Sonoma County
Hazard Mitigation Plan

SEISMIC HAZARDS

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Hazard Description

"Earthquake" is a term that describes ground shaking due to release of seismic energy that is caused by a sudden rupture; by volcanic or magmatic activity; or by other sudden stress changes in the earth. Faults are planes of weakness in the earth's crust where one side has moved relative to the other. Earthquakes can occur without warning, and can cause significant damage and extensive casualties after just a few seconds. The most common effect of earthquakes is ground motion, the movement or shaking of the earth's surface during an earthquake. Ground shaking is caused by seismic waves that are generated by the sudden slip on a fault, and travel through the earth or along its surface.

Sonoma County is located along the west coast of California where the Pacific Plate is slowly moving to the northwest. It grinds against the west-moving North American Plate creating large stresses. When the stress exceeds the strength of the earth materials, fault rupture occurs. As a result, Sonoma County is seismically active area and several major faults traverse the County. The Alquist-Priolo Earthquake Fault Maps identify 3 earthquake faults running the length of the County. The Northern Segment of the San Andreas Fault (plate boundary) crosses Sonoma County land at Bodega Bay, but continues northward offshore. It appears to land again at Fort Ross and continues past the community of The Sea Ranch to the County's northern border. The Rodgers Creek Fault connects southward to other faults that merge into the San Andreas Fault. The Maacama Fault lies to the east of the Healdsburg Fault and continues northward, passing east of the City of Cloverdale. All of these faults are right lateral strike-slip faults, meaning that the land on the western side of the fault moves north in an earthquake. The locations of these faults are shown in Figure 8.1. Seismic activity along other active regional faults, or unknown faults in the area could also affect Sonoma County.

Earthquakes can result in the following adverse physical effects: ground shaking, surface fault rupture, liquefaction, and earthquake induced-landslides or secondary effects such as fires, tsunamis, and hazardous material releases. Each is briefly discussed below.

Ground Shaking

The most significant physical characteristic of a major earthquake is ground shaking. According to the State Hazard Mitigation Plan, damage due to ground shaking produces over 98 percent of all building losses in a typical earthquake. During an earthquake, the ground can shake for a few seconds or over a minute. The strength and duration of ground shaking is affected by many factors. Distance from the fault is the most significant factor; however, geologic conditions, direction of the fault rupture, magnitude and depth are also critical. Shaking, particularly horizontal shaking, causes most earthquake damage, because structures often have inadequate resistance to this type of motion. The strongest shaking is typically close to the fault where the earthquake occurs. Rarely, as in 1906, strong earthquake shaking from a distant fault rupture has caused severe damage to vulnerable zones in Sonoma County. A composite map of potential ground shaking from faults affecting Sonoma County is shown in Figure 8.2.

There are a number of different scales and terms used to describe the amount of shaking that occurs in an earthquake, including: Moment Magnitude, Richter Magnitude, Modified Mercalli Intensity (MMI), and Peak Ground Acceleration (PGA). All of these terms capture different aspects of earthquake shaking and are important to accurately assess risk.

The Modified Mercalli Intensity (MMI) scale classifies earthquake shaking intensity into 12 classes - I through XII, by the amount of damage observed. Generally little damage is caused or observed at MMI levels I through V which have only imperceptible to light shaking. However, as shaking intensity becomes moderate observed damage begins to appear and intensifies with levels VI –XII.

Table SH-1: Comparison of MMI Shaking Intensity Levels

MMI value	Shaking severity	General Damage level	Description of effects:
VI	Moderate	Objects Fall	Felt by all. People walk unsteadily. Many frightened. Windows crack. Dishes, glassware, knickknacks, and books fall off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster, adobe buildings, and some poorly built masonry buildings cracked. Trees and bushes shake visibly.
VII	Strong	Nonstructural Damage	Difficult to stand or walk. Noticed by drivers of cars. Furniture broken. Damage to poorly built masonry buildings. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices, unbraced parapets and porches. Cracks in better masonry buildings.
VIII	Very Strong	Moderate Damage	Steering of cars affected. Extensive damage to unreinforced masonry buildings, including partial collapse. Fall of some masonry walls. Twisting, falling of chimneys and monuments. Wood-frame houses moved on foundations if not bolted; loose partition walls thrown out.
IX	Violent	Heavy Damage	Damage to masonry buildings ranges from collapse to serious damage unless modern design. Wood-frame structures rack, and, if not bolted, shifted off foundations. Underground pipes broken.
X	Very Violent	Extreme Damage	Poorly built structures destroyed with their foundations. Some well-built wooden structures and bridges heavily damaged and needing replacement.
XI	*MMI Not Mapped	* MMI Not Mapped	Rails bent greatly. Underground pipelines completely out of service.
XII	* MMI Not Mapped	* MMI Not Mapped	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

*These intensities and damage levels are so great that they generally occur only in areas where there is ground failure. As a result these MMI areas are not mapped.

Table SH-2 details how the MMI scale correlates with PGA in terms of perceived shaking and potential damage. In this Plan, the term magnitude refers to the Moment Magnitude, which represents both the strength and duration of shaking and is commonly used. This is similar to the well-known Richter Magnitude scale, but it is generally a more accurate way to measure an earthquake's damage potential.

Table SH-2: Comparison of MMI to PGA

Perceived Shaking	**Not felt**	**Weak**	**Light to Moderate**	**Strong to Very Strong**	**Severe to Violent**	**Extreme**
Potential Damage	none	none	None to very light	Moderate to heavy	Heavy	Very heavy
PGA (%g)	<0.17	0.17-1.4	1.4-9.2	9.2-34	34-124	>124
MMI Intensity	I	II-III	IV-V	VI-VII	VIII-IX	X or greater

Surface Fault Rupture

Surface fault ruptures can result from large magnitude earthquakes. Surface rupture occurs when movement on a fault deep within the earth breaks through to the surface. Structures located within the fault rupture zone are subjected to ground displacement and deformations. Most structures are not designed to withstand such large deformations and experience major damage. Pipelines crossing the fault zones can also be damaged by surface fault rupture. During the 1906 San Francisco earthquake, horizontal displacement along the San Andreas Fault averaged 15 feet in Sonoma County. The Healdsburg, Rodgers Creek and Maacama faults also show evidence of surface displacement during the past 11,000 years.

Surface rupture is the most easily avoided seismic hazard. The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting to structures. Its main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. It requires projects to conduct a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults. A structure for human occupancy cannot be placed over the trace of the fault and must be set back from the fault (generally 50 feet). The fault zones subject to the Act’s requirements are shown on Figure 8.1.

Liquefaction

Liquefaction is the sudden loss of sheer strength of saturated material during ground shaking. Three factors are necessary for liquefaction to occur: a high water table, layers of loose sand, and moderate or greater earthquake shaking. When shaken, the soil grains consolidate, pushing water towards the surface and causing a loss of strength in the soil. The soil surface may sink or spread laterally. Structures located on liquefiable soils can sink, tip unevenly, or even collapse during an earthquake. Pipelines and paving can tear apart.

The potential for liquefaction in Sonoma County exists primarily in the low-lying areas adjacent to San Pablo Bay; along the Russian and Petaluma Rivers, Santa Rosa and Sonoma Creeks; the Laguna de Santa Rosa and Santa Rosa Plains. Areas susceptible to liquefaction are shown in Figure 8.1.

Landslides

Landslides are slope failures that can occur with or without earthquakes. Landslide hazards are discussed further in Chapter 6. Seismically triggered landslides are a concern in areas with steep and unstable slopes. Two types of landslides can cause damage to the built environment: 1) disrupted slides and falls (i.e. rock falls, soil falls, disrupted soils slides, and rock slides) can impact property or infrastructure from above and 2) Coherent slides (i.e. rock slumps, soil slumps, rock block slides, and slow earth flows) can impact property if land masses slide downslope below or beneath developed properties, as has occurred on a large slide mass in Santa Rosa referred to as “moving mountain.”

Earthquake-induced landslides can also be exacerbated during periods of high rainfall, where the ground is saturated and even normally stable materials can fail. These slides could result in significant property and infrastructure damage, and potential injury and loss of life in many areas of the County. Areas susceptible to earthquake-induced landslides are shown in Figure 8.11.

Post-Earthquake Fire

Fire often accompanies earthquakes, caused by breaks in natural gas lines, damaged electrical systems, or toppled appliances. Fire following an earthquake is particularly difficult to suppress because of the likelihood of numerous simultaneous ignitions, broken water mains, blocked or damaged routes for evacuation and firefighter access, and other demands on fire personnel. This threat was evident in the 1906 earthquake in both San Francisco and Santa Rosa, the 1989 Loma Prieta earthquake in the San Francisco Marina District, and the 1995 Kobe, Japan earthquake. Densely populated neighborhoods with wooden homes, like many of the residential areas in Sonoma County are most at risk.

Tsunami

A tsunami is a series of travelling ocean waves generated by undersea earthquakes or landslides. When a tsunami enters shallow coastal waters, its speed increases and the wave height increases. This action creates the large wave that becomes a threat to life and property in low-lying shoreline areas. It is most common for tsunamis to be generated by offshore subduction zone faults around the Pacific Rim such as those in Washington, Alaska, Japan, and South America.

Tsunamis are less commonly associated with strike-slip faults, such as the San Andreas system. Sonoma County's rugged cliffs and generally elevated coastline reduces its exposure and vulnerability to tsunamis. The areas in Sonoma County that have the greatest exposure to potential damages by a tsunami are those coastal communities along the southern Sonoma County coast from Jenner to Bodega Bay. Tsunami inundation maps for the Sonoma Coast area near Jenner, Bodega Bay, and the San Pablo Bay were released in 2009 and form the basis for the County's Tsunami Response Plan (See Map Figures).

There are no known recorded deaths from a tsunami in Sonoma County, but there were small tsunami impacts in 1946 and 1964. The disastrous effect of tsunamis has been demonstrated in a number of past occurrences in other locations. In 1964, a tsunami generated from an earthquake in Alaska caused tsunami waves 10 and 20 feet high along parts of the California, Oregon, and Washington coasts. The coast of damages in California was $32 million dollars (calculated in 1983 dollars), with the bulk of the costs incurred in Crescent City, where 11 fatalities were recorded. There were more than 120 deaths in Canada and the United States combined.

Hazardous Materials

Hazardous materials releases pose a secondary threat that is typically associated with earthquakes. Releases can occur during transport or at fixed locations, such as manufacturing plants or storage facilities. Hazardous materials accidents or releases can occur at any time, and when limited to single events, are generally contained by facility owners or community hazardous materials response teams. In an earthquake, there is the potential for numerous simultaneous hazardous materials releases that are not detected immediately, lead to fire ignitions, or overwhelm resources due to competing priorities.

More information regarding hazardous materials sites can be found in the Community Profile Chapter.

Hazard History

Pre-1900 Earthquakes

The Bay Area has experienced significant, well-documented earthquakes. Since 1855, more than 140 earthquakes have been felt in the Santa Rosa area. Although earthquake records prior to the year 1900 are difficult to interpret, seven earthquakes are believed to have caused damage to structures in Sonoma County during the 19th century. For the most part, damage from these earthquakes indicates a Modified Mercalli Intensity (MMI) ranging from VI-VIII. The MMI scale is based on observed damage, which indicates that damage from most earthquakes was limited to broken glass, cracked walls, and falling chimneys (Table SH-1). Two earthquakes are of note: the 1868 M7.2 earthquake on the Hayward Fault, and the 1898 M6.7 earthquake believed to have occurred on the Rodgers Creek Fault. Although damage from these two events was limited due to the area's sparse population at the time, a recurrence of either of these events could result in significant damage to today's widespread and varied infrastructure and building stock.

1906 San Francisco Earthquake

The April 18, 1906, M8.3 earthquake on the northern segment of the San Andreas Fault, known for devastating San Francisco, caused major damage in Santa Rosa, Sebastopol, Healdsburg, Petaluma and other communities. Santa Rosa, only 20 miles from the San Andreas Fault, is said to have suffered more damage proportionally to its size than any other Bay Area city. The population of Santa Rosa at the time was about 6,000. The only reported casualties in Sonoma County were in the City of Santa Rosa, where 65 persons died and 12 remained missing. The shaking lasted for about fifty seconds. The Santa Rosa Courthouse was totally destroyed by the shaking and ensuing fire, as were approximately eight blocks of commercial buildings. It was reported that almost all non-wood buildings were destroyed by the shaking alone. The amount of fire damage was attributed to insufficient firefighters and equipment, and a delay in getting the fire equipment out of the fire house, where falling debris blocked the entrance.

The California Earthquake Investigation Commission postulated that, in part, the damage was exacerbated by the high ground water level in the alluvial fan the City of Santa Rosa was built upon. In April, the ground was still saturated from the spring rains. This likely amplified and contributed to the length of ground shaking that occurred. As a result of the damage, new building regulations were adopted in May 1906, and amended in May 1907. They included requirements for brick buildings to be reinforced with steel and that cement mortar be used, in place of the former practice of using weaker lime mortar.

1969 Rodgers Creek / Healdsburg Fault Earthquake

The last major earthquakes epicentered in Sonoma County occurred on October 1, 1969. Two earthquakes of Magnitudes 5.6 and 5.7 originated near the juncture of the Rodgers Creek and Healdsburg Fault, approximately two miles north of Santa Rosa. Damage was concentrated in the City of Santa Rosa, and principally confined to the partial collapse or near collapse of unreinforced masonry buildings and wood frame buildings with substandard foundations or inadequate bracing. In all, ninety-nine structures were significantly damaged, approximately half in the business district and half in residential areas. Nearly half of all significantly damaged buildings were demolished. Total building damage was estimated at $6 million, with dwelling contents losses at $1.25 million. Several County buildings suffered damage, including the Library, Post Office, and Veterans Memorial Building. There was more than expected damage to the newly constructed two-story Sonoma County Social Services Building at the County Administration Center. There was significant damage to the Fremont Elementary School, a two-story unreinforced masonry building that had recently been identified as failing Field Act standards for school structural safety, but was still in active use. Santa Rosa Memorial Hospital incurred approximately $240,000 in damage, of which only $40,000 was attributable to building damage. The more serious damage was caused by a fire, which was ignited in a chemical laboratory after the second shock. The fire was extinguished quickly because a fire truck had been dispatched, per the emergency plan, immediately following the first shock.

Electric power and telephone communications were disrupted for a short period of time. Although the Mayor of the City of Santa Rosa sought state and federal disaster assistance, there was not enough damage to public facilities to warrant a declaration. Small Business Administration loans were made available to commercial and residential property owners at a three percent interest rate. Fortunately, there was no loss of life from the earthquakes, which can be attributed to the limited structural damage that occurred and the earthquakes striking in the evening hours, when most residents were at home. The population of Santa Rosa at the time was 49,000. The city has since grown to approximately 167,000, putting significantly more people, buildings and infrastructure at risk from future earthquakes.

1989 Loma Prieta Earthquake

This M6.9 magnitude earthquake was caused by slip along the San Andreas Fault. Though the damage in Sonoma County from the quake was very minor (only 5 dwellings were yellow tagged), the quake killed 63 people and injured 3,757 throughout Northern California. It caused a total of over 16,700 housing units to be uninhabitable throughout the Monterey and San Francisco Bay Areas and left some 3,000-12,000 people homeless. The earthquake caused severe damage in some very specific locations in the San Francisco Bay Area, most notably on unstable soil in San Francisco and Oakland, where some 12,000 homes and 2,600 businesses were damaged. In Santa Cruz, close to the epicenter, 40 buildings collapsed. Many homes were dislodged that were not bolted to their foundations.

The worst disaster of the earthquake was the collapse of the two-level Cypress Street Viaduct of Interstate 880 in West Oakland. The failure of support columns along a 1.25-mile (2.0 km) section of the viaduct, also known as the "Cypress Structure" killed 42 and injured many more. This stretch of Interstate 880 was a double-deck freeway section built in the 1950s of non-ductile reinforced concrete that was constructed above and astride Cypress Street in Oakland. The quake caused an estimated $6 billion ($11 billion in current value) in property damage, becoming one of the most expensive natural disasters in U.S. history at the time. It was the largest earthquake to occur on the San Andreas Fault since the great 1906 San Francisco earthquake.

2014 South Napa Earthquake

On August 24, 2014, a M6.0- earthquake shook Napa, Solano, and Sonoma County. The epicenter was located about 4.2 miles northwest of American Canyon, six miles southwest of the City of Napa and nine miles southeast of the City of Sonoma, according to the United States Geological Survey (USGS). The earthquake occurred on the West Napa Fault, a fault that was not mapped under the Alquist-Priolo earthquake fault hazard zone. The earthquake was the largest event in the Bay Area since the 1989 Loma Prieta Earthquake. The earthquake lasted 10 to 26 seconds, depending on location, and caused 8 miles of surface rupture (with up to 18 inches of offset). At least twelve aftershocks followed, including one of M3.9. 257 people were injured during the quake and one person was killed. 163 structures, many in downtown Napa, were severely damaged and red-tagged by Inspectors. Several structures in eastern Sonoma County were also severely damaged. An additional 3,517 structures were inspected, of which 1,749 were identified as being moderately damaged. Several older commercial buildings in downtown Napa showed signs of extensive external damage even though they had undergone seismic retrofit.

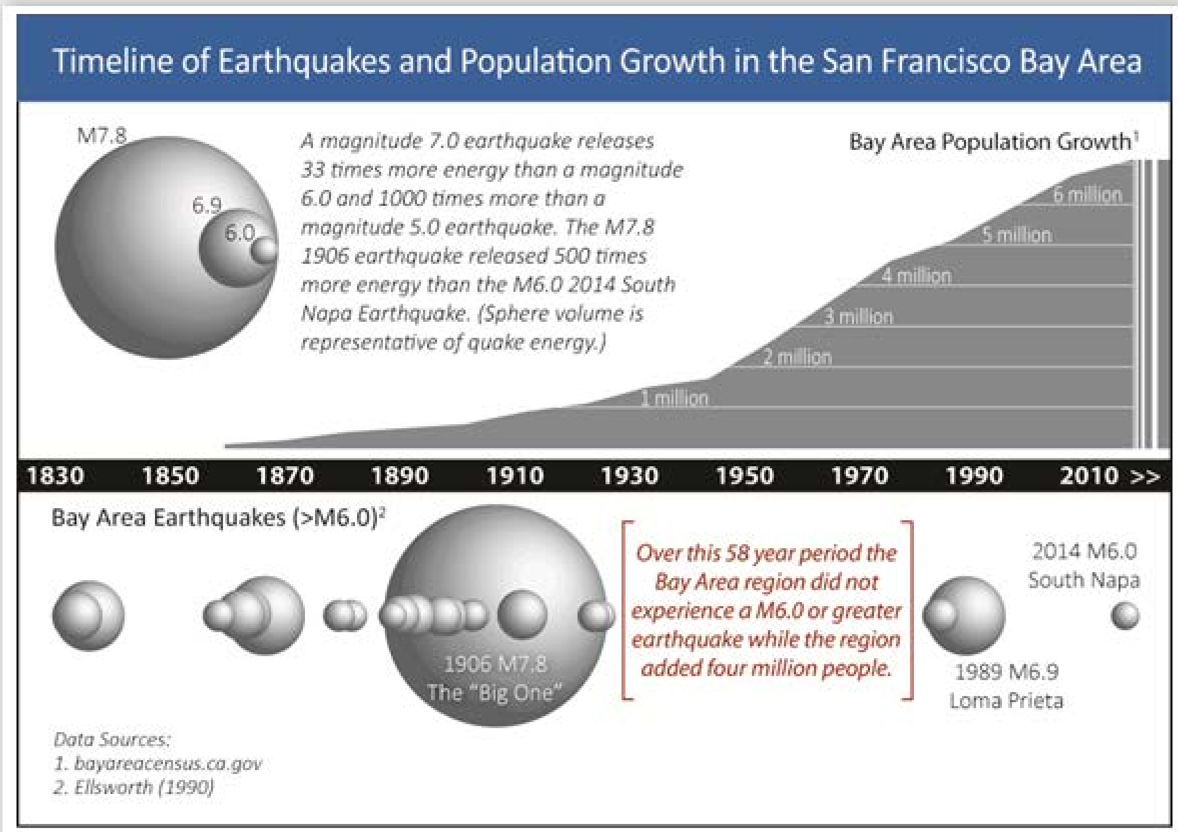
Napa and Solano Counties experienced minor damages to several roads, water mains, and gas line breaks. Napa, Solano, and Sonoma County experienced electrical and water service disruptions.

Due to the extensive damages, Governor Brown issued an emergency proclamation on August 24, 2014 for the State of California. President Obama declared the incident a major disaster on September 11, 2014. The total economic loss was estimated at 400 million dollars. State and federal disaster assistance totaled more than $30 million for people and businesses affected by the earthquake. Of that total, $8.8 million where in grants from the Federal Emergency Management Agency (FEMA) and the California Governor’s Office of Emergency Services (Cal OES), and $21.2 million in low-interest disaster loans from the Small Business Administration (SBA).

Future Potential

Historic records of earthquake occurrences may give some indication of future probabilities. Figure SH-1 shows that seismic activity was more frequent from 1830 to 1930 than it has been since. This leads some scientists to suspect that pressure is building up along the faults in the Bay Area that can result in a large quake. Such a quake could have dramatic and devastating effects throughout the Bay Area.

Figure SH-1: Timeline of Earthquakes and Population Growth in the San Francisco Bay Area



In 2008, the United States Geological Survey (USGS) Working Group concluded that there is a 63 percent probability of at least one M6.7 or greater earthquake striking in the San Francisco Bay region before 2032, a 31 percent chance along the Hayward/Rogers Creek fault, and a 21 percent chance of occurrence along the Northern San Andreas Fault. Figure SH-2 illustrates the above analysis. An earthquake of the above magnitude on either of these fault systems could result in serious damage to buildings, facilities, and infrastructure in densely populated areas of the County.

In March 2015, the USGS released an update to the above 2008 earthquake probabilities for California faults using the Uniform California Earthquake Rupture Forecast 3 (UCERF3) model. It considers data such as fault length; how much energy the faults release annually through fault slip; and, known historical return periods for the fault. As a result of the updated analysis, the USGS estimates there is a 72 percent chance of one, or more, M 6.7, or larger earthquakes in the next 30 years on one of the Bay Area's faults. This new analysis changed the probability along the San Andreas Fault to 33 percent and the lowered Rodgers Creek Fault to 15%. Smaller magnitude earthquakes are more likely to occur, potentially producing significant local damage. The results of the USGS 2015 earthquake probability assessment is indicated in Table SH-3 below.

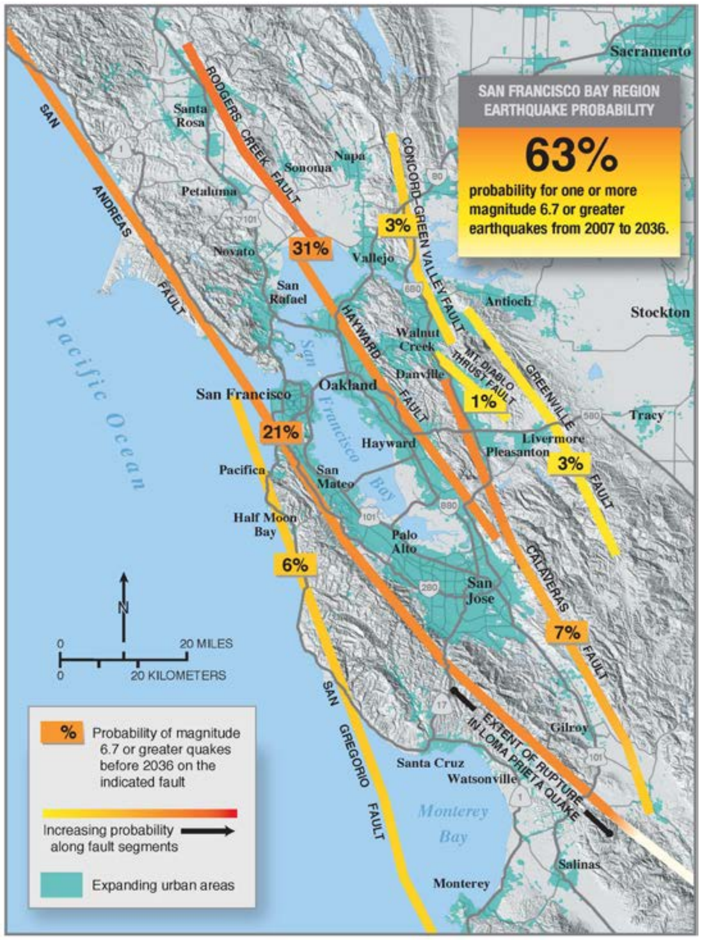
Table SH-3: Likelihood of a M6.7 or greater earthquake over the next 30 years

Earthquake Fault	Probability
San Andreas (Mendocino Coast to San Benito County)	33%
Hayward	28%
Calaveras	24%
Hunting Creek, Berryessa, Green Valley, Concord	24%
Maacama	23%
Rodgers Creek	15%
San Gregorio	5%
Greenville	6%
Mt. Diablo	3%
West Napa	2%

Source: Uniform Earthquake Rupture Forecast, Version 3, 2014

Change in probabilities is attributed to 1) the impacts of the 2014 South Napa earthquake, which is thought to have relieved pressure in some areas; 2) the segment lengths considered between 2008 and 2015. For instance, the 2008 study assessed probabilities along the Northern San Andreas Fault while the 2015 study looked at the entire length of the San Andreas Fault. The 2008 report considered Hayward and Rogers Creek faults together, while the 2015 report addressed them separately. This plan takes a more conservative approach and considers both probability assessments together.

Figure SH-2: San Francisco Bay Region Earthquake Probability



Exposure and Vulnerability

Every part of Sonoma County could experience ground shaking during an earthquake. Every building, road, pipeline, and other structure in the county is vulnerable to earthquakes and could be damaged. Some of these structures face an elevated risk because they are located in high hazard zones, such as near the trace of an active fault, on liquefiable soils, or on slopes subject to landslides. Other structures face high risk because they are inadequate to withstand strong shaking, primarily because they were built decades ago before modern building codes were enacted. Some structures support critical County functions, such as emergency response activities, and it is especially important that these structures remain functional after an earthquake.

This section examines the exposure and vulnerability of important assets of Sonoma County to earthquake risk. The term exposure refers to the number of facilities, their value, and functions they support and their location relative to earthquake hazard zones. The term vulnerability refers to how likely each of those facilities is to be damaged if impacted by an earthquake.

Whenever possible, facilities exposed to earthquake risk are listed and their values are presented.

Methodology

This section reviews the exposure and vulnerability of the facilities and community elements listed below. For each of the facilities examined, available information was collected from the County and other sources, including GIS, databases, reports, and studies. An explanation of the data sources and analysis techniques used for each type of facility is presented in the Community Profile. Critical facilities include: emergency operations center and communications system, police and fire stations, hospitals and shelters; schools; transportation systems; lifeline utility systems; high potential loss facilities, such as dams; and facilities housing hazardous materials. Some of these facilities are owned and operated by the County, while others are operated by other government jurisdictions or private entities.

Critical facility buildings in the County could potentially be damaged by earthquake shaking. Some critical facilities face further risk because they are located in liquefaction or fault rupture zones. Risk may increase depending on the type, age of construction, and the precedent of seismic building code in effect at the time of construction (more stringent seismic standards were incorporated into the building codes in 1970's and 80's). Critical facilities built since the 1986 enactment of the Essential Services Building Seismic Safety Act (i.e,. a fire station, police station, emergency operations center, California Highway Patrol office, Sheriff's office or emergency communication dispatch center), have been subject to enhanced regulatory oversight, plan review, and built to higher design standards to assure their ability to function after an earthquake.

Emergency Operations Center

The Sonoma County/Operational Area Emergency Operations Center (EOC) is a reinforced concrete building constructed in 1973. The seismic safety of this structure has not been evaluated according to current standards. Typically, engineers consider pre-1975 reinforced concrete structures to be potential risks in earthquakes because significant advances in life safety have been made in the design and construction of reinforced concrete structures since that time. To remain functional during and after an earthquake, power and communication services must also be undamaged. The EOC has a back-up power generator and stored fuel, uninterrupted power supply, computer network, radios and telephone communication systems.

Emergency Communications System

While the communications system is designed to be functional even after the loss of one or more antennas, a major earthquake impacting multiple sites could significantly reduce communications effectiveness. Antenna towers are potentially vulnerable to damage by earthquakes; five towers are located in areas that could experience violent shaking or ground failure resulting in possible tower failure. Structural analyses has been conducted for these 5 buildings between 2010 and 2015. The primary earthquake mitigation is redundancy, which involves building new/rebuilding old sites. Emergency generators and uninterrupted power supply have been installed at tower sites to help assure operability.

The County structure at 445 Fiscal Drive, which formerly housed much of the County's communication system, was considered at risk of collapse in the event of an earthquake in the 2011 HMP. In 2015, this vulnerability was eliminated by relocating all voice services and network infrastructure from 445 Fiscal to the updated ISD Data Center at Paulin Drive.
The building at 2604 Ventura Avenue, houses the lines and equipment for all telephone service used by County agencies (except 911 lines), and is a reinforced concrete tilt-up building built in 1973 that the County has identified as a collapse hazard risk.

Law Enforcement Facilities

The main County Sheriff's office building was constructed in 2000 and meets stringent building codes for essential facilities. This building and the functions that are performed within are expected to perform well in a large earthquake. Most Sheriff operations are conducted out of this facility, along with law, fire and EMS emergency dispatch center operations. Vulnerability of city police department offices to earthquake would be assessed in the hazard mitigation plan of the individual city.

Fire Stations

Fire station structural integrity and equipment must be resistant to seismic shaking and remain functional for post-earthquake operations. A 2001 assessment of the fire and emergency services in Sonoma County identified concerns about the ability of some fire stations to remain functional after an earthquake. This assessment covered 13 fire agencies in the County, including CSA 40. These 13 fire agencies have 45 fire stations between them, and only 13 stations reported that their station is built to seismic safety standards. Nineteen stations reported that they maintain an emergency power supply, however, many smaller stations serve only as truck barns so they may not need an emergency power supply.
All fire stations in the County could be damaged by earthquake shaking as shown in Figure 8.3. The following fire stations may face additional risk because they are located in areas that may experience ground failure due to liquefaction during an earthquake.

- California Department of Forestry offices in Hilton and Cazadero
- Lakeville VFC, Reclamation Road (Petaluma)
- Rohnert Park DPS, City Hall Drive, Country Club Drive stations
- Petaluma FD, N. McDowell Street and D Street stations
- Rancho Adobe FPD, Main Street (Penngrove)
- Cazadero CSD, two stations on Cazadero Hwy, one on Austin Creek Road
- Russian River FPD, Canyon 7 Road and Armstrong Woods Rd stations (Guerneville)
- Monte Rio FPD, Church Street (Monte Rio), Hwy 116 (Duncan's Mill), and Hwy 1 (Jenner) stations

The following fire districts have unreinforced masonry buildings in "active" status, which could be more vulnerable to damage and potentially impede emergency response if they failed.

- Monte Rio Fire Protection District
- Sonoma Valley Fire and Rescue

The likelihood of each fire station to remain undamaged and operable after a significant earthquake is not known and site specific analysis and mitigations should be conducted.

Other County Emergency Response Buildings

The buildings housing each critical operation should be resistant to earthquake shaking and, able to remain functional after a large seismic event. Information about the value of essential and critical County buildings and their contents within hazard zones is presented in Appendix G. A number of buildings used by these County departments have been upgraded to improve their seismic performance, including the Permit and Resource Management Department Building, the La Plaza buildings, and the Administration building. The safety of other buildings used by these departments is not known.

These buildings critical for emergency operations may pose seismic safety risks, but site specific engineering evaluations are required to evaluate their survivability. The following three buildings are especially vulnerable to earthquake due to their construction dates and locations and warrant re-evaluation:

- The Building at 2604 Ventura Avenue, which houses the lines and equipment for all telephone service used by County agencies (except 911 lines), has been identified as a collapse hazard risk. Damage to this building could disrupt phone and data service into and out of all County offices, as well as law enforcement data services used by city and state agencies within the County.
- The Coroner's Office and Morgue, at 3336 Chanate Road in Santa Rosa, built in 1948 and is located in the Rodger's Creek fault zone, and is at risk of strong ground shaking and possible fault rupture.
- The Department of Health Services Administration Building, at 3313 Chanate Road in Santa Rosa, was constructed of reinforced concrete in 1970, prior to significant safety changes in building codes and may be at risk.

Hospitals

The seismic ratings of each hospital's buildings as of October 2015 with respect to structural and non-structural components, as provided by the Office of Statewide Health Planning & Development (OSHPD) are shown in Table SH-4. Laws regulating the seismic standards for hospital facilities are discussed later in this chapter.

The Office of Statewide Health Planning & Development has five structural performance category (SPC) ratings, ranging from SPC 1 to SPC 5. A rating of SPC1 is assigned to buildings that may collapse during a strong earthquake, while a rating of SPC 5 means the building is reasonably capable of providing services to the public following a strong earthquake.
Much progress has been made since 2000 when 14 of the 50 hospital structures in the County had a risk of collapsing during a strong earthquake. By 2015, all of these structures have either been retrofitted or replaced.

In 2015, the County decommissioned its hospital facility on Chanate Road in Santa Rosa in which five out of six buildings had a SPC 1 rating. The hospital was replaced by a new 108 bed regional hospital built by Sutter Health on Mark West Springs Road. All buildings in the new facility have a SPC 5 rating. The remaining seismic improvements were carried out at Santa Rosa Memorial Hospital campus and several other hospitals.

Even hospital structures meeting the highest standards of seismic construction can still be adversely impacted by non-structural damage. Earthquake shaking can damage sensitive equipment, topple storage units, and dislodge ceilings or light fixtures. Damage to water pipes could flood portions of buildings. This type of damage can be serious, and make critical areas within hospitals be non-functional during the hours immediately following a major quake.
All of Sonoma County's hospitals are located away from the Bay and coast in inland areas. Residents on the coast could be isolated from hospital care in an emergency if roads through the coastal mountains become impassable due to bridge collapses, landslides or fires. Coastal residents have access to an urgent care clinic in Gualala; paramedics based in Bodega Bay, Guerneville and Gualala; and helicopter ambulances.

Table SH-4: Seismic Safety of Hospitals in the County as of 10/22/2015

Hospital	Number of Buildings	Number of Buildings at Structural Rating					Number of Buildings at Non-structural Rating					Total Number of Beds	Number of Acute Care Beds
		1	2	3	4	5	1	2	3	4	5		
Healdsburg District Hospital	6		1			5	4					43	34
Kaiser Foundation Hospital	10			3	3	4		4	2			117	117
Palm Drive Hospital	5			4	1		5					49	39
Petaluma Valley Hospital	9			6	1	2		8	1			80	60
Santa Rosa Memorial Hospital	19		2	2	9	5		4	11	3		222	222
Sonoma Valley District Hospital	11		2	3	3	3	8					83	56
Sutter Santa Rosa Regional Medical Center	7					7				7		108	84

Key to Structural Ratings:

1. Building has significant risk of collapse in a strong earthquake. Must be upgraded or replaced by 2008 (extensions available until 2013).
2. Building does not pose high risk to life safety, but may be inoperable or unrepairable after a strong earthquake. Building built to pre-1973 code standards. Must be upgraded or replaced by 2030.
3. Building does not pose high risk to life safety, but may be inoperable or unrepairable after a strong earthquake. No upgrades required.
4. Building may withstand earthquake shaking, but may not be capable of providing service after strong shaking. No upgrades required.
5. Building may be capable of providing service after strong shaking. No upgrades required.

Key to Non-structural Ratings:

1. Basic non-structural systems are inadequately braced. Significant non-structural damage could occur. Should have been braced by 2002.
2. Non-structural systems vital to a safe evacuation are braced. Significant non-structural damage could occur.
3. Critical non-structural systems are braced. If hospital is undamaged, should be able to provide some care.
4. All non-structural systems are braced up to current codes. Should be able to provide care, but may suffer water, sewer and power outages.
5. All non-structural systems are braced up to current codes. Backup water, sewer and power systems are in place.

Shelters

Only the Santa Rosa Veteran's Memorial building was considered potential exposed to vulnerable to severe seismic shaking due to its proximity to the Rodgers Creek Fault. The building had significant structural weaknesses that could threaten life-safety. Temporary repairs were made, and a more detailed seismic analysis is planned. It is possible that other Veteran's Memorial buildings in the County, which were retrofit in the same time period as the Santa Rosa building, could have similar seismic safety concerns.

Schools

Many schools in the County are located in high hazard areas. Public schools in California generally are constructed to very high standards as their design and construction is strictly regulated by the state. Older school buildings, however, may have some structural or non-structural problems that could cause injuries, economic losses, and possibly fatalities. One public elementary school in Santa Rosa is located in the Rodger's Creek Alquist-Priolo Fault Zone. Three public schools, all in Petaluma, are located in zones at very high risk of liquefaction. Twenty additional public schools sit on soils at high risk of liquefaction. These schools range all grades, with most of them in Petaluma, Guerneville, Monte Rio, Rohnert Park, or Windsor.

Substantial improvements in the seismic design of buildings were incorporated into the 1976 Uniform Building Code and were adopted for the design and construction of public schools on July 1, 1978. In 1999, passage of Assembly Bill 300 (AB300) required the California Department of General Services (DGS) to conduct a seismic safety inventory of California school buildings (Kindergarten through grade 12) that are of concrete tilt-up construction and those with non-wood frame walls that do not meet the minimum requirements of the 1976 Uniform Building Code. The Field Act, discussed later, also triggered significant improvements in school retrofits. The state has conducted an assessment and based on the construction type classified schools into two seismic vulnerability categories:

- Category 1: Those building types that are likely to perform well and are expected to achieve life-safety performance in future earthquakes; and
- Category 2: Those building types that are not expected to perform as well as Category 1 building types in future earthquakes and that require detailed seismic evaluation to determine if they can be expected to achieve life-safety performance when subjected to earthquake ground motions specified in the 1997 Uniform Building Code design requirements.

Sonoma County has 76 schools listed on the AB300 list. These are shown in Table SH-5 below. The listing reflects status changes and /or corrections submitted by school districts through 2015. Roughly 66 to 71 of the subject school buildings are considered Category 2.
In those cases where a Category 2 building will not achieve life-safety performance when subjected to the specified ground motions, several risk reduction options are available, including (1) seismically rehabilitating the building to meet the Division of the State Architect's (DSA's) life safety requirements, (2) a change in use, or (3) demolition.

Table SH-5: Sonoma County School Districts on State's AB300 List

School District	Number of Bldgs on AB 300 List		Updated Status
	Existing	Demolished	
Bennett Valley	2		No changes
Cotati-Rohnert Park	15		No changes
Geyserville	2		No changes
Guerneville		1	No changes
Healdsburg Union	10		No changes
Mark West Union El	3		No changes
Old Adobe	4		No changes
Petaluma Joint	2		Both bldgs reviewed
Santa Rosa Elementary	9		No changes
Santa Rosa High	10		No changes
Sebastopol		1	No changes
Sonoma Valley	11		No changes
West Sonoma	3	2	No changes
TOTALS	71	4	

The County's list of unreinforced masonry buildings also includes seven private school sites, all but 1 of which has undergone seismic retrofit.

Roads and Highways

A review of the road network on Figures 8.1, 8.2 and 8.11, shows that there are numerous segments of state, county and city roads which pass over fault zones or through areas of high liquefaction, landslide or ground-shaking potential.

For planning purposes, the County General Plan classifies roads based on their importance and level of use. Major roadways are generally classified as either: "Freeway", Arterials, or Collectors with the remaining minor roads serving only their immediate vicinity. Arterials are critical transportation arteries that serve the larger public and commerce and provide an efficient way to travel to different portions of the county. What is a collector road? These designations are indicated in Figures CT-4a through CT-4i of the County's General Plan. These designations and their location relative to high earthquake hazard areas, provide a means to prioritize hazard mitigation work on road infrastructure.

Emergency responders and Sonoma County residents rely on state and federal highways to get from one end of the County to the other. U.S. Highway 101 is a federal interstate highway. State Highways include Highway 1, Highway 12, Highway 37, Highway 116, and Highway 128. If any of these highways are made impassable by an earthquake, emergency response efforts will be hampered. In the longer term, lack of these major roadways will seriously disrupt commercial activities and daily living.

The California Department of Transportation (Caltrans) is responsible for maintaining and improving state highways. The County does not have authority over state highways, but would be heavily impacted if they fail during an earthquake. Fault rupture, liquefaction and ground shaking can all have major adverse effects on roadways, including bridges.

According to the Sonoma County Department of Transportation and Public Works, about 1,384 miles of County-maintained roads consist of about 400 miles of arterial and collector roadways and 972 miles of local serving roads. Many county road segments pass over fault zones, areas of high liquefaction, landslide or ground-shaking potential and are susceptible to liquefaction and landslide damage from an earthquake. Roadways that experience liquefaction can develop very large cracks that prevent their use, and smaller cracks and sinkholes that impede traffic. Landslides triggered by earthquakes can both block and destroy sections of roads. These risks can create access problems to residents in isolated communities and impede emergency operations, including rescues and urgent medical care needs.

Earthquake shaking can cause severe damage to bridges. Liquefaction can exacerbate that damage, especially in older structures with inadequate foundations. Bridge supports may sink unevenly into liquefiable soils, which can cause severe structural problems. In addition to State-owned bridges, there are about 333 bridges in the county road network. Almost 150 County bridges are located in zones of high liquefaction probability. Many of these bridges are old: seventy-five percent were constructed before 1975, and a quarter of these were constructed before 1950. Older bridges may be more vulnerable to damage in earthquakes, particularly reinforced concrete bridges supported by columns. Two of these older bridges are located in the Rodgers Creek fault zone, meaning they could be exposed to particularly violent shaking or fault rupture.

After the destruction in the 1989 Loma Prieta and 1994 Northridge earthquakes, it was recognized that many bridges were not adequately designed to withstand the types of seismic forces to which they may be subjected and are at risk of failure.
To mitigate these weaknesses in the state highway system, Caltrans initiated a Seismic Retrofit Program to evaluate the seismic stability of the state bridges. As of 2015, thirty-eight of these bridges in the County requiring seismic retrofits or replacement have had such work completed. All other state bridges in the County were inspected and determined not to require seismic retrofitting.

The County and State have regular bridge inspection program and most bridges are inspected every two years, annually if it is a bridge of high concern. Both the County, and Caltrans, through their Local Assistance Program, have active programs to retrofit or replace seismically unsafe bridges. More information about this program is included below.

Airports

The Charles M. Schulz - Sonoma County Airport is not within an Alquist-Priolo Earthquake Fault Zone. However, Healdsburg-Rodgers Creek Fault and the Maacama Fault lie about four miles east of the Airport. The Airport is not located in a high risk landslide or liquefaction zone. Since the runways are located in an area at low risk of liquefaction and other types of ground failure, runways are expected to remain serviceable after an earthquake.

However, the Airport could potentially experience very strong ground shaking. According to the California Geologic Survey, a probabilistic earthquake in the area would produce ground shaking at the Airport that could cause slight damage on modern buildings and slight to moderate damage on older buildings. Many structures were built in the early 1960's, including Control Tower and Terminal Building, and may have structural deficiencies as measured by modern building codes. Both of these buildings are planned for replacement in the Airport 2030 Master Plan.

All recent and new construction at the Airport complies with the current seismic design requirements of the California Building Code. All foundations and geotechnical recommendations presented in the site-specific geotechnical investigations have been incorporated in construction design.

The major source of seismic hazards at the airport would likely be from non-structural building elements. Potential damage and injuries may be caused by falling objects such as suspended ceilings and light fixtures, toppling furniture; overturned shelving; broken glass; falling plaster, ceiling tiles, and rupture of overhead water pipes. As part of the Master Plan Improvement Program, the all non-structural features of the proposed construction would be tied into structural elements of the building. Heavy equipment and other potentially hazardous objects would be secured to floors or walls.

The airport has backup power generation capabilities for runway lighting systems, instrument landing systems and other navigational aids during power outages. The tower has an emergency generator for essential radio equipment.

A larger earthquake could potentially cause strong ground shaking that could rupture fuel and natural gas pipelines, resulting in leaks/spills and fire hazards. In accordance with the requirements in the CA Building Code (CBC) new gas lines would be equipped with automatic shut-off valves that would be activated in the event of an earthquake.

Railways

The railway infrastructure in Sonoma County vulnerability to seismic hazards was assessed in the 2005 and 2008 project Environmental Impact Report and supplemental addenda prepared to assess the Sonoma-Marin Area Rail Transit (SMART) system. The potential impacts of earthquake events on the 38 mile initial operating segment, including bridges, were subject to extensive geotechnical analysis. Design and construction approaches were incorporated into the building of the tracks to minimize the impacts of seismic shaking and liquefaction. Portions of the tracks in areas at risk for fault rupture, seismic shaking, liquefaction, and landslides were also identified. All SMART facilities associated with their passenger rail project are designed to meet current seismic requirements, thereby reducing the potential for damage. Severe ground shaking could disrupt service of moving or stopped trains. Project approval required implementation of Mitigations G1-G7 to minimize the risk to acceptable levels.

Ports and Harbors

Spud Point Marina is located on the coast in Bodega Bay in close proximity to the San Andreas Fault. Port Sonoma Marina is located at the mouth of the Petaluma River in an area of potentially high liquefaction approximately 3 miles west of the Rodgers Creek Fault. Both of these facilities are subject to the effects of earthquake shaking, and liquefaction they also face a potential risk from earthquake induced tsunamis. Modelling of maximum credible tsunami scenario projected that a tsunami of 25 feet could occur in the coastal areas of Sonoma County, and that areas off San Pablo Bay could experience a 5 foot tsunami. While these ports are not used for shipping of goods or for ferry commuting, Bodega Bay serves the fishing industry and recreational boaters. Port Sonoma is used as an emergency response water access point. The U.S. Coast Guard houses personnel and conducts operations at Bodega Bay and are important emergency responders.

Solid Waste Disposal Systems

The County has one landfill outside of Petaluma and four transfer stations, in Annapolis, Healdsburg, Guerneville, and Sonoma. The Central Disposal Site operated by Republic Services on 389 acres currently has remaining capacity for about 450,000 tons. This facility integrates reuse & recycling, household hazardous waste management services, yard debris and wood waste, solid waste disposal, along with production of electrical energy from landfill gas in a coordinated system at a single location.

The State 2010 Hazard Mitigation Plan indicates that 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. A significant vulnerability of this landfill is the loss of electrical power to run leachate collection and control systems and landfill gas collection and control systems. If either of these occurs, release of leachate or landfill gas could occur. The Central Disposal Site has a back-up generator for emergency power and gas collection and leachate collection systems are constructed of flexible materials so that in the event of an earthquake, collected gas can be routed to a flare to burn off.

Solid waste operations could also be affected by the huge quantities of earthquake debris and rubble. Immediately following a major disaster, the cleanup effort and reconstruction often results in a need to handle more and different types of debris than existing solid waste facility permits allow. One estimate by CGS indicates that a 7.3 earthquake on the Hayward and Rodgers Creek fault could generate 800 thousand tons, or 32,120 truck loads (at 25 tons per load). This amount would exceed the remaining capacity of the land fill at the Central site. In the past, to assist in the recovery phase of a disaster, the California Department of Resources Recycling and Recovery has issued emergency regulations on a case-by-case basis.

Title 14 California Code of Regulations, Section 17210, presents the Emergency Waiver of Standards that grants temporary relief from specific standards or permit conditions in the event of a state or local emergency. These emergency regulations waived certain standards of a solid waste facility permit (e.g., origin of waste, maximum daily tonnage, hours of facility operation) to facilitate the clean-up effort. The County's Integrated Waste Management Division has a contingency response plan to respond to disasters that involve getting authorization to store waste at several sites before sorting and separating it for recycling or disposal.

Water Supply Systems

Sonoma County Water Agency conducted a multi-hazard reliability assessment of its water supply and transmission system, prepared a hazard mitigation plan for its facilities, and is actively carrying out an improvement plan to decrease the systems vulnerability to earthquakes and increase its ability to remain operable after an earthquake. These plans identified earthquake related hazards as the primary hazard to critical components of the water system, including collector wells, aqueducts and storage tanks. The Agency assessed risks to its infrastructure and services from surface fault rupture, strong ground shaking, liquefaction and lateral spread, and earthquake induced landslides.

Sonoma County Water Agency transmission pipelines pass through areas with very high liquefaction potential and cross the Rodgers Creek fault. Pipelines can experience extreme stress when they pass through soils of varying consistency, possibly causing them to buckle or break. Fault rupture could cause the aqueducts to offset, rupture, and become non-functional. Severely leaking pipelines and aqueducts could drain the system of water rapidly, causing shortages for firefighting and drinking. The Agency's facilities are most significantly impacted by the Rodgers Creek Fault, which passes through the Agency's service area and cuts across the Santa Rosa aqueduct near Doyle Park in the City of Santa Rosa. The Bennett Valley fault in the Spring Lake area crosses the Sonoma aqueduct and the Oakmont pipeline near the Sonoma Booster station #2.

The Agency considered the potential ground shaking that the USGS projects to result from a maximum earthquake on Rodgers Creek Fault. The Agency determined the estimated Peak Ground Acceleration (PGA) expected at each of the Agency's facilities range between 0.3g to 0.8g. Because of their proximity to the Rodgers Creek fault, the Kawana and Ralphine tanks and the Sonoma booster station have the highest predicted ground motions. Many parts of the system are in areas of high and very high liquefaction potential and include the collector sites, Mirabel well-field and Ely booster station, transmission lines, the Wohler Intertie, most of the Santa Rosa aqueduct, significant portions of Petaluma aqueduct and localized areas of the Cotati and Sonoma aqueduct. Creek crossings along these portions of the transmission lines have a very high potential for damage due to the likelihood of lateral spread. The main power line from the Wohler substation to the collector wells is also located in an area of very high liquefaction potential.

A detailed assessment of the projected performance of each Sonoma County Water Agency water storage tank has been conducted as part of the reliability assessment. One half of the Sonoma County Water Agency welded steel water storage tanks have been anchored to prevent seismic related failure resulting from sloshing and uplift. The other half, which are broader and shorter, have not been anchored, but pose less risk of such failure. Of greater concern at the tanks sites are the over-constrained piping and connectors which could potentially lead to rupture and water leakage that empties the tanks. The impact to the functionality of the water system if these tanks are damaged, both for drinking and firefighting, could be significant. The

Agency has developed a conceptual project to help mitigate this risk and is pursuing grant funding to implement these vulnerabilities.

Wastewater Systems

Wastewater treatment could be severely impaired by earthquake shaking. If facilities are damaged, it may be necessary to discharge partially treated wastewater from treatment plants. Breakage of sewer lines and loss of power could lead to overflows from manholes and cause untreated sewage to flow in some street gutters. It is possible sewer lines (both main lines operated by Sanitation Districts and laterals maintained by homeowners) could collect explosive gases, which could cause dangerous conditions particularly if ignited by earthquake-sparked fires.

In 2015, Sonoma County Water Agency conducted multi-hazard reliability assessments for Sonoma Valley County Sanitation District (SVCSD) and Russian River County Sanitation District (RRCSD). SCWA identified earthquake related hazards as the primary hazard to critical components of the respective districts, including the treatment plants, collection systems and pump stations. The Agency assessed risks to its infrastructure and services from ground shaking, liquefaction, creek/stream hazards, landslide hazards, and surface fault rupture. SVCSD facilities were found to be particularly susceptible to ground shaking, liquefaction, and creek hazards. RRCSD was found to be susceptible to similar hazards, as well as landslide hazards. The Sonoma County Water Agency conducted a multi-hazard reliability assessment of its water supply and transmission system, prepared a hazard mitigation plan for its facilities, and is actively carrying out an improvement plan to decrease the systems vulnerability to earthquakes and increase its ability to remain operable after an earthquake.

The RRCSD facilities are primarily affected by the San Andreas Fault System; the Rodgers Creek Fault poses the greatest risk to SVCSD facilities. Both Districts have pipelines (sewer and recycled water) that pass through areas with very high liquefaction potential. Pipelines can experience extreme stress when they pass through soils of varying consistency, possibly causing them to buckle or break. Leaking or ruptured pipelines could spill sewage or non-potable recycled water into the community resulting in severe consequences on human and environmental health. The high liquefaction areas tend to be around creek crossings, meaning spills could quickly spread over an extensive area, spreading the damage and increasing clean-up costs.

Natural Gas Pipelines

There are 177 miles of high pressure gas transmission lines traversing through Sonoma County, owned by PG&E. Some gas lines were installed over 50 years ago. Transmission lines are 12 to 20 inch diameter steel pipes carrying natural gas at high pressure and compressed for higher carrying capacity. Transmission lines connect to smaller distribution lines delivering gas directly to homes and businesses. There are significantly more miles of lower pressure, gas distribution lines according to PG&E.

During earthquakes, these lines may be subjected to significant displacement caused by ground deformation, strong ground shaking, liquefaction, fault rupture, subsidence, and landslides. An earthquake can cause natural gas lines to leak or break, which result in loss of service and possible fire or explosion. Such failures can result in loss of life, injury, property damage, and environmental impacts. In Sonoma County, pipelines cross the Rodgers Creek Fault in several locations. Growth in population, urbanization, and land development near transmission pipelines may increase the likelihood of exposure of people and property to pipeline failures. Large gas transmission lines serving the Santa Rosa Plain may be vulnerable to breakage because they pass through areas of weak soil.

The state and federal regulations and responsible actions by pipeline operators, have resulted in decline in gas pipeline incidents in the past 40 years. Given the tremendous forces and strains which pipelines may be subjected to in an earthquake, community reliance upon the pipeline transmission system, and the possible consequences of loss of service and/or explosions or fires, increasing the disaster resistance and reliability of these systems remains a high priority. The importance of pipeline maintenance was underscored by a rupture and explosion of a 60-year old gas transmission line in a City of San Bruno neighborhood in September of 2010. The blast and resulting fire resulted in 8 deaths, 66 injuries, 34 destroyed structures, and 8 damaged structures.

Specific information on pipeline vulnerability is maintained by the owner or utility operator. Regulation and oversight of pipeline operations is provided by Federal and state entities. PG&E monitors system status in real time on a 24-hour basis and regularly conducts leak inspections, surveys, and patrols of its natural gas transmission. PG&E uses the data to plan and set priorities for future work. PG&E visually inspects the condition of the inside of the pipes and welds which traverse the full interior length of pipelines. Records provided to the California Public Utilities Commission (CPUC) indicate that all pipeline segments in Sonoma County are operated below the maximum allowable operating pressure set by the manufacturer and pipelines are tested at higher pressures than typical operating pressure. Pipelines are also equipped with cathodic protection to limit corrosion. PG&E uses a risk management program that considers each pipeline segment’s design and characteristics and whether it has the potential for corrosion, ground movement, third-party damage, and its location relative to high–density populations.

Typical mitigation measures to offset this seismic vulnerability include assessing siting requirements, flexible couplings, and above ground fault crossings. Mitigation for fault crossings may also be accomplished by making pipes flexible and building pipe supports to allow movement to accommodate the anticipated ground displacements without rupture. Since a number of pipelines in the County cross the Rodgers Creek Fault it is advisable that the seismic vulnerabilities of pipelines in the County be given added attention and priority by PG&E.

Other Utilities

Utility networks are essential for County emergency response and recovery activities, but many of these facilities are in areas of potential earthquake shaking. PG&E maintains about 556 miles of electrical transmission lines and 4,617 miles of overhead distribution lines and operates 21 substations. Three AT&T telephone facilities and two PG&E substations (Mirabel and Fitch Mountain) are in locations at high risk of liquefaction. The PG&E Salmon Creek substation is located within the San Andreas Fault Alquist-Priolo zone, and three more substations (Fort Ross, Eagle Rock, and Geysers) are located in areas with high landslide risk. After a major earthquake, it is common for power and phone service to be unavailable for up to a week, and longer.

Dams

The largest dam in Sonoma County is the Warm Springs Dam that impounds Dry Creek and provides water supply and flood management. The dam was built in 1982 and forms Lake Sonoma Reservoir which holds a water supply of 212,000 acre-feet and a flood pool of 130,000 acre-feet.

The dam is located about 2.5 miles from the Healdsburg fault, a northward extension of the Rodgers Creek fault, and about 6 miles from the Maacama, about 14.5 miles from the Hayward and 18 miles from the San Andreas Fault. It is owned by the US Army Corps of Engineers (USACE). Water supply releases from this dam are controlled by the Sonoma County Water Agency (SCWA), with the exception of water released for flood control, which is managed by the USACE.

The Coyote Valley Dam in Mendocino County regulates the northern Russian River and was built in 1959. It forms the Lake Mendocino Reservoir which holds 122,400 acre feet. Dam failure in an earthquake could affect areas in Sonoma County. This dam is also owned by the USACE and water releases are controlled in a similar manner to Warm Springs Dam. The Coyote Valley dam is located less than 1 mile from the Maacama fault, and more than 31 miles from the San Andreas, Rodgers Creek and Healdsburg faults.

USACE has an ongoing Dam Safety Program to perform inspections and “Screening for Portfolio Risk Analysis” (SPRA) assessments to identify vulnerabilities and prioritize project work. USACE assessed the seismic integrity of the Warms Springs Dam in 2006. It is categorized as Dam Safety Action Class (DSAC) IV (considered marginally safe- the combination of life and economic consequences in the event of a failure is low).

Although the SPRA team did not report any potential failure modes, they did analyze the consequences of a failure. The occurrence of a seepage, overtopping, or a seismic event that could lead to a total breach of the dam could not entirely be ruled out due to the lack of updated studies. A breach could conceivably occur within a relatively short period of time, perhaps a few hours. A relatively low probability of failure along with a moderate sized downstream population, residential and commercial structures including contents, roads, farm land, bridge damage, and utilities, has led to the dam’s inclusion in the DSAC IV category.

USACE assessed the seismic integrity of the Coyote Valley Dam in 2005 and, after considering probability of failure and potential failure consequences, categorized it as being in Dam Safety Action Class (DSAC) III. Dams in Class III, for confirmed and unconfirmed Dam Safety issues, are considered to be Significantly Inadequate or have Moderate to High Risk in that the combination of life or economic consequences with probability of failure is moderate to high. Despite the DSACS ratings for the above dams, dams with DSAC ratings of I or II are considered to be of higher risk and priority. The USACE plans to conduct additional safety assessment of both dams and appurtenant structures using the most recent information on seismic and flood conditions. In addition to the damage to the dam itself, economic losses would occur downstream of these dams if they were to fail. USACE has prepared inundation maps to identify the areas that could potentially be inundated should dams fail. These are shown in Figure 8.7. The potential impacts that could result from inundation due to dam failure are discussed in Chapter 3 on flood hazards.

According to information from the California Department of Water Resources, there are 61 smaller dams dispersed throughout the County that are regulated by the Division of Dam Safety. Other dams in the County are small and generally used for agricultural, drinking water, or stormwater management purposes. Failure of one of these dams could pose a significant threat to limited areas of the County. A Dam Inundation Contingency Plan for each dam is filed with the County PRMD.

Hazardous Materials Sites

Earthquake shaking can release hazardous materials. There are about 190 sites with hazardous materials located in high or very liquefaction risk zones. Three sites are located within the Rodgers Creek fault zone. Many of these sites are also near rivers and, if damaged in an earthquake, could potentially lead to harmful contamination of the environment. Some sites contain chemicals that are potentially harmful to human health.

Transportation corridors in the County, such as Highway 101, state routes, Geysers Road, and the North Coast Railway, also carry hazardous materials on a regular basis. There is the potential that trucks or train cars carrying hazardous materials could be derailed during an earthquake and materials dangerous to health or the environment could be released. In particular, Geysers Road, from the Geysers geothermal fields to State Highway 128, is heavily travelled by trucks carrying hazardous materials and spills have occurred there in the past.

The County owns a number of gasoline and diesel fuel tanks that are used by County vehicles. Recently, a number of older underground tanks have been replaced by aboveground storage tanks. These newer structures meet modern codes and are expected to perform well during strong ground shaking.

County Buildings

Each of the County's buildings could be impacted by earthquake shaking. Some hold more risk of physical damage than others due to their location, construction, or use. Important County-owned buildings are evaluated for their exposure to the highest risks from strong earthquake shaking, fault rupture, liquefaction and earthquake-induced landslides in Appendix G.

A summary of County building exposure is shown in Table SH-5. Note that Table SH-5 and Appendix G include important County-owned buildings that are maintained primarily by the Department of General Services; there are many other County owned and leased buildings that are not covered, including those located at the Sonoma County Fairgrounds.

Table SH-6: Summary of Exposure of Key County Buildings to Earthquake Hazards

	Number	Building Value (millions)	Contents Value (millions)
Buildings in Violent Shaking zones	67	$221.9	$48.7
Buildings in Liquefaction zones	26	$38.9	$5.7
Buildings in landslide zones	18	$31.1	$12.1
Buildings in fault rupture zones	3	$7.5	$1.5

This table lists ensured value that often does not reflect current or replacement value. The Risk Management Division of the Human Resources Department is responsible for insurance procurement. The County insures approximately fifty percent of its building inventory and building contents against earthquake damage. Insured properties currently include major administrative buildings, health facilities, the county jail, and data processing centers Coverage is currently obtained through participation in the California State Association of Counties – Excess Insurance Authority's (CSAC-EIA) Property Insurance Program. Coverage is applied to specific buildings based on critical mission needs, age of building, seismic vulnerability, budget constraints, the availability of insurance, the cost of insurance, and other mitigation options. Since the previous HMP, the County has made significant progress in evaluating insurance coverage by use of HAZUS based loss modelling to assess earthquake insurance priorities. Risk Management will continue to update this modelling and work with the County Administrator's Office, General Services, Fire & Emergency Services, PRMD, and Information Systems to allocate insurance premium costs to achieve the most cost effective coverage for the County, and integrate with other mitigation efforts.

In the case of a significant seismic event, ultimate net loss after insurance and possible State/Federal disaster assistance is uncertain. However, the County believes that the approach described above protects a significant portion of the County's building inventory and represents the most efficient expenditure of County funds to mitigate financial loss and service disruption. Structures on or very close to a fault may be subject to extremely strong shaking or fault ruptures. Table SH-9 lists County buildings that may pose a seismic risk due to their age or construction type. Other County buildings have not been identified as seismic risks but may be of concern due to the age and type of their construction. The level of risk posed is uncertain until complete building assessments can be made. All structures built in 1959 or earlier, before significant improvements were made to seismic design codes, should be assessed. All reinforced concrete buildings built before 1976, when changes were also made to seismic design codes should be evaluated.

County Mental Health Services offers psychiatric inpatient and outpatient services and day treatment on Chanate Road in Santa Rosa. The Public Health Division operates some clinics administration, and the County Morgue is operated by the County Sheriff-Coroner. The County is currently exploring options for adaptive reuse of the site and seismic safety remains a consideration.

People and Private Buildings

The entire County population faces some risk and vulnerability to earthquake activity but the risk is considered greatest in areas in close proximity to earthquake fault zones. Less than ten percent of the unincorporated area's population, or about 13,800 people, live close to the Rodger's Creek or San Andreas faults in areas with the highest probability of violent shaking. An estimated 10,600 people in the County live in areas potentially at risk of liquefaction. Another 19,200 people live in areas that could experience seismically-induced landslides. Typically, damage in an earthquake is most intense near the epicenter, along the trace of the fault, and in high risk areas (liquefaction zones and landslide hazard zones). The total damage area affected, and the cost would vary with the size, location, and type of earthquake.

Every privately owned building in the County is exposed to high risk of damage in earthquakes by virtue of being located in a seismically active region. Thousands of private buildings are also located in areas at risk of damage from secondary hazards triggered by earthquakes. 420 buildings are located in the Alquist-Priolo Fault Zone along the Rodgers Creek fault, and about 400 are in the San Andreas Fault Zone. These structures are subject to extremely strong shaking and possible displacement by a fault rupture. About 3,400 buildings are situated in very high or high liquefaction risk areas. 6,500 buildings are located in areas that have significant risk of landslides triggered by seismic shaking. The buildings located in zones at risk of secondary hazards represent $4.4 billion in real estate, assuming a replacement value of $150 per square foot, as shown in Appendix G. The construction quality, age, maintenance and other factors related to seismic risk of these buildings is unknown.

Table SH-7: Population and Building Exposure in Hazard Zones

Hazard	**Number of Buildings**	**Square Feet of Buildings**	**Estimated Value of Buildings (in billions $)**
Very high or high liquefaction risk	3,400	10,400,000	$1.6 billion
Landslide risk	6,500	17,000,000	$2.6 billion
Fault rupture risk - San Andreas	400	930,000	$0.1 billion
Fault rupture risk - Roger's Creek	420	1,200,000	$0.1 billion
Total	10,720	29,530,000	$4.4 billion

Note: Estimated value of buildings is based on insurance value that may not reflect current or replacement value.

There are a number of general categories of private buildings in the County that are particularly vulnerable to earthquake shaking. Houses of any style with brick chimneys may be vulnerable to collapse and can cause damage and injury.

Residential and Commercial Building Types Particularly Vulnerable to Earthquakes

Old wood framed single-family houses with a crawl space under the first floor. These structures may be at risk when walls are not be adequately bolted to the foundation, as structures can shift off the foundation during strong shaking. Old foundations may be constructed of weak or deteriorated materials, such as brick or concrete. Cripple walls may have inadequate bracing and deterioration of wood members from termite attack and dry rot.

Houses located on steep, hillside lots. These homes have increased risks of failure to cripple walls and poorly braced extra-tall walls along the sloping sides. Single family homes over a garage may be vulnerable to shaking because of inadequate bracing on the garage floor.

Multi-unit family units with an open or “soft” first story. Often these structures have an open first story for parking with apartments above. When subjected to an earthquake, these structures can be severely damaged, shift, or even collapse.

Unreinforced masonry (URM) buildings. URM buildings often cannot support the horizontal forces exerted by earthquakes. URMs have been responsible for a number of fatalities in California earthquakes over the last 50 years. This type of building is regulated by state law and is discussed in more detail below.

1970’s era tilt-up buildings. These pre-fabricated reinforced concrete buildings may have inadequate connections between the walls and the roof. The walls can splay out with strong ground shaking, and with severe shaking may cause the roof to collapse.

Pre-1973 reinforced concrete buildings. Older reinforced concrete buildings, also referred to as non-ductile concrete buildings, have proven to have poor seismic performance through the catastrophic failures seen in earthquakes since the 1970s.

The age of buildings plays a significant role in their seismic risk because building codes and standards have continually improved as the building profession has learned more about seismic safety. Table SH-8 indicates dates when some key seismic safety improvements were made to the Uniform Building Code used in California.

Table SH-8: Dates of Key Changes to Seismic Safety Resistant Design in UBC

Date	Selected Seismic Safety Improvements in UBC
1933 - 1935	Masonry buildings must be reinforced, and mortar standards and seismic zones considering soils introduced
1949	Standards introduced to strengthen tall buildings
1959	Calculation methods improve to better represent different types of structures
1973 - 1976	Ductile elements introduced into reinforced concrete buildings to prevent catastrophic failure and improvements to wood frame design
1988	Soft and weak stories addressed and wood frame construction improved

However, even if a building is constructed in accordance with current seismic codes, residential structures are generally built to life safety standards and will not necessarily be inhabitable after an earthquake. The current building code is designed to a life safety standard to protect occupants during an earthquake. Newly constructed residential buildings can still experience significant damage during an earthquake, displacing residents until repairs or rebuilding occurs.

Unreinforced Masonry Buildings (URMs)

The County inventoried all URM buildings in the unincorporated areas as required by state law. A total of 316 URM buildings in unincorporated areas were identified and classified as posing a seismic risk (active), or otherwise remediated or outside County jurisdiction. These structures remain on the list and as of November 2015 are classified as follows:

- 131 Active,
- 35 Annexed,
- 63 Conforms,
- 87 Exempt

131 of the structures are classified as "Active" because they have not been strengthened or otherwise brought into conformance. The remaining 185 structures are now exempt from the state law for the following reasons:

- they have been seismically strengthened;
- they have been demolished;
- they were determined after the inventory not to be URM buildings;
- they are not used as structures for human occupancy as defined by law;
- they are historic structures; or
- the site was annexed into a city and are outside County jurisdiction.

Most URMs in the unincorporated County are commercial buildings that are privately owned. A number of the URMs in the County have important functions, including public safety or assembly, as shown in Table SH-9. Included are: eleven fire stations, one public utility building and 8 school buildings classified as classrooms and assembly areas.

Table SH-9: Use of Unreinforced Masonry Buildings in the County

Use	Number of Active Status URM Buildings
Agricultural	0
Church	4
Fire Department	2
Garage	8
Hotel	2
Industrial	13
Office	10
Police Department	0
Public utility	0
Residential	5
Restaurant	8
Retail	39
School K-12 (private)	2
Warehouse	7
Winery	11
Other	20
Total	**131**

Following the South Napa earthquake in 2014 PRMD reviewed the hazardous building inventory (SB 547 list) and worked with property owners to accurately document the status of unreinforced masonry buildings (URMs). Property owners were notified of the hazard poses by URMs on their property and of their obligation under state law to post buildings with the following notice:

> "*Earthquake Warning. This is an unreinforced masonry building. You may not be safe inside or near unreinforced masonry buildings during an earthquake.*"

PRMD confirmed that more than 95 percent of buildings on the SB 547 list have posted required URM warning signage. The number of active URMs in the County has been reduced from an estimated 201 reported in the 2011 Local Hazard Mitigation Plan to the current 131 documented in 2016 (refer to the Seismic Safety Section above). In the five-year implementation period about 70 URMs were removed from "active" status. The County is currently reviewing a seismic retrofit ordinance, based on a model ordinance provide by the California Seismic Safety Commission, to reduce earthquake hazards and create incentives to encourage building owners to improve their structures.

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 an earthquake. In California, almost 40 percent of the tilt-ups were built prior to

1976 before building codes began to require stronger wall-to-roof connections. Additional enhancements to the building code for new tilt-up construction were adopted in 1997.

Historic Buildings

Older structures are particularly at risk of damage in earthquakes. This includes historic buildings that contribute to the County's character and economy. Eight buildings on the County's Landmark Commission list of historic structures are located inside the Alquist-Priolo Fault Zone. These structures are likely to experience extreme stress during future earthquakes that occur on these faults. The County received a grant from the State Office of Historic Preservation which enabled the County to retrofit the Hood House and Pythian buildings at Los Guilucos. It is probable that many more structures are located in areas at risk of liquefaction and seismically-induced landslides. Some of these structures may have survived one or more large earthquakes in the past, but this does not imply they will survive future earthquakes undamaged. These buildings may have experienced unnoticed minor damage in previous quakes that may have weakened their structural integrity. The risk of any particular building can only be determined through a structural analysis.

Impact and Loss Estimates

Methodology

Future earthquakes in Sonoma County will vary in intensity and resulting damage depending on a number of factors: the earthquake fault, the depth of epicenter, and duration of the earthquake. The likely consequences of earthquakes affecting the County can be estimated by using computer modelling software developed for FEMA. The California Geological Survey (CGS) has developed additional methods to model ground-shaking and ground motion from seismic events and characterize different earthquake scenarios. The HAZUS model incorporates this analysis and uses a geographic information system (GIS) to create an estimate of the damages that might result from different earthquake scenarios. Each scenario assumes a certain magnitude of epicenter location, rupture mechanism, and time of day and applies this hypothetical earthquake to estimate losses. The Model's damage and loss projections estimates are based in part on the actual types and levels of damages experienced by other communities during past earthquakes. Though each earthquake and location is unique and actual damage and the loss caused by future earthquakes will differ, the model's results provide reasonable numbers to help the County plan its mitigation and emergency preparedness activities.

Updated 2011 HAZUS Analysis

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences and the California Geologic Survey. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates are used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The estimates of social and economic impacts contained in this report were produced using FEMA's HAZUS –MH loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modelled results contained in this report and the actual social and economic losses following a specific earthquake.

The Sonoma County Fire and Emergency Services has acquired HAZUS and received training to facilitate disaster planning and emergency response efforts in Sonoma County. Using HAZUS loss estimation software, the estimated economic losses, social impact, and structural damage to Sonoma County from two different earthquakes scenarios, provides a reliable model to plan for such disasters. The two earthquakes modelled are a M7.3 quake scenario on the Hayward-Rodgers Creek Fault, and a M8.0 quake scenario on the San Andreas Fault.

The model results presented are countywide figures and include the population, structures, and infrastructure within the incorporated city limits as well as the unincorporated County areas. To enable later assessment of the data by jurisdiction, the County developed 91 records which represent the 2000 Census tracts residing within the Sonoma County incorporated areas [e.g. City of Cloverdale, etc.]. The data includes the area, acreage and sq. mile per each city's respective census tract. This data contained in these specific records is carved out of the common areas amongst two GIS datasets, city limits and census tract, and calculates the area/acreage/sq. mile per attribute feature.

The model runs were prepared by Brentt Blaser of the Sonoma County Fire and Emergency Services Department on April 1, 2016.

The first, and most damaging scenario, is a M7.3 earthquake on the Rodger's Creek fault. The second scenario earthquake is a M8.0 event on the San Andreas Fault. While this earthquake has a larger magnitude than the first scenario, the area along the San Andreas Fault has less development than other areas of the County, leading to a less damaging scenario. However, most of the damage in an earthquake on the San Andreas occurs in unincorporated areas of the County, whereas most damage in a Rodger's Creek event occurs within incorporated cities. The model's results for each scenario are summarized and compared in Table SH-10. Each scenario is discussed in greater depth in the following paragraphs and in Appendix C.

Table SH-10: Comparison of Projected County Impacts for two Earthquake Scenarios

2011 Estimated Impacts	**M7.3 Rodger's Creek Scenario**	**M8.0 San Andreas Scenario**
Deaths	42	2
Injuries requiring medical care or hospitalization	972	126
Households seeking temporary shelter	1246	65
Single family dwellings with moderate to complete damage	11,030	888
Multi-residential units with moderate to complete damage	11,427	59
Commercial buildings with moderate to complete damage	3,615	995
Industrial buildings with moderate to complete damage	1229	457
Total buildings with moderate to complete damage	27,826	7,958
Households without potable water service on day after	19,372	31,802
Households without electricity service on day after	50,006	0
Total income losses	565.7 million	113.3 million
Total capital stock losses (includes losses from structures, contents, inventory and non-structural damage)	2,921.0 million	745.6 million

Note: This is if quake occurs midday; casualties will be lower at other times. This table includes losses to buildings, building contents, transportation systems, and utilities. Data developed by the County Emergency Services using HAZUS modeling.

Scenario of M7.29 on Rodgers Creek Fault

Overview:

This earthquake scenario would result in strong, damaging, ground shaking in areas near the fault, including the communities of Santa Rosa, Larkfield, Wikiup, Windsor, Rohnert Park, Petaluma, Roseland, Sonoma and Healdsburg. Much of the expected damage described below would occur in incorporated cities that have adopted Hazard Mitigation Plans to reduce future risk. The shaking will cause ground failure in some locations. The fault may rupture at the surface in various locations between Petaluma and Windsor, causing buildings, streets, sidewalks, power lines, fences, and other structures along the fault to be displaced by up to several feet. Liquefaction and landslides may occur and may be exacerbated if the quake coincides with wet weather.

Building Damage:

More than 11,030 single-family homes would be moderately to completely damaged, particularly wooden structures that are not bolted to their foundations. Over 1,200 households in the County will be displaced from their homes immediately after this quake, seeking temporary shelter with friends, relatives or emergency shelters. Many will be able to return to their homes within a few days; others will need to temporarily relocate as their homes are reconstructed. Most of these displaced families will be residents of cities. It is likely that only several hundred residents of the unincorporated areas of the County will seek shelter.

The HAZUS model projects that 11,427 multi-residential units, 3,615 commercial units, and 1,229 industrial units will be moderately to completely damaged. Most of these damaged structures are located in the major cities along the fault, but about a dozen commercial buildings in the unincorporated areas may experience partial or complete collapse.
Given the high number of County buildings on or near the fault, this earthquake scenario could have significant impact on the County facilities and its post-disaster operations. Considerable financial losses could be incurred to the County, in structural and non-structural damage.

<u>Casualties:</u>
An earthquake on the Roger's Creek Fault would be most lethal if it occurs in the middle of a weekday. Under that scenario the model predicts that 42 people in the county could be killed. 972 people would be injured such that medical care or hospitalization is required. Casualties will be slightly lower if the earthquake occurs at commute time, and significantly lower if it occurs in the middle of the night. One reason the lethality of the earthquake varies by time of day is that wood-frame buildings, the predominant structural type of residences in the county, are less likely to cause injury and death than structural types commonly used for commercial buildings, such as reinforced concrete. Ninety percent of all casualties will occur within cities along the Rodger's Creek fault, with fewer casualties occurring in the unincorporated areas.

Hospitals may be damaged during a Rodger's Creek earthquake. It could take several hours before emergency medical personnel from other areas of the region are able to assist overwhelmed facilities in the County. The speed of outside help arriving will be impacted by the condition of major roadways and the amount of damage sustained outside the County's borders. Medical care could be further impeded by power failures and limited potable water.

<u>Post-Earthquake Fire:</u>
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, fires can often burn out of control. HAZUS model estimate that two fires will break out under this scenario. These fires are sparked by various sources, such as pilot lights on toppled water heaters. They can be fueled by broken gas lines. If the earthquake occurs during a time of year with high wildfire risk, it is possible for small fires to ignite wildfire.

<u>Infrastructure:</u>
Water, power and phone services will likely be unavailable in many areas immediately after the earthquake. An estimated 19,372 households will be without potable water and about 50,000 households will be without electricity. Power to many areas will be restored within days, but areas of fault rupture or other ground failure may experience longer delays. Both land-based and cellular telephone systems will be affected by the shaking, but are likely to be largely restored within days. Communication systems used by emergency personnel, such as radios and microwave systems, may also be impacted and retain only partial functionality.

County infrastructure will be significantly impacted by the earthquake. Key roads in the County such as Highway 101, 12, 116 and 121 may be impacted and could be impassable due to liquefaction, landslides or bridge collapse, hampering emergency response efforts, including emergency medical care and fire suppression efforts. If the earthquake occurs when the ground is saturated after a rainstorm, landslide and liquefaction impacts will significantly increase.

Summary:
An earthquake of this magnitude would have long-term economic impacts for the County. A major earthquake on the Rodger's Creek Fault could cause total income losses of more than $565 million dollars and total capital losses of about 2.9 billion dollars in the County, including losses from structures, contents, inventory and non-structural damage. The most expensive damage will occur within cities. Long-term business losses and indirect economic damage could significantly exceed direct damage figures.

Scenario of M8.0 on San Andreas Fault

Overview:
This scenario earthquake causes strong ground shaking in areas near the fault, such as coastal areas between Bodega Bay and Fort Ross. Strong ground shaking is also likely in the Santa Rosa Plain and along the Baylands. The effects of shaking could be exacerbated in areas prone to liquefaction, such as along the banks of the Russian River near Jenner and Monte Rio. The shaking is also likely to trigger landslides in many locations along the coast.

Building Damage:
More than 888 single-family homes would be moderately to completely damaged, particularly wooden structures that are not bolted to their foundations. Nearly all of these structures would be in the unincorporated areas of the County in coastal communities such as Bodega Bay, Bodega, Jenner, Fort Ross, Timber Cove, and Duncan's Mills. Commercial and agricultural structures would also be damaged, especially older structures such as unreinforced masonry buildings. About 65 households in the County will be displaced from their homes immediately after this quake, seeking temporary shelter with friends, relatives or County-established shelters. Many will be able to return to their homes within a few days; others will need to temporarily relocate as their homes are reconstructed. The HAZUS model projects that a total of 59 Multi-residential units, 995 commercial units, and 457 industrial units will be moderately to completely damaged.

Model projections for a major earthquake predict 2 deaths and 126 injured people requiring medical care or hospitalization. All major trauma centers in the County are located inland, creating difficulties transporting injured people to hospitals, especially if roads are inaccessible in some areas. Casualties are expected to be greatest if the earthquake occurs during the day when people are at work, shopping, and driving. If the seismic event occurs in the middle of the night, when people are asleep in their homes, casualties will be reduced.

Infrastructure:
Water, power and phone services will likely be unavailable in many areas, especially near the coast, immediately after the earthquake. Power to many areas will be restored within days, but areas of fault rupture or other ground failure may experience longer delays. Both land-based and cellular telephone systems will be affected by the shaking, but are likely to be largely

restored within days. Communication systems used by emergency personnel, such as radios and microwave systems, may also be impacted and only partially functional. Certain areas of the County may be completely cut-off from all communications with the County Emergency Operations Center Large transmission pipelines owned and operated by the SCWA are less likely to be damaged by this scenario than by a large quake on the Rodger's Creek Fault.

The model predicts that roads may be impassable in areas, hampering emergency responders. Bridges and retaining walls along Highway 1 may be damaged in the shaking. Landslides may block Highway 1, 12, and 116 in various locations.

Summary:
This earthquake is estimated to cause total income losses of about 113 million dollars and total capital losses of about 745 million dollars in the County, including losses from structures, contents, inventory and non-structural damage. Most of these losses are incurred by property owners in unincorporated areas of the County near the coast. Long-term business losses and indirect economic damage could significantly exceed the cost of direct damage. The amount of these total losses that would be directly borne by the County is unknown.

Earthquake Loss Estimates

Estimated Sonoma County Loss Report from a Hayward/Rodgers Creek Fault earthquake scenario.

Table SH-11: Building-Related Economic Loss Estimates (Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	6.61	119.62	4.37	5.33	135.93
	Capital-Related	0.00	2.82	102.46	2.58	1.54	109.40
	Rental	14.64	24.98	62.69	1.79	3.01	107.10
	Relocation	51.50	32.06	97.18	9.94	22.65	213.33
	Subtotal	**66.14**	**66.47**	**381.95**	**18.67**	**32.52**	**565.75**
Capital Stock Losses							
	Structural	136.67	56.73	135.37	28.97	24.51	382.25
	Non_Structural	880.25	303.62	409.65	97.87	78.19	1,769.59
	Content	368.27	77.73	199.39	64.88	41.85	752.13
	Inventory	0.00	0.00	4.87	11.35	0.89	17.11
	Subtotal	**1,385.19**	**438.09**	**749.28**	**203.08**	**145.44**	**2,921.08**
	Total	**1,451.33**	**504.55**	**1,131.23**	**221.76**	**177.97**	**3,486.84**

Table SH-12: Expected Building Damage by Occupancy Type

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	382	0.48	275	0.36	162	0.76	50	0.89	11	1.14
Commercial	2,689	3.37	2,526	3.33	2,549	11.95	908	16.18	158	16.72
Education	128	0.16	109	0.14	68	0.32	21	0.37	3	0.33
Government	59	0.07	30	0.04	33	0.15	18	0.32	5	0.53
Industrial	923	1.16	808	1.07	856	4.02	315	5.62	58	6.14
Other Residential	9,522	11.94	9,197	12.12	6,644	31.16	4,086	72.81	697	73.75
Religion	212	0.27	180	0.24	140	0.65	54	0.96	11	1.14
Single Family	65,813	82.55	62,752	82.70	10,868	50.97	160	2.85	2	0.25
Total	**79,728**		**75,878**		**21,320**		**5,611**		**945**	

Shelter requirements: HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. Under the M7.3Hayward/Rodgers Creek earthquake scenario, the model estimates 1,246 households to be displaced due to the earthquake. Of these, 818 people will seek temporary shelter in public shelters.

Table SH-13: Expected Building Damage Type (all designs levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	73,278	91.91	70437	92.83	12,373	58.03	218	3.88	14	1.49
Steel	1,016	1.27	781	1.03	1,220	5.72	556	9.91	91	9.66
Concrete	1,188	1.49	1061	1.40	857	4.02	357	6.36	82	8.64
Precast	697	0.87	689	0.91	909	4.26	316	5.63	41	4.39
RM	2,295	2.88	1345	1.77	1,333	6.25	400	7.13	44	4.70
URM	263	0.33	281	0.37	373	1.75	181	3.22	56	5.88
MH	991	1.24	1283	1.69	4,254	19.95	3,584	63.87	617	65.24
Total	79,728		75,878		21,320		5,611		945	

Table SH-14: Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	10	6	0	1	10
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	14	1	0	12	14
Communication	17	8	0	14	17

Table SH-15: Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	7,848	1218	305
Waste Water	4,709	612	153
Natural Gas	3,139	210	52
Oil	0	0	0

Table SH-16: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	172,403	19,372	12,781	2,953	0	0
Electric Power		50,006	29,785	11,530	2,096	72

Casualties: A summary of the casualties estimated for this earthquake. HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels as follows:

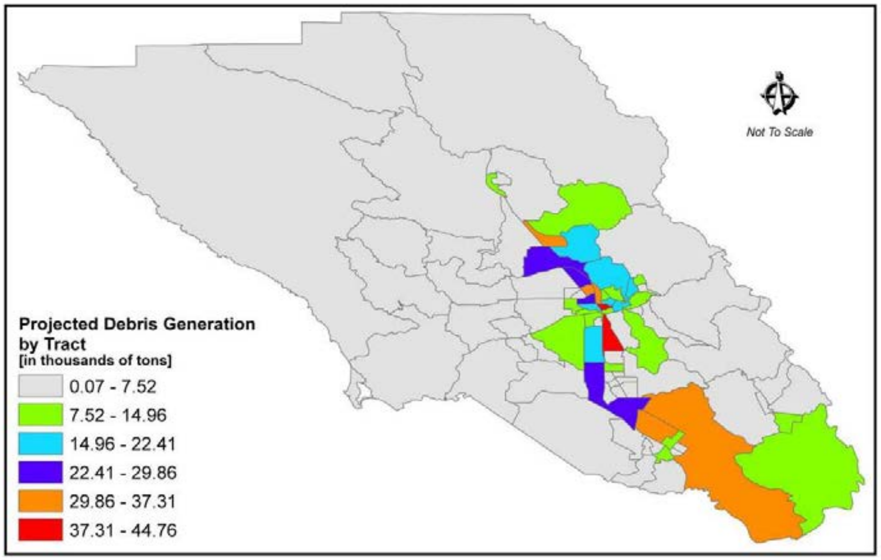
Level 1: Injuries will require medical attention but hospitalization is not needed
Level 2: Injuries will require hospitalization but are not considered life-threatening
Level 3: Injuries will require hospitalization and can become life-threatening
Level 4: Victims are killed by the earthquake

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table SH-17: Earthquake Casualty Estimates Based on Time

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	9	2	0	1
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	5	1	0	0
	Industrial	11	2	0	1
	Other-Residential	271	50	4	8
	Single Family	167	11	0	0
	Total	**464**	**66**	**5**	**10**
2 PM	Commercial	506	111	15	29
	Commuting	1	1	2	0
	Educational	117	24	3	6
	Hotels	1	0	0	0
	Industrial	82	17	2	4
	Other-Residential	50	9	1	1
	Single Family	28	2	0	0
	Total	**785**	**164**	**23**	**42**
5 PM	Commercial	383	82	11	21
	Commuting	30	39	67	13
	Educational	17	4	0	1
	Hotels	2	0	0	0
	Industrial	51	10	1	2
	Other-Residential	99	18	2	3
	Single Family	62	4	0	0
	Total	**644**	**158**	**82**	**41**

Figure SH-3: M7.3 Earthquake on Hayward Rodgers Creek Fault



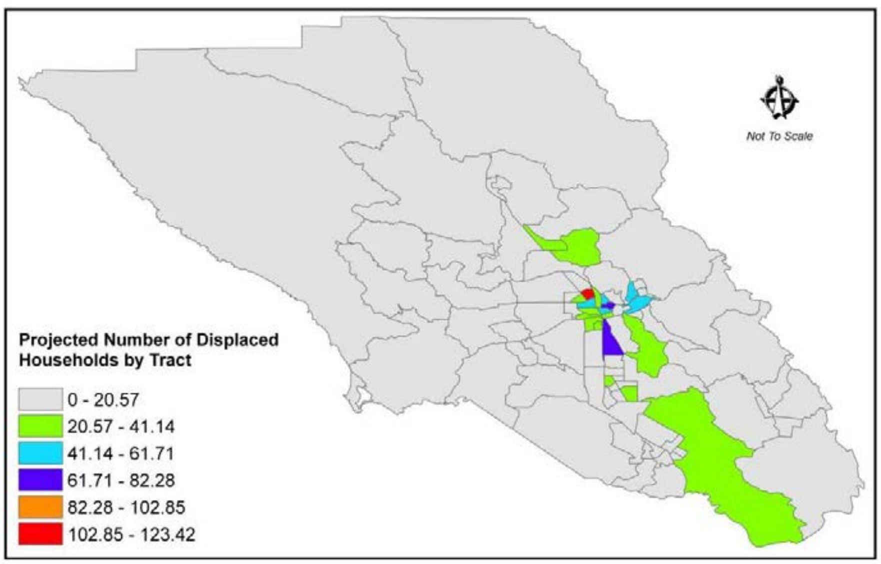
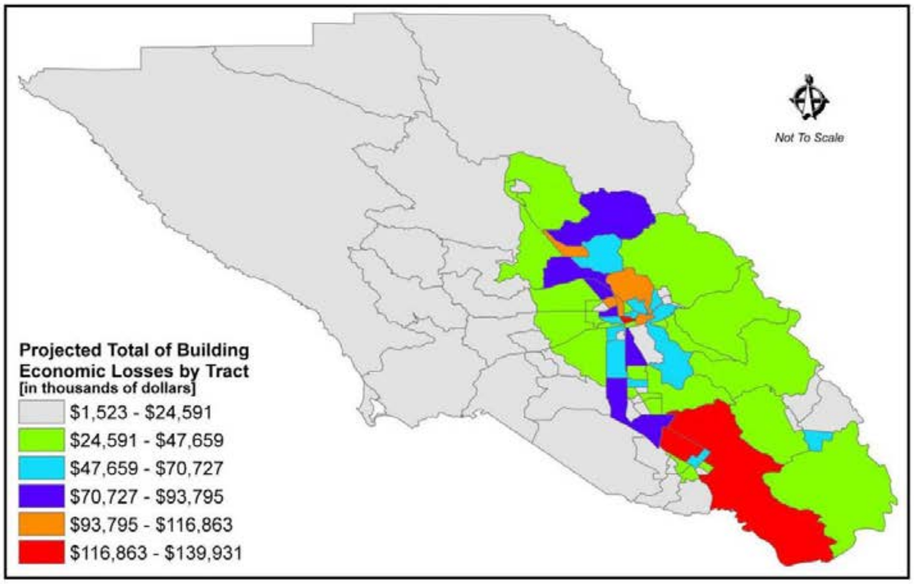
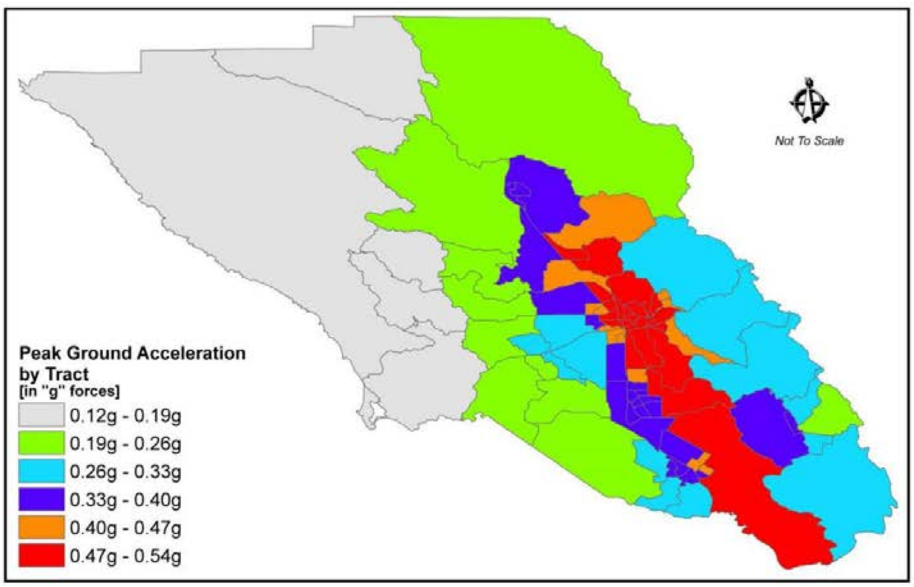


Figure SH-4: M7.3 Earthquake on Hayward Rodgers Creek Fault





Estimated Sonoma County Loss Report from a M8.0 earthquake on San Andreas Fault.

Table SH-18: Building-related Economic Loss Estimates (Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	1.82	24.19	1.30	1.27	28.59
	Capital-Related	0.00	0.79	22.53	0.77	0.30	24.38
	Rental	1.84	4.94	13.57	0.59	0.49	21.43
	Relocation	4.02	9.01	18.74	3.30	3.89	38.96
	Subtotal	**5.86**	**16.55**	**79.03**	**5.97**	**5.95**	**113.36**
Capital Stock Losses							
	Structural	28.52	12.96	24.98	8.97	6.29	81.73
	Non_Structural	228.30	69.92	96.87	34.33	18.73	448.14
	Content	103.77	18.71	53.13	22.78	11.62	210.01
	Inventory	0.00	0.00	1.38	4.02	0.39	5.79
	Subtotal	**360.59**	**101.60**	**176.35**	**70.10**	**37.03**	**745.66**
	Total	**366.44**	**118.15**	**255.38**	**76.07**	**42.98**	**859.02**

Table SH-19: Expected Building Damage by Occupancy Type

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	622	0.43	164	0.54	73	1.07	18	1.73	2	3.76
Commercial	6,052	4.18	1,782	5.82	860	12.59	128	12.04	7	10.63
Education	254	0.18	54	0.18	19	0.28	2	0.23	0	0.12
Government	93	0.06	28	0.09	18	0.27	5	0.43	0	0.69
Industrial	1,852	1.28	652	2.13	377	5.52	74	6.95	6	9.30
Other Residential	18,059	12.47	6,670	21.76	4,546	66.56	822	77.26	47	74.51
Religion	432	0.30	106	0.35	49	0.72	9	0.84	1	0.96
Single Family	117,509	81.11	21,193	69.15	887	12.98	6	0.52	0	0.03
Total	**144,874**		**30,650**		**6,830**		**1,064**		**64**	

Shelter requirements: HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. Under the M8.0 Northern San Andreas Fault earthquake scenario, the model estimates 65 households to be displaced due to the earthquake. Of these, 42 people will seek temporary shelter in public shelters.

Table SH-20: Expected Building Damage by Building Type (all designs levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	131,205	90.56	24012	78.34	1,094	16.01	9	0.84	0	0.36
Steel	2,138	1.48	850	2.77	560	8.19	107	10.03	11	16.85
Concrete	2,367	1.63	716	2.33	382	5.59	76	7.14	4	6.75
Precast	1,741	1.20	565	1.84	296	4.33	49	4.64	1	2.28
RM	4,415	3.05	628	2.05	328	4.80	46	4.35	1	1.33
URM	715	0.49	299	0.98	122	1.78	17	1.56	2	2.44
MH	2,294	1.58	3580	11.68	4,050	59.29	760	71.42	44	70.00
Total	**144,874**		**30,650**		**6,830**		**1,064**		**64**	

Table SH-21: Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	10	6	0	1	10
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	14	1	0	12	14
Communication	17	8	0	14	17

Table SH-22: Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	7,848	1557	389
Waste Water	4,709	782	196
Natural Gas	3,139	268	67
Oil	0	0	0

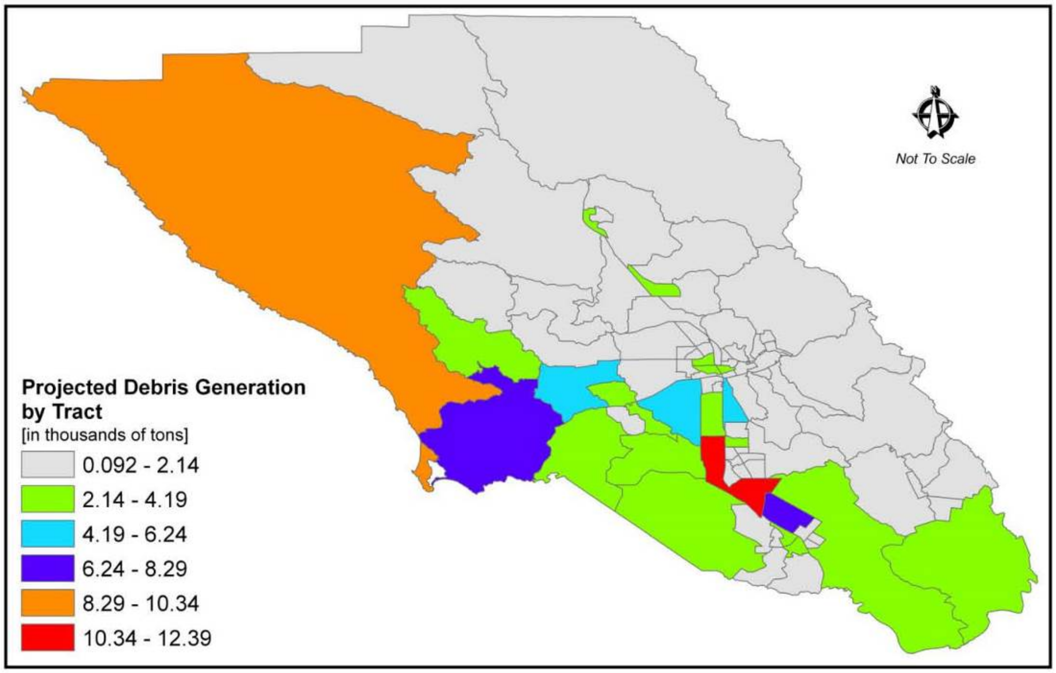
Table SH-23: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	172,403	31,602	24,285	10,933	0	0
Electric Power		0	0	0	0	0

Table SH-24: Earthquake Casualty Estimates Based on Time of Day

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	1	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	2	0	0	0
	Other-Residential	51	6	0	0
	Single Family	31	1	0	0
	Total	**86**	**7**	**0**	**0**
2 PM	Commercial	63	8	0	1
	Commuting	0	0	0	0
	Educational	18	2	0	0
	Hotels	0	0	0	0
	Industrial	16	2	0	0
	Other-Residential	9	1	0	0
	Single Family	5	0	0	0
	Total	**112**	**13**	**1**	**2**
5 PM	Commercial	51	6	0	1
	Commuting	3	4	7	1
	Educational	3	0	0	0
	Hotels	0	0	0	0
	Industrial	10	1	0	0
	Other-Residential	18	2	0	0
	Single Family	11	0	0	0
	Total	**97**	**14**	**8**	**2**

Figure SH-5: M8.0 Earthquake on San Andreas Fault



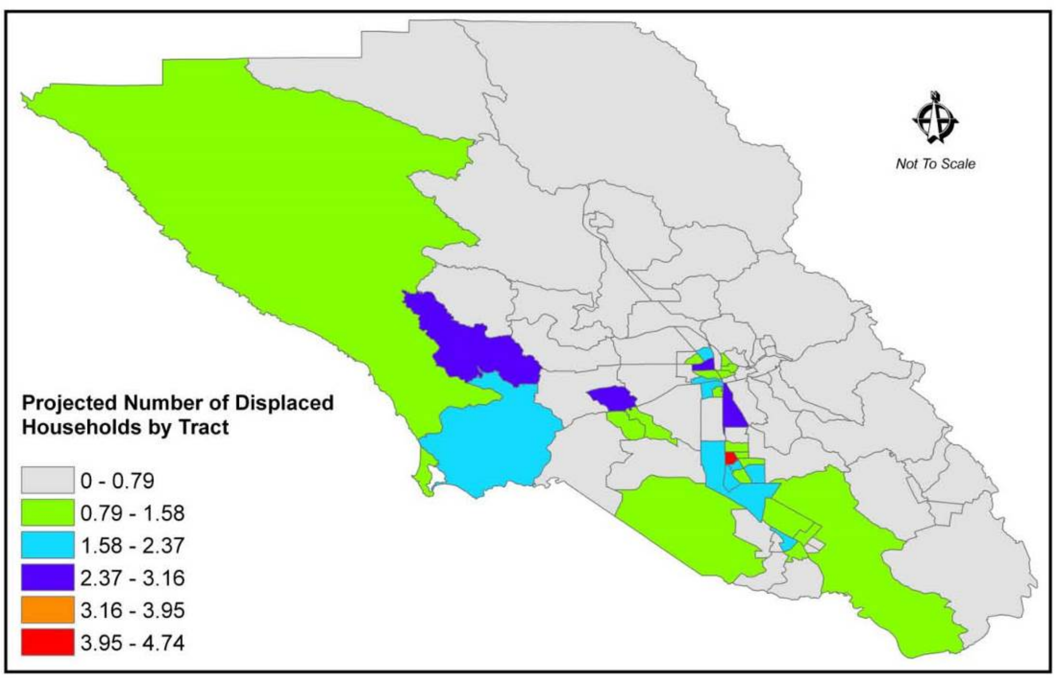
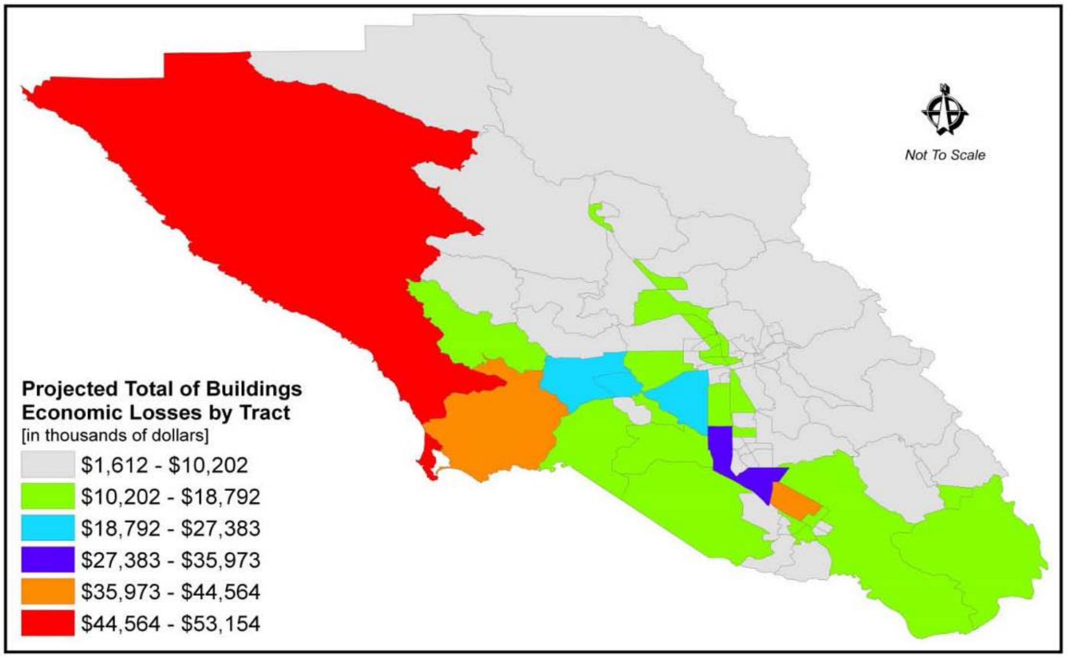
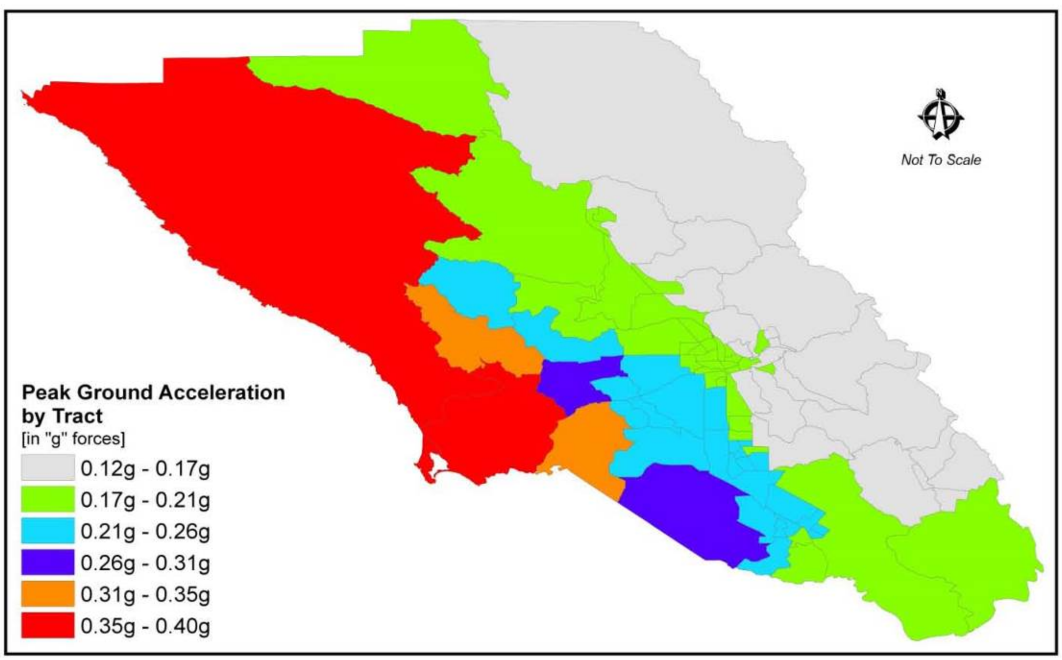


Figure SH-6: M8.0 Earthquake on San Andreas Fault





Plans

Sonoma County General Plan 2020

California State law requires each County to prepare a General Plan to set forth its community policies and objectives to guide the growth, development, and distribution of future land uses while protecting the public health, safety and welfare. The General Plan guides the County's land use and development decisions and any discretionary ordinances, land use or zoning changes, development proposals, use permits, subdivisions, and capital improvement plans must be found consistent with the General Plan before they can be approved.

Each General Plan contains a Public Safety Element which sets forth policies to protect the community from any unreasonable risks associated with the effects of seismic hazards, and related secondary natural hazards. It must also include mapping of known seismic and other geologic hazards.

The County's General Plan Safety Element was updated in 2014 to incorporate the 2011 Hazard Mitigation Plan analysis and hazard maps. The Safety Element has implementation programs to:

- Maintain records of all mapping and reports regarding geologic information,
- Develop a recovery plan for essential public facilities following earthquake,
- Adopt an ordinance addressing unreinforced masonry buildings, and
- Carry out the Hazard Mitigation Plan implementation actions.

Sonoma County Operational Area Tsunami Response Plan 2010

The Tsunami Response Plan incorporates the 2009 mapping of the Tsunami Run-Up zone for the maximum credible earthquake (MCE) along the Sonoma Coast as delineated under the National Oceanic and Atmospheric Administration (NOAA) National Tsunami Hazard Mitigation Program by CalOES, CGS and University of Southern California (USC). If the MCE is a MM,it establishes notification and evacuation response procedures to help minimize casualties from tsunamis. When a large seismic event occurs that could trigger a tsunami affecting the coast, the Pacific Tsunami Warning Center and the West Coast and Alaska Tsunami Warning Center issue tsunami warnings and monitor coastal communities. Warnings include information on the estimated time of arrival of the expected waves.

This system provides information to local governments who issue further warnings to individuals residing in or visiting potential impact areas. Tsunamis generated by near shore seismic events may occur without sufficient time to issue warnings or evacuation orders. Local officials must then rely on public awareness and education efforts to ensure the population reacts appropriately.

The California Earthquake Loss Reduction Plan

The 2007 California Earthquake Loss Reduction Plan was prepared by the State Seismic Safety Commission to set forth the State priorities and strategies for reducing earthquake losses. It incorporates lessons learned other earthquakes and emphasizes the importance of upgrading existing vulnerable structures, better design of new construction, and increased preparedness in all areas as the most cost-effective methods of reducing loss and improving recovery from earthquakes. The plan contains forty-four strategies and 148 implementation measures to be accomplished by the private sector, state, and local governments.

Russian River County Sanitation District Local Hazard Mitigation Plan

Russian River County Sanitation District serves 3,161 Equivalent Single-Family Dwellings within a 2,700-acre service area. The sanitation facility has a design capacity of 710,000 gallons per day and treats wastewater to tertiary treatment levels. The District also provides tertiary treated water for local agricultural uses. The District is managed by the Sonoma County Water Agency. The District and Agency are in the process of conducting a Natural Hazards Reliability Assessment which includes identifying seismic vulnerabilities and preparing a Hazard Mitigation Plan to develop a long term strategy to reduce potential for seismic damage and increase disaster resiliency and post-disaster functionality to provide public health protection. This Plan is scheduled to be completed in 2016.

Sonoma Valley County Sanitation District Local Hazard Mitigation Plan

The Sonoma Valley County Sanitation District began operations in 1953 and serves 17,027 Equivalent Single-Family Dwellings within a 4,500-acre service area. The treatment plant has a design capacity of 3 million gallons per day and the District provides tertiary treated water for local agricultural uses. The District is managed by the Sonoma County Water Agency and its Plan is scheduled to be completed in 2016.

Sonoma County Hazardous Waste Management Plan

Assembly Bill 2948 established procedures for the preparation of county Hazardous Waste Management Plans (HWMP). The plan must be prepared in accordance with California Health and Safety Code Section 24135 et seq. Sonoma County prepared a Hazardous Waste Management Plan that was adopted in 1989. The HWMP is intended to serve as the primary planning document for hazardous waste management within a County, and contains goals, policies, and recommended programs for the management, recycling, and disposal of hazardous wastes.

Codes and Regulations

California Environmental Quality Act (CEQA)

Prior to approving a discretionary project subject to CEQA, the lead agency must evaluate environmental impacts of the proposed project. Environmental review typically includes evaluation of impacts due to the following:

- Fault rupture,
- Strong seismic ground shaking,
- Seismic-related ground failure, including liquefaction, or
- Landslides.

Each project-specific environmental review must identify mitigations where necessary to mitigate significant impacts Local agencies may require implementation of the mitigations as a condition of approval.

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. This state law was a direct result of the 1971 San Fernando Earthquake, which was associated with extensive surface fault ruptures that damaged numerous homes, commercial buildings, a major hospital and resulted in significant damage to a major urban dam. Surface rupture is the most easily avoided seismic hazard. The main purpose of the Alquist-Priolo Act is to prevent the construction of buildings for human occupancy on the surface trace of active faults. The Alquist-Priolo Act's provisions only addresses the hazard of surface fault rupture and do not address other types of earthquake hazards such as liquefaction, shaking and landslides.

The State Geologist identified active faults and mapped regulatory zones (known as Earthquake Fault Zones) around the surface traces of known faults. The maps are provided to the local agencies, who must regulate development projects within the zones. Projects regulated include all land divisions and most structures for human occupancy. Single family wood-frame and steel-frame dwellings up to two stories not part of a development of four units or more are exempt. However, local agencies can be more restrictive than state law.

Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults. An evaluation and written report of a specific site must be prepared by a licensed geologist. If an active fault is found, a structure for human occupancy cannot be placed over the trace of the fault and must be set back from the fault (generally 50 feet). These California Geological Survey Earthquake Fault Zones are reflected in the County Zoning maps as areas zoned with the "G"-Geologic Zone Overlay District.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act, codified in 1991, seeks to protect public from the effects of strong ground shaking, liquefaction, landslides, caused by earthquakes (Public Resources Code, Division 2, Chapter 7.8). The Seismic Hazard Mapping Act establishes the following requirements:

- The State Geologist is required to delineate the various "seismic hazard zones" through the "Seismic Hazards Mapping Program". The California Geological Survey (CGS) is responsible for preparing maps of ground failure, liquefaction and landslide hazards zones for the most earthquake prone areas of the state.
- Cities and Counties, or other local permitting authority, must regulate certain development "projects" within the zones. They must withhold the development permits for a site within a zone until the geologic and soil conditions of the project site are

investigated and appropriate mitigation measures, if any, are incorporated into development plans.
- Cities and Counties must take into account seismic hazard zones when preparing the safety elements of their general plans, adopting and revising land use planning and permitting ordinances, and reviewing building permits.
- The State Mining and Geology Board provides additional regulations, policies, and criteria, to guide cities and counties in their implementation of the law.
- Sellers (and their agents) of real property within a mapped hazard zone must disclose that the property lies within such a zone at the time of sale.

Essential Services Building Seismic Safety Act

Passed in 1986, the Essential Services Building Seismic Safety Act requires that that essential services buildings shall be designed and constructed to be capable of providing essential services to the public after a disaster, to minimize fire hazards, and to resist, insofar as practical, the forces generated by earthquakes, gravity, and winds. Essential services building means any building, or portion of a building used or designed to be used as a fire station, police station, emergency operations center, California Highway Patrol office, sheriff's office or emergency communication dispatch center. It requires enhanced regulatory oversight, plan review, and design standards for these buildings.

Existing buildings housing essential services facilities owned or leased by the County prior to 1986 are exempt from these regulations, except for the installation of new or replacement equipment.

Responsibility for enforcement falls to the local building jurisdiction for locally owned or leased facilities and to the Division of the State Architect (DSA) for State owned or leased facilities. The duties and responsibilities of the State Architect also include observing the implementation and administration of the Act's provisions including "…providing advice and assistance to local jurisdictions regarding essential services buildings".

Alfred E. Alquist Hospital Seismic Safety Act of 1983 (Alquist Act)

The Alquist Act seeks to ensure that acute care hospital buildings remain intact and capable of continued operation and provision of acute care medical services after a seismic event. The Alquist Act establishes a seismic safety building standards program which requires all hospitals built after 1973 to be built to higher seismic standards so they can be reoccupied after major earthquakes. The Alquist Act was in response to the loss of life in the partial collapse of a hospital during the 1971 San Fernando earthquake. Hospitals built in accordance with the standards of the Alquist Act resisted the January 1994 Northridge earthquake with minimal structural damage, while several facilities built prior to the new standards experienced major structural damage and had to be evacuated.

The Alquist Act was amended in 1994 (Senate Bill 1953) to address this issue by establishing seismic performance categories, specifically the Structural Performance Categories (SPC) and the Non-structural Performance Categories (NPC) for new and existing general acute care hospital facilities. The SB1953 amendments requires that all acute care hospital buildings built before 1973 be replaced or retrofitted by 2013 (or by authorized extension date) so they can reliably survive earthquakes without collapsing or posing threats of significant loss of life. If they are not, acute care services may no longer be allowed to be provided in the building(s). It mandated that all hospital structures built after 1973 be seismically evaluated and retrofitted, if needed, by 2030 so they are reasonably capable of providing services to the public after disasters. These regulations apply to all acute care facilities (including those built after 1973) that have Structural Performance Category 1 (SPC-1) buildings.

Field Act and Other School Seismic Safety Legislation

Since 1933, public schools have been constructed in accordance with the Field Act. In order to assure seismically safe school construction, the Field Act requires strict building standards and thorough reviews of construction plans, strict inspections, and quality control. The Field Act was enacted in 1933, one month after the Long Beach earthquake in which 70 schools were destroyed, 120 schools suffered major damage, and 300 schools received minor damage. Private schools are not subject to the Field Act and fall solely under the jurisdiction of the local building departments and the Private Schools Building Act of 1986, which has similar provisions to the Field Act. Charter schools must comply with the Field Act requirements if their charter requires it.

In 2002, the Division of the State Architect (DSA) released a report entitled: "Seismic Safety Inventory of California Public Schools". It found that nearly all public schools that were built before the 1933 Field Act had either been retrofitted or were no longer being used for instructional purposes by 1977. It found that there were 42,000 school buildings which may not perform as well as intended because they were approved prior to major changes to the building code in 1978 that were adopted to improve seismic performance of structures. The list included 7,537 buildings of non-wood construction that may not perform well and will require more seismic evaluations and possible retrofits.

In 2007, the DSA adopted emergency seismic evaluation and retrofit regulations 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, as a retrofit standard for public school.

School districts are defined as local governments at 44 CFR Part 201.2, and are therefore required to have a FEMA-approved local mitigation plan to be eligible for project grants under FEMA hazard mitigation assistance programs. A school district may also demonstrate their participation as a separate government entity in another local government's approved mitigation plan to be eligible. Though many school districts have prepared hazard mitigation plans or participated in multijurisdictional plans to qualify for FEMA grants.
The Katz Act, Education Code Sections 35295-35297, requires schools to plan for earthquakes and other emergencies).

Pipeline Codes and Regulations

There are several federal regulation and safety standards which govern pipeline design and operation. Pursuant to the Natural Gas Pipeline Safety Act (NGPSA), the Department of

Transportation's (DOT) Office of Pipeline Safety (OPS) and the Pipeline and Hazardous Materials Safety Administration (PHMSA) and the Federal Energy Regulatory Commission (FERC), have overall regulatory responsibility for hazardous liquid and gas pipelines in the United States. Through certification by OPS, the State of California regulates, inspects, and enforces intrastate gas and liquid pipeline safety requirements. The California Office of the State Fire Marshal (OSFM) performs this work. The California Public Utilities Commission (CPUC) also regulates natural gas utility service for customers that receive natural gas from PG&E through utility-owned natural gas pipelines.

The OSFM and CPUC work in partnership with the federal Pipeline and Hazardous Materials Safety Administration (PHMSA) to assure pipeline operators are meeting requirements for safe, reliable, and environmentally sound operation of their facilities. Operator compliance with state and federal pipeline safety regulations is monitored through a comprehensive inspection and enforcement program. The program is comprised of field inspections of operations, maintenance, and construction activities; programmatic inspections of operator procedures, processes, and records; incident investigations and corrective actions; and direct dialogue with operator management.

In 2006, the Pipeline Inspection, Protection, Enforcement and Safety Act (PIPES Act) was passed improving safety and strengthening Federal and state pipeline safety programs. Implementation and enforcement of this law continue to be a priority for PHMSA. Federal regulators and legislators have proposed stronger gas pipeline safety requirements.
The regulatory agencies referenced above released guidelines in December of 2010 with recommendations to aid local jurisdictions plan land uses around transmission lines and minimize risks.

Unreinforced Masonry Building Law

The Unreinforced Masonry Building Law (California Senate Bill 547) adopted in 1986, requires local agencies to: 1) inventory and classify the unreinforced masonry buildings within their jurisdiction; 2) notify owners regarding the expected performance of these buildings; and 3) require owners of URMs to post warning signs on the outside of URM buildings used by the public. The County identifies each structure on the inventory list and classifies into one of the following four status categories:

- Active: A structure designated to be a potentially hazardous building that is in need of a retrofit,
- Annexed: A property that has been annexed into an incorporated city and is outside County jurisdiction,
- Exempt: A structure that has 5 or less residential units or any building that is listed as a historical property by an appropriate governmental agency.
- Conforms: A structure where information has been provided demonstrating the structure is not a potential hazardous building; has been seismically retrofitted under permit and inspected; or has been demolished.

The above law urges jurisdictions to adopt plans or programs to minimize the seismic vulnerabilities arising from URMs. The State adopted retrofit standards for URM buildings in Title 24, Part 10 of the 2007 California Building Standards Code.

Zoning Regulations

The County Zoning Ordinance, Chapter 26 of the Sonoma County Code, establishes various base districts in the County and designates the lawful permitted uses allowed in each along with the required review and approval procedures and siting and design criteria. It establishes several combining districts which further modify requirements to evaluate hazards or other resources on a parcel.

The Geologic Hazard Area combining district ("G") was implemented in 1993 and is applied on those areas near one of the major fault zones identified by the State Alquist-Priolo Act. It imposes additional geologic study and design requirements on new construction and development proposed within these areas to limit the risk of fault rupture to structures. It prohibits structures from being placed within fifty feet of the surface trace of any fault. The zoning code also provides the discretionary authorities to condition project approvals and such approvals must be found consistent with the General Plan.

Subdivision Regulations

The County Subdivision regulations, Chapter 25 of the Sonoma County Code, establishes standards to regulate the division of land, defines minimum lot sizes, densities and development standards. Applications for subdivisions in areas with geologic hazards must prepare geologic reports analyzing the site. Sites that warrant geological investigation need to identify areas of the site that can use standard foundation and construction techniques, areas that require mitigating construction techniques, and areas that require additional geologic testing to determine suitability for building. Recommended mitigation actions must be included in all project reports. Based on these requirements, subdivision approval may include conditions such as limiting areas that can be developed and requiring geologic mitigation in construction. Subdivision maps must include identification of seismic and geologic risks.

Building Code Regulations

The Uniform Building Code (UBC) sets forth structural design requirements to assure structures withstand seismic forces. The UBC is published and periodically updated by the International Conference of Building Officials (ICBO) it covers earthquake provisions (Chapter 16), foundations and retaining walls (Chapter 18), and excavation and grading (Chapter A33). In California it is referred to as the California Building Code (CBC). Seismic site factors are derived from the UBC/CBC and are required to be used by state and local agencies in geotechnical investigations to ensure critical structures in areas of high seismicity are properly designed.

The County applies stringent building codes through the California Building Code as codified in Chapter 7 of the Sonoma County Code. The code must be applied to all new construction and to substantial renovations. It includes state-of-the-art standards for site preparation, design, materials, and construction methods to minimize risk from earthquakes. The County applies different building code, anchor bolts and wall bracing requirements in the higher risk areas and requires dynamic structural analysis for complex structures.

Geologist and Geophysicist Act

This Act seeks to assure that geologic or seismic assessments are carried out by qualified geologists and geophysicists. (Bus. and Prof. Code §§ 7800 – 7887).

Hazardous Materials Codes

The Unified Hazardous Waste and Hazardous Management Regulatory Program (SB 1082, 1993) is a State and local efforts to consolidate, coordinate, and make consistent existing programs regulating hazardous waste and hazardous materials management. Cal EPA adopted implementing regulations for the Unified Program in January 1996. The Unified Program is implemented at the local level by Certified Unified Program Agencies (CUPAs).

The Hazardous Materials (HazMat) Unit has the responsibility for the County's Certified Unified Program Agency (CUPA) Programs. This program inspects, tracks, and permits manufacturing and storage facilities. The Hazmat unit is also responsible for developing HAZMAT emergency response plans and maintains a state certified Type 2 Hazardous Materials Response Team. There are approximately 1400 businesses covered by one or more of the CUPA programs within Sonoma County. Portions of the California Fire Code which address hazardous materials are also enforced by this Division. Inspections of businesses in the County which are included in any of these programs are conducted on a routine basis, and our Division often works in conjunction with the County's Environmental Health Department, Permit and Resource Management Department (PRMD), as well as local fire departments.

Sonoma County Code of Ordinances Chapter 29 – Hazardous Materials Management is intended to regulate the storage, handling, and management of hazardous materials, whether in waste or nonwaste form, unless specifically preempted by state or federal law. The purpose of which is to remedy or prevent an imminent risk of harm to the public health, domestic livestock, wildlife, or the environment arising out of any actual or threatened disposal or release of a material.

Mitigation Programs and Activities

County Building Evaluations and Retrofits

The County has an ongoing practice of evaluating County owned buildings for seismic performance as part of major remodeling projects and in conjunction with facility planning as funding becomes available. In the past few decades, several buildings have been retrofitted in compliance with these evaluations, including all of the Veteran's Memorial buildings, the Administration Building, the Permit and Resource Management Department building, La Plaza and others. A comprehensive assessment of the seismic safety of County-owned buildings is planned as part of the Capital Project Plan.

Earthquake Resistant Bracing System Program (ERBS)

This program is carried out by the County's Community Development Commission. Since 1994 it has installed earthquake bracing on 1,309 homes throughout Sonoma County (167 of these have been completed or are under construction since 2011). This program continues to take applications and funds construction. In addition, the Community Development Commission provides bracing assistance to mobile home owners.

Retrofit of County Bridges

The 2009 Bridge Plan identifies a number of County-owned bridges for retrofit or replacement due to seismic, scour, or other safety concerns. These bridges were selected by the County, with consultation from Caltrans Local Assistance. The County has an on- going program of bridge maintenance, retrofit and replacements. As of 2011, 15 bridges had been retrofitted or replaced. The County completed one additional seismic replacement since 2011 using Federal Highway Funds. Additional Bridges are scheduled to be completed in the next five-year implementation period. Implementation of the bridge safety program has experienced delays in recent years due to stricter environmental regulations and concerns about potential historic or cultural resources. The projects left to be completed will be prioritized and included in the County's 5-Year Capital Project Program (CPP) as funding allows.

Table SH-25: Status of Bridges in the Local Bridge Safety Program

Bridge Location	Type	Status	Date
Guerneville Rd at Laguna de Santa Rosa	Retrofit	Completed	2002
Boyes Blvd at Sonoma Creek	Replacement	Planned	2017/18
Petaluma Blvd at Petaluma River	Retrofit	Completed	2002
Crocker Rd at Russian River	Retrofit	Completed	2006
Moscow Rd at Russian River	Retrofit	Completed	2003
Bohemian Hwy at Russian River (Monte Rio)	Replacement	Planned	2021/22
Stewarts Point Rd at Dry Creek	Retrofit	Completed	2002
W. Dry Creek Rd at Pena Creek	Replacement	Planned	2017/18
Annapolis Rd at Gualala River	Retrofit	Completed	2011
Stewarts Point Rd at House Creek	Retrofit	Completed	2002
Alexander Valley Rd at Russian River	Retrofit	Completed	1994
Rockpile Rd at Warm Springs Creek	Retrofit	Completed	2001
Hauser Bridge Rd at S. Fork Gualala River	Replacement	Planned	2016/17
Freezeout Rd at Freezeout Creek	Retrofit	Completed	2002
Freestone Flat Rd at Salmon Creek	Replacement	Planned	2018/19
Wohler Rd at Russian River	Retrofit	Planned	2016/17
Wohler Rd at Mark West Creek	Replacement	Planned	2018/19
Watmaugh Rd at Sonoma Creek	Replacement	Planned	2019/20
Geysers Rd at Big Sulphur Creek	Replacement	Planned	2019/20
Riverside Dr at Sonoma Creek	Replacement	Completed	2006
Chalk Hill Rd at Maacama Creek	Replacement	Planned	2021/22
Porter Creek Rd at Porter Creek	Replacement	Completed	2013
Lambert Bridge Rd at Dry Creek	Replacement	Planned	2019/20
Yoakim Bridge Rd at Dry Creek	Retrofit	Completed	2001
River Rd at Russian River (Hacienda Bridge)	Retrofit	Completed	2002
Westside Rd at Dry Creek	Retrofit	Completed	2000
Grange Road at Matanzas Creek	Replacement	Completed	2004
River Rd at Gill Creek	Replacement	Planned	2021/22
Brickway Blvd at Mark West Creek	Replacement	Planned	2021/22
O'Donnell Ln at Calabazas Creek	Retrofit	Planned	2021/22
Bohan-Dillon Rd at S. Fork Gualala River	Replacement	Planned	2010/22
Geysers Rd at Fraiser Creek	Replacement	Planned	2020/21
King Ridge Rd at Austin Creek	Replacement	Planned	2020/21

Sonoma County Water Agency Reliability Improvement Project

For its water supply production and transmission facilities, the Sonoma County Water Agency is carrying out a multi-phase improvement plan to carry out hazard mitigation measures identified in its 2012 Hazard Mitigation Plan to increase the disaster resiliency and reliability of its system. Recent mitigation activities include:

- FEMA grant funding ($2.3 million) was awarded to SCWA to improve the Santa Rosa Aqueduct where it crosses the Rodgers Creek Fault. Construction of the new pipeline segment was completed in 2013.

- Improvements in the vicinity of the River Diversion Facilities along the Russian River were completed in 2014 to address liquefaction and lateral spread hazard.
- FEMA grant funding was obligated in 2014 to install 20 additional isolation valves at strategic locations throughout the water transmission system. The project is scheduled to be complete in 2017.
- Preliminary award of FEMA grant funding has been issued to address the liquefaction and lateral spread hazard at the Russian River – Cotati Aqueduct crossing of the Russian River, additional funding to modify the crossing is anticipated in 2016 and the project is to be completed by 2017.
- Preliminary award of FEMA grant funding has been issued to address the liquefaction and lateral spread hazard at the Russian River-Cotati Aqueduct crossing of Mark West Creek. The funding to modify the crossing is anticipated to be fully secured in 2016 and the project completed by 2018.
- A consultant has completed a preliminary investigation into potential design strategies to mitigate the liquefaction and lateral spread hazards at the water supply production facilities along the Russian River – in particular Collector Wells 3, 5, and 6. The current liquefaction mitigation study is anticipated to be expanded in 2016 to include a preferred design strategy. The Water Agency anticipates submitting an application for FEMA funding for implementation of this project following completion of the study.

County Of Sonoma TsunamiReady

The County of Sonoma was officially recognized as a TsunamiReady community in March 2016 by National Weather Service representatives. This designation recognizes voluntary community programs that promote collaborative tsunami hazard preparedness efforts. In order to become a TsunamiReady community, the County developed a local Tsunami Response Plan, mapped inundation areas along the coast, identified evacuation routes, established refuge areas, installed over 160 tsunami signs in the hazard zones, provided education to the public, deployed and maintained redundant and reliable means to disseminate tsunami warnings and participated in readiness exercises.

Financial Resources

Property Tax Relief for Seismic Improvements

The State Revenue and Taxation Code was amended in 2001 to provide property tax relief to property owners who undertake seismic retrofit projects. Property tax relief related to seismic retrofits was furthered by the adoption of Seismic Retrofitting Amendment in 2010. It prohibits tax assessors from re-evaluating new construction for property tax purposes when the point of the new construction is to seismically retrofit an existing building. The law exempts the seismic retrofit portion of a construction or remodeling project from re-assessment and increase in property taxes for the specified period of time, thus removing one of the financial disincentives for property owners to make seismic improvements to their buildings. This is critical to the successful implementation of seismic safety programs, where costly seismic retrofit projects improve seismic safety, but do not result in a proportional increase in market value of the property. The Code provides a 15-year new construction exclusion for improvements to unreinforced masonry buildings undertaken to comply with local ordinances on seismic safety. The regulations also provide a new construction exclusion for earthquake hazard mitigation technologies for existing structures other than unreinforced masonry buildings.

Earthquake Insurance

Residential earthquake insurance is one tool residents can use to help recover from earthquake damage. The California Earthquake Authority (CEA) provides about 70 percent of the state's earthquake insurance, which is sold through 16 participating insurers and the California FAIR plan (the state's insurer of last resort for those who can't obtain home insurance in the standard market). CEA currently is the largest provider of earthquake insurance in California. 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.

Earthquake insurance from the California Earthquake Authority (CEA) or other private insurers may provide incentives for some retrofitting activities by offering discounts on the insurance premiums when certain actions are taken. The CEA is works 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 annual earthquake insurance premium if an insured has met certain mitigation criteria. The minimum criteria currently required for a residential policyholder to qualify for a five percent premium discount are:

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

Depending on the homeowner's earthquake insurance provider, the successful application of the seismic retrofit standards may be considered when awarding discount points to homeowners to lower their earthquake insurance premiums. It is anticipated that home retrofits will help lower the potential for loss of life, injury, and structural and non-structural damage as well as contents damage resulting from an earthquake.

Despite the availability of earthquake insurance, just 12%of Californians who buy residential insurance policies also buy earthquake insurance. Earthquake insurance is costly, particularly in high risk areas. The policies include a standard 10% or 15% deductible; so, for a $400,000 house, a homeowner would have to pay for the first $40,000 to $60,000 in repairs.

Geologic Hazard Abatement District (GHAD)

A Geologic Hazard Abatement District (GHAD) is a potential approach to reducing impacts of development in geologically active areas, such erosion and failure of bluffs in the Coastal Zone. Established by the Beverly Act in 1979, a GHAD is an independent public entity (public agency) formed as a Board of Directors which oversees the prevention, mitigation, and abatement of geologic hazards. The public entity has similar authority to tax and bond and certain legal immunity as do other public agencies. Funding of the GHAD is through supplemental property tax assessments.

A GHAD increases the recognition of the long-term nature of geologic processes and the inability to eliminate all geotechnical risk. A GHAD was proposed for shoreline protection and bluff stabilization for the Gleason Beach community in 2003, but was not adopted.

Bridge Funding

The Local Highway Bridge Program (HBP) is established to replace or rehabilitate public highway bridges when the State and the Federal Highway Administration determine that a bridge is unsafe because of structural deficiencies, physical deterioration, or functional obsolescence. About $240 million of federal funds are made available to local agencies annually. The federal reimbursement rate under this program is 88.53 percent of the eligible participating project costs including preliminary engineering, right of way, and construction costs.

Local Bridge Seismic Safety Retrofit is a part of the statewide Seismic Safety Retrofit Program. Established after the 1989 Loma Prieta Earthquake, it provides funding to assistance local agencies in the retrofit or replacement of public bridges with seismic deficiencies in California. At the time this program was created, there were about 12,000 publicly-owned bridges in California. These bridges were screened for risk of collapse during seismic events. The voters of the State of California passed Proposition 1B in 2006 that created a Local Bridge Seismic Retrofit Account. Prop 1B funds provide the 11.5 percent match for federal highway bridge funds.

Other Potential Funding Sources

Additional potential multi-hazard funding sources are identified in Chapter 8 of this Plan

Stakeholders

In addition to Local, State and Federal agencies and nongovernmental entities identified in Chapter 1 (Introduction) the following entities play a key role with respect to mitigation of geologic hazards.

Department of Transportation (Caltrans)

Caltrans is responsible for planning, designing, building, operating and maintaining California’s state highway system. Caltrans works to ensure new and existing state highway infrastructure are properly designed and maintained to be resilient in disasters. Caltrans also administers and provides funding for local bridge seismic retrofit programs and has evaluated and strengthened thousands of state and local bridges at risk of damage in earthquakes, including a number of County bridges, described in Table SH-25 above.

Division of State Architect (DSA)

The DSA provides design and construction oversight for K-12 schools and community colleges in the state. DSA ensures that all new public schools in California meet stringent disaster-resistant design and construction standards and conducts site inspections during construction to verify proper implementation of the rules.

Office of Statewide Health Planning and Development (OSHPD)

OSHPD, among other activities, monitors compliance of California hospitals with the Alquist Hospital Seismic Safety Act. This regulation requires all existing hospital with specific structural deficiencies to upgrade their structures to defined seismic safety levels.

US Geological Survey (USGS)

The USGS researches natural science issues and provides data and maps valuable for mitigation activities. For example, the USGS develops probabilities for future earthquake events, and has produced maps landslide and liquefaction hazard maps.

California Geological Survey (CGS)

The CGS develops and disseminates technical studies and technical support to identify and plan for geologic hazards. For example, it maps fault rupture, liquefaction, and landslide hazard zones under the Alquist-Priolo Act and the Seismic Hazards Mapping Act.

Engineering Geologists and Geophysicists

These licensed professionals provide qualified expert analysis of geologic and seismic conditions and vulnerabilities consistent with Geologist and Geophysicist Act.

State Mining and Geology Board

This Board provides additional regulations, policies, and criteria, to guide cities and counties in their implementation of the Alquist-Priolo and Seismic Hazard Mapping Acts (see Map Figures). The Board also provides guidelines for preparation of the Seismic Hazard Zone Maps and for evaluating and mitigating seismic hazards.

Seismic Safety Commission

The Commission investigates earthquakes, researches earthquake-related issues, and recommends to the Governor and Legislature policies and programs needed to reduce earthquake risk. In particular, the Commission oversees the County's compliance with state regulations for un-reinforced masonry buildings (URMs).

Earthquake Engineering Resource Institute – Northern California Chapter

The EERI NC Chapter is dedicated to reducing the earthquake risk in the Northern California by advancing the science and practice of earthquake engineering; by improving understanding of the impact of earthquakes on the physical, social, economic, political and cultural environment; and by advocating comprehensive and realistic measures for reducing the harmful effects of earthquakes. Their school safety committee seeks to help high seismic risk schools reduce risk and minimize life loss in a big earthquake through outreach programs, risk surveys, emergency planning assistance, disaster response training, and non-structural hazard abatement.

State Allocation Board (SAB)

The State Allocation Board (SAB) is responsible for determining the allocation of voter-approved school construction bonds. The SAB also administers the School Facility Program Seismic Mitigation Program and other programs administered by the Office of Public School Construction, which provides the staff and support for state financing of school facilities. Funds for these projects are provided by bonds authorized under Propositions 1D, 47 and 55. SAB will allocate $194.8 million in unused seismic retrofit funds for the School Facility Program (SFP) Seismic Mitigation Program.