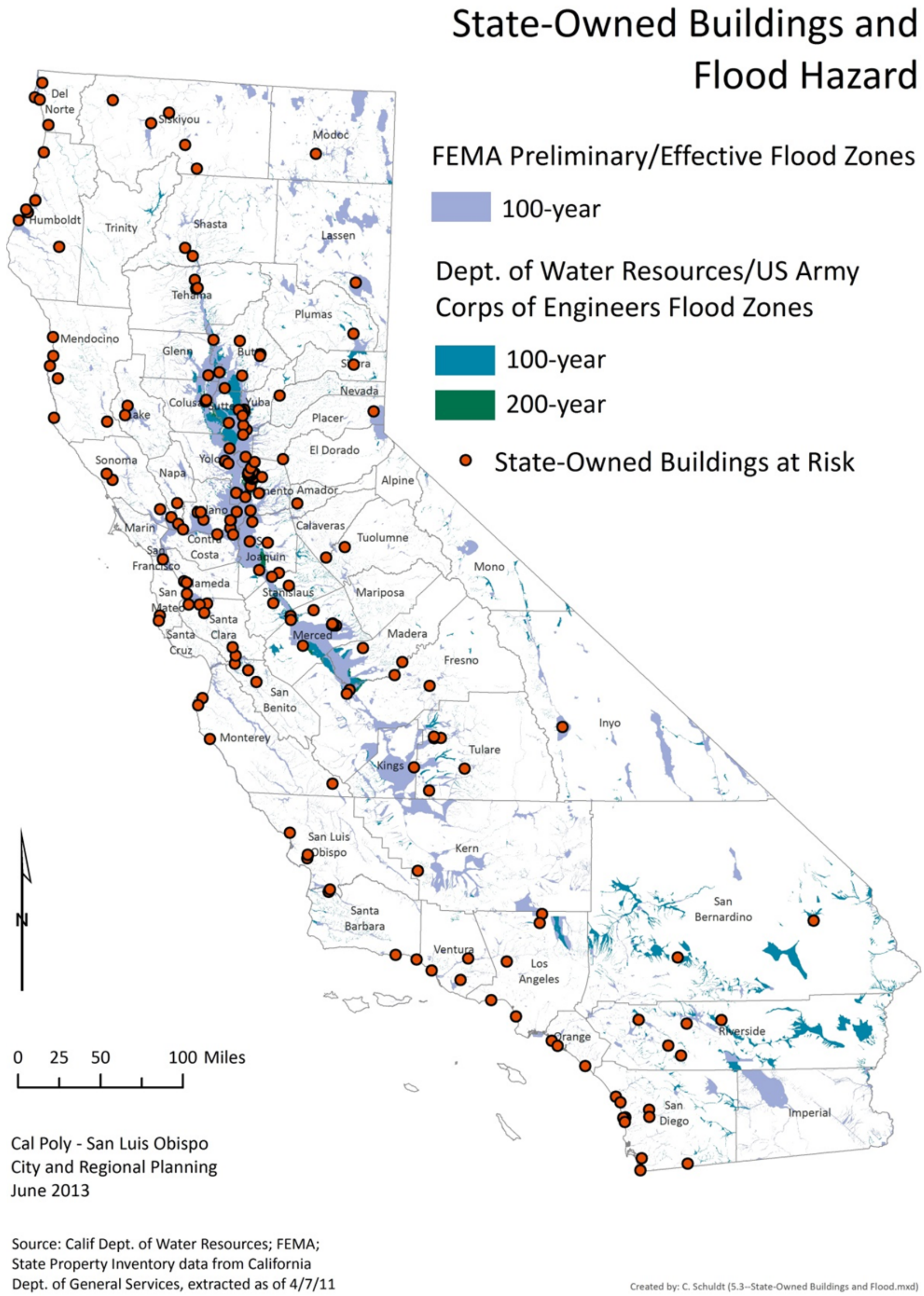
Table 5.U: Potential Loss of State Facilities from Flood Hazards

	State Ownership Status	Number of Buildings	Square Feet	$ at Risk (billions)
FIRM 100 (Zone A)	Own	1,671	27,553,251	9.64
	Lease	433	5,657,268	1.98
	Total	**2,104**	**33,210,519**	**11.62**
FIRM 500 (Zone X)	Own	609	5,665,724	1.98
	Lease	218	1,759,612	0.62
	Total	**827**	**7,425,336**	**2.60**

Source: Department of General Services, Cal OES

(Continued on next page)

MAP 5.AA: State-Owned Buildings in Higher Flood Hazard Areas



Map 5.AA shows general locations of state-owned buildings in relation to the 1-percent Special Flood Hazard Area (SFHA) portion of the 100-year floodplain areas. Altogether there are over 800 structures with over 4 million square feet within these areas. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

5.3.4 ASSESSMENT OF LOCAL FLOOD VULNERABILITY AND POTENTIAL LOSSES

This section addresses local flood hazard vulnerability and potential losses based on estimates provided in local risk assessments, comparing those with findings of the state risk exposure findings presented in the GIS analysis in Section 5.1.1 of this chapter.

5.3.4.1 FLOOD VULNERABILITY AND MITIGATION

Analysis of Damage from Historic Flood Events

Damage data from California's historic flood events are useful for characterizing flood risk and identifying areas that probability-based assessments such as FIRM floodplains may miss. According to a study of population living in floodplains as of 1998, a majority of NFIP flood loss claims occur during flood events that do not rise to the level of a federal disaster declaration. Thus, the extent of flood disaster declarations is not a complete measure of vulnerability.

Robert's Island, San Joaquin County, 1996-97
A home that was required to meet Design Flood Elevation Level

Source: Cal OES

Table 5.V provides a summary analysis of historic Individual Assistance (IA) and Public Assistance (PA) damage claims and Repetitive Loss (RL) payments from 1992 to 2002.

Table 5.V: Individual Assistance (IA), Public Assistance (PA), and Repetitive Loss (RL) Analysis

Assistance Type	County
IA: County with greatest number of damage locations (accounts for 45% of total state dollar damage claims)	Los Angeles
PA: Counties with greatest dollar damage claims (accounts for 50% of total state dollar damage claims)	Los Angeles
	Santa Barbara
	Monterey
	Ventura
	Orange
	San Mateo
	Santa Clara
	Alameda
	Sonoma
RL: County with greatest dollar payments (accounts for 34% of total state dollar payments)	Sonoma

Source: FEMA; Cal OES

Repetitive Loss Communities

Areas flooded in the past continue to be inundated repeatedly. The repetitive nature of flood damage causes the greatest concern. FEMA, in coordination with the state, identifies California's top Repetitive Loss (RL) Communities. Repetitive Loss Communities in California account for nearly $171 million in total payments, representing 8,019 losses on 2,903 properties throughout the state.

The top 10 Repetitive Loss Communities account for over $103 million in total payments, or 60 percent of total payments for Repetitive Loss Communities in the state. Sonoma County is the top-ranking community in California, accounting for more than 52 percent of the total top ten repetitive losses. In order of losses, the top 10 are:

- Sonoma County
- City of Malibu
- City of Los Angeles
- Sacramento County
- Lake County
- Monterey County
- Marin County
- Santa Cruz County
- City of Napa
- Ventura County

The comparison of Repetitive Loss Communities in 2010 with Repetitive Loss Communities in 2013 shows a generally steady pattern, with relatively few changes in the top 10. For details about the top 10 Repetitive Loss Communities, see Appendix P.

Most of the historic damage reported in Table 5.V occurred in nine counties. Of these three —Santa Barbara, San Mateo, and Sonoma — are not shown as high risk on FIRM floodplain maps.

5.3.4.2 LOCAL HAZARD MITIGATION PLAN HAZARD RATINGS

An important source of local perceptions regarding vulnerability to flood threats is found in the collection of over 300 FEMA-approved Local Hazard Mitigation Plans (LHMPs) adopted by cities, counties, and special districts as of May 2013. The most significant hazards reported in this review are earthquakes, floods, and wildfires—the three primary hazards also identified on a statewide basis by the 2013 SHMP. Including these three primary hazards, LHMPs identified a total of 58 distinct local hazards.

Map 5.Y summarizes relative ratings of flood hazards in the 2013 review of LHMPs. Displayed are predominant flood hazard ratings shown as high (red), medium (orange), and low (yellow) rankings reflecting ratings given by at least 51 percent of the jurisdictions with LHMPs within each county. Counties shown without color represent either jurisdictions not having FEMA-approved LHMPs or counties where data are missing or problematic.

For a detailed evaluation of LHMPs approved as of May 2013, see Annex 5, California Local Hazard Mitigation Plan Status Report.

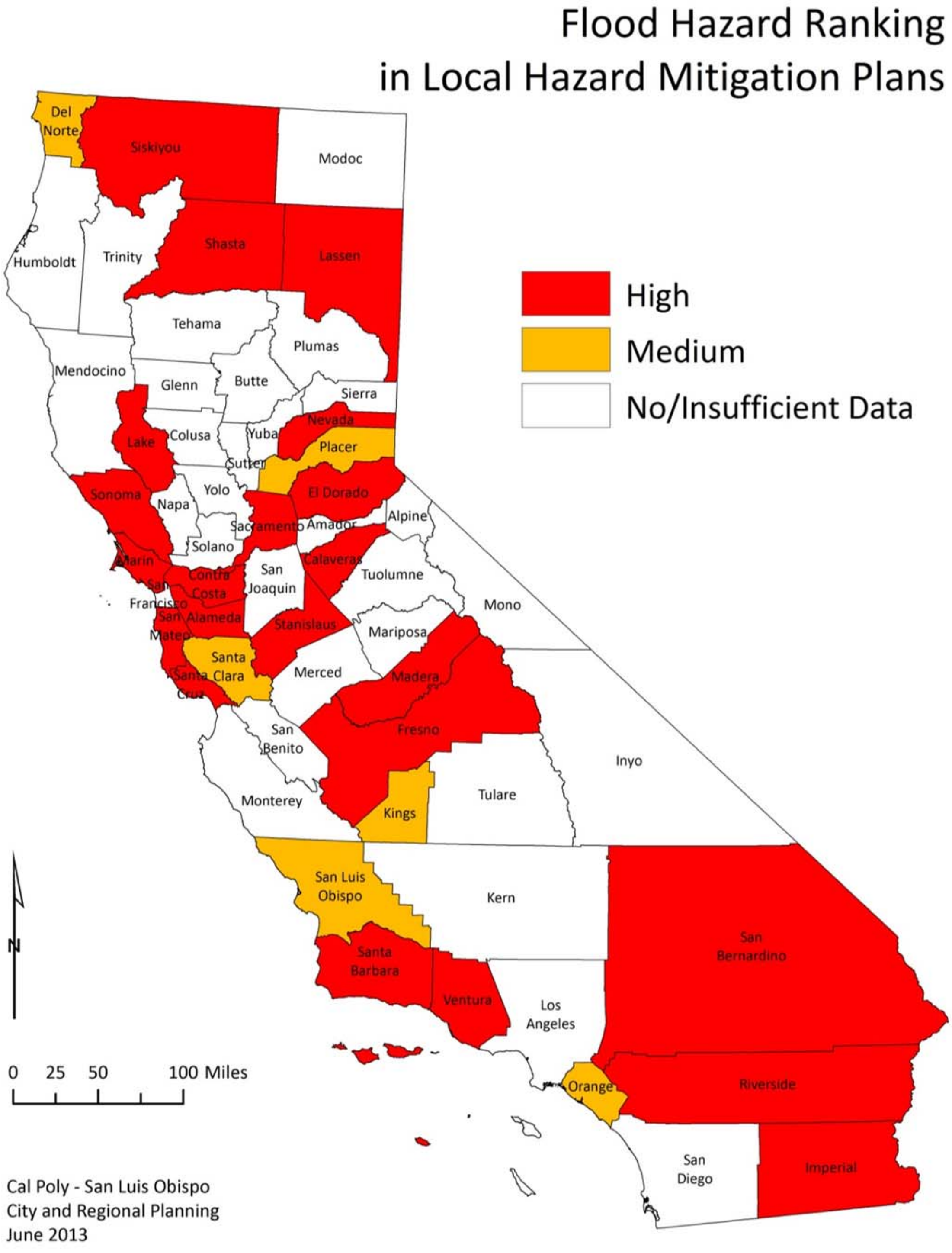
Implications for Local Loss Potential

Local hazard rankings are highly variable, responding to a wide variety of very specific local conditions. Each county has its own set of variables conditioning flood loss potential within its cities and unincorporated area. Descriptions of loss potential are very specific within individual LHMPs and are not consistently drawn up between plans, nor is there even coverage of all cities and unincorporated areas. Such variability will diminish as more cities and counties prepare LHMPs and greater standardization enables comparability of local data with statewide data.

Comparison with Statewide Vulnerability

Map 5.Y reveals that most LHMPs reviewed in 2013 in Southern California, San Francisco Bay Area, and some Central Valley area counties rated floods high in their hazard rankings. This is consistent overall with the patterns of flood hazards and population/social vulnerability patterns identified previously in Section 5.1.1.

MAP 5.BB: Flood Hazard Ranking in Local Hazard Mitigation Plans



Source: Cal OES

Created by: C. Schuldt (5.3--LHMP Flood Hazard Ranking.mxd)

Map 5.BB identifies flood hazards as being a predominant concern in the 2013 LHMP review for most Southern California and San Francisco Bay Area counties with approved LHMPs, and some Central Valley and eastern Sierra counties.

5.3.5 CURRENT FLOOD HAZARD MITIGATION EFFORTS

5.3.5.1 LEGISLATION

Progress Summary 5.N: New Flood Laws

Progress as of 2013: In the latter part of 2007, the California Legislature passed and the Governor signed five interrelated bills (flood legislation) aimed at addressing the problems of flood protection and liability and helping direct use of the bond funds. These were Senate Bills (SB) 5 and 17, and Assembly Bills (AB) 5, 70, and 156. A sixth bill passed in 2007, AB 162, requires additional consideration of flood risk in local land use planning throughout California.

These bills, effective January 1, 2008, collectively outline a comprehensive approach to improving flood management at the state and local levels, with elements to address both the chance of flooding and the consequences when flooding does occur. These new laws are intended to improve local land use and other planning decisions by strengthening the link between land use and flood management. The laws contain requirements and considerations that outline a comprehensive approach to improving flood management at the state and local levels.

Since 2007, multiple bills were passed by the State legislature to clarify certain aspects of the 2007 legislation relative to urban level of flood protection requirements in the Sacramento-San Joaquin Valley. These bills included AB 1965 of 2009, SB 1070 of 2010, and SB 200 and SB 1278 and AB 1965 of 2012. AB 1165 amended the definition of adequate progress for urban level of flood protection applications and SB 1070 clarified the geographic boundaries of the Sacramento-San Joaquin Valley. SB 200 extended the state cost-share for the Delta levee maintenance program at "up to 75 percent" of the costs in excess of $1,000 per levee mile.

SB 1278 and AB 1965 revised the definition of urban level of flood protection and modified the dates and timeframes for general plan and zoning ordinance updates established in SB 5.

The flood legislation is intended to address a number of problems, and the underlying causes of those problems, associated with flood management in the state. These include flood control system deficiencies, the availability of flood risk information, and links between land use planning and flood management. Key initiatives include the following:

Plans to Address Flood Control System Deficiencies in Central Valley
Much of the existing flood management system in the Central Valley is made up of a complex, integrated system of levees, channel improvements, bypasses, and related facilities. Rapid development and land use changes in the Central Valley have exposed deficiencies in this flood management system. Over time, historically agricultural lands and rural communities have been, and continue to be, converted to densely populated residential and urban centers. Facilities originally constructed to reclaim and reduce flooding on agricultural lands may provide inadequate protection for these urban and urbanizing areas, even if improvements are made to meet minimum federal standards. Further, while levees and other facilities may decrease the frequency of flooding, they do not offer complete protection from flooding.

The Central Valley Flood Protection Act, enacted by SB 5, seeks to address these problems by directing the California Department of Water Resources (DWR) and the Central Valley Flood Protection Board to prepare and adopt a Central Valley Flood Protection Plan (CVFPP) by mid-2012. The CVFPP was adopted by the Central Valley Protection Board on June 2012 and recommends a State System-wide Investment Approach to improving flood management in the Central Valley.

The flood legislation establishes the 200-year flood event (flood with a 1-in-200 chance of occurring in any year) as the minimum level of flood protection to be provided in urban and urbanizing areas in the Sacramento-San Joaquin Valley. The flood legislation also limits the state's liability for developing and adopting the CVFPP beyond the scope of the existing state Plan of Flood Control.

Updated Information on Flood Risk

Cities and counties throughout the state rely upon federal floodplain information when approving developments. However, information available is often out-of-date and may not provide sufficient information to characterize the potential flood risk. The primary purpose of federal flood standards provided by the Federal Emergency Management Agency (FEMA) is to establish a basis for requiring flood insurance for participating communities. These federal maps are being updated through FEMA's Risk MAP, a new program designed to better convey flood risk, promote risk awareness and stimulate loss reduction through mitigation.

Meanwhile, in California various flood risk management initiatives are under way. California Water Code Section 8612 requires the DWR to develop and the California Flood Protection Board to adopt a schedule for mapping flood risk areas in the Central Valley (Sacramento River and San Joaquin River drainages). Water Code Section 9130 requires DWR to prepare levee flood protection zone (LFPZ) maps. Also, as required by Water Code Section 9121, DWR has provided yearly flood risk notices to owners of property in a LFPZ since September 2010.

Land Use Planning and Management to Consider Flood Risk

Linking land use decisions to flood risk estimates comprises another element of protecting lives and property in the Central Valley. Federal, state, and local agencies may construct and operate flood protection facilities to reduce flood risks, but some amount of flood risk will nevertheless remain for those who choose to reside in floodplains. Improving flood risk awareness will help ensure that Californians make careful choices when deciding whether to live in Central Valley floodplains, and if so, whether to prepare for flooding and/or maintain flood insurance.

The flood legislation sets deadlines for cities and counties in the Central Valley to amend their general plans and zoning ordinances. With the passage of SB 1278 and AB 1965, cities and counties in the Sacramento-San Joaquin Valley have up to 24 months to amend their general plans after DWR releases informational 200-year floodplain maps for urban areas protected by the State Plan of Flood Control (SPFC). These maps are specifically intended to assist cities and counties in their determinations relating to urban level of flood protection. The maps will include data on flood depths in urban areas in the event of SPFC levee failures. DWR is required to make the maps available to the public on or before July 2, 2013.

The flood legislation also links flood liability with local planning decisions. As of January 1, 2008, cities and counties now share flood liability with the state in the case of litigation over unreasonably approved new development on previously undeveloped areas. This does not apply when the city or county has amended its general plan and zoning and otherwise makes land use decisions consistent with the CVFPP.

DWR has prepared three documents to inform the public and assist local governments with implementation of the legislative requirements:

DWR's 2007 California Flood Legislation Summary

DWR presents this booklet to provide the public with a better understanding of the roles of government agencies in its implementation and the responsibilities placed on those agencies. This booklet can be found at: http://www.water.ca.gov/legislation/2007-summary.pdf

DWR's 2007 California Flood Legislation Companion Reference
This document is intended to be a companion to the 2007 Flood Legislation Summary. This document provides a listing of the code sections referenced in the flood legislation, including amendments and deletions. In order to illustrate the content of the flood legislation in a straightforward manner, this document has grouped the bill text by the code that it modifies. Therefore, the document is broken up into four groupings; Pertinent Government Code Sections, Pertinent Health and Safety Code Sections, Pertinent Public Resources Code Sections, and Pertinent Water Code Sections. This booklet can be found at: http://www.water.ca.gov/legislation/2007-reference.pdf

Local Land Use Planning: Handbook for Communities Implementing Flood Legislation - October 2010
This guidance handbook is an important element in the multi-faceted FloodSAFE initiative which California established in 2006. As noted earlier, in 2007, the California legislature passed and the Governor signed six flood bills aimed at addressing the problems of flood protection and flood risk management in California. DWR has prepared a guidance document that describes the new legislative requirements that affect city and county local planning responsibilities such as general plans, zoning ordinances, development agreements, tentative maps, and other actions. The document entitled "Implementing California Flood Legislation into Local Land Use Planning: A Handbook for Local Communities" is intended to assist cities and counties to comply with the new legislation by:

- Identifying the new code requirements
- Noting additional factors and actions that jurisdictions should consider
- Highlighting the schedule for compliance
- Directing where jurisdictions can obtain information and assistance

Some of the requirements of the 2007 flood risk management legislation apply statewide, with additional provisions applicable to lands within the Sacramento-San Joaquin Valley and others applicable to lands within the Sacramento-San Joaquin Drainage District. This handbook can be found at: www.water.ca.gov/LocalFloodRiskPlanning/

For additional information regarding specific provisions of the aforementioned legislation, see Annex 2, Guide to California Hazard Mitigation, Laws, Policies, and Institutions.

5.3.5.2 HAZARD ASSESSMENT

Best Available Maps

As part of the Best Available Mapping (BAM) project, DWR is collecting and compiling the best available floodplain maps statewide to make them digitally available to the public. These 100-, 200- and 500- year floodplain maps are available on a statewide basis for all counties in order to communicate flood risk hazards to property owners, flood risk managers, and land use planners. Through providing these maps in a user friendly format, DWR strives to facilitate better and more informed local and statewide planning decisions. This current statewide BAM effort builds upon previous efforts, directed by Senate Bill 5 (2007) to develop maps for California's communities depicting 100- and 200- year floodplains for areas located within the Sacramento-San Joaquin Valley watershed based on data sets from DWR, Federal Emergency Management Agency, US Army Corp of Engineers, and regional studies. This is the first time in California that a compilation of flood maps from these agencies has been made available to the public. The 100-, 200-, and 500-year floodplains are displayed on a DWR web viewer at http://gis.bam.water.ca.gov/bam/

Progress Summary 5.O: Senate Bill 1278 - 200-Year Floodplain Maps and General Plan Amendments

Progress as of 2013: As mandated by Senate Bill (SB) 1278 (2012), the Department of Water Resources (DWR) developed and released 200-year informational floodplain maps for 10 urban communities within the Sacramento-San Joaquin Valley. The development of the maps met the legislative deadline of July 2, 2013. The maps provide information on the water surface elevation of flooding in urban areas in the event of failure of the State Plan Flood Control (SPFC) facilities during a 200-year event.

The 10 urban communities are the following:

- Chico
- Yuba City and Marysville
- Woodland and Davis
- Merced
- Sacramento Metropolitan Area (Sacramento and West Sacramento)
- Stockton Metropolitan Area (Stockton and Lathrop)

SB 1278 also extended the date for cities and counties to amend their general plans and zoning ordinances. General Plans must be amended no later than July 2, 2015. The general plan amendments must include data and analysis contained in the 2012 Central Valley Flood Protection Plan (CVFPP), including the location of the facilities of the SPFC and locations of real property protected by those facilities. Additionally, general plans must include the locations of flood hazard zones mapped by the Federal Emergency Management Agency (FEMA) and flood hazard locations mapped by local flood agencies or flood districts. Cities and counties have an additional 12 months after their general plan amendments (or until July 2, 2016) to update their zoning ordinances to be consistent with the general plan amendments.

After these amendments (to be completed no later than July 2, 2016), cities and counties will be required to make findings related to an urban level of flood protection as stipulated in California Government Code Sections 65865.5, 65962, and 66474.5, using criteria consistent with, or developed by, DWR. DWR is currently developing criteria in collaboration with cities, counties, other state entities, federal agencies, and associated professional organizations to address public comments and the recent passing of this legislation.

DWR is also developing guidance to help cities and counties in the Sacramento-San Joaquin Valley comply with the SB 1278 General Plan amendments requirements. The guidance will identify the CVFPP data and analysis that must be incorporated into the general plan amendments, as well as model language to help cities and counties address goals, policies, and objectives for flood risk management planning. It is anticipated that the general plan guidance information will be completed by late 2013. For more information visit: http://www.water.ca.gov/floodsafe/urbancriteria

5.3.5.3 CODES AND STANDARDS

California Building Standards Code Update Project Submittal Narrative

This narrative document is intended to provide clarity on the DWR California Building Standards Code update documents dated June 2009. The proposed code update was divided into three documents based upon occupancy groups and DWR's intention to submit as mandatory or voluntary code requirements. Specifically, these code update documents are proposed to affect:

- Educational Occupancy, Group E (with Mandatory Requirements)
- Residential Occupancy, Group R-3 and R-3.1 (with Mandatory Requirements)
- Residential Occupancy, Group R-1, R-2, and R-4 and Institutional Occupancy, Group I (with Voluntary Requirements)

A description of this effort can be found at:
http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fas/specialprojects/bldgcode/

The proposed code language and the accompanying narrative can be found at: http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fas/specialprojects/bldgcode/Apr2009meetings.cfm

5.3.5.4 PARTICIPATION IN NATIONAL FLOOD INSURANCE PROGRAM (NFIP)

U.S. Congress established the National Flood Insurance Program (NFIP) with the passage of the National Flood Insurance Act of 1968. The NFIP is a program administered by the Federal Emergency Management Agency (FEMA) enabling property owners in participating communities to purchase insurance as protection against flood losses in exchange for state and community floodplain management regulations that reduce future flood damages. In California, approximately 99 percent of California communities participate in the NFIP. For broader training, DWR provides statewide NFIP workshops annually. More information on DWR's management of California's NFIP and Community Rating System (CRS) can be found at: http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fas/nfip/

Currently there are 524 NFIP-participating communities throughout the state. With 255,378 flood insurance policies, California has the fourth largest policy count nationwide. Among other activities, the DWR provides the following services in support of the NFIP:

- Provides technical assistance, guidance, and NFIP training to local communities, other NFIP stakeholders, and federal and state agencies
- Acts as a resource for flood maps, technical data, and other general NFIP information
- Assists local floodplain administrators in maintaining community compliance and wise land use decision-making
- Supports the Community Rating System and provides guidance and opportunities for communities to join and increase their participation
- Participates as an active partner in FEMA's Risk MAP Program
- Provides assistance to local communities and state agencies on FEMA grants
- Writes and edits white papers addressing floodplain management and other NFIP topics
- Provides assistance to the Cal OES and local communities on Local Hazard Mitigation Plans, general plans, and emergency management plans
- Pursues leadership roles and actively participates in national, state, and local Floodplain Management Associations and organizations
- Coordinates with state and local agencies on flood management issues statewide
- Provides pre- and post-disaster support to federal, state, and local agencies, and the general public[54]

Community Rating System Participation

The Community Rating System (CRS), part of the National Flood Insurance Program (NFIP), is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. This is done by providing flood insurance premium discounts to property owners in communities participating in the CRS program. Credit points are earned for a wide range of local floodplain management activities; the total number of points determines the amount of flood insurance premium discounts to policyholders.

The CRS provides Uniform Minimum Credit (UMC) for certain state laws, regulations, and standards that support floodplain management within the state and have proven effective in reducing flood damage. Based on the 2013 CRS Coordinator's Manual, California communities may be eligible for as many as 700 credits depending on their location, level of participation, and compliance with state initiatives.

[54] Five-Year Floodplain Management Strategic Plan 2009-2013

Communities with a current CRS ranking of 10 need a total of 500 credits to reduce their CRS ranking to 9, resulting in a 5% reduction in their community's NFIP insurance premiums. Examples of state programs that qualify for UMC include: California Building Standards Code, State Dam Safety, Hazard Disclosure Requirements, Stormwater Management Requirements, Floodplain Mapping, State Levee Inspections, State Model Ordinances, and State sponsored Outreach Projects. Additional details about the UMC criteria and verification process can be found at the following link:
http://crsresources.org/files/200/umc/california_umc_august_2013.pdf

In California, there are 173,922 flood insurance policies in CRS communities, representing a total of $124,209,085 in premiums paid by policyholders who realize $14,995,861 in savings from their communities' participation in the CRS. The City of Roseville in Placer County has the distinction of being the only community in the United States to achieve a CRS Class 1, thus entitling policyholders to a 45-percent reduction in flood insurance premiums for properties located in special flood hazard area.

Of the top California Repetitive Loss (RL) communities, fewer than half participate in the CRS program. The state encourages all RL communities to participate in the CRS program. Although only 14 percent of the California NFIP-participating communities are also enrolled in the CRS program, this accounts for more than 55 percent of the California NFIP policy base.

For a list of California communities participating in the CRS program, see:
http://www.fema.gov/business/nfip/crs.shtm and click on the "Community Rating System (CRS) Communities and their Classes" link.

Progress Summary 5.P: CRS Coordinator's Manual Update

Progress as of 2013: The 2013 CRS Coordinators' Manual was approved by the Office of Management and Budget for implementation by FEMA beginning on April 1, 2013.

At its first cycle verification visit after April 1, 2013, each participating CRS community will need to meet the new prerequisites and credit criteria set out in the 2013 CRS Coordinator's Manual. No new requirements (including annual recertification requirements) will take effect until the ISO/CRS Specialists review them one-on-one with the community at the next cycle visit. As with all verification visits, the ISO/CRS Specialists will work with communities on items needed for credit verification (documentation), and to identify additional activities for which the community may not have been receiving credit.

The new Coordinator's Manual will affect each CRS community differently. Some communities will see an increase in credit for their existing activities. For example, there will be more credit for Activity 420 (Open Space Preservation). Other communities will see a decrease in credit for certain activities. For example, the credit points provided for Activity 320 (Map Information Service) are being reduced. Webinars providing more details about the Coordinator's Manual and about certain activities are being planned and will be announced through this newsletter in the coming months. In addition, more informational materials will be added to the CRS resources website. These postings will be listed in this newsletter.

The new CRS Coordinators' Manual is available for download at http://crsresources.org/manual

Strategy for Mitigating Severe Repetitive Loss Properties

The Flood Insurance Reform Act of 2004 provided a new opportunity for state governments to mitigate the most flood-prone properties by creating the Severe Repetitive Loss (SRL) Pilot Program. In order to qualify for the SRL program, the properties must meet the following criteria based on paid flood losses since 1978:

- Four or more separate claim payments of more than $5,000 each (building and/or contents) and the cumulative amount of such claims payments exceeds $20,000

Or

- Two or more claim payments (building payments only) where the total exceeds the current market value of the property

At least two of the referenced claims must have occurred within any 10-year period and must be greater than 10 days apart.

(On July 6, 2012, President Obama signed the Biggert-Waters Flood Insurance Reform Act of 2012, which combined the SRL funding into the FMA program, and created a combined National Flood Mitigation Fund. This resulted in administrative changes to how SRL projects are funded as described in the following section.)

Flood Insurance Reform Act of 2012

The Flood Insurance Reform Act, also known as the Biggert-Waters Insurance Reform Act, was passed by Congress in 2012 contains many reforms and changes in the areas of flood insurance and flood mitigation with the goal of making the National Flood Insurance Program more sustainable and more financially sound over the long term. Some aspects of the law are already implemented and other changes will occur in the coming months of 2013. The new law is intended to create a better reinsurance fund to more accurately reflect risk by eliminating subsidized rates and discounts which are no longer sustainable. The Act combined SLR funding into the FMA program, and created a combined National Flood Mitigation Fund.

The Biggert-Waters Act has substantial impacts on the administration of the NFIP through individual states; among other things combining flood mitigation assistance, severe repetitive loss and repetitive flood claims procedures as well as adding elevation, relocation or flood proofing of utilities as allowed mitigation activities. The impacts of these changes are currently being studied by Cal OES.

For an overview of the Biggert-Waters Insurance Reform Act please visit: http://www.fema.gov/flood-insurance-reform-act-2012

5.3.5.5 PLANS AND PROGRAMS

Progress Summary 5.Q: Statewide Flood Management

Progress as of 2013: Major new progress in statewide floodplain management is reflected in the following significant initiatives

FloodSAFE Initiative
Following the passage of Propositions 1E and 84 in 2006, the Department of Water Resources (DWR) established FloodSAFE California (FloodSAFE). FloodSAFE is a long-term strategic initiative developed to reduce flood risk in California. It is designed with the recognition that addressing risks of flood damage statewide will take decades. FloodSAFE is also an important component of DWRs Integrated Water Management (IWM) Initiative, which is designed to achieve a sustainable, robust, and resilient flood and water management system for the benefit of all Californians.

FloodSAFE has established specific principles to guide its program implementation. These principles include:

- Promoting integrated multi-benefit programs
- Approaching flood risk management on a system wide basis
- Investing first where the flood risk is highest
- Promoting integration of land use planning in flood management
- Incorporating ecosystem enhancement, environmental stewardship, and conservation strategy into flood management

During its first phase (2007 to 2012), FloodSAFE implemented various flood risk reduction programs that have improved the level of flood protection for more than three million Californians. In the next phase, FloodSAFE will continue to implement flood risks reduction within the broader context of an integrated water management vision for sustainable multi-benefit integrated flood management that improves public safety, protects and enhances environmental and cultural resources, and supports economic growth by reducing flood risks.

More information on FloodSAFE can be found at:
http://www.water.ca.gov/floodsafe

Flood Risk Notification Program
The Flood Risk Notification Program (FRN) was established due to Water Code Section 9121 and is part of DWR's FloodSAFE California Initiative. The program's key goal is to increase flood risk awareness by effectively communicating that risk to individual property owners, the public, and local, state, and federal agencies. FRN will achieve this goal by:

- Sending out an annual notice to property owners whose property is at risk of flooding.
- Maintaining accurate Levee Flood Protection Zone (LFPZ) maps and an associated parcel information database.
- Providing people with useful ways to assess risk and reduce flood loss.
- Establishing outreach and educational projects with public involvement.
- Expanding its interactive Flood Risk Notification website. Collaborating with federal agencies, local agencies, and communities.

In September 2010, DWR provided the first annual written notice of flood risks to each landowner whose property is protected by State Plan of Flood Control levees and is within a Levee Flood Protection Zone. The notice informs recipients of their property's potential flood risks and potential sources of flooding, and offers flood emergency planning and preparedness tips. An LFPZ web viewer was developed to assist the municipalities and landowners are notified of requirements to satisfy Water Code 9121. The web viewer

allows property owners to view their property location on the LFPZ map and tends to receive the most visits when notices are sent. There were over 4,000 hits on the web viewer in the month of September 2012 (month when notices are sent). More information about the FRN program and the LFPZ web viewer can be found at:
http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fas/risknotification/

California's Flood Future
In 2013, DWR and the U.S. Army Corps of Engineers published the report, "California's Flood Future" (CFF) to look at statewide exposure to flood risk and to identify and address the barriers to improved flood management. The publication was guided by three principles:

- Floods cannot be entirely prevented, but flood management seeks to reduce the risk and consequence of flooding.
- Multiple-benefit flood management from a system-wide perspective provides the most responsible use of public resources.
- Public agencies must achieve sustainable, durable solutions for flood management, informed by flood risk and considering climate change.

CFF includes numerous findings based on consultation with over 140 State agencies responsible for flood management. CFF found that $50 billion in new funding is needed for currently identified projects and more than $100 billion will be needed for additional statewide protection from a 100-year flood. CFF concludes with seven recommendations addressing all levels of necessary flood management. For a more detailed discussion of CFF, see the following section. A copy of the CFF can be accessed at:
http://www.water.ca.gov/sfmp/resources/PRD_FFR_4-3-13MainRPT.pdf

California's Flood Future

The California's Flood Future Report charts a path forward to flood management success that depends upon the following principles:

- Improved information and understanding leads to enhanced public safety and other Integrated Water Management (IWM) benefits
- Flood management solutions must be developed using an IWM approach
- Agencies throughout the State should strive for alignment on governance and policies for flood management
- Financial investment priorities and sustained funding must be established
- California's future depends on elected officials, stakeholders, and agencies at every level of government working together to improve public safety, enhance environmental stewardship, and achieve economic stability

The report points out that investment in flood management will result in savings many times greater for future flood damages and avoid loss of life, livelihood, and ecosystems. Identified short-term actions not requiring additional funding are: the incorporation of flood management in land use planning; improved planning and permitting processes; broader flood management projects (which also benefits other areas such as the environment and water supply); and public agency outreach programs to disseminate information on flood risks and consequences. Urgent long-term solutions include developing stable funding mechanisms for flood management and cooperation among public agencies to achieve efficient, economical, and multiple-benefit projects.

IWM is the preferred approach. It combines specific flood management, water supply, and ecosystem actions to deliver multiple benefits. This approach promotes system flexibility and resiliency. It will require striking a balance between sometimes competing objectives.

CFF consulted with more than 140 of the 1,300 California public agencies responsible for flood management. Findings obtained from those agencies include:

- Different methodologies and inadequate data make risk assessment complex and costly.
- Public understanding of flood risk is inadequate.
- Emergency preparedness and response are not well-funded in every region of the State.
- Land use decisions may not give public safety adequate priority.
- Flood management projects are not prioritized from a system wide or multiple-benefit perspective.
- Flood management responsibility is fragmented.
- Complex permit requirements are obstacles to flood risk reduction.
- Lack of reliable, sustained funding puts California at significant risk.

Flood risk exists in all regions of California, varying according to the terrain, weather patterns, and cultural development of the area. The cost of reducing this risk includes managing floodwater, managing floodplain resources to avoid floodwater, and protecting and restoring natural ecosystems. CFF research identified flood management investment needs of more than $50 billion, including project development, construction, operation, and maintenance costs. The value of agricultural crops subject to flood damage is more than $7 billion, including nearly $6 billion in the Sacramento and San Joaquin River watersheds. San Joaquin, Tulare, and Fresno Counties lead the list with more than $600 million each in crops at risk. No county has fewer than 110 rare, listed, or endangered plant or animal species exposed to flood hazards in 500-year floodplains.

Management of the flood risk is undertaken by a complex framework of public agencies with overlapping and sometimes conflicting mandates. The number of agencies in a hydrologic region ranges from 23 in the North Lahontan region to 326 in the Sacramento River region. These agencies plan, construct, operate, and/or maintain more than 20,000 miles of levees, 1,500 dams, 1,000 debris basins, and other facilities, but these works are still insufficient, leaving people and property at risk. CFF local agency research identified more than 835 new flood management projects being planned or implemented.

CFF also found that $50 billion is needed in new funding for currently identified projects, including operation and maintenance, and more than $100 billion will be needed to provide Statewide protection from a 100-year flood. Some factors contributing to this need are:

- Existing State bond funding will be depleted by 2017.
- The ability of local agencies to fund flood management projects has suffered from public opposition to new property assessments.
- The cost of operations, maintenance, and permitting for existing projects consumes a large portion of local flood management agency budgets.
- Federal interest has historically emphasized damage-reduction benefits and placed less emphasis on ecosystem restoration, regional economic development, and other social benefits.
- Federal funding constraints have led to a lower level of USACE study and construction funding.

DWR and USACE are committed to an Integrated Water Management (IWM) approach to flood management, and are structuring programs to support multiple-benefit projects. IWM is a strategic approach to planning and implementation that combines specific flood management, water supply, and ecosystem actions to deliver multiple benefits. With IWM, there is potential access to funding sources that may not have been available to narrowly focused projects. IWM will require unprecedented alignment and cooperation among public agencies, tribal entities, landowners, interest-based groups, and other stakeholders.

CFF concludes with seven recommendations for State and federal government assistance to reduce risk and consequences of flooding, provide flood risk information for policymaker and public decisions, protect ecosystems, preserve floodplain functions, deliver multiple project benefits, improve flood management governance, identify Statewide investment priorities, and provide sufficient and stable funding for flood management:

1. Conduct regional flood risk assessments to help local governments make informed decisions on land use, emergency response, ecosystem functions, and flood management projects. Strategies include identifying standard risk evaluation methods for each region, assisting local determination of risk reduction goals and acceptable residual risk, identifying opportunities to restore or maintain natural systems, and assisting local assessment of impacts of climate change and sea level rise.

2. Increase public and policymaker awareness about flood risks to engender local, State, and federal government support for flood risk reduction actions, voter support for flood risk reduction funding, and resident support for flood preparedness efforts. For this effort State and federal government should provide consistent language and outreach program tools for increasing public awareness, provide online catalogued information about flood risk programs, grants, and related topics, promote the availability of this information, and share research data.

3. Increase support for flood emergency preparedness, response, and recovery programs to provide effective and comprehensive emergency preparedness, response, and recovery. State and federal strategy will be to provide funding and support for increased coordination, develop or improve Emergency Management Plans, conduct emergency exercises statewide, increase local participation in flood fight training, and identify data and forecasting needs.

4. Encourage land use planning practices that reduce the consequences of flooding to reduce risk to people, property, and economies in floodplains. Strategies include working with land use professionals to develop planning principles facilitating determination of flood risk, facilitating regular coordination at all levels, and linking flood project funding to use of best floodplain management practices.

5. Implement flood management from regional, system wide, and statewide perspectives to provide multiple benefits through use of IWM. The approach would be to identify regional flood planning areas consistent with watersheds, agency jurisdictions, and existing Integrated Regional Water Management Plan funding areas. (IRWM is the application of IWM principles on a regional basis.)

6. Increase collaboration among public agencies to foster innovative solutions, improve planning and permitting, develop high-value multiple-benefit projects, and prioritize investment needs. Strategies would be to establish regional working groups that focus on planning and implementing flood management projects, provide funding and credit for regional planning directed toward multiple-benefit or watershed-based projects, and develop a method of prioritizing and implementing flood management investments.

7. Establish sufficient and stable funding mechanisms to reduce flood risk, eliminate the backlog of identified but unfunded projects, and avoid much larger future costs for flood recovery. State and federal agencies should assess the applicability of potential funding sources, propose new funding options, develop a catalog to improve local access to information on State and federal funding sources, and increase funding for regionally based IWM flood management projects.

More information about the report California's Flood Future can be found at
http://www.water.ca.gov/sfmp/resources/PRD_FFR_4-3-13MainRPT.pdf

Progress Summary 5.R: Central Valley Flood Management

Progress as of 2013: During the upcoming five years, floodplain management will be affected by the changing priorities in California government. This includes strengthened focus on the state's flood condition, increased liability, and deteriorating levees. In addition to FloodSAFE and legislatively mandated activities outlined elsewhere in this section, future achievements will also focus on more education and awareness of flood risks to local communities. This will be accomplished through additional courses and workshops. A Comprehensive Floodplain Management Reference Manual and workshop for locals are forthcoming. In addition, more effort in increasing the Community Rating System program participation is being developed.

Central Valley Flood Management Planning (CVFMP)
The purpose of the Central Valley Flood Management Planning (CVFMP) Program is to develop a sustainable, integrated flood management plan for areas protected by facilities of the state-Federal flood protection system in the Central Valley. The program is one of several that DWR is implementing within FloodSAFE California to accomplish the goals of Propositions 1E and 84. The CVFMP Program will develop and periodically update three important documents: State Plan of Flood Control Descriptive Document, Flood Control System Status Report, and the Central Valley Flood Protection Plan (CVFPP). After the completion of the CVFPP, the CVFMP Program will assist in the planning and coordination of major implementation actions of the 2012 CVFPP including the State-led Basin-Wide Feasibility Studies, locally-led Regional Flood Management Planning, and the Central Valley Flood System Conservation Strategy.

More information about the CVFMP Program can be found at: http://www.water.ca.gov/cvfmp/

State Plan of Flood Control Descriptive Document
DWR has completed the State Plan of Flood Control Descriptive Document to meet the legislative requirements of California Water Code Section 9614, in part, for the Central Valley Flood Protection Plan. The document provides the first complete inventory and description of the flood management facilities, land, programs, conditions, and mode of operations and maintenance for the State-federal flood protection system in the Central Valley. The flood protection system comprises federally and State authorized projects for which the Central Valley Flood Protection Board or DWR has provided assurances of cooperation to the United States federal government.

This report serves as a reference document required by Proposition 1E for the project facilities, lands, programs, plans, conditions, and mode of operations and maintenance that comprise the SPFC. It provides information of what is known about the current SPFC and the major elements of the SPFC. The report will be updated in the future to incorporate any changes made to the SPFC.

The full document can be found at: http://www.water.ca.gov/cvfmp/documents.cfm

Building Standards Code Update Project
DWR developed flood "Life Safety" building codes for two occupancy groups in areas protected by the facilities of the State Plan of Flood Control where flood depths are anticipated to exceed 3 feet for a 200-year flood event, in accordance with Senate Bill 5. Among other things, the building code updates require evacuation locations in residential structures that are easily accessible to emergency personnel. The code updates were unanimously adopted by the California Building Standards Commission. Cities and counties are currently adopting the codes voluntarily.

Flood Control System Status Report
The Flood Control System Status Report (FCSSR) was completed by DWR to meet the legislative requirements of California Water Code Section 9120 and contribute to the development of the Central Valley Flood Protection Plan. The report presents information on the current status (physical condition) of State Plan of Flood Control facilities at a system wide level and guide future inspection, evaluation, reconstruction, and improvement of the facilities.

The full document can be found at: http://www.water.ca.gov/cvfmp/documents.cfm

Central Valley Flood Protection Plan (CVFPP) 2012

The Central Valley Flood Protection Plan (CVFPP) is a document to guide California's participation (and influence federal and local participation) in managing flood risk along the Sacramento River and San Joaquin River systems. The CVFPP is a long-term planning document that will address the flood management challenges as part of a sustainable, integrated flood management approach in areas currently protected by facilities of the State Plan of Flood Control (SFPC). The document fulfills the requirements of the Central Valley Flood Protection Act of 2008 and will be updated every five years.

The CVFPP describes the existing flood risk in the Central Valley and provides recommended actions that can reduce the probability and consequences of flooding. It identifies the mutual goals, objectives, and constraints important in the planning process and recommends improvements to the State-federal flood protection system.

The primary goal of the CVFPP:

Improve Flood Risk Management – Reduce the chance of flooding, and damages once flooding occurs, and improve public safety, preparedness, and emergency response through the following:

- Identifying, recommending, and implementing structural and non-structural projects and actions that will benefit the areas protected by SPFC facilities.
- Provide standards, criteria, and guidelines to guide implementation of structural and non-structural actions for protecting urban areas and other lands of the Sacramento and San Joaquin river basins and the Delta.

Supporting goals of the CVFPP include:

- **Improve Operations and Maintenance** – Modify the flood management systems to reduce system wide maintenance and repair requirements
- **Promote Ecosystem Functions** – Integrate ecosystem functions into flood management system improvements
- **Improve Institutional Support** – Develop stable institutional structures, coordination protocols, and financial frameworks that enable effective and adaptive integrated flood management
- **Promote Multi-Benefit Projects** – Describe flood management projects and actions that also contribute to broader integrated water management objectives identified through other program

Three preliminary approaches were produced and evaluated to address the CVFPP goals. The preliminary approaches were primarily used to explore different potential physical changes to the existing flood management system and to assist in highlighting the need for policy or other management actions. The three preliminary approaches are:

- Achieve State Plan of Flood Control Design Flow Capacity – Focuses on improving SPFC facilities so that they can convey their design flows with a high degree of reliability based on current engineering criteria.
- Protect High Risk Communities – Evaluates improvements to levees to protect life safety and property for high risk population centers, including urban and small communities.
- Enhance Flood System Capacity – Seek opportunities to achieve multiple benefits through enhanced flood system storage and conveyance capacity, to protect high risk communities, and to fix levees in place in rural-agricultural areas.

These preliminary approaches were evaluated based on their costs, benefits, and overall effectiveness in contributing to the CVFPP Goals and other performance measures. The purpose of the evaluation is to examine the performance of each approach and combine the strengths of each into a single preferred approach – State Systemwide Investment Approach (SSIA).

State Systemwide Investment Approach (SSIA)

The State Systemwide Investment Approach (SSIA) reflects the State's strategy for modernizing the SPFC to address current challenges and affordably meet the CVFPP Goals. The SSIA consists of the most promising, affordable, and timely elements of the three preliminary approaches and provides guidance for future State participation in projects and programs for integrated flood management in the Central Valley.

There are two primary types of physical actions for the SSIA:

1. Regional Improvements – Physical actions or projects to achieve local and regional benefits.
2. System Improvements – Large-scale SPFC improvements that provide cross-regional benefits and improve overall flood system function, flexibility, and resiliency.

In order to advance both ongoing and long-term implementation of the SSIA, DWR has initiated Basin-Wide Feasibility Studies, along with associated Regional Flood Management Planning, and the Central Valley Flood System Conservation Strategy. These three planning efforts will be incorporated into the 2017 CVFPP update. The CVFPP document can be found at:
http://www.water.ca.gov/cvfmp/docs/2012%20CVFPP%20FINAL%20lowres.pdf

Basin-Wide Feasibility Studies (BWFS)

DWR will conduct two Basin-Wide Feasibility Studies, one in the Sacramento River Basin and one in the San Joaquin River Basin, to evaluate the feasibility of different alternatives for improving the flood management system including:

- Improving flood management system flexibility and resiliency through expansion and extension of the flood bypass system and other system improvements.
- Integrating ecosystem enhancements and other multi-objective projects with system wide flood management improvements.
- Combining regional improvements with system improvements to identify the State's system wide investment package.

The studies are anticipated to be completed by mid-2016. More information about the studies can be found at:
http://www.water.ca.gov/cvfmp/bwfs/

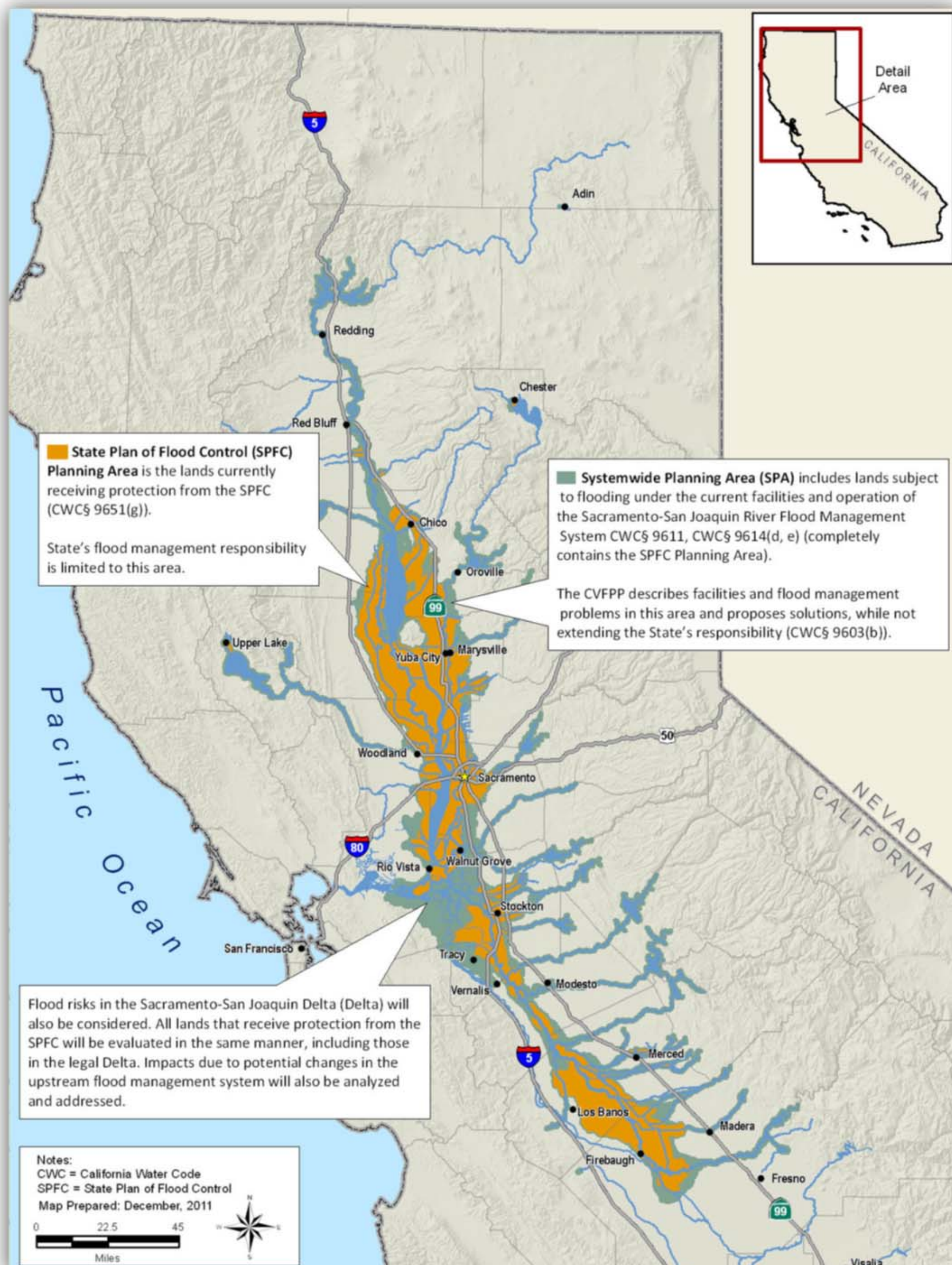
Regional Flood Management Planning (RFMP)

DWR has launched the Regional Flood Management Planning effort to assist local agencies to develop long-term regional flood management plans that address local needs, articulate local and regional flood management priorities, and establish the common vision of regional partners. DWR will provide funding and resource support to help develop regional plans consistent with the 2012 CVFPP.

The regional plans will present local agencies' perspectives of flood management with a prioritized list of projects that need to be implemented to reduce flood risks in each region. Each plan will also present an assessment of the proposed project costs and benefits, considering the projects' potential contributions to an integrated multi-benefit and basin-wide solution. DWR will participate in the planning process as requested by the regional agencies, exchange planning information, provide technical information, and financial assistance through a directed funding program. Feasible components of the completed regional plans will be incorporated in the 2017 CVFPP update.

More information about the RFMP can be found at:
http://www.water.ca.gov/cvfmp/regionalplan/

MAP 5.CC: Geographic Scope of Central Valley Flood Protection Plan



Map 5.CC shows the geographic scope of the Central Valley Flood Protection Plan. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

Central Valley Flood System Conservation Strategy
The Conservation Strategy is integral to implementing the State Systemwide Investment Approach. It describes how to integrate environmental stewardship in flood management improvements and establishes environmental objectives throughout the flood management system. Led by the FloodSAFE Environmental Stewardship and Statewide Resources Office, the Conservation Strategy will be an ongoing part of the 2017 update and flood management projects throughout the State.

More information about the Conservation Strategy can be found at:
http://www.water.ca.gov/floodsafe/fessro/floodway/conservation/

State Plan of Flood Control

Floodplain evaluation activities for the State Plan of Flood Control (SPFC) were initiated in January 2008. The Central Valley Floodplain Evaluation and Delineation program (CVFED) was used to evaluate the SPFC flood flow conveyance. This program is divided into three projects. The first project (Topographic Acquisition) has been completed, providing the following data:

- CVFED aerial photography for 9,000 square miles
- CVFED base LiDAR for 7,800 square miles
- Post-processed CVFED LiDAR for 5,800 square miles
- CVFED surveys for 3,000 cross-sections
- CVFED bathymetry for 2,500 cross-sections
- 100 miles of multi-beam bathymetry for CVFED

Using this topography and recently completed DWR geotechnical studies, the second project (Hydraulic Evaluation) will be completed in 2013, providing the following hydraulic models for the Sacramento River and San Joaquin River Basins:

- Riverine hydraulic models for 1,800 miles
- Floodplain hydraulic models for 5,600 square miles

The third project (Floodplain Delineation) will complete the Urban Level of Flood Protection (200-year flood event) floodplains for 10 urban communities in the Sacramento and San Joaquin River Basins by July 2013. As these projects are completed, their products will be made available for public agency use.

The Flood Protection Corridor Program (FPCP)

The Flood Corridor Program (FCP) includes three flood protection grant programs:

- Flood Protection Corridor Program (FPCP) authorized and funded under Propositions 13 and 84
- Floodway Corridor Program authorized and funded under Proposition 1E
- Central Valley Nonstructural Grants Program authorized and funded under Proposition 1E

The FPCP was established when California voters passed Proposition 13, the Safe Drinking Water, Watershed Protection and Flood Protection Act, in March 2000. The FPCP authorized bond sales of $70 million for primarily non-structural flood management projects that include wildlife habitat enhancement and/or agricultural land preservation.

Proposition 84, the Safe Drinking Water, Water Quality & Supply, Flood Control, River & Coastal Bond Act of 2006, provided renewed funding of $40 million to the FPCP.

Proposition 1E, the Disaster Preparedness and Flood Prevention Bond Act of 2006 (Section

5096.800 of Chapter 1.699 of Division 5 of the Public Resources Code), provided $38 million in additional funds for the Floodway Corridor Program, including funds for constructing new levees necessary for the establishment of a flood protection corridor or bypass and relocating or flood-proofing structures necessary for the establishment of a flood protection corridor. Funds from Proposition 1E must be allocated by 2016.

FCP recognizes the substantial flood protection, floodplain habitat, and agricultural needs of the Central Valley. Following the passage of Proposition 1E in 2006, FCP authorized Proposition 1E funds dedicated to projects that benefit areas protected by State Plan of Flood Control (SPFC) facilities.

More information on the FCP, the propositions that initiated it, and the bonds that fund it can be found at: http://www.water.ca.gov/floodmgmt/fpo/sgb/fpcp/

Any local agency or nonprofit organization with interest in flood management issues is eligible to sponsor projects under FCP that seek to acquire, restore, enhance, and protect real property for the purposes of flood control protection and agricultural land preservation and/or wildlife habitat protection. This includes California Native American Tribes that are registered as a nonprofit organization or that partner with a nonprofit or local public agency. Sponsoring agencies or other organizations that meet the criteria can partner with other types of agencies and organizations, as necessary, to ensure diverse funding sources and necessary expertise on the project team.

Fundable activities under the FPCP include:

- Non-structural flood damage reduction projects within flood corridors
- Acquisition of real property or easements in a floodplain
- Acquisition and removal of structures from flood-prone areas
- Setting back existing flood control levees or strengthening or modifying existing levees in conjunction with levee setbacks
- Preserving or enhancing flood-compatible agricultural use of real property
- Preserving or enhancing wildlife values of real property through restoration of habitat compatible with seasonal flooding
- Repairing breaches in the flood control systems, water diversion facilities, or flood control facilities damaged by a project developed pursuant to Chapter 5, Article 2.5 of the Clean Water, Watershed Protection and Flood Protection Act of 2000
- Establishing a trust fund for up to 20 percent of the money paid for acquisitions to generate interest in maintaining the acquired lands
- Paying the costs associated with the administration of projects

FCP accomplishments through 2013 are as follows:
Between 2000 and 2012, FCP awarded more than $130 million in grant funding for over 35 projects statewide that cover more than 53 square miles in 21 counties, provide flood risk reduction for thousands of people and structures, and reduce the possibility of flood damage. The projects benefit water quality, water supply, wildlife habitat, agriculture, recreation and public access.

FCP grantees have completed 13 projects statewide, including 6 in the Central Valley. All of the projects reduced flood risk and potential flood damage. The projects conserved, restored, and reconnected stream and river floodplains, which enabled the waterways to function more naturally, enhanced native wildlife habitat, and preserved agricultural uses. Statewide, the awarded projects achieve the following benefits:

- 22 projects with detention basins or transitory water storage (5 completed, 17 underway)
- 5 projects removing structures from flood-prone areas (1 completed, 4 underway)
- 28 projects preventing development in floodplains (8 completed, 20 underway)

- More than 9,000 acres of habitat conserved (3,264 acres conserved, over 5,500 acres underway)
- More than 15,000 acres of agricultural land protected (9,138 acres protected, over 6,000 acres underway)

Alluvial Fan Task Force

In 2004, the Governor and Legislature authorized the Alluvial Fan Task Force (Assembly Bill 2141) to review the state of knowledge regarding alluvial fan floodplains, determine future research needs, and prepare recommendations relative to alluvial fan floodplain management. The Task Force plenary meetings were held throughout Southern California, both to help the Task Force understand the current state of alluvial fan knowledge and to develop tools to better manage them and their associated risks in the future. The Task Force found that local governments in Southern California face special challenges in planning and evaluating the suitability of alluvial fans for new development. Each alluvial fan has individual hazards characteristics and resources that could affect public safety, costs, and the environment.

In mid-2010, the Task Force finalized two reports: The Integrated Approach for Sustainable Development on Alluvial Fans and the Findings and Recommendations Report (which includes a model ordinance).
The Integrated Approach is intended to assist local governments by offering a suite of pre-project screening tools that provide a comprehensive process for evaluating alluvial fan hazards and resources. The Integrated Approach also includes flood management tools that are consistent with FEMA regulations and guidelines.

In addition, the Task Force formulated 14 recommendations. These recommendations identify areas that local governments should consider when planning for or considering future development on alluvial fans, as well as other recommendations that the state and federal government provide funding for further work to help communities identify and address the unique issues on alluvial fans. Those recommendation categories are as follows and are detailed in the Findings and Recommendations Report:

- Advance the Understanding of Alluvial Fan Flooding and Flood Hazards
- Integrate Information on Other Hazards, Beneficial Values, and Long-Term Costs for Local Land Use Decisions
- Enhance Support for Local Land Use Decisions
- Provide Technical Assistance and Funding

The Task Force also developed a model ordinance for governing, planning, and development on alluvial fans that cities and counties may voluntarily adapt, and adopt to meet local needs.

To view the reports and obtain additional information about the Alluvial Fan Task Force, please visit: http://aftf.csusb.edu/

Alluvial Fan Floodplain Evaluation and Delineation

The Alluvial Fan Floodplain Evaluation and Delineation (AFFED) project is one component of the California DWR FloodSAFE Initiative. The AFFED project study area is currently limited to the ten southern California counties that participated in the Alluvial Fan Task Force (AFTF). The AFFED project goals support the overall FloodSAFE goals. These include reducing flood risk to residents of California, their homes and property, the State's infrastructure, and public trust resources; developing a sustainable flood management system for the future; and reducing the adverse consequences of floods when they do occur.

To achieve these goals, the project will create preliminary maps of flood hazard boundaries for all alluvial fans within the 10-county study area. The mapping will utilize a methodology that includes the use of two-dimensional computer modeling techniques for the estimation of flooding extents. As of February 2013, DWR has completed preliminary flood hazard maps for alluvial fans in Riverside and Ventura counties.

Urban Streams Restoration

The Urban Streams Restoration Program (USRP) funds grants to local communities for projects to reduce flooding and erosion and associated property damages; restore, enhance, or protect the natural ecological values of streams; and promote community involvement, education, and stewardship. Since 1985, the program has provided over 240 grants ranging from $1,000 to $1 million to communities throughout California. Twelve projects have been awarded over a total of $8,840,335 in grant funds under Propositions 84 and 40 for the 2008 application solicitation.

More information about the Urban Streams Restoration Program can be found at:
http://www.water.ca.gov/urbanstreams/

Coastal Resources Grant Program

Part B grants under the Coastal Resources Grant Program fund projects to help coastal cities and counties effectively exercise their responsibility for improving the management of the state's coastal resources. Only those jurisdictions with Local Coastal Programs approved by the California Coastal Commission are eligible to apply for grant funding.

The types of expenditures eligible for funding through Part B grants include:

- Protection of coastal habitat – projects that provide for the protection of wetlands, floodplains, estuaries, beaches, and dunes that support fish and wildlife and their habitat within coastal areas
- Protection of life and property – projects that minimize the loss of life and property in coastal areas prone to flood, storm surge, geologic hazard, and erosion
- Protection of recreational resources – projects that provide public access to the coast for recreational purposes, acquire coastal viewsheds, and preserve, maintain, and restore historic, cultural, and aesthetic coastal sites
- Protection of coastal economic resources – projects that facilitate siting major facilities along the coast related to fisheries, recreation, ports, and other coastal-dependent commercial uses
- Projects that promote other coastal management improvements that are determined by the Secretary of the Resources Agency to be consistent with the state's coastal management program

Damage is surveyed in a mobile home park as flood water recedes, 1997

Source: Cal OES

FMA Program

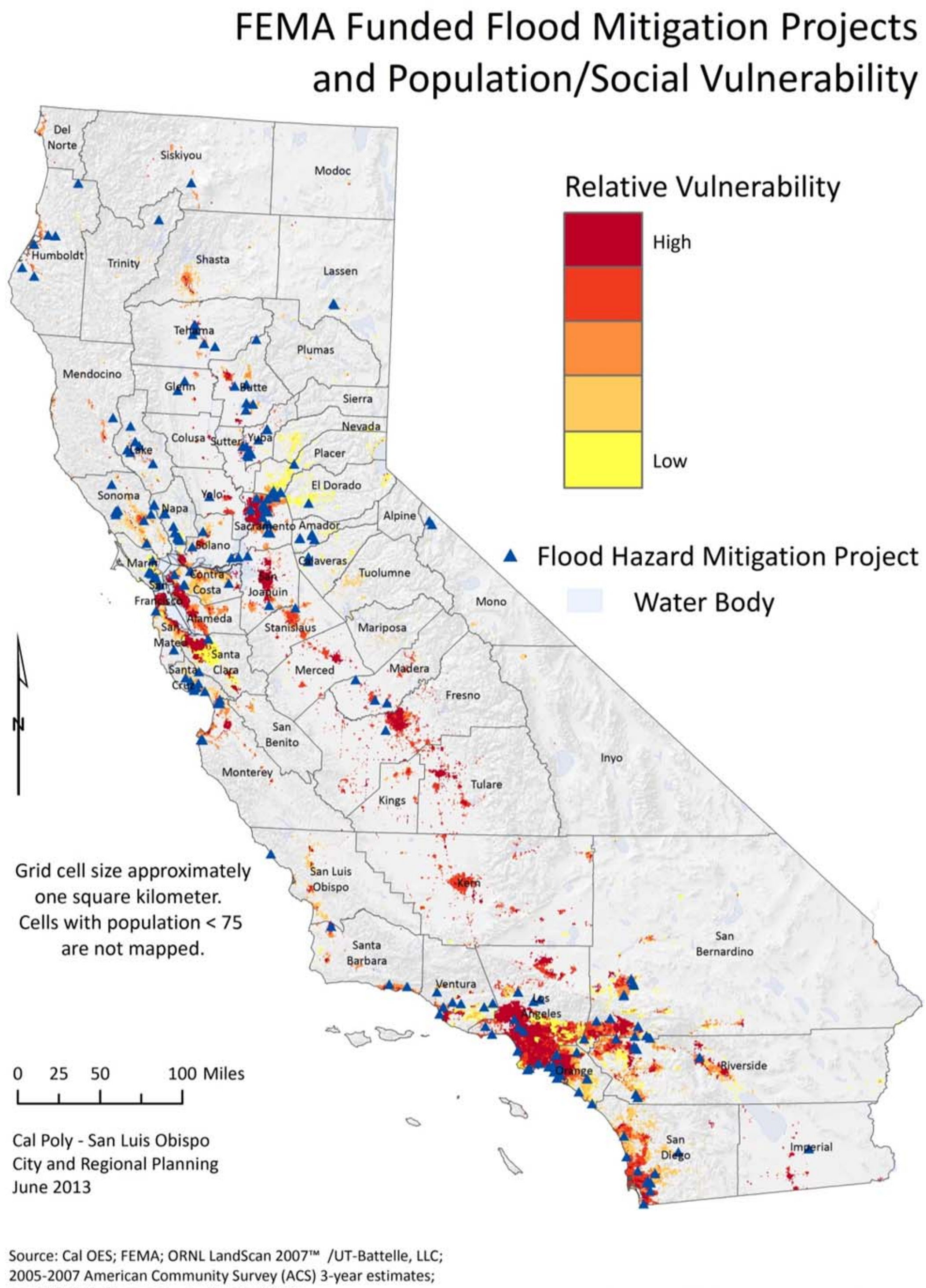
The Flood Mitigation Assistance (FMA) program assists states and local communities in implementing flood hazard mitigation measures before a major disaster occurs. The program targets NFIP communities with numerous repetitive loss structures. The program offers two types of grants to local communities: planning and project grants. A community must have a FEMA-approved Floodplain Management Plan (FMP) or a Local Hazard Mitigation Plan (LHMP), as long as the LHMP includes a flood assessment and mitigation strategy and has been FEMA-approved according to §201.4 or §201.5 of 44 Code of Federal Regulations, to be eligible for FMA grant funding.

A community has two years to develop an FMP and three years to complete a project with FMA funds. Eligible communities may apply for up to $50,000 in FMA planning funds once in a five-year period. The total planning grant funding made available in any fiscal year to any state, including all communities located in the state, cannot exceed $300,000. Project grant funding during any five-year period cannot exceed $10 million to any state or $3.3 million to any eligible community. States also receive technical assistance grants to administer the FMA program. The total assistance grants in any fiscal year during a five-year period cannot exceed $20 million.

Flood Mitigation Projects

During the past ten years, local government and state agencies requested $72.3 million in flood mitigation projects from the Hazard Mitigation Grant Program (HMGP) under the Stafford Act and received a total of $42.6 million.

MAP 5.DD: FEMA-Funded Flood Mitigation Projects and Population/Social Vulnerability



Map 5.DD shows the distribution of flood-related hazard mitigation projects in relation to vulnerable populations in high flood hazard areas. More projects are in the San Francisco Bay Area, Central Valley, and Northern California than in Southern California. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

5.3.5.6 WATER MANAGEMENT AND ENVIRONMENTAL INITIATIVES

Progress Summary 5.S: Water Plans and the Delta

California Water Plan (2013 Update)
The California Water Plan serves as the state's blueprint for integrated water management and sustainability. It details initiatives to ensure reliable water supplies and foundational actions for sustainable water use. It also provides an investment guide for the water community with an array of strategies to achieve multiple goals and benefits; integrates state government initiatives, objectives, and strategies; and incorporates consideration of uncertainties, risks, and resource sustainability into water and flood planning for the future. The 2013 update is currently being developed by DWR and other agencies through rigorous public involvement and State and federal agency coordination processes. It will build on the contents of the previous 2009 update, which provided a strategic plan, a suite of resources management strategies, reports on California's hydrologic regions, and reference and technical guides and will introduce a number of key additional and enhancements in response to stakeholder recommendations and evolving decision-making information needs. The final draft will be prepared and published at the end of 2013. More information on the progress of the California Water Plan Update 2013 is available at:
http://www.waterplan.water.ca.gov/index.cfm

Integrated Water Management
The California Department of Water Resources' Integrated Water Management (IWM) Initiative is designed to achieve a sustainable, robust, and resilient flood and water management system for the benefit of all Californians. Through the successful implementation of an integrated water management program, a broader range of real and lasting benefits can be realized more cost effectively. For example, DWR can improve public safety by reducing flood risk and enhancing environmental quality and ecosystems. Additionally, DWR can contribute to the state's economic sustainability and future economic growth through capital investment that improves flood protection and creates communities that are safer and more secure from flooding while ensuring long-term stability of ecosystems and wildlife, and addressing climate change adaptation.

DWR's IWM approach for managing and upgrading California's aging flood infrastructure incorporates the following elements:

- Considering flood management actions within the context of broader water resources management and land use planning.
- Coordinating flood management activities across geographic, political, and agency boundaries.
- Evaluating opportunities and potential impacts from a system perspective.
- Recognizing the importance of environmental stewardship and sustainability.
- Considering changing climate conditions and population growth in studies and projects.

Delta Stewardship Council
The Delta Reform Act of 2009 created the Delta Stewardship Council (DSC), an independent state agency. The goals of the DSC are to provide a more reliable water supply for California and protecting, restoring, and enhancing the Delta's ecosystem. These goals must be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place. The DSC developed a comprehensive management plan for the Delta (Delta Plan) in 2012 which will include the Bay Delta Conservation Plan (BDCP) providing it is approved by state regulatory agencies and meets certain additional criteria.

More information on the Delta Stewardship Council can be found at: http://deltacouncil.ca.gov/

Bay Delta Conservation Plan

DWR continues work on the Bay Delta Conservation Plan (BDCP), which is being prepared through a collaboration of state, federal, and local water agencies, state and federal fish agencies, environmental organizations, and other interested parties. The plan will identify a set of water flow and habitat restoration actions to contribute to the recovery of endangered and sensitive species and their habitats in California's Sacramento-San Joaquin Delta. The Administrative Draft BDCP was released in three sections between March-May 2013 with the last hearing for review of the third release to occur in July 2013. The Public Draft is planned for release in October 2013 with the Final Draft Planned for approval in early 2014.

Coequal goals of the BDCP are to provide for:

- Species/habitat protection and ecological restoration of sensitive habitats
- Improved reliability of water supplies through dual water conveyance tunnels

The BDCP planning process and the supporting EIR/EIS process is being funded by state and federal water contractors. Cost of implementation of the BDCP over 50 years is projected to be over $25 billion. For a more detailed discussion of BDCP, see the following section.
More information on the BDCP can also be found at: http://baydeltaconservationplan.com/default.aspx

Bay Delta Conservation Plan

The Bay Delta Conservation Plan (BDCP) is a 50-year, ecosystem-based plan designed to restore fish and wildlife species in the Delta in a way that also protects California's water supplies while minimizing impacts to Delta communities and farms. The BDCP is a multiyear collaboration effort between local water agencies, environmental and conservation organizations, state and federal agencies, and other interest groups. It serves as a natural community conservation plan (NCCP) under state law and a habitat conservation plan (HCP) under federal law which will support the issuance of permits from California Department of Fish (CDFW), U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS).

The California Department of Water Resources (DWR), Bureau of Reclamation (Reclamation), and those state and federal water contractors who are seeking to take authorizations for activities covered under the BDCP will have ultimate responsibility for compliance with the provisions of the BDCP and the associated regulatory authorizations. This group is referred to as the Authorized Entities and will work with the fish and wildlife agencies to implement the BDCP.

Projects must agree to implement a suite of habitat restoration measures, other stressor reduction activities, and water operations criteria to obtain approval of necessary long-term permits for various projects and water operations to proceed. The BDCP intends to conserve and improve upon the ecosystem of the Delta while protecting reliable water supplies.

The key elements of the BDCP include:

- Biological goals and objectives for 57 species, 11 of them fish
- Up to 113,000 acres of restored and protected aquatic and terrestrial habitat
- Measures to address other ecological stressors
- A new governance structure to collaboratively implement the BDCP
- New water conveyance facilities to improve flow patterns for Delta fisheries while improving water supply reliability
- A clear process for addressing issues and conflicts as they arise
- Financing mechanisms and funding responsibilities

Conservation Strategy

The conservation strategy was designed to achieve the BDCP's overall goals of restoring and protecting ecosystem health, water supply, and water quality within a stable regulatory framework while meeting regulatory requirements of the Endangered Species Act (ESA) and the Natural Community Conservation Planning Act (NCCPA). The strategy includes the biological goals and objectives and identifies a set of implementation actions. These biological goals and objectives are the means by which the BDCP will measure how well the Plan is working. The biological goals and objectives are the basis of the conservation strategy and serve four important functions:

1. Describe the desired biological outcomes of the conservation strategy and how those outcomes will contribute to the long-term conservation of covered species and their habitats
2. When possible, provide quantitative targets and timeframes for achieving desired outcomes
3. Serve as yardsticks to measure progress in achieving outcomes
4. Provide metrics for the monitoring program to evaluate the effectiveness of conservation measures and as a basis for adaptively managing the conservation measures to achieve the desired biological outcomes.

The conservation strategy is composed of 22 conservation measures and the adaptive management and monitoring program. These 22 conservation measures comprise specific actions to be taken to meet the biological goals and objectives and fall into the following categories:

- Development and operation of new water conveyance infrastructure and the establishment of operational criteria associated with both existing and new facilities
- Protection of existing functioning natural communities that are not currently protected
- Restoration or creation of specific natural communities in areas that do not currently support those communities
- Improvement of existing habitat functions within existing natural communities
- Ongoing management of natural communities and habitat to maximize the ecological function in the reserve system over the long term
- Reduction of the adverse effects on covered fish species that result from specific stressors such as predation, toxic constituents in water, or sediment, and illegal harvest
- Avoidance and minimization of adverse effects of covered activities on covered species

Conservation Measure 1 Water Facilities and Operation

A cornerstone of the BDCP is to construct and operate a dual-conveyance water delivery system that would balance the needs of California's water supplies and the Delta ecosystem. This falls under Conservation Measure 1 Water Facilities and Operation with the primary purpose of constructing and operating a facility that improves conditions for covered species and natural communities in the Delta while improving water supply. CM 1 will consist of:

1. Construction of new water facilities, including:
    - Three new north Delta intakes with state-of the art fish screens. (Capable of diverting 9,000 cfs of water)
    - Two 35-mile long tunnels to carry water to the existing pumping plants in the south Delta (from there, water would flow into existing aqueducts)
    - New Head of Old River operable gate

2. Operation of both new and existing water conveyance facilities, including:
    - North Delta intakes
    - South Delta export facilities
    - Delta Cross Channel gates

- Suisun marsh Salinity Control Gates
- North Bay Aqueduct intake

A decision tree approach will be used to address the uncertainties of spring and fall flow output from the water facilities in CM 1. The decision tree will involve testing hypotheses addressing spring outflow needs and fall outflow needs for different aquatic species before the dual conveyance operations proceed. The decision tree process will end after the hypotheses testing and the adaptive management and monitoring will continue as the primary process for adjusting all aspects of the conservation strategy.

Adaptive Management and Monitoring Program

The adaptive management and monitoring program is designed to use new information and insight gained during the course of Plan implementation to develop and potentially implement alternative strategies to achieve the biological goals and objectives. This adaptive management process describes how changes to the conservation measures may be made in order to improve the effectiveness of the BDCP over time. It will measure the effectiveness of the conservation measures and provide insights to changes in the Delta conditions as a result from climate change.

More information on the BDCP can be found at; http://baydeltaconservationplan.com/Home.aspx

Delta Vision

Gov. Arnold Schwarzenegger's Delta Vision process concluded at the end of 2008, a little more than two years after it began, with a suite of strategic recommendations for long-term, sustainable management of the Sacramento-San Joaquin Delta. The imperiled Delta provides two-thirds of Californians – an estimated 25 million people – with some of their water and is home to more than 750 plant and animal species that, in some cases, are unique to the Delta. More information on Delta Vision, as well as the Delta Vision Committee Implementation Report, the Final Delta Vision Strategic Plan, and the Final Report, can be found at:
http://www.deltavision.ca.gov/index.shtml

A summary document, "Our Vision for the California Delta," can be found at:
http://www.water.ca.gov/deltainit/docs/Delta-Vision-Summary.pdf

Various reports Delta Vision's consultants developed can be found at:
http://www.deltavision.ca.gov/DeltaVisionConsultantReports.shtml

5.3.5.7 EMERGENCY RESPONSE INITIATIVES

Enhanced Flood Response and Emergency Plan Projects

DWR initiated two programs to assist California communities with development or enhancement of existing flood emergency response and recovery plans. A detailed template to create or enhance a flood emergency plan and a grant program to provide financial assistance to local agencies to improve local flood emergency response are now both available to local agencies**.**

Funding for the development of flood emergency response and recovery plans is possible through the Flood Emergency Response Projects grant program. Funded by Propositions 1E and 84, local agencies are required to apply through a grant application process. A total of three grants are available to local agencies: Statewide (outside Delta), Sacramento-San Joaquin Delta, and Delta Emergency Communications. Complete information, including application periods and more detailed description, is available at: http://www.water.ca.gov/floodmgmt/hafoo/fob/floodER/

To aid agencies in the development of comprehensive flood emergency plans, DWR has developed a "Sample Flood Safety Plan." This template provides Central Valley agencies with a general framework, minimum standards, and typical language that may be integrated in existing plans so that those plans would comply with Water Code 9650 requirements. The template is available at: http://www.water.ca.gov/floodmgmt/hafoo/fob/rass/Sample_Flood_Safety_Plan/safetyplan.cfm

Flood Fighting

The emergency measures used to prevent levee failure or to protect structures are known as "Flood Fight Methods." The Department of Water Resources and the U.S. Army Corps of Engineers have been using specific flood fighting methods for many years. The Department of Water Resources provides training in flood fighting methods to local and regional agencies throughout the state including the California Conservation Corps and California Department of Forestry and Fire Protection (CAL FIRE). While most of these methods are designed to be used to protect levees, others have been adapted to defending homes and other structures from floodwaters. These measures are temporary, however, and cannot be expected to last for extended periods of time. DWR has published two instructional documents on flood fighting methods. For levee-oriented methods, see the "Flood Fighting Methods" document at:
http://www.water.ca.gov/floodmgmt/docs/flood_fight_methods.pdf. This document is also available in Spanish.

For home- or structure-oriented methods, see "How to Fight Flooding At Home" at
http://www.water.ca.gov/floodmgmt/docs/brochure_floodfightingathome.pdf

For specific mitigation ideas related to floods, see "Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards" January 2013, prepared by FEMA, available on the FEMA website: http://www.fema.gov/library/viewRecord.do?id=6938

5.3.6 OPPORTUNITIES FOR ENHANCED FLOOD HAZARD MITIGATION EFFORTS

Recent cooperative planning efforts addressing severe storm events hold promise for future mitigation related to potential catastrophic flooding and related impacts. Initiated by the USGS and other agencies, including Cal OES, a severe storm scenario has been developed in a manner similar to the 2008 Southern California ShakeOut Scenario.

The ARkStorm Scenario

Chapter 4 includes a section on the United States Geological Survey (USGS) Multi-Hazards Demonstration Project (MHDP). Within Section 4.6 is a brief discussion about ARkStorm's severe winter storm scenario devised for preparedness, mitigation, and recovery planning purposes. The following discussion expands on the information provided in Chapter 4

Upon conclusion of the initial ShakeOut Scenario, MHDP turned attention to California's other "Big One," a massive, statewide winter storm. The last such storms occurred in the 19th century, outside the memory of current emergency managers, officials, and communities. However, massive storms are a recurring feature of the state, the source of rare but inevitable disasters. Over the last decade, scientists have determined that the largest storms in California are the product of phenomena called Atmospheric Rivers, and so the MHDP storm scenario is called the ARkStorm, for Atmospheric River 1000 (a measure of the storm's size).


K Street, Sacramento, looking east, 1861-1862

For the ARkStorm Scenario, experts designed a large, scientifically realistic meteorological event followed by an examination of the secondary hazards (e.g., landslides and flooding), physical damages to the built environment, and social and economic consequences. The hypothetical ARkStorm would be similar to the intense winter storms of 1861-62 that left California's Central Valley impassible. Storms far larger than the ARkStorm, dubbed megastorms, have also hit California at least six times in the last two millennia.

The ARkStorm produces precipitation in many places exceeding levels experienced on average every 500 to 1,000 years. Extensive flooding in many cases overwhelms the state's flood protection system, which is at best designed to resist 100- to 200-year runoffs (many flood protection systems in the state were designed for smaller runoff events). The Central Valley experiences widespread flooding. Serious flooding also occurs in Orange County, Los Angeles County, San Diego, the San Francisco Bay Area, and other coastal communities. In some places, winds reach hurricane speeds, as high as 125 miles per hour. Hundreds of landslides occur, damaging roads, highways, and homes. Property damage exceeds $300 billion, most of it from flooding. Agricultural losses and other costs to repair lifelines, dewater flooded islands, and repair damage from landslides brings the total direct property loss to nearly $400 billion, of which only $20 to $30 billion would be recoverable through public and commercial insurance. Power, water, sewer, and other lifelines experience damage that takes weeks or months to restore. Flooding evacuation could involve over one million residents in the inland region and Delta counties.

A storm of ARkStorm's magnitude has important implications: 1) it raises serious questions about the ability of existing national, state, and local disaster policy to handle an event of this magnitude; 2) it emphasizes the choice between paying now to mitigate, or paying a lot more later to recover; 3) innovative financing solutions are likely to be needed to avoid fiscal crisis and adequately fund response and recovery costs; 4) responders and government managers at all levels could be encouraged to conduct self-assessments and devise table-top exercises to exercise their ability to address a similar event; 5) the scenario can be a reference point for application of FEMA and Cal OES guidance connecting federal, state, and local natural hazards mapping and mitigation planning under the NFIP and Disaster Mitigation Act of 2000; and 6) common messages to educate the public about the risk of such an extreme event could be developed and consistently communicated to facilitate policy formulation and transformation.

To better prepare California for large-storm disasters, MHDP brought together key decision-makers from state, local, and federal government as well as scientific, planning, response, and forecasting agencies.
ARkStorm will be used in an upcoming golden Guardian exercise.

The ARkStorm report was published in January 2011. To download the ARkStorm report, visit: http://pubs.usgs.gov/of/2010/1312/

5.4 WILDFIRE HAZARDS, VULNERABILITY AND RISK ASSESSMENT

This section addresses wildfire as one of three primary hazards in the classification system introduced earlier in this chapter and includes information identifying the following dimensions of this hazard:

- Current and historical trends in wildland fire
- Wildland-urban interface (WUI) fires versus wildland fires
- Wildfire protection responsibility in California
- Location within the state (i.e., geographic area affected)
- Previous occurrences within the state
- Probability of future events (i.e., chances of recurrence)

5.4.1 IDENTIFYING WILDFIRE HAZARDS

Among California's three primary hazards, wildfire, and particularly wildland-urban interface (WUI) fire, represents the third most destructive source of hazard, vulnerability, and risk, both in terms of recent state history and the probability of future destruction of greater magnitudes than previously recorded.

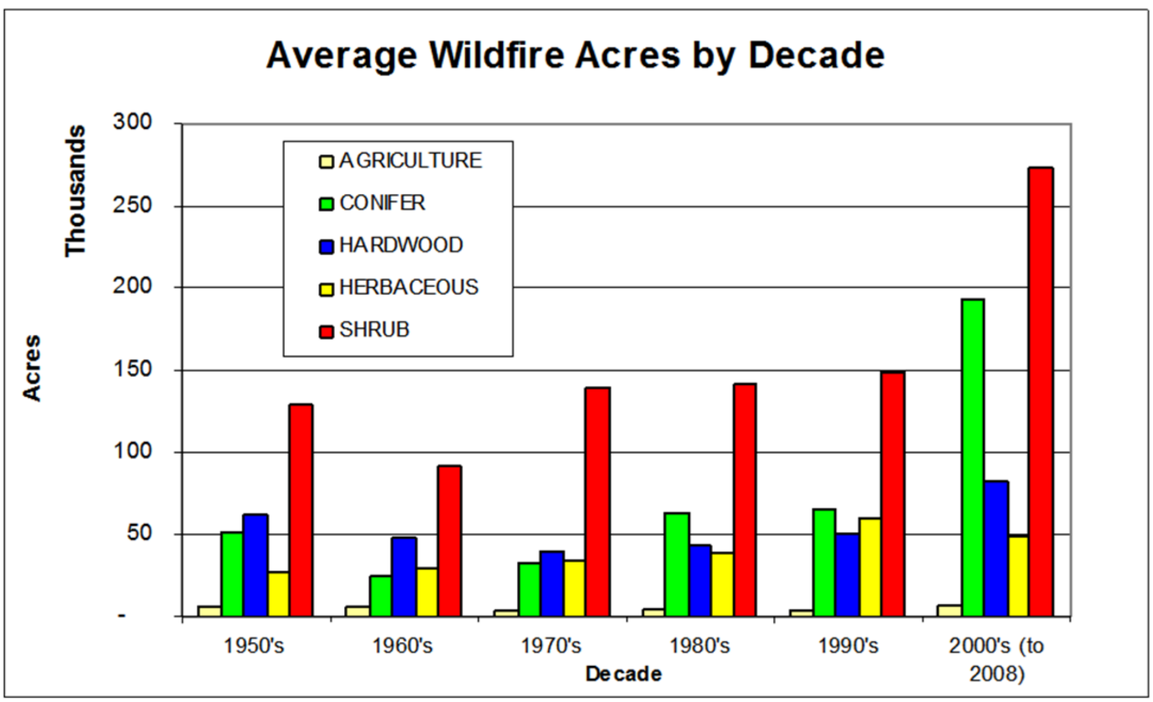
Current and Historical Trends in Wildland Fire

California is recognized as one of the most fire-prone and consequently fire-adapted landscapes in the world. The combination of complex terrain, Mediterranean climate, and productive natural plant communities, along with ample natural and aboriginal ignition sources, has created a land forged in fire. Excluding fires occurring in the desert, estimates of annual acreage burned prior to the arrival of European settlers range between 4.5 and 12 million acres annually (Stephens et al., 2007). These findings indicate the dramatic influence of natural wildfire, which supports and maintains ecosystem structure and function in California's wildlands.

Dramatic changes in fire activity accompanied the European settlement of California, partly due to agriculture, grazing, logging, and mining. These changes were magnified through land use practices (agriculture, urbanization) that removed natural fuel. After the turn of the 20th century, these land uses were organized around fire suppression designed to protect people and property.

From 1950 to 2008, an average of 320,000 acres burned annually. However, there is substantial annual variability, attributable to weather conditions and large lightning events that result in many dispersed ignitions in remote locations. Annual totals range from a low of 31,000 acres in 1963 to a high of 1.37 million acres in 2008. Looking at acreage burned by decade and life form confirms these basic trends. Fire is most common in shrublands across all decades, with a large spike in the first decade of the 2000s (see Chart 5.A).

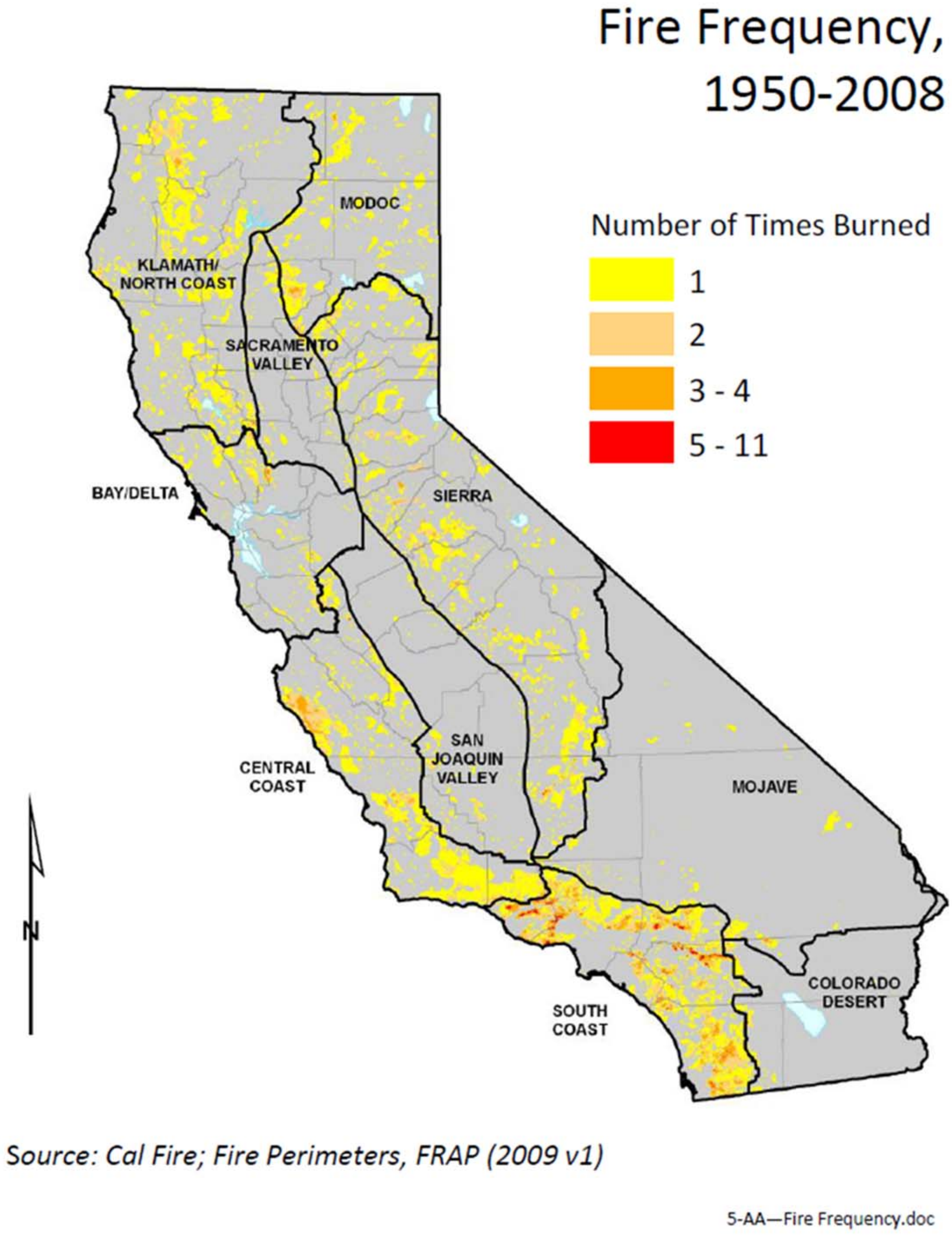
Chart 5.A: Annual Acres Burned by Decade and Life Form, 1950-2000s



Source: Fire perimeters, FRAP (2009 v1); Statewide Land Use/Land Cover Mosaic, FRAP (2006)

Since 1950, an upward trend in acres burned is strongly evident. Although conifer, hardwood, and herbaceous (grassland) burned at relatively similar amounts through the 1970s, 1980s, and 1990s, conifer shows a very large increase in annual acres burned during the 2000s, averaging 193,000 acres burned per year, contrasted with an average of 48,000 acres burned each decade over the preceding four decades. The three largest fire years were all in the most recent decade (2003, 2007, 2008). The total annual average acres burned since 2000 is 598,000, or almost twice that burned in the pre-2000 period (264,000 acres).

MAP 5.EE: Fire Frequency (Number of Times Burned), 1950-2008



Map 5.EE shows the distribution of burn frequency from 1950 to 2008. The South and Central Coast bioregions show highest frequencies. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

Research additionally indicates trends of 1) increased fire severity, particularly in coniferous forest types of the Sierra (Miller et al., 2008; Lutz, et al., 2009); 2) increased human infrastructure at risk (Theobald and Romme, 2007); 3) increased hazards and risks associated with vegetation fires due to climate change (Fried et al., 2006; Lenihan et al., 2006; Westerling et al., 2009); and 4) increasing cost of fire suppression (Calkin et al., 2005; Gebert, 2008) and losses (Bryant and Westerling, 2009). These studies together suggest that patterns exhibited in recent history will intensify due to changes in both threats and assets exposed.

Wildland Fire vs. Wildland-Urban Interface Fires

There are two primary types of wildfires: "wildland-urban Interface" (WUI) fire and "wildland" fire. This distinction is important because mitigation, damage, and actions related to the two types may differ significantly.

California experiences an average of 5,000 WUI fires each year. WUI is defined as "the area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels." For more information and definitions, see: http://www.nwcg.gov/pms/pubs/ and select "glossary".

Most WUI fires are controlled so that they cover minimal acreage and cause minimal damage; the remainder cause extensive damage. Many of these WUI fires occur in areas that have a historical pattern of wildland fires that burn under extreme conditions. The most common extreme fire behavior factor is high wind, such as Santa Ana winds, that follow a predictable location and seasonable pattern.

WUI fire represents a significant concern for the State of California for several reasons. First, California has a chronic and destructive WUI fire history. Since 1950, 56 percent (86) of federally declared disasters in the state were the result of WUI fires. California has widespread WUI fire vulnerability, as indicated by CAL FIRE mapping of WUI zones showing increasing pattern of development encroaching into previously wildland areas. WUI fire zones are present near many populated areas. Third, nearly all local governments that have submitted Local Hazard Mitigation Plans (LHMPs) have identified fire and WUI fires as hazards.

WUI fires occur where the natural forested landscape and urban-built environment meet or intermix and tend to be the most damaging. Even relatively small acreage fires may result in disastrous damages. The 1991 Oakland Hills WUI fire (Tunnel Fire) destroyed more than 2,800 buildings and claimed 25 lives, yet only burned 1,600 acres, a small to medium-sized fire at most by wildland fire standards. The damages are primarily reported as damage to infrastructure, built environment, loss of socio-economic values, and injuries to people.

The pattern of increased damages is directly related to increased urban spread into historical forested areas that have wildfire as part of the natural ecosystem. Many WUI fire areas have long histories of wildland fires that burned only vegetation in the past. However, with new development, a wildland fire following a historical pattern now burns developed areas. WUI fires can occur where there is a distinct boundary between the built and natural areas or where development or infrastructure has encroached or is intermixed in the natural area. WUI fires may include fires that occur in remote areas that have critical infrastructure easements through them, including electrical transmission towers, railroads, water reservoirs, communications relay sites, or other infrastructure assets.

Wildland fires that burn in natural settings with little or no development are part of a natural ecological cycle and may actually be beneficial to the landscape. Century-old policies of fire exclusion and aggressive suppression have given way to better understanding of the importance fire plays in the natural cycle of certain forest types.

Fire is being used more extensively as a land management tool to replicate natural fire cycles; this policy change has resulted in intentionally larger acreages burned, especially in federally managed land areas. There may be secondary negative impacts from the wildland fire related to air quality, soil erosion resulting in siltation of streams and lakes, or mudslides. However, unless these fires affect occur in developed areas, they are rarely classified as disasters because they do not affect people or the built environment. Wildland fires, regardless of size, that burn primarily on federally managed lands are only rarely classified as disasters.

The 2007 Zaca Fire and 2009 Station Fire, the largest wildland fires in the history of Santa Barbara and Los Angeles counties, respectively, burned on land managed by the U.S. Forest Service; neither fire obtained federal disaster status. The 2007 Zaca Fire burned more than 220,000 acres in Santa Barbara County and was one of the largest fires in the history of California. Because it burned in a wildland area and did not burn structures, however, the Zaca Fire did not even meet Fire Management Assistant Grant (FMAG) criteria. Concerns about the secondary hazard of downstream flooding, especially in the vulnerable Santa Maria River levee system, were high because a high percentage of the watershed that feeds that river was burned.

Wildfire Protection Responsibility in California

There are literally hundreds of agencies that have fire protection responsibility for wildland and WUI fires in California. Local, state, tribal, and federal organizations have legal (and financial) primary responsibility for wildfire fire protection. In many instances, two fire organizations have dual primary responsibility on the same parcel of land — one for wildland fire protection and the other for structural or “improvement” fire protection.

This layering of responsibility and resulting dual policies, rules, practices, and legal ordinances can cause conflict or confusion. To address wildland fire jurisdictional responsibilities, the California state legislature in 1981 adopted Public Resource Code Section 4291.5 and Health and Safety Code Section 13108.5 establishing Federal Responsibility Areas (FRAs), State Responsibility Areas (SRAs), and Local Responsibility Areas (LRAs).

Federal Responsibility Areas (FRAs)

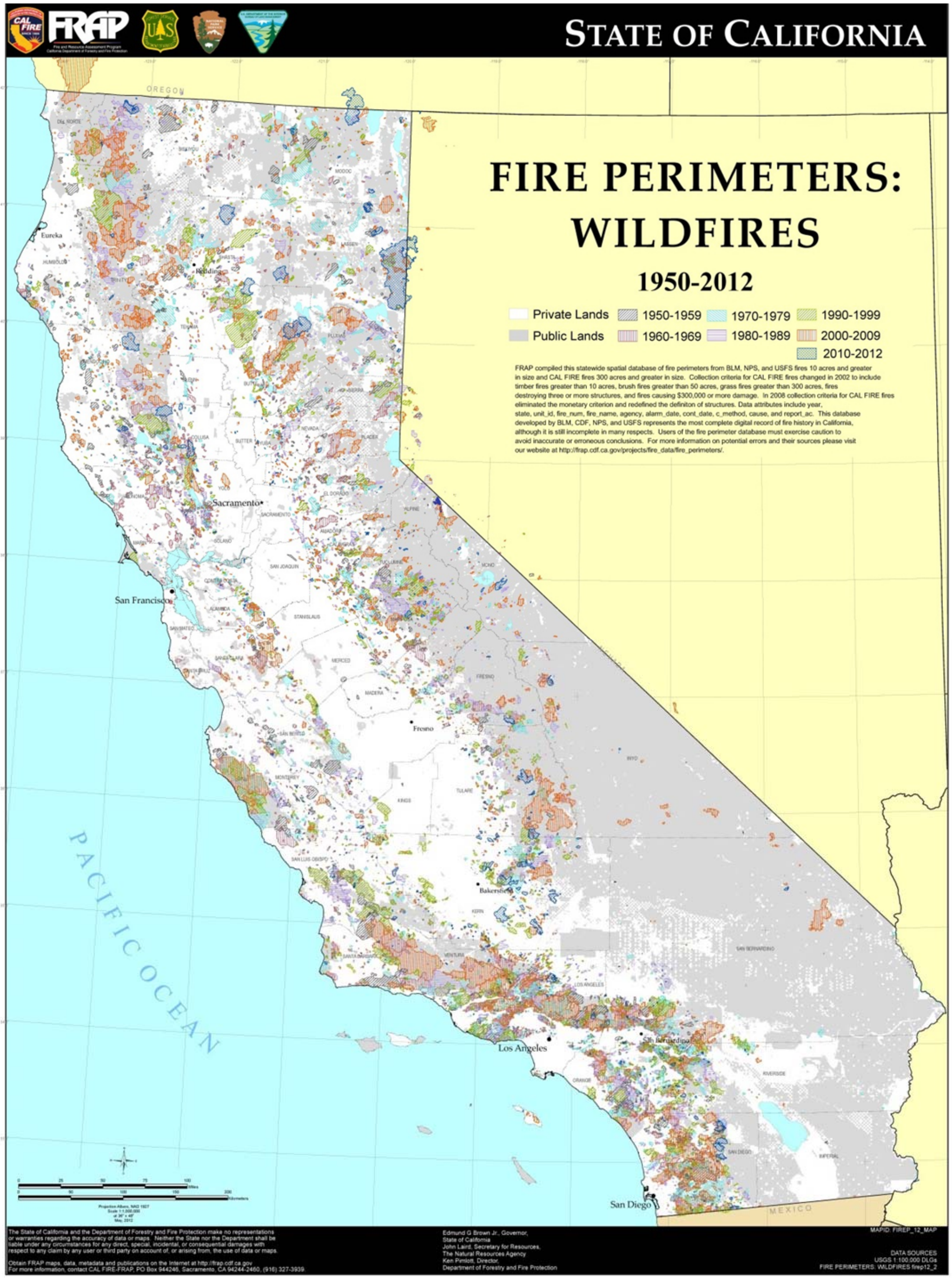
Federal Responsibility Areas (FRAs) are fire-prone wildland areas that are owned or managed by a federal agency such as the U.S. Forest Service, National Park Service, Bureau of Land Management, U.S. Fish and Wildlife Service, or U.S. Department of Defense. Primary financial and rule-making jurisdictional authority rests with the federal land agency. In many instances, FRAs are interspersed with private land ownership or leases. Fire protection for developed private property is usually NOT the responsibility of the federal land management agency; structural protection responsibility is that of a local government agency.

State Responsibility Areas (SRAs)

State Responsibility Areas (SRAs) are those lands within California that meet specific geographic and environmental criteria. These are areas where CAL FIRE has legal and financial responsibility for wildland fire protection and where CAL FIRE administers fire hazard classifications and building standard regulations. SRAs are defined as lands that 1) are county unincorporated areas, 2) are not federally owned, 3) have wildland vegetation cover rather than agricultural or ornamental plants, 4) have watershed and/or range/forage value, and 5) have housing densities not exceeding three units per acre.[55] Similar to the FRAs, where SRAs contain built environment or development, the responsibility for fire protection of those improvements (non-wildland) is that of a local government agency.

[55] CAL FIRE web page, url: http://frap.cdf.ca.gov/projects/hazard/hazard.html#SRAdef

MAP 5.FF: Fire Perimeters: Wildfires 1950-2012



Map 5.FF, published by CAL FIRE shows fire perimeters from 1950 to 2012. Fires are shown by decade intervals, overlaid on public lands shown in grey. Most fires have occurred in hilly and mountainous areas of the state, especially in mountainous regions near populated areas of Southern California. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

Local Responsibility Areas (LRAs)

Local Responsibility Areas (LRAs) include land within incorporated cities, cultivated agriculture lands and non-flammable areas in unincorporated areas and those lands that do not meet the criteria for SRA or FRA. LRA fire protection is typically provided by city fire departments, fire protection districts, and counties, and by CAL FIRE under contract to local governments. The significance of these terms for land use and building regulation is discussed later in this section. LRAs may include flammable vegetation and WUI areas where the financial and jurisdictional responsibility for improvement AND wildland fire protection is that of a local government agency.

Rule-Making Authority and Financial Responsibility

The significance of the FRA, SRA, and LRA designations relates to the rule-making authority and financial responsibility for fire protection. Local government agencies (cities and counties) typically control the authority to enact and enforce land use ordinances, building codes, and fire codes for development within their boundaries. This land use authority includes those areas where the local agency shares fire protection responsibility with either FRAs or SRAs. Financial responsibility for wildland fire protection is a significant issue because wildland fire protection is very expensive and considerably more expensive in WUI areas.

Urban Fire Conflagration Potential

Although this SHMP focuses primarily on wildfires, it recognizes urban conflagration, or a large disastrous fire in an urban area, as a major hazard that can occur due to many causes such as wildfires, earthquakes, gas leaks, chemical explosions, or arson. The urban fire conflagration that followed the 1906 San Francisco Earthquake did more damage than the earthquake itself. A source of danger to cities throughout human history, urban conflagration has been reduced as a general source of risk to life and property through improvements in community design, construction materials, and fire protection systems.

For example, following the Great Chicago Fire of 1871, improvements in architecture, building design, and construction materials helped to reduce the likelihood of recurrence. Subsequent improvements in construction have been encouraged throughout the U.S. by modern building and fire codes. The Great Chicago Fire burned approximately 2,000 acres and is estimated to have killed 200 to 300 people and damaged 17,500 buildings. It is interesting to note that on the same day as the wind-driven Great Chicago Fire, one of the most devastating WUI fires in United States history occurred in Peshtigo, Wisconsin. Driven by the same winds that spread the fire in Chicago, the fires in Wisconsin burned more than 1,000,000 acres of forest, destroyed several entire towns, and killed more than 1,500 people. While the urban fire codes changed significantly after the Great Chicago Fire, WUI fire codes have only recently gathered significant attention.

Although the frequency of urban conflagration fires has been reduced, they remain a risk to human safety. One reason is the current trend toward increased urban density and infill in areas adjacent to the wildland-urban interface. In an effort to keep housing close to urban jobs, areas previously left as open space due to steep slopes and high wildland fire risk are being reconsidered as infill areas for high-density housing.

A memorable example of urban conflagration linked to wildland fire in recent California history is the Oakland Hills firestorm, officially known as the Tunnel Fire. The firestorm occurred on October 20, 1991, within a larger high fire hazard zone that is part of an approximately 60 mile stretch of hills running from the Carquinez Strait to San Jose in the east San Francisco Bay Area. The fire occurred in portions of the cities of Oakland and Berkeley situated near the juncture of the State Route 24 and 13 freeways. In Oakland 2,777 units were destroyed or badly damaged. An additional 69 units were destroyed within the city of Berkeley.

The fire happened in an economically well-off, largely built-out residential area that has a long standing fire history linked to hot, dry fall winds and the presence of dense, flammable vegetation. Seasonably strong, dry winds drove flames furiously and rapidly across an approximately two-and-one-half square mile area of densely developed hillside neighborhoods.[56]

5.4.2 PROFILING WILDFIRE HAZARDS

The Challenge of Wildland-Urban Interface Fire

California has a history of WUI fires that have destroyed thousands of buildings, caused catastrophic damage to vital infrastructure, and killed and injured many people. Not all of this damage occurs in disastrous-sized WUI fires; thousands of WUI fires occur in California every year.

Many of these cause damage to buildings and infrastructure without reaching disaster proportions. Likewise, fires that originate in the WUI from structures or other improvements can cause damage to the wildland resources and non-WUI assets at risk. Where bio-geophysical conditions (weather, flammable vegetation, and topography) exist to support wildland fires, those fires will continue to occur on a repetitive cycle. Unless the weather, fuel, or topography conditions change such that wildland fires can no longer burn, these areas will have repetitive fires. When development encroaches into these historical fire-prone areas creating a WUI area, damaging WUI fires will repeatedly occur.

California has had a long history of disastrous WUI fires beginning with the 1923 Berkeley Fire that destroyed 584 buildings while burning 123 acres. Repetitive wildland fires do occur, as noted above; a significant lesson about this 1923 fire is that WUI fire revisited this same location in 1970 and again in 1991 with the most damaging WUI fire in California history. Other important WUI fire events in California history that caused changes in the approach to WUI fires were:

- The 1961 Bel Air Fire, which resulted in examination of wooden roofs in WUI areas
- The 1970 Fire Siege, which resulted in development of the Incident Command System (ICS) and enhanced state and federal wildland fire service mutual aid methods for WUI fires
- The 1980 Southern California Fire Siege, which resulted in the creation of the CAL FIRE Vegetation Management Program
- The 1985 Fire Siege, which resulted in major expansion of local government fire service mutual aid on WUI fires
- The 1988 49er Fire, which was identified as the “WUI fire problem of the future” due to urban expansion from Sacramento metropolitan area into Sierra foothills
- The 1991 Tunnel Fire, which resulted in creation of the Standardized Emergency Management System (SEMS) in California and legislation requiring Fire Hazard Severity Zone mapping in LRAs (AB 337-Bates)
- The 1993 Laguna Fire, which resulted in creation of the California Fire Safe Council concept and changes to flammable roofing codes
- The 2003 Fire Siege, which resulted in changes to defensible space clearances from 30 feet to 100 feet and formation of Governor’s Blue Ribbon Commission on WUI fires
- The 2007 Angora Fire, which resulted in a California-Nevada Governors’ Blue Ribbon Commission examination of WUI fire issues in Lake Tahoe area
- The 2008 Sylmar Fire in Los Angeles, which led to revision of mobile home fire safety
- The 2009 Station Fire in the Angeles National Forest which led to re-examination of wildland fire management in proximity to urban areas

In October 2007, a series of large wildfires ignited and burned hundreds of thousands of acres in Southern California. The fires displaced nearly one million residents, destroyed thousands of homes, and took the lives of 10 people. Within the context of wildland fire, the Southern California Siege of 2007, along with the

[56] K. C. Topping, J. Schwab, et al. Planning for Post-Disaster Recovery and Reconstruction, American Planning Association, Planning Advisory Service, Report No. 483/484. 1998. p. 261-262.

Angora Fire in South Lake Tahoe, demonstrated again a well-recognized fact that fire is an integral component of California's ecosystems. The Angora Fire burned 3,100 acres and destroyed 242 homes and 67 commercial structures during late June 2007. Wildfires are costly, compromising watersheds, open space, timber, range, recreational opportunities, wildlife habitats, endangered species, historic and cultural assets, wild and scenic rivers, other scenic assets, and local economies, as well as putting lives and property at risk.

On average, 9,000 wildfires burn half a million acres in California annually. While the number of acres burned fluctuates from year to year, a trend that has remained constant is the rise in wildfire-related losses. Likewise, fires that originate in the WUI from structures or other improvements can cause damage to the wildland resources and non-WUI assets at risk. The challenge is in how to reduce wildfire losses within a framework of California's diversity.

Table 5.W shows the most disastrous WUI fires listed in order of structures destroyed. Eighty percent of the most damaging WUI fires have occurred in the last 20 years. Of the fires in the two decades the Tunnel Fire in Oakland and the Cedar Fire in San Diego were by far the most destructive in terms of structures burned.

Table 5.W: Fire History by Number of Structures Destroyed

	FIRE NAME	DATE	COUNTY	NUMBER OF ACRES	NUMBER OF STRUCTURES
1	*TUNNEL*	October 1991	ALAMEDA	1,600	2,900
2	*CEDAR*	October 2003	SAN DIEGO	273,246	2,820
3	*WITCH*	October 2007	SAN DIEGO	197,990	1,650
4	*OLD*	October 2003	SAN BERNARDINO	91,281	1,003
5	*JONES*	October 1999	SHASTA	26,200	954
6	*PAINT*	June 1990	SANTA BARBARA	4,900	641
7	*FOUNTAIN*	August 1992	SHASTA	63,960	636
8	*SAYRE*	November 2008	LOS ANGELES	11,262	604
9	*CITY OF BERKELEY*	September 1923	ALAMEDA	130	584
10	*HARRIS*	October 2007	SAN DIEGO	90,440	548
11	*BEL AIR*	November 1961	LOS ANGELES	6,090	484
12	*LAGUNA FIRE*	October 1993	ORANGE	14,437	441
13	*LAGUNA*	September 1970	SAN DIEGO	175,425	382
14	*HUMBOLDT*	June 2008	BUTTE	23,344	351
15	*PANORAMA*	November 1980	SAN BERNARDINO	23,600	325
16	*TOPANGA*	November 1993	LOS ANGELES	18,000	323
17	*49ER*	September 1988	NEVADA	33,700	312
18	*ANGORA*	June 2007	EL DORADO	3,100	309
19	*SIMI*	October 2003	VENTURA	108,204	300
20	*SLIDE*	October 2007	SAN BERNARDINO	12,759	272

Source: CAL FIRE, Data from CAIRS and EARS databases and Red Book

MAP 5.GG: State of California Fire Threat

Map 5.GG, published by CAL FIRE, shows wildfire threat widely distributed across hilly and mountainous terrain throughout California. Threat is a measure of the potential fire severity. Urban areas are shown as facing a moderate threat in this model due to exposure from WUI fires and windblown embers that could result in urban conflagration. (*Online or download viewers can zoom in for a closer view of the information on this map.*)

Hazard vs. Risk

The diversity of WUI settings and disagreement about alternative mitigation strategies have led to confusion and different methods of defining and mapping WUI areas. One major disagreement has been caused by terms such as “hazard” and “risk” being used interchangeably. Hazard is the physical condition that can lead to damage to a particular asset or resource. The term “fire hazard” is related to those physical conditions related to fire and its ability to cause damage, specifically how often a fire burns a given locale and what the fire is like when it burns (its fire behavior). Thus, fire hazard only refers to the potential characteristics of the fire itself.

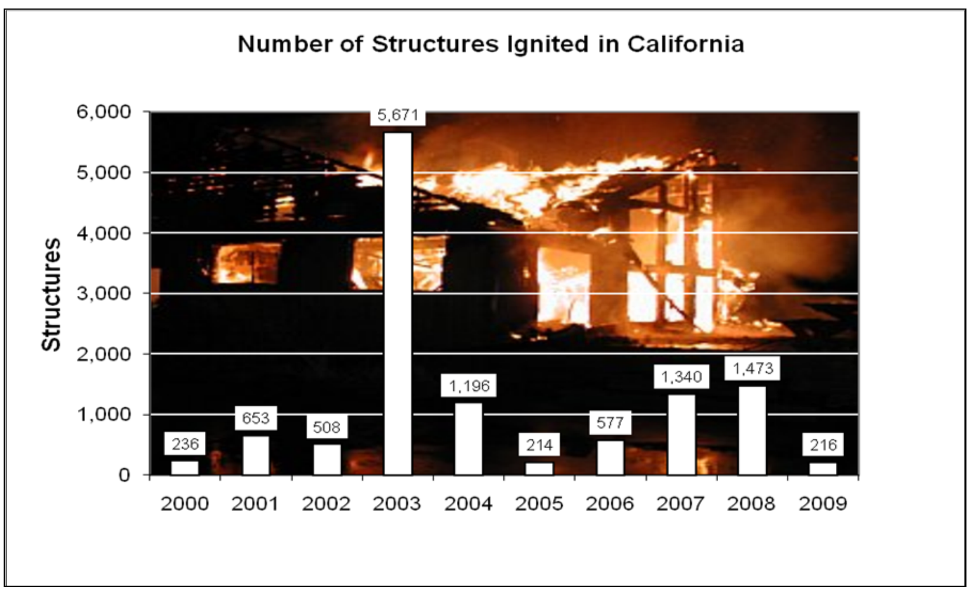
Risk is the likelihood of a fire occurring at a given site (burn probability) and the associated mechanisms of fire behavior that cause damage to assets and resources (fire behavior). This includes the impact of fire brands (embers) that may be blown some distance igniting fires well away from the main fire.

Wildland Fire Suppression

The 2010 Strategic Fire Plan has seven broad goals that identify a variety of actions to minimize the negative effects of wildland fire. Additionally, CAL FIRE has a suppression goal to contain 95 percent of fires at 10 acres or less. Statewide, approximately 97 percent of all vegetation fires are contained within the first few hours after they are reported. The remaining 3 percent either move too quickly or are too intense for available fire suppression resources to handle. Multiple large fires can quickly draw down the pool of fire suppression resources, making it more difficult to bring the fires under control.

Chart 5.B shows structures ignited by wildfire in California from 2000 through 2009. Overall, 5,000 wildfires have burned 200,000 acres in California. The numbers of ignited structures rose significantly with the Southern California wildfires of 2003 and then dropped back substantially in the period from 2004 through 2008.

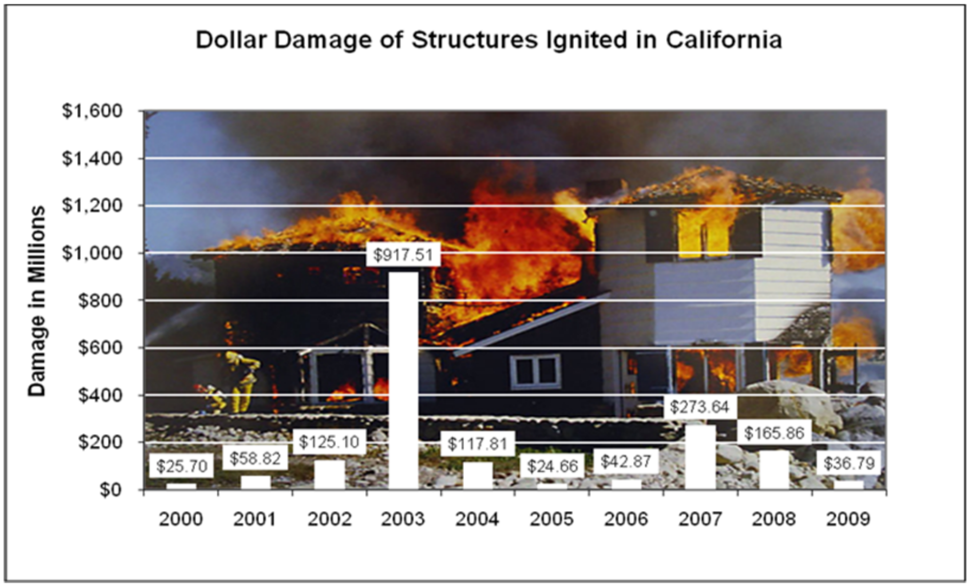
Chart 5.B: Structures Ignited in California Since 2000



Source: Data from CAIRS, CFIRS and EARS databases; CAL FIRE

While the number of acres burned fluctuated, wildfire-related financial losses tended to increase in recent decades. From 1947 to 1990, dollar damages (in 2001 dollars) to structures and other resources in California exceeded $100 million only once, as contrasted with five occasions in the 2000s. Chart 5.C shows financial losses since 2000.

Chart 5.C: Wildfire-Related Dollar Damage in California Since 2000



Source: Data from CAIRS, CFIRS and EARS databases; CAL FIRE

5.4.3 ASSESSMENT OF STATE WILDFIRE VULNERABILITY AND POTENTIAL LOSSES

Homes in Wildland-Urban Interface (WUI) Areas

Wildfire poses significant risk to the people of California and their homes, as evidenced by an increasing trend in structural losses from wildland fires. The risk is predominantly associated with wildland-urban interface (WUI) areas. WUI is a general term that applies to development interspersed within or adjacent to landscapes that support wildland fire.

Threatened Homes in Wildland-Urban Interface Area

Source: CAL FIRE

Significant WUI Fire Events

Significant wildfire events in recent California history include the previously mentioned Oakland firestorm in October 1991 and the 2003, 2007, and 2008 Southern California wildfires. These events have led to major new legislation affecting development in such areas, described below. The Oakland firestorm, also known as the Tunnel Fire, ignited in an area that had experienced fires before, including one in 1923 that burned into Berkeley destroying more than 600 homes in one hour, as well as one in September 1970 in the same neighborhood that burned 200 acres and destroyed 37 homes. This sort of repetitive fire occurrence and structure loss in a given area is not uncommon in California, where extreme weather and fuel conditions often combine to create a cyclical potential for major fire losses.

With structure loss five times greater and loss of life twice as great as any previously recorded wildfire in California, the Oakland firestorm became the baseline for discussing fire loss potential in the state until the Southern California wildfires of 2003. This event consisted of 13 fires that burned a total of 750,043 acres and claimed 22 lives between October 21, 2003, and November 4, 2003. Affected counties were Los Angeles, Riverside, San Bernardino, San Diego, and Ventura. Total dollar losses in SRAs associated with the Southern California wildfire events were a record $974 million (see Chart 5.C).

Housing in WUI Areas

Table 5.X describes housing density classes in California for areas exposed to significant wildfire risk. All classes other than wildland are considered WUI.

Table 5.X: Housing Unit Density Classes

Class	Description
Wildland	Less than one housing unit per twenty acres
Rural	From one housing unit per five acres to one housing unit per twenty acres
Interface	From one housing unit per acre to one housing unit per five acres
Urban	Greater than one housing unit per acre

Source: FRAP, 2003 Assessment

Relative WUI Fire Threat by Acreage and Housing Density

Table 5.Y lists a statewide summary of total acres in the WUI by housing density and proximate threat classes as of 2000. A total of 7.8 million acres are developed at densities considered to meet the WUI criteria. Of this total, 920,000 acres are exposed to an Extreme Fire threat, 3.4 million acres to a Very High threat, and an additional 1.2 million acres to a High threat. If all WUI lands with threat levels greater than Moderate are considered to be at significant risk to damage from fire, the total area at significant risk is 5.5 million acres, or 71 percent of the total WUI area. The density breakdown of this group shows that 1.7 million acres (32 percent) of the WUI at risk are Urban, 1.2 million acres (21 percent) are Interface, and the remaining 2.6 million acres (47 percent) are Rural. (Note: These figures are based on the 2000 Census)

Table 5.Y: WUI Acreage by Density Class and Fire Threat

Density Class	Total Acres	WUI By Fire Threat Class				
		Extreme	Very High	High	Moderate	None
Rural	3,126,842	459,507	1,733,775	392,808	475,188	65,564
Interface	1,322,620	249,996	722,877	176,144	156,197	17,406
Urban	3,391,215	209,799	909,622	609,386	1,608,606	53,802
Total	7,840,677	919,302	3,366,274	1,178,338	2,239,991	136,772

Source: FRAP, 2003 Assessment

While the majority of areas considered WUI are low-density rural areas, when viewed in terms of assets at risk, most housing assets are concentrated in urbanized areas. Of the 4.9 million homes exposed to High or greater fire threat, 4.1 million homes (84 percent) are in the Urban density class. The dominant density/threat class is the Urban/Very High threat class, comprising 2.1 million homes. Table 5.Z summarizes the total number of housing units in WUI areas as of 2000. (www.frap.cdf.ca.gov/assessment2003) (Note: These figures are based on the 2000 Census)

Table 5.Z: WUI Housing Units by Density Class and Fire Threat

Density Class	Total Housing Units	Housing Units by Fire Threat Class				
		Extreme	Very High	High	Moderate	None
Rural	323,282	49,167	178,491	41,793	47,842	5,989
Interface	597,497	109,892	316,246	83,347	80,000	8,012
Urban	10,886,536	380,220	2,131,667	1,624,185	6,627,360	123,104
Total	11,807,315	539,279	2,626,404	1,749,325	6,755,202	137,105

Source: FRAP, 2003 Assessment

Potential Dollar Losses for State-Owned and -Leased Facilities

Estimating potential dollar losses for state-owned and -leased facilities involves a careful review of location of these facilities in relation to varying kinds of wildfire hazards. Many of these facilities are within urban areas where wildfire threat is relatively low. However, some facilities are within urban fringe areas, including WUIs, and a few are within very high fire hazard severity zones. Completion of the current CAL FIRE remapping will provide specific new insights into the state's overall risk exposure in terms of critical facilities.

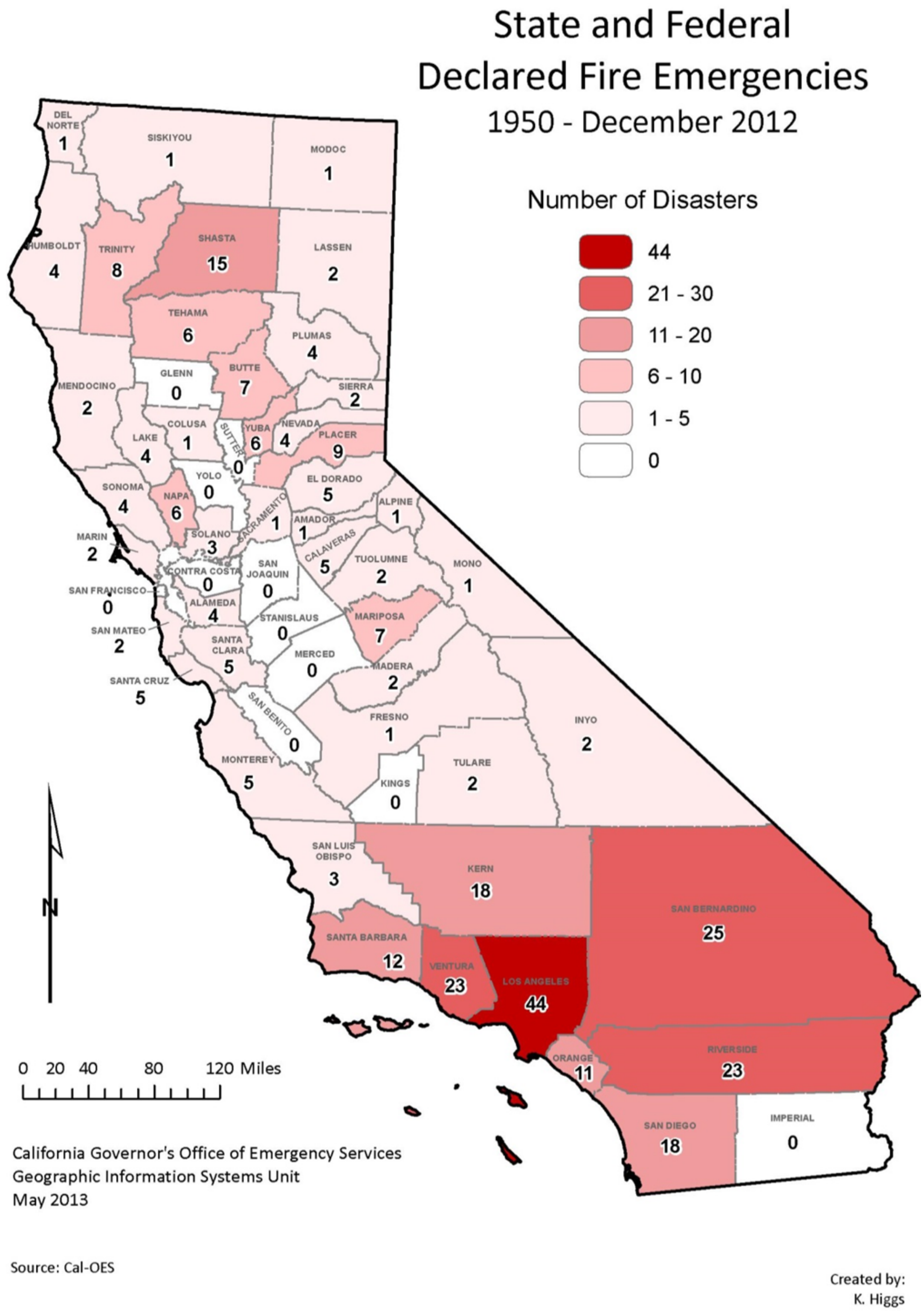
Table 5.AA shows an estimate of maximum potential exposure of state-owned and -leased facilities to wildfires, given best available data. It identifies a total wildfire risk exposure of $34.5 billion for buildings in Very High and Extreme Risk areas. These figures overstate potential losses from this hazard for two fundamental reasons: 1) wildfire events are centered within one region or another, and 2) only a small portion of the inventory within a region may be affected by any given wildfire event.

Table 5.AA: Potential Loss of State Facilities from Wildfire Hazards

	State Ownership Status	Number of Buildings	Square Feet	$ at Risk (billions)
Zone 2 (High Risk)	Own	8,115	107,041,618	37.46
	Lease	1,561	14,369,254	5.03
	Total	9,676	121,410,872	42.49
Zone 3 (Very High Risk)	Own	13,073	90,591,456	31.71
	Lease	451	1,901,682	0.67
	Total	13,524	92,493,138	32.38
Zone 4 (Extreme Risk)	Own	1,080	6,228,278	2.18
	Lease	33	107,619	0.04
	Total	**1,113**	**6,335,897**	**2.22**

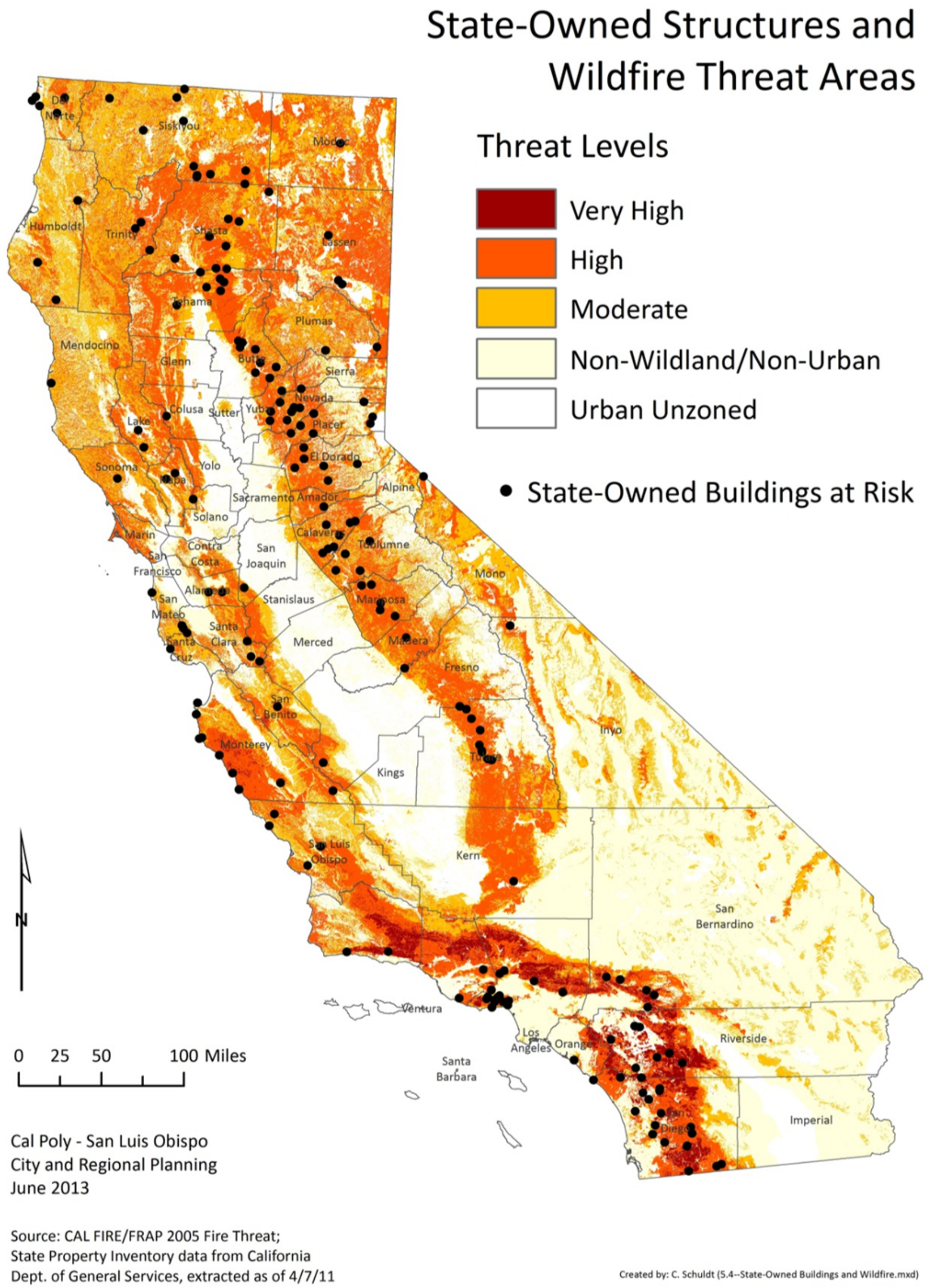
Source: Department of General Services, Cal OES

MAP 5.HH: State and Federal Declared Fire Disasters, 1950-December 2012



Map 5.HH shows declared wildfire disasters from 1950 to 2009. Highest numbers occurred in Southern California, showing the influence of major populated urban areas in Los Angeles and other nearby counties on fire emergency and disaster events.

MAP 5.II: State-Owned Buildings in Higher Wildfire Threat Areas



Map 5.II indicates the location of state-owned buildings in High and Very High fire threat areas. Altogether there are a total of 1,952 structures with over 4 million square feet within such areas. Concentrations are found primarily in mountainous areas. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

Fire and the Natural Environment

Fire is a natural and critical ecosystem process in most of California's diverse terrestrial ecosystems, dictating in part the types, structure, and spatial extent of native vegetation in the state. Many of California's ecosystems are adapted to a historic "fire regime," which characterizes historic patterns of fire occurrence in a given area. Fire regimes include temporal attributes (e.g., frequency and seasonality), spatial attributes (e.g., size and spatial complexity), and magnitude attributes (e.g., intensity and severity), each of which have ranges of natural variability (Sugihara et al. 2006).

Ecosystem stability is threatened when any of the attributes for a given fire regime diverge from its range of natural variability, which currently is prevalent throughout California. In general, when compared to historic fire regimes, many mixed-conifer forests now experience fires that are more intense and severe, while chaparral shrublands experience fire at a greater frequency. Both trends have profound impacts on ecosystem stability throughout California.

A principal cause of intensifying wildfire severity in mixed-conifer forest types in the state is the mounting quantity and continuity of forest fuels that have been brought about by a century of fire exclusion. Fire exclusion in California and throughout the western U.S. has been attributed largely to fire suppression, elimination of Native American ignitions, and introduction of grazing that removed fine fuels necessary for fire spread in and between forested stands. Conifer forests that historically experienced frequent but low-intensity surface fires, which are prevalent throughout California, are now predisposed to high-intensity, high-severity crown fires.

Conversely, native chaparral shrublands, which typically burn in high-intensity stand-replacing events, are threatened due to too-frequent ignitions, which are leading to a type conversion to non-native grasslands (Keeley et al., 2009). This trend is particularly acute in Southern California where burgeoning population growth in fire-prone areas has resulted in increased ignitions through accident or arson (Syphard et al., 2008).

One measure of derivation from the range of natural variability is the fire regime condition class (FRCC) (Hardy et al., 2008). FRCC classifies landscapes into three classes dependent on their degree of departure from natural fire regimes (shown in Table 5.BB).

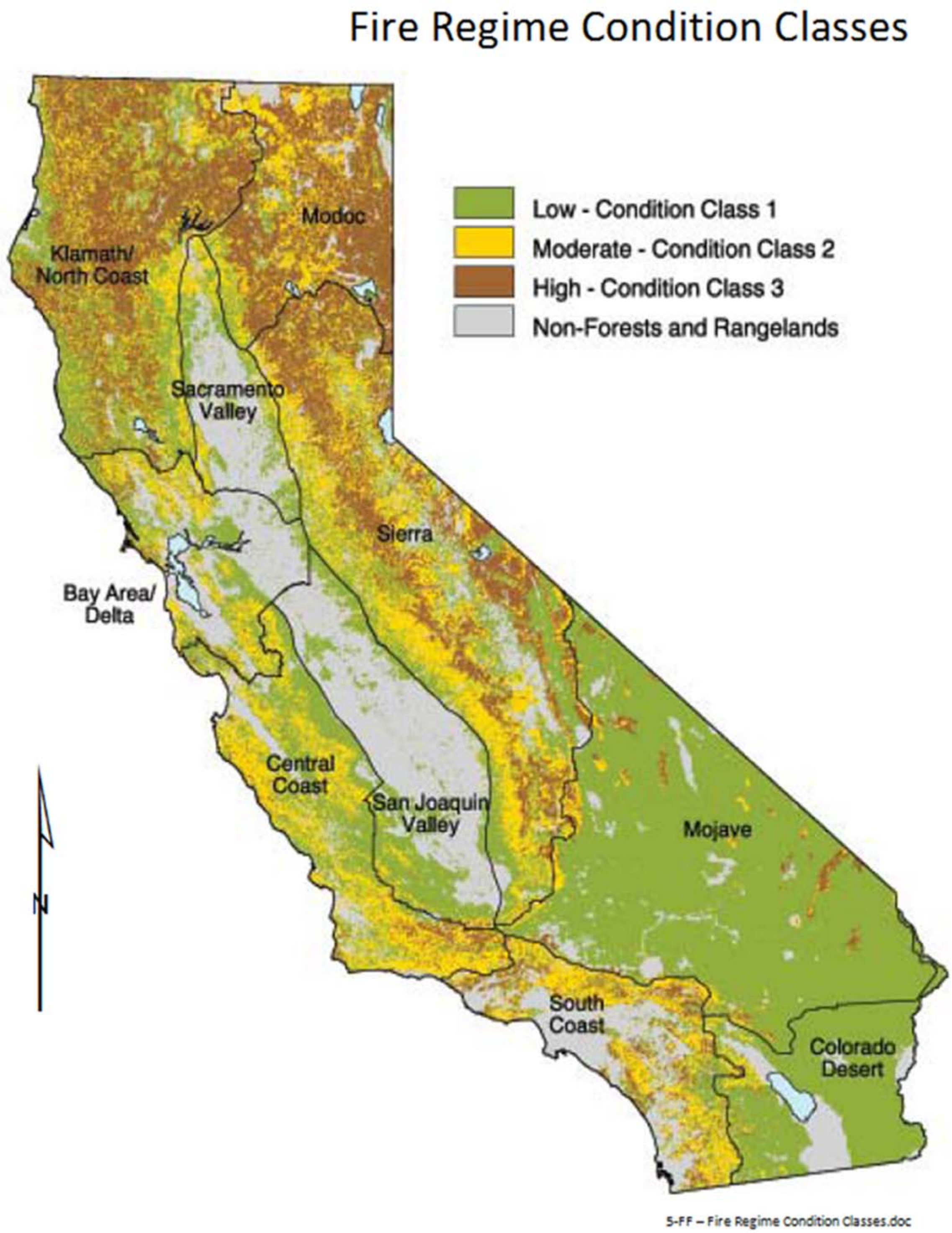
Table 5.BB: Fire Regime Condition Class Descriptions

Class	Description
Low: Condition Class 1	Fire regimes are within the natural or historical range and risk of losing key ecosystem components is low. Vegetation attributes (composition and structure) are well intact and functioning.
Moderate: Condition Class 2	Fire frequencies may have departed by one or more return intervals (either increased or decreased). This departure may result in moderate changes in fire and vegetation attributes.
High: Condition Class 3	Fire frequencies may have departed by multiple return intervals. This may result in dramatic changes in fire size, fire intensity and severity, and landscape patterns. Vegetation attributes have been substantially altered.

Source: Hardy et al., 2008

A coarse-scale assessment of FRCC was conducted for the lower 48 states in support of the initial policy development for the National Fire Plan (Hardy et al., 2001; Schmidt et al., 2002; USFS, 1999). The process continues to be refined to better meet the needs of local and regional efforts to reduce risks to ecosystem health and stability, while maintaining a centralized and consistent approach nationwide (Hann, 2002).

MAP 5.JJ: Fire Regime Condition Classes



Source: 2003 Forest and Range Assessment

Map 5.JJ shows fire regime condition classes (FRCC) in California's bioregions. Fire regime classes reflect the potential for severe ecosystem damages due to fire occurrence (either too frequent or not frequent enough).

The 2003 Forest and Range Assessment demonstrated that a significant portion of the state is currently in Condition Classes 2 and 3 (Map 5.JJ). Roughly 37 million acres in California are ecologically at risk from fire with 17 million acres at high risk. Particularly susceptible are the mixed-conifer forests of the Klamath Mountain and Sierra Nevada bioregions, sagebrush-grasslands of the Modoc bioregion, and coastal sage scrub in the South Coast bioregion (Table 5.CC). The only area without significant widespread ecosystems at risk is the southeastern desert region, where fire has been a relatively rare phenomenon. Even there, however, invasion of fire-stimulated annual grasses is projected to significantly increase fire frequency (Brooks, 1999).

Table 5.CC: Percentage of California Bioregions Containing Landscapes in Either Fire Regime Condition Class 2 or 3

Bioregion	Percentage	Habitats with Large Proportions of Condition Classes 2 and 3
Bay Area/Delta	41	Mixed Conifer
Central Coast	51	Sagebrush; Grassland
Colorado Desert	5	Sagebrush; Grassland
Klamath/North Coast	68	Klamath Mixed Conifer
Modoc	86	Sagebrush; Grassland
Mojave	6	Sagebrush; Grassland
Sacramento Valley	30	Ponderosa Pine
San Joaquin Valley	11	Sierran Mixed Conifer
Sierra	68	Ponderosa Pine
South Coast	72	Coastal Sage Scrub

Source: 2003 Forest and Range Assessment

The 2010 Forest and Range Assessment builds off the FRCC and other data to develop a more refined landscape analysis of fire risks to ecosystems. The 2003 Forest and Range Assessment and the 1997 California Fire Plan (both of which have been updated) identified some detrimental effects of fire for various ecosystem components, focusing primarily on impacts that follow high-intensity stand-replacing events outside the range of natural variability in conifer stands. These detrimental effects that were identified are described below.

Fire Effects on Timberlands

Timberlands, defined as conifer-dominated habitat types that likely support 20 cubic feet of volume growth per year and are not in reserved status, are a significant economic resource in California and are the primary economic base in some rural areas. Fire can pose significant risk to timber assets through direct loss from combustion, mortality of growing stock, and fire-induced susceptibility to insect, pathogen, and decay mechanisms. The actual loss of timber value associated with a given fire event is a function of tree structure, fire severity, and post-fire salvage opportunity. Roughly three-quarters of California's timberland face a high fire threat or greater and over half of these lands have very high or extreme fire threat conditions. Only about one-fifth of California's timberlands face a moderate fire threat, where expected losses to timber assets are likely to be low. While some of the standing timber value can be salvaged following a wildfire, much of California's timber assets are exposed to significant risk from wildland fire.

Fire Effects on Woodlands

California's extensive distribution of woodland vegetation, especially hardwood woodlands, provide key habitat for many species. The risk of habitat loss associated with fire in woodland areas is highly variable, due both to varying habitat quality and the unique fuel and vegetation response characteristics of specific areas. Habitat characteristics such as tree canopy height and closure, presence or absence of a developed shrub understory, and occurrence of special habitat elements—such as snags and downed logs—are important determinants of habitat quality for many species. Roughly two-thirds of California's hardwood woodlands are exposed to very high or extreme fire threat. While many areas may respond favorably to wildland fire, initial changes in the post-fire environment may cause temporary habitat loss and species dislocation.

Fire Effects on Recreation and Open Space

After a wildfire, significant alteration of watershed lands and the associated stream systems is noticeable for periods varying from a few years to decades. In the short term, the presence of partially burnt vegetation reduces recreational and open space values. Fires can also destroy campgrounds, trails, bridges, and other recreational facilities within the area. Increased amounts of downstream sedimentation may significantly affect streams and lakes, which tend to be the most heavily used spots within larger recreational areas. As the vegetation grows back and damaged recreational infrastructures are replaced, the recreational and open space values would increase. However, it may take decades before vegetation types such as mature forests return to their pre-burn character. Grasslands and shrublands, on the other hand, can return to their pre-burn character within a decade.

Fire Effects on Water and Watersheds

Wildfires can have significant adverse effects on watershed lands, watercourses, and water quality. Large, hot fires cause serious, immediate damage from which a watershed can take decades to recover. By burning off vegetation and exposing mineral soil, fire impairs the ability of a watershed to hold soil in place and to trap sediment before it enters stream systems. Loss of vegetation also means less water being absorbed by plants, causing a short-term increase in the quantity and the delivery rate of water entering streams. This can have significant effects downstream from the site of a fire, such as with the fire-flood cycle commonly experienced in Southern California. This increased runoff and its large sediment load can cause costly damage to downstream assets such as homes, roads, debris basins, and other infrastructure. It can also result in the loss of human life when at-risk residents are not evacuated.

Fire Effects on Soils

Fire presents a significant risk to soil, especially in denuded watersheds, through accelerated erosion potential in the immediate post-fire environment, particularly when subjected to severe rainstorms prior to any vegetation recovery (Wells et al., 1979). The Fire and Resource Assessment Program (FRAP) has developed a statewide risk assessment based on the expected marginal increase in surface erosion from a potential fire.

Erosion is a natural process that occurs across a watershed at varying rates, depending on soils, geology, slope, vegetation, and precipitation. The intensity of a fire and the subsequent removal of vegetative cover increase the potential rate of soil erosion and new sediment sources. Wildfires affect surface erosion in a watershed by altering detachment, transport, and deposition of soil particles. Most wildfires create a patchwork of burned areas that vary in severity. Severely burned areas suffer increased erosion due to loss of the protective forest floor layer and creation of water-repellent soil conditions that can cause flooding, downstream sedimentation, and threats to human life and property.

Fire Effects on Riparian and Aquatic Habitats

Wildfire can produce a wide range of water quality and aquatic habitat outcomes, from beneficial to catastrophic. Wildfire outcomes are determined by weather, fuels, terrain, and, to a lesser extent, suppression efforts. Large wildfires pose the greatest risk to water quality and riparian habitat. If a wildfire encounters fuel levels that have been reduced through prescribed burning and/or mechanical means, there is a good chance the fire would produce conditions more favorable to maintaining good water quality and aquatic habitat. Highly destructive fires are thus minimized.

Fire Effects on Aquatic Habitat

Fire can also dramatically affect aquatic habitat. Increased erosion and sediment deposition can result in channel aggradations (i.e., wider, shallower channels), filling of pools that provide important fish habitat, increased turbidity that makes it harder for fish to find food and can damage gills, and changes in water chemistry

Fire Effects on Water Quality

Wildfires can potentially affect water quality through increased sedimentation and increased turbidity and through increases in nutrient loadings. Concentration of nutrients (phosphorous and nitrogen) are increased from burned vegetation and delivered to streams through surface runoff. Stream temperatures often increase after fire occurs, typically through the removal of overhead protective vegetation. Elevated stream temperatures are detrimental to most cold-water fish species.

Fire Effects on Water Infrastructure

Water delivery systems may be dramatically affected by fire. With the exception of the North Coast, most watersheds in California have extensive downstream water supply infrastructures serving rural residents, larger municipalities, and agricultural users. Increased sediment can decrease storage capacity in dams and reservoirs.

Trade-offs in Fire Hazards vs. Ecosystem Services Provided by Vegetation

To facilitate sustainable, disaster-resistant communities, there is a critical need to assess the tradeoffs in vegetation's potential to facilitate destructive wildfires versus the biological and economic benefits that it provides. Paradoxically, vegetation is both an asset and a liability to residents living in the WUI areas. The same vegetation that regularly burns with great intensity and destruction simultaneously provides both tangible and intangible benefits to local communities (Dicus and Zimmerman 2007; Dicus et al., 2009).

Minimizing fire hazard while maximizing the economic, biological, aesthetic, and social values that vegetation provides are seemingly conflicting objectives in the WUI, particularly to those living in high hazard areas with elevated population densities. Continued immigration to highly fire-prone areas in California will likely continue unabated in the near future. For example, the population of San Diego, Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties in Southern California was 19.2 million in 2000 and is expected to grow by at least 15 percent over the next 10 years (California Department of Finance, 2004), which will increase both wildfire risk and the likelihood of ignition (Syphard et al., 2008).

Immigration to fire-prone areas in California has exponentially increased the costs and losses associated with WUI fires in the last two decades. Indeed, in spite of increased fire agency staffing, equipment, and training, 9 of the 10 most destructive wildfires in California history have occurred since 1990, resulting in the loss of 56 lives and almost 14,000 structures (California Department of Forestry and Fire Protection, 2009a). Watershed events include the 2003 Southern California fires, which burned ~750,000 acres, killed 22 people, consumed over 4,800 homes, and cost $123 million to suppress (California Department of Forestry and Fire Protection, 2004); and the 2007 Southern California fire siege, which again burned ~750,000 acres, killed 17 people, consumed 3,069 homes, and cost $155 million to suppress (California Department of Forestry and Fire Protection, 2009b). Given the ever-increasing migration to California's WUI, similar destructive wildfires are possible for the foreseeable future. Thus, effective fuel treatments in the WUI are critical to maintain sustainable communities.

However, treatment- and development-induced losses in tree and shrub canopy cover cost society in many direct and indirect ways. Vegetation is more than fuel, providing various levels of tangible and intangible benefits to society, dependent on its composition and structure. For example, WUI vegetation not only enhances community attractiveness but also reduces home cooling costs and air pollution (Taha et al., 1997), lessens needed storm water runoff infrastructure (Sanders 1986), sequesters carbon (Nowak and

Rowntree, 1991), and provides wildlife habitat. From 1985 to 2002, the City of San Diego experienced a 41 percent increase in urban lands coupled with a subsequent loss of 29 percent in tree canopy cover and 8 percent of shrubland canopy cover, which had profound impacts on societal benefits (American Forests 2003). Fuel treatments will only serve to further reduce vegetation and their subsequent social and economic benefits (Dicus et al., 2009).

The need to adequately understand how fuel treatments affect both fire hazard and societal benefits is especially critical in light of recent legislation that calls for a significant increase in mandatory fuel treatments around structures. California Senate Bill 1369, signed into law as a direct result of the 2003 California fires, amended Public Resources Code Section 4291 to increase mandatory vegetation clearance around homes in all designated areas where the state has primary suppression responsibilities. These new standards have the potential to significantly reduce the losses caused by wildfire but will also likely reduce the many tangible benefits to society that vegetation provides (Dicus et al., 2009). Thus, there is an acute need for California land managers to develop fuel management strategies in the WUI that minimize fire risk while simultaneously reducing loss of native vegetation and the many societal benefits that it provides.

5.4.4 ASSESSMENT OF LOCAL WILDFIRE VULNERABILITY AND POTENTIAL LOSSES

Assessment of Local Vulnerability and Potential Losses

This section addresses local wildfire hazard vulnerability and potential losses based on estimates provided in local risk assessments, comparing those with state risk exposure findings presented in the GIS analysis in Section 5.1.1 of this chapter.

Local Hazard Mitigation Plan Hazard Ratings

An important source of local perceptions regarding vulnerability to wildfire threats is found in the collection of over 300 FEMA-approved Local Hazard Mitigation Plans (LHMPs) adopted by cities, counties, and special districts as of May 2013. The most significant hazards reported in this review are earthquakes, floods, and wildfires—the three primary hazards also identified on a statewide basis by the 2013 SHMP. Including these three primary hazards, LHMPs identified a total of 58 distinct local hazards.

Map 5.KK summarizes relative ratings of wildfire hazards in the 2013 review of LHMPs. Displayed are predominant wildfire hazard ratings shown as high (red), medium (orange), and low (yellow) rankings reflecting ratings given by at least 51 percent of the jurisdictions with LHMPs within each county. Counties shown without color represent either jurisdictions not having FEMA-approved LHMPs or counties where data are missing or problematic. For a detailed evaluation of LHMPs approved as of May 2013, see Annex 5, California Local Hazard Mitigation Plan Status Report.

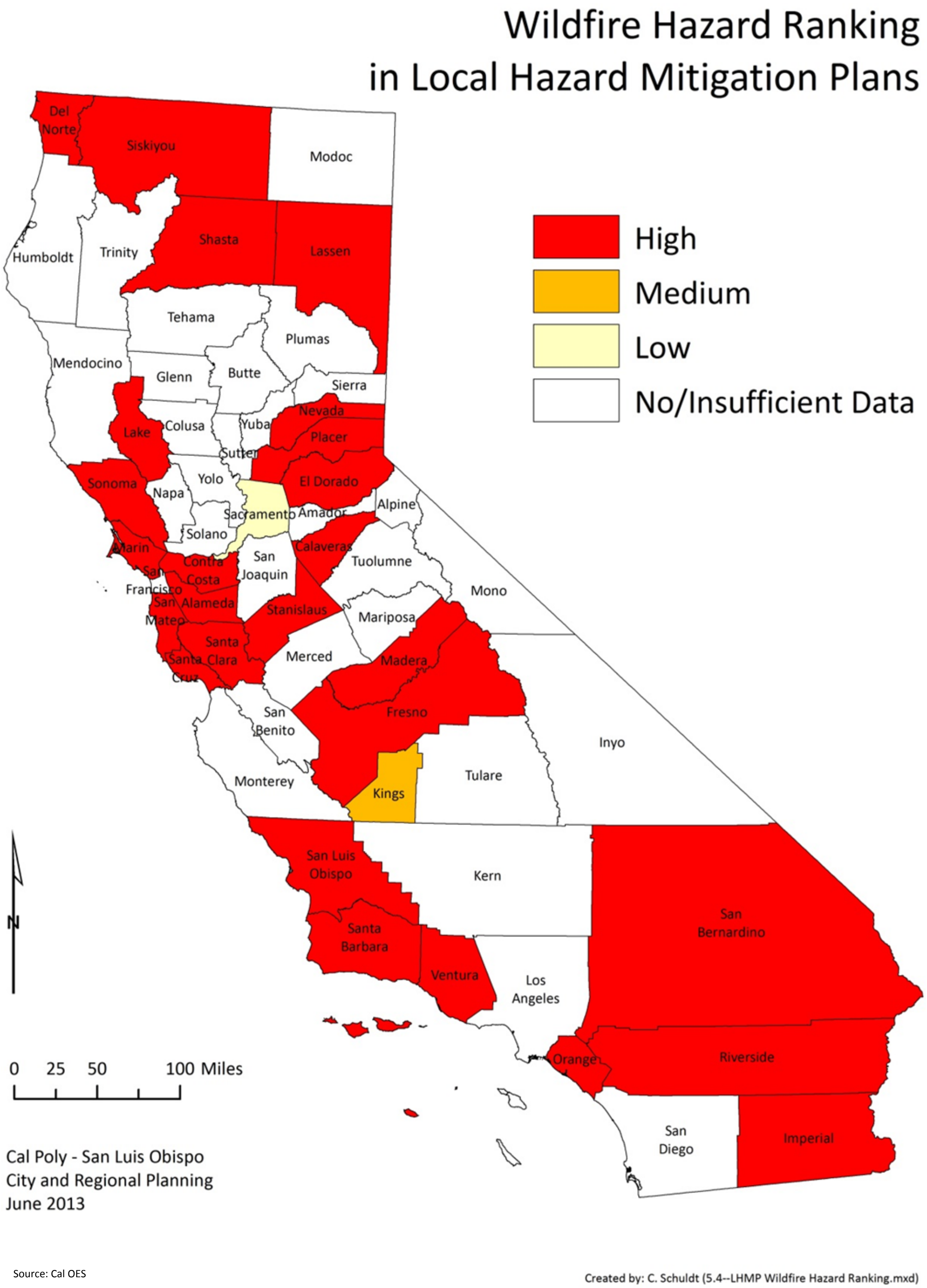
Implications for Local Loss Potential

Local hazard rankings are highly variable, responding to a wide variety of very specific local conditions. Each county has its own set of variables conditioning wildfire loss potential within its cities and unincorporated area. Descriptions of loss potential are very specific within individual LHMPs and are not consistently drawn up between plans, nor is there even coverage of all cities and unincorporated areas. Such variability will diminish as more cities and counties prepare LHMPs and greater standardization enables comparability of local data with statewide data.

Comparison with Statewide Vulnerability

Map 5.KK reveals that most LHMPs reviewed in 2013 in Southern California and San Francisco Bay Area counties, some Central Valley counties, and many North Coast and Sierra Mountain counties rated wildfires high in their hazard rankings. This is consistent overall with the patterns of wildfire hazards and population/social vulnerability patterns identified previously in Section 5.1.1.

MAP 5.KK: Wildfire Hazard Ranking in Local Hazard Mitigation Plans



Map 5.KK identifies wildfire hazards as being a predominant concern in the 2013 LHMP review for most Southern California and many San Francisco Bay Area counties with approved LHMPs, as well as many Sierra Mountain counties.

5.4.4.1 FIRE HAZARD SEVERITY ZONE (FHSZ) MAPPING

Progress as of 2013: Public Resources Code (PRC) 4201-4204 and Government Code 51175-89 direct the California Department of Forestry and Fire Protection (CAL FIRE) to map areas of significant fire hazards based on fuels, terrain, weather, and other relevant factors. These zones, referred to as Fire Hazard Severity Zones (FHSZs), define the application of various mitigation strategies to reduce risk associated with wildland fires. State Responsibility Areas (SRAs) were originally mapped in 1985 and last updated in 2007.

CAL FIRE has remapped both state and local fire responsibility areas to provide updated map zones, based on new data, science, and technology that will create more accurate zone designations such that mitigation strategies are implemented in areas where hazards warrant these investments. The zones will provide specific designation for application of defensible space and building standards consistent with known mechanisms of wildfire impacts on people, property, and natural resources.

Wildland-urban interface (WUI) building codes that have been adopted by the California Building Standards Commission took effect January 1, 2008 and use Fire Hazard Severity Zone (FHSZ) maps as the basis for applicability of certain code sections. FHSZ maps will follow established adoption processes required by state statute. http://osfm.fire.ca.gov/strucfireengineer/pdf/bml/wuiproducts.pdf

Local Responsibility Areas (LRA) were originally mapped in 1996 and are currently undergoing the local adoption process for those changes. CAL FIRE has made recommendations for Very High Fire Hazard Severity Zones for over 200 cities. The process was completed in 2011. CAL FIRE recommendations are available at:
http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones_maps_citylist.php.

Many local governments have made similar designations under their own authority. Current FHSZ mapping is available for 2007 and 2008 for most LRA areas. LRA FHSZ maps must be ratified by the local government agency and the state for full adoption. There are still a few LRA maps pending local ratification prior to being fully adopted.

(Continued on next page)

MAP 5.LL: Fire Hazard Severity Zones in State Responsibility Areas

Map 5.LL shows Fire Hazard Severity Zones only in SRAs. SRAs are essentially private lands in WUI areas within unincorporated county areas. They do not include Local Responsibility Areas (LRAs) within cities or federally owned lands such as national forests. *(Online or download viewers can zoom in for a closer view of the information on this map.)*

5.4.4.2 LEGISLATION FOR LOCAL WILDFIRE HAZARD PLANNING

Progress Summary 5.T: Significance of Senate Bill 1241 Wildfire Legislation

Progress as of 2013: This legislation is a significant addition to hazard mitigation efforts for wildfire areas because it follows the legislative model used in the 2007 flood legislation of hazard mitigation through state oversight of general plans. Similar to flood legislation adding flood plain planning responsibilities to local general plans (AB 162, etc.), SB 1241, passed in 2012, mandates wildfire planning responsibilities by local agencies through requirements regarding 1) wildfire updates to general plans; 2) mandatory findings for subdivision approvals in state responsibility areas (SRAs) and very high fire hazard severity zones (VHFHSZs); and 3) California Environmental Quality Act (CEQA) checklist updates for wildfire safety.

Senate Bill 1241: Wildfire Hazard Legislation

Safety Element

Planning and Zoning Law requires that cities and counties adopt a comprehensive general plan with various elements including a safety element for protection of the community from unreasonable risks associated with various hazards, including wildfires.

SB 1241 addresses local general plan safety elements (and all elements of a general plan, whether mandatory or optional, must be consistent with one another) in the following ways:

1. Revises safety element requirements for state responsibility areas and very high fire hazard severity zones
2. Requires local general plan safety elements, upon next revision of the housing element on or after January 1, 2014, to be reviewed and updated as necessary to address the risk of fire in SRAs and VHFHSZs
3. Requires each safety element update to take into account the most recent version of the Office of Planning and Research's "Fire Hazard Planning" document
4. Requires Office of Planning and Research (OPR), at the next update of its general plan guidelines, to include the provisions of SB 1241, or a reference to the provisions of SB 1241, as well as any other materials related to fire hazards or fire safety deemed appropriate for reference.

Local general plan safety element (and all elements of a general plan, whether mandatory or optional, must be consistent with one another) updates are required to include:

1. Comprehensive review of local fire hazards in relation to distribution of existing or planned uses in SRA and VHFHSZ area within that jurisdiction

2. Goals, policies and objectives for protection of the community from unreasonable risk of wildfire based on the identified fire hazard information

3. Feasible implementation measures to carry out the defined goals, policies and objectives

4. Attachment of or reference to any previously adopted fire safety plan that fulfills the goals of SB 1241

For any county containing SRAs or VHFHSZs, SB 1241 requires that the draft safety element update be submitted to the State Board of Forestry and Fire Protection and to every local agency that provides fire protection for the territory in the city or county for a 90 day review period prior to adoption or amendment of that safety element. Any recommendations provided by State Board of Forestry and Fire Protection or any local agency must be considered by the city council or county's board of supervisors. Any rejection of recommendations must be communicated in writing to the State Board of Forestry and Fire Protection or local agency.

Subdivision Map Act
The Subdivision Map Act requires the legislative body of a city or county to deny approval of a tentative map, or parcel map for which a tentative map was not required unless it makes certain findings.

SB 1241 requires the legislative body of a county to make three findings prior to approval of a tentative map or parcel map for any area located within an SRA or VHFHSZ. These new required findings are:

1. That the design and location of each lot in the subdivision and the subdivision as a whole are consistent with any applicable regulations adopted by the State Board of Forestry and Fire Protection per Sections 4290 and 4291 of the Public Resources Code
2. That structural fire suppression services will be available for the subdivision (this finding must be supported by substantial evidence in the record)
3. That ingress and egress for the subdivision meets the regulations regarding road standards for fire equipment access per Sections 4290 and 4291 of the Public Resources Code

CEQA
The California Environmental Quality Act (CEQA) requires a lead agency to prepare and certify the completion of an environmental impact report on a project that it proposes to carry out or approve that may have a significant effect on the environment, or to adopt a negative declaration if it finds that the project will not have that effect. CEQA requires OPR to prepare and develop guidelines for the implementation of CEQA by public agencies.

SB 1241 requires OPR to prepare, develop, and transmit to the Secretary of the Natural Resources Agency recommended proposed changes or amendments to the initial study checklist for the inclusion of additional, specific questions related to fire hazard impacts for projects located in SRAs and VHFHSZs. These changes or amendments to the initial study checklist must be made on or after January 1, 2013, at the time of the next update of the guidelines for implementing CEQA, in cooperation with the Department of Forestry and Fire Protection.

5.4.5 CURRENT WILDFIRE HAZARD MITIGATION EFFORTS

Once thought of as a seasonal hazard, wildfires are an almost everyday occurrence in California. However, much of the state's approach to dealing with wildfire is still seasonal in nature. Flammable expanses of brush, diseased timberland, overstocked forests, hot and dry summers, extreme topography, and intense fire weather wind events, summer lightning storms, and human acts all contribute to California's wildfire threat.

The number of homes in the wildland-urban interface is increasing at a rate of 2.4 percent per year in SRAs. The number of homes outside the wildland-urban interface is increasing at a rate of 2.1 percent per year. Wildfire and human development have always been in conflict. Wildfire is a natural part of our environment and human development in wildlands is an accepted practice. This inherent conflict requires careful management in order to reduce or eliminate losses to life, property, and resources from wildfires. Some past management practices have failed to address the comprehensive nature of the human/wildfire conflict and have exacerbated conditions that can lead to more damaging fires. One example is wildfire suppression without aggressive management of hazardous fuels or defensible space. Another is development in historical WUI fire areas without performance-based fire-resistant construction standards or fire-safe development requirements. Daily actions and decisions often fail to consider WUI fire risks and the potential for resulting losses.

Managing the human/wildfire conflict requires a commitment of resources and a focused mitigation plan over the long term. The approach must be system-wide and include the following:

- An informed, educated public that takes responsibility for its own decisions relating to wildfire protection
- An effective wildfire suppression program
- An aggressive hazardous fuels management program
- Land use policies and standards that protect life, property, and natural resources
- Building and fire codes that reduce structural ignitions from windblown embers and flame contact from WUI fires and impede or halt fire spread within the structure once ignited
- Construction and property standards that provide defensible space

Progress Summary 5.U: Strategic Fire Plan

The California State Board of Forestry and Fire Protection approved the 2010 Strategic Fire Plan in June 2010. The Strategic Fire Plan forms the basis for assessing California's complex and dynamic natural and human-made environment and identifies a variety of actions to minimize the negative effects of wildland fire.

Vision

The vision of the Strategic Fire Plan is for a natural environment that is more resilient and human-made assets that are more resistant to the occurrence and effects of wildland fire through local, state, federal, and private partnerships.

Goals and Objectives

Through government and community collaboration, the following goals established in the Strategic Fire Plan will enhance the protection of lives, property, and natural resources from wildland fire, as well as improve environmental resilience to wildland fire. Each goal listed here is meant to build upon the previous one (e.g., Goal 3 builds upon the accomplishments in Goals 1 and 2). Although full attainment of a goal is ultimately dependent upon the success of previous goals, any of the goals can be worked on at any given time based on available funding and other opportunities.

1. Identify and evaluate wildland fire hazards and recognize life, property and natural resource assets at risk, including watershed, habitat, social and other values of functioning ecosystems. Facilitate the sharing of all analyses and data collection across all ownerships for consistency in type and kind.
2. Articulate and promote the concept of land use planning as it relates to fire risk and individual landowner objectives and responsibilities.
3. Support and participate in the collaborative development and implementation of wildland fire protection plans and other local, county and regional plans that address fire protection and landowner objectives.
4. Increase awareness, knowledge and actions implemented by individuals and communities to reduce human loss and property damage from wildland fires, such as defensible space and other fuels reduction activities, fire prevention and fire safe building standards.
5. Develop a method to integrate fire and fuels management practices with landowner priorities and multiple jurisdictional efforts within local, state and federal responsibility areas.
6. Determine the level of fire suppression resources necessary to protect the values and assets at risk identified during planning processes.
7. Address post-fire responsibilities for natural resource recovery, including watershed protection, reforestation and ecosystem restoration.

Other Aspects of the Plan

CAL FIRE has developed an estimate of fire risk in WUI areas that is consistent with National Fire Plan methods but is more refined in terms of both mapping extent and quantification of risk. CAL FIRE uses spatial data to distinguish fire-related characteristics from assets and applies spatial rules for determining relative risk of loss. http://cdfdata.fire.ca.gov/fire_er/fpp_planning_cafireplan

The 2010 Strategic Fire Plan is a strikingly different fire plan than those developed in the past. The plan recognizes that fire will occur in California and works to answer the question of "how do we utilize and live with that risk of wildfire?

The approach taken in the revised plan is to focus on a vision and goals and objectives that will help reach that vision. The overall vision is to create a state that is more resistant and resilient to the damaging effects of catastrophic wildfire while recognizing fire's beneficial aspects. The 2010 Strategic Fire Plan is a living document.

The entire fire plan can be viewed at: http://osfm.fire.ca.gov/fireplan/fireplanning.php

The 2010 Forest and Range Assessment

California law requires that CAL FIRE make periodic assessments of forest and range resources and that the Board of Forestry and Fire Protection use the results to develop a policy statement and strategic plan. In addition, the 2008 Federal Farm Bill amended the Cooperative Forestry Assistance Act (CFAA) to require that states prepare state forest resource assessments and resource strategies. The CFAA amendments are reflected in the USDA Forest Service State and Private Forestry "Redesign Program" (http://www.fs.fed.us/spf/redesign/index.shtml). The intent of this program is for the states to identify priority landscape areas and to underscore work needed to address national, regional and state forest management priorities.

In June, 2010 the Fire and Resource Assessment Program (FRAP) finished a new assessment and a related strategies document. The results are found at the CAL FIRE FRAP website at: http://frap.fire.ca.gov/

One of the overarching findings of the 2010 Forest and Range Assessment is that California is a complex wildfire-prone and fire-adapted landscape. Natural wildfire has supported and is critical to maintaining the structure and function of California's ecosystems. As such, the ability to use wildfire, or to mimic its impact by other management techniques, is a critical management tool and policy issue. Simultaneously, wildfire poses a significant threat to life, public health, infrastructure and other property, and natural resources.

Data suggest a trend of increasing acres burned statewide, with particular increases in conifer vegetation types. This is supported in part by the fact that the three largest fire years since 1950 have all occurred this decade. Wildfire-related impacts are likely to increase in the future based on trends in increased investment in fire protection, increased fire severity, fire costs and losses, and research indicating the influence of climate change on wildfire activity.

Both the assessment and strategies documents are organized around themes and subthemes delineated in the federal Redesign Program. For each subtheme, an analytical framework was designed that uses GIS techniques to perform a spatial analysis of the pattern of assets and threats across landscapes. Assets include items of commercial and non-commercial value, both natural and human-made, such as buildings, commercial standing timber, and production of water. Threats are agents that can trigger major negative impacts on assets; examples include wildfire, development, and insect outbreaks. Location information on various assets, and potential threats to those assets, are taken together to identify high value/high threat areas. These delineate landscapes (called "priority" landscapes) where strategies and actions especially need to be focused.

Chapters Relevant to the SHMP

Several of these 2010 assessment themes and related strategies are relevant to the SHMP. Three chapters are of special interest and are mentioned here for those who wish more detailed information:

- Wildfire Threat to Ecosystem Health and Community Safety

(http://frap.fire.ca.gov/assessment/assessment2010/document.html)
This chapter reflects the findings cited above and contains three unique spatial analyses that generate priority landscapes:

- Preventing Wildfire Threats to Maintain Ecosystem Health
- Restoring Wildfire-Impacted Areas to Maintain Ecosystem Health
- Preventing Wildfire Threats for Community Safety

- Forest Pests and Other Threats to Ecosystem Health and Community Safety (http://frap.fire.ca.gov/assessment/assessment2010/document.html)

  This chapter covers the impacts of forest pests, including both forest insects and diseases, in wildland areas and communities. Collectively, losses from forest pests typically exceed those from wildfire and create serious hazards. It includes four unique spatial analyses that identify priority areas where forest management practices are most likely to prevent and mitigate impacts:

  - Restoring Forest Pest Impacted Areas to Maintain Ecosystem Health
  - Restoring Forest Pest Impacted Communities for Public Safety
  - Preventing Forest Pest Outbreaks to Maintain Ecosystem Health
  - Preventing Forest Pest Outbreaks for Community Safety

- Planning for and Reducing Wildfire Risks to Communities (http://frap.fire.ca.gov/assessment/assessment2010/document.html)

This chapter looks at the current status of collaborative, community-based wildfire planning and the extent of available planning resources relevant to community wildfire safety and protection. It identifies priority communities where wildfire threat coincides with human infrastructure such as houses, transmission lines, and major roads. These priority communities are then summarized in terms of the presence of a CWPP and Firewise Communities/USA recognition. The availability of community planning resources is also examined.

Ecosystem Health Analyses

There are three types of ecosystem health analyses. The first analysis is designed to identify priority landscapes that represent areas at risk from wildfire. These are critical for the overall health of the Ecosystem as defined here, referring to each unique vegetation type by tree seed zone. These ecosystems represent areas potentially having unique genetic resources.

Since an unhealthy condition class is most typically associated with fire exclusion, tools for treating priority landscapes include management practices such as fuels reduction and biomass projects. For the case of too-frequent fire, tools include fire prevention and increased fire suppression.

The second analysis is designed to identify priority landscapes that represent those areas already affected by past wildfire events, that are critical for the overall health of the Ecosystem.

The third analysis derives priority landscapes as the convergence of areas with high wildfire threat and human infrastructure assets. During or following a wildfire event, large dead trees in urban areas can fall and block major transportation routes, hit power lines (thus starting fires), or crush structures. This is summarized using indicators for setting priorities for community investments to prevent likely wildfire events that would create the most severe public safety hazards.

Assessment Functions

The process for developing the 2010 assessment was based on looking at the location of forest and range resource assets in the context of potential threats across the state. This information is used to determine priority landscapes that have high asset values that are likely to be threatened. The Assessment will help guide efforts to acquire and direct funding that can enable programs and other tools that create desired future landscape conditions

A key function of the 2010 assessment is to support California in allocating financial resources available from the federal government. Increasing threats to natural resources and tighter limits on available funds mean that priorities must be carefully examined.

California Interagency Coordination Efforts

Leading the coordination of wildfire prevention is the California Wildfire Coordination Group Interagency Prevention Committee (CWCG). The CWCG Prevention Committee was formed as a way to coordinate the pre-fire management efforts of its member agencies: Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), California Governor's Office of Emergency Services (Cal OES), CAL FIRE, California Fire Safe Council (CFSC), Los Angeles County Fire Department (LAC), National Park Service (NPS), Regional Council of Rural Counties (RCRC), the U.S. Forest Service (USFS), and U.S. Fish and Wildlife Service (USFWS).

The CWCG Prevention Committee provides a forum for sharing information so that its member agencies can make decisions and operate pre-fire management programs in a coordinated, integrated fashion. Working together, they discuss and reach consensus on California wildfire prevention and fire loss mitigation strategies.

Examples of pre-fire management programs are:

1. Grants Clearinghouse administered by California Fire Safe Council which provides a one-stop shop concept for fire prevention community assistance grants. It allows a mechanism for Alliance members to pool their grant resources and fund grant projects around the state of California and parts of Nevada. The Grants Clearinghouse has provided an efficient organizational structure for mobilizing wildfire mitigation activities and strategies to deal with the WUI issues in California. Projects funded include a variety of fuel reduction projects supporting prescribe fire, mechanical treatments, and grazing methods, education and outreach activity, Community Wildfire Protection Plan (CWPP) development, and biomass reutilization.

2. Workshops and Networking:
    - Development and maintenance of Community Wildfire Protection Plans
    - Environmental compliance/Best Management Practices
    - Networking lunches with local community groups active in fire prevention

The collaborative energy portrayed by the members has directly benefited the pursuit and mission to build fire-safe communities and healthy wildland ecosystems. The CWCG Prevention Committee provides a single point of contact between the local Fire Safe Councils and its member agencies, while, in turn, the local Fire Safe Councils provide a single point of contact for coordination with individual communities.

Additional work and benefits are:

- Establishing priorities and opportunities for joint actions to collect information, maintain records, monitor progress,
- Maintaining awareness of social, economic, and technological advances; assessing how these changes influence wildfire threats; and informing decision-makers how to decrease wildfire threats and promote healthy wildland ecosystems
- Clarifying and coordinating policies and exploring issues that affect communities threatened by wildfire
- Coordinating a common message in order to improve the quality of information
- Education to enhance the public's understanding of wildland fire ecosystems, hazard fuels reduction and mitigation, and wildland fire management

Fire Safe Councils

The California Fire Safe Council (CFSC) is a state-wide level nonprofit organization and member of the California Fire Alliance. Since its formation in April 1993 as a committee of CAL FIRE, the CFSC has offered a range of fire-safe education tools and activities for individuals, business or local Fire Safe Councils to raise awareness of the need to prepare for wildfires. In 2002, the group reformed as an independent 501(c)(3) California nonprofit corporation. Their mission is to "mobilize Californians to protect their homes, communities and environments from wildfires". The CFSC accomplishes its mission through public education programs and by funding community fire safety projects. The CFSC distributes fire prevention education materials to industry leaders and their constituents, evaluates legislation pertaining to fire safety, and empowers grassroots organizations to spearhead fire safety programs. In addition, CFSC provides education and training in capacity building and other topics focusing on nonprofit organizations.

The CFSC administers the Grants Clearinghouse program, which provides a one-stop-shop concept for fire prevention community assistance grants. The Grants Clearinghouse is made possible by California Fire Alliance member agencies with funding originally authorized through the National Fire Plan and provided through the U.S. Forest Service (USFS), Bureau of Land Management (BLM), National Park Service (NPS), and U.S. Fish and Wildlife Service (USFWS). From 2008 through 2013, the Grants Clearinghouse has funded over 581 wildfire mitigation projects valued at over $63 million (see Table 5.DD). Consistently, CFSC has found that the Grant Clearinghouse is able only to fund approximately one third of the applications it receives. This is due to the continuing high need for such funds throughout the State of California. Since funding streams have recently changed, the primary federal funder for the Grants Clearinghouse for the past two years has been the U.S. Forest Service.

In 2012, through an MOU with CAL FIRE, Firewise and California Fire Safe Council, CFSC is now the State Liaison for Firewise rather than CAL FIRE; however, CAL FIRE remains an active participant in the process and CFSC partners with them with the Firewise program to encourage and assist existing Fire Safe Councils as well as new neighborhoods to become Firewise. There are currently 53 Firewise Communities in California.

Table 5.DD: Wildfire Mitigation Projects Funded by California Fire Safe Council

Year	Total Value of Projects	# of Grants
2008	$5,281,054	77
2009	$17,791,675	160
2010	$20,874,237	158
2011	$8,,950,627	81
2012	$5,437,783	52
2013	$4,937,941	53
Total	**$63,273,317**	**581**

Source: The California Fire Safe Council

Local Fire Safe Councils (FSCs) are community-based organizations organized to educate groups on Fire Safe programs, projects, and planning, in addition to providing resources to assist communities to take the education into action. The FSCs have been instrumental in securing funding and resources and work closely with the local fire agencies to develop and implement project priorities. For example, the FSCs provide education about defensible space and provide free chipping service to help residents create defensible space by eliminating fuel loads. Much of the value in the FSCs lies in their ties to their communities by educating their neighbors and assisting with planning Fire Safe projects that fit the needs of their local area. Local FSCs have made great stride where agencies and governing bodies have struggled. Many communities have their own Defensible Space Programs (Public Resources Code Section 4291), neighbors helping neighbors with fire prevention education and improving their home's chances to survive a wildland fire by supporting the state law 100-foot defensible space requirement. There are approximately 200 local and 20 county-wide Fire Safe Councils. Information regarding the California Fire Safe Council and the Grants Clearinghouse can be found at: http://www.firesafecouncil.org/

Community Wildfire Protection Plan (CWPP)

A Community Wildfire Protection Plan (CWPP), as defined by the Healthy Forests Restoration Act (HFRA), enables a community to plan how it will reduce the risk of wildfire. The CWPP is a benchmark of accomplishment in local efforts to reduce wildfire risk by identifying and ranking areas for hazardous fuel reduction and recommending measures to reduce the flammability of structures. The additional benefit of having a CWPP includes National Fire Plan funding priority for projects identified in a CWPP.

The development of a CWPP is a collaborative effort involving government entities and affected non-governmental interests, including community grassroots organizations, such as local, county, and regional Fire Safe Councils and local community residents. Communities throughout the state have been encouraged to develop a CWPP and integrate their CWPP planning process into other planning processes such as:

- County general plan
- Local Hazard Mitigation Plan
- Flood Mitigation Plan (prepared by communities participating in the National Flood Insurance Program (NFIP)
- Other local hazard, evacuation, and emergency plans

For communities without a CWPP, a good starting place in the plan development process is working from an existing plan such as a CAL FIRE Unit Plan and building in the CWPP minimum requirements, which consist of the following:

1. **Collaboration.** A CWPP must be collaboratively developed with local, state, and federal agencies that manage land in the vicinity of the community among other non-governmental stakeholders (i.e., large industrial land owners and utility companies).

2. **Priorities for Fuel Reduction.** A CWPP must identify and rank areas for hazardous fuel reduction treatments on both federal and non-federal land. It needs to recommend the types and methods of treatment that, if completed, would reduce the risk to the community.

3. **Treatment of Structural Ignitability.** A CWPP must recommend measures that homeowners and communities can take to reduce the ignitability of structures throughout the area addressed by the plan.

4. **Final Certification and Agreement Page.** The CWPP must be agreed to and signed off by three entities: local government, local fire department, and State Forester. Communities with a completed CWPP are required to attach this signature page to their plans.

Through the 2010 Assessment analysis, the Fire and Resource Assessment Program (FRAP) was able to find 317 communities identified by name from the information provided on the website. Some communities may be listed or covered within a countywide CWPP and/or they created their own. El Dorado County is an example in which there is a countywide plan and approximately 17 communities within the countywide plan have been creating individual CWPPs supported by the El Dorado County Fire Safe Council.

"Communities At Risk "(CAR)

To help protect people and their property from potential catastrophic wildfire, the National Fire Plan directs funding to be provided for projects designed to reduce the fire risks to communities. A fundamental step in achieving this goal was the identification of communities that are at high risk of damage from wildfire. At the request of Congress, states have submitted lists of all communities within their borders that meet the criteria of structures at high risk from wildfire and are adjacent to federal lands. These high-risk communities identified within the WUI were published in the Federal Register in 2001. With California's extensive WUI situation, the list of communities extends beyond only those adjacent to federal lands and includes 1,272 communities. California's "Communities at Risk" are unique communities ranging from large cities, such as San Diego and Los Angeles, to small unincorporated areas with few residents.

Firewise

Firewise Communities/USA is a unique opportunity available to America's fire-prone communities. Its goal is to encourage and acknowledge action that minimizes loss of homes to wildfire. It teaches homeowners to prepare for a fire before it occurs. The program adapts especially well to small communities, developments, and residential associations of all types. The program reports that as of February 2010 there are 538 Firewise communities in the nation and currently 53 in California. These communities are found throughout the State. Firewise Communities/USA is a simple, three-legged template that is easily adapted to different locales. It works in the following way:

- Wildland fire staff from federal, state, or local agencies provides a community with information about coexisting with wildfire along with mitigation information tailored to that specific area
- The community assesses its risk and creates its own network of cooperating homeowners, agencies, and organizations
- The community identifies and implements local solutions

As mentioned previously, in 2012 CAL FIRE, Firewise and California Fire Safe Council signed a MOU to allow CFSC to act as the State Liaison for Firewise Communities in California. However, CAL FIRE remains an active participant by partnering with CFSC in this effort.

Defensible Space Law

A new state law that became effective in January 2005 extended the required defensible space clearance around homes and structures from 30 feet to 100 feet. In summary, Public Resources Code Section 4291 now states that a person who owns, leases, controls, operates, or maintains a building or structure in, upon, or adjoining a mountainous area, forest-covered lands, brush-covered lands, grass-covered lands, or land that is covered with flammable material shall at all times maintain defensible space of 100 feet from each side and from the front and rear of the structure, but not beyond the property line.

A home with tree cover and vegetation cleared and/or thinned of combustible fuels, providing "defensible space" where fire personnel have defended the house from the onslaught of wildfire

Source: CAL FIRE Communications Program

Proper clearance to 100 feet dramatically increases the chance of a house surviving a wildfire. The vegetation surrounding a building or structure is fuel for a fire. Even the building or structure itself is considered fuel. Research and experience have shown that fuel reduction around a building or structure increases the probability of it surviving a wildfire. Good defensible space allows firefighters to protect and save buildings or structures safely without facing unacceptable risk to their lives. Fuel reduction through vegetation management coupled with ignition-resistant construction is the key to creating good defensible space.

Numerous local jurisdictions have adopted more stringent standards. Defensible space programs, otherwise known as fire safe inspections, can be implemented at many different levels. For example:

- CAL FIRE uses firefighters to inspect high hazard areas
- USFS inspects where it has direct protection responsibility on private lands
- Fire Safe Council inspections are conducted with the support of grant dollars, homeowners association dues, and counties funds such as Title III
- Local fire agencies, both paid and volunteer, inspect with firefighters and volunteers

Fuel Reduction Programs

Fuel reduction programs are administered and implemented at many of the same levels as defensible space programs.

CAL FIRE has the Vegetation Management Program (VMP), a cost-sharing program that focuses on the use of prescribed fire and mechanical means for addressing wildland fire fuel hazards and other resource management issues on State Responsibility Area (SRA) lands. A significant provision of the VMP is the public-private partnership authorized by legislation, wherein state-funded CAL FIRE fire protection resources can be used on private land at state expense to reduce hazardous fire-prone vegetation. Prior to this legislation, use of public resources was not allowed on private land.

The California Forest Improvement Program (CFIP) provides cost-share assistance to private forest landowners, Resource Conservation Districts, and nonprofit watershed groups. Cost-shared activities include management planning, site preparation, tree purchase and planting, timber stand improvement, fish and wildlife habitat improvement, and land conservation practices.

Additionally CAL FIRE uses local government agencies or nonprofit organizations, (any California corporation organized under Section 501(c)(3)) to implement Community Assistance Grants (CAGs). Lastly, CAL FIRE assists local agencies and councils in the wildland-urban interface grant process.

In addition to state-sponsored programs, the Natural Resources Conservation Service provides the Environmental Quality Incentives Program (EQIP). EQIP was reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP contracts provide financial assistance to implement conservation practices. Program practices and activities are carried out according to an EQIP plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or measures needed to address the resource concerns.

Fire Safe Councils assist with the award and administration of the grants that are awarded through the Grants Clearinghouse; these grant dollars may come from federal agencies such as BLM or the USFS.

The FEMA Pre-Disaster Mitigation Grant program provides assistance to communities that have identified wildfire hazard mitigation needs, in the form of fuel reduction, structural modifications, and planning grants.

Fire Safe Planning efforts such as the California Fire Plan, CAL FIRE Unit Fire plans and local Community Wildfire Protection Plans (CWPPs) are the road maps for reducing the risk of wildfire. These plans identify projects that fit within communities' priority areas and are considered to be of most value. These documents are invaluable to the implementation of Fire Safe programs throughout the state.

Wildland-Urban Interface Building Code

More than 50 percent of structures lost in WUI fires are in fires that burn more than 300 structures. These fires are what CAL FIRE has termed "conflagration" fires. These fires burn during extreme fire behavior conditions that usually include high winds and hot temperatures when flames spread rapidly. Extreme winds sometimes blow embers ½ to 1 mile from the main fire into urban interface areas. These fires are located near homes, moving so fast and so destructively that it is not possible to get enough firefighters and equipment on scene soon enough. The solution to this problem is to design and build communities that are resistant to the unwanted effects of WUI fires. Reducing structural ignitions from windblown embers or direct flame contact through use of appropriate design, materials, and assemblies is the goal of the WUI fire and building codes. A successful design would allow for a wildland fire to burn through a developed area with no damage to built assets and no injuries to people.

For this reason, state and local governments in California have enacted numerous laws related to protecting communities from wildfire. Many of the laws focus on roofing or vegetation, the two major factors that affect structure loss during wildland fires. In many cases, these laws were passed immediately following a major fire.

On September 20, 2005, the California Building Standards Commission approved the Office of the State Fire Marshal's emergency regulations amending the California Code of Regulations (CCR), Title 24, Part 2, known as the 2007 California Building Code (CBC). The amendment states as follows:

> 701A.3.2 New Buildings Located in Any Fire Hazard Severity Zone. New buildings located in any Fire Hazard Severity Zone within State Responsibility Areas, any Local Agency

Very-High Fire Hazard Severity Zone, or any Wildland-Urban Interface Fire Area designated by the enforcing agency for which an application for a building permit is submitted on or after January 1, 2008, shall comply with all sections of this chapter. New buildings located in any Fire Hazard Severity Zone shall comply with one of the following:

1. State Responsibility Areas - New buildings located in any Fire Hazard Severity Zone within State Responsibility Areas, for which an application for a building permit is submitted on or after January 1, 2008, shall comply with all sections of this chapter.

2. Local Agency Very-High Fire Hazard Severity Zone - New buildings located in any Local Agency Very High Fire Hazard Severity Zone for which an application for a building permit is submitted on or after July 1, 2008, shall comply with all sections of this chapter. The Legislation gave Local Government an additional year (2009-2010) to adopt the VHFHSZ recommendations.

Post-Fire Assessments of Effects of Wildfire on Natural Resources

The U.S. Forest Service has conducted Burn Area Emergency Response (BAER) team assessments for burned areas located on federal lands. The BAER teams provide a rapid assessment of the fire area and downstream values at risk to determine whether the potential post-fire effects pose a threat to life or property. However, BAER teams only examine federal lands. The directives issued in the Governor's Executive Order S-07-08 collectively require Cal OES, the California Resources Agency, and the California Environmental Protection Agency to provide similar service to citizens living near burned areas on state, local, tribal, or private lands. The State Emergency Assessment Teams (SEATs) have been used to conduct similar assessments where needed on state responsibility lands. While BAER teams are comprised of USFS personnel, the funding and personnel availability for SEATs is not provided for by regulation or statute. In many cases, SEATs also worked closely with federal post-fire assessment teams (BAER teams) to avoid duplication of effort and also to ensure that entire watershed effects were evaluated, since debris torrents and mudslides, more common after catastrophic wildfire, occur without regard to jurisdictional boundaries. Both SEATs and BAER teams set work priorities based on potential values and threats to life, property, safety, and resources.

Natural Hazard Disclosures

Natural Hazard Disclosures (NHDs) in real estate transactions have been required for wildland fire hazards since 1990 but were not widely used until the late 1990s. NHDs are required in Very High Fire Hazard Severity Zones (VHFHSZs) in LRAs and in all SRAs regardless of fire hazard. CAL FIRE provides Natural Hazard Disclosure maps and data for two types of fire hazard areas referred to in legislation as disclosure items in real estate transactions.
(http://frap.cdf.ca.gov/projects/hazard/hazard.html#)

For specific mitigation ideas related to wildfires, see "Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards" January 2013, prepared by FEMA, available on the FEMA website: http://www.fema.gov/library/viewRecord.do?id=6938

Hazard Mitigation Grant Program (HMGP) Projects

During the past ten years, local government and state agencies requested $23.1 million in wildfire mitigation projects from the Hazard Mitigation Grant Program (HMGP) under the Stafford Act and received a total of $15.9 million.

5.4.6 OPPORTUNITIES FOR ENHANCED WILDFIRE HAZARD MITIGATION

California law requires each city and county to adopt a general plan "for the physical development of the city or county, and any land outside its boundaries which…bears relation to its planning" (Government Code Section 65300). The general plan is the "constitution" for all local development. It expresses the community's goals and embodies public policy relative to the distribution of future land uses, both public and private. The general plan must contain seven mandatory elements—land use, housing, circulation, conservation, open space, noise, and safety. Although WUI issues could be addressed in almost any of the mandatory elements, the most logical place for them is the safety element.

The goal of the safety element is to reduce the potential risk of death, injuries, property damage, and economic and social dislocation resulting from hazards such as fires, floods, earthquakes, and landslides. Within the safety element, local jurisdictions must address fire-safe standards, including evacuation routes, water supplies, road widths, and clearance around structures. Although this information has been required to be included in general plans since 1974, compliance is not universal. SB 1241, among other things, intensifies the application of OPR's Fire Hazard Planning Guidelines in SRA Areas and Very High Fire Hazard Severity Zones (see Section 5.4.2.2).

In 2003, OPR provided specific guidance for incorporating fire issues in the general plan in a publication entitled Fire Hazard Planning, which is part of the General Plan Technical Advice Series. The document can be downloaded at: http://opr.ca.gov/s_publications.php#pubs-F

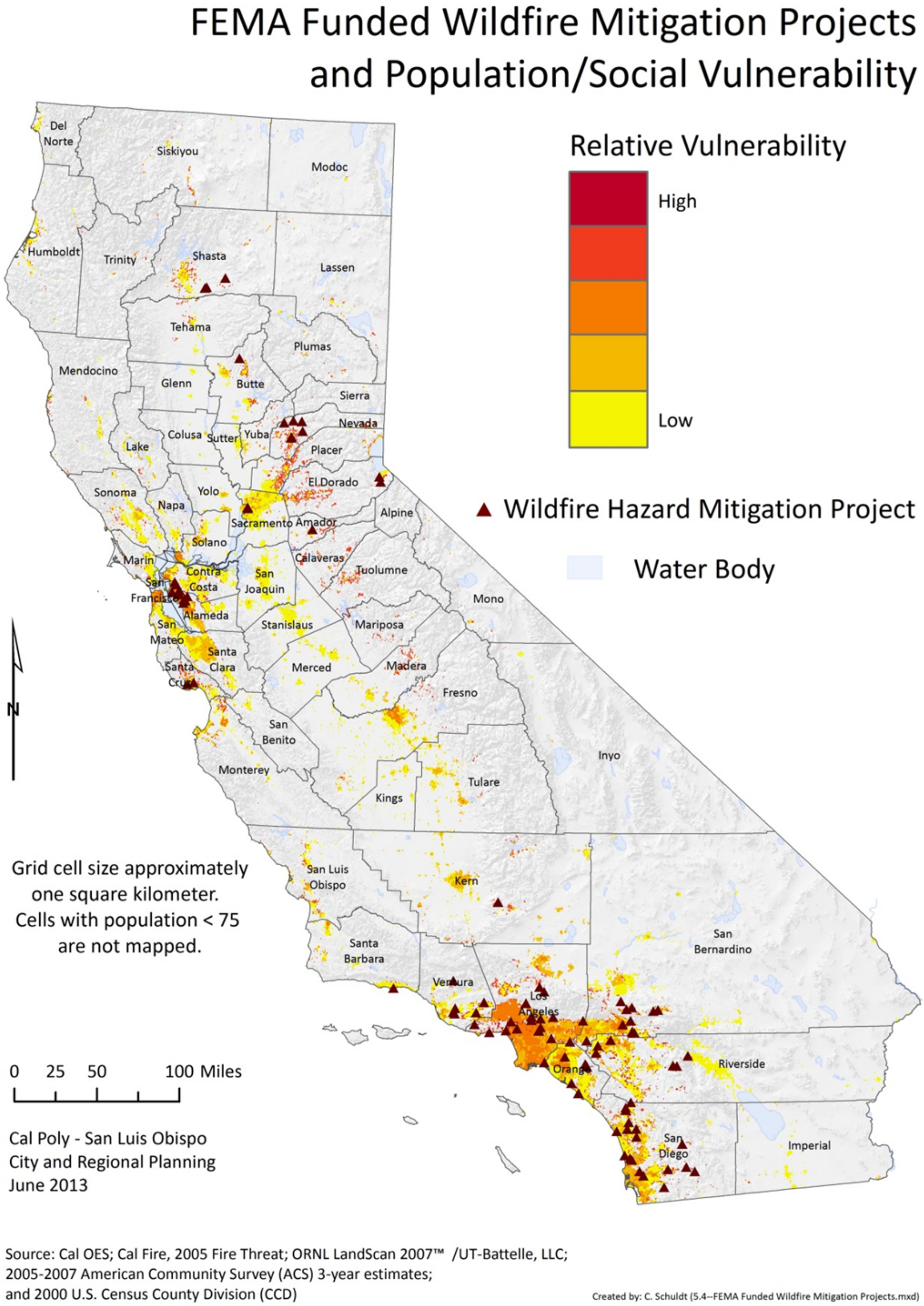
The purpose of the document is to help local jurisdictions develop effective general plan policies related to fire hazard mitigation and to help Fire Safe Councils, concerned citizens, and other interested parties develop fire plans that contain policies that can easily be integrated into local general plans.

Fire Hazard Planning encourages a collaborative approach to hazard mitigation planning that links local mitigation efforts with local land use decision-making and that involves state and local government agencies, elected officials, local planners, community members, nonprofit organizations, fire districts, and others. This approach maximizes community safety and can help link planning and funding decisions. It has provided a model for other community guidance, such as that provided for communities in flood hazard zones represented by DWR's handbook for communities implementing flood hazard legislation (see Progress Summary 5.O: New Flood Laws).

The publication of *Fire Hazard Planning* was OPR's first step in developing a larger guidance toolkit for incorporating multi-hazard mitigation planning policies into the general plan and associated local prevention, response, and mitigation plans. Since then, substantial wildfire hazard mitigation knowledge has been gained as a result of major wildfires in 2003, 2007, 2008, and 2009. Such experiences provide a rich opportunity to enhance knowledge available to WUI area stakeholders through a future update to *Fire Hazard Planning.*

The *Fire Hazard Planning* document is further strengthened by the passing of wildfire hazard Senate Bill 1241 (SB 1241) in 2012. Among other things, SB 1241 requires communities to take the most recent *Fire Hazard Planning* document into account during periodic general plan safety element updates (see Section 5.4.4.2 for more information on SB 1241).

MAP 5.MM: FEMA-Funded Wildfire Mitigation Projects and Population/Social Vulnerability



Map 5.MM shows the pattern of wildfire-related Hazard Mitigation Grant Program projects approved or completed in the past decade in relation wildfire vulnerability. *(Online or download viewers can zoom in for a closer view of the information on this map.*)

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