# Local Hazard Mitigation Plan

Earthquake

Fire

Landslide

Flood

**Adopted: January 8, 2008**

## Sonoma County Water Agency

SONOMA COUNTY WATER AGENCY

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# 1.0 INTRODUCTION

## 1.1 AGENCY PROFILE

The Sonoma County Water Agency (Agency) was created as a special district in 1949 by the California Legislature to provide flood protection and water supply services to portions of Sonoma and Marin counties. Legislation enacted in 1995 added the treatment and disposal of wastewater to the Agency's responsibilities. Although the Sonoma County Board of Supervisors acts as the Agency's Board of Directors, the Agency is a separate legal entity created by State law, having specific limited purposes and powers, and separate sources of funding. The Agency is thus different from County departments, which are created by the Board of Supervisors for administrative purposes, but are not separate legal entities.

The Agency is a wholesale water supplier to eight primary water contractors, several smaller communities and water companies, a range of surplus (curtailable) customers and off-peak customers. The total population served by the Agency is approximately 600,000 people in southern Sonoma County and Marin County. The projected total annual water demand from the Agency's customers is approximately 74 mgd for 2010 to 96 mgd for 2030.

The Agency also provides wastewater collection and treatment, and recycled water distribution and disposal services to approximately 22,000 residences and businesses and maintains more than 70 miles of engineered flood control channels and over 80 miles of natural channels (creeks). As part of flood control works, the Agency also maintains levees, and fish ladders, and embankment protection on the Russian River.

The Agency's eight prime water supply customers include the City of Santa Rosa, North Marin Water District, City of Petaluma, City of Rohnert Park, Valley of the Moon Water District, City of Sonoma, City of Cotati and Town of Windsor. Approximately 2% of the Agency's water is supplied to customers such as California-American Water Company (Larkfield District), Penngrove Water Company, Lawndale Mutual, Kenwood Village Water Company, Forestville Water District, and various government entities. Depending upon the Agency's transmission system capacity and the availability of excess water in the Russian River, the Agency sells as much as 12% of its water to the Marin Municipal Water District (MMWD). However, MMWD's rights to Agency's transmission system capacity are subordinate to the rights of the Agency's eight prime contractors. Less than 1% of Agency's total water deliveries are provided to several curtailable (surplus customers) such as local wineries.

Each of the Agency's water contractors is responsible for maintaining their own retail distribution system, including storage tanks and pumping stations. Most of the Agency's water contractors maintain some local source of supply in addition to water purchased from the Agency, but that constitutes a very small percentage of their total water requirements. Water to its various contractors is provided through tie-ins into the Agency's aqueducts. In addition to the contractor tie-ins into the aqueducts, the transmission system is also tied to about thirty fire hydrants. However, the primary fire-fighting capability within the Agency's service area is through fire hydrants within the local distribution systems.

The Agency is also responsible for wastewater collection, treatment and disposal services for the Airport/Larkfield/Wikiup, Geyserville, Penngrove and Sea Ranch County Sanitation Zones and the Occidental, Russian River, Sonoma Valley, and South Park County Sanitation Districts. For flood control purposes, the Agency has helped build and manage the Warm Springs Dam, Spring Lake, Coyote Valley Dam, Matanzas Creek Reservoir, Piner Creek Reservoir, Brush Creek Reservoir.

## 1.2 PURPOSE OF THE PLAN

Sonoma County is located in an area impacted by multiple natural hazards. Historically it has been subjected to many floods, wildfires, landslides and mudflows. Due to its proximity to the San Andreas Fault System, one of the major active fault systems in the world, Sonoma County also has a very high earthquake hazard.

The Agency's water, wastewater and flood control systems are distributed over a large geographical area and traverse zones of varying geology and potential hazards. A comprehensive Hazard Mitigation Plan (Plan) was prepared in recognition of the Agency's responsibility to the community and its role in preserving the economic vitality of the region. As stated in the Sonoma County Emergency Operations Plan, the public places trust in the operators of water systems to provide high quality drinking water, even after a disaster. An uninterrupted supply of clean drinking water and water for fire fighting is essential for the health and safety of the community and to minimize the potential for loss of life and property damage following a major natural disaster.

As has been shown numerous times in the past, natural disasters can result in enormous cost to the public through loss of life, human suffering, property damage and economic loss. Lack of preparedness can make recovery a very long and arduous process, which can last for many months or years and can depress a region for a time long after the physical signs of the disaster have disappeared. Recognizing this, the Federal Government passed the Disaster Mitigation Act of 2000 (DMA 2000), which encourages and rewards pre-disaster planning at all levels of local, tribal and State government.

As an incentive for pre-disaster mitigation planning, the DMA 2000 has established a pre-disaster hazard mitigation program and new requirements for the national post-disaster Hazard Mitigation Grant Program (HMGP). Accordingly, a larger amount of HMGP funds are available for communities that have developed a comprehensive mitigation plan prior to a disaster. In addition States, tribes and communities must have an approved mitigation plan in place before receiving HMGP funds. In addition, the Federal Emergency Management Agency (FEMA) has a Pre-Disaster Mitigation (PDM) program that provides funds to states, territories, Indian tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. PDM grants are awarded on a competitive basis and without reference to state allocations, quotas, or other formula-based allocation of funds. An approved Hazard Mitigation Plan is a pre-requisite for applying for a PDM grant.

## 1.3 PLAN DEVELOPMENT PROCESS

Recognizing its obligation to provide high quality water to the public, the Agency on its own initiative in 2004 embarked on a natural hazard reliability improvement program for its water supply system. This multi-phase project was initiated by the Department of Engineering and Resource Planning, with the Agency's Capital Projects Manager, Mr. Cordel Stillman, as the Project Manager for the project. Throughout the course of the project Deputy Chief Engineers from the Agency's Engineering and Resource Planning Division (Mr. James Jasperse), Maintenance Division (Mr. Michael Thompson) and Operations Division (Ms. Pamela Jean) were involved in setting the course of the project, attended meetings and reviewed drafts of the plan.

The Agency contracted the services of MMI Engineering (MMI), a specialty engineering firm with expertise in the assessment of natural and man-made hazards and their impact on water system reliability. The MMI team included specialists in structural/earthquake engineering, geotechnical/foundation engineering, geology and tectonics, engineering seismology, pipeline performance, hydrology, risk analysis, water resources and economic analysis. To involve the Agency's staff at all levels and not just management and to obtain their buy-in, a one day workshop was conducted to discuss the philosophy of the program and its approach and to obtain feedback. During the course of the work MMI's engineers interacted with Agency's maintenance, operations and engineering staff at many levels to obtain intelligence and operational knowledge of the Agency's system. MMI and Agency management staff met with the Agency's contractors at all significant decision points to receive input.

### 1.3.1 Water System Reliability Study

The initial phase of the project included identification of all credible natural hazards that could impact the system. The effects of each hazard (for example, expected ground accelerations in an earthquake, available fuel for wild fires, flood maps and zones of liquefaction and landslide) were plotted on a detailed Geographical Information System (GIS) map of the Agency's water system. This information was used to perform a preliminary assessment of the water system vulnerabilities to these hazards.

In the preliminary assessment, threats to the system that resulted in the greatest impact in the Agency's ability to reliably meet its mandate were identified. Since the benefits of hazard mitigation are a reduction in potential losses, vulnerabilities that could result in greatest losses were identified with the belief that, if mitigated, they would likely produce the greatest benefits. The preliminary assessment identified earthquakes and earthquake related hazard as the most significant hazards to the Agency's infrastructure followed by flood and fire. However, the vulnerability of Agency's facilities to flood and fire were significantly below the seismic vulnerability.

Following this preliminary assessment a more comprehensive assessment of Agency's facilities identified as potentially vulnerable was conducted through detailed structural, geotechnical and geological analysis including, as needed, subsurface investigations. In this study, which is nearing completion, the impact of these hazards and system vulnerabilities in terms of water supply to the Agency's contractors was studied through a detailed hydraulic model of the system. Based on these assessments a Capital Improvement Program (CIP) has been prepared that identifies mitigation actions through a combination of pre-hazard planning, system upgrades, component retrofits and plans for post-hazard repair.

The results of the preliminary and comprehensive assessments were presented to the Agency in a series of reports and technical memoranda. Prior to finalizing, the reports and memoranda were first submitted to the Agency in draft form.[1-7] The draft reports were circulated within the Agency to the Deputy Chief Engineers of the Engineering and Resource Planning, Maintenance and Operations Divisions for their comments.

### 1.3.2 Document Review

This plan has been developed through an extensive review of available information on hazards, Agency's emergency response plans,[8,9] Agency's urban water management plans,[10] engineering drawings and reports for Agency's facilities (Appendix A), historic aerial photographs and available geotechnical and geologic data both from the Agency and outside sources (for example, California Geological Survey for detailed fault investigation reports, California Department of Transportation for geotechnical reports).

In addition to the risk assessment of Agency's water supply facilities conducted as part of water supply reliability improvement program, an overview of the general vulnerabilities of the Agency's wastewater and flood control facilities is included in the development of this plan.

Other documents such as the FEMA 386[11-16] series of documents the Sonoma County's County Hazard Mitigation Plan,[17] and FEMA approved plans for other entities.[18,19]

### 1.3.3 Public Involvement

Stakeholder involvement during this process included meetings with the Agency's eight primary water supply contractors to describe the Agency's objectives, solicit input and apprise them of the findings of the hazard assessments. The Agency's General Manager and Board of Directors (who are also the County's Board of Supervisors) have also been kept informed of the ongoing work. To involve the Agency's staff at all levels and not just management and to obtain their buy-in, a one day workshop was conducted to discuss the philosophy of the program and its approach and to obtain feedback. During the course of the work MMI's engineers interacted with Agency's maintenance, operations and engineering staff at many levels to obtain intelligence and operational knowledge of the Agency's system.

After completing the preliminary water system reliability study, the Agency's contractors were briefed in a series of two hour meetings attended by the contractor representatives, MMI Project Manager and the Agency's Capital Projects Manager and the Deputy Director Engineering and Resource Planning.[20-24]

The following additional activities are planned as part of public involvement process:

- The draft hazard mitigation plan posted on the Agency's website on November 6, 2007 for public review and comment.

- The draft hazard mitigation plan presented to the Agency's Water Advisory Committee (WAC) on November 5, 2007 for review and comment.

- The draft hazard mitigation plan presented to the Agency's Technical Advisory Committee (TAC) on November 5, 2007 for review and comment.

- The draft hazard mitigation plan presented to the Agency's contractors for review and comment as follows:
  - City of Santa Rosa, October, 2007
  - City of Sonoma, October, 2007
  - City of Petaluma, October, 2007
  - Town of Windsor, October, 2007
  - City of Rohnert Park, October, 2007
  - City of Cotati, October, 2007
  - North Marin Water District, October, 2007
  - Valley of the Moon Water District, October, 2007
- The draft hazard mitigation plan presented to the Agency's Board of Supervisors on January 8, 2008 for review, comment and formal adoption.

No comments on the Plan were received from the public. Several minor comments were received from the Agency's contractors which were incorporated into the Plan.

## 1.4 PLAN ADOPTION

This plan was formally adopted by the Sonoma County Water Agency Board of Supervisors on January 8, 2008. The formal resolution of adoption is included in Appendix B.

# 2.0 SONOMA COUNTY WATER AGENCY FACILITIES

## 2.1 WATER SUPPLY SYSTEM

The Agency's water system is shown in Figure 1 and Figure 1a. The primary source of water for the Agency's water supply system is a ground water aquifer located in the Mirabel Park area just north of the town of Forestville. The aquifer is located adjacent to the Russian River and receives water from the river by natural filtration through an approximately 60 feet thick sand and gravel riverbed. Water from the aquifer is pumped by six Ranney type collector wells and released into 83 miles of large diameter pipelines (aqueducts) that transmit water throughout the Agency's service area. Three out of the six collectors are located along the eastern bank of the river in the Wohler area and are referred to the Wohler collectors, while the remaining three are located along the western bank of the river in the Mirabel area and are known as the Mirabel collectors. On the average, the Mirabel and Wohler collectors can provide a sustained flow of approximately 15 mgd each. In addition to the collector wells, the water supply system has ten conventional wells (with an average sustained flow of 7 mgd) that supplement the water supply from the collectors. Seven of these wells are located along the Russian River in the general vicinity of the collectors, while the remaining three are located in the Laguna De Santa Rosa area near Sebastopol.

The transmission system has eight booster pump stations that provide the necessary head to move the water through the system. Water storage is provided by 18 steel storage tanks with a collective storage capacity of 128.8 million gallons. The Agency also maintains two major reservoirs impounded by two large dams (heights of 319 feet and 160 feet), an inflatable rubber dam, a system of ditches, infiltration ponds and a dike, three water treatment facilities, an electric power substation, a hydroelectric plant, and several emergency power generators.

The key facilities that constitute Agency's water supply system are summarized below:

- **Russian River system –** includes the Russian River, the Russian River aquifer and the Warm Springs and Coyote Valley dams (319 feet high and a 164 feet high earth-fill embankment dams).
- **Diversion system –** includes collector wells, inflatable dam, River Diversion Structure (RDS), Mirabel well field, dikes and diversion channels in the Wohler-Mirabel area and infiltration ponds.
- **Transmission system –** includes all of the Agency's aqueducts that transport water from the Agency's diversion system facilities to storage and to its contractors.
- **Storage system –** includes 18 storage tanks that provide 128.8 million gallons of storage.

- **Pumping facilities –** includes 8 booster stations.
- **Treatment facilities –** includes three chlorination and corrosion control facilities.
- **Power system –** includes the electric substation, fixed and portable emergency generators and the 12kv power line.
- **Supplementary facilities –** includes Laguna de Santa Rosa wells and the Agency's office and operations buildings.
- **Equipment and non-structural components –** Most of the Agency's facilities that include boosters stations, pump houses at the collectors, chlorination and corrosion control facilities, wells and office buildings house a range of equipment and non-structural components, which if unanchored are vulnerable to damage or can either cause injury or damage to an adjacent critical piece of equipment.

## 2.2 SANITATION SYSTEM

The Agency's sanitation system includes eight Sanitation Districts and Zones. The service area for the zones (systems owned by the Agency) and districts (independent special districts operated by the Agency) varies from 70 to 4600 acres. Figure 2 shows the location of the 8 sanitation districts/zones. Each district/zone has its own wastewater collection system that typically includes gravity flow in pipelines. Out of the eight districts/zones, six have wastewater treatment plants. The remaining two, the Penngrove Sanitation Zone and the South Park County Sanitation District, collect wastewater and transport it to the City of Petaluma and the City of Santa Rosa treatment facilities, respectively. The total pipeline length for each district/zone ranges from as little as one mile for the Occidental County Sanitation District to over 100 miles for the Sonoma Valley Sanitation District. The Agency has 29 lift stations located across these systems. The wastewater treatment plants treat wastewater to either secondary or tertiary standards and include a series of aeration basins, settling ponds, clarifiers, holding ponds, chlorination chambers and dechlorination facilities.

The average dry weather flow for the treatments plants vary from 2000 gallons per day (Sea Central Sanitation Zone) to 2.8 mgd (Sonoma Valley County Sanitation District). After treatment, the wastewater is either used for irrigation or discharged to percolation ponds or waterways. The Geyserville and Sea Ranch North Sanitation Zone use percolation ponds to discharge the treated wastewater. Some recycled water from the Sonoma Valley County Sanitation District is discharged through Shell Slough which ultimately flows into the San Pablo

Bay. Recycled water from the Russian River County Sanitation District and Occidental County Sanitation District ultimately flows into the Russian River.

## 2.3 FLOOD CONTROL SYSTEM

The Agency, in cooperation with the United States Army Corps of Engineers (USACE), is responsible for maintaining specific federal and non-federal flood control improvement projects on the Russian River. The Agency's flood control works include Lake Mendocino, Lake Sonoma, the Central Sonoma Watershed Project and the Laguna De Santa Rosa.

Lake Mendocino is located on the East Fork Russian River three miles northeast of Ukiah. It was formed by the construction of the Coyote Valley Dam by the United States Army Corps of Engineers (USACE) in 1959. The dam is a 160-foot high rolled earth embankment used for water storage and flood control purposes. The Agency and the Mendocino County Russian River Flood Control and Water Conservation Improvement District share permits by the State for rights to store up to 122,500 acre-feet of water per year in the reservoir. However, the Agency has the exclusive right to control the releases of water from the water supply pool in Lake Mendocino because it was the local sponsor for the dam project. When the water level rises above the top of the water supply pool and into the flood control pool the USACE assumes control of releases.

Lake Sonoma is located approximately 14 miles northwest of Healdsburg at the confluence of Warm Springs Creek and Dry Creek. The reservoir was formed by the construction of Warm Springs Dam, a 319-foot high rolled earth dam, in 1982 by the USACE. Similar to Lake Mendocino, the Agency has exclusive rights to control the rate of release of water from the water supply pool in Lake Sonoma. When the water level in the Lake rises above elevation 451 feet and goes into the flood control pool, the USACE assumes control of the water release. The Agency has constructed and operates a 2.6 mega watt hydropower plant at the dam.

The Central Sonoma Watershed Project includes four flood control reservoirs that include the Santa Rosa Creek Reservoir (Spring Lake), Matanzas Creek Reservoir, Piner Creek Reservoir, and the Brush Creek Middle Fork Reservoir. Each of these reservoirs are equipped with appurtenant structures but unlike the Warm Springs and Coyote Valley dams they are not equipped with flood gates and instead operate passively either as detention basins or bypass systems. Several waterways have also been shaped and stabilized as part of the Central Sonoma Watershed Project.

The Laguna de Santa Rosa is a natural overflow basin covering 254 square miles and connects the Mark West creek and other smaller creeks with the Russian River.

The Agency provides maintenance services for over 150 miles of engineered and natural channels (creeks) in addition to the maintenance of the Central Sonoma Watershed reservoirs and upper Russian River channel and levee maintenance.  The Agency's maintenance activities include debris removal, bank stabilization and protection, maintenance of inlet/outlet structures, silt removal, vegetation management, levee repair, service road maintenance and dam and reservoir structure maintenance.  The Agency also maintains several gauging stations along the Russian River that provide information on rainfall intensity, river height and discharge that is essential to flood forecasting.

## 2.4 EMERGENCY POWER

Electrical power to operate the Agency's booster pumps and equipment is provided by the Power and Water Resources Pooling Authority (PWRPA) and Pacific Gas and Electric Company (PG&E).  Power to the collector wells is provided by an Agency owned and operated substation located at the Wohler Corporation Yard.  Power from the substation is supplied to the collectors at Wohler and Mirabel through a 12-kV power-line that runs along the river and infiltration ponds as shown in Figure 3.

The Agency has provisions to provide emergency electrical power for its main pumps at the collector wells.  Three fixed place emergency generators are located at the Wohler Corporation Yard.  These generators can run any combination of pumps, up to a maximum of six, at both the Wohler and Mirabel collectors.  The Mirabel facility has two fixed place 480 volt, 1100 kW diesel generators that can operate two of the main pumps at Mirabel.  The diesel generators are fueled by two diesel fuel tanks, a 10,000 and a 25,000 gallon, located at each generator site.

Emergency power to the booster pumping stations and emergency wells can be provided by portable trailer mounted 480 volt generators.  In addition, fixed place diesel generators are also located at the Sonoma No. 2 booster station and the Ely Road booster station.

The Operations and Maintenance Center, Service Center and Administration Buildings at College Avenue have standby generators that operate automatically when power is lost.

## 2.5 ADMINISTRATIVE INFRASTRUCTURE

The Agency owns two office facilities located on 404 Aviation Boulevard and 2150 West College Avenue in Santa Rosa.  The Aviation Boulevard facility is the Administration Building and houses a majority of the Agency's engineering, administration, accounting, environmental, public affairs and executive management staff.  The College Avenue facility is occupied by the operations and maintenance staff, equipment and the supervisory control and data acquisition

(SCADA) system. The College Avenue facility also has a Service Center where maintenance and management of Agency fleet vehicles and gas-powered equipment is also performed. The Administration Building is powered by solar photovoltaic panels that have been installed on the building roof and on ground-mounted power canopy.

# 3.0 HAZARD ASSESSMENT

## 3.1 EARTHQUAKE HAZARD

Sonoma County is the northernmost of the nine counties that constitute the seismically very active San Francisco Bay Area. Earthquakes in the Bay Area occur due to a sudden slip on one of the several major faults of the San Andreas Fault system. The slip releases tremendous amount of strain energy stored along these faults from the relative movement (approximately 2 inches per year) between the Pacific oceanic plate and the North American continental plate. When the accumulated strain on the fault reaches the threshold strength of rock in the earth's crust, it is released in an earthquake by a sudden rupture of several kilometers along the fault. Some of the major faults in the San Andreas Fault system include the Hayward, Calaveras, San Gregorio Fault, Rodgers Creek and Maacama faults. Many of these faults (in particular the San Andreas and Rodgers Creek Faults) have been seismically active in historical time and have produced large earthquakes. Figure 4 shows the fault map of the Bay Area.

### 3.1.1 Historic Seismicity

The Bay Area has experienced at least nineteen earthquakes greater than Magnitude[1] 6.0 during the last 150 years the largest of these has been the April 21, 1906 Great San Francisco earthquake.[25] The Magnitude 7.8, 1906 earthquake caused extensive damage in the San Francisco Bay Area including Sonoma County. Other significant historic earthquakes that caused substantial damage in the Bay Area include the 1838 earthquake, the 1868 earthquake on the Hayward Fault and the recent Loma Prieta earthquake in 1989.

For the Bay Area, a plot of moderate to large earthquakes on a time scale (Figure 5) shows that the seismic activity in the region prior to the 1906 earthquake to be significantly higher than that following it. Most likely, this is because the 1906 earthquake created a stress shadow by substantially relaxing stress on all of the Bay Area faults that form the San Andreas Fault system.[26] As shown in Figure 5 there appears to be an increased earthquake activity in the last two decades suggesting that the Bay Area might be emerging from the 1906-induced stress shadow, and that faults that have been quiescent during the past century, may now once again become more seismically active.

Recent work by the Working Group on California Earthquake Probabilities (WGCEP), a group of leading scientists, practitioners and academicians has estimated very high probabilities (67%)

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[1] Magnitude is a quantitative measure of energy released in an earthquake. Due to the logarithmic nature of the magnitude scale, an increase in magnitude by one unit produces 30 times more energy. A qualitative descriptor of the effects of earthquake on the built environment or those experienced by humans is the Modified Mercalli Intensity. It ranges from I (not felt) to XII (complete destruction) with intermediate values such as VI described as felt by everyone, many frightened and run outdoors or IX described as general panic, complete destruction of poorly constructed masonry.

of a major earthquake in the Bay Area in the next 30 years (Figure 6). The most significant contributors to this probability are the Hayward and the Rodgers Creek faults, the latter runs through the Agency's service area and cuts across one of its major pipelines (Figure 7). The WGCEP has estimated an 18% probability for a major earthquake on the Rodgers Creek fault and 27% for the Hayward-Rodgers Creek fault system. The probability for these faults is even higher than the probability of a major earthquake on the San Andreas Fault.

The most recent earthquakes on the Rodgers Creek fault include the October 1, 1969 M 5.6 and 5.7 earthquakes near Santa Rosa.[27-30] The earthquakes occurred within a span of about 2.5 hours and resulted in considerable damage in Santa Rosa including significant damage to water distribution system including cracks in the Lake Ralphine Dam. Prior to the 1969 events, the other known earthquake on the fault consists of the 1898 Mare Island event with an estimated magnitude between 6.2 and 6.7. It is estimated that for the portion of the fault located in the Agency's service area the average earthquake recurrence interval is on the order of 131-370 years.[31-33]

### 3.1.2 Surface Fault Rupture Hazard

In large magnitude earthquakes fault rupture can extend to the ground surface resulting in one side of the fault moving relative to the other by as much as several feet. Structures located within the fault rupture zone are subjected to excessive ground deformations. Most structures are not designed to withstand such large deformations and experience major damage.

From the surface fault rupture hazard viewpoint, the Agency's facilities are most severely 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. Paleoseismic observations on the Rodgers Creek fault show the occurrence of three surface-rupturing earthquakes between about AD 1000 and 1776 with approximately 5.1 to 7.2 m of offset. The CDMG Special Publication 112, the Planning Scenario for a major earthquake on the Rodgers Creek fault prepared by the California Geological Survey[34] considers a Magnitude 7.0 earthquake with an average offset of 3 feet as most likely. Surface displacements on this order of magnitude are almost certain to rupture the Santa Rosa aqueduct, which is not designed to withstand such large displacements.

In addition to the Rodgers Creek fault, recent studies by the USGS suggest that the Bennett Valley Fault, a fault previously considered inactive may be an active structure. This fault is located in the step over region between Rodgers Creek and Maacama fault and transfers slip across the two faults (Figure 7). Mapping of the Bennett Valley fault in the Spring Lake area shows that the fault crosses the Sonoma aqueduct and the Oakmont pipeline near the Sonoma booster stations. The fault is well expressed in this area and crosses beneath the Sonoma Booster Station No. 2. The amount of possible lateral slip and/or vertical offset across the mapped fault traces is currently unknown but the inferred high slip rate[35] suggests a correspondingly high potential for surface fault rupture.

### 3.1.3 Strong Ground Shaking

Seismic waves generated as a result of fault rupture propagate through the earth's crust from the rupture front and cause strong shaking of the ground. The intensity of ground shaking at a particular location is measured in terms of ground acceleration, which generally decreases with distance from the earthquake source unless modified by local subsurface conditions. The maximum acceleration recorded at a site is referred to as the peak ground acceleration (PGA) and is reported as a fraction of earth's gravitational acceleration (g). The total force experienced by a structure can be related directly to the level of acceleration it experiences.

The distance of the Agency's facilities from the nearest major Bay Area faults is shown in Table 1. The table also shows the expected PGA at each of the Agency's facilities from a maximum earthquake on these faults. In addition, the table also lists the PGA values estimated by the United States Geological Survey (USGS) for a 10% probability of exceedence in 50 years (mean return period of 475 years). This probability level is typically used in seismic design of structures and forms the basis of the 1997 Uniform Building Code (UBC). The table shows that the estimated median PGA values at the Agency's facilities range between 0.3g to 0.8g. Figure 8 shows the Agency's system together with a plot of USGS estimates of PGA contours in Sonoma County. 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.

**Table 1**
**Peak Ground Acceleration (g) at Agency's Facilities**

| Name | Distance to Fault (km) | Deterministic (M = 7) | | Probabilistic 500 Year |
|---|---|---|---|---|
| | | Median | Median + σ | |
| Diversion Facilities | 10.9 | 0.29 | 0.44 | 0.40 |
| Occidental Road Well | 9.8 | 0.38 | 0.58 | 0.42 |
| Sebastopol Road Well | 9.8 | 0.38 | 0.58 | 0.42 |
| Todd Road Well | 9.1 | 0.40 | 0.61 | 0.42 |
| Ralphine Tanks | 3.3 | 0.67 | 1.03 | 0.57 |
| Cotati Tanks | 8.8 | 0.41 | 0.63 | 0.46 |
| Forestville Tank | 11.4 | 0.33 | 0.51 | 0.40 |
| Annadel No. 1 Tank | 6.4 | 0.51 | 0.78 | 0.46 |
| Annadel No. 2 Tank | 8.3 | 0.43 | 0.66 | 0.46 |
| Eldridge Tanks | 8.5 | 0.42 | 0.65 | 0.41 |
| Sonoma Tanks | 7.0 | 0.48 | 0.74 | 0.42 |
| Kastania Tank | 7.8 | 0.45 | 0.69 | 0.51 |
| Kawana Springs Tank | 1.0 | 0.77 | 1.19 | 0.54 |
| Forestville Booster Station | 11.4 | 0.33 | 0.51 | 0.40 |
| Sonoma Booster Station | 4.1 | 0.63 | 0.96 | 0.57 |
| Ely Booster Station | 6.8 | 0.49 | 0.75 | 0.53 |
| Eldridge Booster Station | 8.5 | 0.42 | 0.65 | 0.41 |
| Wilfred Booster Station | 5.5 | 0.55 | 0.85 | 0.51 |
| Kastania Booster Station | 7.8 | 0.45 | 0.69 | 0.51 |
| Kawana Booster Station | 6.9 | 0.48 | 0.75 | 0.48 |
| River Road Chlorination Facility | 11.4 | 0.33 | 0.51 | 0.40 |
| Mirabel Chlorination Facility | 12.0 | 0.32 | 0.49 | 0.40 |
| Wohler Chlorination and Corrosion Control Facility | 10.0 | 0.37 | 0.57 | 0.40 |

Note: The peak ground acceleration values are for rock conditions

Deterministic ground motions were computed using the Abrahamson and Silva attenuation relationship[36]

Probabilistic ground motions computed by USGS were based on an average of multiple attenuation equations including the Abrahamson and Silva

### 3.1.4 Liquefaction and Lateral Spread

Liquefaction is a phenomenon in which loose granular soils saturated with water lose their ability to carry load when subjected to strong shaking. The shaking causes an increase in pressure exerted by the entrapped water within the pores of soil matrix and causes the soil to flow as a liquid. This subsurface process manifests itself in the form of large ground deformation and sand volcanoes at the ground surface. When liquefaction occurs near a free face such as a stream or river bank large horizontal movement of ground can occur as the overlying soil layers slide over the liquefied layer towards the free face. This phenomenon known as lateral spread is very detrimental to buried pipelines and pose a much greater hazard to facilities and pipelines than liquefaction alone[37,38]. Lateral spreads can develop on gentle slopes (less than 3 degrees) and may produce horizontal displacements of as much as tens of feet.[39]

The potential for liquefaction depends on both the susceptibility of a soil deposit to liquefy as well as the opportunity for ground motions to exceed a specified threshold level. Given the proximity of Sonoma County to the San Andreas and Rodgers Creek faults, virtually all parts of the County are exposed to long duration peak ground accelerations in excess of 0.15g (Figure 8). To assess the liquefaction and lateral spread hazard to the Agency's facilities, potentially liquefiable soils that consist of young alluvial deposits and artificial fill present within the Agency's service area are overlain on the Agency's water supply system as shown in Figure 9. The figure also shows locations where the pipelines cross streams and open slope faces. Such stream crossing locations coupled with high liquefaction potential have a very high likelihood of lateral spread and resulting pipeline damage.

All of the Agency facilities that lie in areas marked as moderate, high and very high will likely experience liquefaction because the estimated ground acceleration at all Agency facilities is greater than 0.3g, the triggering threshold for a moderate susceptibility rating. As shown in Figure 9, significant portions of the Agency's system are vulnerable to liquefaction. **Areas of high and very high liquefaction potential exist at collector sites, Mirabel well-field and Ely booster station. A high susceptibility to liquefaction exists along the 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, as shown in Figure 9, have a very high potential for damage due to the potential for lateral spread. The main power line from the Wohler substation to the collectors is also located in an area of very high liquefaction potential.**

### 3.1.5 Earthquake Induced Landslides

Earthquake-induced slope failures or landslides commonly occur over wide areas on hill slopes during large (magnitude 6.5 or larger) earthquakes and can produce significant damage. The most common earthquake-induced failures are rockfalls, rock and soil slides, and soil avalanches, slumps and flows. Rockfalls, avalanches, and flow-type failures are especially hazardous because they often occur rapidly and travel great distances from the point of initiation. These types of rapid failures present significant impact to structures sited on slopes or valley areas downhill from the initiation site, and can distort or break shallow-buried pipelines crossing the sliding plane of the slope failure.

The opportunity for seismically induced slope failure is dependent on the potential for appropriately high levels of ground shaking to initiate movement. The susceptibility for failure is based on conditions that predispose the slope to failure including static stability, local geology, slope inclination, groundwater conditions, rock strength, and the duration and intensity of shaking. The potential for landslides is higher during seasonal wet periods when hill slopes are saturated with water.

Figure 10 shows the USGS regional landslide hazard mapping for Sonoma County. Though various workers have mapped the geology of the study area, most published geologic maps of the Agency's service area do not delineate active or recently active landslides or slope failures. Therefore, there is a possibility of small localized landslides that could result in damage to pipelines especially along the runs that connect to the tanks located on hills.

**Figure 10 shows that most of the Agency's water system is located outside of active landslide areas with only a few locations such as a portion of the Santa Rosa aqueduct near the collectors, a small potion of the Russian River-Cotati Intertie south of Forestville tanks and areas near the Kastania, Eldridge, Cotati and Annadel No. 2 tanks may be somewhat susceptible to landslide hazard. However, more detailed assessments show that the landslide hazard at these locations is low.**

## 3.2 FLOOD HAZARD

Flooding is defined as the overflow of excess water from a water body onto adjacent floodplain lands. Flooding typically results from large-scale weather systems generating prolonged rainfall or on-shore winds. Other causes of flooding include locally intense thunderstorms, snowmelts, ice jams and dam failures. Floods are capable of undermining buildings and bridges, eroding shorelines and riverbanks, tearing out trees, washing out access routes, and causing loss of life and injuries.

Flash floods pose more significant safety risks than other riverine floods because of the rapid onset, the high velocity of water, the potential for channel scour, debris load and increase in turbidity of water that can directly impact the Agency's water supply. In addition, more than one flood crest may result from a series of fast moving storms.

Sonoma County has had significant flooding in the past and is expected to have floods in the future. Table 2 shows the highest recorded flood levels between 1955 and 1996 at the Hacienda Bridge on the Russian River. Flood water getting as high as approximately 15 feet above the flood level (34 feet) has occurred in the past.

**Table 2**
**Historic Floods in Sonoma County**

| No. | Date | Water Level at Hacienda Bridge (feet) |
|---|---|---|
| 1 | February 18, 1986 | 48.56 |
| 2 | January 9-10, 1995 | 48.01 |
| 3 | December 23, 1955 | 46.95 |
| 4 | December 23, 1964 | 46.85 |
| 5 | January 1, 1997 | 45.10 |
| 6 | January 5, 1966 | 42.53 |
| 7 | March 10, 1995 | 42.24 |
| 8 | January 27, 1983 | 41.63 |
| 9 | January 24, 1970 | 41.20 |
| 10 | February 1, 1963 | 40.95 |

Flood level at Hacienda Bridge = 34 feet

Figure 11 shows the flood hazard within the Agency's service area prepared by the Federal Emergency Management Agency (FEMA). These maps use computed or estimated water surface elevations combined with topographic mapping data to represent the flood hazard. The 100-year flood represents a compromise between minor floods and the greatest flood likely to occur in a given area. In most cases the 100 year flood is less than the flood of record and has been widely adopted as the common design and regulatory standard in the US. It was formally established as a standard for use by Federal agencies in 1977 and later confirmed by FEMA in 1982.

Figure 11 shows the Agency's system overlain on the FEMA flood maps. The figure also shows the locations where the pipelines cross creeks. These locations together with areas of high flood hazard are at the highest risk of damage due to channel scour. Debris flow in streams and the potential for bottom scour and the resulting pipeline damage is also a potential hazard. **As shown in the figure, the Agency facilities with the highest risk of flooding include those located in the Mirabel and Wohler area, Ely booster station, the Sebastopol and Todd Road wells, significant sections of the Russian River-Cotati Intertie, Forestville aqueduct and Wohler Intertie and some portions of the Santa Rosa aqueduct. Stream crossing locations of the transmission lines located in the areas of high flood hazard are most vulnerable to damage due to flood related scour. In addition, there are three locations where a pipeline is suspended from a bridge at the stream crossing location. At these locations, the pipeline is vulnerable to damage by impact from floating debris.**

## 3.3 GEO-HAZARDS

### 3.3.1 Landslides

Hillslopes along the Agency's pipeline corridors and their facilities have been modified by mass wasting processes, including landslides, debris flows, soil creep, gully and stream erosion, and sheet wash. These processes are episodic, with failures typically occurring during or shortly after periods of heavy precipitation. Types of slope failure that are usually caused by prolonged rainfall include rotational slumps, earthflows, and rapidly moving debris flows. Figure 12 shows historic landslides in Sonoma County during El Nino storms of 1997-1998.

Most of the landslides present along the Agency's pipeline corridors fall into two primary types: (1) rotational and translational landslides involving bedrock and colluvium, and (2) debris or earth flows involving colluvium.

Rotational and translational landslides pose the primary slope stability hazard along the pipeline corridors. The landslides commonly are distinguished by vegetation changes and characteristic slope morphology, including undulating, hummocky ground surface. Deep rotational and translational landslides typically involve underlying bedrock and are mainly associated with steep slopes greater than 15˚ and showing signs of water seepage. As shown in Figure 10 the overall landslide hazard within the Agency's water system is low.

Debris and/or earthflows typically occur where colluvium collects in topographic swales on hillslopes. During heavy rainfall, saturated colluvium may flow rapidly down drainage channels. Poorly sorted debris within a flow may be deposited where the slope angle decreases or may increase in volume with distance traveled downslope. The primary potential hazard posed by debris flows to the pipeline is the relatively rapid movement of soil surrounding the pipeline, and associated displacement of the pipeline. Pipeline displacement is more likely at the debris-flow headscarp than in lower parts of a debris flow. Figure 13 shows debris flow hazard in Sonoma County mapped by the USGS. Because debris flow travels downslope and downstream from the source area, the hazard associated with debris flow extends beyond the mapped areas. The map also shows debris-flow sources (represented by black dots on the map) mapped after the major storms of January 1992.

### 3.3.2 Corrosive Soils

Potential external corrosion hazards to pipeline systems are dependent in part on the conductivity of the ground and the corrosive nature of soils in which the pipeline is buried. Corrosivity of soils is dependent on soil texture, soil pH, moisture content, and geochemical composition of fluids within the soil. These factors, in turn, are influenced by the physical and mineralogic composition of soils. Soil composition often is directly derived from the characteristics of the underlying geologic deposits on which they develop. Silty and clayey soils tend to have the highest corrosion potential in contrast with granular soils (sands and gravels). In addition, the topography of the land, depth to groundwater, and native vegetation all influence the soil corrosivity potential.

Although soil corrosivity can exist within a broad range of soil conditions, the extent of acidity or alkalinity of a soil, as expressed by pH, directly influences corrosion susceptibility. Soil with pH generally less than 9.0 has been found to be among the more corrosive types. Typically soils with a pH of 0.0 to 4.0 are acidic and, where saturated, can serve as a corrosive electrolyte. Soils with a near neutral pH of 6.5 to 7.5 and low Redox conditions are optimum for sulfate reduction by bacteria, which can cause localized corrosion.

Soil resistivity also has a strong influence on the corrosion rate. Generally, the higher the resistivity of the soil, the lower is its corrosion rate. Soil resistivity arises from a number of factors, but fine-grained soils (silts and clays) typically have the lowest resistivities and thus the greatest corrosion susceptibility.

The distribution and type of soils within the Agency's service areas were digitized from Department of Agriculture Soil Conservation Service (SCS) county soil report. Soils are generally sampled only to a depth of 5 to 6 feet (most pipelines are buried within this zone); therefore, soil descriptions are limited to that depth and may not be representative of deeper soil conditions. Soil surveys typically generalize soil properties and thus soil corrosivity estimates likely are conservative. In the SCS report, soil unit codes were referenced to the shrink-swell and corrosivity engineering properties and the corrosion potential as Low, Medium, or High. Corrosivity values compiled from SCS soil surveys, although unitless, are calculated by the SCS based on the rate uncoated steel and concrete might corrode when buried in a soil. These index values are derived from soil texture, drainage, acidity, and electrical conductivity data. Both sets of values are depicted in the soil corrosion maps for the Agency's service area as shown in Figure 14 and Figure 15. **The figures show that except for the Sonoma aqueduct, which has a limited exposure to corrosive soils, all of the Agency's aqueducts lie in highly corrosive soils. The Agency has an active corrosion control program, and as a result there are no indications of prevalent corrosion related damage to the transmission system. The Agency's corrosion control program consists of maintaining cathodic protection systems on all of its aqueducts. These systems employ either impressed current or sacrificial anodes. The Agency has an anode testing program that ensures that anodes are replaced as they**

**are consumed by the system. No mitigation measures were identified in the planning process due to the Agency's on-going maintenance program.**

## 3.4 FIRE HAZARD

Fire is relevant to the Agency's system from two perspectives: (a) potential damage that fires may directly cause to the Agency's facilities, and (b) fire fighting demands on the Agency's system – that is, the emergency water supply needs of fire departments who may be relying on the Agency to supply that water. Both aspects are driven by the fire hazard in Sonoma County.

Periodic fires are part of the natural environment and consist of four categories that include wildland fires, urban-wildland interface fires, firestorms and prescribed fires. Wildfires are fueled by naturally occurring trees, brush and grasses; the urban-wildland interface fires are fueled by vegetation and built environment; firestorms occur during extreme weather and generally burn until conditions change or the available fuel is exhausted and; prescribed fires are controlled burns intentionally set for fire management.

The behavior of wildfires is impacted by three principal factors that include topography, fuel and weather. Topography is important because the movement of air over the terrain tends to direct a fire's course and gulches and canyons can funnel air and act as a chimney. Saddles and ridgetops tend to offer lower resistance to the passage of air and will draw fires. Water tanks, which are usually located on ridgetops are, therefore, susceptible to fire with south facing slopes being more susceptible because they receive higher solar radiation. Steeper uphill slopes tend to increase the rate of spread, whereas downhill slopes tend to slow down the rate of spread.

Fuel for fires is provided by the amount of vegetative material available. Different fuels have different burn qualities. For example grasses, release little energy but can sustain very high rates of spread. Moisture and continuity of fuel is also very important for the spread of fire.

Figure 16 shows the fire threat map in Sonoma County prepared by the California Department of Forestry. The map shows five threat classes that range from no threat to extreme threat. The figure shows that most of the Agency's water system is in an area of low fire hazard except for the facilities in the Wohler and Mirabel area. The figure also shows a high fire threat near the Annadel No. 2 tank. However, a more detail examination during the site reconnaissance confirmed a low fire hazard because of a clearing zone around the facilities. The Agency has an active maintenance program to address such issues. Furthermore, since the Agency is a wholesaler it does not have direct responsibility for fire fighting.

Table 3 shows some of the major fires in Sonoma County that burned over 1,000 acres.  The burn area of these fires is shown in Figure 17.  The figure shows that none of these historic fires have impacted the Agency's service area.

**Table 3**
**Major Historic Fires in Sonoma County**

| Date | Location | Acres Burned |
|---|---|---|
| Sep-64 | Series: Hanly, Mt. George, Nunns Canyon in Napa and Sonoma County | 71,500 |
| | Hanly (Sonoma County) | 52,700 |
| | Nunns Canyon (Sonoma County) | 10,400 |
| 1965 | Series of nine fires in Glenn, Napa and Sonoma County | 113,766 |
| | Knight's Valley (Sonoma County) | 6,000 |
| | Pocket Ranch (Sonoma County) | 4,000 |
| | Arrowhead (Sonoma County) | 4,000 |
| | Chileno Valley (Sonoma County) | 5,000 |
| | Pressley (Sonoma County) | 5,500 |
| | Coleman Valley (Sonoma County) | 1,500 |
| | Austin Creek (Sonoma County) | 7,000 |
| 1972 | Bradford | 1,760 |
| Aug-78 | Creighton Ridge | 11,405 |
| Aug-88 | Cloverdale | 1,833 |
| Sep-88 | Geysers | 9,000 |
| Aug-96 | Cavedale | 2,100 |
| Oct-99 | Geyser Road | 1,300 |
| Jun-00 | Berryessa (Napa and Sonoma) | 5,731 |
| Sep-04 | Geysers (Sonoma and Lake) | 12,525 |

Because of the wholesale nature of the Agency's transmission system, the Agency does not have a direct responsibility to provide fire water, except for a very limited number of fire hydrants located along the Agency's aqueducts.

## 3.5 DROUGHT

Unlike typical natural disasters such as earthquakes, floods or fires, drought occurs gradually over a multi-year period. One dry year does not normally constitute a drought in California. For example the driest single year of California's measured hydrologic record was 1977. California's most recent multi-year statewide drought was 1987-1992.[40, 41] The Agency's extensive system of water supply infrastructure -- its reservoirs, groundwater basins, and inter-regional conveyance facilities -- mitigates the effect of short-term dry periods for most water users in its service area.

Defining when a drought begins is a function of drought impacts to water users and therefore, there is no universal definition of when a drought begins or ends. Impacts of drought are typically felt first by those most reliant on annual rainfall -- ranchers engaged in dryland grazing, rural residents relying on wells in low-yield rock formations, or small water systems lacking a reliable source. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline.

The historical record of California hydrology is brief in comparison to the time period of geologically modern climatic conditions. As a result, measured hydrologic data for droughts prior to 1900 are minimal. Multi-year dry periods in the second half of the 19th century can be qualitatively identified from the limited records available combined with historical accounts but the severity of the dry periods cannot be directly quantified. Paleoclimatology data based on tree ring studies suggest sustained drought throughout much of the continental U.S. during the mid-1500s that may have lasted as long as 50 years. In addition, some climate researchers describe a "Medieval Megadrought" to describe a series of long duration droughts in the Western U.S. during the 900 to 1400 A.D. time period. Researchers identified two epic drought periods from these remains, one lasting more than two centuries prior to A.D. 1112, and the other lasting more than 140 years prior to 1350.

Droughts, in California within the recorded history, that span over several years include: 1912-1913, 1918-1920, 1923-1924, 1929-1934, 1947-1950, 1959-1961, 1976-1977, and 1987-1992. The criteria commonly used in designing storage capacity and yield of large Northern California reservoirs was established as a result of the 1929-1934 drought. The 1987-1992 drought was notable for its six-year duration and the statewide nature of its impacts. However, droughts exceeding three years are relatively rare in Northern California, the source of much of California's developed water supply.

In the 1987-1992 drought, water users served by most of the State's larger suppliers did not begin to experience shortages until the third or fourth years of the drought. Reservoir storage provided a buffer against drought impacts during the initial years of the drought. During this time period groundwater extraction increased substantially and wells or springs serving several small water systems in the Russian River corridor went dry such that water haulage became necessary.

Droughts can have a significant impact on society that can include lost jobs and revenues in the landscaping and nursery industries, unemployment and other socioeconomic impacts in farming dependent regions, increased risk of wildfire, additional cost for homeowners to replace lawns and landscaping, loss of forests, decline in fish population, lost revenues to water based recreation businesses and reduced hydroelectric power generation. Droughts result in a decline of revenues and an increase in operational costs for water agencies. The former occurs due to voluntary or mandatory reductions in water use and the later due to additional cost of purchasing water, deepening wells, or implementing water education and conservation campaigns.

It is not easy to predict droughts because climate is inherently variable and predicting drought depends on the ability to forecast two fundamental meteorological surface parameters, precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades and how long they last depends on many factors such as air–sea interactions, soil moisture and land surface processes. Generally, the immediate cause of drought is the predominant sinking motion of air (subsidence) that results in compressional warming or high pressure, which inhibits cloud formation and results in lower relative humidity and less precipitation. Much of California enjoys a Mediterranean-like climate with cool, wet winters and warm, dry summers. An atmospheric high pressure belt results in fair weather for much of the year, with little precipitation during the summer. The high pressure belt shifts southward during the winter, placing the State under the influence of Pacific storms bringing rain and snow. Most of California's moisture originates in the Pacific Ocean. As moisture-laden air moves over mountain barriers such as the Sierra Nevada, the air is lifted and cooled, dropping rain or snow on the western slopes. This orographic precipitation is important for the State's water supply. The majority of California's groundwater production occurs from alluvial materials in the large basins. Groundwater levels in such basins typically decline during droughts due to increased extractions.

The fundamental drought impact to water agencies is a reduction in available water supplies. As a result, historic occurrences of drought have encouraged water agencies to review the reliability of their water supplies and to initiate planning programs addressing identified needs for improvement. In addition, public and media interest in droughts fosters heightened awareness of water supply reliability issues in the Legislature. More than 50 drought-related legislative proposals were introduced during the severe, but brief 1976-77 drought. About one-third of these eventually became law. Similar activity on drought-related legislative proposals was observed during the 1987-92 drought. One of the most significant pieces of legislation was the 1991 amendment to the Urban Water Management and Planning Act, in effect since 1983, which requires water suppliers to estimate available water supplies at the end of one, two, and three years, and to develop contingency plans for shortages of up to 50 percent. The Sonoma County Water Agency's 2005 Urban Water Management Plan (SCWA, 2006) presents water supply to demand comparisons through 2030. The plan also presents water supply to demand comparisons for single dry to multiple dry year scenarios. The comparisons show that the Agency has adequate supply through 2030. For dry years, water demands exceed supply starting in 2020 but the Agency has developed plans to work with its contractors to reduce demands.

## 3.6 OTHER HAZARDS

Table 4 shows major weather related events in Sonoma County. Description for some of the most significant weather related hazards is provided in the following sections.

**Table 4**
**Historic Weather Related Hazards in Sonoma County**

| Hazard | Date | Time | Magnitude | Deaths | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|---|
| Blowing Dust | November 2, 1994 | 5:21 AM | N/A | 0 | 0 | 0 | 0 |
| | November 10, 1994 | 10:43 PM | N/A | 0 | 0 | 0 | 0 |
| Dense Fog | December 2, 1994 | 11:22 AM | N/A | 0 | 0 | 0 | 0 |
| | December 3, 1994 | 1:20 PM | N/A | 0 | 0 | 0 | 0 |
| | December 8, 1994 | 12:45 PM | N/A | 0 | 0 | 0 | 0 |
| | December 9, 1994 | 5:04 PM | N/A | 0 | 0 | 0 | 0 |
| | December 10, 1994 | 6:18 AM | N/A | 0 | 0 | 0 | 0 |
| Excessive Heat | August 15, 1996 | 4:00 PM | N/A | 4 | 0 | 0 | 0 |
| | June 14, 2000 | 12:00 PM | N/A | 9 | 102 | 0 | 0 |
| Flash Flood | February 4, 1996 | 10:00 AM | N/A | 0 | 0 | 0 | 0 |
| | February 2, 1998 | 6:50 PM | N/A | 0 | 0 | $2.0M | 0 |
| | February 3, 1998 | 4:00 AM | N/A | 0 | 0 | $5.0M | 0 |
| | February 3, 1998 | 9:30 AM | N/A | 0 | 1 | $200K | $159K |
| | February 5, 1998 | 6:00 PM | N/A | 0 | 0 | 0 | 0 |
| | February 6, 1998 | 12:22 PM | N/A | 0 | 0 | 0 | 0 |
| | February 7, 1998 | 1:18 PM | N/A | 0 | 0 | 0 | 0 |
| | February 13, 2000 | 9:00 PM | N/A | 0 | 0 | 0 | 0 |
| | January 20, 1993 | 7:15 AM | N/A | 0 | 0 | $500K | 0 |
| | March 9, 1995 | 10:34 AM | N/A | 0 | 0 | $3.5M | $0.5M |
| | December 31, 1996 | 7:00 PM | N/A | 1 | 0 | 0 | 0 |
| | January 3, 1997 | 8:00 PM | N/A | 1 | 0 | 0 | 0 |
| | February 13, 2000 | 10:00 AM | N/A | 0 | 0 | 0 | 0 |
| | January 11, 2001 | 10:00 AM | N/A | 0 | 0 | $7.0M | 0 |
| | December 16, 2002 | 2:00 AM | N/A | 0 | 0 | 0 | 0 |
| Hail | December 9, 2003 | 11:15 PM | 0.75 in. | 0 | 0 | 0 | 0 |
| Heavy Rain | December 12, 1995 | 2:45 AM | N/A | 0 | 0 | 0 | 0 |
| | December 29, 1996 | 12:00 AM | N/A | 0 | 0 | 0 | 0 |
| | January 2, 1998 | 4:00 AM | N/A | 0 | 1 | 0 | 0 |
| | January 1, 2002 | 3:00 AM | N/A | 0 | 0 | $200K | 0 |
| | December 15, 2002 | 8:00 PM | N/A | 0 | 0 | 0 | 0 |
| Heavy Snow | February 11, 2001 | 8:00 AM | N/A | 0 | 0 | 0 | 0 |
| High Wind | July 16, 1996 | 3:30 PM | 35 kts. | 1 | 0 | 0 | 0 |
| | November 29, 1998 | 10:00 PM | 75 kts. | 0 | 0 | $1.8M | 0 |
| | February 9, 1999 | 11:00 AM | 60 kts. | 0 | 0 | $1.0M | 0 |
| | April 3, 1999 | 8:00 AM | 85 kts. | 1 | 2 | 0 | 0 |
| | February 13, 2000 | 10:00 AM | 0 kts. | 0 | 0 | $250K | 0 |
| | March 19, 2000 | 3:10 PM | 72 kts. | 0 | 0 | $250K | 0 |
| | October 21, 2000 | 9:45 PM | 97 kts. | 0 | 1 | 0 | 0 |
| | March 4, 2001 | 10:54 AM | 71 kts. | 0 | 0 | $2.7M | 0 |
| | November 24, 2001 | 7:00 AM | 85 kts. | 0 | 0 | $7.1M | 0 |
| | November 7, 2002 | 4:00 PM | 100 kts. | 0 | 0 | $1.0M | 0 |
| | December 30, 2002 | 11:21 PM | 63 kts. | 0 | 0 | $600K | 0 |
| | December 14, 2003 | 4:33 AM | 61 kts. | 0 | 0 | 0 | 0 |
| | February 25, 2004 | 8:29 AM | 58 kts. | 0 | 0 | 0 | 0 |
| | February 4, 1993 | 9:00 PM | 0 kts. | 0 | 0 | $500K | 0 |
| Lightining | January 25, 2001 | 12:00 PM | N/A | 0 | 1 | $1.0M | 0 |
| Storm Surge | February 25, 2004 | 10:00 AM | N/A | 0 | 0 | 0 | 0 |
| Tornado | June 1, 1958 | 7:55 AM | F2 | 0 | 0 | $25K | 0 |
| | February 17, 1959 | 6:45 AM | F | 0 | 0 | $3K | 0 |
| | November 10, 1964 | 3:34 AM | F | 0 | 0 | $3K | 0 |
| | February 27, 1983 | 7:20 AM | F1 | 0 | 0 | $25K | 0 |
| | December 2, 1992 | 5:00 PM | F1 | 0 | 0 | $25K | 0 |
| | December 2, 1992 | 5:00 PM | F1 | 0 | 0 | $25K | 0 |
| | December 2, 1992 | 5:00 PM | F1 | 0 | 0 | $250K | 0 |
| | February 22, 1996 | 1:00 AM | F1 | 0 | 0 | 0 | 0 |
| | December 23, 1996 | 11:30 AM | F0 | 0 | 1 | $1K | 1K |
| | December 5, 1998 | 6:20 PM | F1 | 0 | 0 | $1.0M | 0 |
| Winter Storm | February 16, 1994 | 8:00 PM | N/A | 0 | 0 | $500K | 0 |
| | December 9, 1995 | 10:00 AM | N/A | 1 | 15 | $60.0M | 5.0M |
| | March 10, 1995 | 5:09 AM | N/A | 0 | 0 | 0 | 0 |

### 3.6.1 Tornadoes

While California does have tornadoes, it is relatively low-risk compared to states in the Midwestern and Southern United States as shown in Figure 18.[42]

Since 1950, 292 tornadoes have occurred in 42 counties in California, resulting in 103 injuries. However, no deaths have occurred, and none of the California tornadoes since 1950 have been over F2 on the Fujita Scale (see Table 5). Of these 292 tornadoes, only eight percent reached F2, whereas 53 percent were at F0, the least severe type and 39 percent reached F1. No major tornadoes (those of F3-F6) have occurred after 1880 in California. The biggest risks of tornadoes in California include light to moderate damage to homes, destruction of mobile homes, and injuries caused by light object projectiles during F2 scale tornadoes. In the 52 years between 1950 and 2002, the average occurrence of an F2 scale tornado has been approximately once every 2.36 years.[43]

**Table 5**
**Fujita Scale for Tornado Intensity**

| Scale Value | Wind Speed Range and Description of Damage |
|---|---|
| F0 | **40-72 mph (17.8-32.6 m/s)**: Light damage. Some damage to chimneys; tree brances broken off; shallow-rooted trees pushed over; sign boards damaged. Average number per year, 1953-1989: 218 (29 percent). |
| F1 | **73-112 mph (32.7-50.3 m/s)**: Moderate damage. The lower limit is the beginning of hurricane wind speed. Roof surfaces peeled off; mobile homes pushed off foundation or overturned; moving autos pushed off road. Average number per year, 1953-1989: 301 (40 percent). |
| F2 | **113-157 mph (50.4-70.3 m/s)**: Considerable damage. Roof torn out from houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated. Average number per year, 1953-1989: 175 (23 percent). |
| F3 | **158-206 mph (70.4-91.9 m/s)**: Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown. Average number per year, 1953-1989: 43 (6 percent). |
| F4 | **207-260 mph (92.0-116.6 m/s)**: Devastating damage. Well constructed houses leveled; structures with weak foundations blown off some distance; cars thrown; large missiles generated. Average number per year, 1953-1989: 10 (1 percent). |
| F5 | **261-318 mph (116.7-142.5 m/s)**: Incredible damage. Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 yards; trees debarked. Average number per year, 1953-1989: 1 (0.002 percent). |
| | * Wind speeds in the range are defined by Fujita to be "the fastest 1/4-mile wind" |

**Source: Golden and Snow, "1991: NOAA, NWS Disaster Survey Report", 1991**

### 3.6.2 Hurricanes and Other Weather Related Hazards

California is also at very low risk of hurricanes, although it is possible for one to threaten the southern California coast.[44] No hurricanes have hit California in recorded history because tropical storm winds generally blow from east to west, however, the State is affected by heavy rain resulting from tropical winds that blow north from Mexico and become colder by the time they hit California.[45]

**Risk to the Agency's facilities from tornadoes or a hurricane is low compared to earthquakes and flood because any damage will be localized and not likely to be system wide. Therefore, it would be possible to respond in a timely manner to repair the damage with small downtime. The most vulnerable system components to tornados, hurricanes, high wind and lightning strike will be the power and SCADA systems. The Agency has the ability to operate its system from three locations that include the College Avenue facility, the Sonoma Valley County Sanitation District (SVCSD) reclamation plant and the Russian River County Sanitation District (RRCSD) treatment facility. In the event the College Avenue facility is nonfunctional, radio communications to the other two locations most likely cannot be maintained. The Agency is currently in the early planning stages of setting up a mobile command center for their SCADA system.**

## 3.7 HAZARDS SUMMARY

Table 6 provides a hazards summary for the Sonoma County Water Agency.

**Table 6**
**Hazards Summary for Sonoma County Water Agency**

| Hazards | History | Frequency | Probability | Impact | Comments |
|---|---|---|---|---|---|
| ***Natural Hazards*** | | | | | |
| Avalanche | No | Low | Low | No | Snow uncommon |
| Coastal Erosion | Yes | Low | Low | No | No infrastructure near coast |
| Coastal Storm | Yes | Low | Low | No | No infrastructure near coast |
| Corrosive Soils | Yes | Medium | Medium | Yes | Active corrosion control program |
| Dense Fog | Yes | Low | Low | Low | Limited impact |
| Earthquake | Yes | Low | High | High | Included in the plan |
| Expansive Soils | No | Low | Low | Low | Uncommon in Sonoma County |
| Extreme Heat | Yes | Low | Low | Low | Short duration event |
| Flood | Yes | High | High | High | Included in the plan |
| Hailstorm | Yes | Low | Low | Low | Limited impact |
| Hurricane | No | Low | Low | Low | Limited impact |
| Land Subsidence | Yes | Low | Low | High | Part of earthquake hazard |
| Landslide | Yes | Medium | Medium | Low | Facilities located outside of hazard area |
| Severe Winter Storm | Yes | Medium | Medium | High | Included in the plan as part of flood |
| Tornado | Yes | Low | Low | Low | Low hazard, limited impact |
| Tsunami | No | Low | Low | Low | Facilities located outside of hazard area |
| Volcano | No | Low | Low | Low | No active volcanoes |
| Wildfire | Yes | High | High | Low | Facilities located outside of hazard area |
| Windstorm | Yes | Low | Low | Low | Limited impact |
| ***Agricultural Hazards*** | | | | | |
| Drought | Yes | Low | Low | Med. | Part of urban water management plan |
| Freeze | Yes | Low | Low | Low | Limited impact |
| Pest | Yes | Low | Low | Low | No impact to the Agency |
| Salmon Fishing | Yes | Low | Low | Low | Private sector economic loss |
| ***Technological Hazards*** | | | | | |
| Dam Failure | No | Low | Low | Med. | Included in plan |
| Power Failure | Yes | Low | Low | Low | Emergency power at critical locations |
| Hazardous Material Release | Yes | Medium | Low | Med. | Emergency plans in place |
| Pandemic Influenza | Yes | Low | Unknown | Low | Public health issue |
| Radiological | No | Low | Low | Low | Limited impact |
| Terrorism/Bioterrorism | No | Low | Unknown | Unk. | SVA study performed |

# 4.0 VULNERABILITY ASSESSMENT

Damage to water supply and wastewater collection systems following a major disaster, especially an earthquake, can lead to significant disruption. This is based on observations from several recent earthquakes such as the 1989 Loma Prieta earthquake, the 1994 Northridge earthquake and the 1995 Kobe, Japan earthquake. In Kobe water pipelines sustained severe damage with numerous breaks that resulted in lack of service in several communities. Approximately 29,000 people were without water supply for a month following the earthquake[46]. Over 100 fires broke out within minutes after the earthquake. Water for firefighting was available for only 2 to 3 hours, and subsequently water was available from tanker trucks only. For several days after the earthquake there were long lines of people waiting for water and food. Similarly there was significant disruption of water service following the Northridge earthquake. There was damage at 15 locations in the three transmission system pipelines that bring water from Northern California, at 74 locations in large diameter trunk lines and 1,013 locations in the Los Angeles Department of Water and Power's (LADWP) distribution pipeline network including damage to tanks and other facilities. Water system damage was distributed over approximately 1,200 square kilometers.[47]

During the 1989 Loma Prieta earthquake 20 million gallons of raw sewage were reportedly dumped into the Oakland Estuary in a six hour period following the earthquake. Damage to sewage treatment facilities during the 1994 Kobe and the 2004 Chuetsu, Japan earthquakes resulted in release of polluted water to flow directly into public bodies of water. Damage resulted from the lifting of pipes and manholes in zones of liquefaction. Damage to sewage systems can also create a public health hazard, for through backing up of sewage in homes and uncontrolled release of untreated water.

## 4.1 WATER SUPPLY

A vulnerability assessment of the Agency's water supply facilities was performed through a review of available drawings, site reconnaissance and as needed engineering calculations (ranging from simplified to detailed). The Agency's water transmission system is shown in Figures 1 and 1a with the most credible hazards overlain shown in Figures 7 through 18. A review of the overall system shows that portions of the system lack redundancy and a single pipe break or loss of a single component such as a key pump station can result in significant disruption. The portions of the system that are especially vulnerable are those that serve the Sonoma Valley and the Cotati area. The sections below describe the significant vulnerabilities associated with the identified hazards.

### 4.1.1 Russian River System

The primary source of water for the Agency's water system is the Russian River that feeds an aquifer beneath and adjacent to the river through the overlying gravel by natural filtration. The most significant vulnerabilities associated with the river consist of possible contamination and increase in turbidity associated with major floods, wildfires, debris flow and landslides. A hazardous material spill from an accident can also result in possible contamination. The effect of such contamination can be minimized, depending upon its extent, by releasing water from the upstream dams and flushing the contaminants. The Agency's emergency operations plan addresses such events. During a major earthquake there could be a loss of permeability of the aquifer due to liquefaction or dynamic densification of the gravel that can result in compression or dilation of the aquifer. Significant loss of production capacity during a short time following a major earthquake can occur, but generally the aquifers tend to recover after a period of time. Such changes have been observed in past earthquakes.

The Agency's Warm Springs and Coyote Valley dams are located within close proximity of major active faults. The dams were constructed in 1982 and 1959, respectively. The Warm Springs dam is located 4 kilometers from the Healdsburg fault, a northward extension of the Rodgers Creek fault, and 10 kilometers from the Maacama, 23 kilometers from the Hayward and 29 kilometers from the San Andreas Fault. The Coyote Valley dam is located 1.4 kilometers from the Maacama fault, and more than 50 kilometers from the San Andreas, Rodgers Creek and Healdsburg faults. Both dams are part of the flood control system, and the US Army Corps of Engineers is responsible for dam safety. As reported by the Army Corps, the safety assessment of both dams and appurtenant structures to account for the most recent information on seismic and flood conditions are currently overdue.

### 4.1.2 Diversion Facilities

The components of the Agency's system that facilitate the diversion of water from the source (the Russian River aquifer) to the transmission system are referred to as the diversion facilities. The diversion facilities can be grouped into those that draw water from the aquifer and those that help recharge it. The former include the six collector wells and the Mirabel well field, while the latter include the inflatable dam, the RDS (river diversion system) caisson, infiltration ponds, diversion channels and the main dike.

The earliest of the six collector wells were built in 1958 and the latest in 2005. The general construction of the collector well includes a large diameter (ranging from 13 to 18 feet inside diameter and 18 to 33 inch thick walls) concrete caisson that extends from the ground surface into the aquifer. The caissons range in length from about 108 feet to 123 feet. At the bottom of each caisson, perforated pipes (known as laterals) extend radially into the aquifer. Each lateral is over a 100 feet long and ranges in size from 8 to 10 inch diameter for the older five collectors and 12 to 18 inches for the newest sixth collector. Each caisson supports a pump house with two pumps that draw water collected inside the caisson. All of the supporting electrical and communication systems to operate the pumps remotely are located in the pump house.

The pump houses of each collector well are located well above the maximum flood levels and have a low likelihood of direct damage from flood or debris impact. The diversion system facilities are located in an area of very high liquefaction hazard and because of the proximity to a free face of the river bank the collectors are also subject to a very high lateral spread hazard. **Structural assessment of the collector wells and the RDS show that three of the six collectors and the RDS have a high likelihood of sustaining major damage**. Strong earthquake shaking can also cause damage to the electrical and communication equipment that is not adequately anchored.

Other diversion system facilities such as the inflatable dam, the diversion dike, ditches and the infiltration ponds are also located in an area of high liquefaction and flood hazard. Recently portions of the dike were severely damaged due to overtopping of flood waters. The seven conventional wells of the Mirabel well field are susceptible to flood related debris impact. The overall water quality during floods and wild fires is also a concern.

### 4.1.3 Aqueducts

The SCWA transmission system consists of 85 miles of aqueducts (pipelines) ranging in size from 16 inches to 54 inches. The system transports water from the Russian River diversion facilities, located in the Wohler-Mirabel area, southwards and eastwards to the Agency's service area. The transmission system consists of 11 pipeline segments that include the Russian River Cotati Intertie, the Santa Rosa Aqueduct, the Sonoma Aqueduct, the Petaluma Aqueduct, the Oakmont Pipeline, the Wohler-Forestville Pipeline, the Wohler-Mirabel Intertie, the Kawana Pipeline, the North Marin Aqueduct, the Collector 6 Pipeline and the Eldridge-Madarone Pipeline. The configuration of the Agency's entire transmission system is shown in Figure 1.

The water transmission system is distributed over a large geographical area and traverses zones of varying geology and topography, and is subject to a range of natural hazards. The system was built incrementally over a period of several decades (ranging from 1959 to 2003) and under a range of evolving design standards and construction techniques. Pipeline construction consists of predominantly mortar lined and coated steel pipe and some pre-stressed concrete cylinder pipe. Typical joint types consist of gasket joints, welded bell-and-spigot joints, and welded buttstrap joints. Most river and stream crossings include concrete encasement over some or most of the pipeline between the banks of the river or stream.

Major hazards to the pipeline system include earthquakes, floods and landslides, with the earthquakes and earthquake induced hazards such as liquefaction, surface fault rupture, lateral spread and strong ground shaking being the most significant.

In general, buried pipelines, such as the SCWA's aqueducts, are designed for internal pressure with limited consideration to large relative displacements of ground along its length. Such pipelines are typically designed with bell and spigot type connections (also known as segmented pipelines) and do not perform well when subjected to ground failure resulting from earthquakes, floods and landslides. In the 1964 Anchorage, Alaska earthquake more than 100 water pipe breaks were reported. In 1971 San Fernando earthquake, the City of San Fernando temporarily lost water, gas and sewage services due to liquefaction induced lateral spreading along the eastern and western shores of Upper Van Norman reservoir. For relatively small ground displacements associated with earthquake ground shaking, the pipelines perform reasonably well with certain amounts of random damage that can usually be handled as part of emergency repairs following an earthquake.

The Agency's pipelines cross many locations where they may be subjected to ground deformation. The most obvious location is the Rodgers Creek fault crossing of the Santa Rosa aqueduct. Surface fault rupture displacement of several feet is expected during a major earthquake on the fault, which the pipeline is not designed for. In addition, the Agency's Sonoma aqueduct and the Oakmont pipelines cross the Bennett Valley fault and will likely fail in a surface rupturing event on this fault. Other vulnerable locations include the Russian River crossing of the Russian River Cotati intertie and multiple stream crossings as shown in Figure xx. Depending upon the geometry of the stream bank and the potential for liquefaction, these locations could have large lateral spread displacements and consequently the pipelines may fail. The Sonoma aqueduct is also vulnerable to damage from debris impact in a high flood scenario at three locations where the pipeline is suspended from bridges across creeks.

### 4.1.4 Storage Facilities

The Agency has a total of 17 flat bottom steel tanks located at eight independent sites. Out of the 17 tanks, seven are anchored while the other 10 are unanchored. The tanks range in size from 0.3 M.G. to 18 M.G. Most of the tanks have overconstrained piping connections that are potentially vulnerable to damage in an earthquake. Such piping connections consist of the pipe that is rigidly attached to the tank shell and restrained by burial near the tank or connection to an adjacent nearby tank. As a result, the piping is unable to accommodate movement of the tank as it tries to uplift due to seismic overturning moments. Most of the Agency's tanks also have bottom penetrating inlet/outlet and drain piping. Typically, the steel tank base plate is relatively thin (typical thickness of ¼ inch) and is vulnerable to tearing if tank uplift occurs at the bottom penetration piping connection. The Agency is currently in the process of mitigating most of these vulnerabilities.

### 4.1.5 Booster Pump Facilities

The Agency has eight booster stations. Five of the pump stations are single-story buildings while the other three are open to air. The most significant vulnerabilities include potential damage to the pump station building and electrical control cabinets. Minor to moderate damage to the pump station building may not necessarily be a significant hazard since the buildings are not manned. However, major damage or collapse of the building can result in associated damage to the pump motor or motor control centers (MCC) by falling debris. A building that is significantly damaged may also prevent or delay any required manual reset of pump controls thereby impeding system operations. In terms of the potential for major collapse, the most vulnerable pump stations are the Sonoma Booster Station because the pump stations are situated within the fault deformation zone of the Bennett Valley fault.

### 4.1.6 Treatment Facilities

The Russian River aquifer water is naturally filtered and does not require treatment. However, to maintain regulatory levels of residual chlorine in the transmission system, the Agency has three chlorination facilities. Two of the three chlorination facilities are also corrosion control facilities to chemically treat the water's pH to minimize the potential for corrosion. The three facilities include the Wohler chlorination and corrosion control facility located at the Agency's corporation yard on Wohler Road, the Mirabel chlorination facility located near the Mirabel collectors and the River Road chlorination and corrosion control facility located on River Road. The River Road facility is currently used only for corrosion control.

The Mirabel and the Wohler facilities are single story reinforced masonry buildings that generally perform adequately in an earthquake provided the buildings have adequate roof to wall connections. The River Road facility is a two story masonry building with a soft first story and has been retrofitted by the addition of braces at some of the open bays at the first floor. Typically buildings with soft first story perform poorly in earthquakes with excessive damage. The extent of potential damage to this building will depend upon the adequacy of the retrofit scheme. The most significant hazard at the treatment facilities is the potential for a chlorine release or damage to the contents and non-structural elements.

### 4.1.7 Supplementary Water Sources

In addition to the main water source, the Russian River aquifer, the Agency has supplementary sources in three conventional wells located in the Santa Rosa Plain area. The three wells known as the Occidental Road Well, the Sebastopol Road Well and the Todd Road Well collectively provide a sustained flow of about 7 mgd. Two of the three wells are located in FEMA flood zone with the third located close to the boundary of the flood zone. Flooding at the site can significantly impact water quality and cause damage to the well infrastructure in terms of electric short circuiting due to inundation and direct physical damage due to debris impact. All of the wells are located in medium to low liquefaction hazard areas. The most significant hazard from an earthquake viewpoint is the damage to the above ground infrastructure, communication and electrical control systems from strong ground shaking.

### 4.1.8 Emergency Power

The Agency's facilities receive power from PWRPA and PG&E including power to the Agency owned substation at Wohler. This substation is a key component of the power network for the Wohler and Mirabel collectors. Emergency power to all feeders in the substation is provided by three 2000kW diesel generators, located near the Wohler Chlorination Building. The generators require manual start and can run for approximately 2.5 days before re-fuelling. Fuel for the generators is provided by a 25000 gal diesel tank located onsite. In addition, two 1250kW diesel generators are located near the Mirabel chlorination building. Fuel to these generators is provided by 10,000 and 25000-gal fuel tanks located onsite. These generators can run for approximately 5 days without re-fuelling. When all five generators are run at full power, nine out of ten pumps at the collectors (excluding new Collector #6) can be operated simultaneously.

The chlorination facilities also have emergency generators for operating the chlorine sensors and scrubber systems. Emergency power to two of the eight booster stations is provided by generators located at the Sonoma Booster Station and the Ely Booster Station site. The Agency also has a series of uninterruptible power supply (UPS) units located at essentially all of their facilities to operate the communication and SCADA systems for a period of three to four hours after a major power loss.

## 4.2 SANITATION

Independent vulnerability assessment of Agency's sanitation facilities has not yet been performed. Considering that these facilities are located in the same geographical region as the water system facilities, they are also subject to the same types of hazards with similar types of vulnerabilities. Figures 19 through 27 show the sanitation facilities overlain on maps of significant hazards in Sonoma County. A general overview of the sanitation system vulnerabilities is as follows:

- Treatment facilities and lift stations within the Sea Ranch Sanitation Zone are located in close proximity to the San Andreas Fault (Figure 19) and are subject to strong ground shaking hazard with PGA exceeding 0.5g (Figure 20).

- The lift station for the Airport/Larkfield/Wikiup is located adjacent to the Rodgers Creek fault (Figure 19) and is subject to strong ground shaking hazard with PGA exceeding 0.6g (Figure 20).

- Sanitation facilities not in immediate proximity to the San Andreas or Rodgers Creek fault are still located close enough to be subject to signification ground shaking with PGA exceeding 0.4g.

- Figure 21 shows the liquefaction and lateral spread hazard for the sanitation facilities. Facilities of the Geyserville Sanitation Zone, the treatment plant for the Russian River Sanitation District and portions of the Sonoma Valley Sanitation District are located in high to very high liquefaction zones. A significant number of the Agency's sanitation facilities are located in medium liquefaction zones with some in zones of low liquefaction hazard. Pipelines, especially the pipeline connections to fixed facilities, are most vulnerable to damage within zones of potential liquefaction hazard.

- Most of the Agency's facilities are located outside the landslide hazard zone, with some facilities, for example, lift stations of the Occidental County Sanitation Zone and the Airport/Larkfield/Wikiup Sanitation Zone and treatment plants for the Occidental County Sanitation Zone and the Russian River County Sanitation Zone are located in areas of potential landslide hazard (Figure 22).

- Figure 23 shows that the potential for flooding hazard is high at the Geyservile Sanitation Zone, Russian River County Sanitation District, and the Forestville County Sanitation District.

- Figure 24 shows that the debris flow hazard at the sanitation facilities is relatively low.

- Figures 24 and 25 show that several facilities are located in areas that have corrosive soils, however, based on discussions with the Agency corrosion is not a predominant hazard.

- Facilities at the Sea Ranch Sanitation Zone, Occidental County Sanitation District, Russian River County Sanitation District and the Airport/Larkfield/Wikiup Sanitation Zone are located in areas of high fire hazard (Figure 26), with some of the facilities of the Russian River County Sanitation District and the Airport/Larkfield/Wikiup located close to the boundary of historic fire zones.

- The Airport/Larkfield.Wikiup Sanitation Zone and the Sonomy Valley Sanitation District have wastewater treatment ponds with high embankments (California Division of Safety of Dams (DSOD), jurisdictional embankments) that could be subjected to high liquefaction and ground shaking hazard and therefore, require detailed vulnerability assessment.

A detailed multi-hazard reliability assessment of Agency's sanitation facilities is a primary goal in this five year hazard mitigation plan. It is anticipated that mitigation of vulnerabilities identified during this cycle of the plan will be included in the next five year cycle.

## 4.3 FLOOD PROTECTION

Independent vulnerability assessment of Agency's flood protection facilities has not yet been performed. Considering that these facilities are located in the same geographical region as the water system facilities, they are also subject to the same types of hazards with similar types of vulnerabilities. A detailed multi-hazard reliability assessment of Agency's flood protection facilities is a primary goal in this five year hazard mitigation plan. However, while the Agency is responsible for the management of the large reservoirs (Lake Sonoma and Lake Mendocino), the primary responsibility of the reliability of major components of the infrastructure is with the U.S. Army Corps of Engineers. During this plan cycle the Agency will work with the Corps to develop a plan to address the identified vulnerabilities in the future cycles of this plan. The Agency is responsible for the reliability of reservoirs associated with the Central Sonoma Watershed Project.

## 4.4 ADMINISTRATIVE INFRASTRUCTURE

Independent vulnerability assessment of Agency's administrative infrastructure has not yet been performed. A detailed vulnerability assessment of Agency's office facilities is a primary goal in this five year hazard mitigation plan. Upgrade of the identified vulnerabilities will be included in the future cycles of this plan.

# 5.0 MITIGATION GOALS, OBJECTIVES AND ACTIONS

Sonoma County Water Agency is directly responsible for providing water to over 600,000 people in the rapidly developing and expanding North Bay Area. The Agency is the primary wholesale provider of water to eight cities and water agencies who maintain their own distribution networks but very little redundant sources of supply. The Agency's contractors and in turn the public relies on the water supplied by the Agency for domestic water supply and for both emergency and non-emergency, use such as irrigation and other domestic and industrial needs.

The Agency's water system and its facilities stretch over an area of multiple natural hazards. The system has a range of vulnerabilities to these hazards. Hydraulic analysis conducted as part of the natural hazard vulnerability assessment of the water system show that damage to one or more such facilities can deplete water storage and cause significant pressure loss at turnouts serving the contractors within a matter of hours. Loss of supply from the Agency will leave the contractors vulnerable in their ability to provide fire flow and drinking water to the public.

The Agency takes this responsibility seriously and has developed this plan to systematically address the vulnerabilities of its water supply, wastewater collection and flood control systems. In this capacity, the Agency's goals are in line with the goals of the community as addressed in the Sonoma County (County) hazard mitigation plan. The County's main goals are to reduce the vulnerability of people and property exposed to earthquake, landslide, flood, and wild-land fire hazards. One of the objectives identified by the County for meeting these goals is to promote the implementation of disaster mitigation projects identified as high priority through the SCWA multi-hazard reliability assessment study and to increase the disaster resistance and reliability of the SCWA's transmission system. Keeping in view the desires of the community, as expressed in the County's plan and the understanding of the Agency vulnerabilities through a detailed multi-hazard reliability assessment of its facilities, the Agency has formulated the following three main goals:

**Goal 1: Provide safe and reliable water supply to the public during and after a natural disaster to reduce the vulnerability of people and property**

**Goal 2: Provide reliable wastewater collection, treatment and disposal services during and after a natural disaster to reduce risk to the public's health and environmental damage**

**Goal 3: Maintain reliable flood control works to reduce the vulnerability of people and property to flood hazard**

Based on the insights obtained from a comprehensive multi-hazard reliability assessment of the Agency's water system, a series of mitigation goals and actions are included in this plan. In addition, first tier objectives and actions for the Agency's wastewater collection and flood control systems are also presented. The Agency believes that the upgrades and safe operations of its systems require an ongoing program in which the most obvious vulnerabilities and those with the highest probability of occurrence are mitigated first followed systematically by vulnerabilities with lower probabilities, or newly identified vulnerabilities based on new information, with a continued improvement in the reliability of the system. This process will be managed through continuous maintenance of this hazard mitigation plan through a five year update cycle.

**Goal 1: Provide safe and reliable water supply to the public during and after a natural disaster to reduce the vulnerability of people and property**

***Objective 1.1*: Implement system-wide improvements that reduce the overall system vulnerability by adding redundancy to the system and by enhancing Agency's response through better monitoring of its system.**

1.1.1 Minimize potential for uncontrolled release of water by providing isolation valves at strategic locations.

1.1.2 Plan, design and add redundant/emergency supply sources to minimize dependence on the Russian River aquifer as the main source of water supply. Install new emergency ground water wells located strategically throughout the system.

1.1.3 Provide seismic restraints to electrical and communication equipment at various facilities.

1.1.4 Install flow measuring devices at key turnouts for real time monitoring of flow.

1.1.5 Develop a GPS based system map with real-time monitoring at critical locations. For example, significant portions of the Agency's aqueducts run through large zones of undeveloped areas and pipe leaks in such areas are hard to precisely locate.

1.1.6 Procure large diameter flexible hose and its deployment and retrieval system for emergency use.

1.1.7 Install emergency manifolds at strategic locations to connect emergency hoses.

***Objective 1.2*: Perform diversions system improvements**

1.2.1 Develop and implement designs to retrofit collectors against liquefaction and lateral spread hazard.

1.2.2 Develop and implement design strategy to mitigate liquefaction and lateral spread hazard to the RDS.

***Objective 1.3*:** ***Perform transmission system improvements***

1.3.1 Develop and implement a design strategy to mitigate fault rupture hazard to the aqueducts that cross the Rodgers Creek and the Bennett Valley faults.

1.3.2 Develop and implement a design strategy to mitigate the liquefaction and lateral spread hazard at the several river and creek crossings identified in the natural hazard reliability assessment. Some of the most vulnerable include the aqueduct crossings at Russian River, Petaluma River, Mark West Creek, Santa Rosa Creek and Calabasas Creek.

1.3.3 Develop and implement a design strategy to mitigate the liquefaction, lateral spread and flood hazard for the Sonoma aqueduct suspended at the two pedestrian and one traffic bridge over Sonoma Creek at Lawndale Road, Madrone Road and Verano Avenue.

1.3.4 Develop and implement a design or operational strategy to mitigate lateral spread damage to the Wohler-Mirabel Intertie.

1.3.5 Develop plans to relocate or parallel the pipeline that crosses beneath the Spring Lake and the Spring Lake dam.

1.3.6 Develop a design or operational strategy to respond to unexpected pipeline damage within the Wohler-Mirabel area.

1.3.7 Develop a long term strategy to address lower probability damage to transmission system pipelines. Due to the non-redundant nature of the transmission system such damage can be just as disruptive as that due to damage with a high probability of occurrence.

***Objective 1.4*:** ***Perform pumping system improvements***

1.4.1 Develop and implement a retrofit design for mitigation of liquefaction and lateral spread hazard at the Ely Booster station.

1.4.2 Develop and implement a seismic retrofit design for the Kastania pump station building.

1.4.3 Develop and implement a seismic retrofit design or replacement of the Wilfred booster station building.

1.4.4 Develop and implement a design an operational solution, such as procuring large portable pumps, to mitigate the Bennett Valley fault rupture hazard to the Sonoma Booster Station.

***Objective 1.5*:** ***Perform storage system improvements***

1.5.1 Perform a piping retrofit by replacing existing rigid piping with piping with flexible joints at the storage reservoirs.

1.5.2 Implement other retrofits such as removing overconstrained conditions identified in the natural hazard reliability study.

***Objective 1.6*: Improve the Agency's emergency response capabilities**

1.6.1 Plan and procure stockpile material for use in emergency.

1.6.2 Conduct first responder training of a broad pool of Agency's personnel to respond in an emergency.

1.6.3 Plan and develop a dedicated Emergency Operations Center such that the operators and decision makers are in close proximity to each other.

1.6.4 Procure a mobile EOC.

***Objective 1.7*: Reliable emergency power systems**

1.7.1 Develop and implement design and operations plans to mitigate liquefaction related damage to electric power lines feeding collectors and pump stations.

1.7.2 Procure and install additional UPS units at each facility to prolong the ability to communicate with the system beyond the current 4 hour limit.

***Objective 1.8*: Reduce supply vulnerability**

1.8.1 Assess vulnerability of Russian River upstream of the aquifer to earthquake and non-earthquake induced landslides that could potentially block the river channel.

1.8.2 Assess vulnerability of Russian River upstream of the aquifer to contamination from accidents and wildland fire.

1.8.3 Design and implement mitigation schemes for reducing the potential of flood damage to the well fields in the Mirabel and Laguna de Santa Rosa area.

***Objective 1.9*: Minimize life safety risk and reduce operational vulnerability**

1.9.1 Conduct a detailed seismic vulnerability assessment of structural and non-structural elements of the Agency's facilities located at 404 Aviation Boulevard and College Avenue.

***Objective 1.10*: Improve understanding of fault rupture hazard**

1.10.1 Work with the United States Geological Survey (USGS) to design and conduct a detailed geologic study including trenching of Bennett Valley and Rodgers Creek faults to more accurately define the fault activity and paleoseismic history of the fault, the rupture zone and the extent of surface rupture.

***Objective 1.11*: Minimize economic exposure to the Agency**

1.11.1 Work with the U.S. Army Corps of Engineers to expedite the earthquake safety assessment of Warm Springs and Coyote Valley dams.

1.11.2 Conduct a detailed seismic vulnerability assessment of electric power station at the Warm Springs dam.

1.11.3 Develop project design criteria document for new construction.

**Goal 2: Provide reliable wastewater collection, treatment and disposal services during and after a natural disaster to reduce public health risk and environmental damage**

**<u>Objective 2.1</u>:** Improve the understanding of the vulnerability of the sanitation systems under the Agency's control.

2.1.1 Perform a multi-hazard vulnerability assessment of the sanitation systems.

2.1.2 Develop project design criteria document for new construction.

**Goal 3: Maintain reliable flood control works to reduce the vulnerability of people and property to flood hazard**

**<u>Objective 3.1</u>:** Improve the understanding of the vulnerability of the Agency's flood protection works.

3.1.1 Perform a vulnerability assessment of the flood control works for multiple flood recurrence intervals with consideration to potential impacts from global and local climate change.

3.1.2 Work with the U.S. Army Corps of Engineers to expedite reassessment of Coyote and Warm Springs dam under the revised PMF (probable maximum flood) conditions as impacted by the recent PMP (probable maximum precipitation) study results included in the hydro-meteorological report HMR57 for Pacific Northwest and HMR 58 and HMR59 for California.

3.1.3 Work with the U.S. Army Corps of Engineers to develop and implement a plan for the assessment of flood control levees within the Upper Russian River area between Colverdale and Healdsburg.

3.1.4 Develop project design criteria document for new construction.

# 6.0 IMPLEMENTATION STRATEGY

For the successful mitigation of hazards identified in this plan and to meet the Agency's goals within a reasonable time frame, an implementation strategy has been developed. The strategy includes an identification of the objectives identified in Section 6.0, development of planning level cost estimates and a time frame for implementation.

The Agency's implementation strategy includes first identifying a set of first tier objectives. These objectives are considered the highest priority and once implemented will result in substantial improvement in the overall reliability of the system. The remaining objectives, not included in the first tier objectives, are considered desirable and will further enhance the system reliability once the first tier objectives are achieved. In addition, the Agency, as part of its maintenance program, has undertaken some of the objectives identified in Section 5.0. The most noteworthy of these include; seismically restraining electrical and communication equipment (Objective 1.1.3), retrofitting overconstrained conditions at storage tanks (Objective 1.5.1 and 1.5.2), procuring some stockpile material (Objective 1.6.1), working towards enhancing the emergency operations center (Objective 1.6.3) and reducing vulnerability of electric power lines (Objective 1.7.1).

The Agency's objectives have been prioritized based on the following:

- Impact to the Agency's system from the identified vulnerability. The system impacts were studied through detailed hydraulic modeling of the system. Factors such as time to significant loss of pressure or significant loss of storage and the population impacted. For example, a break at Rodgers Creek fault will result in loss of flow to the entire Sonoma Valley and is considered a high priority

- Overall cost/benefit of the mitigation strategy. For example, anchorage of equipment at the Agency's facilities is considered a high priority because of very high benefit to cost ratio.

The Agency's first tier objectives include:

1. **Mitigation Action 1.3.1 (partial) –** Develop and implement design strategy to mitigate fault rupture hazard at Rodgers Creek fault crossing of Santa Rosa aqueduct

2. **Mitigation Action 1.1.4 –** Install flow measuring devices at key turnouts for real time monitoring of flow

3. **Mitigation Action 1.1.1** – Minimize potential for uncontrolled release of water by providing isolation valves at strategic locations

4. **Mitigation Action 1.3.2 (partial)** – Develop and implement design strategy to mitigate the liquefaction and lateral spread hazard at the Russian River crossing

5. **Mitigation Action 1.3.2 (partial)** – Develop and implement design strategy to mitigate the liquefaction and lateral spread hazard at the Mark West Creek crossing

6. **Mitigation Action 1.2.1 (partial)** – Develop and implement retrofit design for Collectors 3 and 5 against liquefaction and lateral spread hazard

7. **Mitigation Action 1.2.1 (partial)** – Develop and implement retrofit design for Collector 6 against liquefaction and lateral spread hazard

8. **Mitigation Action 1.1.2** – Plan, design and add redundant/emergency supply sources to minimize dependence on the Russian River aquifer as the main source of water supply. Install new emergency ground water wells located strategically throughout the system (assumed three locations)

9. **Mitigation Action 1.3.2 (partial)** – Develop and implement design strategy to mitigate the liquefaction and lateral spread hazard at the Santa Rosa Creek crossing

10. **Mitigation Action 1.2.2** – Develop and implement design strategy to mitigate liquefaction and lateral spread hazard to the RDS

The implementation strategy has been developed based on the recommended Capital Improvement Program developed as part of the multi-hazard reliability project. Once these objectives are achieved, implementation schedule and planning level budget estimates for second tier objectives can be developed in future revisions to the plan, if so desired by the Agency, the public and the Agency's contractors. The first tier mitigation actions are included in the Agency's Capital Improvement Program (CIP), which is administered by the Engineering and Resource Planning Division with the other division heads involved in the yearly CIP development cycle.

The Agency will actively work towards identifying funding sources for these projects. Some of these sources include: FEMA's pre-disaster mitigation program (PDM) and hazard mitigation grants program (HMGP), Agency's maintenance budget and a proposed reliability surcharge within the Agency's rate structure. Since 2003, FEMA has provided close to $540 million in PDM grants to eligible projects. Additional funding from FEMA is available following a Federal disaster declaration as part of its HMGP.

Depending on the level of funding available, the Agency plans to implement the top six first tier objectives in 4 to 10 years following the adoption of this plan with the remainder of the first tier objectives completed within the next 15 to 25 years.

# 7.0 PLAN MAINTENANCE

The Agency's commitment to reducing its hazard vulnerability and improving the reliability of its system is demonstrated by the fact that the Agency on its own initiative undertook a comprehensive multi-hazard reliability improvement program. The Agency recognizes that this commitment can only be met through a dedicated effort. Development of the Hazard Mitigation Plan is part of this effort. In meeting the requirements of the DMA2000, the Agency plans to update the Hazard Mitigation Plan every five years or if new information becomes available, priorities for implementation change or an actual hazard event occurs that may prompt an update to the plan sooner than five years.

## 7.1 MONITORING EVALUATING AND UPDATING THE PLAN

The Agency will keep the plan "alive" through constant monitoring of the plan goals and objectives. The high priority mitigation actions are being included in the Agency's CIP. Because of the involvement of the Agency's Department heads of Planning, Operations, Maintenance and Capital Improvements in the development of the plan, the entire executive management of the Agency is committed to implement the goals and objectives of the plan.

The Agency will incorporate the hazard mitigation plan in its yearly CIP planning process to monitor progress towards the goals of the hazard mitigation plan. To further facilitate this process, the Agency's Capital Projects Manager has been identified as the person responsible for monitoring and updating the hazard mitigation plan. As required by DMA2000, this plan will be updated every five years. The Agency will also update the plan if there is a significant change in the basic assumptions, for example a major hazard event that highlights vulnerabilities in the system not anticipated at the present time.

## 7.2 CONTINUED PUBLIC INVOLVEMENT

The Agency, with its decision to incorporate the hazard mitigation plan in its yearly CIP planning process, has ensured continued public involvement in this plan. The CIP approval is an open public process. As part of the approval process the CIP is presented to the Agency's Board of Supervisors in an open public meeting and by virtue of this, progress towards achieving Agency's goals and objectives identified in the hazard mitigation plan will also be open for public review and comment.

Further, the Agency is contractually obligated to meet on a regular basis with two advisory committees. The Water Advisory Committee (WAC) and the Technical Advisory Committee(TAC) meet quarterly and monthly respectively. The WAC is made up of members of the elected Councils and Boards of the Agency's contractors and they discuss the Agency's programs and budget in an open public forum. They are responsible for making recommendations on the Agency's budget to the Agency's Board of Directors. The TAC consists of managers and technical staff of the Agency's contractors. They meet to discuss the day to day operation of the Agency's system and to discuss the need for capital and mitigation projects. The Plan will be a regular topic of discussion before both of these groups.

references


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3 Sonoma County Water Agency, Draft Technical Memorandum – Seismic Vulnerability Assessment of Diversion System Caissons, 12/14/2006, prepared by MMI Engineering.

4 Sonoma County Water Agency, Addendum I, Draft Technical Memorandum – Seismic Vulnerability Assessment of Transmission System, 02/6/2007, prepared by MMI Engineering.

5 Sonoma County Water Agency, Draft Technical Memorandum – Seismic Vulnerability Overview of Contractor Systems, 03/29/2007, prepared by MMI Engineering.

6 Sonoma County Water Agency, Technical Memorandum – Power Supply of SCWA Facilities, 06/05s/2006, prepared by MMI Engineering.

7 Sonoma County Transmission System Reliability Study, Final Emergency Well Site Selection Results, 7/23/2007, prepared by HydroMetrics LLC.

8 Sonoma County Water Agency, Emergency Operations Plan, Revision No. 6, September, 1998, Operations Edition.

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12 FEMA, 386-2 State and Local Mitigation Planning, How-To Guide, Understanding Your Risks, Identifying Hazards and Estimating Losses, August 2001.

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15 FEMA, 386-4 State and Local Mitigation Planning, How-To Guide, Bringing the Plan to Life, Implementing the Hazard Mitigation Plan, August 2003.

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17 Sonoma County Hazard Mitigation Plan, Sonoma County Department of Emergency Services & Sonoma County Permit and Resource Management Department, Adopted September 19, 2006.

18 Local Hazard Mitigation Planning Guidance, provided by Tennessee Emergency Management Agency

19 Orange County Regional Water and Wastewater Multi-Hazard Mitigation Plan, Orange County, California, Municipal Water District of Orange County, Final Draft Report, September 29, 2006.

20 Meeting June 2, 2005, Alder Conference Room, 404 Aviation Boulevard, Santa Rosa: Attendees: Jay Jasperse (Deputy Chief Engineer, Engineering and Resource Planning), Cordel Stillman (Capital Projects Manager) Sonoma County Water Agency, Ahmed Nisar, MMI Engineering, George Roberts, Forestville Water District and Richard Burt (for Matt Mullan), Town of Windsor.

21 Meeting June 2, 2005, Sequoia Conference Room, 404 Aviation Boulevard, Santa Rosa: Attendees: Jay Jasperse (Deputy Chief Engineer, Engineering and Resource Planning), Cordel Stillman (Capital Projects Manager) Sonoma County Water Agency, Ahmed Nisar, MMI Engineering, Darin Jenkins, City of Rohnert Park and Mike Ban, City of Petaluma.

22 Meeting June 7, 2005, Alder Conference Room, 404 Aviation Boulevard, Santa Rosa: Attendees: Jay Jasperse (Deputy Chief Engineer, Engineering and Resource Planning), Cordel Stillman (Capital Projects Manager) Sonoma County Water Agency, Ahmed Nisar, MMI Engineering, Krishna Kumar, Valley of the Moon Water District and Al Bandur, City of Sonoma.

23 Meeting August 26, 2005, 404 Aviation Boulevard, Santa Rosa: Attendees: Jay Jasperse (Deputy Chief Engineer, Engineering and Resource Planning), Cordel Stillman (Capital Projects Manager) Sonoma County Water Agency, Ahmed Nisar, MMI Engineering, Chris DeGabriele, North Marin Water District.

24 Meeting September 15, 2005, 404 Aviation Boulevard, Santa Rosa: Attendees: Jay Jasperse (Deputy Chief Engineer, Engineering and Resource Planning), Cordel Stillman (Capital Projects Manager) Sonoma County Water Agency, Ahmed Nisar, MMI Engineering, Miles Ferris, City of Santa Rosa.

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34 Toppozada T. et al., 1994, Planning Scenario for a Major Earthquake on the Rodgers Creek Fault in the Northern San Francisco Bay Area, CDMG Special Publication 112.

35 McLaughlin, R.J., and Sarna-Wojcicki, A.M., 2003, Geology of the right stepover region between the Rodgers Creek, Healdsburg, and Maacama faults, northern San Francisco Bay region: U.S. Geological Survey Open-File Report 03-502, 23 p., http://geopubs.wr.usgs.gov/open-file/of03-502.

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APPENDIX A

**Table A-1**
**List of Drawings Reviewed**

| S. No | Name of the File | Year |
|---|---|---|
| 1. | Russian River Cotati Intertie Project – Pipe Contract No. 1 Contract No 60-4-7#1 | 1975 |
| 2. | Russian River Cotati Intertie Project – Pipe Contract No. 2 Contract No 60-4-7#2 | 1975 |
| 3. | Russian River Cotati Intertie Project – Pipe Contract No. 3 Contract No 60-4-7# | 1975 |
| 4. | Special Provisions And Contract Drawings For Construction of Russian River Project – Sonoma Aqueduct Pipeline and Appurtenances | 1962 |
| 5. | Special Provisions And Contract Drawings For Construction of Russian River Project – Sonoma Aqueduct Glen Ellen Branch | 1964 |
| 6. | Russian River Project – Aqueduct Number 1 | 1957 |
| 7. | Petaluma Aqueduct Water Transmission Pipeline | 1963 |
| 8. | Oakmont Pipeline Contract No 60-4-7#5 | 1988 |
| 9. | Eldridge Madarone Pipeline Project | 2005 |
| 10. | Kawana Springs Pipeline East (Petaluma Aqueduct To Kawana Springs Tank No.1) Contract No. 60-4-7 | 2001 |
| 11. | Pump and Collector Capacity Project – Caisson and Access Road For Wohler Collector No. 6 Contract No. 60-5-7 | 2001 |
| 12. | Pump and Collector Capacity Project Wohler-Forestville Pipeline | 2004 |

| S. No | Name of the File | Year |
|---|---|---|
| 13. | Special Provisions And Contract Drawings For Construction of Russian River Project – Horizontal Water Collectors Near Mirabel at The Russian River 60-5-7#1 | 1973 |
| 14. | Special Provisions And Contract Drawings For Construction of Mirabel Collector No. 5 Contract No 60-5-7#5 | 1982 |
| 15. | Project Manual Volume 2 For Pump and Collector Capacity Project – Wohler Forestville Pipeline Contract No 60-4-7#10 | 2004 |
| 16. | Russian River Well Field Development (Equipment) Early Warning System Station No. 1 And Mirabel Inflatable Dam Fabric Replacement | 1995 |
| 17. | Specifications and Contract Drawings For Wohler Site Improvements: Standby Generator Replacement and Temporary Power Delivery System (PDS) For Substation Replacement Contract No 60-6-7#27 | 2000 |
| 18. | Sonoma County Water Agency: Wohler/Mirabel 12 KV Underground and Overhead Power Line Modifications | 2006 |
| 19. | Project Manual Volume 2 For Pump and Collector Capacity Project Pumphouse and Connecting Pipeline For Wohler Collector #6 Contract No 60-4&6-7#1 | 2002 |
| 20. | Project Manual For Eldridge-Madrone Project Contract No 60-4-7#11 | 2004 |
| 21. | Kawana Springs Pipeline West (Vicinity of Wright Road To Petaluma Aqueduct) And Russian River Well Field Valve Replacements (Mirabel Area) Contract No 60-4-7#8 & 60-6-7#19 | 1999 |
| 22 | Special Provisions and Contract Drawings for Ralphine Reservoir No. 3 Contract No 60-7-7 No.2 | 1970 |
| 23 | Special Provisions and Contract Drawings for Grading and Appurtenances For Ralphine Reservoir No. 3 Contract No 60-7-7 No. 1 | 1970 |
| 24 | Project Manual And Contract Drawings For Construction OF Anadel reservoir No.2 And Cotati Reservoir No.3 Contract No 60-7-7 No.23 | 1992 |
| 25 | Project Manual And Contract Drawings For Grading Piping and Appurtenances For Anadel reservoir No.2 , Cotati Reservoir No.3 and Warm Springs Reservoir Contract No 60-7-7 No.21 | 1985 |
| 26 | Special Provisions and Contract Drawings for Construction of Russian River Cotati Intertie Project: Grading and Appurtenances Cotati Reservoir Contract No 60-7-7 No.7 | 1974 |

| S. No | Name of the File | Year |
|---|---|---|
| 27 | Special Provisions and Contract Drawings for Construction of Russian River Cotati Intertie Project: Cotati Reservoir Contract No 60-7-7 No.8 | 1974 |
| 28 | Special Provisions and Contract Drawings: Grading and Appurtenances for Ralphine Reservoir No. 4 Contract No 60-7-7 No.5 | 1973 |
| 29 | Special Provisions and Contract Drawings for Construction of Russian River Cotati Intertie Project: Ralphine Reservoir No. 4 Contract No 60-7-7 No.6 | 1974 |
| 30 | Specifications and Contract Drawings For Ralphine Tank No.4 Valve Seismic Control System Contract No 60-7-7 No.51 | 1999 |
| 31 | Special Provisions and Contract Drawings Russian River Project For Construction Of Ralphine Reservoir No.2 For Petaluma Aqueduct | 1961 |
| 32 | Special Provisions and Contract Drawings for Construction of Russian River Cotati Intertie Project: Grading and Appurtenances Cotati Reservoir No. 2 Contract No 60-7-7 No.10 | 1980 |
| 33 | Special Provisions and Contract Drawings for Construction of Russian River Cotati Intertie Cotati Reservoir No. 2 Contract No 60-7-7 No.11 | 1980 |
| 34 | Specifications and Contract Drawings For Kawana Springs Tank No.1 Contract No 60-7-7 No.45 | 1998 |
| 35 | Special Provisions and Contract Drawings For Construction Kastania Reservoir Contract No 60-7-7 No.14 | 1983 |
| 36 | Specification and Contract Drawings For Seismic Retrofit For Eldridge Reservoir No.1 & Forestville Reservoirs No. 1 & No.2 | 1995 |
| 37 | Special Provisions And Contract Drawings Grading and Appurtenances For Eldridge Reservoir No. 2 Contract No: 60-7-7 #3 | 1972 |
| 38 | Specification and Contract Drawings For Seismic Retrofit For Anadel Reservoir No.1 & Sonoma Reservoir No. 1 Contract No. 60-7-7 #29 | 1994 |
| 39 | Specification and Contract Drawings For Seismic Retrofit for Eldridge Reservoir No.1 & Forestville Reservoir No.1 & No.2 Contract No. 60-7-7 #37 | 1995 |
| 40 | Special Provisions And Contract Drawings For Construction of Grading, Piping and Appurtenances For Forestville Reservoir No. 2 Contract No: 60-7-7 #16 | 1989 |

| S. No | Name of the File | Year |
|---|---|---|
| 41 | Special Provisions And Contract Drawings For Construction of Forestville Reservoir No. 2 Contract No: 60-7-7 #17 | 1990 |
| 42 | Special Provisions And Contract Drawings: Russian River Project For Construction of Forestville Reservoir No. 1 | 1961 |
| 43 | Special Provisions And Contract Drawings For Construction of Sonoma Reservoir No. 2 Grading Piping and Appurtenances Contract No: 60-7-7 #15 | 1991 |
| 44 | Special Provisions And Contract Drawings: Russian River Project For Construction of Storage Reservoirs For Sonoma Aqueduct Contract No. 52-7-7#2 | 1962 |

**Table A-2**
**List of Facility Geotechnical Reports Reviewed**

| S. No | Title | Consultant | Date |
|---|---|---|---|
| 1 | Geotechnical Investigation Proposed Seismic Repair Work Mirabel Collectors NOS. 3 AND 4 Sonoma County, California For The Sonoma County Water Agency. | Consulting Engineers | 08-13-1985 |
| 2 | A Geophysical Survey of the Wohler Aquifer Study Area Russian River, California | NORCAL Geophysical Consultants | 09-14-1987 |
| 3 | Hydrogeologic Investigation Wohler Aquifer Study Sonoma County, California | Harding Lawson Associates | 12-09-1988 |
| 4 | Report of Findings Preliminary Soil and Groundwater investigation: Wohler Road Pumping Facility | Brunsing Asociates Inc | 09-30-1991 |
| 5 | Report of Hydrogeologic Evaluation Russian River well Field Investigation (Near Mirabel) Sonoma County, California | Herzog Associates, Inc | 12-16-1992 |
| 6 | Seismic Refraction Survey Russian River Well Field Investigation Sonoma County, California. | Harding Lawson Associates | 04-30-1993 |
| 7 | Hydrogeologic Evaluation Kaiser sand and gravel company property Healdsburg, California. | PES Environmental, Inc | 12-17-1998 |
| 8 | Hydrogeologic Evaluations Westside Farms and Lazy "W" Ranch Healdsburg, California | PES Environmental, Inc | 12-11-1998 |
| 9 | Seismic Refraction Survey Pump and Collector Capacity Project Sonoma County, California | NORCAL Geophysical Consultants | 06-07-1999 |
| 10 | Geotechnical Investigation Sonoma County Water Agency pH Adjustment/Corrosion Control Facility 9750 Wohler Road, Sonoma County, California | Brunsing Associates | 02-28-1994 |
| 11 | Geotechnical Investigation Sonoma County Water Agency Wohler Substation Replacement 9750 Wohler Road, Sonoma County, California | Brunsing Associates | 02-15-1999 |
| 12 | Geotechnical Investigation Wohler Collector 6 Pumphouse Sonoma County, California | RGH Geotechnical and Environmental Consultants | 04-26-2002 |
| 13 | Seismic Refraction Survey Wohler Pipeline | RGH Geotechnical and Environmental Consultants | 04-2001 |
| 14 | Geotechnical Investigation Proposed Seismic Retrofit Annadel Reservoir No. 1 Sonoma County, California | Brunsing Associates | 06-25-1995 |
| 15 | Geotechnical Investigation Collector 6 Pipeline And Wohler-Forestville Pipeline Projects Sonoma County, California. | RGH geotechnical and Environmental Consultants | 06-25-1995 |

| S. No | Title | Consultant | Date |
|---|---|---|---|
| 16 | Geotechnical Investigation Report For Seismic Retrofits of Eldridge Reservoir No.1 AND Forestville Reservoir NOS. 1 & 2 Sonoma County California | Kleinfelder, Inc | 03-03-1995 |
| 17 | Structural Evaluation of the Sonoma County Water Agency Administration Building and O&M Center for Seismic Conditions. | MKM & Associates | 06-03-1997 |
| 18 | Summary of Subsurface Investigations | WLA | 04-21-2006 |
| 19 | Geological Investigation For The Proposed Santa Rosa Creek Dam and Reservoir | Woodward, Clyde, Sherard and Associates | 02-24-59 |
| 20 | Geology of the Healdsburg Quadrangle, California Mineralogy of the California Glaucophone Schists, State of Califonia (Including Maps) | | July 1951 |
| 21 | Geotechnical Assessment of Aqueduct System | WLA | October 2006 |

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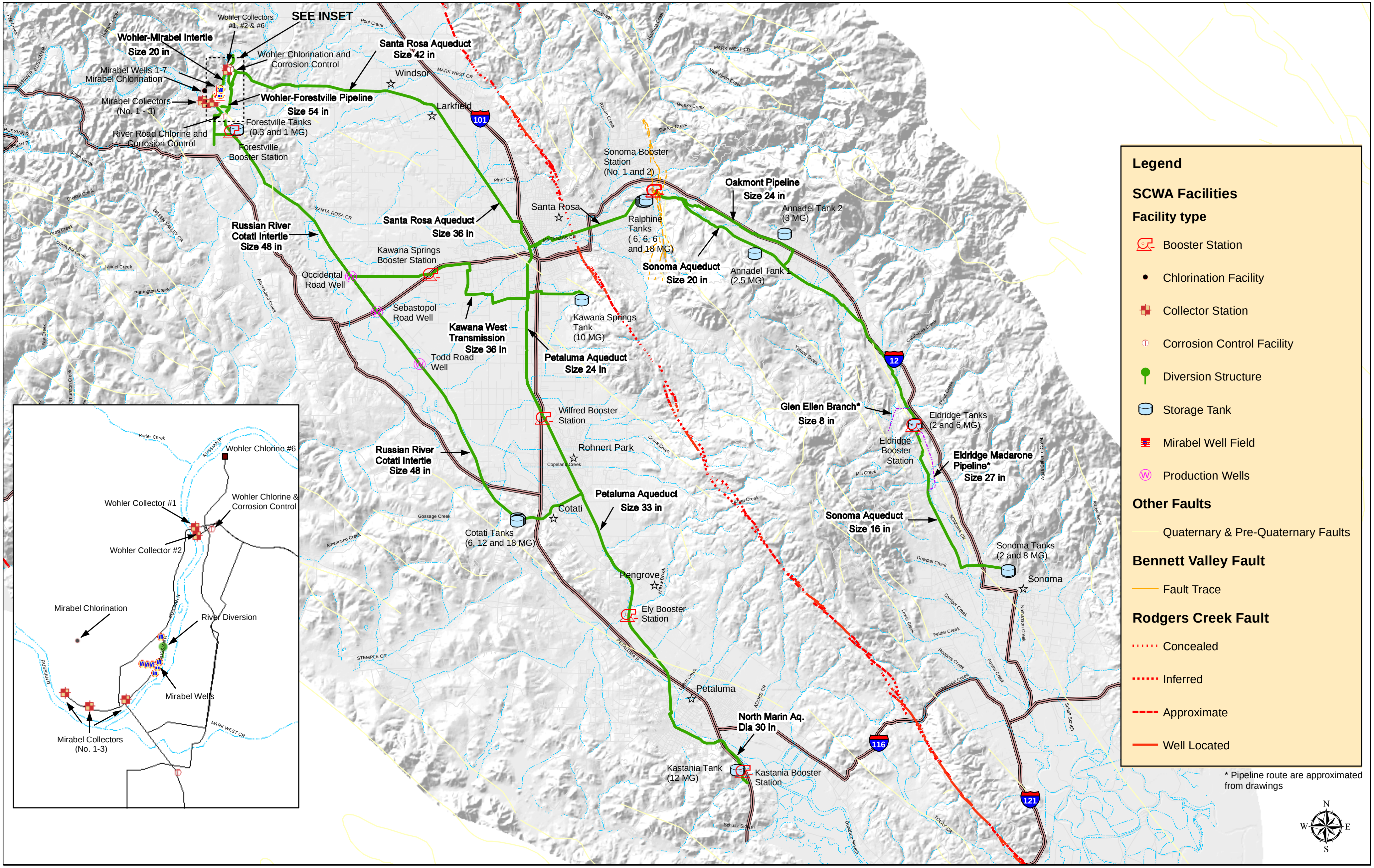
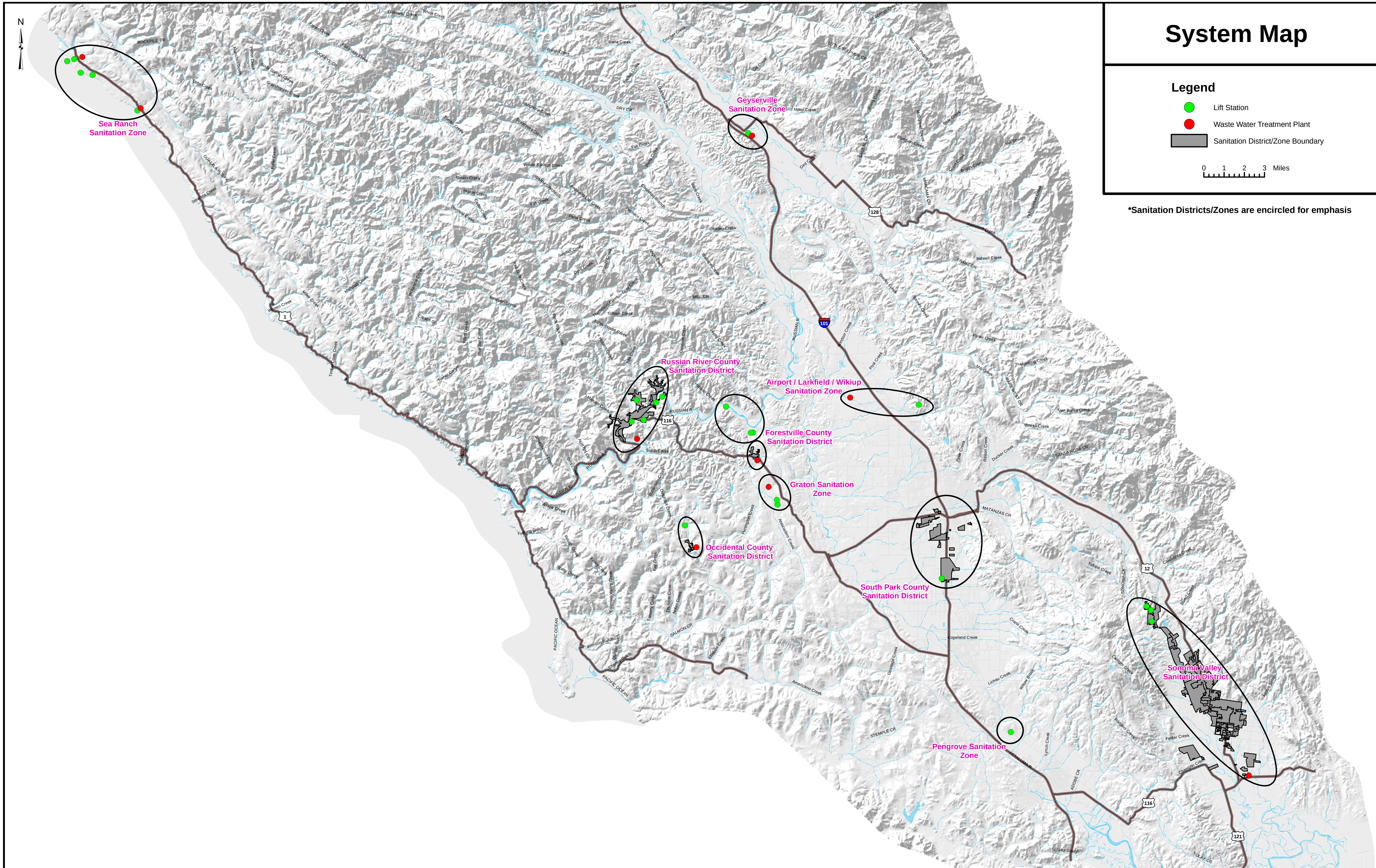
# APPENDIX B

## Board of Supervisors
## Resolution for Adoption of
## Sonoma County Water Agency Local Hazard Mitigation Plan




# Water System Map

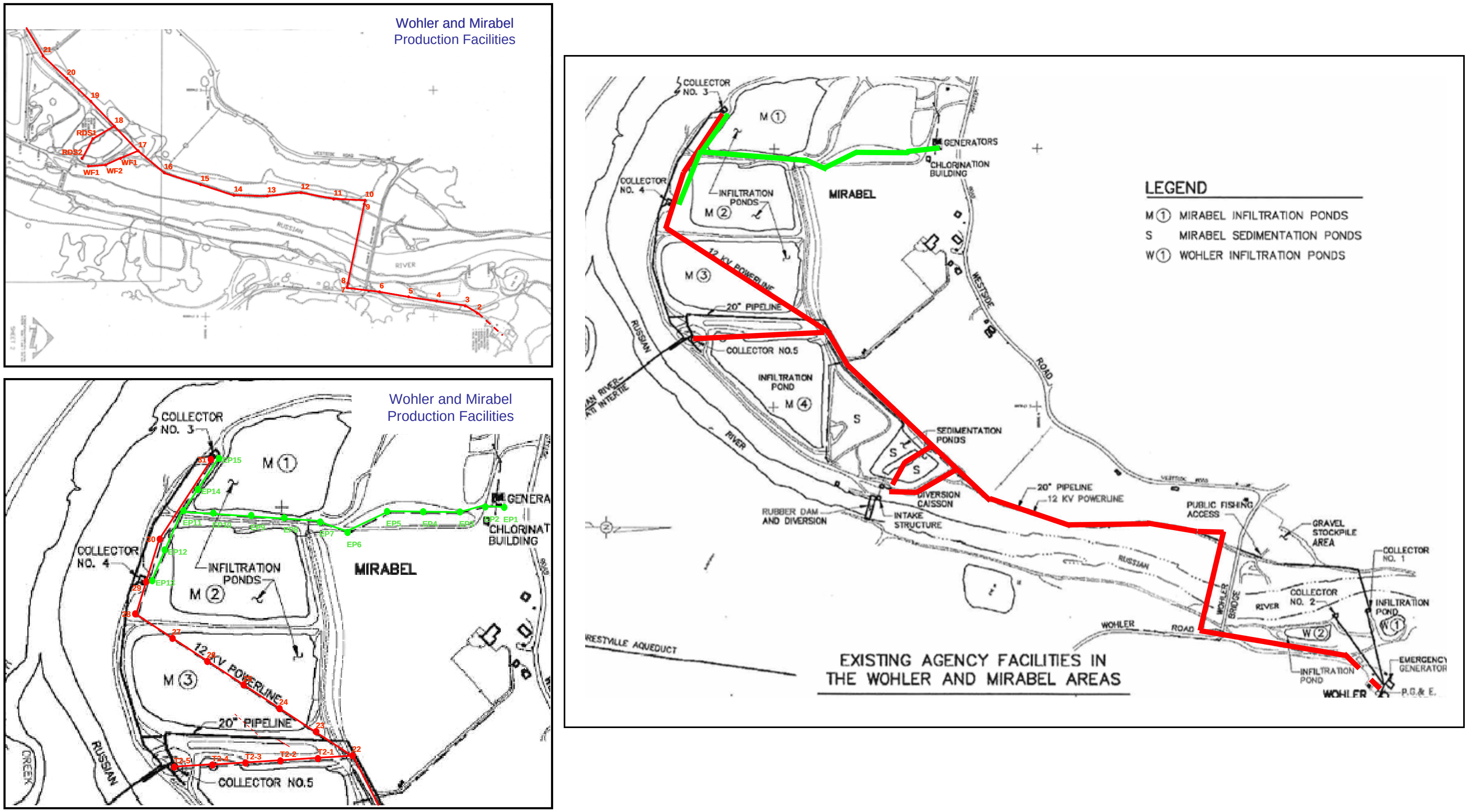
Figure 1





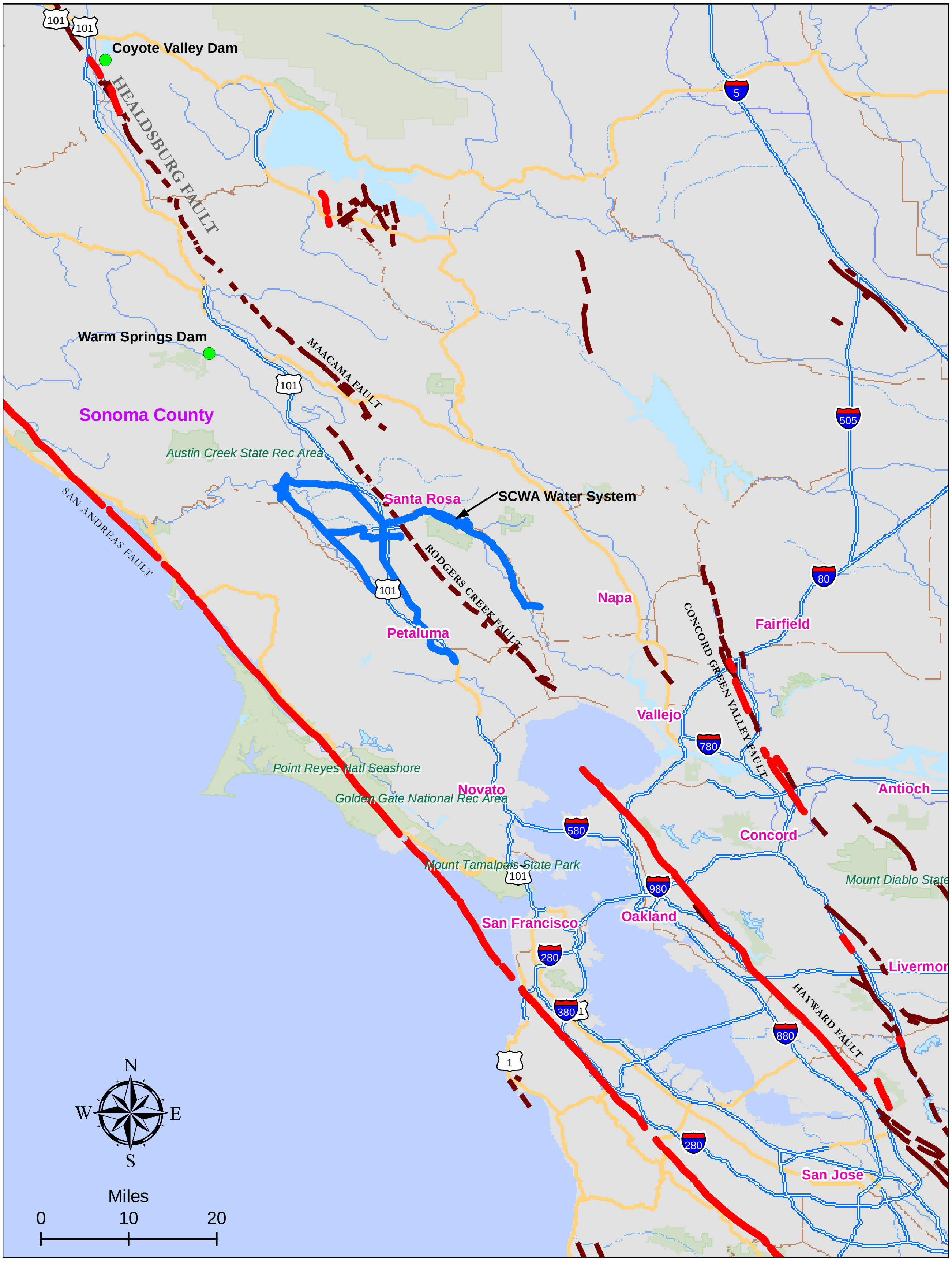

Sanitation District and Zones Map

Figure 2




**Power System**

**Figure 3**

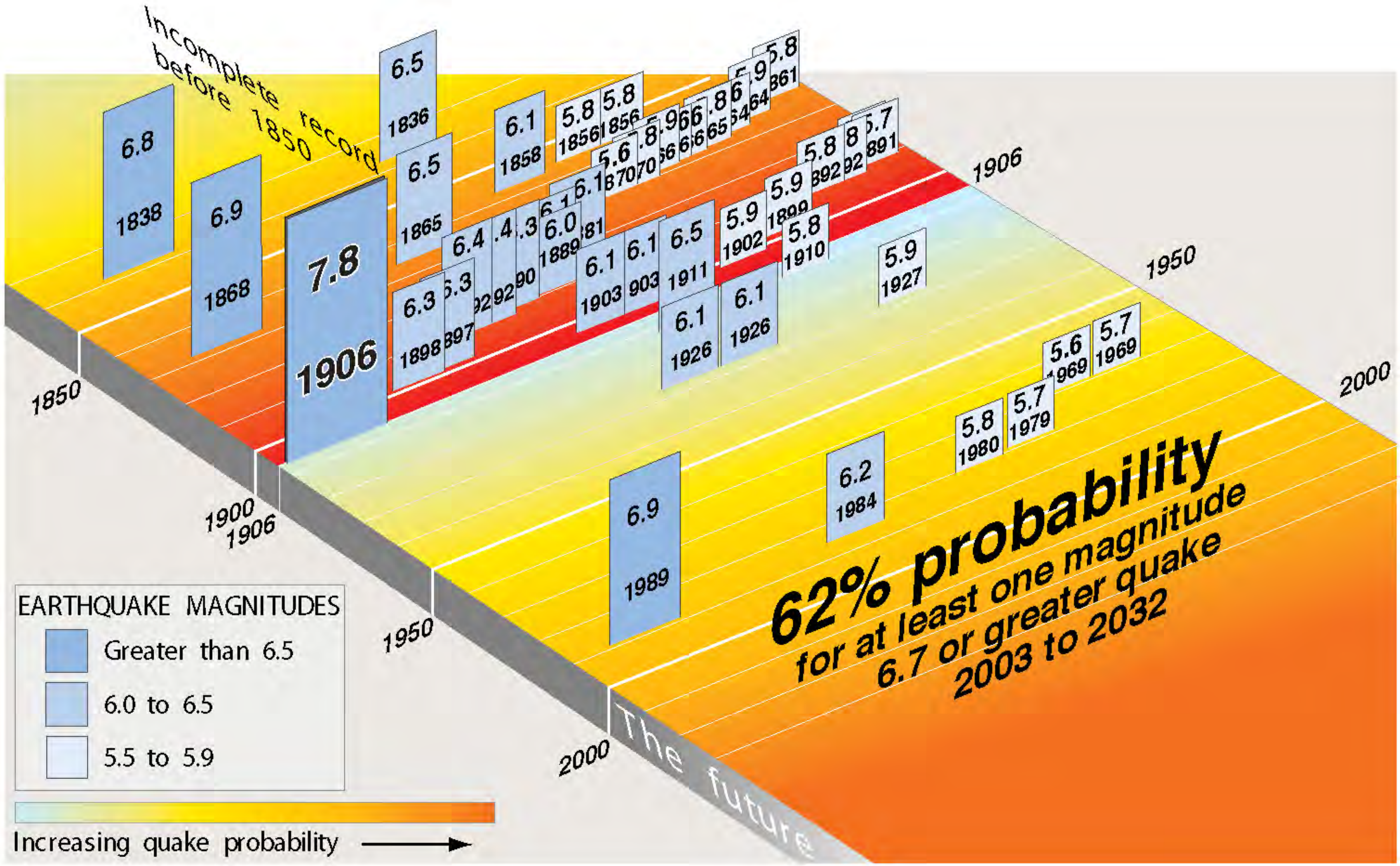



Fault Map of the Bay Area

Figure 4

MMI ENGINEERING

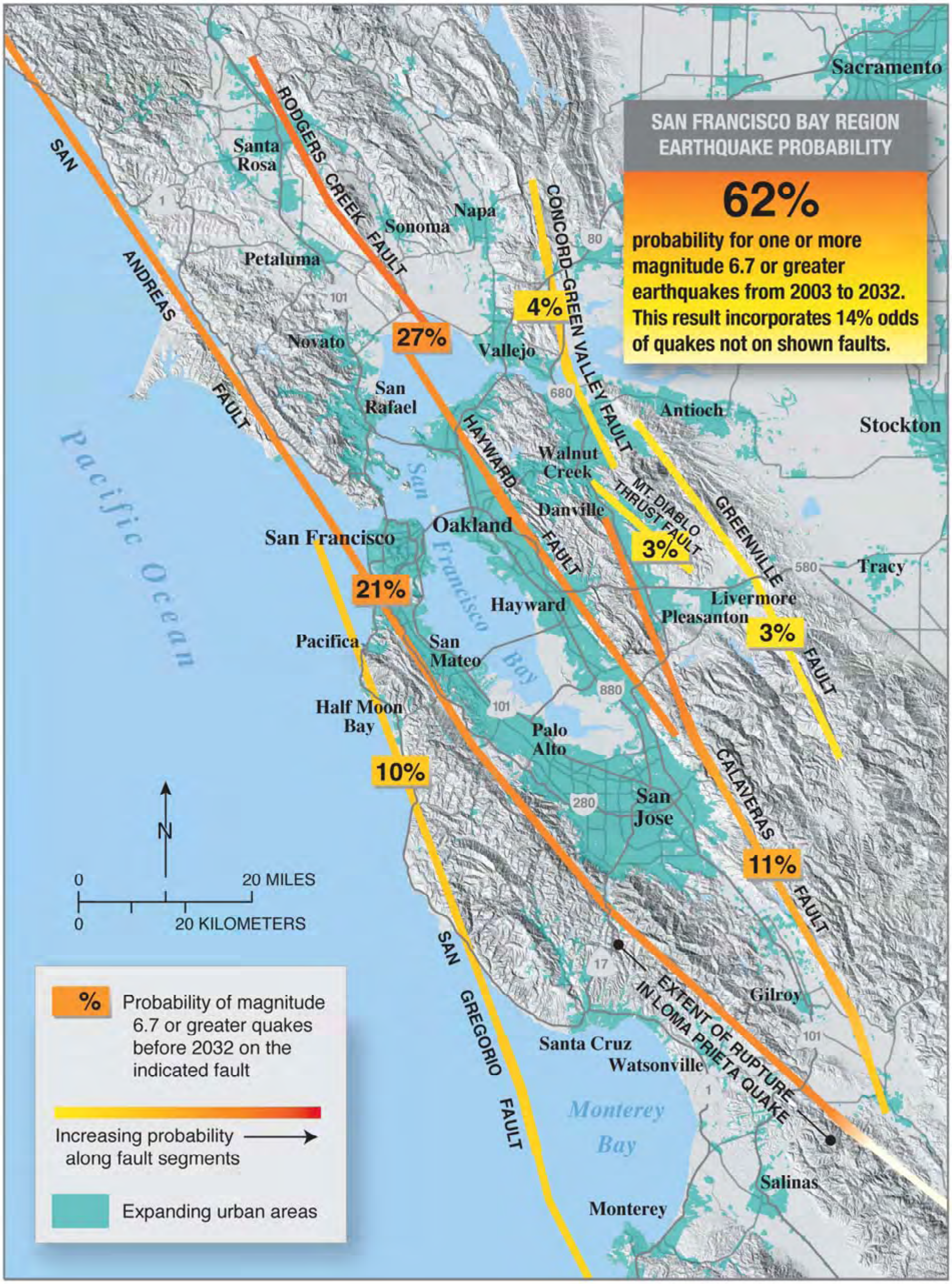
**CONFIDENTIAL**




Source: USGS – http://quake.wr.usgs.gov/research/seismology/wg02/media.html

**Historic Earthquakes in the Bay Area**

**Figure 5**

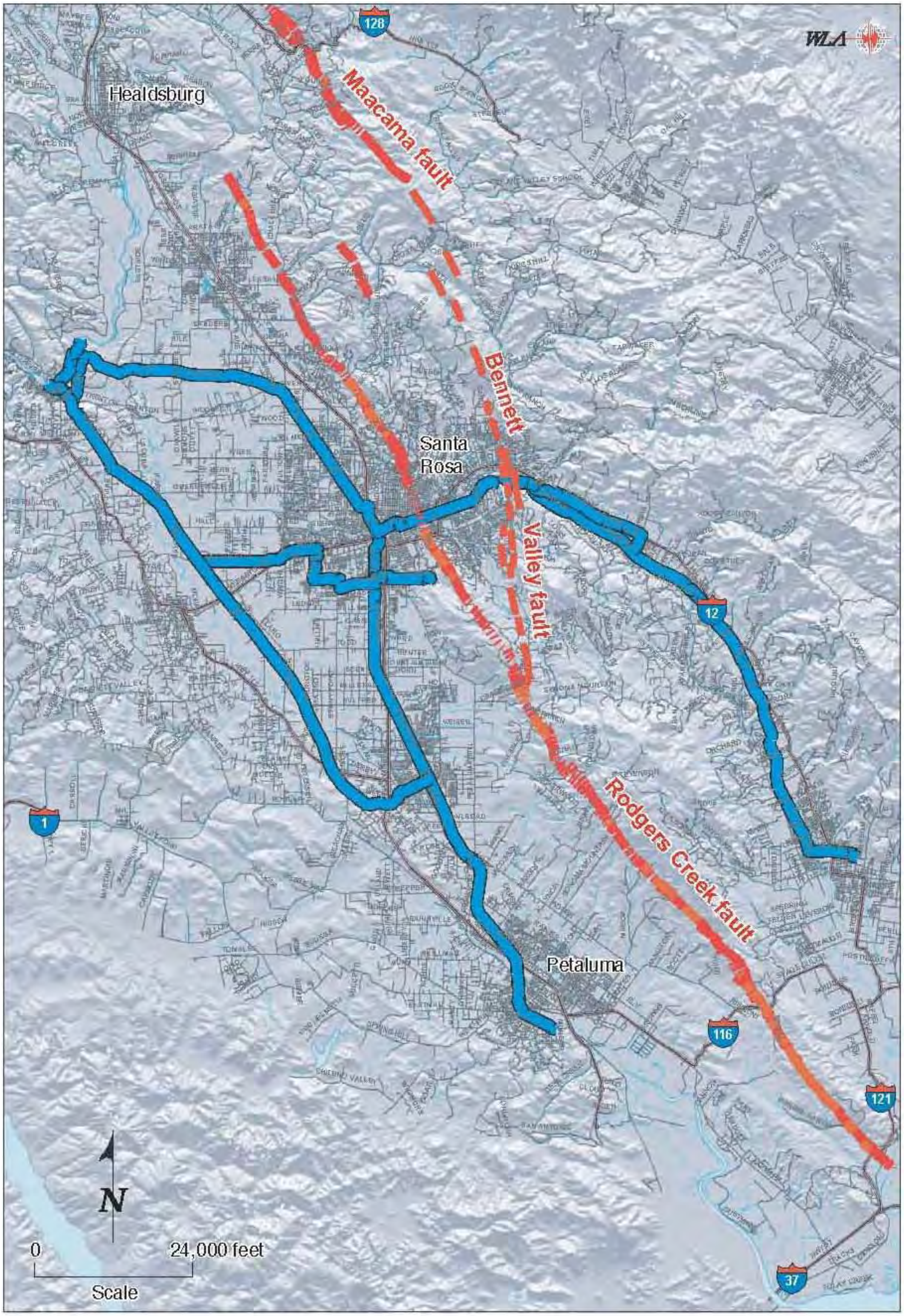



Source: USGS – http://quake.wr.usgs.gov/research/seismology/wg02/media.html



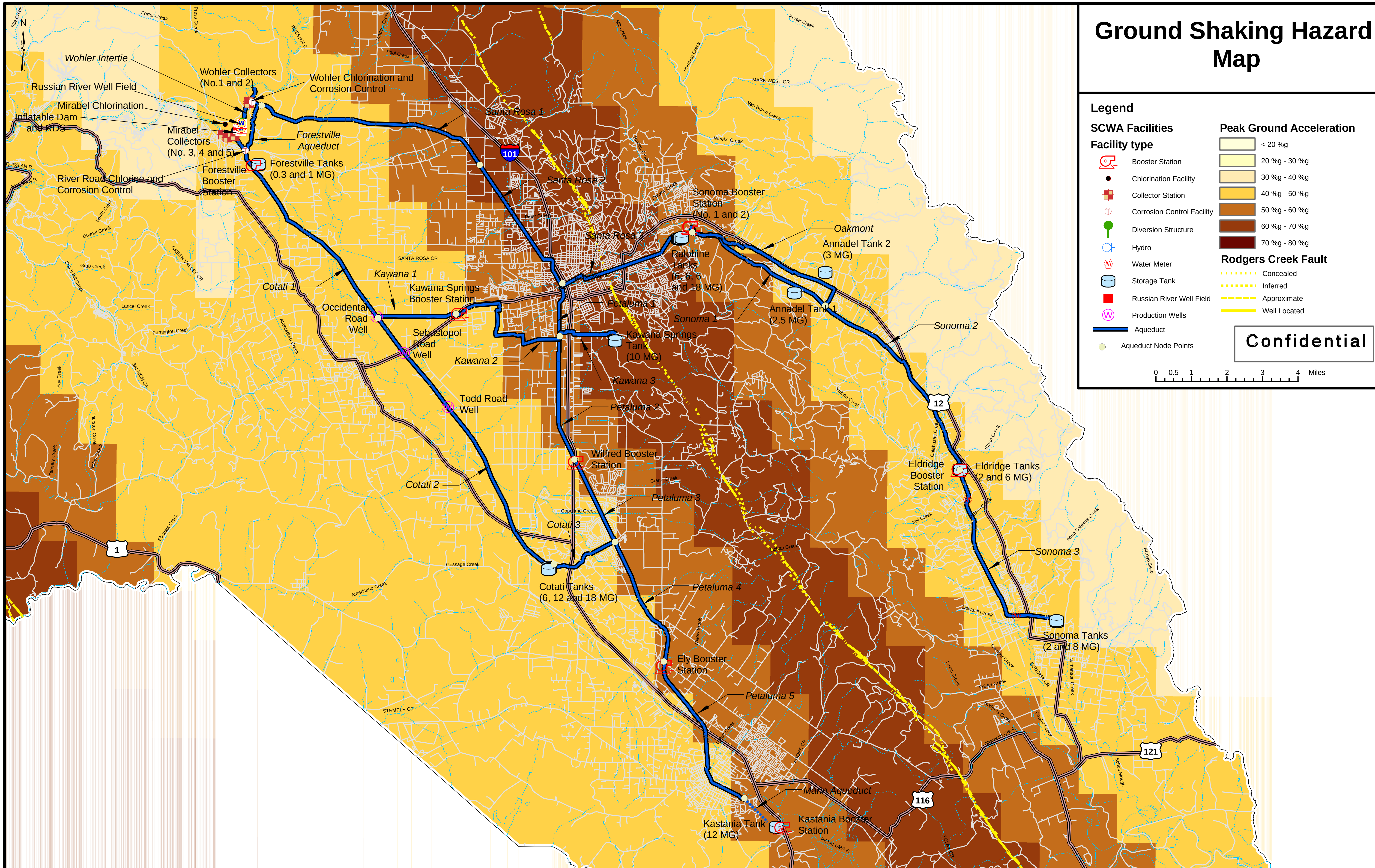
**Earthquake Probabilities in the Bay Area**

**Figure 6**



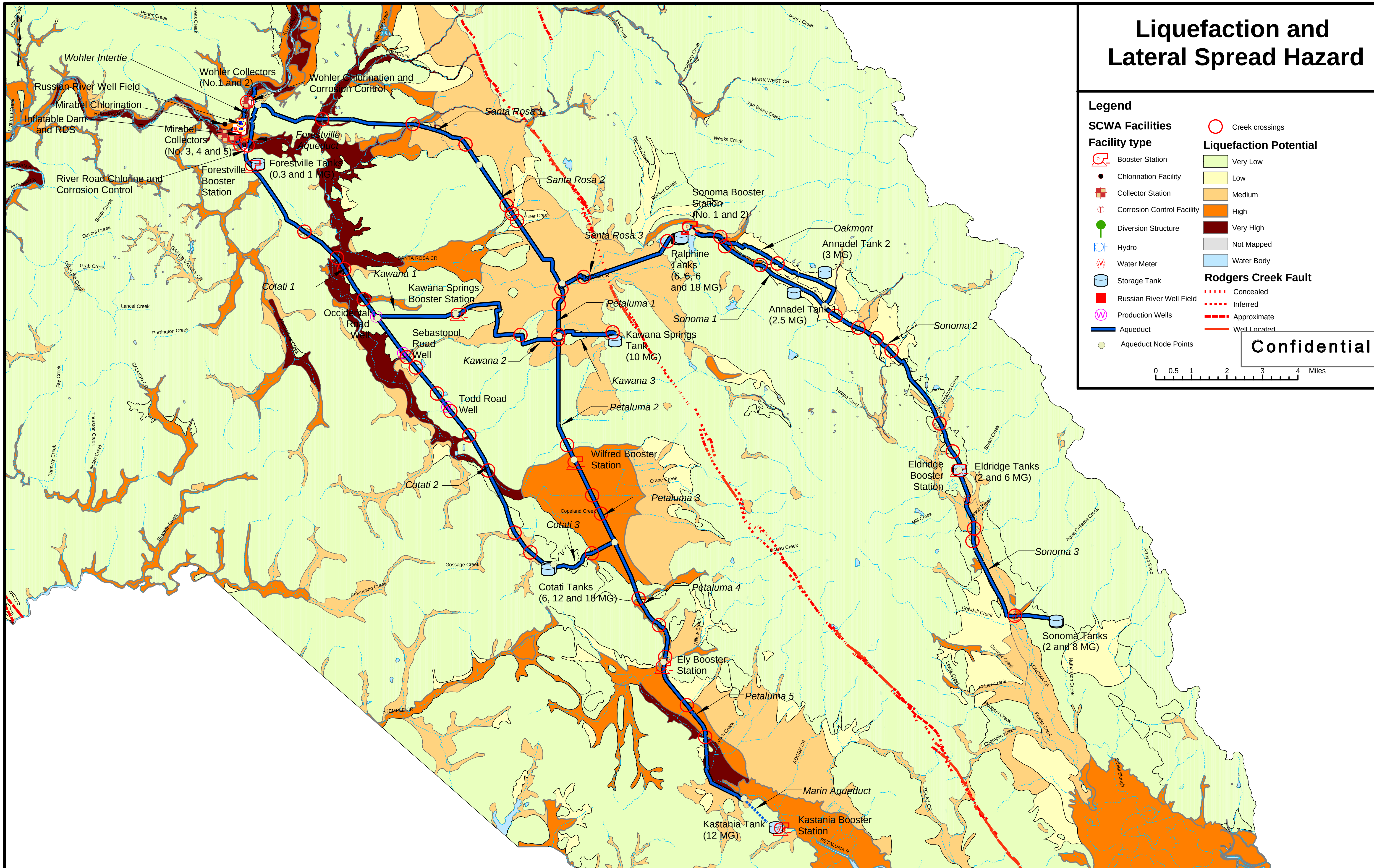

**Fault Map of Agency's Service Area**

**Figure 7**




MMI ENGINEERING

Figure 8




MMI ENGINEERING

Figure 9

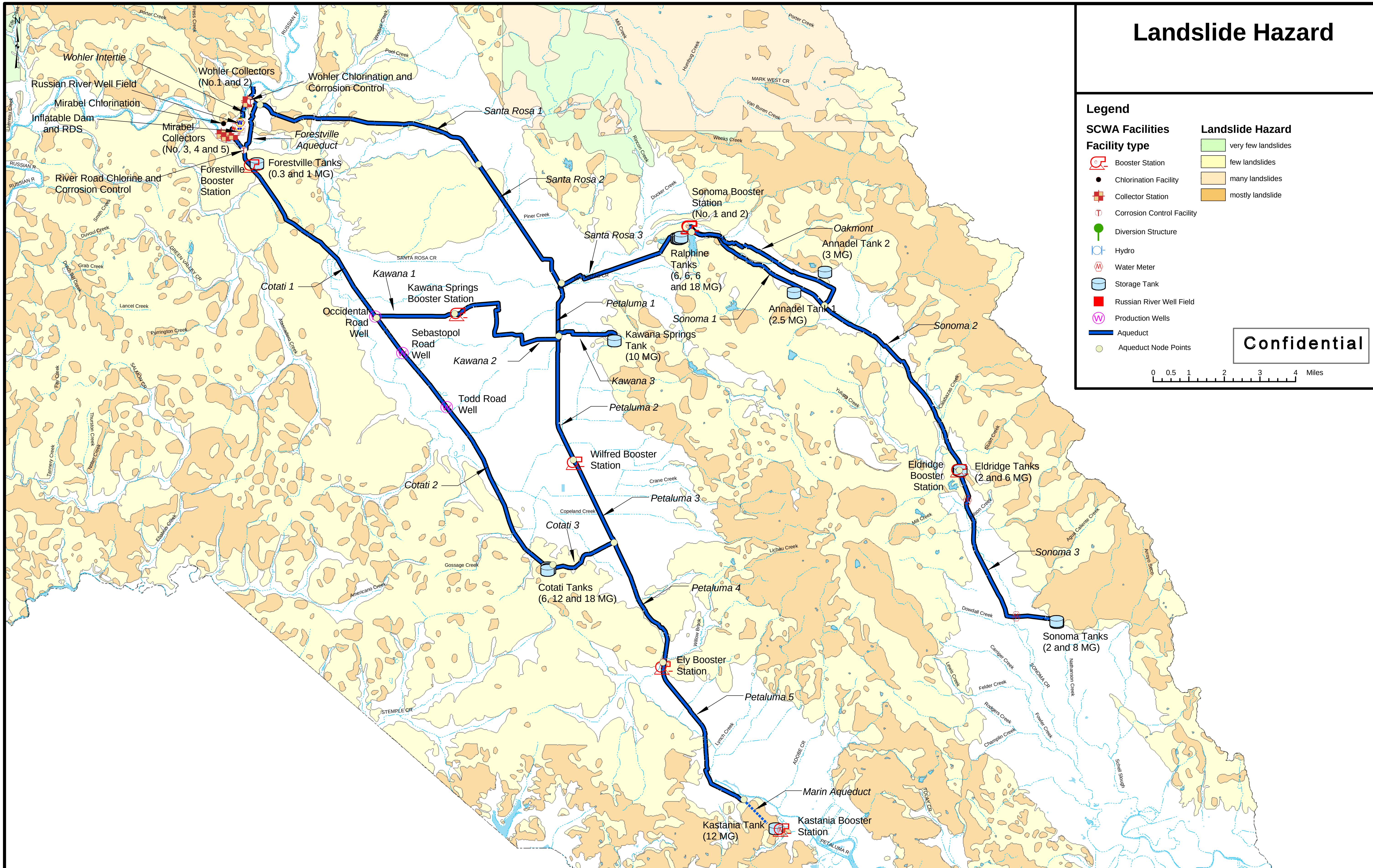



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Figure 10

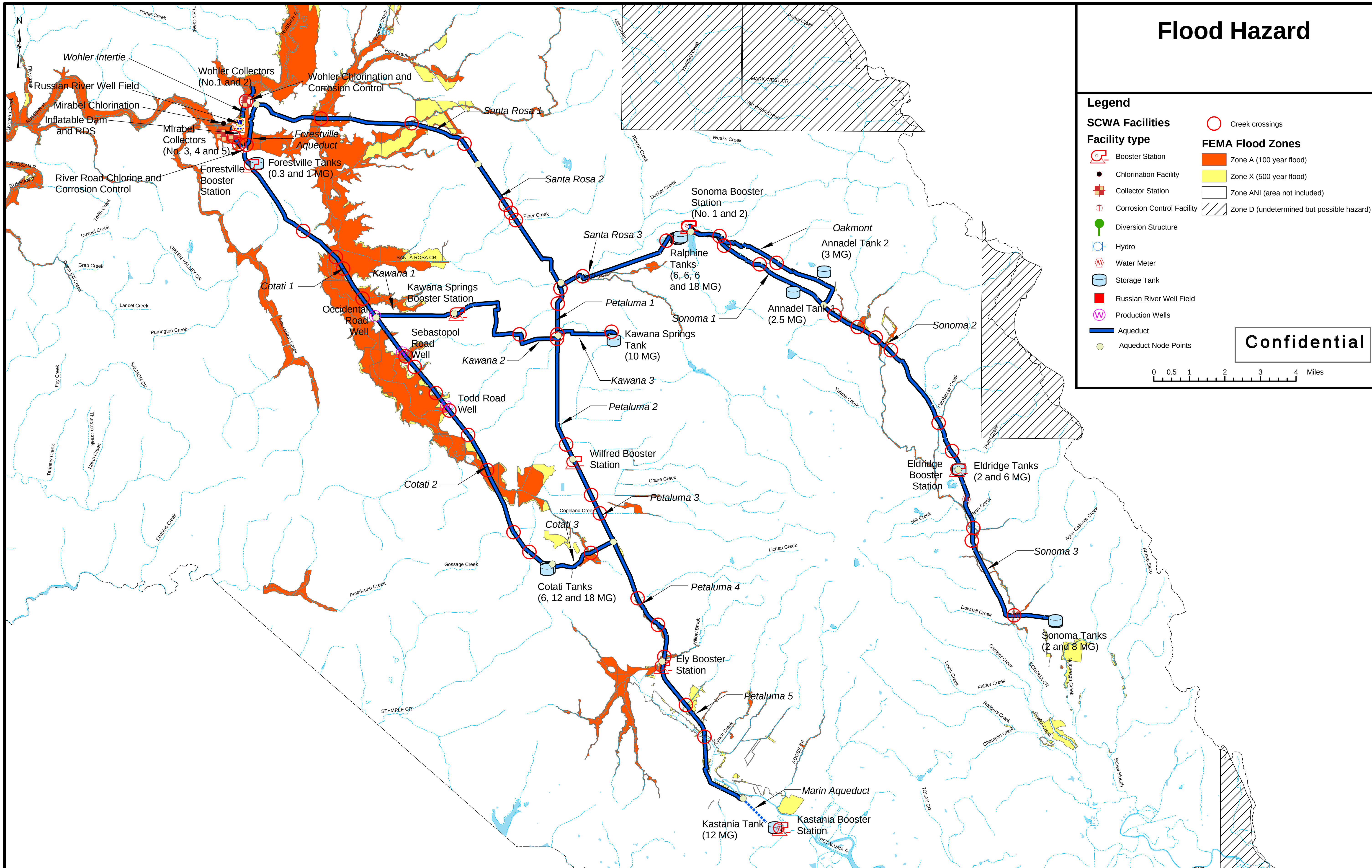


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Figure 11

**CONFIDENTIAL**


MMI ENGINEERING

**Historic Landslides in Sonoma County During 1997-98 El Nino Rainstorms**

**Figure 12**

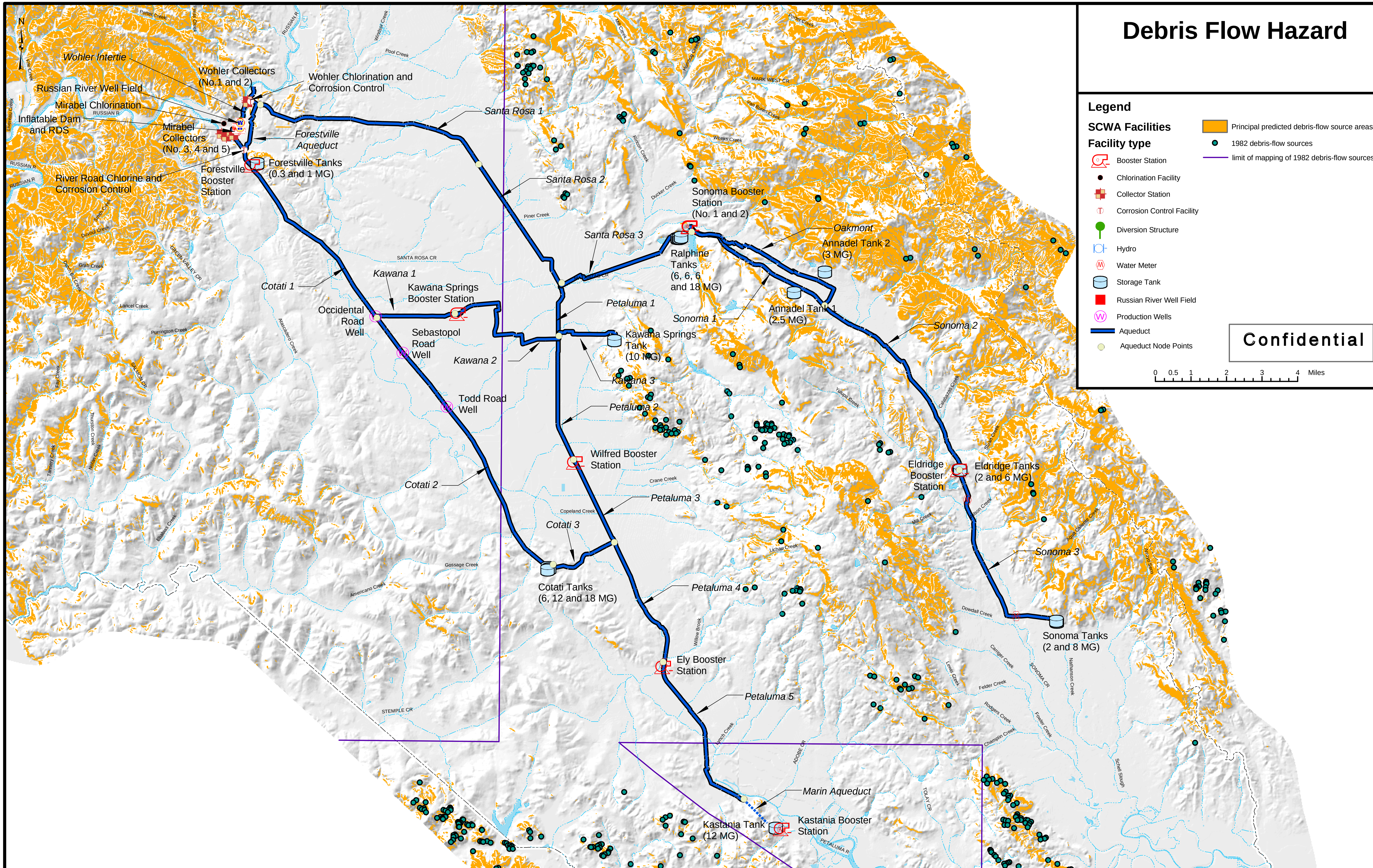
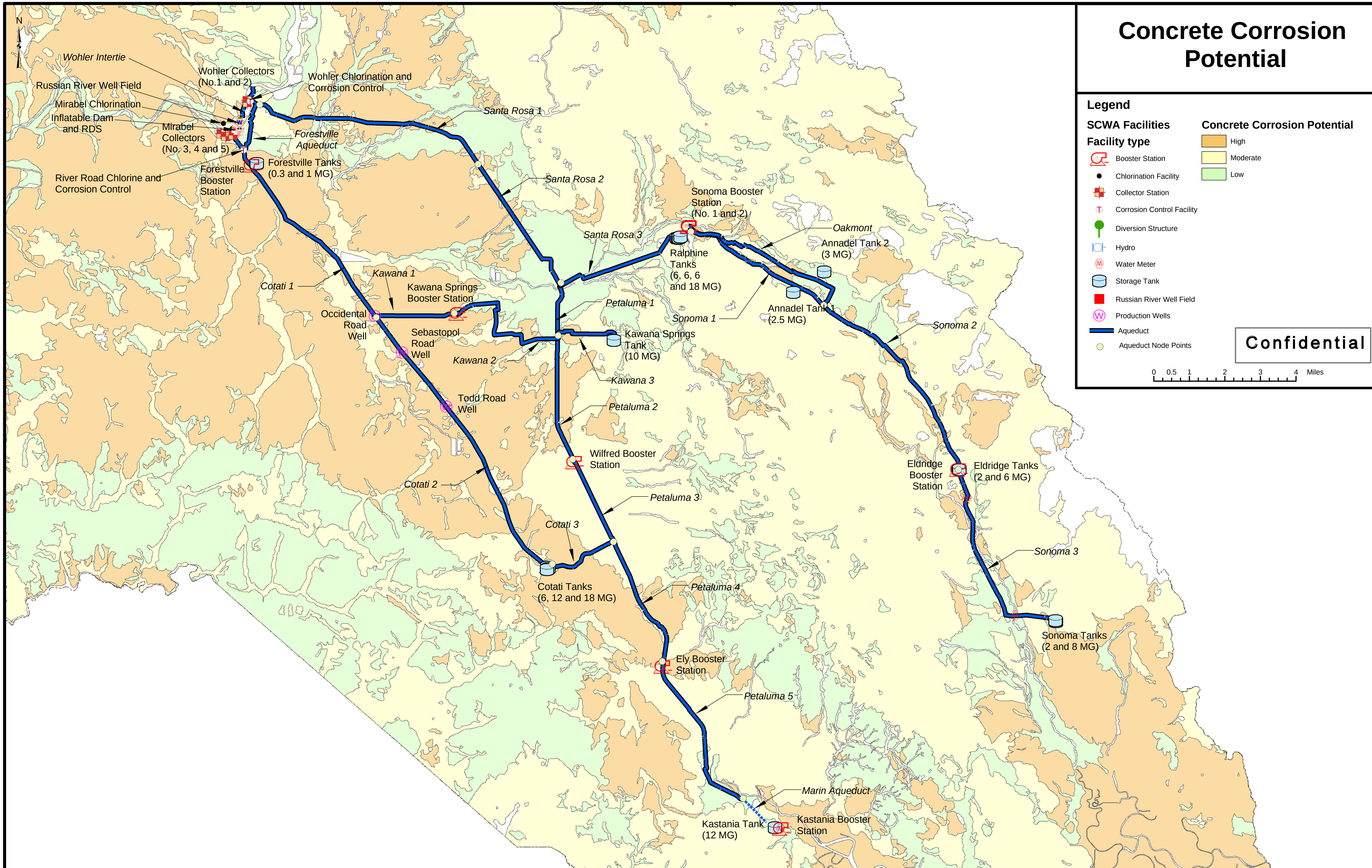
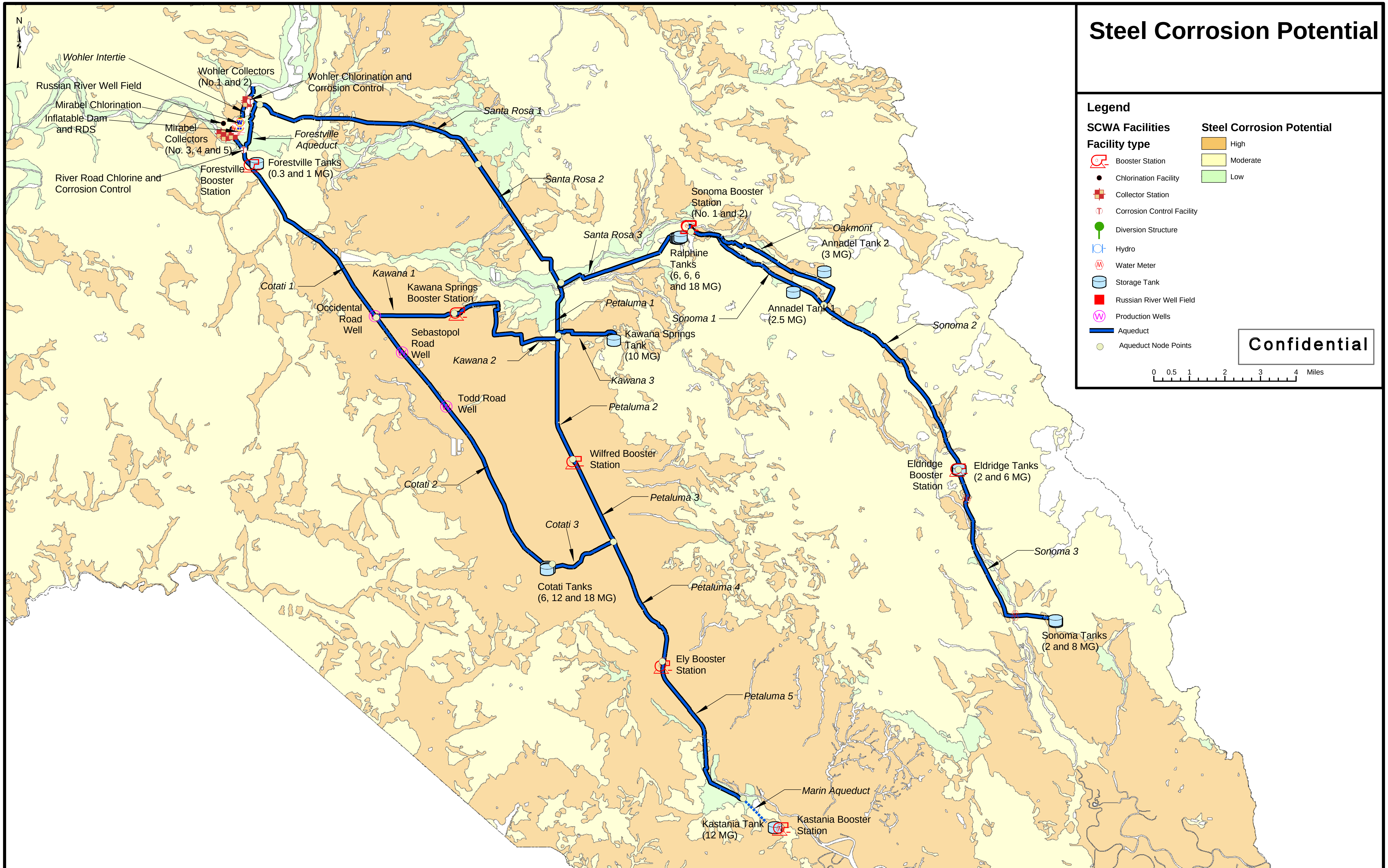

Debris Flow Hazard
Legend
SCWA Facilities
Facility type
Booster Station
Chlorination Facility
Collector Station
Corrosion Control Facility
Diversion Structure
Hydro
Water Meter
Storage Tank
Russian River Well Field
Production Wells
Aqueduct
Aqueduct Node Points
Principal predicted debris-flow source areas
1982 debris-flow sources
limit of mapping of 1982 debris-flow sources
Confidential
0 0.5 1 2 3 4 Miles
N
Wohler Intertie
Wohler Collectors (No.1 and 2)
Wohler Chlorination and Corrosion Control
Russian River Well Field
Mirabel Chlorination
Inflatable Dam and RDS
Mirabel Collectors (No. 3, 4 and 5)
Forestville Aqueduct
Forestville Tanks (0.3 and 1 MG)
River Road Chlorine and Corrosion Control
Forestville Booster Station
Santa Rosa 1
Santa Rosa 2
Santa Rosa 3
Sonoma Booster Station (No. 1 and 2)
Oakmont
Ralphine Tanks (6, 6, 6 and 18 MG)
Annadel Tank 2 (3 MG)
Annadel Tank 1 (2.5 MG)
Sonoma 1
Sonoma 2
Sonoma 3
Cotati 1
Cotati 2
Cotati 3
Kawana 1
Kawana 2
Kawana 3
Kawana Springs Booster Station
Kawana Springs Tank (10 MG)
Occidental Road Well
Sebastopol Road Well
Todd Road Well
Petaluma 1
Petaluma 2
Petaluma 3
Petaluma 4
Petaluma 5
Wilfred Booster Station
Cotati Tanks (6, 12 and 18 MG)
Ely Booster Station
Marin Aqueduct
Kastania Tank (12 MG)
Kastania Booster Station
Eldridge Booster Station
Eldridge Tanks (2 and 6 MG)
Sonoma Tanks (2 and 8 MG)
RUSSIAN R
SANTA ROSA CR
STEMPLE CR
PETALUMA R
SONOMA CR
MARK WEST CR
Porter Creek
Pool Creek
Windsor Creek
Piner Creek
Ducker Creek
Rincon Creek
Crane Creek
Copeland Creek
Gossage Creek
Americano Creek
Lichau Creek
Willow Brook
Dowdall Creek
Felder Creek
Carriger Creek
Rodgers Creek
Fowler Creek
Champlin Creek
Schell Slough
Yulupa Creek
Calabazas Creek
Mill Creek
Lancel Creek
Purrington Creek
Atascadero Creek
Salmon Creek
Ebabias Creek
Thurston Creek
Tannery Creek
Fay Creek
Dutch Bill Creek
Grab Creek
GREEN VALLEY CR
Weeks Creek
Van Buren Creek
Adobe Cr
Tolay Cr
Lewis Creek
Nathanson Creek
Arroyo Seco

Figure 13



Concrete Corrosion Potential
Legend
SCWA Facilities
Facility type
Booster Station
Chlorination Facility
Collector Station
Corrosion Control Facility
Diversion Structure
Hydro
Water Meter
Storage Tank
Russian River Well Field
Production Wells
Aqueduct
Aqueduct Node Points
Concrete Corrosion Potential
High
Moderate
Low
Confidential
0 0.5 1 2 3 4 Miles
N
Wohler Intertie
Wohler Collectors (No.1 and 2)
Wohler Chlorination and Corrosion Control
Russian River Well Field
Mirabel Chlorination
Inflatable Dam and RDS
Mirabel Collectors (No. 3, 4 and 5)
Forestville Aqueduct
River Road Chlorine and Corrosion Control
Forestville Booster Station
Forestville Tanks (0.3 and 1 MG)
Santa Rosa 1
Santa Rosa 2
Santa Rosa 3
Sonoma Booster Station (No. 1 and 2)
Oakmont
Annadel Tank 2 (3 MG)
Ralphine Tanks (6, 6, 6 and 18 MG)
Annadel Tank 1 (2.5 MG)
Sonoma 1
Sonoma 2
Sonoma 3
Kawana 1
Kawana 2
Kawana 3
Kawana Springs Booster Station
Kawana Springs Tank (10 MG)
Cotati 1
Cotati 2
Cotati 3
Occidental Road Well
Sebastopol Road Well
Todd Road Well
Petaluma 1
Petaluma 2
Petaluma 3
Petaluma 4
Petaluma 5
Wilfred Booster Station
Cotati Tanks (6, 12 and 18 MG)
Eldridge Booster Station
Eldridge Tanks (2 and 6 MG)
Sonoma Tanks (2 and 8 MG)
Ely Booster Station
Marin Aqueduct
Kastania Tank (12 MG)
Kastania Booster Station


Figure 14



Steel Corrosion Potential
Legend
SCWA Facilities
Facility type
Booster Station
Chlorination Facility
Collector Station
Corrosion Control Facility
Diversion Structure
Hydro
Water Meter
Storage Tank
Russian River Well Field
Production Wells
Aqueduct
Aqueduct Node Points
Steel Corrosion Potential
High
Moderate
Low
Confidential
0 0.5 1 2 3 4 Miles
N
Wohler Intertie
Wohler Collectors (No.1 and 2)
Wohler Chlorination and Corrosion Control
Russian River Well Field
Mirabel Chlorination
Inflatable Dam and RDS
Mirabel Collectors (No. 3, 4 and 5)
Forestville Aqueduct
Forestville Tanks (0.3 and 1 MG)
Forestville Booster Station
River Road Chlorine and Corrosion Control
Santa Rosa 1
Santa Rosa 2
Santa Rosa 3
Sonoma Booster Station (No. 1 and 2)
Oakmont
Annadel Tank 2 (3 MG)
Ralphine Tanks (6, 6, 6 and 18 MG)
Annadel Tank 1 (2.5 MG)
Sonoma 1
Sonoma 2
Sonoma 3
Kawana 1
Kawana Springs Booster Station
Cotati 1
Occidental Road Well
Sebastopol Road Well
Kawana 2
Petaluma 1
Kawana Springs Tank (10 MG)
Kawana 3
Todd Road Well
Petaluma 2
Wilfred Booster Station
Eldridge Booster Station
Eldridge Tanks (2 and 6 MG)
Cotati 2
Petaluma 3
Cotati 3
Cotati Tanks (6, 12 and 18 MG)
Petaluma 4
Sonoma Tanks (2 and 8 MG)
Ely Booster Station
Petaluma 5
Marin Aqueduct
Kastania Tank (12 MG)
Kastania Booster Station


Figure 15

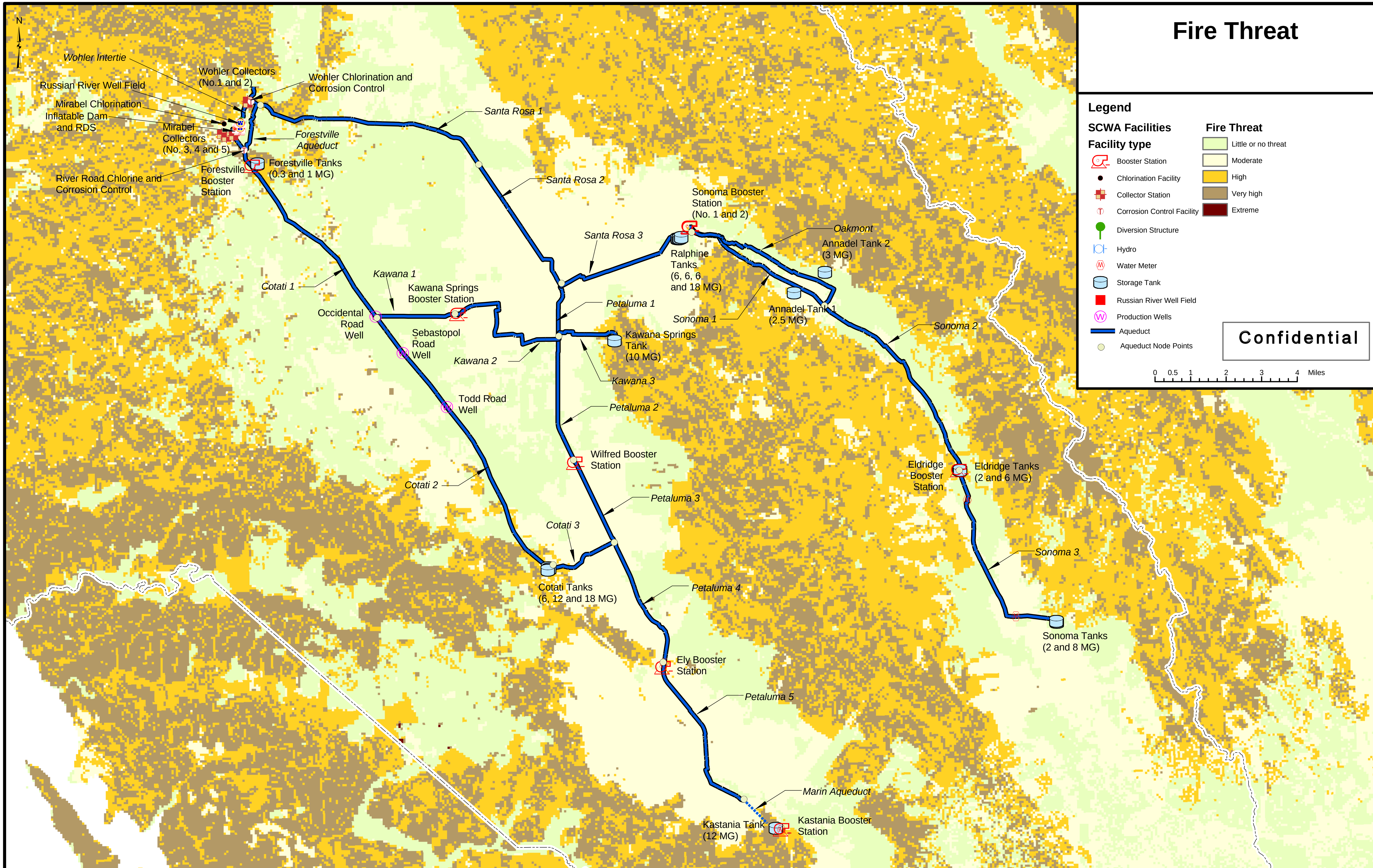



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Figure 16

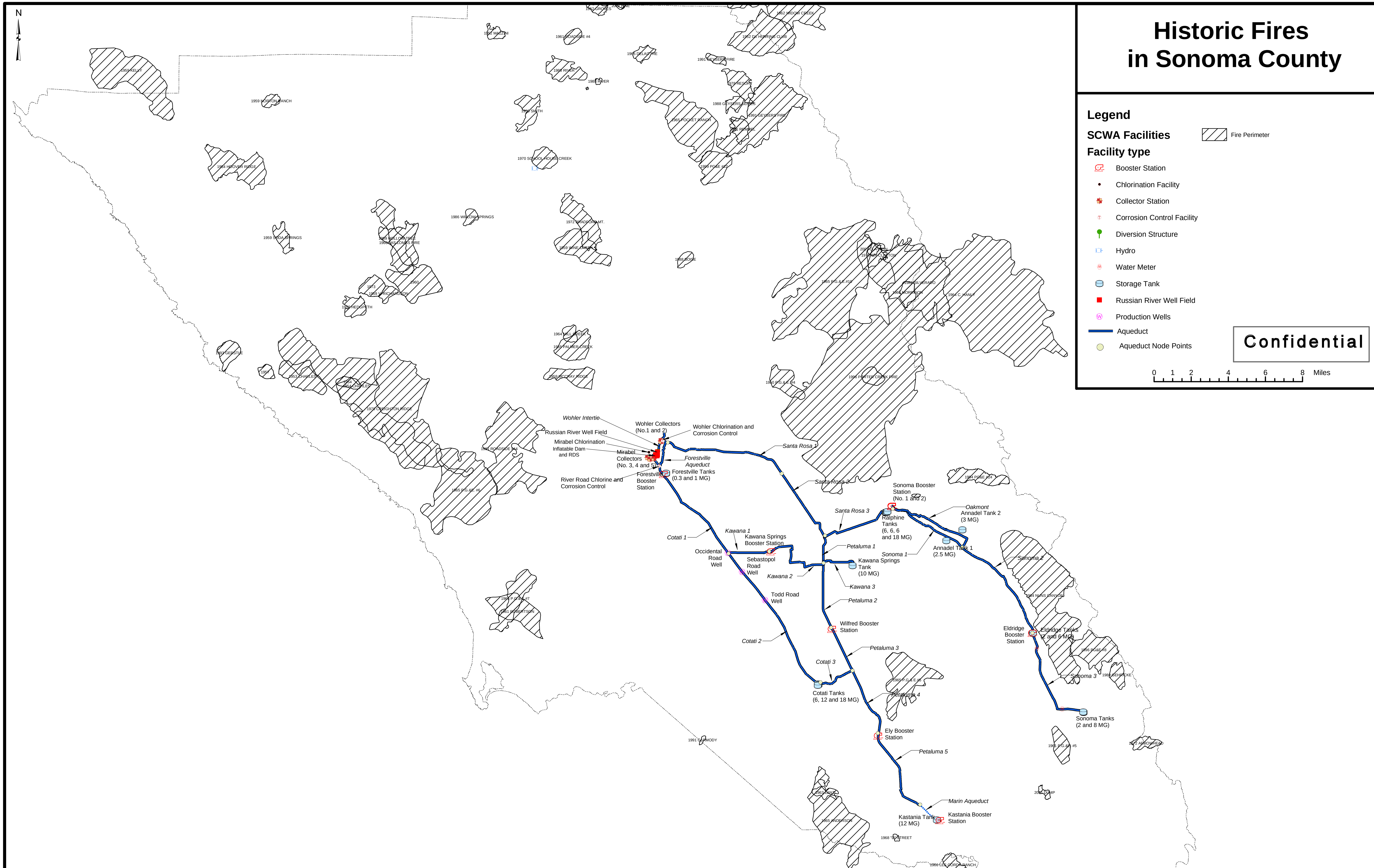


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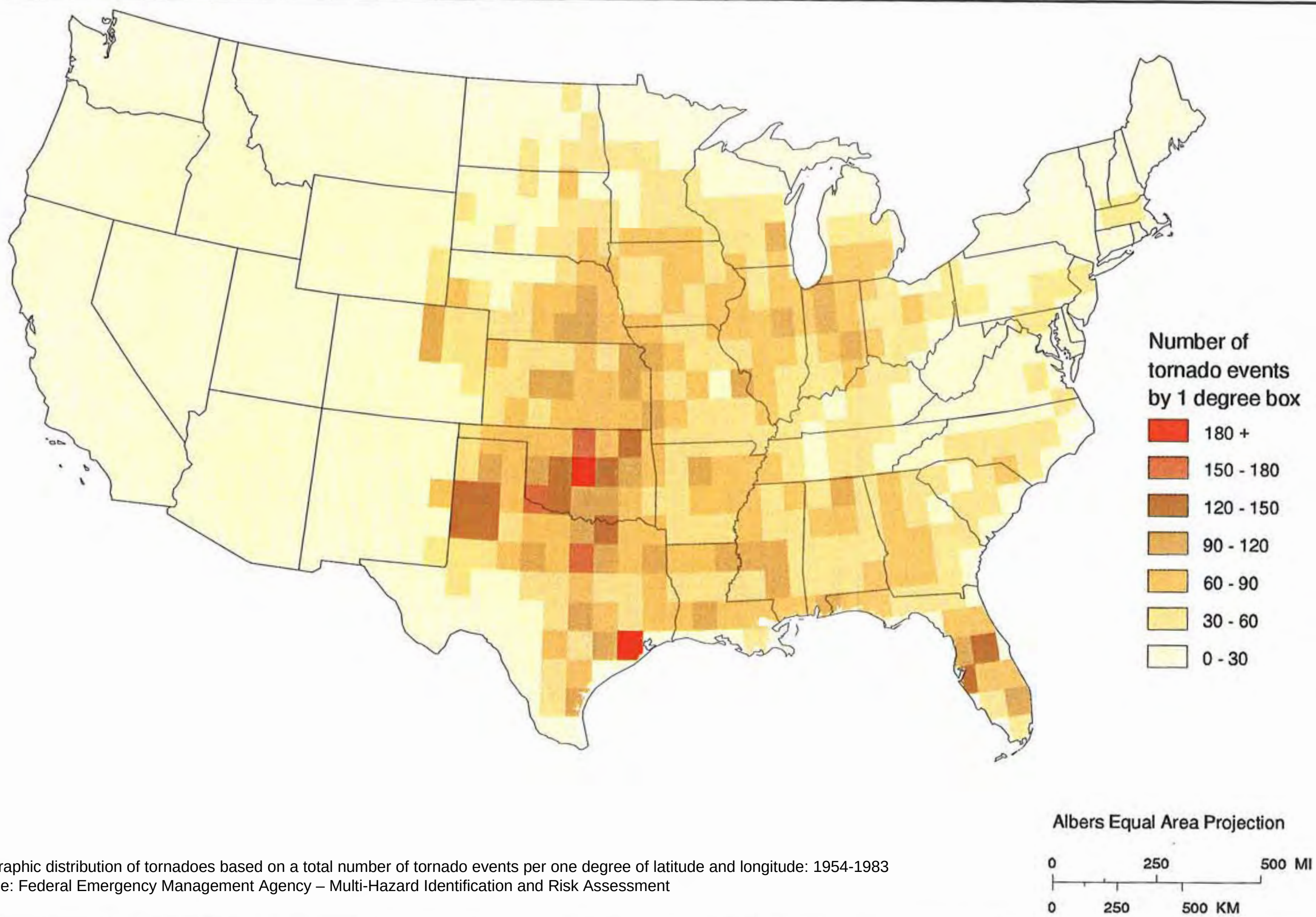
Figure 17

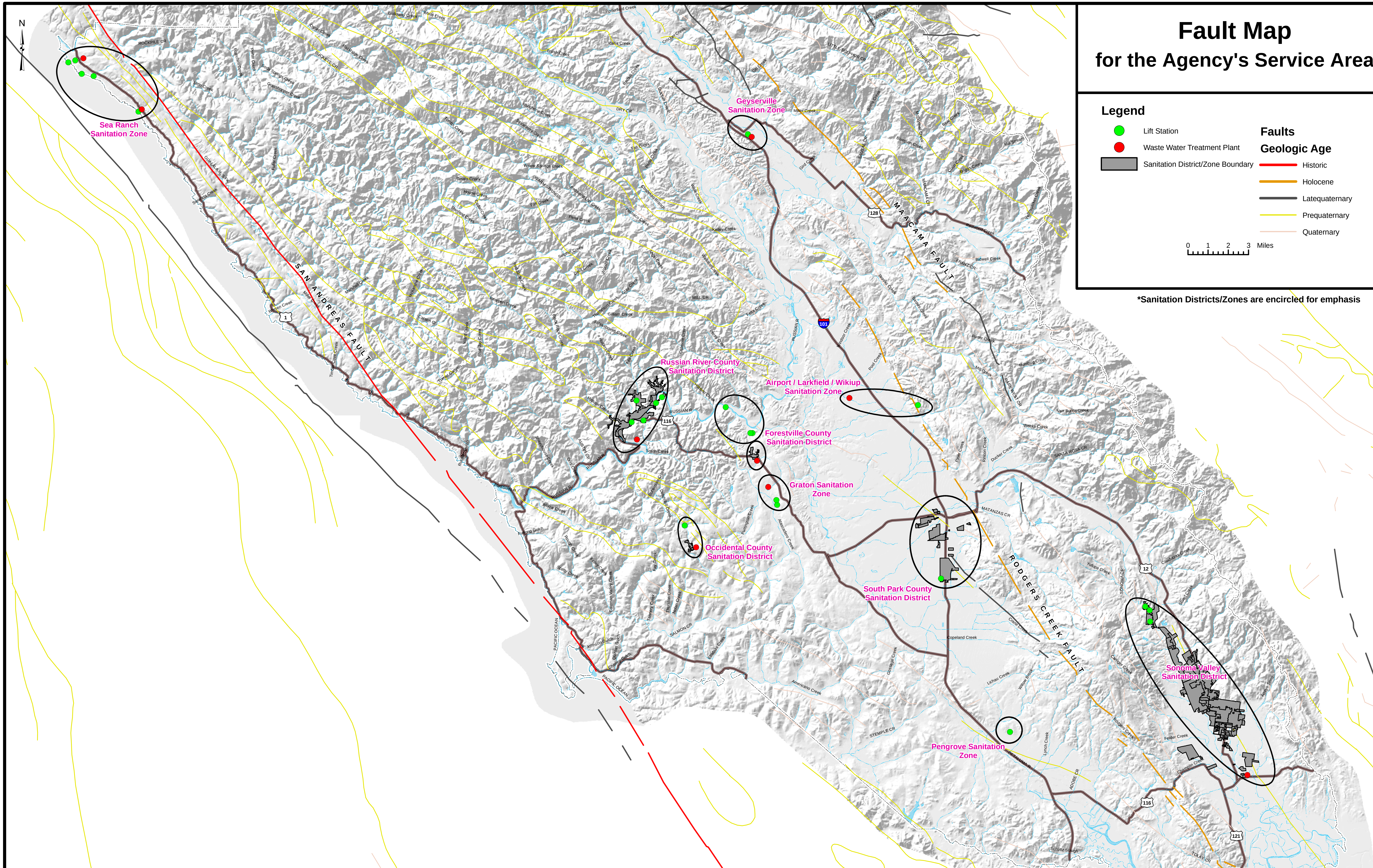



Geographic distribution of tornadoes based on a total number of tornado events per one degree of latitude and longitude: 1954-1983
Source: Federal Emergency Management Agency – Multi-Hazard Identification and Risk Assessment



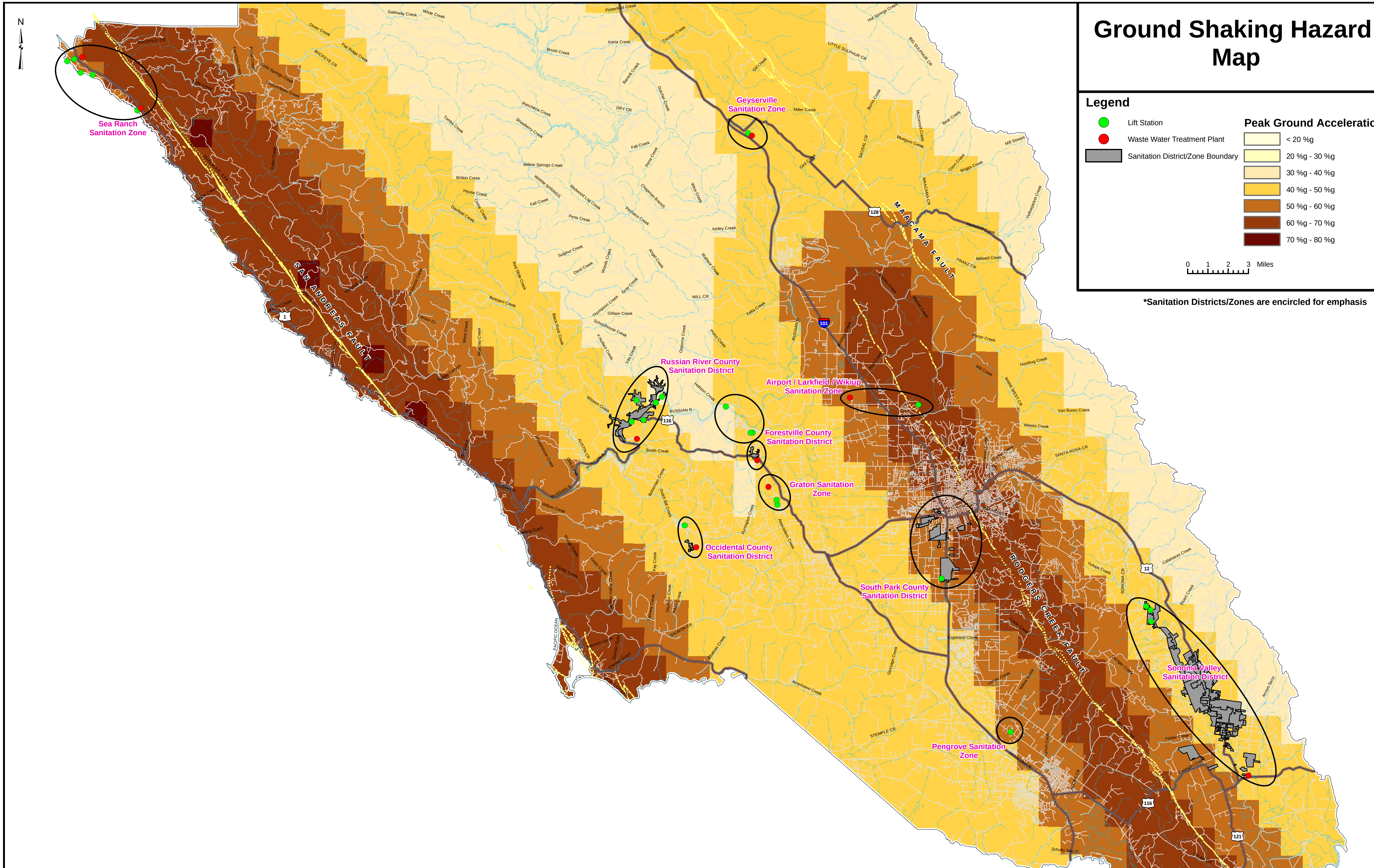
**Tornado Hazard**

**Figure 18**




Fault Map for the Agency's Sanitation System Service Area

Figure 19

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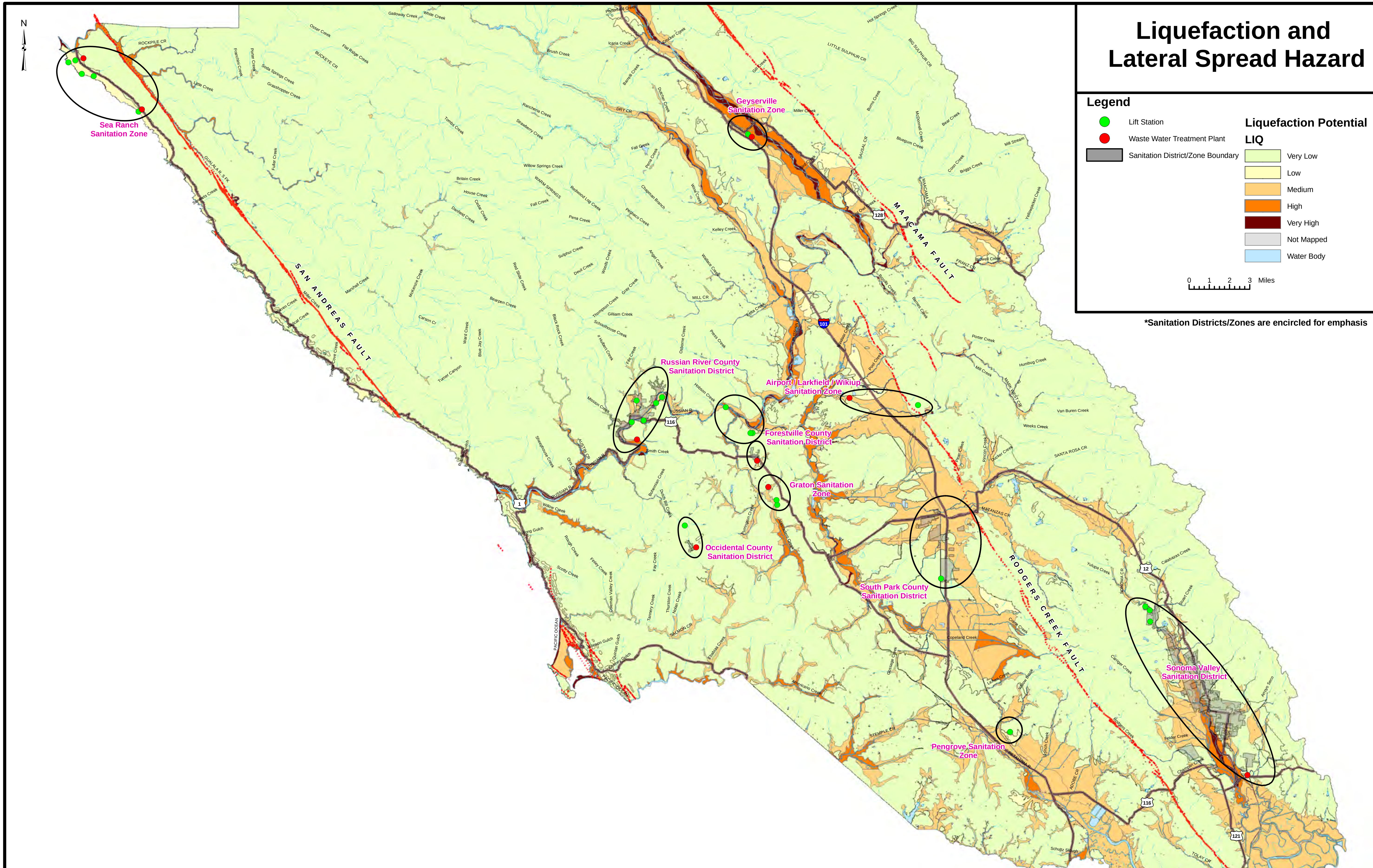
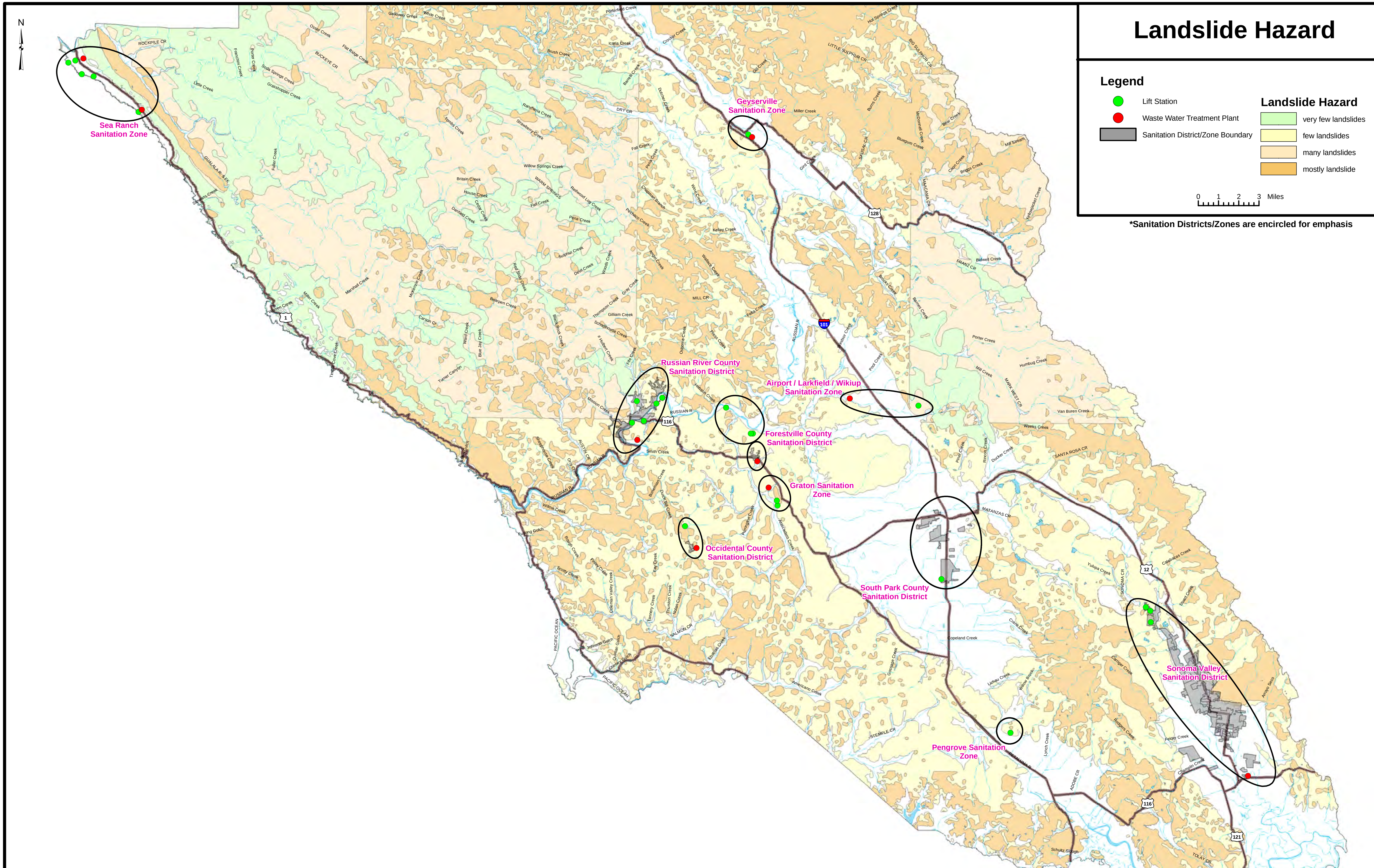
**Ground Shaking Hazard Map (Sanitation System)**

**Figure 20**




Liquefaction and Lateral Spread Hazard Map (Sanitation System)

Figure 21

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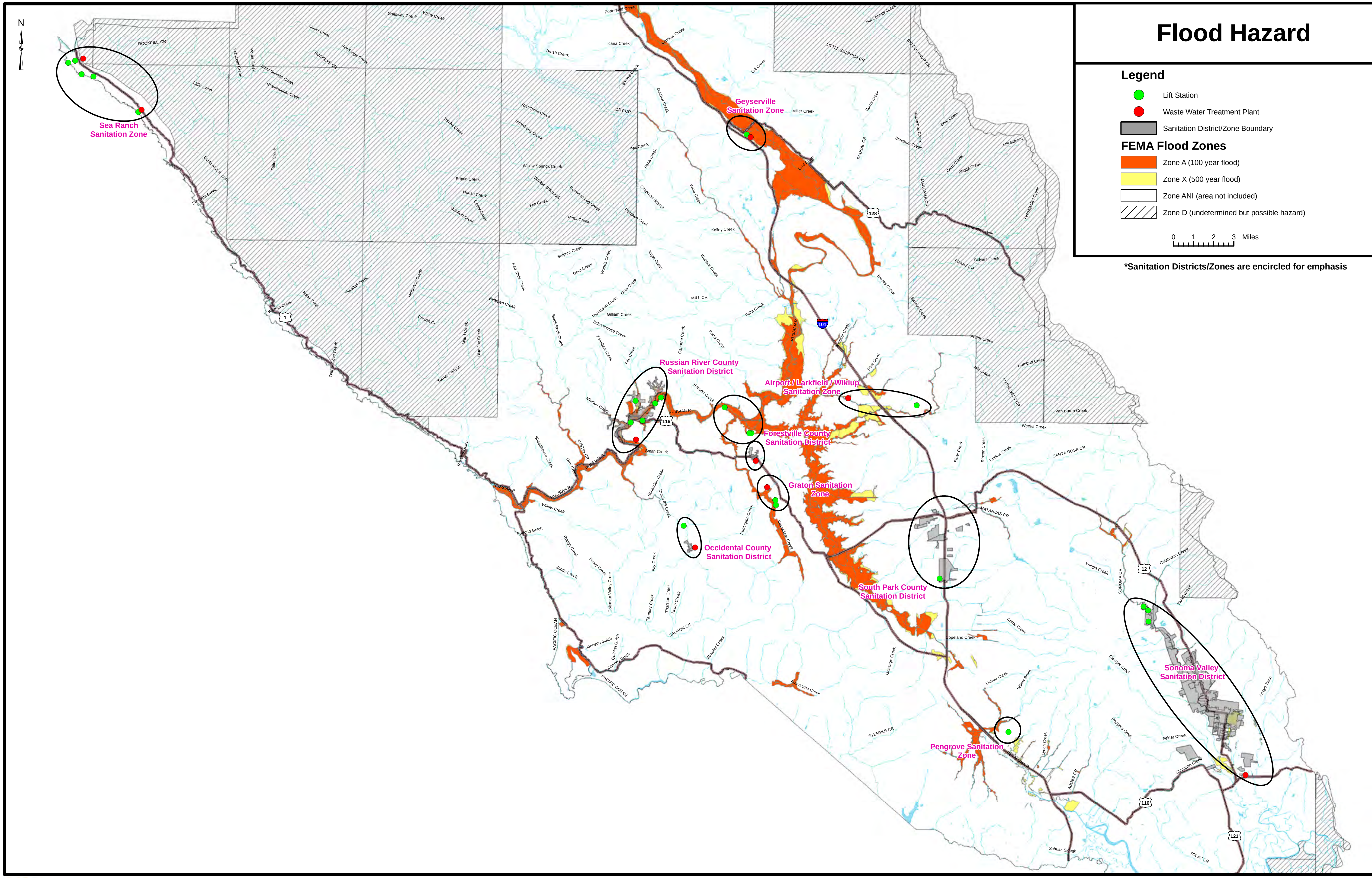
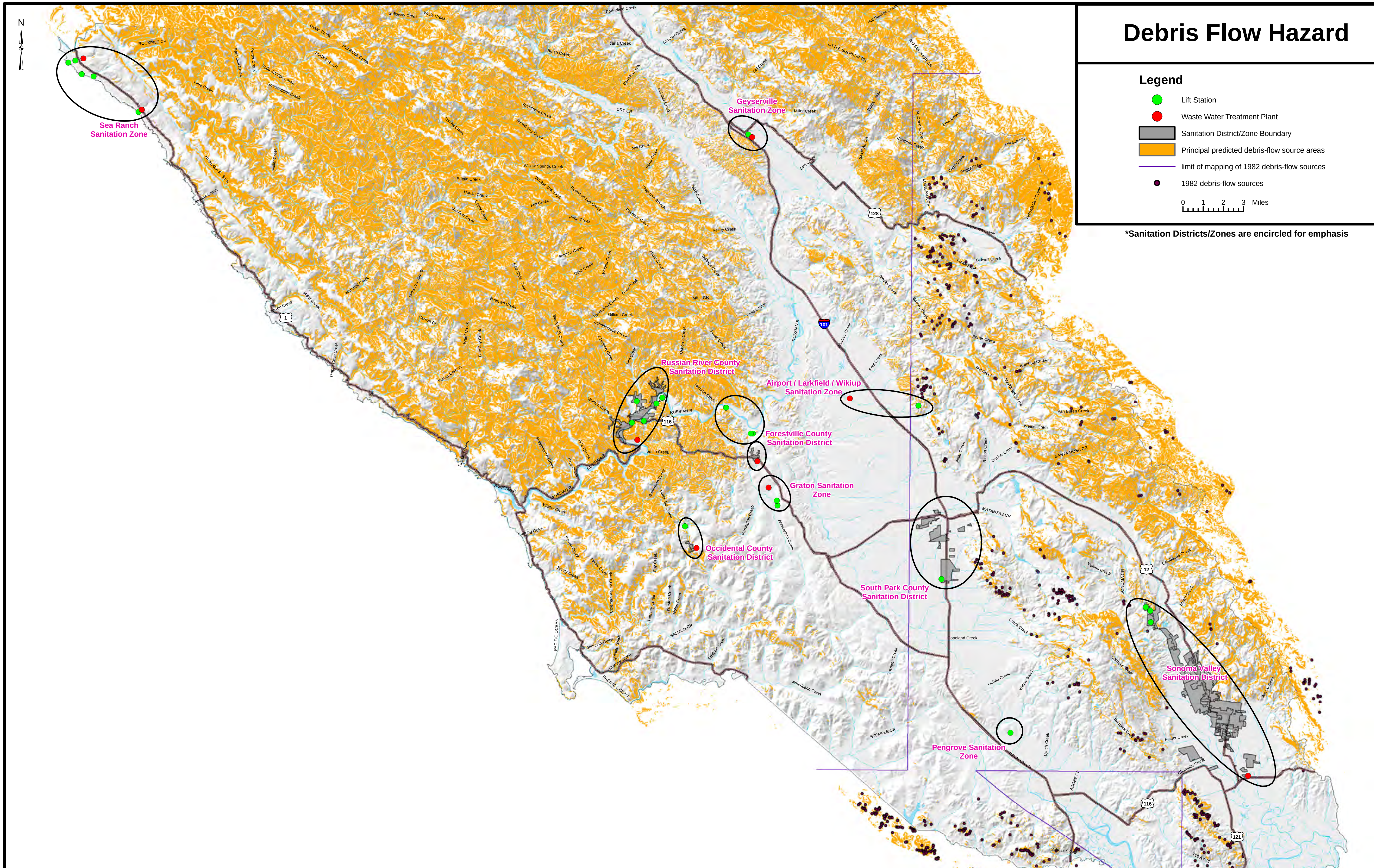
**Landslide Hazard Map (Sanitation System)**

Figure 22



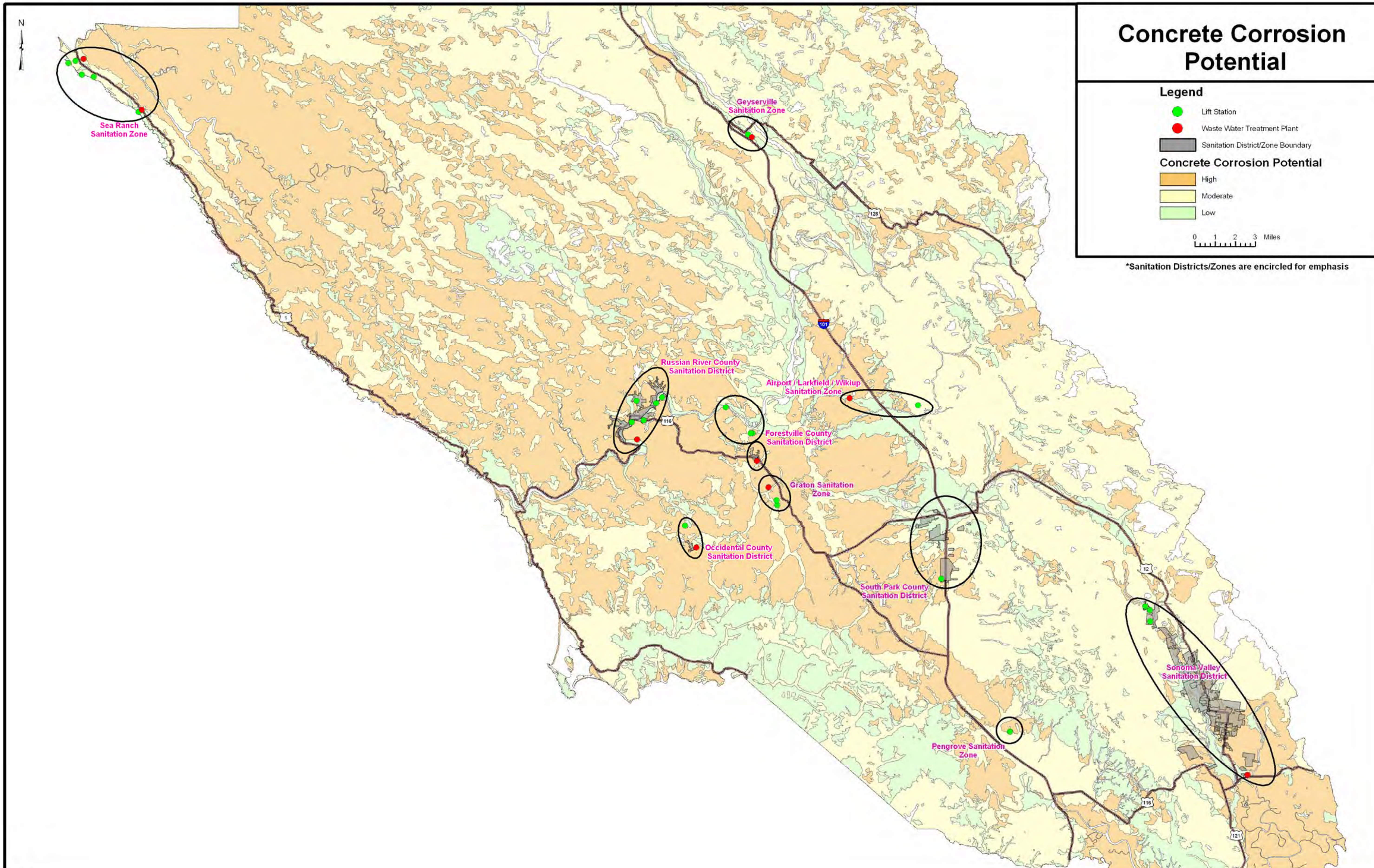

Flood Hazard Map (Sanitation System)

Figure 23




Debris Flow Hazard Map (Sanitation System)

Figure 24

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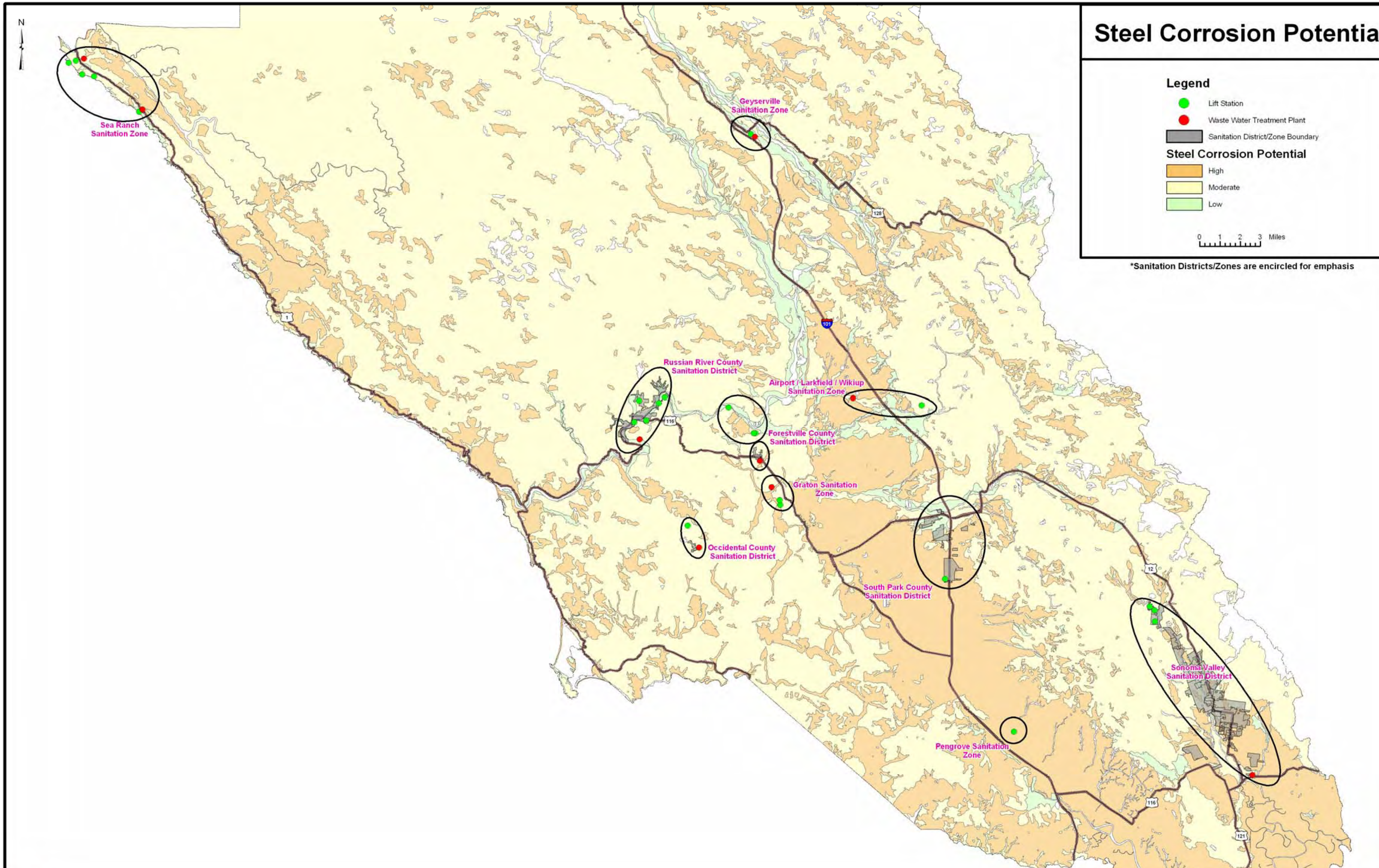
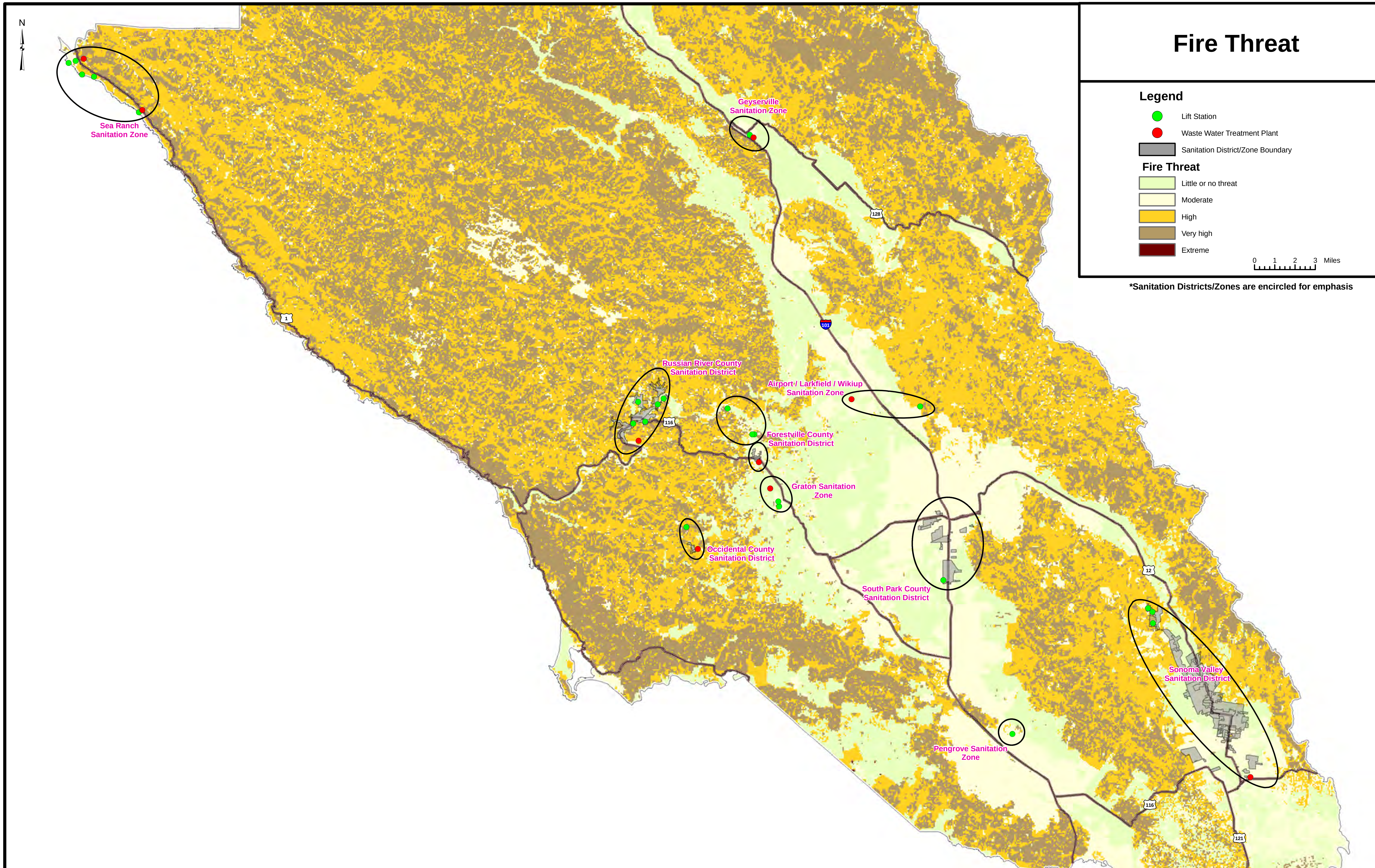
Concrete Corrosion Protection Map (Sanitation System)

Figure 25



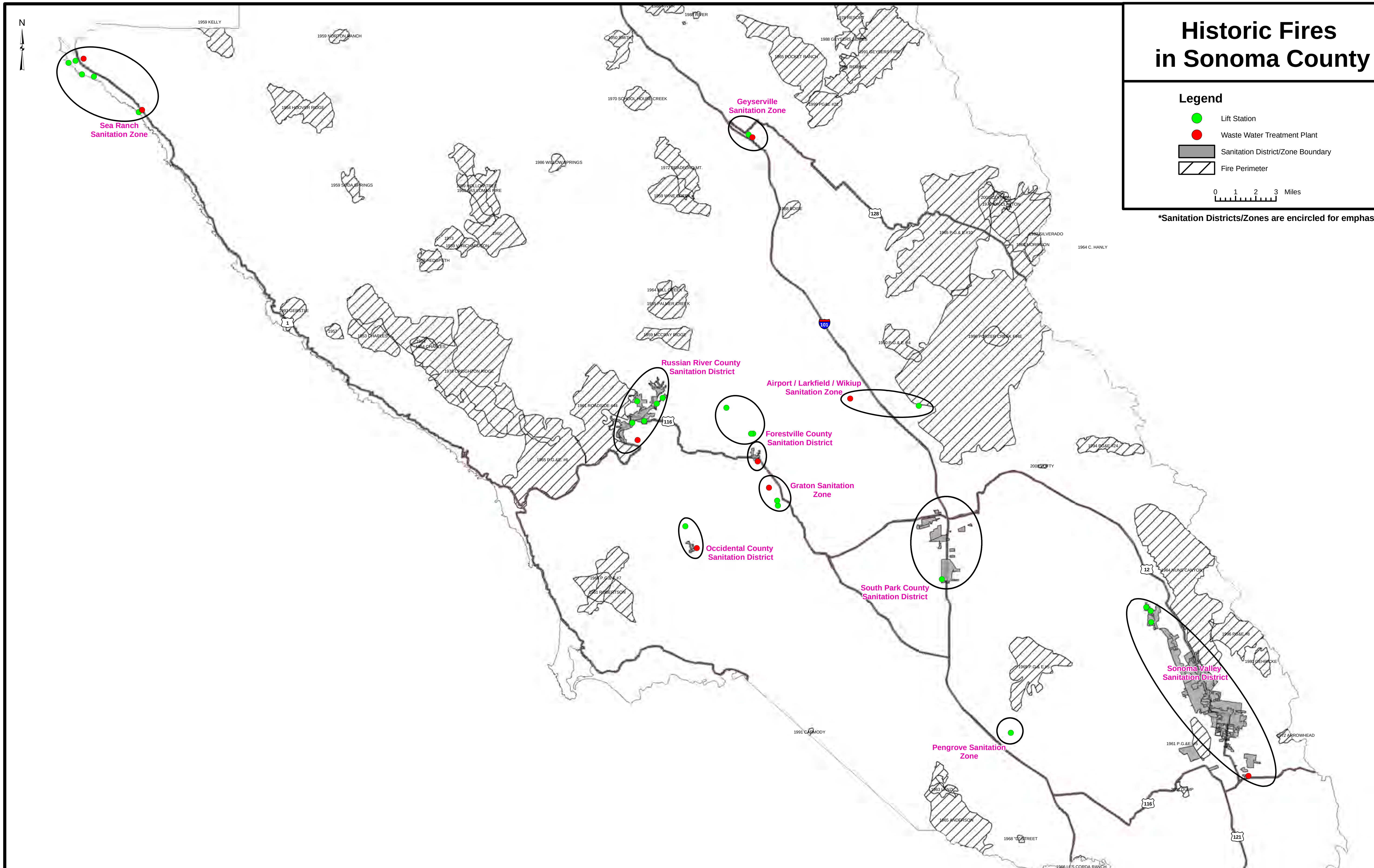

Steel Corrosion Protection Map (Sanitation System)

Figure 26




Fire Threat Map (Sanitation System)

Figure 27

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Historic Fires in Sonoma County (Sanitation System)

Figure 28