CHAPTER 9 – OTHER HAZARDS: RISKS AND MITIGATION

CHAPTER CONTENT

About Chapter 9

Chapter 9 assesses a variety of hazards and risks other than the three hazard groupings of earthquake, flood, and fire hazards examined in *Chapters 6 through 8*. Within this chapter hazards are grouped by "Other Climate and Weather-Influenced Hazards," "Technological Hazards," and "Threat and Disturbance Hazards." As suggested by the headings, the last two hazards groupings represent human-caused rather than natural disasters.

Some but not all of the hazards included in this chapter are typically characterized by more isolated, localized, and/or infrequent disaster incidents. For more information on the criteria and template used for hazard risk assessments and a discussion of the hazard classification system, see *Chapter 1: Introduction, Section 1.2.3*.

9.1 OTHER CLIMATE AND WEATHER-INFLUENCED HAZARDS

California is pursing climate change adaptation through a wide range of guidance and legislation such as Safeguarding California: Reducing Climate Risk, the California Adaptation Planning Guide, Executive Orders S-13-08 (2008) and B-30-15, and Senate Bill (SB) 246 (2015). Matching this state trajectory, the 2018 State Hazard Mitigation Plan (SHMP) integrates climate change considerations throughout the document as climate change has the potential to affect the severity, frequency, and location of hazards events.

Climate change is described broadly in *Section 4.3* and then discussed more specifically for each of the hazards potentially affected. These hazards require consideration of climate change in assessing risk and devising mitigation measures.

Section 9.1 assesses hazards that are influenced and potentially exacerbated by changes in climate and weather patterns, with the exception of various landslide, flood, and wildfire hazards, which are covered extensively in *Chapters 6, 7, and 8*. The discussion is limited to scientific assessments reviewed and validated by the appropriate state agency for the hazard and do not include the entirety of the peer-reviewed scientific literature. The National Aeronautics and Space Administration (NASA) provides the following description of these terms:

> *Weather is basically the way the atmosphere is behaving, mainly with respect to its effects upon life and human activities. The difference between weather and climate is that weather consists of the short-term (minutes to months) changes in the atmosphere. Most people think of weather in terms of temperature, humidity, precipitation, cloudiness, brightness, visibility, wind, and atmospheric pressure, as in high and low pressure. In most places, weather can change from minute-to-minute, hour-to-hour, day-to-day, and season-to-season. Climate, however, is the average of weather over time and space*.[233]

Long-term changes in the climate, especially those driven by the accumulation of human-created greenhouse gases in the atmosphere, are expected to change short-term weather patterns and thus change weather-related impacts, both short- and long-term. Most prominently, climate change is warming the average global temperatures, which will result in more frequent and intense extreme events related to changes in temperature and precipitation, such as heat waves and flooding.

In the SHMP, climate change is treated as a condition that will change and potentially exacerbate the impact of other hazards rather than as a distinct hazard with unique impacts. For example, extreme heat and heat waves are an existing hazard that will be exacerbated by climate change.

Impacts of climate change on the frequency, timing, and magnitude of flooding vary with the geography throughout the state. Areas that experience early run off from snowmelt coupled with intensified rain or coastal areas experiencing sea-level rise may be more affected by flooding than other areas of the state. Hazards that have the potential to be affected by climate change are grouped in this section. However, it is important to note that the hazards grouped in this section can also occur independent of climate change conditions.

It should also be noted that this section presents the "other climate and weather-influenced hazards" in alphabetical order. No hierarchy or ranking of priority of these hazards, or the climate-influenced hazards included in other chapters of the SHMP is implied.

[233] http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

9.1.1 AGRICULTURAL AND SILVICULTURAL PESTS AND DISEASES

Identifying Insect Pest and Disease Hazards

California agriculture and forests are at risk from pests and diseases that, under certain conditions, can cause severe economic, environmental, or physical harm. Table 9.A identifies pests and diseases of concern.

Table 9.A: California Agriculture Pests and Diseases

Dangerous to	Pests and Diseases
Crops and other plants	Asian citrus psyllid/-Huanglong Bing (HLB) disease, Caribbean fruit fly, glassy-winged sharp shooter/Pierce's Disease, European grapevine moth, guava fruit fly, gypsy moth, Japanese beetle, Mediterranean fruit fly, melon fruit fly, Mexican fruit fly, olive fruit fly, oriental fruit fly, bark beetle
Trees	Polyphagous shot hole borers, bark beetle, gold spotted oak borer, sudden oak death (*Phythothora ramorum*), pitch canker, emerald ash borer, Asian longhorn beetle
Livestock or poultry	Foot and mouth disease, highly pathogenic avian influenzas (H5 and H7), Exotic Newcastle Disease
Humans	Africanized honeybee, mosquito
All	Red imported fire ant, bovine spongeform encephalopathy, zoonotic animal viruses

Source: http://www.cdfa.ca.gov/PHPPS/pdep/target_pests.html
Source: http://www.cdfa.ca.gov/ahfss/Animal_Health/pdfs/CA_Reportable_Disease_List_Poster.pdf

Agriculture pests and diseases can result in economic and human health disasters. For example, insect pest hazards can have a major economic impact on farmers, farm workers, packers, and shippers of agricultural products. They can also cause significant increases in food prices for consumers due to shortages. In addition, insect pests and diseases such as bark beetles, sudden oak death, and pitch canker in trees can destroy large expanses of forest and woodland, increasing the fuel load and contributing to greater fire risk.

Profiling Pest and Disease Hazards

Asian Citrus Psyllid

The Asian citrus psyllid (ACP) is a pest that acts as a carrier or vector spreading "Huanglong Bing" (HLB), a devastating disease of citrus trees. This bacterial disease is transmitted to healthy trees by the psyllid after it feeds on infected plant tissue.

The ACP damages citrus by withdrawing large amounts of sap from the plant and producing copious amounts of honeydew. The honeydew coats the leaves of the tree, causing sooty mold to grow. However, the most serious damage caused by ACP is due to its ability to effectively introduce a harmful bacterium that causes HLB disease. HLB is the most devastating disease of citrus in the world. HLB renders the fruit of the infected tree unusable. In a recent study in Florida, the presence of HLB increased citrus production costs by 40 percent.[234] It is estimated that over the last five years in Florida, HLB has caused the loss of over 6,600 jobs, over $1.3 billion in lost revenue to the citrus industry, and the loss of over $3.6 billion in total economic activity.[235]

As of 2017, California is actively eradicating the ACP and has identified only one plant infected with HLB.

Shot Hole Borer Beetles

The polyphagous shot hole borer (PSHB) and Kuroshio shot hole borer (KSHB) (Euwallacea spp.) are insects native to Southeast Asia; PSHB is from Vietnam and KSHB is from Taiwan. The known host range is huge, including 207 species in 58 plant families.

[234] Irey et al. 2008
[235] Hodges and Spreen 2012

Native California host species that can be infected by the shot hole borer include coast live oak and riparian species such as California sycamore, Fremont cottonwood, red willow, box elder, maples, and white alder. The effects of PSHB and KSHB on oak woodland and riparian ecosystems have subsequently decreased rangeland and recreational value, and increased fire risk in Southern California. Urban shade trees including English oak, silk tree, coral tree, Titoki tree, and Liquidambar (sweetgum) also host the shot hole borer. Loss of shade trees can have serious aesthetic and health effects. Commercial agricultural hosts include avocado, persimmon, olive, macadamia, eastern mulberry, hazelnut, loquat, peach, grapevine, citrus, cassava, and crabapple. Damages to these important commercial crops can cause severe economic losses.

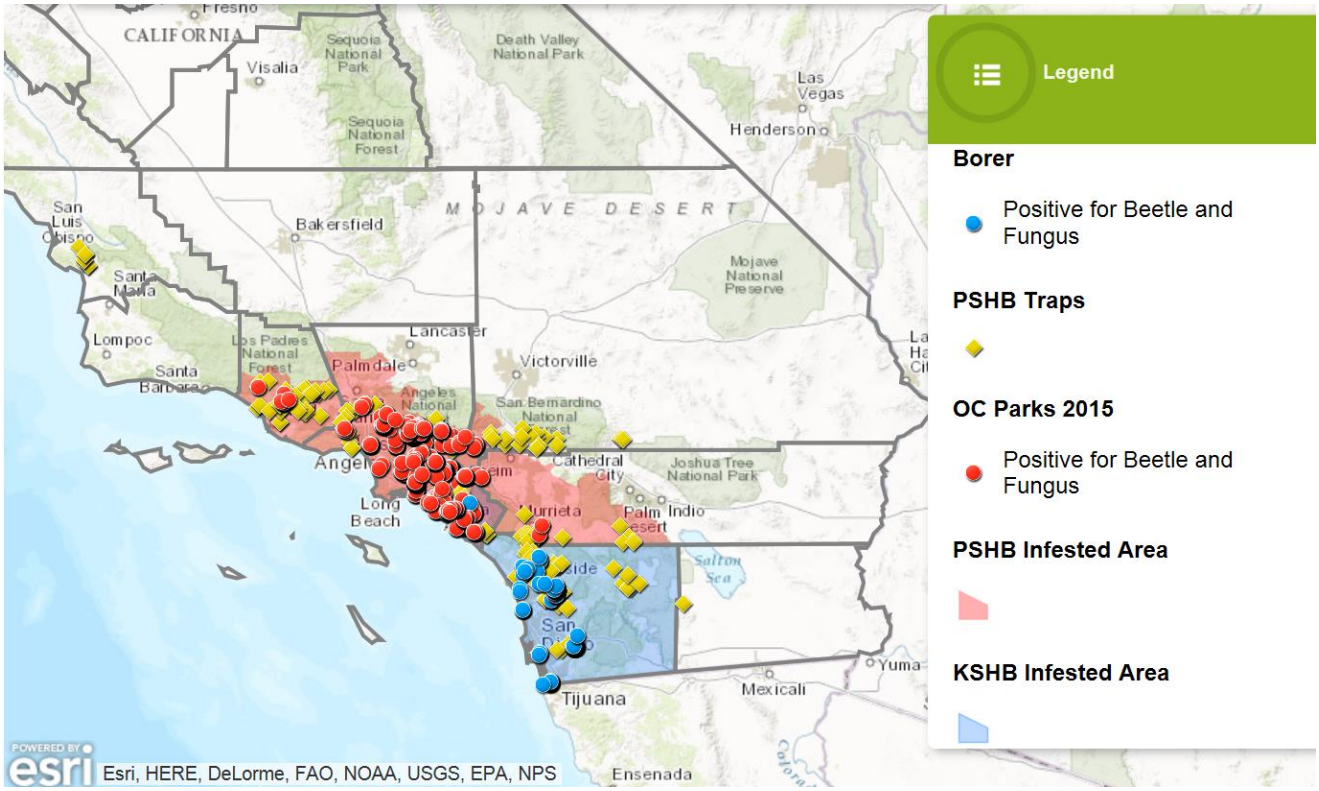
Some trees are reproductive hosts, while some are attacked but do not support the full development of the insect and the associated fungi. Table 9.B summarizes the different categories of host species in California, and Map 9.A shows spread of the PSHB and KSHB in the southern portion of the state.

Table 9.B: California Agricultural and Silvicultural Pests and Diseases, Change from 2012 to 2016

Number of:	2012	2016
Tree species attacked by beetle	286	303
Tree species infected by fungus	117	138
Agricultural crops affected	13	13
California native tree species affected	11	18
Tree families affected	62	64
Reproductive hosts	19	41

Source: California Board of Forestry and Fire Protection

Map 9.A: Polyphagous Shot Hole Borer and Kuroshio Shot Hole Borer Spread in Southern California



Source: Eskalen Lab, Department of Plant Pathology and Microbiology, University of California, Riverside (2016), https://ucanr.edu/sites/pshb/Map/.

Shot hole borers are moving toward northern areas already affected by tree mortality from bark beetle, which further threatens forests in Central California. Most pests prefer distressed or dying trees, but shot hole borers typically attack healthy trees. See *Section 9.1.11, Tree Mortality,* to learn more about vulnerability and mitigation strategies in those regions.

Bark Beetles

Native California conifer trees in the southern Sierra Nevada weakened by years of drought have experienced elevated levels of mortality from bark beetles. Bark beetles are host-specific, generally only attacking a preferred size class of a specific tree species. Bark beetles of specific concern include the western pine beetle (*Dendroctonus brevicomis*) which primarily attacks ponderosa pine; mountain pine beetle (*Dendroctonus ponderosae*), which primarily attacks sugar pine; fir engraver beetle (*Scolytus ventralis*) which primarily attacks true firs (white and red fir); and Jeffrey pine beetle (*Dendroctonus jeffreyi*), which primarily attacks Jeffery pine.

Total tree mortality in California counties from Kern County in the southern portion of the state to Placer County in the north was estimated to be upward of 75 million trees according to 2016 U.S. Forest Service aerial detection survey data. This mortality extends across both private and federal timberlands.

Foot and Mouth Disease

Foot and mouth disease (FMD) is a debilitating disease affecting all cloven–hoofed animals, including cattle, pigs, and sheep. Clinical signs commonly seen in cattle are drooling, lip smacking, and lameness, caused by blisters (vesicles) on the tongue, dental pad, and feet. Sheep and pigs have similar, but often less pronounced, clinical signs.

Many nations in the world are either endemic for various strains of FMD virus or dealing with FMD outbreaks. As of September 2017, there are 181 member counties of the World Organization for Animal Health, or OIE. Of these member countries, 98 have no official status, 68 are categorized as FMD-free, and 15 have FMD-free zones with and without vaccination use. As of 2017, North America and the majority of South America, Western Europe, New Zealand, Australia, and most Pacific island nations are free of the disease.[236] As of 2017, the following countries identified as having continuing FMD infection: Angola, Armenia, Botswana, Iran, Israel, Kuwait, Malawi, Mongolia, Morocco, Mozambique, Namibia, People's Republic of China, Saudi Arabia, South Africa, South Korea, Taiwan, Turkey, Zambia and Zimbabwe.[237] There are other countries where FMD is endemic, but they are not being tracked via OIE's "Immediate Notification and Follow-ups" reports.

Globally, the FMD virus situation changes quickly; the most current information is available in the OIE/World Animal Health Information Database.[238] The California Department of Food and Agriculture (CDFA) and the United States Department of Agriculture (USDA) work cooperatively to closely monitor and regulate the movement of livestock and animal products. Despite these efforts, the risk of disease introduction is always present. Viruses, bacteria, and pests are not controlled by borders and are capable of entering on imported animals, meat and meat products, travelers' clothing and shoes, equipment, and other contaminated objects. CDFA maintains a biosecurity web site providing information on biosecurity measures and provides specific training and exercises to prevent the introduction of this disease into the state and nation. The last outbreak of FMD in California was in 1929.

Bovine Spongiform Encephalopathy

Bovine spongiform encephalopathy (BSE), widely known as "Mad Cow Disease," is a fatal disease of cattle first recognized in the United Kingdom in 1986. Most research suggests that an abnormal protein, known as a prion, causes BSE. Scientific evidence shows the same disease agent that causes BSE in cattle also causes the new human disease, variant Creutzfeldt–Jakob disease. BSE spreads in cattle primarily through animal feed containing processed ruminant products. Cattle infected with BSE take two to eight years before showing signs of disease, which include changes in temperament such as nervousness or aggressiveness, and progressive incoordination.

[236] https://www.cdfa.ca.gov/ahfss/Animal_Health/FMD_Info.html
[237] https://www.cdfa.ca.gov/ahfss/Animal_Health/FMD_Info.html
[238] http://www.oie.int/

The National Veterinary Services Laboratory in Ames, Iowa, confirmed that a routine surveillance sample obtained from a Holstein cow carcass at a rendering plant in the Central Valley of California was positive for the atypical strain of BSE. No part of this carcass entered the human or animal food chain.

Other Animal Pests and Diseases

Diseases such as Exotic Newcastle Disease in poultry and tuberculosis in dairy cattle are credible threats to the state food supply and economy. Other diseases such as anthrax, and Deforming Wing Virus in honeybees, also pose a serious threat to the food supply.

Climate Change and Insect Pests and Diseases Hazard

California farmers contend with a wide range of crop-damaging pests and pathogens. Continued climate change is likely to alter the abundance and types of many pests, lengthen pests' breeding season, and increase pathogen growth rates. For example, the pink bollworm, a common pest of cotton crops, is currently a problem only in southern desert valleys because it cannot survive winter frosts elsewhere in the state. However, if winter temperatures rise 3 to 4.5 degrees Fahrenheit (°F), the pink bollworm's range would likely expand northward, which could lead to substantial economic and ecological consequences for the state.

According to a 2012 California Energy Commission report "Vulnerability and Adaptation to Climate Change in California Agriculture," change in climate can directly impacts crop growth through new temperature patterns and northward shifts of pests and disease. Additionally, longer growing seasons will possibly enable pest species to complete more reproductive cycles, which can increase severity of infestations.[239]

Temperature is not the only climatic influence on pests. For example, some insects are unable to cope in extreme drought, while others cannot survive in extremely wet conditions. Furthermore, while warming speeds up the lifecycles of many insects, suggesting that pest problems could increase, some insects may grow more slowly as elevated carbon dioxide levels decrease the protein content of the leaves on which they feed.

Possible future strategies to address climate change influences on insect pests and diseases might include:

- Inventorying and monitoring invasive species that threaten crops
- Downscaling climate change data to allow informed decisions on biodiversity planning by farmers and rural communities
- Strengthening the dissemination of knowledge, appropriate technologies, and tools to improve management practices related to agricultural biodiversity and ecosystem services

The above strategies were derived from Food and Agriculture Organization of the United Nations, Climate Change for Food and Agriculture, Technical Background Document from the Expert Consultation, 2008, available at: http://www.fao.org/uploads/media/FAO_2008a_climate_change_and_biodiversity_02.pdf.

Assessment of State and local Vulnerability and Potential Losses

No known state vulnerability or loss assessment is available at this time. Information related to community vulnerability and loss assessments may be found in Local Hazard Mitigation Plans.

Current Insect Pests Hazard Mitigation Efforts

Agricultural Pests

The California Department of Food and Agriculture (CDFA) has extensive responsibilities for protecting the food supply, including protecting and responding to the invasion of plant diseases and pests. As part of the Plant Health and Pest Prevention Services and Pierce's Disease Control Program, CDFA administers the statewide programs.

[239] California Energy Commission, 2012. http://www.energy.ca.gov/2012publications/CEC-500-2012-031/CEC-500-2012-031.pdf

These includes the statewide exterior exclusion program, border protection stations, pest detection and emergency projects, trapping, interior exclusion quarantine programs, and Integrated Pest Control weed eradication and biological control programs.

The prevention, detection, immediate containment, and eradication of emergency animal diseases are high priorities. Some animal diseases have human health implications, and all affect production and marketability of livestock and poultry. Therefore, addressing animal disease contributes to a solid foundation for economic prosperity while decreasing human health risks for the people of California. Activities to achieve these goals include outreach and educational services, routine disease surveillance and disease investigations to detect the introduction and spread of injurious animal pests and diseases, and, when necessary, implementation of animal quarantine to control the spread of disease. The California Conservation Corps assists in mitigating the impacts of insect pests by providing human resources to assist in state and local eradication efforts, including surveying private yards and business landscapes to detect the glassy winged sharpshooter, striping citrus fruit infected by the Mexican fruit fly, and helping eradicate Exotic Newcastle Disease by cleaning and disinfecting backyards.

California county-level agriculture commissioners are charged with the protection of California agriculture, the environment, and the public's health and safety. These goals are accomplished through the management of programs that combine public outreach, industry, education, and enforcement actions. County-level agricultural commissioners carry out the following programs to accomplish these aims: Pest Exclusion, Pest Detection, Pest Eradication, Pest Management, Pesticide Enforcement, Seed Certification, Nursery Inspection, Fruits, Nuts and Vegetable Standardization, Egg Inspection, Apiary Inspection, and Crop Statistics.

CDFA licenses the agricultural commissioners and maintains a liaison office to ensure close coordination with the commissioners individually and as a group.

Silvicultural Pests

The movement of firewood is a potential source of introduction and dissemination of invasive silvicultural pests and diseases; thus, firewood management is the best control method for limiting the spread of pests and diseases that can damage forest resources. As shot hole borer beetles continue to spread throughout forests and crops in southern and central California, efforts to manage the movement of firewood have become increasingly important.

The California Firewood Task force was established in 2011, as part of the California Forest Pest Council, to facilitate educational campaigns such as “Buy It Where You Burn it.” The campaign stresses the following messages:

- Buy or collect firewood from a source near where it will be used.
- Don’t take firewood home from a trip.
- Find local firewood vendors at firewoodscout.org.
- Only obtain as much wood as you will need, and burn responsibly.

The California Firewood Task Force website includes information on invasive species of concern, consumer questions to ask when buying firewood from a vendor, firewood best management practices, and more. Also available on the website is Firewood Scout, a database of firewood dealers throughout the state that consumers can use when looking for local firewood vendors. For more information about the Firewood Task Force, visit: http://www.firewood.ca.gov/.

Additional control options include sanitation, chemical prevention, biocontrol, and advanced use of monitoring tools. However, these methods are still being tested and developed by researchers.

Governor Brown issued a Proclamation of a State of Emergency Executive Order on October 30, 2015 due to significant public safety hazards created by elevated levels of tree mortality in and amongst communities in the southern Sierra Nevada. A Tree Mortality Task Force was convened to coordinate the actions of federal, state, and local agencies addressing these public safety hazards. The Tree Mortality Task Force is chaired by the Governor’s Office, the California Department of Forestry and Fire Protection (CAL FIRE), and the California Governor’s Office of

Emergency Services (Cal OES). The high hazard counties participating in the Tree Mortality Task Force are Amador, Calaveras, El Dorado, Fresno, Kern, Madera, Mariposa, Placer, Tulare, and Tuolumne. Each of these counties has declared a local state of emergency and has convened a county-level task force to coordinate hazard mitigation activities at the local level.

Invasive Species Council of California

The Invasive Species Council of California (ISCC) was established in 2009 to provide leadership and authority in state government regarding invasive species, with its primary goal being to guide efforts to keep invasive species out of the state and to eradicate incipient populations of undesirable species. ISCC is an inter-agency council chaired by the Secretary of the California Department of Food and Agriculture with members from the California Natural Resources Agency, the California Environmental Protection Agency, the California Business, Transportation and Housing Agency, the California Health and Human Services Agency, and the California Governor's Office of Emergency Services (Cal OES). The ISCC has appointed a California Invasive Species Advisory Committee (CISAC) primarily tasked with making recommendations to develop an Invasive Species Action Plan and prioritize actions defined in the plan. For more information regarding the ISCC and the CISAC, visit: http://www.iscc.ca.gov/.

Agricultural pests and diseases are an economic hazard and, in some cases, a hazard to human health. Mitigation for pests and diseases should include an integrated pest management strategy. For additional information, visit:

- www.ipm.ucdavis.edu/GENERAL/tools.html
- http://cadms.ucdavis.edu/
- http://www.vetmed.ucdavis.edu/vetext/index.cfm

Progress Summary 9.A: Initiatives and Technology to Combat Pests and Diseases

Progress as of 2018:

California Forest Pest Council – California Firewood Task Force

The California Firewood Task Force has focused on promoting the "Buy It Where You Burn It" campaign since 2011 in an effort to increase public awareness about the risks of spreading pests and diseases via long-distance firewood movement. The Task Force produces outreach materials that are disseminated to local, state, and federal partners as well as other interested parties. Task Force members staff outreach booths at numerous events each year, engaging the public, legislators, and professionals about the importance of acquiring locally sourced wood and not moving it from location to location, to help stop the spread of invasive species. For more information visit: http://www.firewood.ca.gov/.

Pest Reporting App

The pest reporting app provides the public with the ability to photograph and report suspected harmful pest to state and local agricultural officials. Using camera and Global Positioning System (GPS) technology, the app provides California Department of Food and Agriculture (CDFA) invasive species specialists with valuable visual information. The mobile app is connected to CDFA's "Report a Pest" database where an invasive species specialist can identify the pest and contact the citizen with information. Owners of iPads and iPhones can choose to use GPS coordinates to show the location of the find, allowing CDFA to respond quickly to invasive pest emergencies. For more information visit: http://www.cdfa.ca.gov/apps/reportapest.html.

Additional Insect Pests Hazard Mitigation Opportunities

CDFA is using USDA Specialty Crop Block Grants to leverage state and local efforts for research and public outreach programs.

9.1.2 AIR POLLUTION

Identifying Air Pollution Hazards

Although air pollution is rarely a single event as significant as flood, fire, or earthquake, cumulatively it is much more hazardous to the health of large numbers of Californians. Sources of air pollution are generally grouped into four major categories: stationary, mobile, area-wide, and natural sources.

Stationary sources include fixed facilities such as: power plants and landfills. Mobile sources of pollution are typically generated as a result of operation of vehicles such as cars, trucks, ships, and airplanes, and are often the largest source of emission in a region. Area sources of pollution may result from agriculture, construction grading, or unpaved roads. Natural sources of pollution can include plant pollens, biological decay, and windblown dust.

Air pollution from stationary (fixed) and mobile sources (e.g., factories and cars, respectively) is a complex mixture of gases, fumes, and particles released into the atmosphere from the combustion of fossil fuels and evaporation of solvents.

In addition to the cumulative impacts of air pollution, temporarily hazardous air conditions can occur as a result of natural and man-made hazards, including wildfires, high winds and dust, volcanic activities, stratospheric ozone intrusion, hazardous material accidents, structural fires, and fireworks.

Particulate Matter

Particulate matter (PM), one of six U.S. Environmental Protection Agency (EPA) criteria air pollutants, is a mixture that can include organic chemicals, dust, soot, and metals. Differences between $PM_{2.5}$ and PM_{10} are usually described as the difference between fine and coarse particles.

Particulate matter$_{2.5}$ or $PM_{2.5}$, consists of fine particles that are 2.5 micrometers (about 1 ten-thousandth of an inch) or less in diameter. This is less than the thickness of a human hair (typically 50 to 70 micrometers). These particles are typically combustion particles from motor vehicles, power plants, industrial processes and factories, wildfires, residential wood burning, agricultural burning, and other activities.

Particulate matter$_{10}$, or PM_{10}, consists of coarse particles that are 10 micrometers or less in diameter. These particles are larger than $PM_{2.5}$ particles, but are still less than the thickness of a human hair. PM_{10} includes mostly dust, pollen, and mold.

Ozone

Ozone is not directly emitted. It is a secondary pollutant produced from nitrogen oxides (NOx) and volatile organic compounds (VOC) (also called reactive organic compounds [ROG]) in the presence of sunlight. The main sources of the components of ground-level ozone are trucks, cars, planes, trains, factories, farms, construction, and dry cleaners. Ozone levels are typically highest in the afternoon and on hot days.

Studies of historical ozone levels find that increased daytime temperatures increase ozone concentrations.[240] Ground-level ozone increases the risk of disease and death from cardiovascular and respiratory conditions.[241]

Health Risks Resulting from Poor Air Quality

PM and ozone are two indicators of air pollution, that are closely linked to short- and long-term adverse health effects.[242]

[240] Kleeman, Michael J., Chen, Shu-Hua, and Harley, Robert A. Climate Change Impact on Air Quality in California: Report to the California Air Resources Board. June 2010. Available online at: https://www.arb.ca.gov/research/apr/past/04-349.pdf

[241] CalBRACE $PM_{2.5}$ Indicator narrative; https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/BRACE_PM25_776_Narrative_8-1-2017.pdf

[242] CalBRACE $PM_{2.5}$ Indicator narrative; https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/BRACE_PM25_776_Narrative_8-1-2017.pdf

$PM_{2.5}$ is an extremely small pollutant, and human exposure to it is linked to adverse health outcomes. The smaller the particles, the deeper they can move into the lungs when people breathe. $PM_{2.5}$ is capable of reaching deep into the lungs and causing a host of diseases including lung cancer, heart disease, respiratory disease, acute respiratory infections, and mortality. $PM_{2.5}$ is also linked to hospital emergency department admissions for pulmonary inflammation among asthmatic children and people with other respiratory conditions.[243]

PM_{10}, like $PM_{2.5}$, is an extremely small pollutant, and human exposure to it is also linked to adverse health outcomes. PM_{10} is linked to irritation of the eyes, nose, and throat. It can also cause reduced lung function, asthma, heart attacks, heart disease, and premature mortality.

Ozone is among the most widespread and significant air pollution health threats in California. Studies have shown that exposure to ozone is associated with decreased lung function, respiratory symptoms, hospitalizations for cardiopulmonary causes, emergency room visits for asthma, and premature death. At higher daily concentrations, ozone increases asthma attacks, hospital admissions, daily mortality, days of restricted activity, and school absences.[244] Besides harming human health, ground level ozone can harm crops, alter food quality and costs, and have harmful effects on sensitive vegetation and ecosystems.[245]

Profiling Air Pollution Hazards

Overview

Air pollution is a continuing problem, with the largest concentration of pollution in the most populated air basins: the San Francisco Bay Area, San Joaquin Valley, Sacramento Valley, San Diego, and the South Coast. Pollutants include smog, soot, and toxic air contaminants (TACs). However, some air toxic emissions in California are on the decline. Table 9.C shows the average quantities of emissions in tons per day from 2000 to 2015 as well as forecasts to 2035. Forecast emissions for future years take into account emissions data, projected growth rates, and future adopted control measures.

Table 9.C: Air Pollutant Emission Trends and Forecasts in California, 2000-2035

Pollutant	2000	2005	2010	2015	2020	2025	2030	2035
Volatile Organic Compounds (VOC)	2,902	2,261	1,943	1,624	1,561	1,554	1,568	1,574
Nitrogen Oxides (NO_X)	3,782	3,214	2,324	1,887	1,553	1,312	1,224	1,200
Sulfur Oxides (SO_X)	289	287	123	78	82	88	94	101
Diesel Particulate Matter (PM)	86	88	54	31	25	23	23	25
$PM_{2.5}$	661	524	447	410	414	419	434	441
PM_{10}	2,436	1,700	1,549	1,491	1,525	1,544	1,572	1,590
Ammonia (NH_3)	730	741	752	719	742	770	776	779

Source: California Air Resources Board (CARB), Background Material: Almanac of Emissions and Air Quality, 2013 Edition - Chapter 3 Statewide Trends and Forecasts.2013. https://www.arb.ca.gov/aqd/almanac/almanac13/chap313.htm

[243] CalBRACE $PM_{2.5}$ Indicator narrative; https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/BRACE_PM25_776_Narrative_8-1-2017.pdf
[244] CalBRACE Ozone Indicator narrative; https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/BRACE_Ozone_801_Narrative_11-8-2016.pdf
[245] California Department of Public Health. Public Health Impacts of Climate Change in California: Community Vulnerability Assessments and Adaptation Strategies. 2007 Retrieved on 9/4/2017 from http://cehtp.org/download/climate_change/public-health-impacts-of-climate-change-in-ca-report-no-1-heat-related-illness.

The 2013 Edition of the Almanac of Emissions and Air Quality, Chapter 3 – Statewide Trends and Forecasts, includes a detailed discussion of these trends and forecasts and can be downloaded from the California Air Resources Board (CARB) website at the following link: https://www.arb.ca.gov/aqd/almanac/almanac13/chap313.htm.

Most counties in California meet federal and state air quality standards for the pollutants summarized in Table 9.C; however, some counties are still working to attain the ozone, $PM_{2.5}$, and PM_{10} standards. Map 9.B indicates that 23 counties are in attainment, 12 are unclassified, and 23 are in non-attainment for $PM_{2.5}$ standards as of December 2015. Map 9.C indicates that 5 counties are in attainment, 3 are unclassified, and 50 are in non-attainment for PM_{10} standards as of December 2015. Map 9.D indicates there are 10 counties in attainment, 3 counties unclassified, and 45 counties in non-attainment for ozone standards as of December 2015.

These and other air pollutant maps for California can be downloaded from the CARB website at the following link: https://www.arb.ca.gov/desig/adm/adm.htm.

Climate Change and Air Pollution Hazard

Climate change is anticipated to modify long-term weather patterns in California, with direct consequences for air quality and public health. The air pollutants that cause climate change are a global focus for reduction. Many greenhouse gases, such as methane, also have public health consequences. In addition, indirect impacts of climate change, such as changes in weather patterns and increases in wildfire, can exacerbate existing air quality challenges and introduce new ones. For example, higher temperatures increase the production of ozone; with more wildfires comes an increase in particulate matter (PM); and increased drought and wind produce increased dust.

Ozone production increases with higher temperatures and greater penetration of ultraviolet (solar) radiation. Climate change increases the average temperature and, in many locations, reduces precipitation, which in turn increases solar exposure.[246] If ozone precursors (NOx and VOC) are present, climate change can increase ozone production. Even in areas where ozone production is low, wind can deliver ozone to areas less likely to generate it locally, such as higher altitude areas in California which tend to be low ozone-producing settings.[247] Increased ozone production will have consequences for many regions of California, regardless of the presence of precursors.

Climate change has the potential to worsen PM concentrations in California due to increased incidence of wildfire (see *Section 8.1*) as well as the increased temperature and reduced precipitation in many locations. Smoke and ash produced by fire increase PM concentrations. Similarly, dry, warm weather can result in greater amounts of dust being blown and suspended in air.

Among other issues, climate change threatens public health through a decline in the basic human life support system of air quality and increased extreme heat and wildfire events that will further affect air quality. The resulting human health impacts from climate change include increases in the risk and occurrence of asthma, allergies and other respiratory ailments, and cardiovascular disease.[248]

With the projected increasing temperatures, demand for electric power generation to run air conditioning will increase, potentially resulting in increased production of power plant air pollutants which may contribute further to poor air quality. It should also be noted that climate change magnifies existing health inequities including exacerbating health impacts on vulnerable populations due to poor air quality.

[246] IPCC. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. 2013. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 1535 pp.
[247] California Department of Public Health. Public Health Impacts of Climate Change in California: Community Vulnerability Assessments and Adaptation Strategies. 2007. Retrieved on 9/4/2017 from http://cehtp.org/download/climate_change/public-health-impacts-of-climate-change-in-ca-report-no-1-heat-related-illness
[248] Safeguarding California Plan: 2018 Update; http://resources.ca.gov/climate/safeguarding/

Map 9.B: Area Designation Map for $PM_{2.5}$

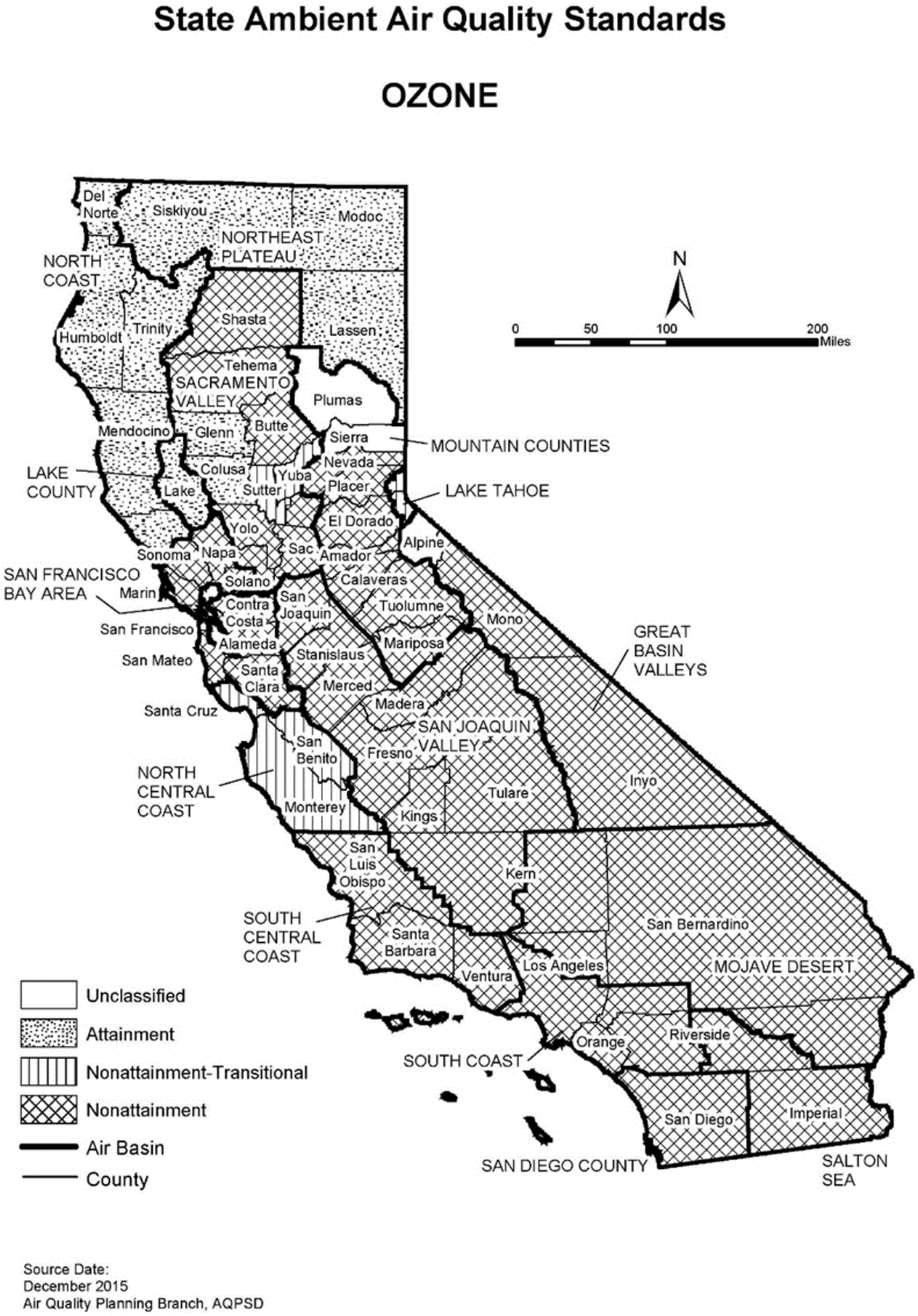
Source: California Air Resources Board https://www.arb.ca.gov/desig/adm/adm.htm

Map 9.C: Area Designation Map for PM_{10}

Source Date:
December 2015
Air Quality Planning Branch, AQPSD

Source: California Air Resources Board https://www.arb.ca.gov/desig/adm/adm.htm

Map 9.D: Area Designation Map for Ozone



Source: California Air Resources Board https://www.arb.ca.gov/desig/adm/adm.htm

State Vulnerability and Potential Losses

Densely populated and agricultural regions are the most exposed and vulnerable to severe air pollution. Negative public health impacts are considered a major risk resulting from air pollution hazards. Certain populations are more prone to illness from air pollution, due to location in proximity to emission sources, socio-economic status, race, occupation, age, or existing health issues.

The California Air Resources Board (CARB) has an active research program to investigate the health effects associated with air pollution exposure, particularly in citizens who may be more sensitive to air pollution effects, such as children and the elderly. Public health impacts are tracked and analyzed in multiple research studies. Health effects research information is available on the CARB website: https://www.arb.ca.gov/research/health/healthres.htm. An assessment of climate change impacts on the state's air quality was prepared for CARB in 2010. The assessment report can be downloaded at: https://www.arb.ca.gov/research/apr/past/04-349.pdf.

Office of Environmental Health Hazard Assessment

The Office of Environmental Health Hazard Assessment (OEHHA) produces and makes publicly available reports, notices, and documents about health risk assessments of chemical contaminants found in air, including those identified as toxic air contaminants (TACs) or on the list of chemicals under the "Hot Spots" Information and Assessment Act. Assessments include development of Cancer Potency Factors to assess the cancer risk from carcinogens in air, and development of Reference Exposure Levels to assess non-cancerous health impacts. OEHHA has developed and updates risk assessment guidance for use in site-specific risk assessments under the Air Toxics Hot Spots program. OEHHA also makes health-based recommendations to CARB for ambient air quality standards. Recent legislation, the Children's Environmental Health Protection Act, requires OEHHA to explicitly consider infants and children in evaluating health risks of air pollutants. OEHHA is evaluating current risk assessment methods for their adequacy to protect children.

OEHHA also conducts epidemiological investigations of the health effects of criteria air pollutants. Such investigations include health impacts on sensitive sub-populations such as children and the elderly. For example, OEHHA conducted an evaluation of the impacts of traffic-related pollutants on children. Specifically, the evaluation analyzed the relationship between respiratory health of children and proximity of their schools to heavily traveled roadways including measured exposure to traffic-related pollutants.

OEHHA also evaluates health effects of chemicals commonly found in indoor air. OEHHA participates in a number of inter-agency activities designed to evaluate indoor air quality health issues and to move California toward safer indoor air quality. OEHHA provides health-related assistance to CARB, air pollution control districts, local health officers, and environmental health officers.[249]

CalEnviroScreen

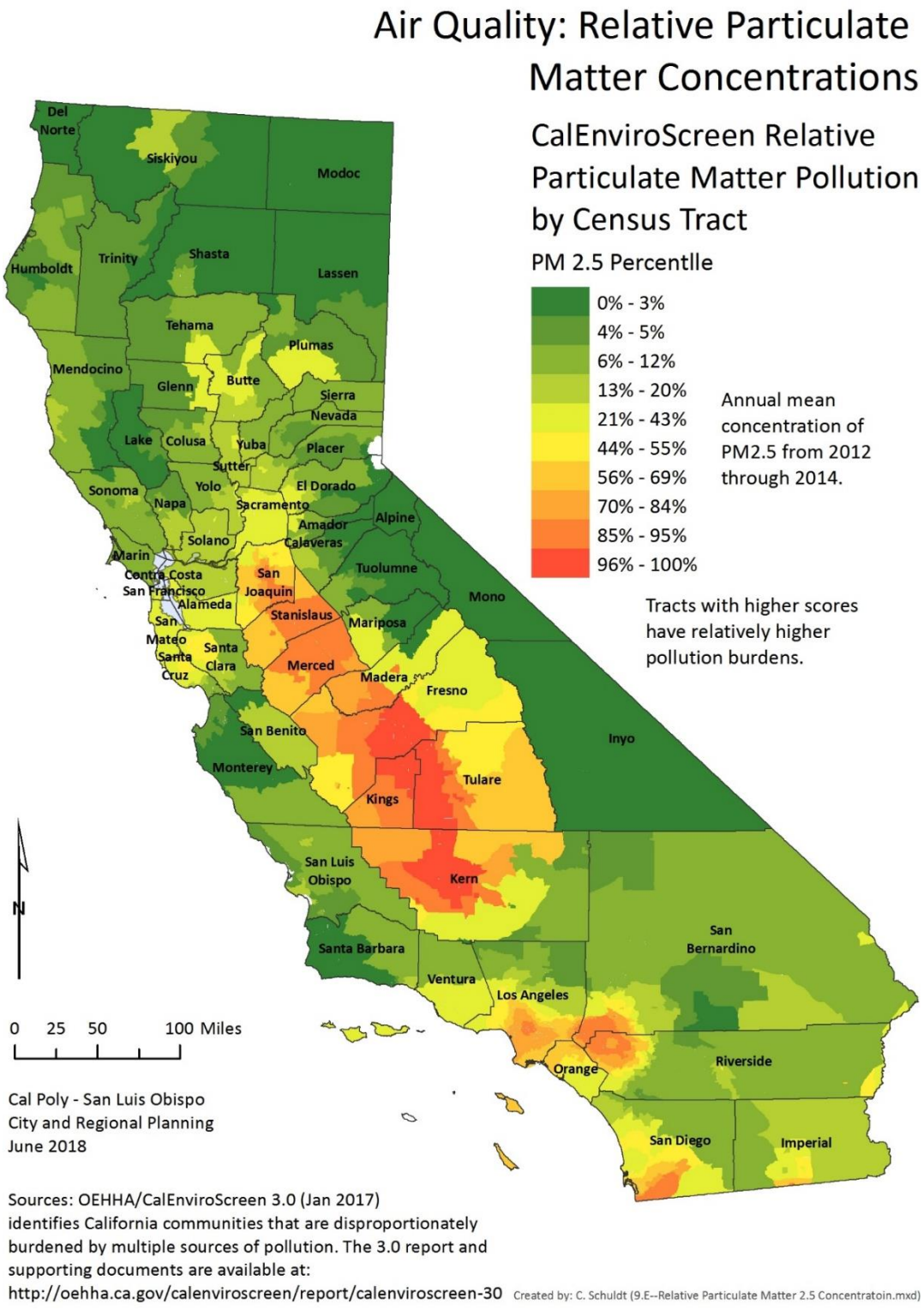
OEHHA developed and maintains the CalEnviroScreen mapping tool as a screening methodology that can be used to help identify California communities that are disproportionately burdened by multiple sources of pollution, including air pollution. "Air Quality: $PM_{2.5}$"and "Air Quality: Ozone" are two of seven pollution exposure indicators used to calculate "pollution burden," which is a factor in overall CalEnviroScreen scores for communities.[250]

Maps 9.E and 9.F present air quality and air pollution data available from CalEnviroScreen. For more information about CalEnviroScreen, see *Section 4.4.6* and also the program website: https://oehha.ca.gov/calenviroscreen.

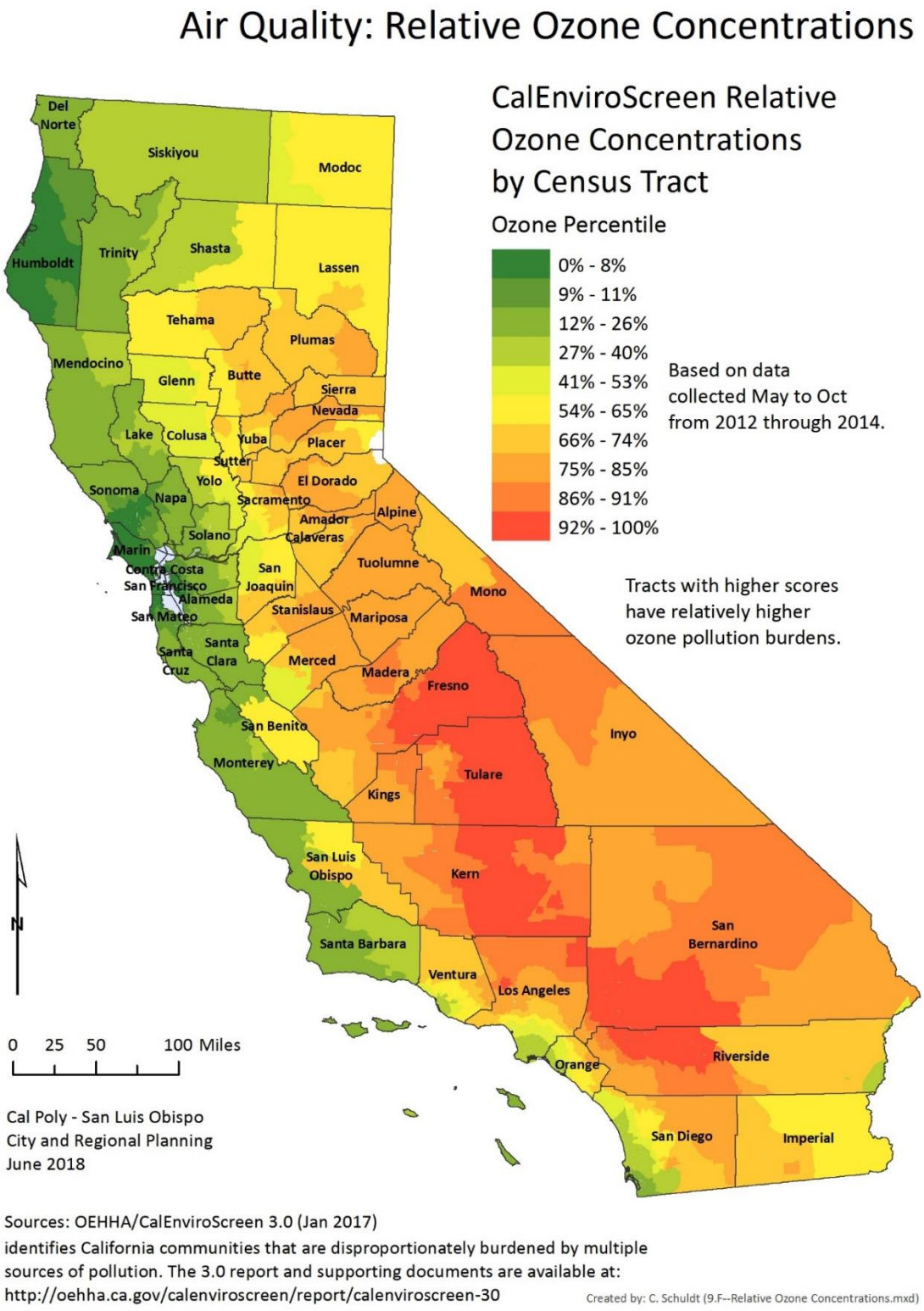
[249] https://oehha.ca.gov/air

[250] Pollution burden and population characteristics together are used to calculate the overall CalEnviroScreen score.

Map 9.E: Relative Particulate Matter Concentrations in California from CalEnviroScreen



Map 9.F: Relative Ozone Concentrations in California from CalEnviroScreen



California Building Resilience Against Climate Effects (CalBRACE)

The California Building Resilience Against Climate Effects (CalBRACE) program has developed data and narrative vulnerability reports for various indicators including air quality ($PM_{2.5}$ and ozone). The CalBRACE air quality indicator narratives describe certain populations that are prone to the impacts of worsened air quality exacerbated by climate change.

To download the CalBRACE air quality indicator data and narrative as well as the population sensitivity and adaptive capacity indicator data and narratives relevant to air quality, visit: https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx.

For more information about CalBRACE, visit the California Department of Public Health (CDPH) Health Equity Program webpage and follow the Climate Adaptation link to the CalBRACE program website: https://www.cdph.ca.gov/Programs/OHE/Pages/CalBRACE.aspx.

California Environmental Health Tracking Program

The California Environmental Health Tracking Program (CEHTP) is a program of the Public Health Institute, in partnership with CDPH.

CEHTP conducts tracking and surveillance of environmental hazards and health outcomes in California, providing publicly available data to visualize and link environmental hazards and health and to explore possible associations between the environment and health outcomes. For more information visit: http://cehtp.org/page/main.

Progress Summary 9.B: Partnerships for Environmental Public Health: Imperial County Community Air Monitoring Project

Progress as of 2018: In 2017, the California Environmental Health Tracking Program, along with academic partners University of Washington, University of California, Los Angeles (UCLA), and George Washington University, partnered with Comité Cívico Del Valle Inc. to develop a community-engaged project aimed at reducing pollutant exposures to improve health of community members in Imperial County through development of a low-cost air quality monitoring network.

The project coordinated community input and assessment for the placement of portable air monitors, and the installation of air monitoring equipment was completed by Comité Cívico Del Valle Inc. staff. Real-time particulate matter (PM) air pollution data from the monitors are accessible on the Identifying Violations Affecting Neighborhoods (IVAN) Imperial website, a platform previously developed by the community to report violations involving toxic substances.

The IVAN Air Monitoring portion of the site provides air quality data in a map or list form and lets users sign up for alerts. To inform the design of the IVAN Air Monitoring site and the health messaging displayed there, the California Environmental Health Tracking Program conducted needs assessments and focus groups with residents and members of the Community Steering Committee.

Project collaborators are conducting analysis of the data from the monitors and intend to use this information to identify "hot spots" and to show how wind direction and transport of the pollutants affects PM levels. Analysis results can be used by the community to inform public health actions, such as developing new routes to school through less polluted areas.

To ensure accuracy and reliability of the low-cost monitoring equipment, project partners are exploring potential collocation of project monitors with regulatory monitors with the local air district, the California Air Resources Board, and the U.S. Environmental Protection Agency.

For more information, visit: https://ivan-imperial.org/air.

Local Vulnerability and Potential Losses

Local Hazard Mitigation Plans may provide information on vulnerability and potential losses associated with air pollution in a specific city or county. Local air district websites may also contain information about vulnerability and potential losses specific to that region.

Current Air Pollution Hazard Mitigation Efforts

There are numerous state and local regulations that mitigate or prevent air pollution from reaching unacceptable standards.

California Air Resources Board

The California Code of Regulations mandates that the California Air Resources Board (CARB) establish and monitor regulatory activity of the state's 35 local air districts, particularly as it relates to motor vehicles and public health. CARB also distributes a substantial amount of information regarding air quality standards, research, health, trends, and measurement methods on its website.

For more information on local, state, and federal statutes plus state and local regulations affecting air quality management in California visit the CARB Laws and Regulations web page: https://www.arb.ca.gov/html/lawsregs.htm.

Local Air Districts

Local Air Pollution Control Districts (APCDs) and Air Quality Management Districts (AQMDs) are responsible for controlling and monitoring stationary sources of air pollutants. Some districts have expanded their scope of activities to include education and incentive programs. Every district has its own website, which can be found by clicking on the district of interest on the following map provided by CARB: https://www.arb.ca.gov/capcoa/dismap.htm.

Senate Bill 1000 (2016), Disadvantaged Communities, and Pollution Reduction

Senate Bill (SB) 1000 (2016) requires cities and counties that have disadvantaged communities to incorporate environmental justice policies into their general plans, either by providing a separate environmental justice element or by integrating related goals, policies, and objectives into the other general plan elements.

New Government Code regulations stemming from SB 1000 (2016) require that, as part of their general plan updates, local jurisdictions with disadvantaged communities identify objectives and policies to reduce pollution exposure, including air pollution exposure.[251] The 2017 General Plan Guidelines include extensive discussion of general plan air quality element requirements and mitigation actions that local jurisdictions can take to address air pollution and improve air quality through their planning decisions. The General Plan Guidelines also examine air quality linkages to climate change and urban heat islands.

Strategic Growth Council – "Affordable Housing and Sustainable Communities Program"

California is a national leader in its efforts to protect natural resources, reduce greenhouse gas emissions, and move toward sustainable communities. In 2010, the Strategic Growth Council (SGC), created through adoption of SB 732, The Council's mission is to help make California's communities more sustainable. The Council defines sustainability holistically through: reducing greenhouse gas emissions; improving air and water quality; improving protection of natural resources and agricultural lands; increasing the availability of affordable housing; improving public health, improve transportation; encouraging sustainable land use plans and greater infill development; and revitalizing urban and community centers in a sustainable manner.

For more information regarding the SGCs grant program, see: http://sgc.ca.gov/programs/ahsc/vision/.

[251] Government Code section 65302(h)

9.1.3 AQUATIC INVASIVE SPECIES

Identifying and Profiling Aquatic Invasive Species

Non-indigenous species (NIS) are transported to new environments, both intentionally and unintentionally, through human activities. Ships transfer organisms to California waters from throughout the world. Once introduced, invasive species could become a permanent part of an ecosystem and may flourish, creating environmental imbalances, presenting risks to human health, and causing significant economic problems. The introduction of non-indigenous species into California's marine, estuarine, and freshwater environments can cause significant economic, human health, and ecological impacts. A non-indigenous species is considered an invasive species when it becomes established in a new geographic location, causing impacts.

Pathways for Introducing Aquatic Invasive Species

Nonindigenous species are introduced into aquatic habitats through multiple pathways, including aquaculture, aquarium trade, commercial shipping, live bait, live seafood trade/commercial fishing, marine debris, and recreational vessels. Each of these vectors contributes to aquatic invasive species introductions, but maritime transportation is the primary vector moving species around the globe. Vessels transport organisms through two primary mechanisms (vectors): ballast water and biofouling. Ballast water is taken on and later discharged by a vessel during cargo loading and unloading operations to maintain the vessel's trim and stability. Biofouling refers to the organisms or community of organisms that are directly attached to, or associated with, wetted hard surfaces of the vessel, such as the hull.

Climate Change and Aquatic Invasive Species

Climate change, which is warming marine waters and altering the water chemistry (such as changes to water salinity and pH), can also bolster invasive species populations and range. The changes in marine environment can weaken native species not accustomed to warmer temperatures or altered water chemistry. Non-indigenous species tend to be more tolerant and resilient to changes in their environment; therefore, shifts in species composition due to climate change events can favor invasive non-indigenous species over native species.

Assessment of State Vulnerability and Potential Losses

The marine, estuarine, and freshwaters environments of California are home to hundreds of invasive species. The San Francisco Bay Delta has more identified non-indigenous species present than any other estuary in North America, and perhaps the world. In aquatic environments, invasive species threaten aquaculture operations, recreational boating, agriculture, water conveyance, commercial and recreational fishing, marine transportation, and tourism, among other industries, all of which are essential to California's economy. In 2013, California's ocean-based economy employed roughly 500,000 people and accounted for almost $41 billion of California's total gross domestic product.[252]

In California's freshwater lakes, rivers, and reservoirs, zebra and quagga mussel infestations now pose a significant threat to the state's complex water conveyance system. As of 2016, more than $24 million has been spent on control and management of these species in California.[253] Water hyacinth, an invasive aquatic plant, has clogged the waterways of the California Delta. In 2014, shipping traffic to the Port of Stockton was restricted to daylight hours due to high densities of hyacinth in waterways. The Port spent $200,000 to mechanically remove the plant, and the shipping industry lost an estimated $300,000 due to delays in cargo operations.[254]

[252] NOEP 2016.
[253] Volkoff, M., pers. comm. 2016
[254] Wingfield, J., pers. comm. 2015

Assessment of Local Vulnerability and Potential Losses

All local aquatic environments are susceptible to aquatic invasive species, although the pathway of introduction may vary markedly from water body to water body. Information related to community vulnerability and loss assessments related to marine invasive species, if any, may be found in Local Hazard Mitigation Plans.

Current and Future Aquatic Invasive Species Hazard Mitigation Efforts

The Ballast Water Management for Control of Nonindigenous Species Act of 1999, as amended and reauthorized by the Marine Invasive Species Act of 2003, established California's program to prevent the introduction of nonindigenous species via vessel vectors (ballast water and biofouling). The Marine Invasive Species Act applies to all U.S. and foreign vessels that are 300 gross registered tons or more that arrive at California ports.[255] The Marine Invasive Species Act is implemented through integrated efforts by the following state agencies:

- California State Lands Commission, which is responsible for policy development, vessel tracking, compliance, enforcement
- California Department of Fish and Wildlife, which conducts species surveys
- State Water Resources Control Board, which consults on water quality issues
- California Department of Fee and Tax Administration, which collects fees from qualifying vessel arrivals to support the program

The California Department of Fish and Wildlife also houses the state's invasive species program. The goal of the invasive species program is to prevent, detect, and respond to species introductions when they occur and prevent the spread of species that have become established. The California Department of Fish and Wildlife is responsible for the state's Dreissenid Mussel Prevention Program. In 2016, the California Department of Fish and Wildlife adopted new regulations to prevent the spread of quagga and zebra mussels in California freshwater environments. The new regulations include provisions requiring vulnerability assessments, prevention programs, monitoring, and management of state reservoirs.

Progress Summary 9.C: Marine Invasive Species Act

Progress as of 2018: Under the Marine Invasive Species Act, vessels are required to submit a Ballast Water Management Report for each arrival at a California port or place and an Annual Vessel Reporting Form that requests information on vessel biofouling management practices and the use of ballast water treatment technologies. Between July 2014 and June 2016, over 96 percent of vessel arrivals complied with reporting requirements. According to the 2017 Biennial Report on the California Marine Invasive Species Program, between July 2014 and June 2016, almost 98 percent of the 122 million metric tons of vessel-reported ballast water carried into California water was managed in compliance with state law.

Furthermore, noncompliant ballast water has accounted for a smaller proportion of all ballast water discharges through the years, with slight variation, from 23.8 percent of the total volume of ballast water discharged in California in 2006 to 1.4 percent in the first half of 2016. These numbers signify a reduction in the risk of invasive species introduction from ballast water discharges to California waters. Furthermore, as of October 1, 2017, the California State Lands Commission has implemented the nation's first regulations to manage biofouling on the wetted surfaces of commercial vessels arriving at California ports. The state has thus made great strides to prevent species introductions from commercial vessel vectors.

[255] http://www.slc.ca.gov/Programs/MISP.html

Additional Aquatic Invasive Species Hazard Mitigation Opportunities

While the Marine Invasive Species Act addresses the threats of species introductions from commercial vessels, many of the other vectors of aquatic invasive species remain unregulated. In particular, the movement of biofouling species on recreational vessels, commercial fishing vessels, and mobile marine infrastructure (e.g., dredges, mobile offshore drilling units) in marine and estuarine environments remains almost entirely unregulated.

For more information, visit:
https://www.fws.gov/answest/coastal%20group/Final%20CC%20Biofouling%20White%20Paper%2011Apr17.pdf).

Furthermore, while the state is well poised to prevent new introductions and the spread of zebra and quagga mussels in freshwater, there has been limited planning and there is almost no funding available for rapid response and species management in the event of detections of new non-indigenous species in the state's marine and estuarine waters. For more information, visit: http://www.slc.ca.gov/Programs/MISP.html.

9.1.4 AVALANCHES

Identifying Avalanche Hazards

An avalanche is a mass of snow, ice, and rocks that fall down a mountainside, usually during heavy winter storms. Avalanches occur in the steep mountainous areas of the state that receive significant amounts of snow. Avalanches are weather-related threats to communities, residents, and visitors in the high mountain areas of the California.

Profiling Avalanche Hazards

Property Damage and Loss of Life

Avalanches have caused property damage and loss of life in California. As shown in Table 9.D, between 1996 and 2016, there were 14 deaths and property damage of $140,000 reported due to avalanches. There are no recorded avalanches between 1950 and 1996. Avalanches pose a threat in the Sierra Nevada range on the eastern side of the state and the Cascade Range in the north. Significant avalanches have damaged or destroyed ski resorts at Mt. Shasta and Lake Tahoe, as well as blocked and damaged roadways.

Table 9.D: Avalanches, 1950-2016

Period	Counties Affected (Number of Events)	Deaths
1996-2006	Amador (1), Alpine (1), Calaveras (1), El Dorado (2), Mono (3), Nevada (1), Placer (2), San Bernardino (1), San Diego (1), Sierra (1), Tuolumne (1)	2
2007-2016	Inyo (2), Nevada (1), Placer (6), San Bernardino (1), Siskiyou (3), Tulare (1),	12

Source: National Oceanic and Atmospheric Administration (NOAA) 2016

Climate Change and Avalanche Hazards

Warmer temperatures and/or rain weaken snowpack. These changes result from rainfall or warm spells weakening the snow pack or from formation of a crust due to early season rain (which is projected to increase due to climate change). These changes to the quality of snow cover lead to increased frequency and severity of avalanche events. Increased wind can also contribute to increased avalanche frequency.

State Vulnerability and Potential Losses

No known assessment of state vulnerability and potential losses is available at this time.

Local Vulnerability and Potential Losses

See Local Hazard Mitigation Plans for detailed information on local vulnerability to avalanches.

Current and Future Avalanche Hazard Mitigation Efforts

The California Department of Water Resources (DWR) monitors snowfall amounts and water content but does not actively monitor avalanche probability or occurrences. It does, however, provide a website link to the Avalanche Center, a 501(c)(3) organization that posts information on avalanche conditions for the United States. The organization is a partnership between the U.S. Forest Service and the private sector and relies heavily on private contributions and volunteer support. There are three Avalanche Centers operating in California that provide up-to-date information on snow conditions and avalanche danger levels:

- Eastern Sierra Avalanche Center – Inyo National Forest in Mammoth Lakes
- Central Sierra Avalanche Center – Tahoe National Forest in Truckee
- Shasta Avalanche Center - Shasta-Trinity National Forest in Mt. Shasta

The information and the avalanche warnings that the centers provide are geared to the general public who engage in snow-related recreational activities.

9.1.5 DROUGHTS AND WATER SHORTAGES

Identifying Droughts and Water Shortages Hazards

Drought is a gradual phenomenon. Normally, one dry year does not constitute a drought in California, but rather serves as a reminder of the need to plan for droughts. California's extensive system of water supply infrastructure (reservoirs, groundwater basins, and interregional conveyance facilities) generally mitigates the effects of short-term dry periods for most water users.

Drought can have secondary impacts. For example, drought is a major determinant of wildfire hazard, in that it creates greater propensity for fire starts and larger, more prolonged conflagrations fueled by excessively dry vegetation, along with reduced water supply for firefighting purposes. More recently, increased tree mortality, exacerbated by drought, has resulted in millions of dead trees around the state causing hazards to people, property, and infrastructure and creating a greater risk of wildland fires.

A significant secondary impact of drought due to the reduced availability of surface water is land subsidence caused by groundwater pumping from wells. Land subsidence is the phenomenon in which the earth's surface gradually settles or sinks due to sub-surface activities, primarily groundwater pumping, which compacts aquifer systems. Although pumping of groundwater occurs in both drought and non-drought years to support urban, rural, and agricultural water needs, it is greatly increased during dry years. Land subsidence due to groundwater pumping can permanently damage or collapse underground aquifers, increase flood risk in low-lying areas, and pose hazards to buildings, infrastructure, and water storage facilities.

Drought also amplifies the risk of loss of biodiversity and affects animal and plant species in the state. In March 2016, the California Department of Fish and Wildlife released an assessment report on the vulnerability of California wildlife affected by the 2012-2016 drought. It indicated that amphibian, reptile, bird, and mammal populations that depend on freshwater marsh, streamside habitat, and wet meadows struggle most to endure the drought. Impacts on salmon and trout hatcheries caused by decreased water supply, inferior water quality, and increased threat of water pathogens are also of concern, as are river conditions for native fish species. In addition to the physical implications of drought, significant economic impacts on California's agriculture industry can occur as a result of short- and long-term drought conditions. These include hardships for farmers, farm workers, packers, and shippers of agricultural products. In some cases, drought can also cause significant increases in food prices to the consumer due to shortages, and can result in lack of water and subsequent feed available to grazing livestock, potentially leading to risk of livestock death and resulting in losses to the state's agricultural economy.

Past experience with California droughts indicates that drought impacts are felt first by those most dependent on or affected by annual rainfall and snowpack, including agencies fighting forest fires, ranchers engaged in dryland grazing, farmers growing crops in arid zones, rural residents relying on wells in low-yield rock formations, or small water systems lacking a reliable water source.

Profiling Drought and Water Shortage Hazards

Drought has affected virtually every county in California at one time or another, causing over $5.1 billion in damages. Droughts exceeding three years are relatively rare in Northern California, the source of much of the state's water supply. The 1929-1934 drought, which affected the entire state, established the criteria commonly used in designing storage capacity and yield for large Northern California reservoirs. Significant droughts occurring within the past 50 years are briefly described below, followed by an in-depth discussion of the extended statewide drought that began in 2012 and ended in 2017.

The 1975-1977 Drought

From November 1975 through November 1977, California experienced one of its most severe droughts. Although people in many areas of the state are accustomed to very little precipitation during the growing season (April to October), they expect it in the winter. In 1976 and 1977, the winters brought only one-half and one-third of normal precipitation, respectively. Most surface storage reservoirs were substantially drained in 1976, leading to widespread water shortages when 1977 turned out to be even drier. Thirty-one counties were affected, resulting in $2.67 billion in crop damage.

The 1987-1992 Drought

From 1987 to 1992, California again experienced a serious drought due to low precipitation and runoff levels. The hardest-hit region was the Central Coast, roughly from San Jose to Ventura. In 1988, 45 California counties experienced water shortages that adversely affected about 30 percent of the state's population, much of the dry-farmed agriculture, and over 40 percent of the irrigated agriculture. Fish and wildlife resources suffered, recreational use of lakes and rivers decreased, forestry losses and fires increased, and hydroelectric power production decreased.

In February 1991, DWR and Cal OES surveyed drought conditions in all 58 California counties and found five main problems: extremely dry rangeland, irrigated agriculture with severe surface water shortages and falling groundwater levels, widespread rural areas where individual and community supplies were going dry, urban area water rationing at 25 to 50 percent of normal usage, and environmental impacts.

Storage in major reservoirs had dropped to 54 percent of average, the lowest since 1977. The shortages led to stringent water rationing and severe cutbacks in agricultural production, including threats to survival of permanent crops such as trees and vines. Fish and wildlife resources were in critical shape as well. Not since the 1928-1934 drought had there been such a prolonged dry period. In response to those conditions, the Governor established the Drought Action Team. This team almost immediately created an emergency drought water bank to develop a supply for four critical needs: municipal and industrial uses, agricultural uses, protection of fish and wildlife, and carryover storage for 1992.

The large-scale transfer program, which involved over 800,000 acre-feet of water, was implemented in less than 100 days with the help and commitment of the entire water community and established important links between state agencies, local water interests, and local governments for future programs.[256]

The 2007-2009 Drought

Water years 2007-2009 were collectively the 15th driest three-year period for DWR's eight-station precipitation index, which is a rough indicator of potential water supply availability to the State Water Project (SWP) and Central Valley Project (CVP). Water year 2007 was the driest single year of that drought, and fell within the top 20 percent of dry years based on computed statewide runoff. In June 2008, a state emergency proclamation was issued due to water shortage in selected Central Valley counties. In February 2009, for the first time in its history, the State of California proclaimed a statewide drought. The state placed unprecedented restrictions on CVP and SWP diversions from the Delta to protect listed fish species, a regulatory circumstance that exacerbated the impacts of the drought for water users.

The greatest impacts of the 2007-2009 drought were observed in the CVP service area on the west side of the San Joaquin Valley, where hydrologic conditions combined with reduced CVP exports resulted in substantially reduced water supplies (50 percent supplies in 2007, 40 percent in 2008, and 10 percent in 2009) for CVP south of Delta agricultural contractors. Small communities on the west side highly dependent on agricultural employment were especially affected by land fallowing due to lack of irrigation supplies, as well as by factors associated with current economic recession. The coupling of the drought and economic recession necessitated emergency response actions related to social services, such as food banks and unemployment assistance.[257]

[256] California Department of Water Resources (DWR). "Preparing for California's Next Drought – Changes Since 1987-92." July 2000.
[257] (DWR, "California's Most Significant Droughts: Comparing Historical and Recent Conditions", February 2015)

The 2012-2017 Drought

Introduction

The statewide drought of 2012-2017 will be remembered as one of the most severe and costliest droughts of record in California. The drought that spanned water years 2012 through 2017 included the driest four-year statewide precipitation on record (2012-2015) and the smallest Sierra-Cascades snowpack on record (2015, with 5 percent of average). It was marked by extraordinary heat; 2014, 2015, and 2016 were California's first, second and third warmest years in terms of statewide average temperatures. By the time the drought was declared officially over in April 2017, the state had expended $6.6 billion in drought response and mitigation programs and had been declared a federal disaster area. The following discussion outlines the chronology of events and milestones reached during the drought as well as a summary of Executive Orders issued by the Governor, disaster assistance programs initiated, and grant programs designed to alleviate the impacts of the drought.

Chronology of the 2012-2017 Drought

Following the dry water years of 2007-2009, water years 2010-2011 marked a return to slightly wetter than average conditions for most of the state. Precipitation in 2011 improved statewide reservoir storage, mitigating the dry conditions that occurred across most of the state in 2012. Although Northern California experienced a series of late November/early December storms in 2013, a record dry January through May resulted in dryness for most of the state, particularly the San Joaquin Valley and Southern California. The impacts of dry years during 2012 and 2013 were notably felt in the agricultural sector, especially rangeland grazing.

With the advent of an exceptionally dry water year in 2014, Northern California began experiencing the significantly below-normal precipitation that had characterized the southern part of the state in the prior years. A blocking high pressure ridge diverted storms away from the state during the key winter precipitation months of December and January, resulting in record warmth and dryness. Some locations in Northern California experienced 50 consecutive days with no measurable precipitation during months that historically exhibited maximum precipitation for the year.

The Governor responded to the continuing drought conditions by forming a state interagency Drought Task Force in December 2013 to provide a coordinated assessment of the dry conditions and recommendations on state actions. The continuing absence of precipitation led to a Governor's proclamation of emergency in January 2014 that ordered state agencies to take specified actions and called on Californians to voluntarily reduce their water usage by 20 percent. In March, the Legislature enacted and the Governor signed measures to provide $687.4 million for drought relief, with the largest amount of that funding ($549 million) dedicated to accelerated expenditure of Proposition 84 and Proposition 1E bond funds for grants to local agencies for integrated regional water management projects.

Above normal late spring 2014 precipitation ameliorated some of the worst-case water supply scenarios that had been considered earlier in the year. Hydrologic conditions did not improve sufficiently, however, to avoid record low allocations for some Central Valley Project (CVP) and State Water Project (SWP) contractors: zero to the CVP's agricultural contractors both north and south of the Delta, zero to the CVP Friant Division contractors, and 5 percent to SWP contractors. Water year 2014 marked the first time that the U.S. Bureau of Reclamation's Friant Division contractors received a zero allocation of their Class 1 water. Reflecting the very dry hydrology, the State Water Resources Control Board (SWRCB) imposed widespread curtailments of diversions in locations including parts of the Sacramento-San Joaquin River watershed and the Eel and Russian River watersheds, another action that had not been taken since 1977.

Close coordination among the water project operating agencies (U.S. Bureau of Reclamation and DWR), and the regulatory agencies (SWRCB, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service) was employed throughout the hydrologically challenging winter-spring water year 2014 runoff season. Decisions were made to balance impacts and to reserve water in storage to be able to meet critical needs such as cold water for salmon and health and safety needs for urban water users.

As the summer of 2014 wore on, increasing numbers of small water systems, often located on unreliable fractured rock groundwater sources in rural areas, were experiencing water shortages, as were rural residents dependent on private wells. Bulk water haulage and distribution of bottled water were used to help some rural communities.

Early seasonal rainfall in November and December 2014, delivered only a third of what would be needed to end the prolonged drought but, combined with close coordination among federal and state agencies, allowed DWR to increase expected water deliveries for 2015 to most customers of the SWP from 10 to 15 percent of requested amounts. The SWRCB announced that the statewide urban water conservation rate climbed to 22 percent in December but declined steeply in during January 2015, which was considered the driest January since meteorological records have been kept. The March snowpack measurements taken by DWR indicated that the water content for the northern Sierra was 16 percent of average for the date. The central and southern Sierra readings were 20 percent and 22 percent of average, respectively. In response to the continuing dry winter, Governor Brown signed emergency legislation to fast track more than $1 billion in funding for drought relief and critical water infrastructure projects.

As the spring and summer of 2015 continued with little measurable precipitation, several new areas of drought response and mitigation were initiated, including construction of a temporary emergency barrier in the Sacramento-San Joaquin Delta to block saltwater from flowing into the central Delta and contaminating water supplies, and emergency actions designed to protect fisheries by releasing additional water into spawning rivers and relocating fish from threatened hatcheries. Additionally, the California Department of Housing and Community Development (HCD) and the California Building Standards Commission (CSBC) adopted new building codes to approve water efficiency requirements for both residential and non-residential construction, as well as schools and hospitals. Despite record-breaking heat in June and July, Californians continued to meet and surpass the Governor's 25 percent water conservation mandate, with a 27.3 percent reduction in water use in June and a 31.3 percent reduction in July.

Early predictions of an "El Nino" in water year 2016 led to a short-lived optimism that there might be a decline in the drought. Rain and snow levels this winter certainly improved from recent years, but not enough to draw the state out of the drought. Rain and snow levels during the winter varied significantly by region, with parts of Northern California receiving-higher-than average precipitation and most of Southern California receiving below-average precipitation.

As of mid-April, the automated snow sensors showed snowpack conditions across the state at 70 percent of normal. Regionally, the northern Sierra was at 75 percent of average, the central Sierra was at 76 percent of average, and the southern Sierra was at 60 percent of average. Reservoir levels had increased throughout the state. Californians continued to conserve water, generally meeting the Governor's mandated target of 25 percent, and saving 1.19 million acre-feet of water from June 2015 through February 2016. However, groundwater conditions had not improved, with approximately 2,180 wells statewide being identified as critical or dry, affecting an estimated 10,900 residents, mostly in the Central Valley.

Water year 2017 (October 1, 2016 to September 30, 2017) surpassed the wettest year of record (1982-1983) in the Sacramento River and San Joaquin River watersheds and was close to the wettest year in the Tulare Basin (set in 1968-1969). Mountain snowpack was well above the April 1 seasonal averages throughout the Sierra Nevada, with the southern Sierra at more than 200 percent of average for the year to date.

The plentiful winter rain and unprecedented water conservation prompted the Governor to end the drought state of emergency on April 7, 2017, for all California counties except Fresno, Kings, Tulare, and Tuolumne, where emergency drinking water projects will continue to help address diminished groundwater supplies. Water reporting requirements and prohibitions on wasteful practices, such as watering during or right after rainfall, hosing off sidewalks, and irrigating ornamental turf in public street medians, will remain in effect for all Californians. The goal is to make conservation a way of life in California. The state will also continue its work to coordinate a statewide response on the unprecedented bark beetle outbreak in drought-stressed forests that has killed millions of trees

across California.[258] Although the severely dry conditions that afflicted much of the state starting in the winter of 2011-2012 are gone, damage from the drought will linger for years in many areas. The drought reduced farm production in some regions, killed an estimated 100 million trees, harmed wildlife and disrupted drinking water supplies for many rural communities. Another serious consequence that of land subsidence due to groundwater pumping, is discussed later in this section.

Summary of California's Drought History

Table 9.E summarizes California droughts initially discussed in a July 2000 DWR report and brings the date forward to 2016. The 1976-1977 and 2012-2017 droughts were among the worst in California history.

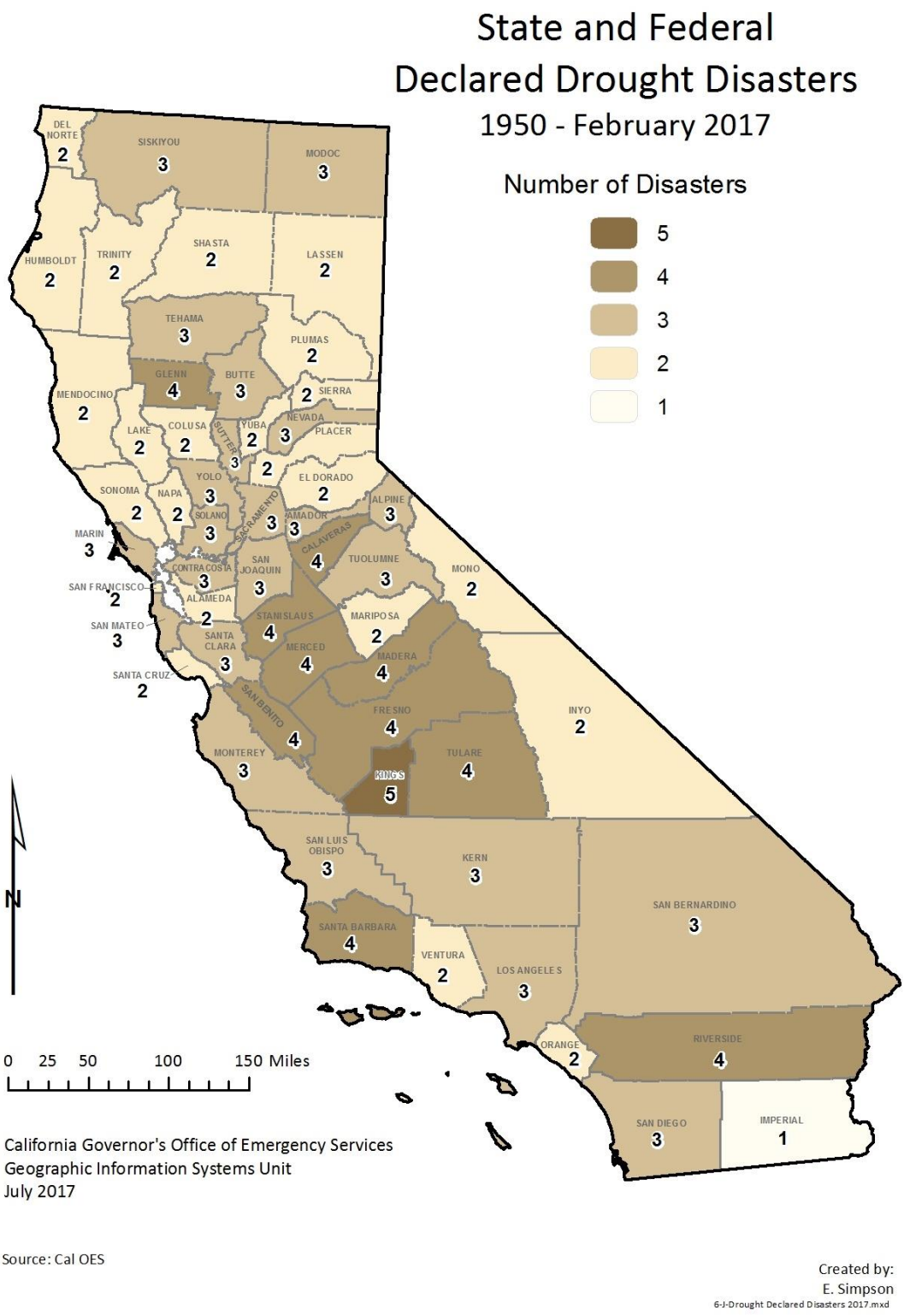
Table 9.E: Drought Incidents, 1972 to 2016

Year	Number of Incidents	Jurisdictions Affected (Counties, Unless Otherwise Noted)	Statewide Crop Damage
1972	1	Glenn, San Benito, Santa Clara	$8 million
1976-1977	1	Alpine, Calaveras, Colusa, Fresno, Glenn, Madera, Merced, San Diego, San Joaquin, Solano, Stanislaus, Sutter, Tuolumne, Alameda, Butte, Contra Costa, Kings, Los Angeles, Riverside, San Luis Obispo, Tulare, Yolo, Amador, Monterey, Napa, Nevada, San Benito, San Bernardino, Tehama, San Mateo, Marin	$2.67 billion
1988	1	Madera County location emergency was ratified every two weeks through 1991.	Not Available
1990	2	Santa Barbara(City and County)	0
1991	1	Alameda, Alpine, Colusa, Fresno, City of Orange Cove, Glenn, Kern, Kings, Lake, Madera, Marin, Mendocino, Monterey, Placer, Santa Barbara, City of Santa Barbara, Shasta, Siskiyou, Solano, Sonoma, Sutter, Tehama, Tulare, Tuolumne, and Yuba. Many of these emergencies continued through 1992.	U.S. Department of Agriculture - nationwide: $995 million for 1990-1991 crop loss. Additional $775 million in emergency funds for 1990-1992 crop losses.
2001	5	Del Norte, Modoc, Siskiyou, Inyo, Humboldt, Kern, Los Angeles, Ventura, Mono, Lassen, Plumas, San Bernardino, Santa Barbara, Sierra, Shasta, Trinity	Not Available
2002	3	Alpine, Amador, Calaveras, Imperial, Modoc, Nevada, Orange, Placer, Riverside, San Bernardino, Sierra, Stanislaus	$12,100
2007	1	Kings, Riverside	(data pending)
2008	1	Fresno, Kern, Kings, Madera, Merced, Sacramento, San Joaquin, Stanislaus, Tulare	(data pending)
2009	1	Fresno	(data pending)
2012	1	All counties	(data pending)
2013	1	All counties	(data pending)
2014	1	All counties	$810 million
2015	1	All counties	$900 million
2016	1	All counties	$921 million

Sources: Cooley et al. (2016), Howitt et al. (2015) http://pacinst.org/publication/impacts-of-californias-ongoing-drought-agriculture/, https://watershed.ucdavis.edu/files/biblio/Final_Drought%20Report_08182015_Full_Report_WithAppendices.pdf, Cal OES Individual Assistance Section, SBA Declarations/USDA Designations database; Cal OES Origins and Development- A Chronology 1917- 1999

[258] Governor's Press Release April 7, 2017. Available at https://www.gov.ca.gov/2017/04/07/news19747/

Map 9.G: State and Federal Declared Drought Disasters, 1950-February 2017



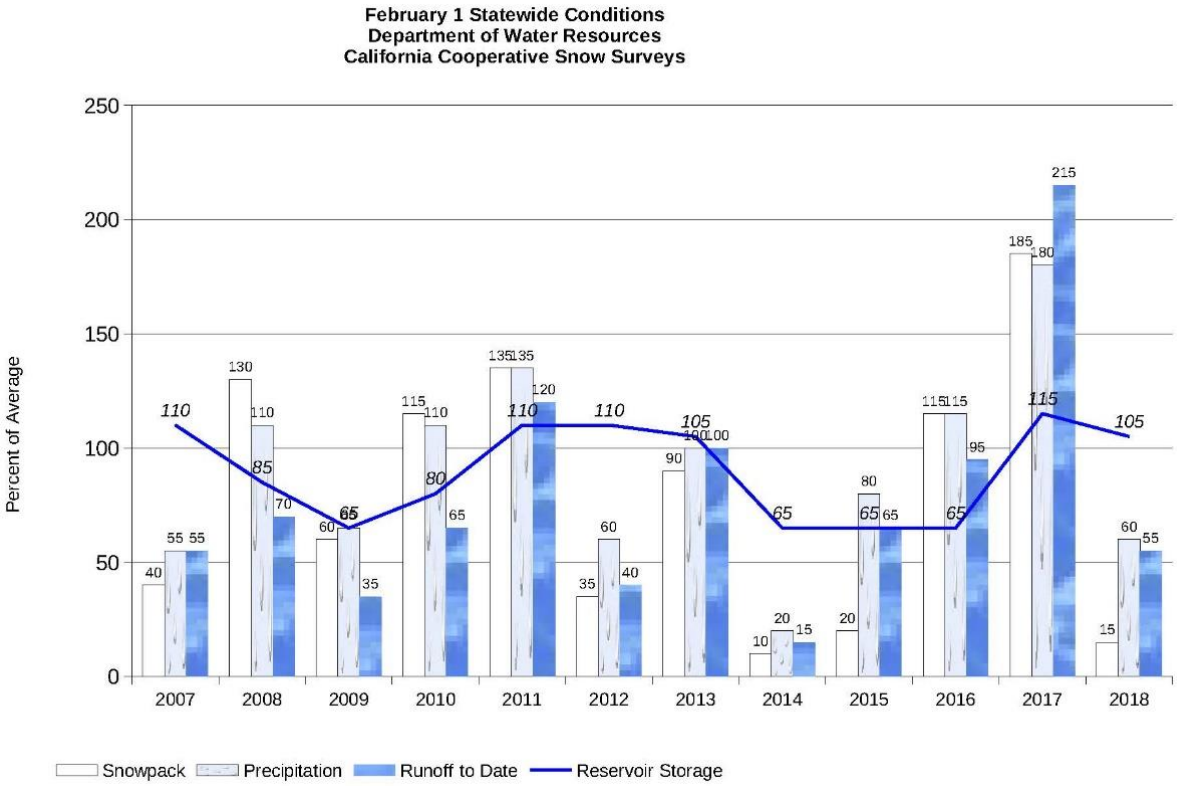
Map 9.G shows the pattern of drought-declared disasters in California over the past 67 years. While heaviest concentrations are centered in the Central Valley area, no part of the state is immune from drought disaster.

Tracking Water Conditions

Chart 9.A illustrates several indicators commonly used to evaluate water conditions in California. The percent of average values are determined by measurements made in each of the ten major hydrologic regions. The chart describes water conditions in California between 2005 and 2018. The chart illustrates the cyclical nature of weather patterns in California.

Snow pack and precipitation increased in 2006, decreased sharply in 2007 through 2009, recovered somewhat in 2010-2011, again dramatically declined in 2012, reached average levels in 2013, and again decreased for 2014-2015, with average levels again reached in 2016. In 2017 precipitation, snowpack, and runoff, were significantly above average (resulting in other hazard events such as flooding), but 2018 follows with rainfall and snowpack well below average.

Chart 9.A: Water Supply Conditions, 2005 to 2018



Source: Department of Water Resources, https://cdec.water.ca.gov/snow/bulletin120/FebHistory.pdf

Drought and Land Subsidence

Subsidence due to groundwater pumping historically has occurred in seven main areas within Central and Southern California, Sacramento Valley, Antelope Valley, Oxnard Plain, greater Los Angeles, the Mojave Desert, Yucaipa and Coachella Valleys, and the San Joaquin Valley. Each is described briefly below, with more focus placed on the San Joaquin Valley.

Sacramento Valley
The Sacramento Valley has seen elevation losses from ranging from 0.73 to 3.9 feet since 1949, which has caused damage to irrigation wells and increased the extent of flooding in certain areas. Although the Sacramento Valley has a large supply of surface water, drought periods have led communities to rely more heavily on groundwater.

Antelope Valley
Although the spatial extent is much less than the San Joaquin Valley, land subsidence due to excessive groundwater pumping has occurred at striking levels in the Antelope Valley as well. Groundwater level declines of more than 270 feet in some parts of the groundwater basin have resulted in an increase in pumping lifts, reduced well efficiency, and land subsidence of more than 6 feet in some areas. Future urban growth and limits on the supply of imported water may increase reliance on groundwater.

Oxnard Plain
While the amount and areal extent of subsidence in the basin from each contributing source remain unknown, groundwater withdrawal and oil and gas production are probably major causes in the Oxnard Plain Sub-Basin, and tectonic activity is likely a minor cause. Water-level declines in this coastal basin have induced land subsidence that was first measured in 1939. Subsidence occurred primarily in the upper-aquifer system prior to 1959; some subsidence also occurred in the lower-aquifer system during 1959-1993, owing to an increase in groundwater extraction.

Greater Los Angeles
Because tectonic deformation, oil field operations, and groundwater extraction and injection occur in overlapping proximity within the greater Los Angeles metropolitan area, it is difficult to determine the cause of observed deformations using standard surveying techniques. However, separate cases of subsidence within the basin have been attributed to a variety of activities, including groundwater pumping, oil extraction, and tectonic movement. Given the expansive infrastructure and population density in this region, the effects of land subsidence are potentially catastrophic; however, the rate of subsidence is presently not high enough to cause major concern.

Mojave Desert
Land subsidence has been ongoing in the dry lakebeds throughout the Mojave and Morongo groundwater basins since the 1960s.

Yucaipa and Coachella Valleys
Land subsidence in these two valleys is primarily due to excessive groundwater pumping, as neither region has adequate surface water to support its domestic and non-domestic uses.

San Joaquin Valley
The most striking case of land subsidence is in the San Joaquin Valley, such that it is considered "the greatest human alteration of Earth's surface."[259] The San Joaquin Valley is the largest and most productive agricultural region in California, but it does not have sufficient surface water to support farming or domestic uses. Beginning around the 1920s, farmers relied upon groundwater for water supply. Over time, over-pumping caused groundwater level declines and associated aquifer system compaction and land subsidence that resulted in permanent aquifer-system storage loss. By 1970, significant land subsidence (more than 1 foot) had occurred in about half of the San Joaquin Valley, or about 5,200 square miles, and locally some areas had subsided by as much as 28 feet.

[259] USGS, 2017

Physical Signs of Subsidence

Source: U.S. Geological Survey (USGS) California Water Science Center, https://ca.water.usgs.gov/land_subsidence/

Reduced surface-water availability during 1976-1977, 1986-1992, 2007-2009, and 2012-2016 caused groundwater pumping increases in the San Joaquin Valley, declines in water levels to near or beyond historic lows, renewed aquifer compaction, and resulting increased subsidence. This suggests that subsidence becomes a larger risk factor during drought events but is more broadly linked to ongoing groundwater management issues.

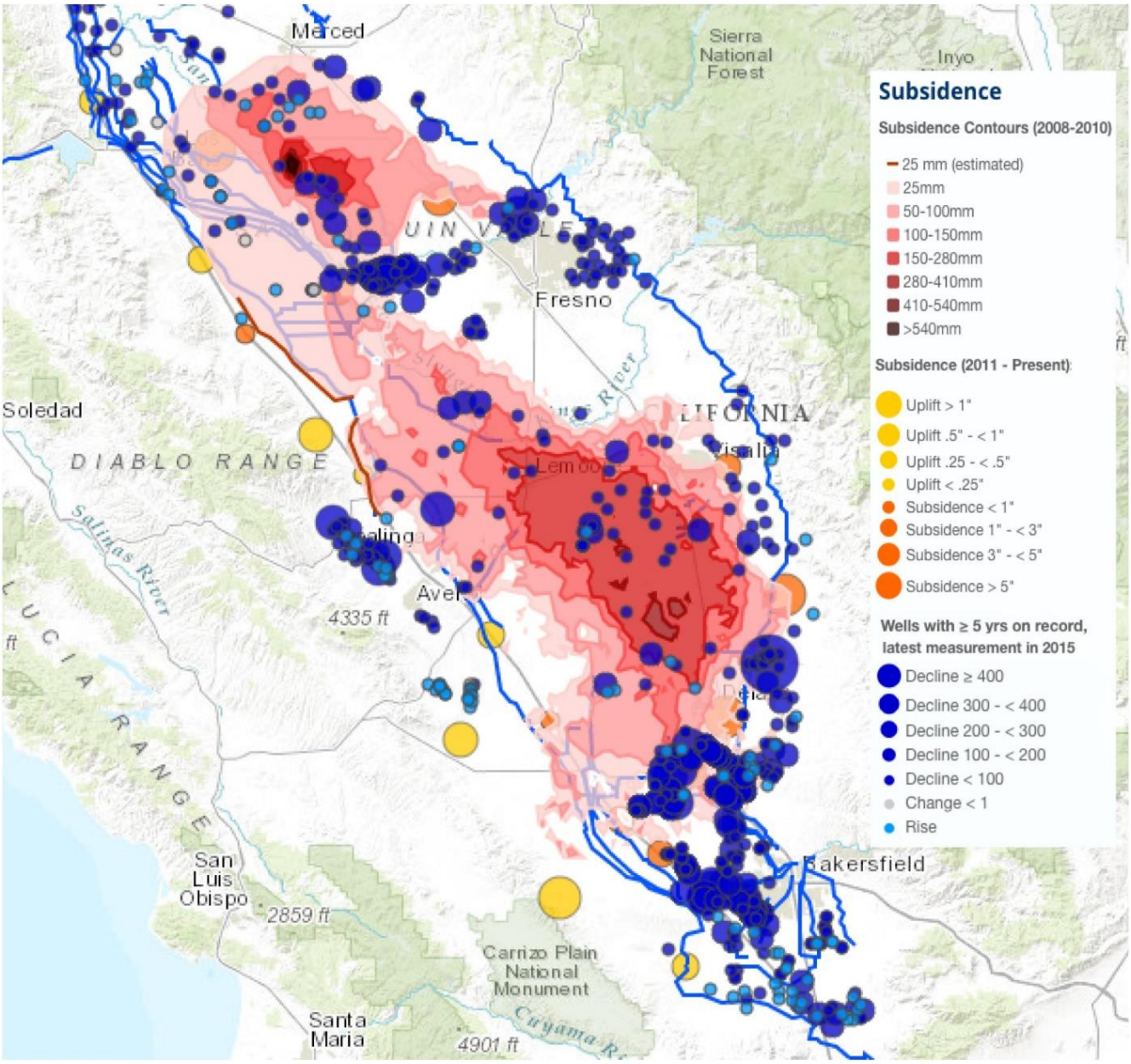
The resulting land subsidence has reduced the freeboard and flow capacity of the Delta-Mendota Canal, as well as the California Aqueduct and other canals that transport floodwater and deliver irrigation water, requiring expensive repairs.

Interferometric Synthetic Aperture Radar (InSAR)[260] analyses in 2017 show that two large areas in the San Joaquin Valley are subsiding substantially. These areas are a large (2,700 square mile) swath of subsidence west of Tulare and east of Kettleman City, and an area about half the size (1,200 square miles), but still very large near El Nido (south of Merced and west of Madera).

Map 9.H shows the areas of subsidence along with occurrences of well decline since 2011 (with the latest well measurement in 2015). Map 9.I shows critically overdrafted groundwater basins as of January 2016.

[260] https://ca.water.usgs.gov/land_subsidence/california-subsidence-measuring.html

Map 9.H: Drought Indicators Map from U.S. Geologic Survey Showing Well Decline Along with Subsidence in the San Joaquin Valley



Source: USGS California Water Science Center, https://ca.water.usgs.gov/land_subsidence/

Map 9.I: Critically Overdrafted Groundwater Basins in the San Joaquin Valley

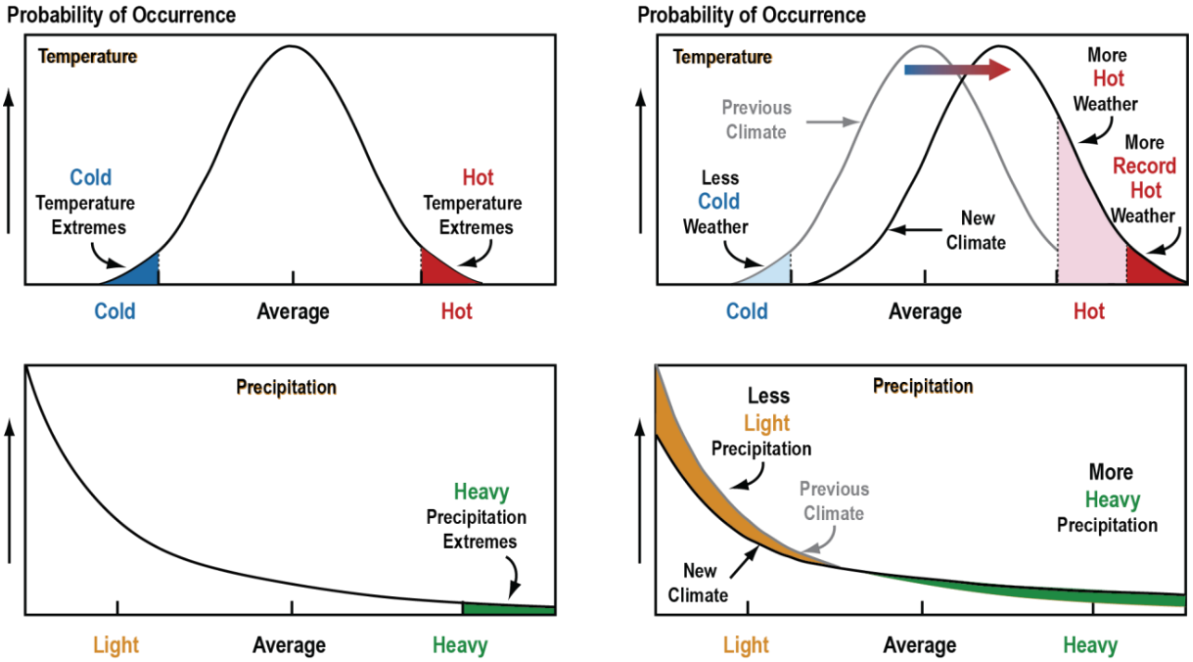
Source: Department of Water Resources, http://www.water.ca.gov/groundwater/sgm/pdfs/GW_basinsCriticalOverdraft_SCentralRegion.pdf

Climate Change, Drought, and Water Shortage Hazards

Climate scientists studying California find that drought conditions are likely to become more frequent and persistent through the 21st century due to climate change. The experiences of California during recent years underscore the need to examine more closely the state's water storage, distribution, management, conservation, and use policies.

As summarized in *Chapter 4: Profiling California's Setting, Section 4.3*, climate change not only alters the annual amount of precipitation and seasonal distribution, but also changes seasonal variability, which is projected to increase the severity and frequency of drought events. Combined with higher temperature, which increases water demand and loss of water due to evaporation, these events can lead to water shortage. In addition to creating water shortages, drought increases wildfire risk, and wildfires in turn increase demand for water. Prolonged periods of drought can result in detrimental changes in the vegetative structure and health of forests, making them more vulnerable not only to pest outbreaks but also to fire.[261] The loss of forests due to distressed health, pests, or fire can produce increased risk of other hazards due to reduced ability to retain runoff during heavy rainfall events. Figure 9.A illustrates the relationships between temperature and precipitation.

Figure 9.A: Graphical Illustration of extreme Events for Temperature and Precipitation



Source: CCSP. Weather and Climate Extremes in a Changing Climate. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [Thomas R. Karl, Gerald A. Meehl, Christopher D. Miller, Susan J. Hassol, Anne M. Waple, and William L. Murray (eds.)]. 2008. Department of Commerce, NOAA's National Climatic Data Center, Washington, D.C., USA, 164 pp.

The 2018 Safeguarding California Plan, an update to the 2009 Climate Adaptation Strategy, stresses the need for public policy development addressing long-term climate change impacts on water supplies. Droughts are expected to increase in frequency, duration, and intensity, and drought affects all sectors, including public health, biodiversity, agriculture, and the economy. During droughts, groundwater use will likely intensify, potentially resulting in increased overdraft and subsidence (which can result in permanent loss of storage and damage to overlying infrastructure, including flood management and transportation facilities), and further stressing groundwater-dependent ecosystems. Agriculture relies extensively on the state's aquifers; groundwater is the only source of water for much of California's most productive farmland, and agricultural water needs are likely to be heightened during prolonged hot and dry periods. Groundwater is also often the only source of water for small, rural water

[261] US EPA Region 9 & CA DWR. (2011). Climate Change Handbook for Regional Water Planning. Sacramento: author, 200p.

systems and households, which may lack the technical, managerial, and financial capacity to respond to drought conditions.[262]

California's snowpack has historically stored about 15 million acre-feet of water and this amount of naturally occurring water storage has been an integral part of California's water supply systems. Snow has traditionally added about 35 percent to the reservoir capacity available to water managers in the state, carrying water over from California's winter wet season to the summer dry season. The water management community has invested in, and depends upon, a system based on historical conditions. Scientists project a loss of at least 25 percent of the Sierra snowpack by 2050.

Assessment of State Vulnerability and Potential Losses

Although no definitive assessment of state vulnerability or potential long-term losses due to drought and water shortages exists, the cyclical occurrence of drought and documentation of past and current losses point to the strong probability that California will continue to be vulnerable to short- and longer-term drought impacts.

Agricultural Vulnerability

Table 9.F shows the economic loss impacts of the 2015 California drought on agriculture.

Table 9.F: Summary of Impacts of 2015 California Drought

Description	Impact
Drought-related idle land	540,000 acres
Crop revenue losses	$900 million
Dairy and livestock revenue losses	$350 million
Costs of additional pumping	$590 million
Direct costs	$1.8 billion
Total economic impact	**$2.7 billion**
Direct job losses	10,100 jobs
Total job losses	21,000 jobs

Source: Howitt et al., "Economic Analysis of the 2015 Drought for California Agriculture," 2015.https://watershed.ucdavis.edu/files/biblio/Final_Drought%20Report_08182015_Full_Report_WithAppendices.pdf

Subsidence Vulnerability

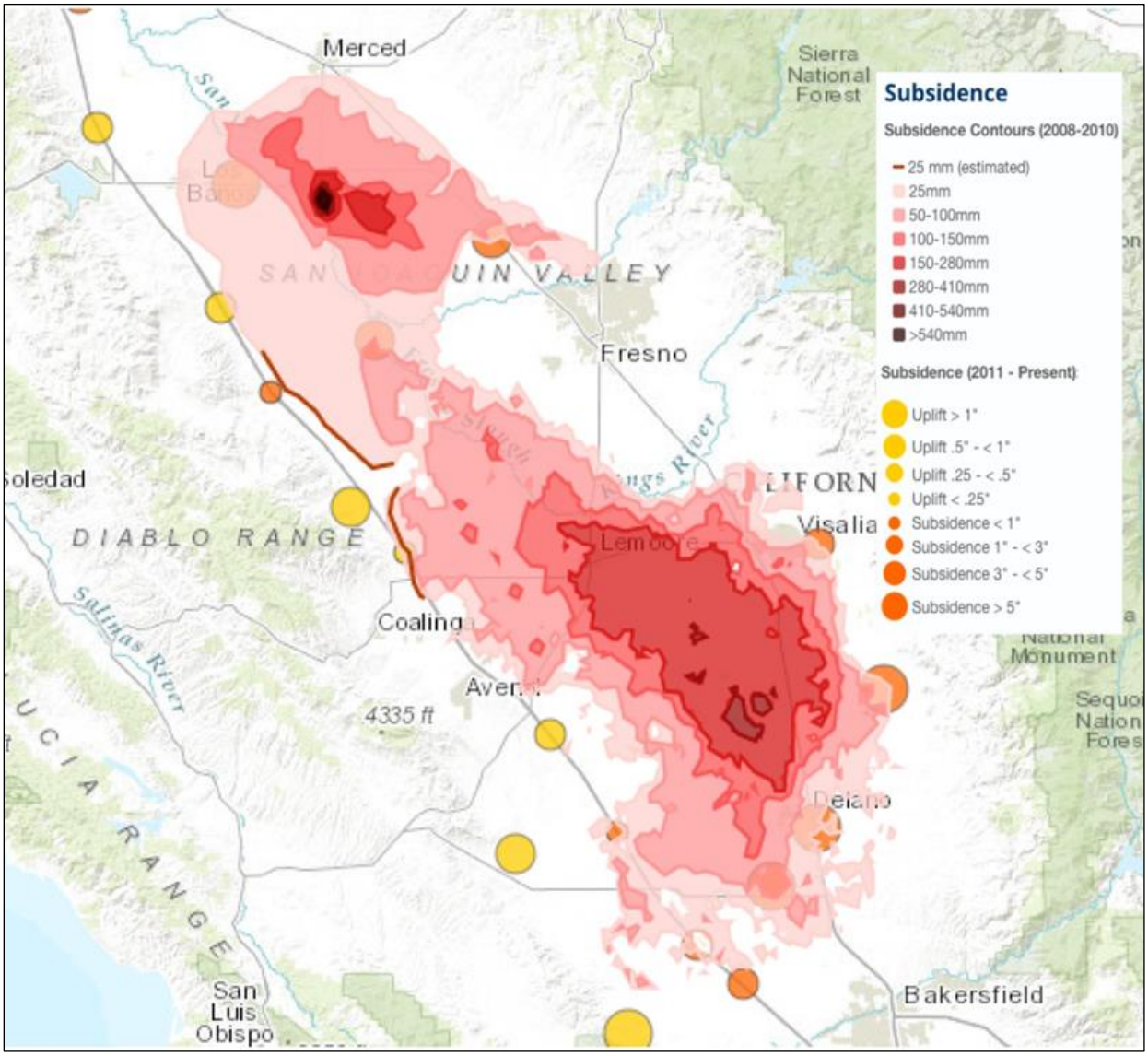
Land subsidence in the San Joaquin Valley and Sacramento-San Joaquin Delta, illustrated in Map 9.J, accounts for the greatest statewide vulnerability and potential loss due to groundwater pumping. The San Joaquin Valley is home to the largest and most economically significant agricultural land in the state. The long-term impacts of subsidence on water storage capacity and flood risk threaten the well-being of the people, property, and the economy. The current drought and cropping patterns that have changed from row crops and rangeland to tree and other permanent crops have again forced reliance on groundwater in the San Joaquin Valley for agricultural irrigation supplies.

The existing and potential economic impacts of land subsidence in the San Joaquin Valley are not well known. Damages directly related to subsidence have been identified, and some have been quantified. Other damages indirectly related to subsidence, such as flooding and long-term environmental effects, merit additional assessment. Some of the direct damages have included decreased storage in aquifers, partial or complete submergence of canals and associated bridges and pipe crossings, collapse of well casings, and disruption of collector drains and irrigation ditches.

[262] Safeguarding California Plan: 2018 Update, http://resources.ca.gov/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf

Costs associated with these damages have been conservatively estimated at $25 million. These estimates are not adjusted for changing valuation of the dollar, and do not fully account for the underreported costs associated with well rehabilitation and replacement. When the costs of lost property value due to condemnation, regrading of irrigated land, and replacement of irrigation pipelines and wells in subsiding areas are included, the annual costs of subsidence in the San Joaquin Valley soar to $180 million per year in 1993 dollars.[263]

Map 9.J: Subsidence Contours in the Central Valley



Source: U.S. Geological Survey California Water Science Center https://ca.water.usgs.gov/land_subsidence/

The subsided islands of the Sacramento-San Joaquin Delta are perpetually at risk of flooding in the event of levee breaks or overtopping and many have flooded in the past, causing millions of dollars in damage. As subsidence progresses, the levees must be regularly maintained and periodically raised and strengthened to support the increasing stresses on their banks. Delta island flooding can also interfere with freshwater exports from the Delta.[264] The statewide water-transfer system in California is so interdependent that decreased water quality in the Delta might lead to accelerated subsidence in other areas. Both the Santa Clara and San Joaquin Valleys rely, in part, on

[263] (USGS, 1999
[264] USGS, 2017

imported water from the Delta to augment local supplies and thereby reduce local ground-water extraction and arrest or slow subsidence. Degradation of the Delta source water could result in increased groundwater use and renewed subsidence.[265]

Social Vulnerability

According to a study conducted by the Pacific Institute, the most vulnerable communities are those considered disadvantaged (characterized by a medium household income less than 80 percent of the state median) and "cumulatively burdened" (according to combined environmental and socio-economic indicators of vulnerability). The 2012-2017 drought adversely affected at least one public water system in 39 out of 58 of the state's counties, but the most impacts were seen in the San Joaquin Valley, North Coast, and Central Coast regions. Among 92 drought-affected water systems, two-thirds served a disadvantaged community and almost one-third served a cumulatively burdened community.

Dry household wells were a major issue within vulnerable communities. Dry household wells were also a major problem for vulnerable communities. In Tulare County, for example, two-thirds of the approximately 1,600 reported dry wells were in a disadvantaged community, and nearly 90 percent were in a cumulatively burdened community. Additionally, 50 percent of state emergency food assistance was distributed to Tulare County residents.[266]

Physical, Mental, and Financial Vulnerability

While many aspects of drought are well understood, very little research has been conducted to discover the extent of public health impacts associated with extended droughts. In an attempt to further explore the potential vulnerability of populations exposed to drought conditions, the California Department of Public Health partnered with two highly drought affected counties (Tulare and Mariposa) to conduct Community Assessments for Public Health Emergency Response. The rapid assessments were conducted in October and November 2015 to evaluate household water access, acute stressors, exacerbations of chronic diseases, behavioral health issues, and financial impacts.

Depending on assessment area, household impact results ranged from 3 to 12 percent of households reporting not having running water, 25 to 39 percent reporting impacts on finances, 39 to 54 percent reporting impacts on property, 10 to 20 percent reporting impacts on health, and 33 to 61 percent reporting impacts on peace of mind. Additionally households reported worsening conditions for the following: 16 to 46 percent for chronic disease, 8 to 26 percent for acute stress, and 14 to 34 percent who considered moving. Impacts on finances or property were each associated with impacts on health, peace of mind and acute stress levels. Other issues related to personal hygiene that could lead to personal health issues included the decrease in frequency or duration of handwashing which ranged from 58 to 68 percent.

Additional information may be found at:
https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/Pages/Emergency-Preparedness-Team.aspx.

Assessment of Local Vulnerability and Potential Losses

In April 2017, Governor Brown declared an end to the drought emergency, although four California counties were still deemed to lack of safe drinking water at that time.

Additional information related to community vulnerability and loss assessments may be found in Local Hazard Mitigation Plans.

[265] USGS, 1999
[266] Feinstein et al., "Drought and Equity in California", 2017. http://pacinst.org/publication/drought-equity-california/

Current Drought Hazard Mitigation Efforts

The state has deployed numerous resources—fiscal, logistical, and personnel—in response to the impacts of the 2012-2017 drought. These include Proposition 1, which was passed by a 67 percent majority of California voters in 2014. It authorized $7.5 billion in general obligation bonds to fund ecosystem and watershed protection and restoration, along with water supply infrastructure projects, including surface and groundwater storage and drinking water protection. Assembly Bill 2480, approved by the Governor in 2016, officially acknowledges that source watersheds are an integral component of California's water infrastructure and are eligible for the same forms of financing as other water collection and treatment infrastructure.

Since 2014, the state has appropriated $6.6 billion for drought response in five primary categories, as shown in Table 9.G.

Table 9.G: Drought Response Funding Since 2014, by Category

Response Measure	Amount Appropriated
Flood Improvements	$737 million
Conservation and Drought Relief	$246.5 million
Human Assistance	$164.4 million
Public Safety	$376.8 million
Environmental Protection	$95.7 million

Source: http://www.drought.ca.gov/

2012-2017 Drought Response, Recovery, and Mitigation Programs

The five-year drought prompted a multitude of response, recovery, and mitigation programs and actions led by Governor Brown and the Drought Task Force and implemented by state and local agencies as well as the general public. The following sections summarize many of the actions taken and the program delivery mechanisms.

Emergency Proclamations and Disaster Declarations

On January 17, 2014, Governor Brown proclaimed a State of Emergency and directed state officials to take all necessary actions to prepare for the drought conditions, to assist farmers and communities economically affected by dry conditions, and to ensure that the state could respond if Californians faced drinking water shortages. On April 25, 2014, the Governor issued a proclamation of continued State of Emergency.

An additional State of Emergency was declared on October 30, 2015, in response to the tree mortality epidemic worsened by the drought. As of March 30, 2017, 55 local emergency proclamations were issued by local governments (22 counties, 10 cities, 11 tribes, and 12 special districts). The U.S. Department of Agriculture included all of California's counties in its drought disaster designations at various times over the course of 2012-2017, either as primary counties or contiguous counties.

Governor's Executive Orders

California's ongoing response to the drought conditions was guided by a series of executive orders issued by Governor Brown. A brief summary of each executive order is listed in Table 9.H.

Table 9.H: 2012-2017 Drought Executive Orders

Executive Order Number	Issue Date	Provisions
B-21-13	May 20, 2013	Directed the California Department of Water Resources (DWR) and State Water Resources Control Board (SWRCB) to expedite review and processing of voluntary transfers of water and water rights.
B-26-14	September 19, 2014	Directed DWR, SWRCB, the Governor's Office of Emergency Services (Cal OES), and the Governor's Office of Planning and Research (OPR) to assist local governments with identification of

Executive Order Number	Issue Date	Provisions
		acute drinking water shortages and to work with local agencies in implementing solutions to shortages. Authorized Cal OES to use California Disaster Assistance Act (CDAA) funds to provide temporary water supplies to households without water for drinking or sanitation.
B-27-14	October 6, 2014	Directed state agencies to assist local governments with wildfire response during the drought conditions.
B-28-14	December 28, 2014	Extended provisions within the State of Emergency Proclamation issued on January 17, 2014.
B-29-15	April 1, 2015	Ordered the SWRCB to impose restrictions to achieve a 25 percent reduction in potable urban water usage, directed state agencies (DWR and California Energy Commission [CEC]) to implement water saving programs including turf replacement and appliance rebate programs, streamlined the state's drought response, and encouraged new drought-resilient technologies.
B-36-15	November 13, 2015	Extended B-26-14, B-28-14, and B-29-15. Called for additional actions to build on the ongoing drought response and assist recovery efforts from 2015 wildfires. Also extended emergency conservation regulations and streamlined permitting for stormwater capture.
B-37-16	May 9, 2016	Established a new water efficiency framework for the state, including measures to achieve longer-term water conservation, reduce urban water use, reduce system leaks, eliminate wasteful practices, strengthen urban drought contingency plans, improve agricultural water management, and improve drought planning for small water providers and rural communities.
B-40-17	April 7, 2017	Lifted the drought emergency in all California counties except Fresno, Kings, Tulare, and Tuolumne. Continued emergency drinking water projects in those counties to address diminished groundwater supplies.

Drought Disaster Assistance Programs

As noted earlier, the state has deployed numerous resources—fiscal, logistical, and personnel—in responding to the impacts of the drought. Table 9.I describes assistance programs designed to mitigate various types of drought impacts.

Table 9.I: Drought Disaster Assistance Programs

Agency	Program	Description	Allocation
California Governor's Office of Emergency Services (Cal OES)	California Disaster Assistance Act	Funding for local government assistance to provide emergency drinking and sanitation water supplies to households.	$20.1 million
Department of Food and Agriculture (CDFA)	State Water Efficiency and Enhancement Program (SWEEP)	Grants to provide financial incentives for California agricultural operations to invest in water irrigation systems that reduce greenhouse gas emissions and save water.	$40 million (Fiscal Year 2015-2016)
California Department of Social Services (CDSS)	Drought Food Assistance Program	Food assistance to affected communities that suffer high levels of unemployment from the drought.	$18.4 million
California Department of Community Services	Migrant and Seasonal Farmworker Drought Assistance Program	Assistance in employment training and placement services to migrant and seasonal	$400,000

Agency	Program	Description	Allocation
and Development (CSD)		farmworkers suffering job loss or reduced employment due to the drought.	
	Utility Assistance	Financial assistance to help low-income families pay their water utility bills.	$1.2 million under the federally funded Community Services Block Grants
	Migrant and Seasonal Farm Worker Drought Emergency Assistance Program	Emergency relief and support services to drought-affected, low-income workers in industries ancillary to agriculture	$7.5 million
California Department of Housing and Community Development (HCD)	Housing Assistance	Emergency rental assistance program in cooperation with La Cooperativa	$10 million
	Drought Housing Assistance	Funding to Tulare, Yolo, Tuolumne, Fresno, and Kings Counties for persons moving from current residences that do not have reasonable access to potable water.	$1.7 million
California Department of Water Resources (DWR)	Turf Replacement Rebate Program	A rebate program for removing turf and replacing it with landscapes that require little water at California single-family residences to support the state's drought response.	$21.8 million
Labor Workforce Development Agency (LWDA)	Employment Assistance	Administration of federally funded Drought Temporary Jobs program for six months of employment on drought-related public works projects.	$18 million funded through the U.S. Department of Labor's National Dislocated Worker Grant Program.
State Water Resources Control Board (SWRCB)	Cleanup and Abatement Account Interim Emergency Drinking Water Program and Public Water System Drought Emergency Response Program	Technical and funding assistance to communities facing drinking water shortages, and monitoring of water systems across the state.	$15 million funded through Cleanup and Abatement Account (Senate Bill 826)

Drought Grant Programs

In addition to the disaster assistance programs outlined above, a number of grant programs were initiated to provide drought relief and to stimulate drought mitigation activities. These programs are listed in Table 9.J.

Table 9.J: Drought Grant Programs

Agency/Department	Program	Description	Available Funding [Finalize these amounts]
California Energy Commission	Energy and Water Saving Research	Demonstration of water and energy saving technologies that promise to make the water, industrial, and agricultural sectors more efficient.	$16 million
California Department of Fish and Wildlife	Fisheries Restoration Grant Program	Removal of barriers to fish migration, restoration of riparian habitat, and creation of a more resilient and sustainably managed water resources system that can better withstand drought conditions.	$16.7 million
California Department of Food and Agriculture (CDFA)	State Water Efficiency and Enhancement Program	Competitive grants to implement irrigation systems that reduce greenhouse gases and save water at agricultural operations.	$18 million (3.75 million for 2017)
California Department of Forestry and Fire Protection (CAL FIRE)	Tree Mortality	Local fire protection grants focused on the removal of dead and dying trees in order to reduce the wildfire threat around homes.	$2 million
California Department of Water Resources (DWR)	High Efficiency Toilet Retrofit Program	Designed to install very low-flush volume toilets in disadvantaged communities.	$6 million funded by Proposition 1
	Turf Replacement Rebate Program	Removal of turf at single-family residences, replacing it with landscapes that require little water.	$21.8 million
	Integrated Regional Water Management	Support for projects and programs to meet California's long-term water management needs, including delivery of safe drinking water, enhancement of recycled water, water conservation, flood risk abatement, watershed protection, ecosystem restoration, and groundwater management.	$232 million

Best Practices Highlight 9.A: A Permanent Solution to Water Shortage in East Porterville, Tulare County

Residents of East Porterville in Tulare County, often called drought's "ground zero," now can turn on their taps and be confident a sustainable, safe-to-drink stream of water will flow.

Imagine losing access to a potable water supply in your own home—not for days, but for years. That happened in East Porterville as California's five-year drought reduced surface water supplies, increased the Central Valley's reliance on groundwater, and dropped the water table below the reach of many wells in the community. Hundreds of wells went dry in unincorporated East Porterville, which has no water distribution system.

Since 2014, the California Governor's Office of Emergency Services (Cal OES) has assisted with water deliveries to temporary holding tanks installed at East Porterville homes at a monthly cost of more than $650,000. Volunteers and non-governmental organizations delivered bottled water during the crisis.

The California Department of Water Resources (DWR) conducted the East Porterville Water Supply Project Feasibility Study, which concluded that the most practical solution among the several options analyzed was to connect East Porterville homes to the City of Porterville's water system. The study was a critical piece because it helped convince residents that the proposed arrangement with the City of Porterville would work. It also established the governance of the new water distribution system to achieve efficient operations. DWR employees designed the new system, negotiated with Tulare County and Porterville officials to achieve necessary agreements, and met numerous times with residents to explain the project.

New water lines were laid along East Porterville streets to expand the City of Porterville's system, which eventually will provide service to up to 1,100 East Porterville homes whose wells are dry or contaminated.

DWR employees worked on a daily basis with their colleagues in the other state agencies and in local government. The State Water Resources Control Board exercised its powers to facilitate the consolidation of East Porterville's unincorporated community with the existing Porterville water system.

DWR also collaborated with East Porterville non-profit organizations that are committed to ensuring social justice for the community's drought victims. Public meetings with simultaneous interpretation services for Spanish speakers helped East Porterville residents understand the project. [267]

Best Practices Highlight 9.B: State Water Efficiency and Enhancement Program (SWEEP)

The State Water Efficiency and Enhancement Program (SWEEP) is a competitive grant program initiated in 2014 in response to California's historic five-year drought. The program provides grant funds on a matching fund basis to agricultural operations in the state to support projects that both save water and reduce greenhouse gas emissions. Agricultural operations are defined as row, vineyard, field and tree crops, commercial nurseries, nursery stock production, and greenhouse operations. The awarded projects can combine multiple strategies to achieve the required water savings and emissions reductions. Eligible system components include soil moisture monitoring, drip systems, switching to low pressure irrigation systems and installing renewable energy to reduce on-farm water use and energy.

Administered by the California Department of Food and Agriculture, in collaboration with the Department of Water Resources and the State Water Resources Control Board, the program is funded as part of California Climate Investments, a statewide program that puts billions of cap-and-trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment—particularly in disadvantaged communities. The SWEEP provides a unique opportunity for government and private enterprise to work together to provide long-term solutions aimed toward reducing agricultural water use.

[267] Department of Water Resources Magazine, fall 2016

Since the SWEEP was launched in 2014, it has funded 587 projects totaling more than $62 million. For funding year 2017, 58 awards covering 19 different counties were made, totaling $4,992,509 in grant funds with $6,782,535. Cumulative benefits are estimated at 958,000 acre-feet of water savings—enough to fill more than two million swimming pools—along with greenhouse gas emission reductions of 741,000 metric tons of carbon dioxide equivalent over 10 years, the equivalent of removing more than 20,000 vehicles from roads.

For additional information go to: https://www.cdfa.ca.gov/oefi/sweep/.

Drought Mitigation Plans and Programs

California develops, maintains, and implements various plans related to drought and water management activities. Each is briefly outlined below. Additional information and details may be found at the weblinks provided.

Drought Contingency Plan

In response to the 2007-2009 drought, Governor Arnold Schwarzenegger issued Drought Proclamations and Executive Orders in 2008 and 2009 directing state agencies to take immediate actions to manage the crisis. DWR responded, with strong support from Cal OES and other agencies, by developing a Drought Contingency Plan. In response to the 2012-2017 drought, the 2016 Drought Contingency Plan directed operations of the State Water Project (SWP) and Central Valley Project (CVP)—two fundamental water supply projects in the state—for February through November 2016. The 2016 Drought Contingency Plan builds on the foundation of the planning work by state and federal agencies over the previous three years and fulfills the condition of the order adopted by the State Water Resources Control Board (SWRCB) on December 15, 2015. The goals of the 2016 Drought Contingency Plan are the following: [268]

- Ensure, as a first priority, that the CVP and SWP will meet essential human health and safety needs, by supplying adequate water supplies throughout their service areas for drinking, sanitation, and fire suppression
- Manage the intrusion of salt water into the Sacramento-San Joaquin Delta through operations of the CVP and SWP
- Provide and maintain adequate protections for state and federal endangered and threatened species and other fish and wildlife resources
- Seek and consider water management flexibilities to maximize the benefit of limited water supplies

2013 California Water Plan and 2018 Update

The most recent California Water Plan was adopted in 2013 and supports the implementation of the Governor's Water Action Plan. The objectives of the California Water Plan are the following:[269]

- Strengthen integrated regional water management planning
- Use and reuse water more efficiently
- Expand conjunctive management of multiple supplies
- Protect and restore surface water and groundwater quality
- Practice environmental stewardship
- Improve flood management using an integrated water management approach
- Manage the delta to achieve the coequal goals for California
- Prepare prevention, response, and recovery plans
- Reduce the carbon footprint of water systems and water uses
- Improve data, analysis, and decision support tools
- Invest in water technology and science
- Strengthen tribal/state relations and natural resources management
- Ensure equitable distribution of benefits
- Public access to waterways, lakes, and beaches

[268] DWR, 2016, "2016 Drought Contingency Plan For Water Project Operations February – November 2016", http://www.water.ca.gov/waterconditions/docs/2016-DroughtContingencyPlan-CVP-SWPOperations-Feb-Nov_1.19.16-FINAL.pdf

[269] DWR, 2013, "California Water Plan Update 2013", https://www.water.ca.gov/Programs/California-Water-Plan

- Strengthen alignment of land use planning and integrated water management
- Strengthen alignment of government processes and tools
- Improve integrated water management finance strategy and investments

As an update to the 2013 California Water Plan, DWR is in the process of developing the 2018 Water Plan to incorporate progress of existing strategies and new strategies in support of the Governor's 2016 Water Action Plan. The purpose of the 2018 Water Plan is to assess the effectiveness of current water actions (programs and projects) in advancing sustainable water management in California.

2016 Water Action Plan

The Governor's Water Action Plan was updated in 2016 and includes the following objectives:[270]

- Make conservation a way of life in California
- Invest in integrated water management and increase regional self-reliance
- Achieve the coequal goals for the Delta
- Protect and restore important ecosystems
- Manage and prepare for dry periods
- Expand water storage capacity and improve groundwater management
- Provide safe drinking water and secure wastewater systems to all communities
- Increase flood protection
- Improve operational and regulatory efficiency
- Identify sustainable and integrated financing opportunities

State Water Resources Control Board Activities

Division of Drinking Water. To help mitigate the hazard of lack of drinking water during emergencies and increased resiliency, the State Water Resources Control Board (SWRCB) Division of Drinking Water has been promoting and implementing consolidation of challenged public water systems. The Division of Drinking Water has encouraged the establishment of interconnections among public water systems, updates of vulnerability assessments and emergency response plans, and review of development of recycled water projects and desalination projects. The Division of Drinking Water also encourages public water systems to engage with county emergency services to be included in local hazard mitigation planning, specifically with recognition of and calling attention to the human right of access to water. For more information, visit: https://www.waterboards.ca.gov/water_issues/programs/hr2w/

Safe Drinking Water Plan for California. Originally developed by the California Department of Health (CDPH) in 1993, the Safe Drinking Water Plan for California is required to be periodically updated in accordance with Senate Bill (SB) 1307, passed in 1996. During the preparation of the 2014 draft update, responsibility for the plan was transferred from CDPH to the SWRCB. The current update of the Safe Drinking Water Plan for California, submitted to the Legislature in June 2015, focuses on how the SWRCB proposes to improve access to reliable and healthy drinking water for communities throughout the state. The plan focuses on the nearly 8,000 public water systems that are under the purview of the Division of Drinking Water. The plan includes recommendations to effectively support and provide resources to the water systems that serve the 2 percent of consumers who do not receive safe drinking water.

The Safe Drinking Water Plan identifies the improvements needed to bring the smaller systems into compliance with a secure and reliable supply. Some of the key areas addressed in the report include:

- Obtaining water in a drought
- Providing safe drinking water for disadvantage communities
- Increasing and sustaining capacity development of systems
- Identifying shared solutions to supplying safe drinking water, including the consolidation of systems
- Developing cheaper and effective treatment and analytical methods
- Building better emergency preparedness and response protocols for small systems

[270] CNRA, 2016, "California Water Action Plan", http://resources.ca.gov/california_water_action_plan/

The plan may be found at:
https://www.waterboards.ca.gov/publications_forms/publications/legislative/docs/2015/sdwp.pdf

Urban and Agricultural Water Management Plans
The Governor's drought declaration also called upon local urban water suppliers and municipalities to implement their local water shortage contingency plans immediately in order to avoid or forestall outright restrictions that could become necessary later in the drought season. Furthermore, the Governor directed local water agencies to update their legally required Urban and Agricultural Water Management Plans, which can help plan for extend drought conditions.

Progress Summary 9.D: California Groundwater and the Sustainable Groundwater Management Act of 2014

Progress as of 2018: In September 2014, Governor Jerry Brown signed a historic three-bill package known as the Sustainable Groundwater Management Act of 2014 (SGMA) into law. Intended to strengthen local control and management of California's groundwater basins, the SGMA collectively commits California to local management of groundwater supplies with the goal of achieving sustainable management of groundwater basins through development and implementation of groundwater sustainability plans (GSPs) by local agencies within 20 years.

The SGMA provides the following timeline for the state, counties, and local agencies to provide tools and technical assistance to empower local entities to achieve groundwater sustainability:

- ACTION 1: Local agencies must establish groundwater sustainability agencies (GSAs) for all medium- and high-priority basins by June 30, 2017.
- ACTION 2: GSAs for medium- and high-priority basins must develop and begin implementation of GSPs by January 31, 2020 for those in critical condition of overdraft and by January 31, 2022 for all other medium- and high-priority basins.
- ACTION 3: After the development of GSPs, agency implementation of the GSP must occur over the following 20 years. GSPs must include measurable objectives and milestones to show progress toward sustainability goals.

To guide the implementation of the SGMA, the California Department of Water Resources (DWR) is tasked with several actions. DWR's next objectives include completing regulations for changing basin boundaries and establishing content for and review of GSPs, updating basin priorities (low, medium, or high), and conducting groundwater assessments into the next decade.

To date, DWR has identified basins subject to critical conditions of overdraft and held public meetings on the topic. DWR posts notifications for GSA formation on its web page and provides a graphical summary of the SGMA's timeline.

The SGMA also required DWR to develop Best Management Practices (BMPs) that provide technical assistance for GSAs to develop GSPs. As of 2016, DWR published the following BMPs, which include assistance for monitoring and modeling land subsidence in addition to the sustainable management of groundwater:

- BMP 1: Monitoring Protocols, Standards, and Sites
- BMP 2: Monitoring Networks and Identification of Data Gaps
- BMP 3: Hydrogeologic Conceptual Model
- BMP 4: Water Budget
- BMP 5: Modeling

For more information regarding the GGMA and progress toward implementation, visit DWR's Sustainable Groundwater Management web page (https://www.water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management) or the U.S. Geological Survey's Sustainable Groundwater Management Act web page: https://ca.water.usgs.gov/sustainable-groundwater-management/

Countywide Drought and Water Shortage Contingency Plans

In May 2016, Governor Brown issued Executive Order B-37-16 that included drought hazard and planning-related actions. Directive 10 from the order specified that, "For areas not covered by a Water Shortage Contingency Plan, the Department shall work with counties to facilitate improved drought planning for small water suppliers and rural communities."

In the April 2017 final report titled "Making Water Conservation a California Way of Life," state agencies identified the following efforts as a pathway to developing recommendations: improved engagement with cities, counties, and stakeholders; state agencies' commitment to develop initial data collection and outreach; engagement of stakeholders through a public process to develop drought plan recommendations; and incorporation of drought planning into county hazard mitigation plans.

Since issuance of Directive 10, the California Department of Water Resources (DWR) has been working with a diverse group of stakeholders to develop a framework for improved drought planning, for areas not covered by Urban Water Management Plan Water Shortage Contingency Planning that could be incorporated by counties into their hazard mitigation and land use planning efforts and documents. The framework would allow counties to demonstrate preparation, planning, and response strategies to water shortages—especially shortages resulting from prolonged droughts and climate change.

Assembly Bill 1668 pending legislation (as amended May 3, 2018) would require DWR, in coordination with the State Water Resources Control Board (SWRCB), to identify small water suppliers and rural communities that may be at risk of water shortage vulnerability and develop recommendations for countywide drought and water shortage contingency planning to address the planning needs of small systems and rural communities.

The current draft of the countywide drought preparedness framework will be made available on DWR's website at: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Conservation-As-a-Way-of-Life.

Additional Drought Hazard Mitigation Opportunities

Sub-Seasonal to Seasonal (S2S) Precipitation Forecasting

Improved National Weather Service (NWS) forecasts at the sub-seasonal to seasonal (S2S) timescale are sorely needed for improving California's drought preparedness, response, and mitigation capabilities. Such forecasts can answer questions such as "will the next six weeks be wet or dry?" or "will this winter be wet or dry?" Having longer lead times as a result of better forecasting allows for more timely response actions and better operation of water infrastructure. DWR is working through the Western States Water Council and the National Oceanic and Atmospheric Administration (NOAA) to identify proposed actions for improving forecasting. Additional background on S2S forecasting is available at: http://www.westernstateswater.org/wp-content/uploads/2016/05/A2227_precip-forecasting-brochure_v6_FINAL.pdf.

California Statewide Groundwater Elevation Monitoring (CASGEM) Program

The California Statewide Groundwater Elevation Monitoring (CASGEM) Program tracks seasonal and long-term groundwater elevation trends in groundwater basins statewide as mandated by the November 4, 2009 Water Code amendment with Senate Bill x7-6 (2009). In accordance with this amendment to the Water Code, DWR developed the CASGEM Program. The amendment requires collaboration between local monitoring entities and DWR to collect groundwater elevation data.

DWR has completed the 2015 CASGEM Status Report, prepared for the Governor and the Legislature as required by the Water Code (Section 10920 et seq.). This report describes the significant number of CASGEM Program accomplishments achieved during calendar years 2012 through 2015. Collection and evaluation of such data on a statewide scale is an important fundamental step toward improving management of California's groundwater resources. CASGEM groundwater elevation data are necessary for determining groundwater elevation and storage trends and the effectiveness of groundwater management measures, including those implemented under

Sustainable Groundwater Management Act (SGMA). For more information on the CASGEM Program, visit the program website: https://www.water.ca.gov/Programs/Groundwater-Management/Groundwater-Elevation-Monitoring--CASGEM.

Promoting Continued Efficient Water Use

Collaborative water conservation campaigns such as "Save our Water" provide educational resources to the public to facilitate personal water conservation practices. For more information, visit: http://saveourwater.com.
A top priority of the Water Action Plan is to "Make Conservation a California Way of Life." As a result of Executive Order B-37-16, the SWRCB will permanently prohibit wasteful practices, such as hosing off sidewalks, driveways, and other hardscapes; washing automobiles with hoses not equipped with a shut-off nozzle; and watering lawns in a manner that causes runoff. DWR and the SWRCB will also work to eliminate leaks in water systems across the state. Figure 9.B is a graphic summary of recommended conversation actions outlined in the report. To view the full report, go to:
http://www.water.ca.gov/wateruseefficiency/conservation/docs/20170407_EO_B-37-16_Final_Report.pdf

Figure 9.B: "Make Conservation a California Way of Life" Report Actions Summary

Table ES-1. Actions and Recommendations Summarized in this Report

Chapter Section and Title where Item is Addressed	Executive Order Items: Use Water More Wisely			Eliminate Water Waste				Strengthen Local Drought Resilience			Improve Agricultural Water Use Efficiency & Drought Planning			Within Existing Authorities (Chapter 2)	Requires New Authority (Chapter 3)
	1	2	3	4	5	6	7	8	9	10	11	12	13		
2.1 Emergency Water Conservation Regulations for 2017	●													✓	
2.2 Permanent Prohibition of Wasteful Practices			●	●										✓	
2.3 Reduced Water Supplier Leaks and Water Losses					●	●								✓	
2.4 Certification of Innovative Technologies for Water Conservation and Energy Efficiency							●							✓	
3.1 New Water Use Targets Based on Strengthened Standards		●				●									✓
3.2 Water Shortage Contingency Plans						●		●	●						✓
3.3 Drought Planning for Small Systems & Rural Communities										●					✓
3.4 Agricultural Water Management Plans						●					●	●	●		✓

Source: Make Conservation a California Way of Life Implementation Report, page iv
http://www.water.ca.gov/wateruseefficiency/conservation/docs/20170407_EO_B-37-16_Final_Report.pdf

9.1.6 ENERGY SHORTAGE AND ENERGY RESILIENCY

Identifying Energy Shortage Hazards

The California energy system includes the following elements: energy extraction, transport, and conversion (such as combusting natural gas in power plants to generate electricity or producing gasoline and diesel from crude oil in refineries); energy consumption for services (such as electricity for lighting, natural gas use in homes and buildings for space and water heating, and gasoline and diesel to fuel cars and trucks); and use of electricity from out-of-state plants serving California.

California gets its electric power from a number of sources.[271] Most in-state electrical generation is derived from natural gas (49.9 percent). Even when combined with imports from other regions, natural gas remains dominant at 36.5 percent. Hydro-generation provides 12.31 percent of California's electric power, with the balance coming from fossil fuels, nuclear, and renewable sources. Renewables comprise 27.9 percent of in-state electrical generation and the percentage is very similar (25.5 percent) when combined with imports.

Renewable energy sources include wind (6.8 percent), solar (10.0 percent), geothermal (5.8 percent), biomass (3.0 percent), and small hydroelectric (2.3 percent). In-state electrical generation is 68.2 percent (198,227 gigawatt hours [GWh]) of the total (290,567 GWh), with the remaining being provided through southwest and northwest imports. Coal, provided primarily from imports, makes up only 4 percent of California's electrical generation. About 97 percent comes from out-of-state power plants. Imports of coal-fired generation are expected to become zero by the end of 2025.

Natural gas continues to play an important and varied role in California. Nearly 45 percent of the natural gas burned in California is used for electricity generation, and much of the remainder is consumed in the residential (21 percent), industrial (25 percent), and commercial (9 percent) sectors. California continues to depend upon out-of-state imports for nearly 90 percent of its natural gas supply.

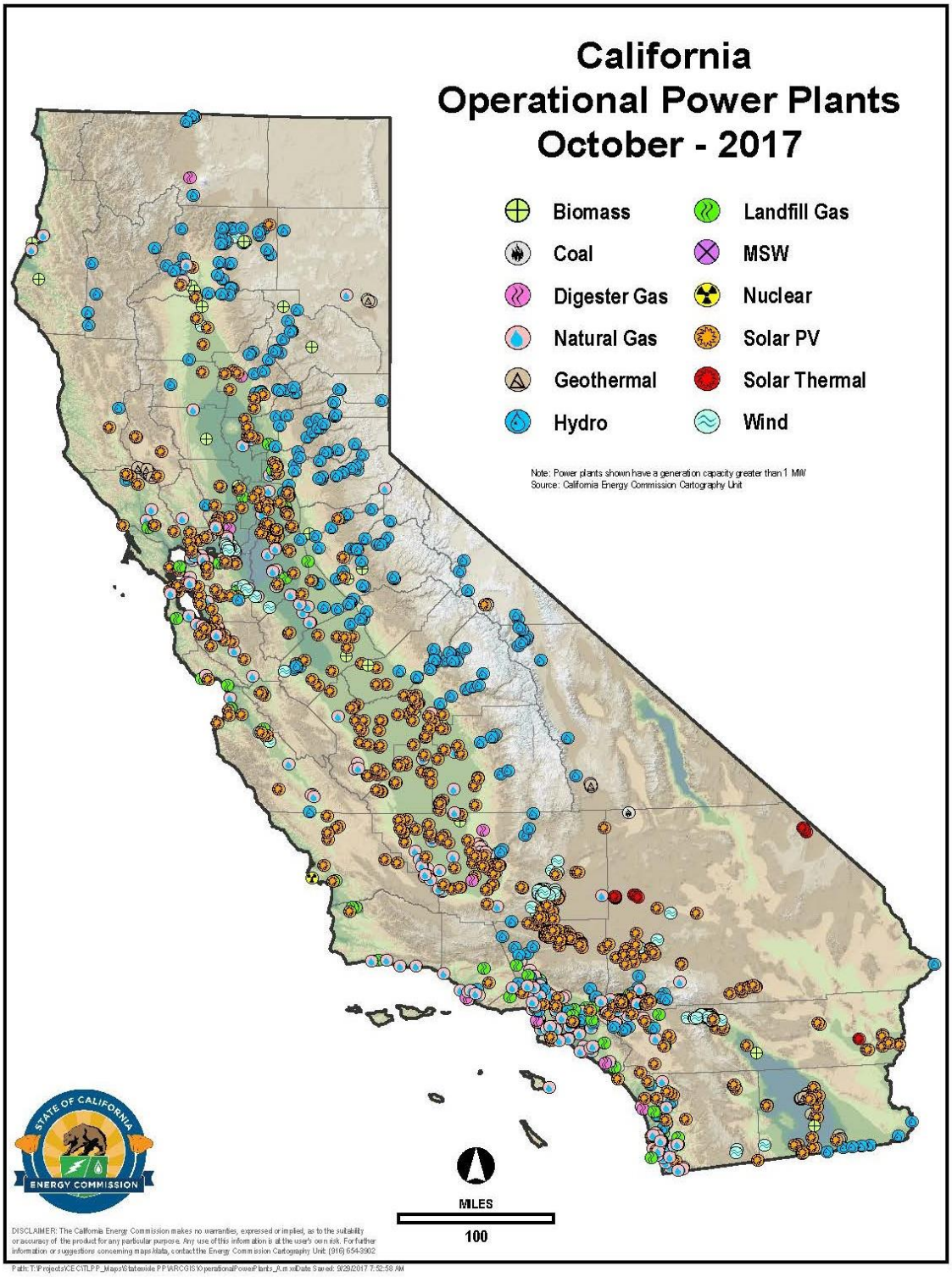
Transportation accounts for a major portion of California's energy budget and has a significant impact on air quality. It is also the single largest source of the state's greenhouse gas emissions. Gasoline is the most used transportation fuel in California, with 97 percent of all gasoline being consumed by light-duty cars, pickup trucks, and sport utility vehicles. In 2015, 15.1 billion gallons of gasoline were sold, according to the State Board of Equalization. Gasoline sold in California at retail is made up of 90 percent petroleum-based gasoline (as specified by the California Air Resources Board) and 10 percent ethanol.

Diesel fuel is the second largest transportation fuel used in California, representing 17 percent of total fuel sales behind gasoline. According to the State Board of Equalization, in 2015 4.2 billion gallons of diesel, including off-road diesel, were sold. Since 2003, natural gas use for transportation in California has more than doubled from under 80 million gallons to 160 million gallons of gasoline equivalent. It is estimated that 88 percent of this value is used in medium and heavy-duty vehicles.[272]

Additional information and resources on energy disruptions or emergencies can be found at: http://www.energy.ca.gov/emergencies/.

[271] California Energy Commission, http://www.energy.ca.gov/almanac/electricity_data/total_system_power.html
[272] California Energy Commission Almanac, http://www.energy.ca.gov/almanac/electricity_data/total_system_power.html

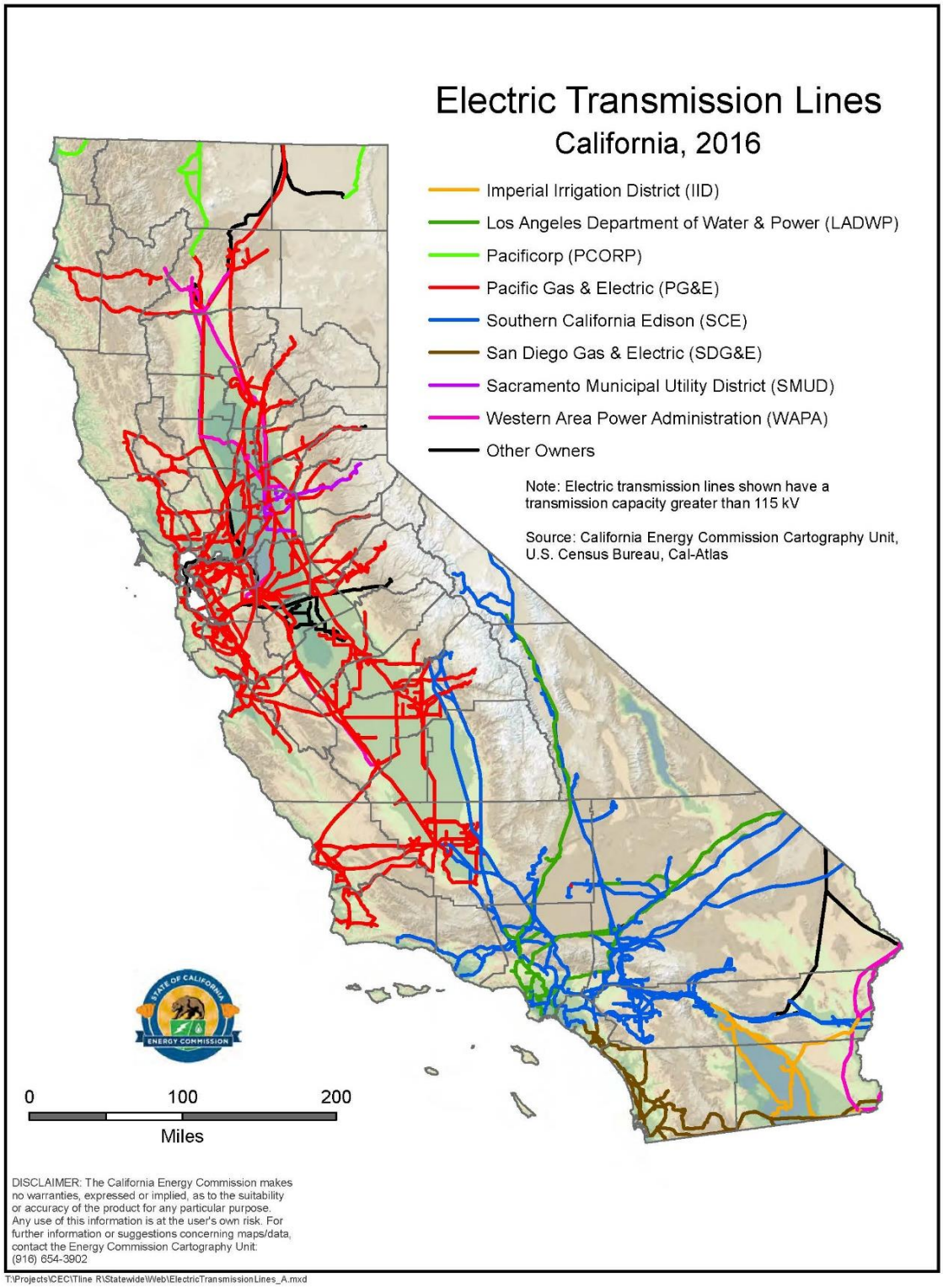
MAP 9.K: California's Operating Power Plants



Source: California Energy Commission, http://www.energy.ca.gov/maps/

Map 9.K shows the location and type of California power plants in operation as of 2017.

Map 9.L: California's Electric Transmission Grid



Source: California Energy Commission, http://www.energy.ca.gov/maps/

Map 9.L illustrates the extent and complexity of California's electrical transmission system.

Profiling Energy Shortage Hazards

Electric Power Disruptions

The electric power industry does not have a universal agreement for classifying disruptions. Nevertheless, it is important to recognize that different types of outages are possible so that plans may be made to handle them effectively. Electric power disruptions can be generally grouped into two categories: intentional and unintentional.

There are four types of intentional disruptions:

1. *Planned*: Some disruptions are intentional and can be scheduled based maintenance or upgrading needs.
2. *Unscheduled*: Some intentional disruptions must be done "on the spot" in response to an emergency.
3. *Demand-Side Management*: Some customers (i.e., on the demand side) have entered into an agreement with their utility provider to curtail their demand for electricity during periods of peak system loads.
4. *Load Shedding*: When the power system is under extreme stress due to heavy demand and/or failure of critical components, it is sometimes necessary to intentionally interrupt the service to selected customers to prevent the entire system from collapsing. These intentional interruptions result in rolling blackouts.

Unintentional or unplanned disruptions are outages that come with essentially no advance notice. This type of disruption is the most problematic. The following are categories of unplanned disruptions:

- Accident by the utility, utility contractor, or others
- Malfunction or equipment failure
- Equipment overload (utility company or customer)
- Reduced capability (equipment that cannot operate within its design criteria)
- Tree contact other than from storms
- Vandalism or intentional damage
- Weather, including lightning, wind, earthquake, flood, and broken tree limbs taking down power lines
- Wildfire that damages transmission lines

The California Independent System Operator (CAISO) is tasked with managing the power distribution grid that supplies most of California, except in areas served by municipal utilities. CAISO is thus the entity that coordinates statewide flow of electrical supply. CAISO uses a series of stage alerts to the media based on system conditions. The alerts are:

- Stage 1 - reserve margin falls below 7 percent
- Stage 2 - reserve margin falls below 5 percent
- Stage 3 - reserve margin falls below 1.5 percent

Rotating blackouts become a possibility when Stage 3 is reached. Rotating outages and/or blackouts such as those experienced in 2000 and 2001 can occur due to losses in transmission or generation and/or extremely severe temperatures that lead to heavy electric power consumption.

On January 17, 2001, CAISO declared a Stage 3 Emergency and notified the Governor's Office of Emergency Services (Cal OES) that Pacific Gas and Electric Company (PG&E) was dropping firm load of 500 megawatts (MW) in Northern California leading to rolling black-outs. Cal OES, in turn, issued an Electrical Emergency Message to all Emergency Services Agencies to prepare for rolling blackouts. This scenario was repeated the following day, January 18, 2001, and again on March 19, 2001.

A July 2006 heat storm event affected the entire state as well as most of the West, producing record energy demand levels in California. The state was able to avoid rotating outages due to a combination of favorable factors that included no major transmission outages, lower than typical generator outages, significant customer response to pleas for energy conservation, high imports from the Pacific Northwest despite unusually high loads, outstanding cooperation among western control area operators, and prompt response to fires that potentially threatened major interties. However, the event brought to light the vulnerability of the electric distribution system, as over 3,500

distribution transformers failed, leaving over two million customers without power at various times over the ten-day event, many for several hours and a small minority for up to three days.

On the afternoon of September 8, 2011, an 11-minute system disturbance occurred in the Pacific Southwest, leading to cascading outages and leaving approximately 2.7 million customers without power. The outages affected parts of Arizona, Southern California, and Baja California, Mexico. All of the San Diego area lost power, with nearly 1.5 million customers losing power, some for up to 12 hours. The disturbance occurred near rush hour, on a business day, snarling traffic for hours. Schools and businesses closed, some flights and public transportation were disrupted, water and sewage pumping stations lost power, and beaches were closed due to sewage spills. Millions went without air conditioning on a hot day.[273]

Gas Hazards

On October 23, 2015, Southern California Gas Company discovered a leak in one well within its Aliso Canyon storage field in the northern San Fernando Valley. The company stores natural gas underground at this storage field until it is pumped up and delivered to its customers. This storage field and others in California help meet peak seasonal demand for natural gas in the state during the winter months. Attempts to plug, or kill, the leaking well failed in November and December 2015. During that time actions were taken to reduce the amount of gas leaking from the facility, including withdrawing gas to reduce the gas pressure, and curtailing injections of gas into the storage facility. Recognizing that the storage field could be out of service or available only at reduced capacity for an extended period, the California Energy Commission (CEC), California Public Utilities Commission (CPUC), Department of Conservation Division of Oil, Gas, and Geothermal Resources (DOGGR), Cal OES, and other state agencies, as well as CAISO and the Los Angeles Department of Water and Power (LADWP), began assessing the potential impacts on natural gas and electricity reliability.

Although the levels of methane gas escaping from the leak were too low to raise flammability concerns, the additive odorant called Scentinel® T-50 was shown to cause limited short-term eye and skin irritation to residents of Porter Ranch, the closest community to the Aliso Canyon facility. The California Department of Public Health published a fact sheet on its website to educate residents on the public health impacts and to inform residents that Southern California Gas Company would temporarily relocate residents who were experiencing health effects.

On February 18, 2016, state officials announced that the leak was permanently plugged after 119 days. Although the well had stopped leaking, the DOGGR maintained the moratorium prohibiting Southern California Gas Company from injecting natural gas for storage at the facility until completion of a comprehensive safety review. This safety review required all 114 wells at the Aliso Canyon storage facility to be either thoroughly tested for safe operation or removed from operation and isolated from the underground reservoir. The Natural Gas Storage: Moratorium 2015-2016 (SB 380) codified this directive.

On July 19, 2017, state regulators confirmed the safety of the Aliso Canyon natural gas storage facility and cleared Southern California Gas Company to resume limited injections at the field to help prevent energy shortages, once certain conditions were met. That same day, the CEC issued a letter to the California Public Utilities Commission (CPUC) urging it to plan for the permanent closure of the facility within 10 years.

Climate Change and Energy Shortage

Changing climate is expected to bring more frequent and intense natural disasters. Key climate parameters are starting to move outside of historically observed variability at a rate that makes historical data a poor predictor of future climate. For example, the warmest years on record in California occurred in 2014, 2015, and 2016. The 2016-2017 year broke the record as the wettest ever recorded in the northern Sierra Nevada Mountains.

[273] FERC/NERC Staff Report on the September 8, 2011 Blackout

Changes in temperatures, precipitation patterns, extreme events, and sea-level rise have the potential to decrease the efficiency of thermal power plants and substations, decrease the capacity of transmission lines, render hydropower less reliable, spur an increase in electricity demand, and put energy infrastructure at risk of flooding.

With climate warming, higher costs from increased demand for cooling in the summer are expected to outweigh the decreases in heating costs in the cooler seasons. Hotter temperatures in California will mean more energy (typically measured in "cooling-degree days") needed to cool homes and businesses both during heat waves and on a daily basis, during the daytime peak of the diurnal temperature cycle. During future heat waves, historically cooler coastal cities (e.g., San Francisco and Los Angeles) are projected to experience greater relative increases in temperature, such that areas that never before relied on air conditioning will experience new cooling demands.[274]

Secondary impacts of energy shortages are most often felt by vulnerable populations. For example, those who rely on electric power for life-saving medical equipment, such as respirators, are extremely vulnerable to power outages. Also, during periods of extreme heat emergencies, the elderly and the very young are more vulnerable to the loss of cooling systems requiring power sources.

Assessment of State Vulnerability and Potential Losses

The CEC provides full forecasts for electricity and natural gas demand every two years as part of the Integrated Energy Policy Report (IEPR) process. The CEC uses detailed models for each economic sector (such as residential, commercial, industrial, and transportation) to project electricity consumption and demand for the full IEPR energy demand forecast. For details on how these forecasts are calculated, go to: http://www.energy.ca.gov/2016_energypolicy/.

California's energy infrastructure is designed to cope with the state's highly variable conditions and frequent disruptions from wildfires, storms, and floods. Generally, power outages caused by these events are short-term and limited to regional impacts. Of more concern are system-wide outages or shortages caused by a major disruption in supply or transmission, such as the recent Aliso Canyon gas leak. During the 18-month period when the facility was shut down, gas flow to meet hourly energy demands in the Los Angeles area was affected, creating uncertainty about the reliability of energy system operations in the area.[275]

The Governor's 2016 emergency proclamation on the Aliso Canyon leak called for an assessment of the long-term viability of all natural gas storage facilities in California. This assessment is well underway and is being conducted by an independent team of scientists organized by the California Council on Science and Technology. It is scheduled to be completed by the end of 2017, and will inform the state's rethinking of all natural gas storage facilities in California.

Assessment of Local Vulnerability and Potential Losses

Information related to community vulnerability and loss assessments may be found in Local Hazard Mitigation Plans.

[274] California Climate Change Center 2009
[275] Source: CEC, IEPR

Current Energy Shortage Hazard Mitigation

Overview

There are a variety of measures California takes to mitigate energy shortages and promote energy resilience. Balancing energy supply and demand on a constant and continuing basis by CAISO helps to ensure that the flow of energy into and within the state meets the energy needs of business, industry, government, and residents in the most reliable and economic way.

Siting of energy system elements away from natural hazards through state and local regulatory mechanisms such as zoning, codes, standards, and environmental review helps to reduce the impacts of earthquake, flood, and fire events.

Energy efficiency standards help to eliminate the least efficient products (such as appliances) and practices (such as in the building industry) from continued use. California utilities energy efficiency programs since the 1970s offer some of the lowest-cost energy resource options and help meet California's energy and climate policy objectives. Still, more action is needed to reduce energy consumption in existing buildings as the energy used in them accounts for more than one quarter of all greenhouse gas emissions in California.

In 2015, the CEC adopted the Existing Buildings Energy Efficiency Action Plan to help meet the Governor's goal to double the efficiency savings of existing buildings by 2030 and adopted the first update in December 2016. Further updates are expected every three years. SB 350 (2015) requires the CEC to establish annual targets for statewide energy efficiency savings and demand reduction that will achieve a doubling of energy efficiency savings from buildings and retail end uses by 2030.

Local governments have the authority to adopt energy efficiency codes that exceed the State 2016 Building Energy Efficiency Standards. Examples include standards developed in Marin County and the City of Santa Monica, which were approved by the CEC in March 2017.

All electric power companies develop projections of long-term demand as a starting point for planning the expansion of electric power generation, transmission, and distribution facilities. Projections are made for a range of planning horizons (from 1 to 20 years) and for a range of geographical resolutions (for the entire system to individual distribution sub-stations and feeder lines). In general, the shorter the planning horizon and the larger the geographic resolution used, the more likely the demand forecast will be reasonably representative of the actual situation.

Energy-Specific Strategies from the California Climate Adaptation Strategy

The 2017 California Climate Adaptation Strategy included a list of energy-specific strategies along with near-term recommended actions for immediate implementation and longer-term recommended actions that require state agency collaboration and support. These energy-specific strategies are:

1. Continue to support climate research for the energy sector to better inform climate adaptation and mitigation strategies.
2. Use common climate scenarios in all energy research and planning, and work to help standardize climate scenarios across state government planning and investment.
3. Continue incorporating implications of climate change into all energy sector planning and decision-making.
4. Support local adaptation planning efforts and increase outreach about available analytical tools.
5. Investigate means to provide long-term support for Cal-Adapt advancement, maintenance, and expansion.

Information on current programs and implementation actions, as well as proposed next steps, can be found at the California climate change portal website: http://www.climatechange.ca.gov/adaptation/strategy/index.html.

Progress Summary 9.E: California Solar Initiative

Progress as of 2018: In January 2007, California began a $3.3 billion ratepayer-funded effort to install new solar facilities capable of generating 3,000 megawatts (MW) of energy over the next decade and transform the market for solar energy by reducing the cost of solar generating equipment. The California Public Utilities Commission's portion of the solar effort is known as the California Solar Initiative (CSI) program. The CSI program goal was to install 1,940 MW of customer-sited solar capacity by the end of 2016 and, along with other statewide solar programs, transition the solar industry to a point where it can be self-sustaining without subsidies.

The CSI program has two funding streams, depending upon whether the rebated technology displaces electricity or natural gas. The electric portion of the CSI program has a 10-year budget of $2.4 billion, collected from electric ratepayers as authorized by Senate Bill (SB) 1. Assembly Bill (AB) 217, passed in 2013, extended the CSI low-income programs with $108 million in new funding, to continue until the incentives are claimed or 2021, whichever is earlier. The natural gas-displacing portion of the CSI program, known as CSI Thermal, is funded by AB 1470, which authorized $250 million in incentives for solar thermal technologies to be collected from gas ratepayers through 2017.
The CSI program has several components:

- The CSI General Market Solar Program provides incentives for residential and non-residential systems from 1 kilowatt (kW) to 1 MW.
- The CSI Single-Family Affordable Solar Homes (SASH) Program provides solar incentives to qualifying single-family low-income households.
- The CSI Multifamily Affordable Solar Housing (MASH) Program provides solar incentives to multi-family low-income housing facilities.
- The CSI Research, Development, Demonstration and Deployment Program provides grants to develop and deploy solar technologies that can advance the overall goals of the CSI program, including achieving targets for capacity, cost, and a self-sustaining solar industry in California
- The CSI Thermal Program provides incentives to eligible solar thermal technologies such as gas or electric-displacing solar water heating systems.

By the end of 2014, residential solar system costs had decreased by 53 percent. By the end of 2015, California had installed over 3,886 MW of solar capacity at over 488,541 customer sites, including approximately 76 MW installed at single- and multi-family low-income properties.

Additional information about the California Solar Initiative may be found at:
http://www.cpuc.ca.gov/General.aspx?id=6043

Source: California Public Utilities Commission, California Solar Initiative Annual Program Assessment. June 2016.

Progress Summary 9.F: California Public Utilities Commission Solar Programs Invest In Disadvantaged Communities

Progress as of 2018: The California Public Utilities Commission (CPUC), in its ongoing efforts to help improve air quality and economic conditions in disadvantaged communities, adopted three programs in June 2018 to promote the installation of solar energy to serve customers in disadvantaged communities:

1. The Disadvantaged Communities – Single-family Solar Homes (DAC-SASH) program will provide up-front financial incentives towards the installation of solar systems for low income homeowners.
2. The Disadvantaged Communities – Green Tariff (DAC-Green Tariff) program will provide a 20 percent bill discount to customers in disadvantaged communities. This will allow customers to choose clean energy options without the need to own their home and without the cost of installing their own solar systems.
3. The Community Solar Green Tariff program is similar to the DAC Green Tariff program, and will also provide a 20 percent bill discount. This program will allow primarily low income customers in disadvantaged communities to benefit from the development of solar generation projects located in or near their communities.

For more details about the programs, visit: http://www.cpuc.ca.gov/discom/.

Progress Summary 9.G: Clean Energy Progress Tracking

Progress as of 2018: Energy efficiency advancements provide the same or better level of energy service (including all the ways people use energy such as for lighting, heating, and air conditioning), while using less energy. Energy efficiency is a critical element of the state's energy policy that can reduce the need for new electricity generation. Energy efficiency efforts in California have reduced greenhouse gases, made businesses more competitive, and allowed consumers to save money, improve health, and increase comfort.

Combining efficiency gains from standards and guidelines, efficiency programs, and market and price effects, the cumulative annual efficiency and conservation savings for electricity were estimated to surpass 95,000 gigawatt hours (GWh) by 2016. This amount of energy savings is equivalent to the annual carbon dioxide emissions produced by more than 7 million automobiles and equivalent to the amount of energy produced annually by more than 31,500-megawatt (MW) power plants. For more information, go to: http://www.energy.ca.gov/renewables/tracking_progress/

Statewide Energy Demand: Since the mid-1970s, per capita consumption has remained relatively constant in California but continues to grow in the U.S. overall. Californians consume 40 percent less electricity per person because of factors ranging from climate and household size to fuel and industry mixes and the state's aggressive energy policies.

Zero-Emission Vehicles and Infrastructure: On September 8, 2016, Governor Brown signed Senate Bill 32, putting into law a statewide goal to reduce greenhouse gas emissions 40 percent below 1990 levels by 2030. Previously, he established the foundation to support 1.5 million zero-emission vehicles (ZEV) by 2025 and published a ZEV Action Plan. As part of its work on ZEV, the California Energy Commission (CEC) provides funding for plug-in electric vehicle charging and hydrogen refueling stations, along with guidance on plug-in electric and hydrogen vehicle infrastructure deployment.

Reliance on Coal: Coal-fired electricity served about 11 percent of California's electricity demand in 2000 but has steadily declined; it served less than 6 percent by the end of 2015 and is expected to decline to zero by the middle of the next decade.

Renewable Energy: Installed capacity of renewable energy in California has more than tripled from 6,800 MW in 2001 to 26,300 MW as of October 31, 2016. Most of the growth in renewable energy resources has come from wind and solar. The addition of utility-scale solar photovoltaic power plants and residential solar installations accounts for the majority of the increase. The state has surpassed the goal of installing 3,000 MW of solar energy systems on new and existing structures by 2017, which was set in response to Senate Bill 1.

The Desert Renewable Energy Conservation Plan is a multi-agency comprehensive effort to identify the most appropriate areas for large-scale renewable energy development within 22 million acres of public and private desert landscape while protecting and conserving desert ecosystems and cultural resources. In September 2016, the U.S. Secretary of the Interior approved Phase I of the plan, covering 10.8 million acres of public lands managed by the U.S. Bureau of Land Management in the California desert.

Once-Through Cooling (OTC): The goal of the once-through cooling (OTC) policy is to reduce the inflow of ocean and estuarine water for power plant cooling. Generators must eliminate or reduce use of coastal or estuarine waters for OTC on a schedule established by the State Water Control Resources Board that considers both environmental goals and the need to maintain electrical reliability. Some generators have proposed alternative dates for specific units, groups of units, or whole facilities.

As water is an increasingly precious resource in California, the state has worked to reduce water consumption associated with electricity generation and the impacts on aquatic environments. Over the past decade, the fossil-fueled power plant fleet in California has become more water-efficient, resulting in a relatively modern fleet of thermal power plants that consume little water. Energy production accounts for less than 1 percent of all consumptive water use in California, but the use can affect the water supply of local communities. The total amount of freshwater used for cooling has not increased in the last decade, despite the addition of numerous thermal power plants. The increased use of dry-cooling technologies and the use of recycled water have significantly increased the water efficiency of power plants in California. For more detailed information, go to: http://www.energy.ca.gov/renewables/tracking_progress/documents/once_through_cooling.pdf.
Source: California Energy Commission: http://www.energy.ca.gov/renewables/tracking_progress/index.html

Progress Summary 9.H: California Clean Energy Jobs Act

Progress as of 2018: The California Clean Energy Jobs Act (Proposition 39) was approved on November 6, 2012, by the voters of California. The initiative makes changes to corporate income taxes and provides for the annual transfer of funds from the General Fund to the Clean Energy Job Creation Fund for five fiscal years, beginning with the 2013-2014 fiscal year. The funds are appropriated by the Legislature annually to fund eligible projects that create jobs in California while improving energy efficiency and expanding clean energy generation.

The 2017-2018 budget allocates $827 million of Proposition 39 revenue to school districts, charter schools, county offices of education (collectively referred to as local educational agencies [LEAs]), and community colleges to support energy efficiency projects. Various aspects of the Proposition 39 program are administered by the following California agencies: the California Energy Commission, the Department of Education, Conservation Corps, Workforce Development Board, and the Community Colleges Chancellor's Office.

The California Energy Commission administers three components of the California Clean Energy Jobs Act: a grant program (Proposition 39 K-12 Program), a revolving loan program (Energy Conservation Assistance Act – Education Subaccount Program), and a technical assistance program (Bright Schools Program). As of June 30, 2016, nearly $827 million in expenditures has been approved—$154 million for energy planning and $673 million for energy projects.

In February 2017, the California Energy Commission released a progress report entitled "Proposition 39: California Clean Energy Act, K-12 Program and Energy Conservation Assistance Act 2015-2016 Progress Report," which documents project status covering the period from December 2013 through June 2016. Projects have already been completed in 52 school districts around the state, representing $27 million in Proposition 39 funding. These projects are projected to save the annual energy consumption equivalent of more than 2,000 homes and save school districts nearly $2.5 million in annual energy costs. An additional 74 school districts, representing $104 million have completed their projects and are in the data documentation phase, which must be done once the project is completed and the school gathers 12 months of energy use data. Another 733 energy projects are still in the construction phase, using $151 million in Proposition 39 funds.

The report also highlights information on the California Energy Commission's zero interest loan program, known as the Energy Conservation Assistance Act, which includes the Education Subaccount Program and the Bright Schools Program, both of which complement the K-12 Program and are appropriated through Proposition 39.

Additional program details may be found at: http://www.energy.ca.gov/efficiency/financing/.
Source: California Energy Commission

Progress Summary 9.I: Regional Efforts

Progress as of 2018: The Bay Area Regional Energy Network (BayREN) is a collaboration of the nine counties that make up the San Francisco Bay Area. Led by the Association of Bay Area Governments (ABAG), BayREN implements effective energy-saving programs on a regional level and draws on the expertise, experience, and proven track record of Bay Area local governments to develop and administer successful climate, resource, and sustainability programs. BayREN is funded by California utility ratepayers under the auspices of the California Public Utilities Commission. One of only two Regional Energy Networks in the state, BayREN represents 20 percent of the state's population. Highlights of the BayREN program are listed below.

Single-Family Residential:

- Provides a Home Upgrade Advisor unit that offers free step-by-step technical assistance to consumers and contractors.
- Administers the Energy Upgrade California® Home Upgrade program in the nine Bay Area counties.
- Provides an additional $300 rebate for whole-home energy audits for homeowners who have participated in the Advanced Home Upgrade program.
- Recruits, trains, and qualifies Specialty Contractors for program participation.
- Provides regional and local marketing, education and outreach activities for customers and contractors.

Multi-Family Residential:

- Offers rebates of $750 per unit for multi-family building upgrades.
- Targets outreach to multi-family property owners to promote energy upgrades.
- Offers comprehensive technical assistance to multi-family property owners to identify and prioritize energy upgrades, qualify for rebates, and find appropriate programs.

Codes and Standards:

- Promotes an integrated, measurement-driven management process for enhancing energy code compliance.
- Establishes code compliance baselines for select jurisdictions in the nine-county Bay Area.
- Offers targeted training based upon identified baselines to institutionalize regular, actionable feedback to local officials.
- Organizes bi-monthly regional forums addressing high-level program policy and program design issues on energy efficiency and energy code compliance.

Financing Portfolio Subprogram:

- Develops and launches a regional public agency led financing portfolio.
- Offers multiple financing options to help diverse consumers undertake energy projects, such as the Multifamily Capital Advance Program, Pay-as-you-Save, and Commercial Property Assessed Clean Energy (PACE).

Additional program details can be found at: https://www.bayren.org/.

Additional Energy Shortage Hazard Mitigation Opportunities

In addition to monitoring energy supply and planning for production, conservation is an important element of energy policy. Reducing the energy consumption and demand per capita can offset the growth in supply needed to keep pace with population growth and urban development.

Of the energy used in the transportation sector, a large percentage is consumed by gasoline-powered vehicles. There are a number of measures that can be taken to reduce energy consumption for gasoline-powered vehicles, including continuing development of alternative energy vehicles and changing work commute patterns through telecommuting or land use policies that encourage mixed-use development. Development and production of alternative energy vehicles combined with a reduction in vehicle trips will result in both reduced reliance on fossil fuels and reduced carbon emissions to lessen the impacts of global warming and climate change.

More work is needed to decarbonize California's overall energy system. The advancements in the state's electricity system demonstrate that California is capable of transforming its energy system in a relatively short time frame. However, much more work is needed to reduce greenhouse gases to 40 percent below 1990 levels by 2030. California must dramatically reduce emissions even as its population is expected to grow from about 38 million today to more than 44 million by 2030. The rapid growth in California's renewable resources has brought new challenges for grid operators trying to maintain reliability while managing swings in wind and solar generation.

Best Practices Highlight 9.C: San Francisco Solar and Energy Storage for Resiliency

San Francisco's Solar+Storage for Resiliency project (Solar Resilient) aims to expand the solar market by serving as a national model for integrating solar and energy storage into the city's emergency response plans. Viewing disaster preparation and resiliency through the lens of on-going sustainability is fairly new in the emergency response arena. Like other cities working on issues at the intersection of sustainability and emergency preparation, the City and County of San Francisco faces the challenge of being unable to use its sustainable energy resources when the electric grid goes down.

As of 2018, all of the pieces to implement a "Solar+Storage" solution are available in the marketplace. However, no one project has put the pieces together to create a comprehensive plan to allow a Solar+Storage solution to be implemented in disaster preparedness plans around the country. Solar+Storage offers an opportunity to systematically bolster emergency preparedness not only in San Francisco, but in the more than 19,000 municipal governments nationwide. By disseminating a plan for increasing solar and energy storage deployment, the project will advance Solar+Storage market and financing mechanisms.

Goals and Objectives: The primary goals of the project are to accelerate the deployment of photovoltaics (PV) nationwide and create a roadmap for using PV as a viable tool for energy security in the event of an emergency. The key elements of the project are:

- Research San Francisco's current disaster preparedness plans with respect to electricity needs of buildings.
- Facilitate stakeholder engagement through the formation and management of a working group.
- Identify Disaster Preparedness Zones in San Francisco, outlined in a series of Geographic Information Systems (GIS) maps detailing building power needs and feasible microgrid locations.
- Address technical and economic barriers and outline solutions in a road map.
- Identify or develop an emergency load assessment tool.
- Develop an approach to use existing solar systems during an outage.
- Disseminate a plan, including a Best Practices Manual, to regional, state, and national networks.

Organization and Partners: Peer review, research support, and dissemination will be provided by: Sandia National Laboratories, Lawrence Berkeley National Laboratory, Pacific Gas & Electric, the San Francisco Public Utilities Commission, the San Francisco Department of Public Health, the San Francisco Department of Emergency Management, the County of Alameda, the Neighborhood Empowerment Network, the Neighborhood Emergency Response Team, Renewable Funding, Clean Coalition, Cal-Charge, and the Urban Sustainability Directors Network.

Funding: This project is funded by the U.S. Department of Energy's SunShot Initiative through the Solar Market Pathways Program in the amount of $1,321,200.

For additional information, go to: https://sfenvironment.org/solar-energy-storage-for-resiliency.

9.1.7 EPIDEMIC/PANDEMIC/VECTOR BORNE DISEASE

Identifying Epidemic/Pandemic/Vector-Borne Disease

Pandemic Influenza

California faces a variety of natural and human-caused hazards that can threaten the lives, health, safety, and property of individuals and communities, and negatively affect California's environment, economy, and infrastructure. The California Department of Public Health (CDPH) has identified influenza as a specific hazard that would have a significant impact throughout the state.

Seasonal Influenza

Seasonal influenza, also known as the flu, is a disease that attacks the respiratory system (nose, throat, and lungs) in humans. Seasonal influenza occurs every year. In the U.S. the influenza season typically extends from October through May, peaking in January or February with yearly epidemics of varying severity. Although mild cases may be similar to a viral "cold," influenza is typically much more severe. Influenza usually comes on suddenly; may include fever, headache, tiredness (which may be extreme), dry cough, sore throat, nasal congestion, and body aches; and can result in complications such as pneumonia. Persons aged 65 and older, those with chronic health conditions, pregnant women, and young children are at the highest risk for serious complications, including death.

Pandemic Influenza

A pandemic influenza occurs when a new influenza virus, for which there is little or no human immunity, emerges and spreads on a worldwide scale, infecting a large proportion of the human population. The 20th century saw three such pandemics, and a fourth one occurred in the 21st century. The most notable pandemic was the 1918 Spanish influenza pandemic that was responsible for 20 million to 40 million deaths throughout the world.

As demonstrated historically, pandemic influenza has the potential to cause serious illness and death among people of all age groups and have a major impact on society. These societal impacts include significant economic disruption that can occur due to death, loss of employee work time, and costs of treating or preventing the spread of influenza.

Vector-Borne Diseases

The Vector-Borne Disease Section (VBDS) of CDPH protects the health and well-being of Californians from diseases transmitted to people from insects and other animals. VBDS conducts prevention, surveillance, and control of vector-borne diseases, including Hantavirus pulmonary syndrome, plague, Lyme disease, West Nile virus (WNV), and other tick-borne and mosquito-borne diseases. VBDS also performs surveillance and advises on control for introduction of exotic vector species that may harbor human pathogens.

Vector-borne diseases and exotic vectors that cause a significant risk to people are discussed further in this section. These include WNV and invasive *Aedes* mosquitoes. Natural disasters such as flooding, fires, and earthquakes may create mosquito-breeding habitat that must be assessed and surveyed. The devastating 2015 wildfires in Lake County resulted in exposed structures, particularly septic systems that became important mosquito-breeding sources, particularly for *Culex* spp. mosquitoes (vector of WNV). Damaged structures from earthquakes may also have new potential to hold water that can serve as mosquito-breeding sources.

Additional information about other vector-borne diseases can be found at the CDPH website: https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/VBDS.aspx.

Profiling Epidemic/Pandemic/Vector-Borne Disease

Pandemic Influenza

In 2009 a pandemic of H1N1 influenza, popularly referred to as the swine flu, resulted in many hospitalizations and deaths. Pandemic H1N1 influenza is spread in the same way as seasonal influenza, from person to person through coughing or sneezing by infected people.

Avian Influenza, commonly referred to as "Bird Flu," remains a looming pandemic threat. Avian Influenza primarily spreads from birds to birds and rarely to humans. Public health experts continue to be alert to the possibility that an avian virus may mutate or change so that it can be passed from birds to humans, potentially causing a pandemic in humans. Some strains of the Avian Influenza could arise from Asia or other continents where people have very close contact with infected birds. Examples are poultry farmers or visitors to live poultry markets who had been in very close contact with infected birds and contracted fatal strains of Avian Influenza.

Thus far, Avian Influenza viruses have not mutated and have not demonstrated easy transmission from person to person. However, if Avian Influenza viruses were to mutate into a highly virulent form and become easily transmissible from person to person, the public health community would be very concerned about the potential for an influenza pandemic. Such a pandemic could disrupt all aspects of society and severely affect the economy.

Vector-Borne Disease

Mosquito-Borne Viruses

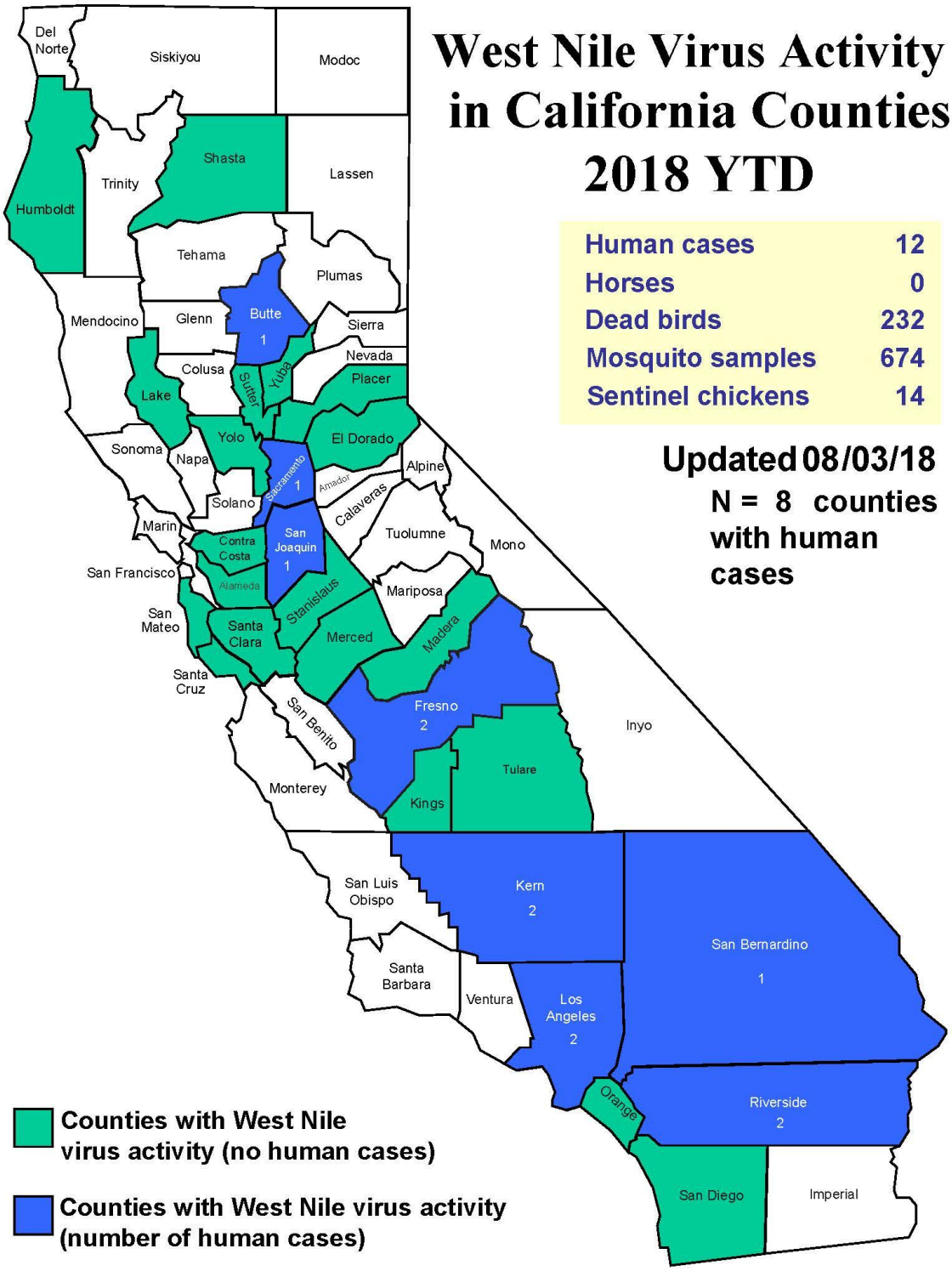
Mosquito-borne viruses belong to a group of viruses commonly referred to as arboviruses (for arthropod-borne). Although 12 mosquito-borne viruses are known to occur in California, only West Nile virus (WNV), western equine encephalomyelitis virus (WEE), and St. Louis encephalitis virus (SLE) are significant causes of human disease. WNV continues to seriously affect the health of humans, horses, and wild birds throughout the state. Since 2003, there have been over 6,000 WNV human cases with 248 deaths, and over 1,200 equine cases. Consequently, the California Arbovirus Surveillance Program emphasizes forecasting and monitoring the temporal and spatial activity of WNV, WEE, and SLE. These viruses are maintained in wild bird-mosquito cycles that do not depend upon infections of humans or domestic animals to persist. Surveillance and control activities focus on this maintenance cycle.

WNV first appeared in the United States in 1999 in New York and rapidly spread across the country to California in subsequent years. California has historically maintained a comprehensive mosquito- borne disease surveillance and control program including the Mosquito-borne Virus Surveillance and Response Plan,[276] which is updated annually in consultation with local vector control agencies. Timely information on WNV activity in mosquitoes, humans, and birds can be found at: www.westnile.ca.gov.

Map 9.M illustrates WNV activity around the state as of mid-2018.

[276] http://westnile.ca.gov/resources.php3

Map 9.M: West Nile Virus Activity in California Counties



Source: www.westnile.ca.gov

Table 9.K summarizes WNV activity for the period of 2003 to 2016. In 2016, 19 fatal human cases of WNV were recorded, down from the previous year. Current information on incidence of WNV is available on the website maintained by CDPH at: www.westnile.ca.gov.

Table 9.K: West Nile Virus Activity, 2003-2016

Number of Cases By Year															
Element	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***Total***
Human cases (fatal)	3[1] (0)	779 (29)	880 (19)	278 (7)	380 (21)	445 (15)	112 (4)	111 (6)	158 (9)	479 (20)	379 (15)	801 (31)	782 (53)	442 (19)	*6,029 (248)*
Horses	1[2]	540	456	58	28	32	18	19	15	22	13	0[3]	0[3]	0[3]	*1,202*
Dead birds	96	3,232	3,046	1,446	1,396	2,569	515	416	688	1,644	1,251	2,442	1,349	1,352	*21,442*
Mosquito samples	32	1,136	1,242	832	1,007	2,003	1063	1305	2087	2,849	2,528	3,340	3,329	3,528	*26,281*
Sentinel chickens	70	809	1,053	640	510	585	443	281	391	540	485	443	449	343	*7,042*
Squirrels	-	49	48	32	26	32	10	24	24	23	0[3]	0[3]	0[3]	0[3]	*276*

[1] Plus 20 imported human cases. [2] Plus three imported horse cases. [3] No longer monitored
Source: www.westnile.ca.gov

Exotic Aedes Mosquitoes

Two invasive (non-native) mosquito species have been found since 2011 in numerous California cities, and there is a potential for them to continue to spread into other areas of California. The two species are Aedes *aegypti* (the yellow fever mosquito) and *Aedes albopictus* (the Asian tiger mosquito). As of 2017, these mosquitoes are found in 12 counties, primarily in Central and Southern California. For more information, visit: https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/AedesDistributionMap.pdf.

Unlike most native mosquito species, *Aedes aegypti* and *Aedes albopictus* bite during the day. Both species are small black mosquitoes with white stripes on their back and on their legs. They can lay eggs in small artificial or natural containers that hold water.

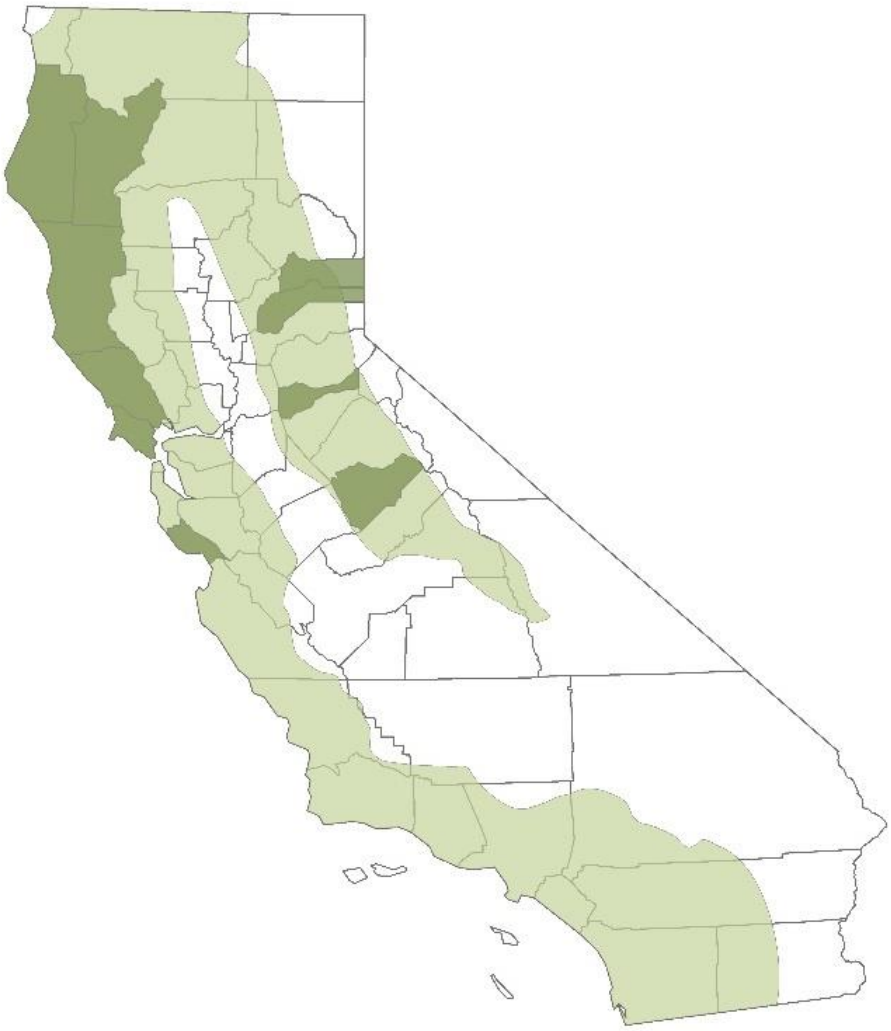
Aedes aegypti and *Aedes albopictus* have the potential to transmit several viruses, including Zika, dengue, chikungunya, and yellow fever. None of these viruses is known to be transmitted within California, but thousands of people are infected with these viruses in other parts of the world, including in Mexico, Central and South America, the Caribbean, and Asia, and recent local transmissions of dengue and Zika in Florida and Texas highlight the need for vigilance. The presence of *Aedes aegypti* and *Aedes albopictus* mosquitoes in California poses a threat that Zika, dengue, and chikungunya viruses can be transmitted in infested areas if the virus is acquired from returned infected travelers.

VBDS has developed a document titled "Guidance for Surveillance of and Response to Invasive *Aedes* Mosquitoes and Dengue, Chikungunya, and Zika in California" to address local issues that may arise with the introduction of these exotic mosquitoes. Updated information on *Aedes* mosquitoes can be found at: https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/Aedes-*aegypti*-and-Aedes-*albopictus*-mosquitoes.aspx.

Lyme Disease

Lyme disease is caused by a spirochete (a corkscrew-shaped bacteria) called *Borrelia burgdorferi* and is transmitted by the Western black-legged tick. Lyme disease was first described in North America in the 1970s in Lyme, Connecticut, the town for which it was then named. Though the tick has been reported from 56 of the 58 counties in California, the highest incidence of disease occurs in the northwest coastal counties and northern Sierra Nevada counties with western-facing slopes. Ticks prefer cool, moist areas and can be found in wild grasses and low vegetation in both urban and rural areas.

Map 9.N: Western Black-legged Tick and Lyme Disease Incidence in California



Source: California Department of Public Health

Map 9.N shows Western black-legged tick and Lyme disease incidence in California. The Western black-legged tick is commonly found in all green areas shown on the map; dark green areas on the map show where reported Lyme disease cases most often had exposure.

Additional information about Lyme disease may be found at:
https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/Tick-Borne-Diseases.aspx.

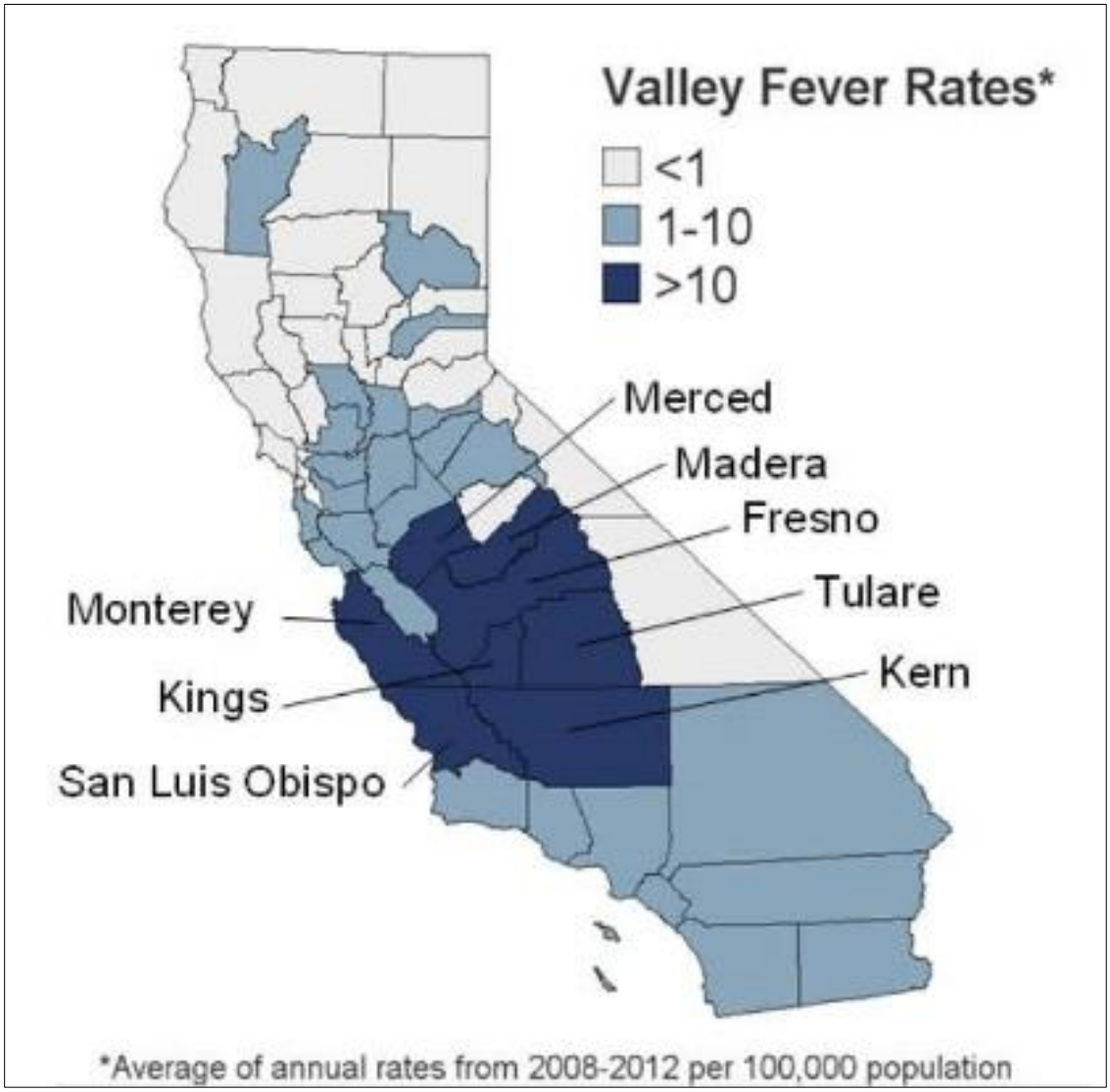
Valley Fever

Valley Fever is caused by *Coccidioides*, a fungus that lives in the soil in the southwestern United States and parts of Mexico, Central America, and South America. Inhaling the airborne fungal spores can cause an infection called coccidioidomycosis, which is also known as "cocci" or "Valley Fever."

Most people who are exposed to the fungus do not get sick, but some people develop flu-like symptoms that may last for weeks to months. In a very small proportion of people who get Valley Fever, the infection can spread from the lungs to other parts of the body and cause more severe conditions, such as meningitis or even death. Valley Fever cannot spread from person to person.

Most cases of Valley Fever in the U.S. occur in people who live in or have traveled to the southwestern United States, especially Arizona and California. Map 9.O shows the areas where the fungus that causes Valley Fever is thought to be endemic, or native and common in the environment. The full extent of the current endemic areas is unknown and is a subject for further study.

Map 9.O: Valley Fever Average Annual Rates by California County



Source: http://www.cdc.gov/features/valleyfever/

A March 2013 Morbidity and Mortality Weekly Report published by the federal Centers for Disease Control and Prevention (CDC) notes that more than 20,000 cases of Valley Fever are reported each year in the United States, but many more cases likely go undiagnosed. Some researchers estimate that each year the fungus infects more than 150,000 people, many of whom are sick without knowing the cause or have symptoms so mild they are not recognized.

The annual number of cases has been increasing in recent years, possibly because of higher numbers of people exposed to the fungus or because of changes in the way cases are being detected and reported.

Anyone, including children, can get Valley Fever, but it is most common among older adults, particularly those 60 and older. Several groups of people are at higher risk for developing the severe forms of Valley Fever; these groups include African Americans, Filipinos, women in their third trimester of pregnancy, and people with weak immune systems, including those with an organ transplant or who have HIV/AIDS.

Additional information about Valley Fever may be found at: http://www.cdc.gov/features/valleyfever/.

Climate Change and Epidemic/Pandemic/Vector-Borne Disease

Climate change will likely affect vector-borne disease transmission patterns. Changes in temperature and precipitation can influence seasonality, distribution, and prevalence of vector-borne diseases. A changing climate may also create conditions favorable for the establishment of invasive mosquito vectors in California.

For most Californians, WNV poses the greatest mosquito-borne disease threat. Above-normal temperatures are among the most consistent factors associated with WNV outbreaks. Mild winters are associated with increased WNV transmission due, in part, to less mosquito and resident bird mortality. Warmer winter and spring seasons may also allow for transmission to start earlier. Such conditions also allow more time for virus amplification in bird-mosquito cycles, increasing the potential for mosquitoes to transmit WNV to people.

The effects of increased temperature are primarily through acceleration of physiological processes within mosquitoes, resulting in faster larval development and shorter generation times, more frequent mosquito biting, and shortening of the incubation period time required for infected mosquitoes to transmit WNV. During periods of drought, especially in urban areas, mosquitoes tend to thrive more due to changes in stormwater management practices. Mosquitoes in urban areas can reach higher abundance due to stagnation of water in underground stormwater systems that would otherwise be flushed by rainfall. Runoff from landscape irrigation systems mixed with organic matter can also create ideal mosquito habitat. Drought conditions may also force birds to increase their utilization of suburban areas where water is more available, bringing these WNV hosts into contact with urban vectors.

The emergence of new infectious diseases associated with invasive species, such as the invasive *Aedes* in California, can be influenced by a number of factors, including land use changes (e.g., agriculture and urbanization), the introduction of new hosts and climate change. Vector-borne disease transmission can be influenced by such factors as adaptations and changes in pathogens, the availability of hosts, human behavior (for example time spent indoors), and the actions of mosquito and vector control programs.

Assessment of State Vulnerability and Potential Losses

The impact of an actual epidemic, pandemic, or vector-borne disease outbreak cannot be predicted precisely, as it will depend on the virulence of the virus, the speed at which the virus spreads, the availability of vaccines and antivirals, and the effectiveness of medical and non-medical containment measures.

Assessment of Local Vulnerability and Potential Losses

Information related to community vulnerability and loss assessments may be found in Local Hazard Mitigation Plans.

Current Epidemic/Pandemic/Vector-Borne Disease Hazard Mitigation Efforts

Pandemic Influenza

The California Department of Public Health (CDPH) takes the lead on planning for pandemic outbreaks in the state. CDPH will coordinate the public health response to a pandemic with the Emergency Medical Services Authority (EMSA), the Department of Health Care Services (DHCS), the California Health and Human Services Agency, Cal OES, local health departments, tribal entities, the health care community, the federal government, and other key partners.

In 2009, in response to the H1N1 pandemic influenza, the Governor established a Cabinet Pandemic Influenza Working Group that met monthly to report on H1N1 activity and review the state's response until the pandemic ended. Since that time period, CDPH has continued statewide planning efforts to meet the Centers for Disease Control and Prevention (CDC) cooperative agreement requirements to benchmark the level of state agency preparedness. Each local health department has a pandemic preparedness plan, including a section on community mitigation. Each year, CDPH reviews the pandemic response planning activities of local health departments as required by the CDC cooperative agreement.

Within CDPH, the Center for Infectious Diseases (CID) Division of Communicable Disease Control (DCDC) provides statewide leadership in communicable disease surveillance, laboratory confirmation, and vaccine management. DCDC provides recommendations for community mitigation strategies as needed for both routine and emergency public health infectious disease control activities.

Year-round, DCDC works closely with other programs within CDPH and external stakeholders including the CDC and other partners in addition to local health departments to protect Californians from the effects of pandemic influenza. DCDC has an internal plan, the DCDC Pandemic Influenza Operational Plan (PIOP), revised in 2016, which provides operational guidance for DCDC's lead response to a pandemic influenza within California, specifically in the areas of Epidemiology and Surveillance, Laboratory, Vaccine Management, and Non-Pharmaceutical Interventions (Community Mitigation).

The DCDC PIOP identifies potential mitigation actions that can be taken to reduce the impacts of the pandemic, including:

- Ensuring rapid and early detection of a novel virus
- Confirming the identity or type of a novel virus by laboratory identification
- Identifying the exposure source of the outbreak and the population at risk
- Controlling and containing the spread of influenza through pharmaceutical and non-pharmaceutical community containment strategies, including isolation, quarantine, infection control, antiviral treatment and prophylaxis, and, if available, vaccination
- Managing and disseminating accurate information for scientific, resource, and policy decisions in public health and healthcare delivery settings

The DCDC PIOP is an annex to the CDPH Emergency Operations Response Plan (EORP) of 2013. The CDPH EORP provides a department-level multi-hazard framework for comprehensive public health and environmental health emergency management to support the needs of California's residents, communities, government, and businesses. The DCDC PIOP is consistent with all CDPH principles and guidelines, to include those identified in the California Public Health and Medical Emergency Operations Manual (EOM). The PIOP also conforms to the California State Emergency Plan, the Standardized Emergency Management System, and the Incident Command System standards.

In addition to CDPH's pandemic planning, Cal OES has a Statewide Concept of Operations Plan for Pandemic Influenza that discusses communication and coordination at the local, state, and federal government levels. At the local level, the Statewide Concept of Operations includes checklists to assist with local government pandemic influenza preparedness, including alert and warning considerations and suggested response actions. At the federal level, the Statewide Concept of Operations describes the established federal role in managing the Strategic National Stockpile, which is vital to pandemic influenza response planning and State Operations Center coordination.

The Statewide Concept of Operations emphasizes that all events begin at the local level and recommends that each local agency prepare a pandemic influenza operations plan. At the state level, the plan outlines 27 preparedness, response, and recovery objectives under three strategic goals as established by the CDC and identifies the agencies that have plans and procedures for each objective. The plan also includes a State Agency Responsibilities Matrix that lists the state agencies that have lead and support roles for each CDC objective.

For more information, see:
http://www.caloes.ca.gov/PlanningPreparednessSite/Documents/StatewideConOpsforPandemicInfuenza%202009.pdf.

Vector-Borne Diseases

The Vector-Borne Disease Section (VBDS) protects the health and well-being of Californians from diseases transmitted to people from insects and other animals. VBDS conducts prevention, surveillance, and control of vector-borne diseases, including Hantavirus pulmonary syndrome, plague, Lyme disease, WNV, and other tick-borne and mosquito-borne diseases. VBDS also performs surveillance and advises on control for introduction of exotic vector species that may harbor human pathogens.

VBDS staff, located in four regional offices and headquartered in Sacramento, provide the following services:

- Develop and implement statewide vector-borne disease prevention, surveillance, and control programs
- Design and conduct scientific investigations to further knowledge of vector-borne diseases in California
- Coordinate preparedness activities for detection and response to introduced vectors and vector- borne diseases, such as WNV, Zika, chikungunya, dengue, and invasive *Aedes* mosquitoes
- Provide laboratory and proficiency testing for vector-borne disease agents in arthropods and vertebrates and testing for pesticide resistance in mosquitoes
- Conduct emergency vector control when disease outbreaks occur
- Advise local agencies on public health issues related to vector-borne diseases
- Advise local agencies on regulatory issues pertaining to mosquito and vector control
- Oversee the Cooperative Agreement (HSC 116180) between CDPH and local vector control agencies
- Oversee the Vector Control Technician Certification and Continuing Education programs
- Provide information, training, and educational materials to governmental agencies, the medical community, and the public
- Maintain the San Francisco Bay Area U.S. Army Corps of Engineers general permit, which allows local vector control agencies to conduct abatement activities
- Oversee Special Local Need permits on restricted use of public health pesticides

Progress Summary 9.J: Updates for Two Vector-Borne Disease Plans

Progress as of 2018: The California Mosquito-Borne Virus Surveillance and Response Plan was developed by the California Department of Public Health, Vector-Borne Disease Section, in conjunction with the Mosquito and Vector Control Association of California and the University of California, Davis. Updated annually to accommodate surveillance and ecology information from previous years, the plan has been updated for 2017 and is designed to enhance the surveillance and response program for mosquito-borne viruses in California.

Specifically, the plan:

- Provides guidelines and information on the surveillance and control of mosquito-borne viruses in California, including West Nile, St. Louis encephalitis, and western equine encephalomyelitis viruses;
- Incorporates surveillance data into risk assessment models;
- Prompts surveillance and control activities associated with virus transmission risk level;
- Provides local and state agencies with a decision support system; and
- Outlines the roles and responsibilities of local and state agencies involved with mosquito-borne virus surveillance and response.

The California Mosquito-Borne Virus Surveillance and Response Plan provides statewide guidelines that can be modified to meet local or regional conditions. The complete plan may be found at: http://westnile.ca.gov/downloads.php?download_id=3744&filename=2017 CA Response Plan.

"Guidance for Surveillance of and Response to Invasive Aedes Mosquitoes and Dengue, Chikungunya, and Zika in California" was developed by the California Department of Public Health, Vector-Borne Disease Section in conjunction with local health departments, local vector control agencies and the University of California, Davis.

This document was developed to guide local vector control agencies and health departments in preparing for, conducting surveillance of, and responding to the detection of invasive *Aedes* mosquitoes and human cases of dengue, chikungunya, Zika, or other exotic mosquito-borne viral infections potentially transmitted by these mosquitoes. Mosquito species of immediate concern are *Aedes aegypti* and *Aedes albopictus*, both of which recently have been detected and become established in some California counties. Although locally acquired human infection with dengue, chikungunya, or Zika has not been detected in California to date, this is an ongoing low risk as travelers return and visitors come from areas with known disease transmission. Latest updates to this document reflect geographic expansion of the mosquitoes and changes in Zika case definition.

The plan may be found here: https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/Aedes-*aegypti*-and-Aedes-*albopictus*-mosquitoes.aspx

Additional Epidemic/Pandemic/Vector Borne Disease Hazard Mitigation Opportunities

The Operational Plan for Emergency Response to Mosquito-Borne Disease Outbreaks describes coordination between the California Department of Public Health (CDPH) and partner agencies in responding to a mosquito-borne disease emergency. It serves as a supplemental document to the California Mosquito-Borne Virus Surveillance and Response Plan (Response Plan) and is consistent with the CDPH Emergency Plan, Departmental Administrative Order, and State Emergency Plan. This document expands on the roles of the agencies mentioned in the Response Plan and provides the policy basis for mosquito-borne disease outbreak planning, response, recovery, and mitigation actions. The plan may be found here:
www.westnile.ca.gov/downloads.php?download_id=2737&filename=2013%20Op%20Plan%20Mosquito%20Disease%20Emergency.pdf

The document includes the following information:

- Description of how CDPH and federal, state, and local agencies function together in a coordinated escalating emergency response
- The progression from normal to emergency operations
- The emergency management structure [Standardized Emergency Management System (SEMS) organization chart for CDPH response], notification system, responsibilities for the various agencies involved in the response, and anticipated agency roles at each jurisdictional (federal, state, local) level

Similarly, an Operational Checklist for Local Health Departments, Local Vector Control Agencies, and California Department of Public Health In the Event of Local Dengue, Chikungunya, or Zika Transmission was developed to provide a summary of roles and responsibilities of local and state California agencies that would be involved should local transmission of dengue, chikungunya, or Zika be detected.

The checklist may be found here:
https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/OperationalChecklistLocalTXZika.pdf.

9.1.8 EXTREME HEAT

Identifying Extreme Heat Hazards

In most areas of the state, summer temperatures are expected to be warm; during certain periods, however, temperatures can rise much higher, to the point of being considered severe or possibly dangerous. Severe heat conditions are much warmer than average for a particular time and place. Severe heat conditions may also include increased humidity. Three or more consecutive severe heat days is referred to as an extreme heat event. Heat wave activity is on the rise in California and humid heat waves, particularly, are becoming more prevalent.[277,278] Heat ranks as among the deadliest of all natural hazards.[279] Even though heat-related deaths and illnesses are largely preventable, many people annually succumb to extreme and especially humid heat.

Heat-Related Illness

Heat-related illness includes a spectrum of illnesses ranging from heat cramps to severe heat exhaustion and life-threatening heat stroke. Heat-related illness results from the "body's inability to dissipate heat produced by metabolic activity, often as a result of increased ambient temperature".[280,281]

Heat related illnesses include:

- Heat cramps
- Heat exhaustion
- Heat stroke

Heat cramps and heat exhaustion can be painful and may progress to heat stroke rapidly if not addressed. Heat exhaustion occurs when the body is dehydrated, resulting in an imbalance of electrolytes. Symptoms include headache, nausea, dizziness, cool and clammy skin, pale face, cramps, weakness, and profuse perspiration. First aid involves moving to a cooler spot and drinking water with a small amount of salt added (one teaspoon per quart). Without intervention, heat exhaustion can lead to collapse and heat stroke.

Heat stroke is a severe and life-threatening failure of the body's ability to cool (e.g., sweating ceases), with core temperature generally over 104°F. Heat stroke ensues when perspiration cannot occur and the body overheats. Symptoms include headache, nausea, face feeling flushed, hot and dry skin, no perspiration, body temperature over 101°F, chills, and rapid pulse. Heat stroke includes severe mental status changes, seizures, loss of consciousness, kidney failure, and abnormal cardiac rhythm.

Heat stroke is an extreme medical emergency that, if not promptly treated, frequently results in death or permanent neurological impairment. First aid involves cooling the person immediately; moving to shade or indoors; wrapping the person in a cool, wet sheet; and getting medical assistance. Without intervention, heat stroke can lead to confusion, coma, and death. With prompt and appropriate emergency medical treatment, survival can approach 100 percent.

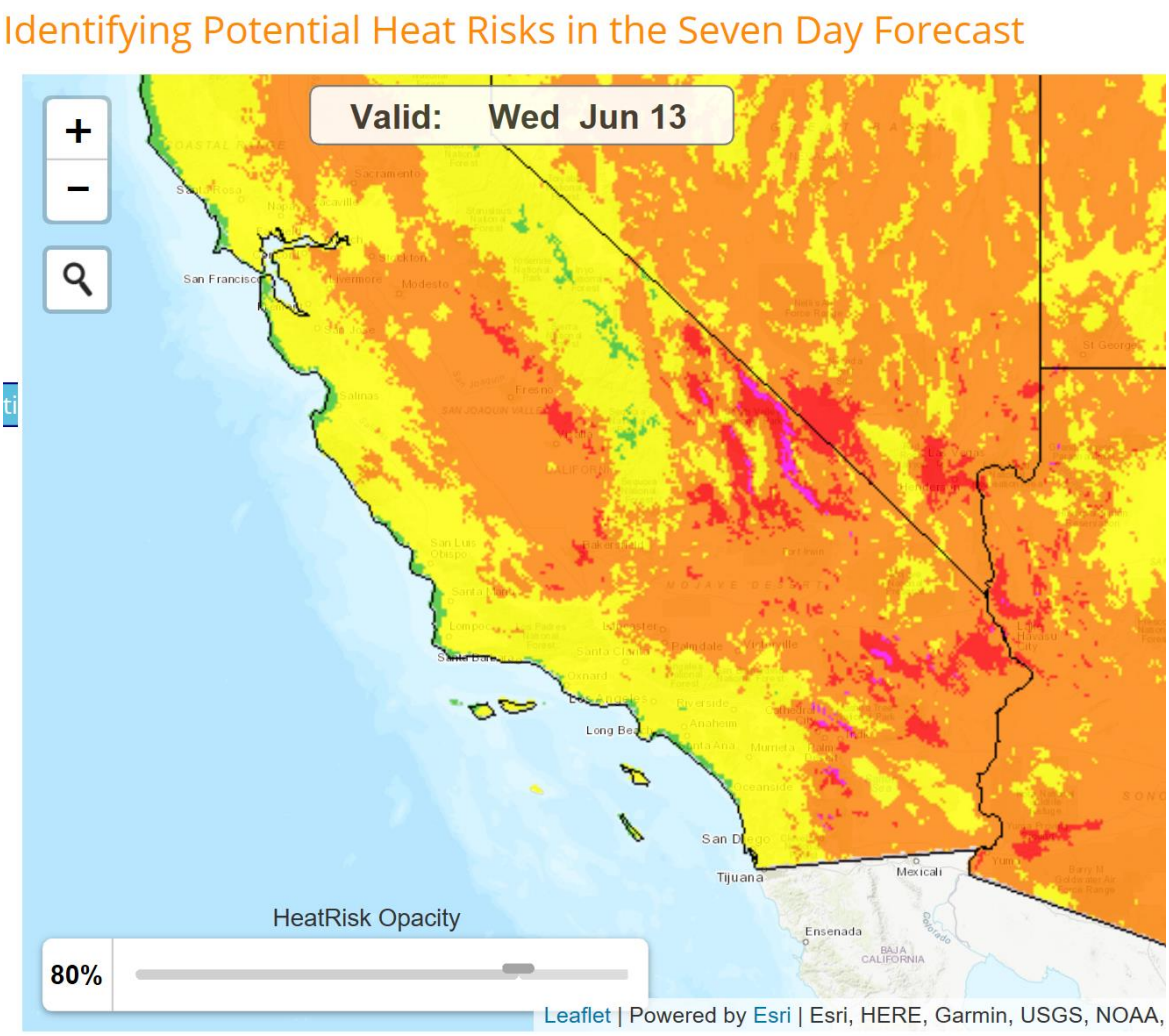
[277] Gershunov, A., D. Cayan and S. Iacobellis, 2009: The great 2006 heat wave over California and Nevada: Signal of an increasing trend. Journal of Climate, 22, 6181–6203.
[278] Gershunov A. and K. Guirguis, 2012: California heat waves in the present and future. Geophysical Research Letters, 39, L18710, doi:10.1029/2012GL052979.
[279] Borden et al, 2008
[280] Preparing California for Extreme Heat: Guidance and Recommendations, October 2013; http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf
[281] Wexler, 2002

National Weather Service HeatRisk Forecast

Heat affects everyone differently. In order to better address heat risk and prepare for upcoming heat events, the National Weather Service (NWS) developed the experimental HeatRisk forecast. The NWS experimental HeatRisk forecast is an online mapping tool that provides daily guidance on potential heat risks out to seven days. Map 9.P is an example screenshot from the HeatRisk mapping tool.

The NWS HeatRisk forecast provides a quick view of heat risk potential over the upcoming seven days. The heat risk is portrayed in a numeric (0-4) scale and a color (green/yellow/orange/red/magenta) scale, similar in approach to the Air Quality Index or the Ultraviolet Index. Table 9.L summarizes the heat risk color scale categories. The scale provides one value each day that indicates the approximate level of heat risk concern for any location, along with identifying the groups who are most at risk. This product is supplementary to the official NWS heat watch/warning/advisory program and is meant to provide continuously available heat risk guidance for decision-makers and heat-sensitive populations who need to take actions at levels that may be below current NWS heat product levels.

Map 9.P: National Weather Service (NWS) Experimental HeatRisk Forecast Mapping Example from NWS Website



Source: National Weather Service, NWS Experimental HeatRisk forecast tool; https://www.wrh.noaa.gov/wrh/heatrisk/, retrieved 06/11/18

Table 9.L: HeatRisk Categories by Color

HeatRisk Category	Level	Meaning
Green	0	No elevated risk
Yellow	1	Low Risk for those extremely sensitive to heat, especially those without effective cooling and/or adequate hydration
Orange	2	Moderate Risk for those who are sensitive to heat, especially those without effective cooling and/or adequate hydration
Red	3	High Risk for much of the population, especially those who are heat sensitive and those without effective cooling and/or adequate hydration
Magenta	4	Very High Risk for entire population due to long duration heat, with little to no relief overnight

Source: National Weather Service, http://www.nws.noaa.gov/om/heat/heat_index.shtml

The NWS issues Excessive Heat Watches, Excessive Heat Warnings, and Heat Advisories to warn of an extreme heat event (a "heat wave") within the next 36 hours. If NWS forecasters predict an excessive heat event beyond 36 hours, the NWS will issue messaging in the form a Special Weather Statement, partner emails, and social media during the a three to seven day time frame. In 2017, the NWS transitioned to using NWS experimental HeatRisk forecast output to determine if Excessive Heat Watches, Excessive Heat Warnings, or Heat Advisories are warranted. This risk is assessed by comparing the official NWS temperature forecast to local thresholds, which change through the year based on climatology.

For more information, visit: https://www.wrh.noaa.gov/wrh/heatrisk/.

Profiling Extreme Heat Hazards

Heat waves do not cause damage or elicit the immediate response that floods, fires, earthquakes, and other disasters do. However, they have claimed many more lives when compared with other disasters.

The worst single heat wave event in Southern California for loss of life occurred in 1955, when an eight-day heat wave is said to have resulted in 946 deaths. The summer 2006 heat wave in California caused the deaths of about 650 people over a 13-day period.[282] In comparison, other types of disasters, such as recent earthquakes and fires, have caused in fewer deaths. For example, the 1989 Loma Prieta Earthquake resulted in 63 deaths, while the 1992 Northridge Earthquake was responsible for the loss of 55 lives. The catastrophic 2003 Southern California firestorms resulted in 24 deaths.

The California Climate Adaptation Strategy, citing a California Energy Commission study of San Diego, states that "over the past 15 years, heat waves have claimed more lives in California than all other declared disaster events combined."[283] Despite this history, however, few heat events were proclaimed at the state level or declared as a federal disaster between 1960 and 2009.[284] Though no formal explanation exists for this seeming contradiction, scholars have written about the exclusion of heat events as declared disasters. Klinenberg, author of an account of a heat wave that killed 739 people in the Chicago in July 1995, suggests that the hidden nature of social vulnerability combined with the inconspicuous nature of heat events (unlike earthquakes, floods, wildfires, tornados, etc.)

[282] Safeguarding California: Reducing Climate Risk, An Update to the 2009 California Climate Adaptation Strategy, July 2014; http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf

[283] California Natural Resources Agency, California Climate Adaptation Strategy, December 2009, p. 32; Messner, Steven, Sandra C. Miranda, Karen Green, Charles Phillips, Joseph Dudley, Dan Cayan, Emily Young. Climate Change Related Impacts in the San Diego Region by 2050. PIER Research Report, CEC-500-2009-027-D, Sacramento, CA: California Energy Commission. 2009.

[284] Guirguis, K., A. Gershunov, A. Tardy and R. Basu, 2014: The Impact of Recent Heat Waves on Human Health in California. Journal of Applied Meteorology and Climatology, 53, 3-19.

prevent them from being declared as legitimate disasters.[285] Further, an evaluation of hospitalizations in California found that heat events in cooler months (due to less acclimatization to heat) and those with above average humidity resulted in greater heath impacts.[286]

According to Safeguarding California: Reducing Climate Risk, An Update to the 2009 California Climate Adaptation Strategy, it is anticipated that extreme heat events in urban centers such as Sacramento, Los Angeles, and San Bernardino could cause two to three times more heat-related deaths then occurred in 2006. Additionally, Safeguarding California notes that urban areas are more likely to experience "heat Island" effects (see discussion below).

Urban Heat Islands

Large urban areas often experience higher temperatures, greater pollution, and more negative health impacts during hot summer months, when compared to more rural communities. This phenomenon is known as the urban heat island. Heat islands are created by a combination of heat-absorptive surfaces (such as dark pavement and roofing), heat-generating activities (such as engines and generators), and the absence of vegetation (which provides evaporative cooling). Heat island effects can occur in urban areas when natural surfaces and materials such as grass, trees, and soil, which dissipate heat, are replaced by road and buildings with materials that increase absorption (and reduce dissipation) of heat. As a result of building and road construction and other human activities, more heat is generated and retained, and air temperatures in urban heat island areas are consistently higher than in surrounding areas.

Increased temperatures also add to the heat load of buildings in urban areas and exacerbate existing urban heat islands adding to the risk of high ambient temperatures. In certain urban settings where conditions create "heat islands," occupants face a greater risk of heat-related diseases.

Treating Heat as a "Legitimate Hazard"

Historic losses due to extreme heat events raise several issues. First, since the primary goal of the SHMP is to significantly reduce the loss of life and injuries in California, heat is considered a legitimate disaster type. The number of people killed by extreme heat underscores the importance of mitigating its impacts. Second, heat events highlight the importance of thoughtful social vulnerability analyses. While changes to the built environment can greatly alter vulnerability to different hazards, social vulnerability and resiliency are especially important during heat events. For example, socially isolated elderly persons are especially vulnerable. Any mitigation efforts aimed at reducing heat losses will focus on ways to reduce social isolation, as well as changes to the built environment. Third, heat events illustrate how seemingly unrelated phenomena combine to create disaster. For example, the increased use of air conditioners during heat waves can lead to power outages, which makes extreme heat events even more deadly. Upgrading water and power infrastructure, then, is a form of extreme heat disaster mitigation.

Situational and physical characteristics help to identify vulnerable populations that may not comfortably or safely gain access to and use disaster resources. Specifically, when discussing heat-related emergency preparedness, the following groups could be considered vulnerable or at greater risk in a heat emergency:

- People with a developmental/intellectual disability, i.e., a severe and chronic disability that is attributable to a mental or physical impairment that begins before an individual reaches adulthood. These disabilities include cerebral palsy, epilepsy, and autism.
- People who are blind or have low vision.
- People who are deaf or hard of hearing.
- People with limited mobility.
- People with injuries from auto accidents, falls, sports, and/or war. These injuries can cause damage to the brain, spinal cord, hearing, and sight, and limit mobility.

[285] Heat Wave: A Social Autopsy of Disaster in Chicago, The University of Chicago, 2002

[286] Guirguis, K., A. Gershunov, A. Tardy and R. Basu: The Impact of Recent Heat Waves on Human Health in California. 2014. Journal of Applied Meteorology and Climatology, 53, 3-19.

- People with chronic conditions such as diabetes, arthritis, dialysis, asthma, and epilepsy.
- Older adults who have age-related limitations (e.g. slow movement, sight, and hearing limitations, etc.).
- Children who may dependent on others, not only for care, but for decision-making. Because children process information and trauma differently than adults, they may be unable to articulate their needs and, may decompensate faster than adults. They are also generally more susceptible to thirst, hunger, and temperature than adults.

Animals, including domestic pets, livestock, and poultry, are also susceptible to extreme heat. For example, dogs and cats are in danger of heat stroke in temperatures of 110°F. The heat wave of 2006 resulted in 15 reported pet deaths and more than 25,000 cattle and 700,000 fowl heat-related deaths. Heat wave impacts on livestock can lead to financial losses in California's agricultural economy.

Climate Change and Extreme Heat

Average temperatures are rising around the world and across the United States, and the western portion of the U.S, including California, is experiencing more warming than other parts of the country. In addition to overall warming, the U.S is experiencing an increase in extreme heat events, with hotter-than-usual days and nights becoming more common.[287]

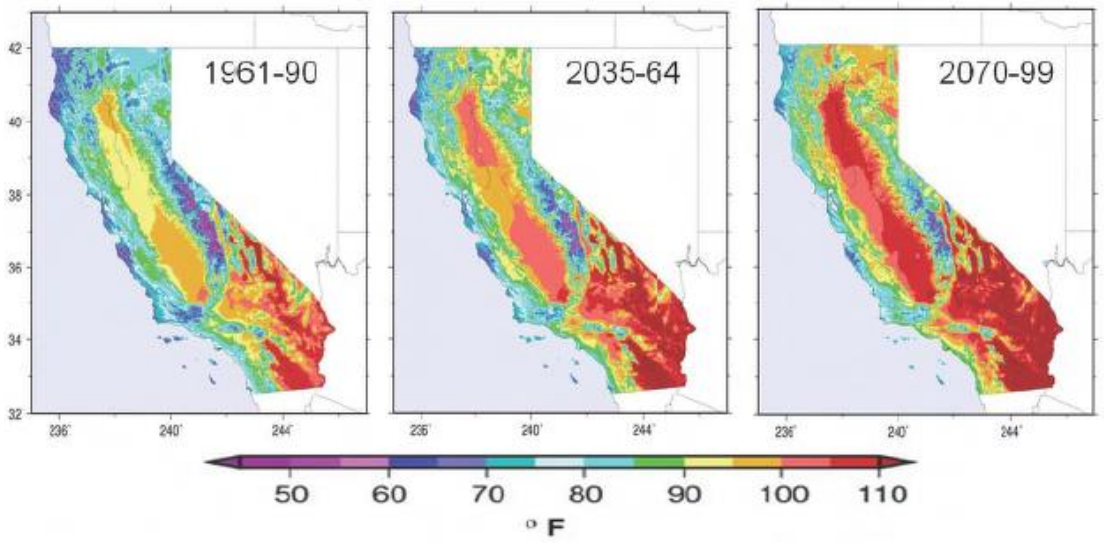
According to the U.S. Environmental Protection Agency (EPA), climate change caused by greenhouse gas emissions is a pattern of change in average weather, such as increases in temperatures that is occurring over many years. Increases in global temperatures have led to other changes such as increases in extreme heat events. Extreme heat events are likely to occur more often, with greater severity, and for longer periods of time. In California, this trend is accentuated specifically for humid heat waves, which are expressed very strongly in nighttime temperatures.[288,289] In California, this trend is accentuated specifically for humid heat waves, which are expressed very strongly in nighttime temperatures.[290,291]

Climate change has the potential to increase the number of communities facing recurrent extreme heat events, particularly in urban settings where extreme heat events will be exacerbated by urban heat islands. Without appropriate preparation, communities unaccustomed to repeated heat events will be unprepared to address the health consequences of extreme heat. The State of California provides a web tool, Cal-Adapt (http://cal-adapt.org/) that projects climate change-influenced heat wave frequency to aid communities in preparing for projected impacts.

According to the 2018 Safeguarding California Plan: California's Climate Adaptation Strategy, California is getting warmer, leading to increasing frequency, intensity, and duration of heat waves, and increased mortality and morbidity associated with increased healthcare costs. Map 9.Q illustrates the statewide temperature increase trend.

[287] Climate change and Extreme Heat: What You Can Do to Prepare, https://www.epa.gov/sites/production/files/2016-10/documents/extreme-heat-guidebook.pdf
[288] Gershunov, A., D. Cayan and S. Iacobellis, 2009: The great 2006 heat wave over California and Nevada: Signal of an increasing trend. Journal of Climate, 22, 6181–6203.
[289] Gershunov A. and K. Guirguis, 2012: California heat waves in the present and future. Geophysical Research Letters, 39, L18710, doi:10.1029/2012GL052979
[290] Gershunov, A., D. Cayan and S. Iacobellis, 2009: The great 2006 heat wave over California and Nevada: Signal of an increasing trend. Journal of Climate, 22, 6181–6203.
[291] Gershunov A. and K. Guirguis, 2012: California heat waves in the present and future. Geophysical Research Letters, 39, L18710, doi:10.1029/2012GL052979.

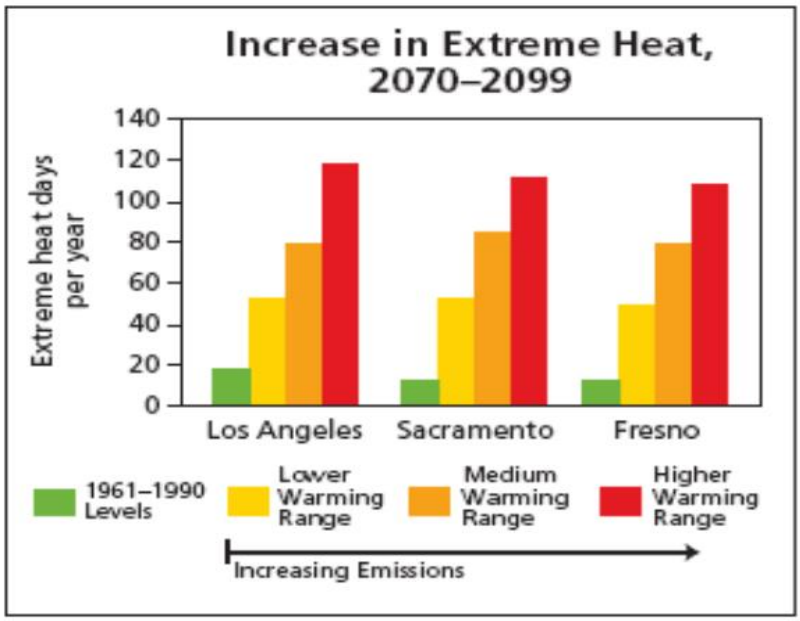
Map 9.Q: California Historical and Projected Temperature, 1961-2099



Source: Dan Cayan; California Climate Adaptation Strategy

As temperatures rise, Californians will face greater risk of death from dehydration, heat stroke/exhaustion, heart attack, stroke, and respiratory distress caused by extreme heat, leading to greater risk of hospitalizations. By mid-century, extreme heat events in urban centers could cause two to three times more heat-related deaths than occur today.[292] By 2100, hotter temperatures are expected throughout the state, with an increase of 3°F to 5.5°F under the lower emissions scenario and 8°F to 10.5°F under the higher emissions scenario. If temperatures rise to the higher warming range, there could be up to 100 more days per year with temperatures above 90°F in Los Angeles and above 95°F in Sacramento, as shown in Chart 9.B. Future heat wave activity, however, will not, increase uniformly and will depend in large part on the local climate (e.g., coast vs. inland valleys, deserts, and mountains).[293]

Chart 9.B: Projected Increase in Extreme Heat, 2070-2099



[292] California Climate Change Center 2006, 2009

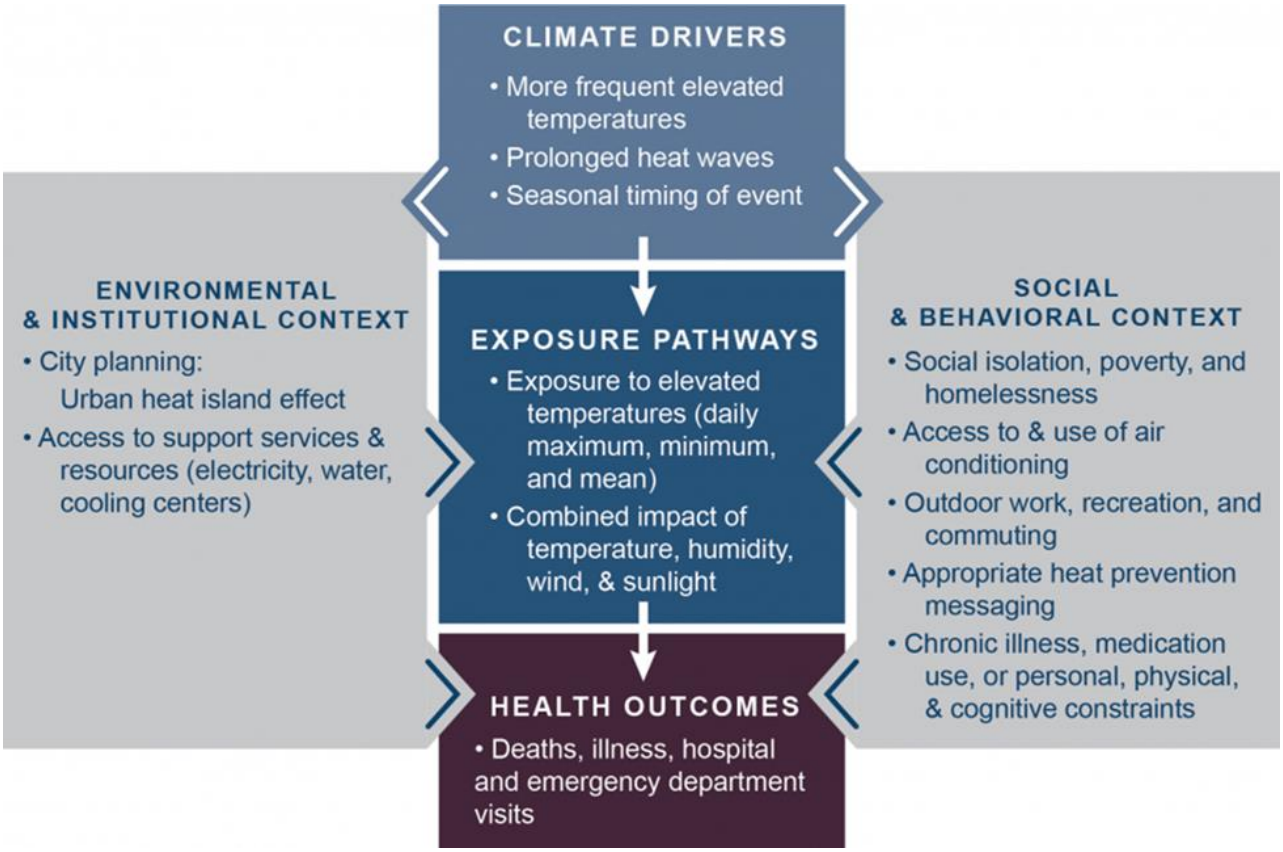
[293] Guirguis, K., A. Gershunov, D.R. Cayan and D. Pierce. Heat wave probability in the changing climate of the Southwest US. 2017. Climate Dynamics, DOI: 10.1007/s00382-017-3850-3.

Other Health Impacts Resulting from Climate Change and Extreme Heat

Climate change is projected to result in an increase in the frequency and severity of extreme heat events. Climate change-influenced heat events (temperature and humidity) may also create a conducive environment for vector-borne diseases. Extended heat events result in the emergence of vectors that can carry infectious diseases, like dengue, Zika, yellow fever, and chikungunya, in areas within California that have not historically experienced their occurrence.

As a result of the increase in vectors due to heat events, spread of disease is rising. The surge in Zika and dengue fever infections is one example. For these two pathogens, the increase in temperature causes mosquitoes to 1) feed more frequently, 2) breed more prolifically, and 3) live longer, which ultimately results in their ability travel farther than ever before.

Figure 9.C: Linking Climate Change, Extreme Heat, and Public Health



Source: https://health2016.globalchange.gov/temperature-related-death-and-illness

Figure 9.C shows a conceptual diagram prepared by the U.S. Global Change Research Program that is a useful illustration of the key pathways by which climate change influences human health during an extreme heat event. The U.S. Global Change Research Program website states as follows: "Key factors that influence vulnerability for individuals are shown in the right box, and include social determinants of health and behavioral choices. Key factors that influence vulnerability at larger scales, such as natural and built environments, governance and management, and institutions, are shown in the left box. All of these influencing factors can affect an individual's or a community's vulnerability through changes in exposure, sensitivity, and adaptive capacity and may also be affected by climate change."[294]

[294] U.S. Global Change Research Program website, retrieved on 8/2/2017. https://health2016.globalchange.gov/temperature-related-death-and-illness

Assessment of State Vulnerability and Potential Losses

As noted *in Safeguarding California: Reducing Climate Risk, (July* 2014 update), not all communities and not all members of a community are equally vulnerable to climate events. Underlying health status ("sensitivity") and socio-economic conditions may vary, and access to information, services, and resources affects how impacts are experienced.

Research on Climate Exposure and Socio-Economic Vulnerability of California Communities

The Third California Climate Change Assessment featured a number of studies on the exposure and vulnerabilities of California communities to climate impacts. These studies assessed particular communities, such as Fresno and San Luis Obispo, and developed a climate vulnerability index to identify the areas of the state most vulnerable to climate impacts. The climate vulnerability index combined 19 indicators into one overall climate vulnerability score and includes factors specifically related to climate impacts, such as air conditioner ownership, percentage of tree cover, and workers in outdoor occupations.

Preparing California for Extreme Heat: Guidance and Recommendations, October 2013, notes that certain populations are more vulnerable to extreme heat. Heat-related illness can be classified as "classic" or "exertional," and different populations are at risk for each type.

The majority of non-working victims who tend to suffer from classic heat-related illness during heat waves come from the following groups: young children, elderly persons, pregnant women, persons who are socially isolated, and persons with access and functional limitations.

Exertional heat-related illness tends to affect persons involved with vigorous physical activities that cause the body to generate more heat—typically workers, outdoor athletes, and military personnel. For workers, exertional heat illness occurs across a wide age range and in numerous industries and occupations, including agriculture, construction, firefighting, warehousing, delivery, and service work.

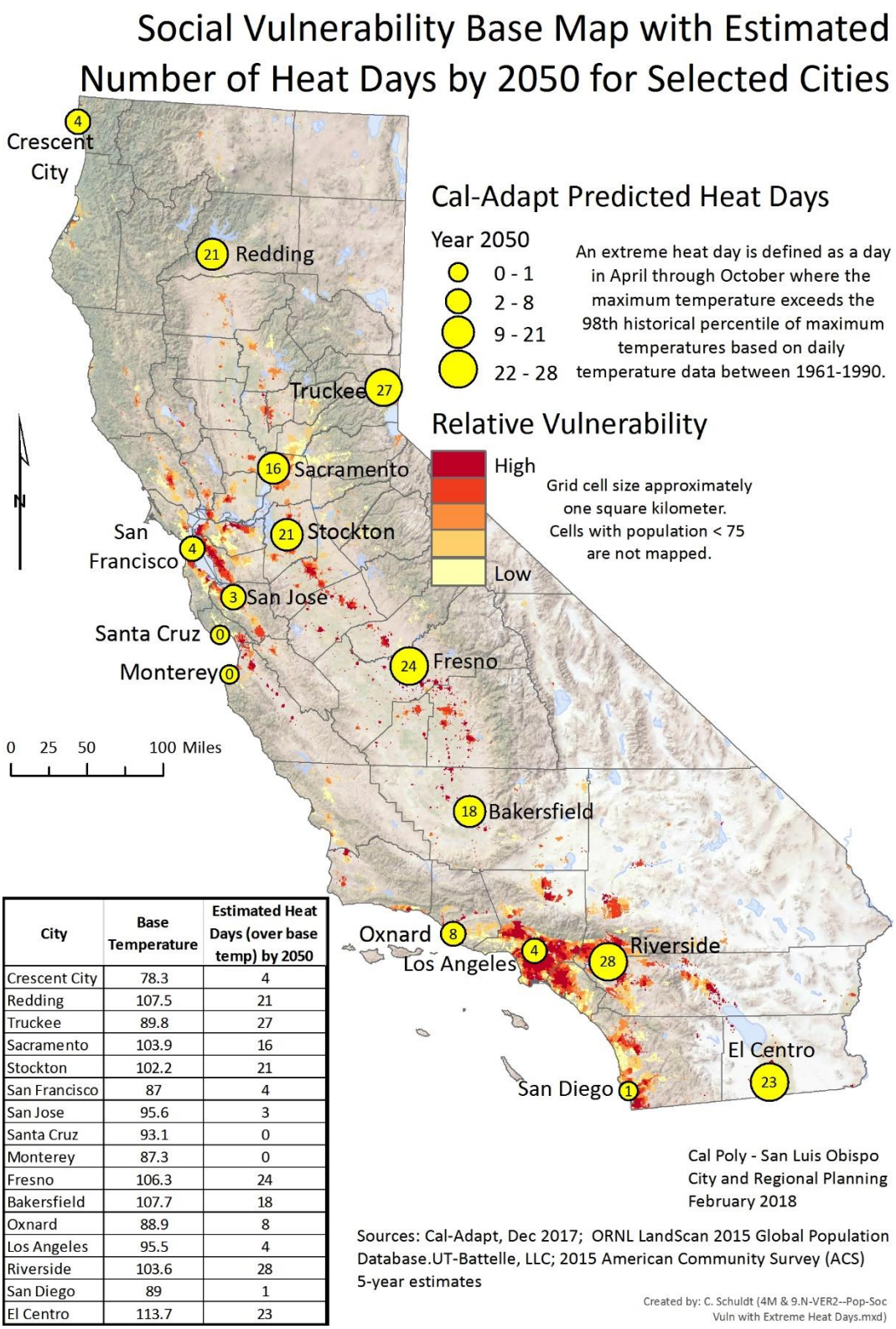
California Building Resilience Against Climate Effects (CalBRACE)

The CalBRACE program has developed data and narrative vulnerability reports for various indicators, including extreme heat. The CalBRACE extreme heat indicator narrative describes certain populations that may have greater difficulty preparing for extreme heat. To download the CalBRACE extreme heat indicator data and narrative, as well as the population sensitivity and adaptive capacity indicator data and narratives relevant to extreme heat events, visit: https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx.

For more information about CalBRACE, visit the CDPH Health Equity Program webpage and follow the Climate Adaptation link to the CalBRACE program website: https://www.cdph.ca.gov/Programs/OHE/Pages/CalBRACE.aspx.

Map 9.R shows moderate to high concentrations of population/social vulnerability (based on the index described in *Appendix N*) in selected cities at risk of increased extreme heat days.

Map 9.R: Social Vulnerability and Extreme Heat



City	Base Temperature	Estimated Heat Days (over base temp) by 2050
Crescent City	78.3	4
Redding	107.5	21
Truckee	89.8	27
Sacramento	103.9	16
Stockton	102.2	21
San Francisco	87	4
San Jose	95.6	3
Santa Cruz	93.1	0
Monterey	87.3	0
Fresno	106.3	24
Bakersfield	107.7	18
Oxnard	88.9	8
Los Angeles	95.5	4
Riverside	103.6	28
San Diego	89	1
El Centro	113.7	23

Assessment of Local Vulnerability and Potential Losses

In July 2012, the California Energy Commission's Climate Change Center published a White Paper, prepared by the University of California (UC), Berkeley, entitled "Mapping Climate Change Exposures, Vulnerabilities, and Adaptation to Public Health Risks in the San Francisco Bay and Fresno Regions." The study first reviewed available frameworks for climate change adaptation in the public health arena and then proposed a conceptual framework and procedure to assess climate change vulnerabilities. The study identified and modeled heat stress, along with environmental, social, and health factors related to climate change and vulnerability. The study also provided a measure of small-scale variations in the urban heat island. The study determined that downtown urban areas in both Fresno County and the San Francisco Bay Area showed a cumulatively higher vulnerability score than more outlying areas (with the exception of the western portion of Fresno County).

More jurisdiction-specific information related to community vulnerability and loss assessments may be found in Local Hazard Mitigation Plans.

Current Extreme Heat Hazard Mitigation Efforts

State of California: Preparing California for Extreme Heat: Guidance and Recommendations

In 2017, in the wake of the hottest July ever recorded in the United States, the State of California released a plan to deal with extreme heat caused by climate change. This broad guidance document was developed by the Heat Committee of the Public Health Workgroup in the Climate Action Team and provides recommendations for incorporating extreme heat projections into planning and decision-making in California.

An important companion to this plan is the state's latest climate change and heat guidance entitled "Preparing California for Extreme Heat: Guidance and Recommendations" produced by the Heat Adaptation Work Group of the Climate Action Team's Public Health Workgroup and coordinated by the California Department of Public Health and the California Environmental Protection Agency (CalEPA).

This document provides an overview of climate change projections for increasing temperature and extreme heat events through 2100, evaluates the health risks associated with these changes, and presents recommendations to guide the state's actions to reduce human health risks in the face of a warming climate in California and promote more heat resilient communities.

To download "Preparing California for Extreme Heat: Guidance and Recommendations," visit:
http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf.

Contingency Plan for Excessive Heat Emergencies.

In June 2014, Cal OES issued a revised version of the Contingency Plan for Excessive Heat Emergencies, as a supporting document to the State Emergency Plan. The Contingency Plan was originally published in 2010.

Although primarily designed to guide preparedness and response activities, the Contingency Plan also identifies mitigation actions to prevent life loss, including:

- Identifying the location of vulnerable populations
- Establishing cooling centers
- Issuing advisories and warnings
- Conducting pre-season public information campaigns
- Promoting and expanding urban greening and the use of green infrastructure as part of cooling strategies in public and private spaces

Details regarding the Contingency Plan for Excessive Heat Emergencies are available at the following link:
http://www.caloes.ca.gov/PlanningPreparednessSite/Documents/ExcessiveHeatContingencyPlan2014.pdf.

California Adaptation Planning Guide.

The California Adaptation Planning Guide: Identifying Adaptation Strategies document presents potential strategies for adapting to climate change, including some strategies addressing heat events. Communities are encouraged to use these strategies to meet adaptation needs. The Adaptation Planning Guide can be found at the following link: http://resources.ca.gov/climate/safeguarding/local-action/.

Protecting Vulnerable Populations at Work

Since 2005, California employers have been required to provide basic elements to protect outdoor workers—adequate water, shade, rest breaks, training, and emergency procedures.[295] In 2010, the standard was strengthened to include a high heat provision that must be implemented by five industries (agriculture, construction, landscaping, oil and gas extraction, and transportation or delivery of agricultural products, construction material, or other heavy materials) when temperatures reach 95°F.

These enhancements included mandates to remind employees to drink water more frequently, to observe employees for signs and symptoms of heat illness, to ensure effective communications to summon help if needed, and to provide close supervision of new employees.

Best Practices Highlight 9.D: Kern County Cooling Centers

Kern County, located in the southern Central Valley, already experiences extreme heat events, and the frequency of these events is projected to increase due to climate change. For community members who do not have access to a setting with temperature control (e.g., air conditioning), cooling centers have been established to provide places to escape the heat. The opening of these centers is tied to a set of temperature triggers that vary by location.

The temperature triggers for opening the cooling centers, based on the National Weather Service forecast as of the previous day, are as follows:

- San Joaquin Valley / Kern River Valley Centers: 105 degrees Fahrenheit (°F)
- Mountain Center(s): 95°F
- Desert Centers: 108°F

Cooling centers include a wide range of community facilities, such as senior centers, parks and recreation facilities, community centers, police departments, and veterans' centers. When the centers have opened, announcements are made via TV, radio, and the Internet. In addition, transportation is available for community members who do not have a way to travel to one of the centers.

Sources: Reported in the California Climate Adaptation Planning Guide; https://www.kerncounty.com/pio/coolingcenters.aspx

California Heat Assessment Tool

California Natural Resources Agency under the California Fourth Climate Change Assessment is sponsoring the California Heat Assessment Tool project. The project, which is projected to launch in 2018, is a decision-support tool for city, county, and state practitioners involved in public health and local planning efforts to better prepare extreme heat events, by supporting their inclusion of extreme heat and its impact on human health in long-term policy and planning decisions. The tool will be available at www.cal-heat.org beginning in late 2018.

[295] California Code of Regulations, Title 8, Section 3395. Heat Illness Prevention, (http://www.dir.ca.gov/title8/3395.html)

Progress Summary 9.K: Urban Heat Island Index for California

Progress as of 2018: Concentration of heat in urban areas is a concern because it creates health risks from heat exposure and the increased formation of air pollutants, particularly ground-level ozone or smog. It also affects energy consumption through additional air conditioning needed to counter-balance the higher temperatures. The urban heat island effect is projected to increase with climate change.

Until now, there has been no way to quantify the extent and severity of an urban heat island for individual cities in California. There was no consistent "index" to define urban heat islands, and no maps to show where and how intensely they manifest at a local scale.[296] To address that gap, in 2012 the California Legislature required that the California Environmental Protection Agency (CalEPA) develop an Urban Heat Island Index (Assembly Bill 296, Chapter 667, Statutes of 2012) and to design it so that "cities can have a quantifiable goal for heat reduction."

Creating the Index

In 2015, CalEPA released a study entitled "Creating and Mapping an Urban Heat Island Index for California." It defines and examines the characteristics of the urban heat island and, for the first time, creates an Urban Heat Island Index to quantify the extent and severity of urban heat islands for individual cities. The index assigns a score for each census tract in and around most urban areas throughout the state. The scores are based on atmospheric modeling over two three-month-long summer seasons, 2006 (the year of a major heat wave) and 2013 (the most recent year for which data were available).

The study also produced Urban Heat Island Interactive Maps showing the urban heat island effect for each census tract in and around most urban areas throughout the state.

Study Findings

Among the study's findings:

- Hotter parts of California do not necessarily have the most intense urban heat islands. For example, the heat island effect in Fresno averages 4 degrees Fahrenheit (°F), a relatively modest increase over the already high average summer temperature of about 84°F. In contrast, the average summer temperature in Ontario is about 78°F, while the heat island effect is greater, averaging around 9°F.
- Wind and topography can shift the urban heat island effect. In major coastal cities, cool ocean air blows heated urban air inland, where it gets trapped against mountain ranges. As a result, urban heat generated in one area tends to move inland to blanket other areas with the overheated air. A similar phenomenon occurs with ozone air pollution.
- Heat island effects are related to the size of the urban area. Large urban areas have average daily summer temperature increases up to 9°F compared with non-urban regions, while smaller cities average an increase of up to 5°F. The largest effect is in Southern California, where the urban heat islands blur together to form an "urban heat archipelago" with temperatures up to 19°F higher than average in the Riverside-San Bernardino region at the eastern end of the basin.

Uses of the Index

The index may have a variety of uses. Urban heat islands may be priority areas for public health education and preparedness for extreme heat. Along with other environmental studies, such as CalEnviroScreen, this research can also help identify vulnerable areas across the state and set priorities for mitigation by providing another indicator of climate change impacts. Local governments may be interested in the maps of individual cities as a tool for identifying areas for activities such as urban greening and projects focused on cooler roofs and pavements. Over time, it may be possible to track changes in the index that result from climate change or mitigation efforts.

To download the maps or for information on how the index is calculated, visit the CalEPA Urban Heat Island Interactive Maps program website: https://calepa.ca.gov/climate/urban-heat-island-index-for-california/urban-heat-island-interactive-maps/.

[296] The closest tool that exists is U.S. EPA's Mitigation Impact Screening Tool (MIST), which provides qualitative assessments of the likely impacts of heat island mitigation strategies averaged at the city-scale. http://www.epa.gov/heatisld/resources/index.htm

Additional Extreme Heat Hazard Mitigation Opportunities

Additional opportunities to prevent or mitigate the impacts of climate change and extreme heat exist in the form of the ongoing climate change science studies and the Cal-Adapt online resource sponsored by the California Energy Commission (CEC).

For more information, visit the CEC's Environmental Research Energy Related Global Climate Change Issues webpage: http://www.energy.ca.gov/climatechange/.

9.1.9 FREEZE

Identifying Freeze Hazards

Sustained temperatures below freezing in California's generally mild weather regions can cause life loss and health risks to vulnerable populations. Although infrequent, freezes can severely affect California agriculture. Freezing temperatures occurring during winter and spring growing seasons can cause extensive crop damage.

Secondary impacts of freeze disasters can include major economic impacts on farmers, farm workers, packers, and shippers of agricultural products. Freezes can also cause significant increases in food prices to the consumer due to shortages.

Freezing spells are likely to become less frequent in California as climate temperatures increase; if emissions follow higher pathways, freezing events could occur only once per decade in a sizable portion of the state by the second half of the 21st century. While fewer freezing spells would decrease cold-related health effects, too few freezes could lead to increased incidence of disease as vectors and pathogens do not die off (CNRA 2009).

Profiling Freeze Hazards

Overview

Map 9.S shows the pattern of declared freeze disasters in California since 1950. Greatest concentrations are in the Central Valley, followed by areas north and south of the San Francisco Bay Area and portions of Southern California. Table 9.M lists freeze disasters that have occurred in the state since 1950.

Climate Change and Freeze

Similar to severe weather discussed in the following section, extremely cold periods below freezing, may also occur due to the increase in variance caused by climate change. While the global average temperature is rising, the increase in variance means that extreme events at the lower end of the historic temperature range remain a possibility.

In addition, periods of freeze intermixed with unusually warm periods may result in layering of snowpack that increases avalanche risk. This is particularly true if the freeze occurs in the fall and following a late-season rainfall event on snow, resulting in a layer of ice as part of the snowpack. At lower elevations, freezing temperatures can disrupt agricultural productivity, as some products are sensitive to freezing temperatures.

Map 9.S: State and Federal Declared Freeze Disasters, 1950-February 2017

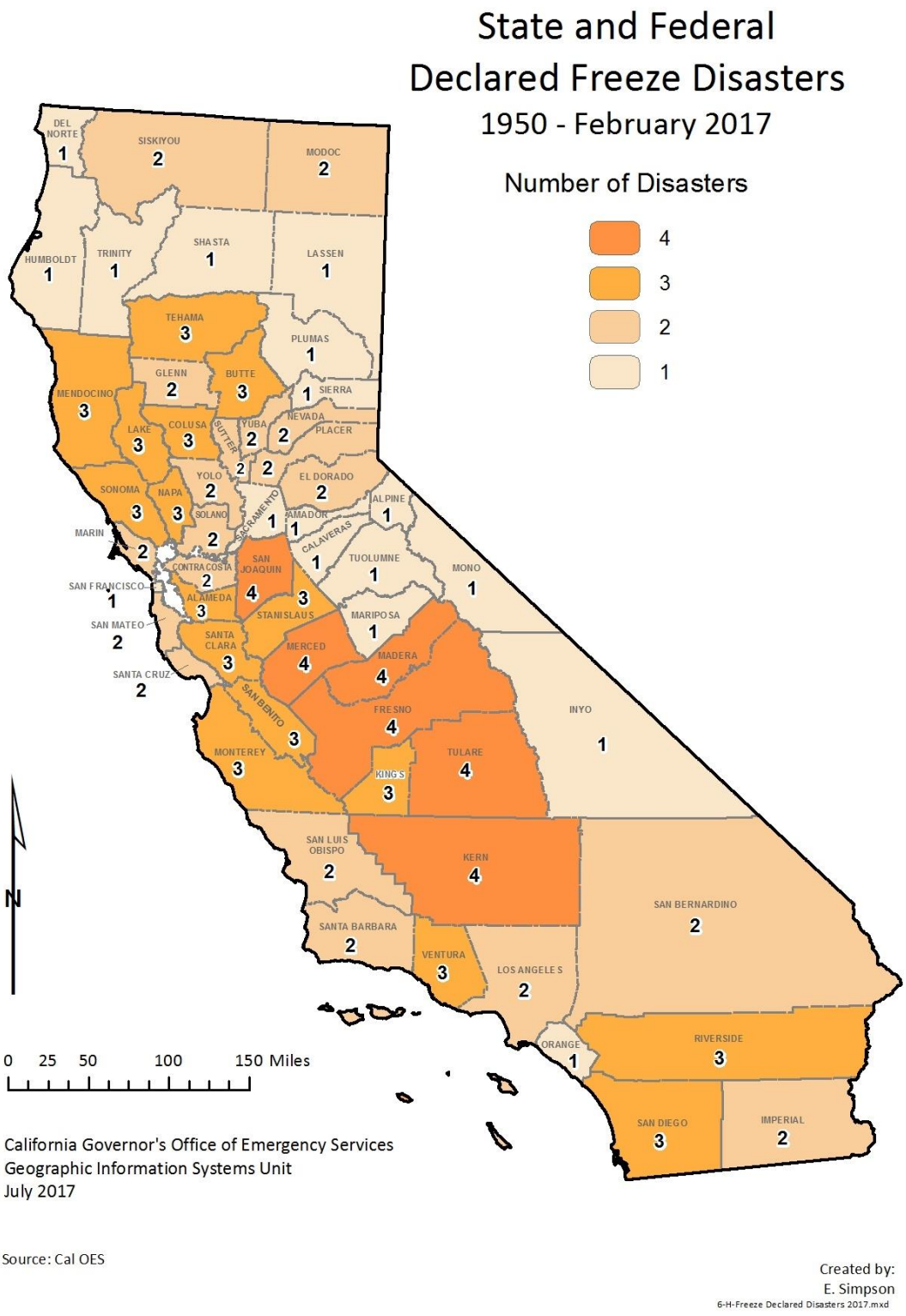


Table 9.M: Freeze Disasters, 1950 to Present

Year*	Number of Incidents	Counties Affected	Crop Damage
1969	1	San Diego	$10 million
1972	2	Colusa, El Dorado, Fresno, Kern, Kings, Lake, Madera, Merced, Modoc, Nevada, Placer, San Benito, San Joaquin, Santa Clara, Stanislaus, Siskiyou, Tehama, Tulare	$113.5 million
1973	1	Alameda, Contra Costa	$8-$10 million
1990	1	Alameda, Butte, Colusa, Fresno, Glenn, Imperial, Kern, Los Angeles, Madera, Marin, Merced, Mendocino, Monterey, Napa, Riverside, Sacramento, San Benito, San Bernardino, San Diego, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Sonoma, Stanislaus, Sutter, Tehama, Tulare, Ventura, Yolo, Yuba	$852.4 million
1998-99	1	Fresno, Kern, Kings, Madera, Merced, Monterey, Tulare, Ventura	N/A
2001	3	Butte, Colusa, Fresno, Glenn, Madera, Mariposa, Merced, Plumas, Sutter, Tehama, Tuolumne, Yuba	N/A
2002	5	Butte, Colusa, Glenn, Lake, Marin, Mendocino, Napa, Orange, Riverside, Sacramento, Shasta, Sonoma, Tehama, Trinity	N/A
2007	1	Alameda, Amador, Calaveras, El Dorado, Fresno, Glenn, Imperial, Kern, Kings, Lake, Los Angeles, Madera, Marin, Mendocino, Merced, Monterey, Riverside, Sacramento, San Benito, San Bernardino, San Diego, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Solano, Stanislaus, Tulare, Ventura, Yolo, Yuba	$1.3 billion
2008	11	Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, El Dorado, Fresno, Glenn, Kern, Kings, Lake, Madera, Marin, Mariposa, Merced, Modoc, Napa, Nevada, Placer, Sacramento, San Joaquin, San Mateo, Santa Clara, Shasta, Siskiyou, Stanislaus, Solano, Sonoma, Sutter, Tehama, Tulare, Tuolumne, Yolo, Yuba	$137,000
2009	15	Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, El Dorado, Fresno, Glenn, Kern, Kings, Lake, Madera, Marin, Mariposa, Merced, Modoc, Napa, Nevada, Placer, Sacramento, San Joaquin, San Mateo, Santa Clara, Shasta, Siskiyou, Stanislaus, Solano, Sonoma, Sutter, Tehama, Tulare, Tuolumne, Yolo, Yuba	N/A
2010	9	Fresno, Kern, Kings, Madera, Mariposa, Merced, Modoc, Siskiyou, Tulare	N/A
2011	10	Del Norte, Fresno, Humboldt, Kern, Kings, Madera, Marin, Mariposa, Mendocino, Merced, Modoc, Napa, Siskiyou, Sonoma, Trinity, Tulare	$300.44 million
2012	12	Fresno, Kern, Kings, Madera, Mariposa, Merced, Modoc, Siskiyou, Tulare	N/A

Year*	Number of Incidents	Counties Affected	Crop Damage
2013	19	Fresno, Imperial, Kern, Kings, Madera, Mariposa, Merced, Modoc, Riverside, San Bernardino, Siskiyou, Tulare	$440.35 million
2014	12	Fresno, Kern, Kings, Madera, Mariposa, Merced, Modoc, Siskiyou, Tulare	N/A
2015	14	Fresno, Imperial, Kern, Kings, Madera, Mariposa, Merced, Modoc, Riverside, San Bernardino, Siskiyou, Tulare	N/A
2016	6	Kern, Modoc, Siskiyou	N/A

Sources: Cal OES Individual Assistance Section, 2001 & 2002 SBA Declarations/ USDA Designations database; Cal OES Origins and Development - A Chronology 1917-1999; NOAA Storm Events Database, 2008-2016

Assessment of State Vulnerability and Potential Losses

Freeze can cause substantial damage to crops in California. Table 9.M shows some of the most detrimental periods of freeze in terms of crop damage dollar losses. As shown in the table, a six-day period of freeze in December 2013 caused more than $440 million in damage to citrus crops.[297] Citrus crops tend to be the most vulnerable to freeze; they accounted for a vast majority of reported damage between 1972 and 2016.

Assessment of Local Vulnerability and Potential Losses

Information related to community vulnerability and loss assessments may be found in Local Hazard Mitigation Plans.

Current Freeze Hazard Mitigation Efforts

Freeze damage is another economic hazard. Mitigation measures for frost include:

- Warning systems
- Selective planting
- Crop insurance
- Frost-fighting equipment
- Biological ice nucleation[298]

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

Additional Freeze Hazard Mitigation Opportunities

There are no additional opportunities identified at this time to prevent or mitigate the impacts of freeze hazards.

[297] NOAA, 2013 and California Citrus Mutual
[298] FEMA Region IX Mitigation Division, Mitigation Strategy Report, FEMA-DR-1267-Ca, The California Freeze of 1998.

9.1.10 SEVERE WEATHER AND STORMS

As pointed out in the discussion of climate change earlier in this chapter as well as in *Chapter 4, Section 4.3*, more extreme weather and severe storms are expected among the future natural hazards challenges in California due to climate change. Increases in severe weather, winter storms, flooding, temperature extremes, and other meteorological effects are anticipated.

Severe weather, what the Intergovernmental Panel on Climate Change refers to as extreme weather, describes a variety of events that are beyond or near the ends of the range of observed weather patterns and behavior.[299] These can include extreme rainfall events, heat waves, storms, unusually cold temperatures, and wind events.

A key theme in the California Climate Adaptation Strategy is the likelihood of more extreme weather-related events requiring planning for adaptation. Because the science is so new, however, little is yet known about certain possible weather effects of climate change. For example, among potential weather-related effects not dealt with in depth in the California Adaptation Strategy is the possibility of increasing numbers and intensities of windstorms, a variable having substantial local impacts and affecting future building code provisions, landscape design and maintenance, and power line and pole design, among other things.

Therefore, although this sub-section focuses primarily on tornadoes and to a lesser degree on hurricanes, it is intended to serve as a placeholder for future assessment of other weather-related hazards representing a broader variety of manifestations in this classification of extreme weather. The severe weather hazards of extreme heat and freeze and are addressed under separate sections within *Chapter 9, Section 9.1*.

Identifying Storm Hazards

A storm disaster is generally defined as a violent atmospheric disturbance occurring over land and/or water and is distinguished by its strength, characteristics, and the scale of the resulting damage. Storms can represent a major potential threat to the state's population because of their frequency, the size of areas devastated and the population affected, and the scale of the potential resulting damage. Storms in California also have historically caused flooding, mudflows, landslides, electrical outages, and other impacts.

There are different types of storms including thunderstorms and winter storms, both of which can produce hazardous conditions. Thunderstorms can produce damaging winds, tornadoes, large hail, flooding and flash flooding. Winter storms can include freezing rain, sleet, heavy snow, and strong winds.

Severe thunderstorms are officially defined as storms that are capable of producing large hail (inch or larger) and/or wind gusts over 58 miles per hour. Hail this size can damage property such as plants, roofs, and vehicles. Wind this strong is able to break off large branches, knock over trees, or cause structural damage to trees. Thunderstorms also produce tornadoes and dangerous lightning; heavy rain can cause flash flooding.

El Nino and La Nina storms are two types of storms that affect the state often. The term El Niño refers to the large-scale ocean-atmosphere climate phenomenon linked to a periodic warming in sea-surface temperatures across the central and east-central equatorial Pacific. La Nina refers to the periodic cooling of ocean surface temperatures in the central and east-central equatorial Pacific that occurs every 3 to 5 years or so. During an El Nino or La Nina, the changes in Pacific Ocean temperatures affect the patterns of tropical rainfall from Indonesia to the west coast of South America, a distance covering approximately one-half way around the world. These changes in tropical rainfall affect weather patterns throughout the world.[300]

[299] IPCC. Intergovernmental Panel on Climate Change. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. 2012. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

[300] http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensofaq.shtml#NINO

Following are other various types of storms that have historically affected the state:

- *Coastal storm:* large wind waves and/or storm surge that strike the coastal zone.
- *Wind storm:* marked by high wind with little or no precipitation.
- *Hailstorm:* a type of storm that precipitates round chunks of ice. Hailstorms usually occur during regular thunderstorms.
- *Ice storm:* Ice storms are one of the most dangerous forms of winter storms. When surface temperatures are below freezing, but a thick layer of above-freezing air remains aloft, rain can fall into the freezing layer and freeze upon impact into a glaze of ice. In general, 8 millimeters (0.31 inch) of accumulation is all that is required, especially in combination with breezy conditions, to start downing power lines as well as tree limbs. [3] Ice storms also make unheated road surfaces too slick to drive on. Ice storms can vary in time range from hours to days and can cripple small towns and large urban centers alike.
- *Snowstorm:* A heavy fall of snow accumulating at a rate of more than 5 centimeters (2 inches) per hour that lasts several hours. Snowstorms, especially ones with a high liquid equivalent and breezy conditions, can down tree limbs, cut off power, and paralyze travel over a large region.
- *Thunderstorms and winter storms* (both discussed later in *Section 9.1.10*)

Identifying Hurricane Hazards

No hurricanes have hit California in recorded history because tropical storm winds generally blow from east to west. California is affected by heavy rain resulting from tropical winds that blow north from Mexico and become colder by the time they hit California.[301]

In the future, monitoring is needed to determine whether present patterns of movement of such storms continue or are modified by the warming of waters off the Pacific Coast due to climate change.

Identifying Tornado Hazards

While California has tornadoes, such storms represent a relatively low risk for most areas, compared to states in the Midwestern and Southern United States where risk exposure is severe and many lives and millions of dollars are lost annually due to this hazard.

Wind speeds in tornadoes range from values below that of hurricane speeds to more than 300 miles per hour. Unlike hurricanes, which produce wind speeds of similar values over relatively widespread areas (when compared to tornadoes), the maximum winds in tornadoes are often confined to extremely small areas and vary substantially over very short distances, even within the funnel itself.

Tornados are measured by the Fujita Tornado Scale which classifies tornadoes by intensity categories (F0-F12), based on the maximum winds occurring within the funnel. Table 9.N describes the Fujita Tornado Scale.

Table 9.N: Fujita Tornado Scale

Category	Wind Speed	Description
F0	40-72 miles per hour	Gale Tornado. Light Damage: Some damage to chimneys; breaks twigs and branches off trees; pushes over shallow-rooted trees; damages signboards; some windows broken; hurricane wind speed begins at 73 miles per hour.
F1	73-112 miles per hour	Moderate Tornado. Moderate Damage: Peels surfaces off roofs; mobile homes pushed off foundations or overturned; outbuildings demolished; moving autos pushed off the roads; trees snapped or broken.
F2	113-157 miles per hour	Significant Tornado. Considerable Damage: Roofs torn off frame houses; mobile homes demolished; frame houses with weak foundations lifted and

[301] The USA TODAY Weather Book by Jack Williams

Category	Wind Speed	Description
		moved; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	158-206 miles per hour	Severe Tornado. Severe Damage: Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forests uprooted; heavy cars lifted off the ground and thrown; weak pavement blown off roads.
F4	207-260 miles per hour	Devastating Tornado. Devastating Damage: Well-constructed homes leveled; structures with weak foundations blown off some distance; cars thrown and disintegrated; large missiles generated; trees in forest uprooted and carried some distance away.
F5	261-318 miles per hour	Incredible Tornado. Incredible Damage: Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 300 feet (100 meters); trees debarked; incredible phenomena will occur.
F6-12	Greater than 319 miles per hour	The maximum wind speeds of tornadoes are not expected to reach the F6 wind speeds.

Source: http://www.spc.noaa.gov/faq/tornado/f-scale.html

Profiling Storm Hazards

The information in Table 9.O extends back to 1993 because that is the year that Cal OES began tracking disaster recovery history information. The 1993 storm was the first federally declared flood disaster since Stafford Act implementation began in 1988.

Table 9.O: Federally Declared Storm Disasters Since 1993 (as of February 2018)*

Disaster #[1]	Date[1]	# of Counties Affected[2]	# of Deaths	Damage in $[2]
DR-979	Jan-Mar 1993	20	20	$175,734,172
DR-1046	Feb-Apr 1995	41	17	$110,327,382
DR-1044	Jan-Feb 1995	33	11	$143,991,187
DR-1155	Dec 1996-Apr 1997	47	8	$174,408,427
DR-1203	Feb-Apr 1998	43	17	$367,638,469
DR-1577	Dec 2004-Jan 2005	7	0	$258,456,701
DR-1585	Feb 2005	7	0	$77,765,373
DR-1628	Dec 2005-Jan 2006	13	0	$155,861,541
DR-1646	Mar-Apr 2006	17	0	$35,332,696
DR-1884	Jan-Feb 2010	6	2	$28,328,920
DR-1952	Dec 2010-Jan 2011	12	0	$75,384,562
DR-4301	Jan 2017	34	[a]	$78,667,600
DR-4302	Jan 2017	Hoopa Valley Tribe	[a]	$3,296,420
DR-4305	Jan 20147	22	[a]	$39,993,640
DR-4308	Feb 2017		[a]	$199,828,031
DR-4312	Feb 2017	Resighini Rancheria	[a]	$269,935
TOTAL				**$2,112,685,689**

[a] Information regarding number of deaths from storm related disasters is not available as of February 2018

Source: [1] https://www.fema.gov/disasters; [2]Cal OES disaster database (Oracle) tracks the amount of obligated funds (Public Assistance and California Disaster Assistance Act [CDAA] funds)

Profiling Tornado Hazards

As shown in Table 9.P, between 1950 and 2017, 354 tornadoes occurred in California, resulting in 87 injuries and more than $103 million in property damage, as well as $267,000 in reported crop damage. No known deaths occurred as a result of California tornadoes, however, and the state has never proclaimed a state of emergency or had a federal disaster declared as the result of a tornado event.

Of the 354 tornadoes that occurred in California between 1950 and 2017, only 2 reached F3; 23 were F2, 93 were F1, and the remaining 236 were at F0. Based on the number of events within the recorded period, in the 67 years between 1950 and 2017, the average recurrence interval of an F0 tornado was about 3.7 per year; the interval for an F1 tornado was about 1.5 per year, the interval for an F2 tornado was approximately once every 2 years, and the interval for an F3 tornado was once every 28 years. However, both F3 tornadoes occurred within a five-year period (1973-1978). 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.

Table 9.P: Tornado Losses, 1950-2017

Magnitude	Number	Injuries*	Property Damage*	Crop Damage*
F0	236	8	$38 million	$212,000
F1	93	26	$18 million	$55,000
F2	23	47	$45 million	N/A
F3	2	6	$2.5 million	N/A

Source: The Tornado Project (www.tornadoproject.com), NOAA national climate data center
**2013-2017 updates pending*

Climate Change and Severe Storms

Climate change increases the variance of weather patterns (described in *Section 4.3.2*) which means the occurrence of events at the edges of the observed range increases. This increase in extreme events or severe weather must be anticipated and planned for.

While a specific event is difficult to project for a particular location, planners should be familiar with local weather patterns and be able to identify which events meet or go beyond the historically observed range that would pose the greatest risk to a community. This could be intense rainfall, wind, heat, powerful hurricanes, or any other climate change-influenced event. Communities should include the potential for these events in their planning process. For example, severe coastal storms may increase in frequency and severity. This potential should be incorporated into coastal community plans for land use and emergency response.

Assessment of State Vulnerability and Potential Losses

No known current assessment of state vulnerability or potential losses due to tornado hazards is available at this time.

Assessment of Local Vulnerability and Potential Losses

Information related to community vulnerability and loss assessments may be found in Local Hazard Mitigation Plans.

Current Severe Weather and Storms Hazard Mitigation Efforts

Voters passed a $4 billion disaster preparedness and flood control bond in 2006, Proposition 1E, that has allowed the state to help local agencies protect homes and lives from levee failures, flash floods, and mudslides. Proposition 84, also passed by voters in 2006, which included $800 million for flood control. Since their passing, those bond dollars have gone to hundreds of safeguarding and mitigation projects such as strengthening the levees that protect Central Valley populations; replacing a 114-year-old dam in Escondido; building stormwater detention basins that improve flood control, create habitat and naturally treat urban runoff; and constructing a five-mile pipeline that will enable Los Angeles County to use stormwater to recharge a groundwater basin.

Tornado mitigation is achieved through the enforcement of wind engineering design and construction codes and standards. Tornado watch and warning announcements are issued to local emergency management agencies and to the media through the Emergency Disaster Information System (EDIS), based on information provided by National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service.

Additional Severe Weather and Storm Hazard Mitigation Opportunities

Storm-related mitigation activities that occur during storm season include winterizing by clearing culverts, marshaling heavy equipment, training crews in flood-fighting techniques, and sharing information with the public on weather-related information.

In addition to maintaining California existing reservoirs and improving groundwater management, California is looking to make major new investments to build the state's water storage capacity through construction of new reservoirs and/or groundwater storage systems. California voters passed Proposition 1 in November 2014 that included $2.7 billion to pay for new water storage projects.

The state and federal governments are also working to modernize the water conveyance system in the Sacramento-San Joaquin Delta to improve the movement of water across the state. California WaterFix is a state and federal proposal to build three new tunnels to allow for a more natural flow of water, reduce dependence on the existing pumping plants, and safeguard a critical water delivery system from catastrophic failure by earthquake, flood, or levee collapse.

9.1.11 TREE MORTALITY

Identifying Tree Mortality Hazards

Tree mortality can create dangerous conditions for people who work in, live in, and/or visit affected areas. High levels of tree mortality increase fuel loads, create hazardous conditions for wildland firefighting personnel, decrease production rates of fireline construction, pose risk of injury from falling branches or trees, and create financial burdens for property owners. Most notable is the high number of hazard trees in or around roads, trails and power lines, administrative sites, campgrounds and communities. Hazard trees require felling and removal to ensure public safety, which may limit access to public lands. Some areas may see a reduction in tourism due to the impact of tree mortality on aesthetics. Additionally, mitigation of hazard trees might alter employee responsibilities and planned forest management activities.

Factors contributing to tree mortality include drought-induced water stress, bark beetles, and high tree density. During water deficit periods, trees become suitable host material for bark beetles. High tree density exacerbates stress on individual trees. In particularly dry areas, trees are dying solely from drought conditions regardless of tree competition; however, tree mortality is largely due to drought conditions coupled with high tree density and/or bark beetles.[302]

Profiling Tree Mortality Hazards

Overview

In California, drought is a recurring event and a catalyst for thousands of acres of stressed trees, bark beetle outbreaks, and extremely high levels of tree mortality.[303] Due to the drought, tree mortality levels have substantially increased in forests in California over the past several years. An estimated 29 million trees covering three million acres died in 2015 alone. From 2010 through the fall of 2017, approximately 129 million trees died on 8.9 acres.[304]

Tree mortality is occurring statewide but is particularly dramatic on the west side of the southern Sierra Nevada range and in parts of the Transverse range. As of 2017, there are over one million acres with high levels of tree mortality across the Stanislaus, Sierra, and Sequoia National Forests. Forest managers are recording 50 percent to greater than 75 percent conifer mortality between 3,000 to 6,000 feet elevation. See Map 9.T.

Climate Change and Tree Mortality

Climate change has the potential to bolster tree mortality by affecting drought and insect populations. Climate change is projected to result in increased frequency and severity of drought events. In addition, changes in seasonal patterns for temperature and precipitation can allow pest populations, such as bark beetles, to increase with limited population reductions in the winter.

Potential repeated and increasingly severe drought events in the future, as well as increases in pest populations stemming from climate changes, may result in additional tree mortality and associated hazards. The potential for increasing incidence of events that cause tree mortality should be incorporated into local and regional mitigation plans.

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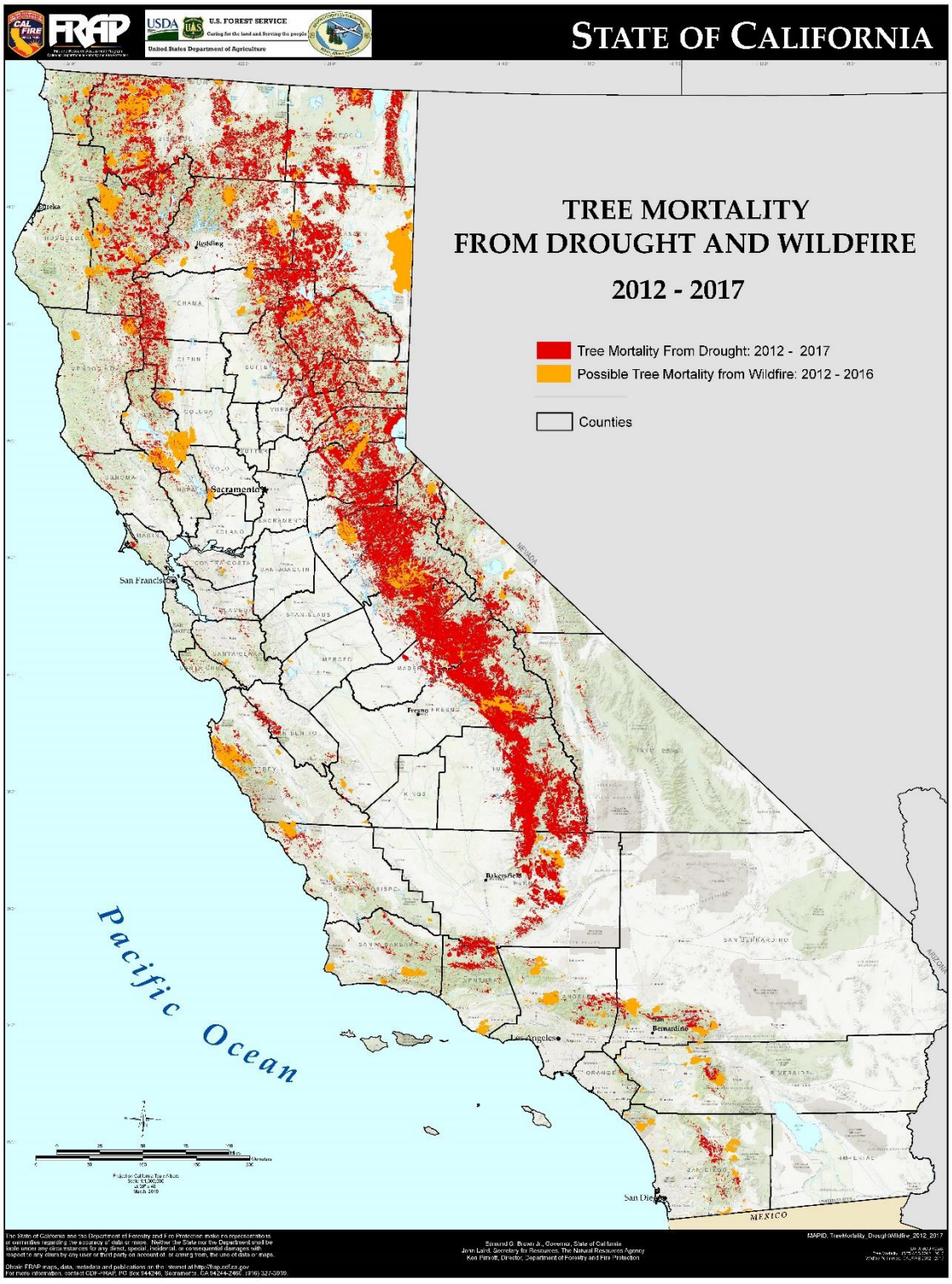
[302] USDA, https://www.fs.fed.us/psw/topics/tree_mortality/index.shtml, https://www.fs.usda.gov/CATreeMortality
[303] USDA, https://www.fs.fed.us/psw/topics/tree_mortality/index.shtml
[304] USFS Tree Mortality Team/CAL FIRE News Release, December 12, 2017; https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd566303.pdf

Map 9.T: Tree Mortality from Drought and Wildfire, 2012-2017



Source: Tree Mortality Task Force reports and deliverables webpage; http://www.fire.ca.gov/treetaskforce/reports#Maps-Data

Map 9.T identifies all tree mortality recorded between 2012 and 2017 throughout the state.

Assessment of State Vulnerability and Potential Losses

Federal, state, and local agencies are working to increase their capacity to mitigate and respond to the impacts of tree mortality on both public and private lands. California's wood processing infrastructure has been declining for decades, limiting state and local capacity to capture the value of the wood in the dead and dying trees. Lack of adequate infrastructure limits the options for quickly removing dead trees. With limited ability to sell the trees, private landowners, and public land managers may need assistance with on-site treatment or transportation of wood to temporary disposal areas.[305]

Map 9.U shows state vulnerability to tree mortality by delineating hazard zones and high priority counties. The High Hazard Zones are those areas designated by the State of California as being in greatest need of dead tree removal due to severe tree mortality levels caused by five years of drought and subsequent bark beetle infestations. Hazard zones are represented in two tiers, representing both potential direct threat to people, buildings and infrastructure from falling trees (Tier 1), and broader fire risk and forest health considerations (Tier 2).

Findings from the Centers for Disease Control and Prevention (CDC) "Community Assessment for Public Health Emergency Response (CASPER) – Mariposa County, 2016," addressing the California drought, indicate that negative impacts of drought on households include financial impacts of dead and dying trees on the properties.

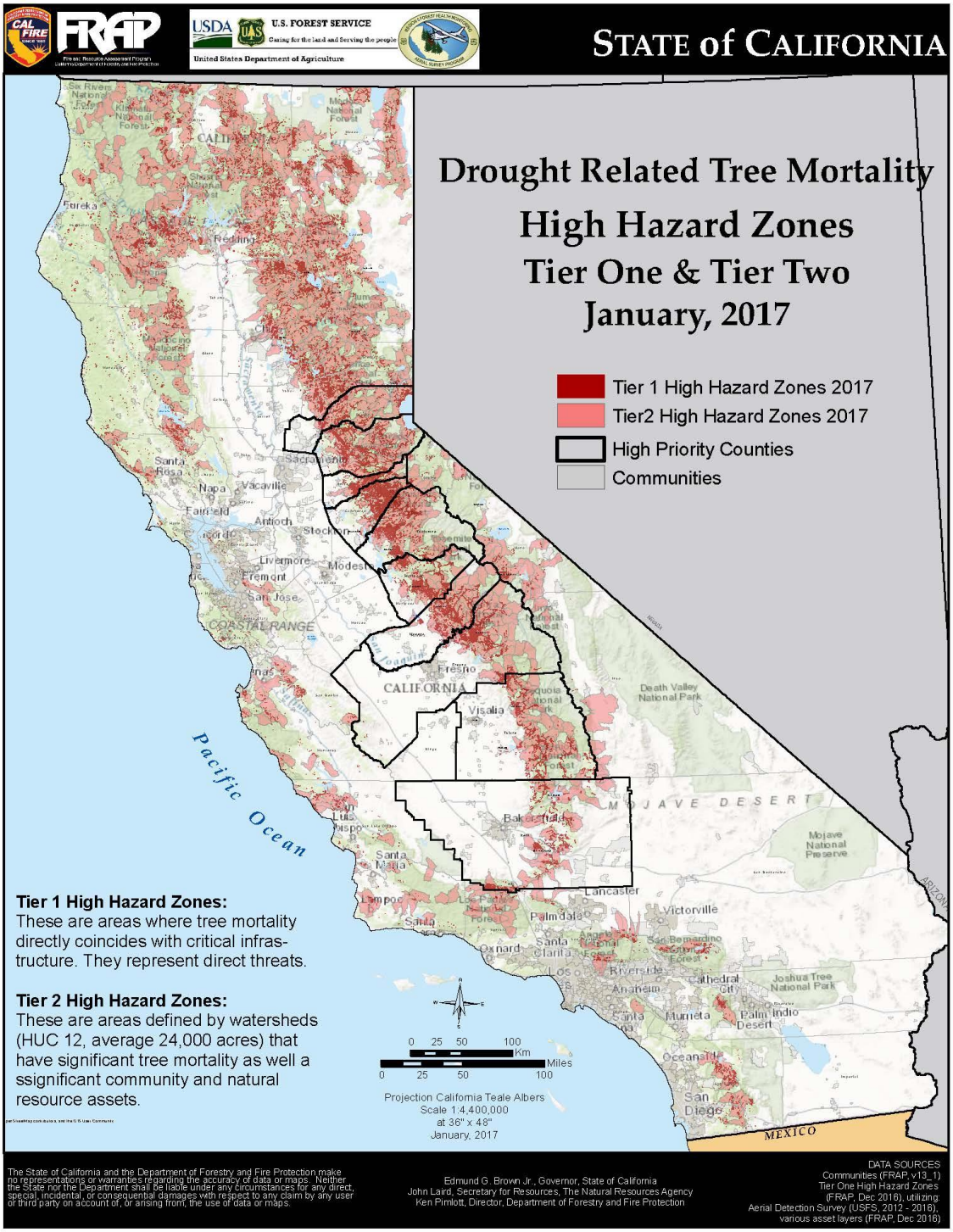
Specifically, the report found that households reported that drought negatively affected their property (40.1 percent) and finances (19.7 percent), and that 62.4 percent of households had dead or dying trees on their property. Almost two-thirds of these households (63.6 percent) have had the dead or dying trees felled, with the cost of felling trees ranging from $0 to $60,000. Of the households that felled trees, 38.1 percent reported no cost, 23.2 percent spent $100 to $999, 14.6 percent spent $1,000 to $4,999, and 8.3 percent spent $5,000 or more.[306]

Assessment of Local Vulnerability and Potential Losses

CAL FIRE identified the following counties as high hazard zones: Amador, Calaveras, El Dorado, Fresno, Kern, Madera, Mariposa, Placer, Tulare, and Tuolumne. Tree mortality threatens forest health, infrastructure, and public safety, and increases risk of wildfire, regardless of the region. For more information on local vulnerability and potential losses, see the jurisdictions' hazard mitigation plan and/or tree removal plan.

[305] USDA, https://www.fs.fed.us/psw/topics/tree_mortality/index.shtml
[306] https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/CDPH%20Document%20Library/Mariposa%202016%20CASPER%20report.pdf

Map 9.U: Tree Mortality (per acre) and High Hazard Zones



Map 9.U identifies tree mortality around the state with the highest concentrations occurring in the central Sierra Nevada range. This map can be downloaded from the Tree Mortality Task Force web page: http://www.fire.ca.gov/treetaskforce/downloads/HighHazardZones_Tier1_Tier2_8x11.pdf

Current Tree Mortality Hazard Mitigation Efforts

Forest Management Task Force (formerly named the Tree Mortality Task Force)

In October 2015, Governor Brown issued an Emergency Proclamation that supplemented his January 17, 2014 Executive Order; the Emergency Proclamation addressed tree mortality and established the Tree Mortality Task Force. The Task Force is comprised of more than 80 state and federal agencies, local governments, utilities, and other stakeholders working together to address public safety hazards associated with epidemic levels of tree mortality driven by California's fifth year of drought. All high-hazard counties have their own disaster declarations and task forces as well.

The objectives of the Tree Mortality Task Force are the following:

- Provide for public health and safety of persons and property in identified high hazard zones.
- Ensure efforts associated with implementation of the directives contained in the Governor's Emergency Proclamation remain coordinated.
- Ensure continuous communication among state, federal, and local governments, as well as with other non-governmental organizations assigned to the task force.
- Provide consistent and coordinated messaging between task force member agencies and the public.
- Manage projects and programs in a financially responsible and efficient manner.

Since its inception, the Tree Mortality Task Force has made significant progress on the 19 directives set forth in the Governor's Executive Order. The progress made on each directive is summarized in Table 9.Q.

Table 9.Q: Progress of Tree Mortality Task Force Directives, through June 2018

Executive Order Directive	Progress
1. The California Department of Forestry and Fire Protection (CAL FIRE), the California Natural Resources Agency, Caltrans, and the California Energy Commission will identify areas of the state that represent high-hazard zones for wildfire and falling trees.	A tree mortality map viewer is now available on the Tree Mortality Task Force website and will be updated as mortality expands.
2. State agencies, utilities, and local governments will undertake efforts to remove dead or dying trees in these high hazard zones that threaten power lines, roads, other evacuation corridors and critical infrastructure.	Ongoing.
3. CAL FIRE shall identify potential storage locations for removed trees across impacted areas in partnership with federal agencies and local jurisdictions.	Completed, and will be updated as mortality expands.
4. Caltrans will seek emergency federal funding to clear hazard trees that threaten state highways and roads.	Completed.
5. The Department of General Services will identify state facilities and Caltrans shall identify highway and road corridors where woodchips produced from dead trees can be used as mulch.	Completed.
6. State agencies will make available portable equipment such as large volume masticators, chippers, and portable sawmills in high hazard zones to aid local entities in tree removal efforts.	Completed.
7. The California Air Resources Board and CAL FIRE shall work together with federal land managers and the U.S. Environmental Protection Agency to expand the practice of prescribed burns and increase the number of allowable days on a temporary basis to burn tree waste that has been removed in high hazard zones.	Completed.
8. The California Public Utilities Commission (CPUC) will utilize its authority to extend contracts on existing forest bioenergy facilities receiving feedstock from high hazard zones.	Completed.

Executive Order Directive	Progress
9. The CPUC will increase capacity for forest biomass generation by expediting actions for qualifying facilities in two of its biomass-oriented programs, BioMat and ReMAT.	Partially completed.
10. The CPUC will work to reduce delays between utilities and facilities in reaching agreement on interconnection terms for new and expanded biomass energy facilities.	Ongoing.
11. The California Energy Commission will prioritize grant funding from the Electric Program Investment Charge for woody biomass-to-energy technology development and deployment, consistent with direction from the CPUC.	Ongoing.
12. CAL FIRE, the California Energy Commission, and other appropriate agencies will work with land managers to estimate biomass feedstock availability, storage locations, and volumes that may be available for use as bioenergy feedstock at existing and new facilities	Partially completed.
13. CAL FIRE and the California Energy Commission will work with bioenergy facilities that accept forest biomass from high-hazard zones to identify potential funds to help offset higher feedstock costs.	Partially completed.
14. Cal Recycle and CAL FIRE will work with affected counties and existing wood products markets to determine feasibility of expanded wood products markets in California.	Ongoing.
15. For purposes of carrying out Directives 1, 2, and 5 through 8, Division 13 (commencing with Section 21000) of the Public Resources Code and regulations adopted pursuant to that division are hereby suspended	Completed, with updates as needed.
16. In order to ensure that equipment and services necessary for emergency response can be procured quickly, state contracts, including, but not limited to, advertising and competitive bidding requirements, are hereby suspended as necessary	Completed.
17. For purposes of this Proclamation, Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of the Government Code is suspended for the development and adoption of regulations or guidelines needed to carry out the provisions in this Order.	Completed, with updates as needed.
18. The Office of Emergency Services shall provide local government assistance as appropriate under the authority of the California Disaster Assistance Act, and California Code of Regulations.	Ongoing.
19. State agencies shall actively monitor tree removal efforts directed by this Proclamation to assess their effectiveness in protecting forest health and strengthening forest resilience.	Ongoing.

Source: CAL FIRE Tree Mortality Task Force, Two Year Review and Status of Executive Order Directives 2015-2017, http://www.fire.ca.gov/treetaskforce/downloads/TMTFMaterials/Factsheet_TMTF2yearreview111317FINAL.pdf

In response to Governor Brown's 2015 Emergency Proclamation, an Incident Action Plan was developed by the Task Force. The Incident Action Plan identifies areas of the state that represent high hazard zones for wildfire and falling trees associated with elevated tree mortality and a corresponding threat to public safety, community assets, and related infrastructure. Guidelines were developed to assist in the implementation of dead and dying tree removal in high hazard zones underscoring the legal and regulatory basis for the project.

In 2018, the Tree Mortality Task Force was absorbed into the Forest Management Task Force as its own working group. The Forest Management Task Force objectives expand the Tree Mortality Task Force efforts to support the broader goals of the 2018 Forest Carbon Plan. The Forest Management Task Force, which is a cooperative effort between state, federal, and local governments, will respond to the overarching need for better management of California's forests and forested watersheds.

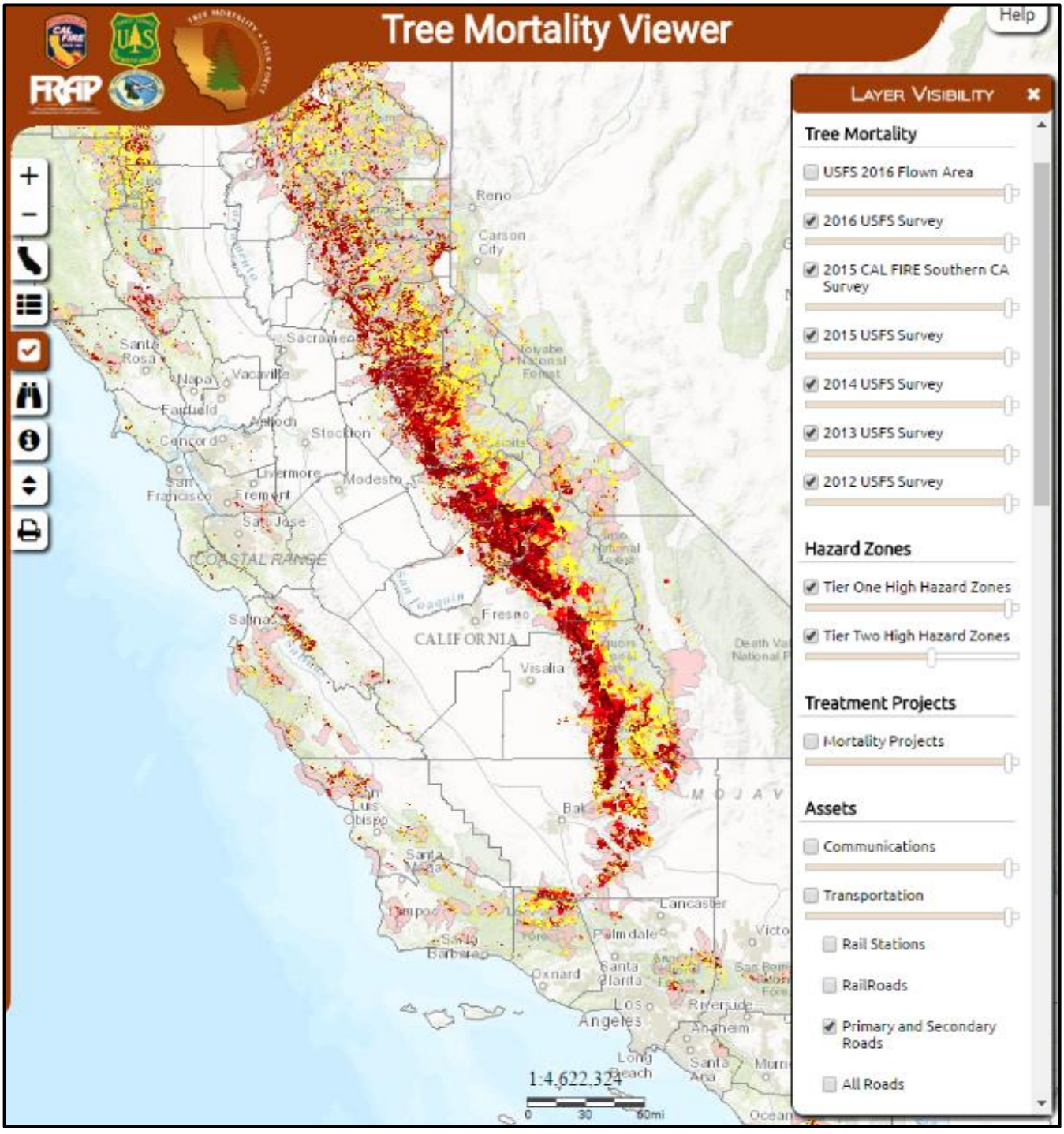
The new Task Force will continue efforts on tree mortality, but will also focus on carrying out the directives contained in the Governor's Executive Order B-52-18, including promoting forest health and vegetation reduction, streamlining permitting for forest health and fuel reduction activities on private property, and promoting use of forest products.

Tree Mortality Map Viewer

Tree Mortality Task Force Directive 1 resulted in the creation of the Tree Mortality Map Viewer, which allows individuals and agencies to view and export a variety of spatial information related to tree mortality. Some of the available data layers are recorded tree mortality, hazard zones, tree removal projects, utility lines, recreational facilities, and fire threat levels. The Tree Mortality Viewer is maintained by the CAL FIRE "Fire and Resource Assessment Program" (FRAP), the U.S. Forest Service, and the Tree Mortality Task Force.

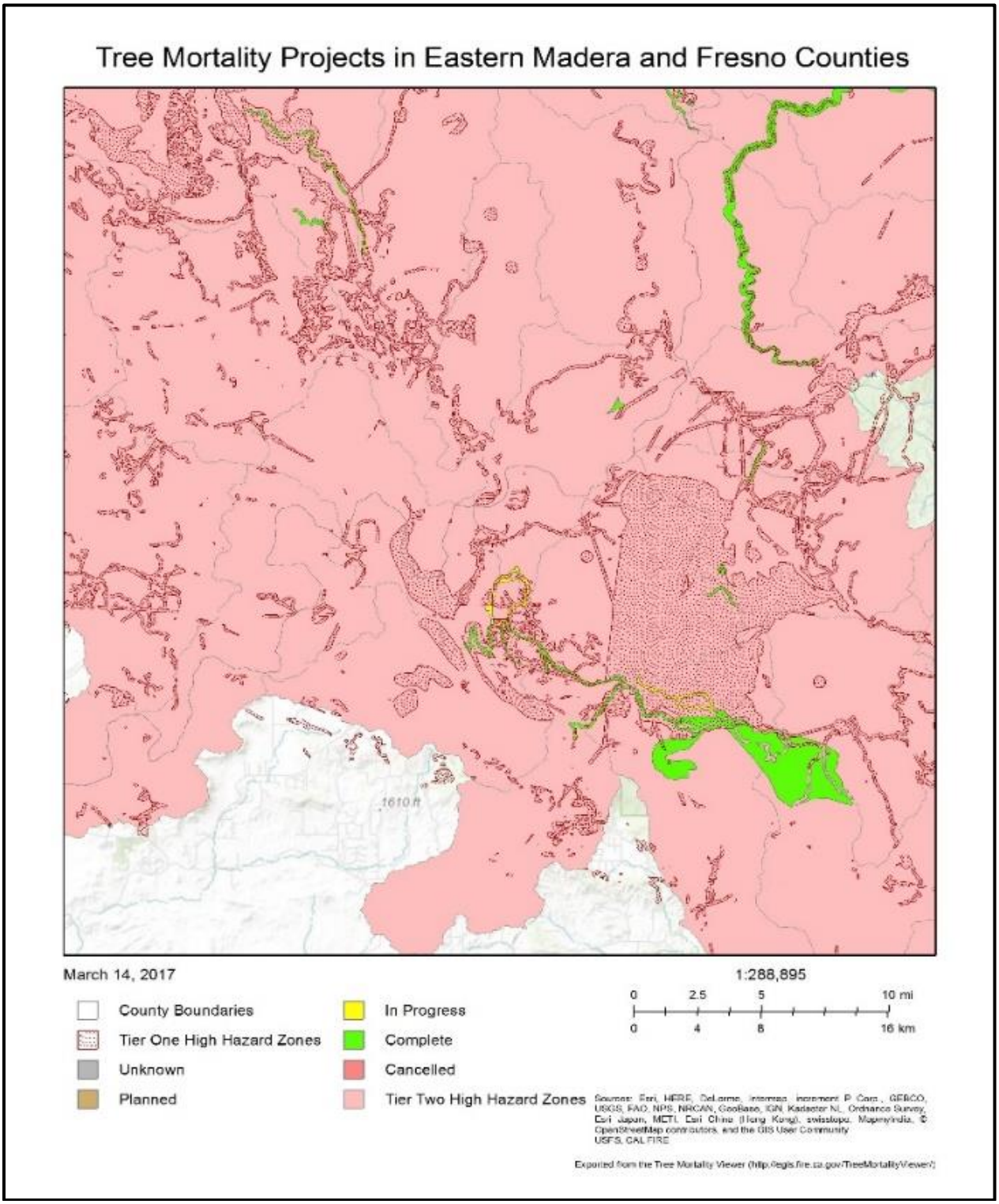
The tree mortality layer consists of results of annual 2012-2016 aerial tree mortality surveys. The map viewer also includes a layer identifying locations of state and local assets. The Tree Mortality, Assets, and Hazard Zones are updated periodically based on local review and the availability of new data.

Map 9.V: Screen Shot of Tree Mortality Viewer



Map 9.V illustrates how the map viewer can be used to watch the worsening progression of tree die-off from 2012 to 2016. To access the viewer, visit: http://www.fire.ca.gov/treetaskforce/

Map 9.W: Tree Mortality Viewer Example of Map Export



Map 9.W is an example of the map views available from the viewer. As shown in Map 9.W, the viewer includes a layer with treatment projects related to the removal of dead trees. This layer is updated every other month with submitted projects. For more information about the Tree Mortality Task Force or to use the tree mortality viewer, go to: http://www.fire.ca.gov/treetaskforce/.

Executive Order B-52-18 Addressing Tree Mortality and Wildfire

In the face of the worst wildfires in California's history, Governor Brown issued an Executive Order on May 10, 2018 to combat dangerous tree mortality, increase the ability of forests to capture carbon, and systematically improve forest management. The issuance of Executive Order B-52-18 coincides with the release of the California Forest Carbon Plan prepared jointly by CAL FIRE, the California Environmental Protection Agency (Cal EPA), and the California Natural Resources Agency (CNRA). The plan's intent is to provide a detailed implementation plan for the forest carbon goals embodied in the California Air Resources Board (CARB) 2030 Target Scoping Plan Update, which outlines strategies to achieve the 2020 greenhouse gas emissions reduction goals.

Key elements of the Executive Order include:

- Doubling the land actively managed through vegetation thinning, controlled fires and reforestation from 250,000 acres to 500,000 acres.
- Launching new training and certification programs to help promote forest health through prescribed burning.
- Boosting education and outreach to landowners on the most effective ways to reduce vegetation and other forest-fire fuel sources on private lands.
- Streamlining permitting for landowner-initiated projects that improve forest health and reduce forest-fire fuels on their properties.
- Supporting the innovative use of forest products by the building industry.
- Expanding grants, training, and other incentives to improve watersheds.

Executive Order B-52-18 will improve the health of the state's forests and help mitigate the threat and impacts of deadly and destructive wildfires, which hinder the state's progress toward its climate goals. Forests serve as the state's largest land-based carbon sink, drawing carbon from the atmosphere and storing it in trees and shrubs and in forest soils. But even a single wildfire can immediately cancel all those benefits.[307]

To support implementation of Executive Order B-52-18 and the Forest Carbon Plan, a Forest Management Task Force will be convened, and $96 million is allocated to these efforts in the Governor's May 2018 budget revision. For more information about the California Forest Carbon Plan: Managing our Forest Landscapes in a Changing Climate, visit: http://fire.ca.gov/fcat/.

US Forest Service Activities

In addition, the U.S. Forest Service is undertaking the following actions to address tree mortality:

- Removing hazardous trees near communities, along roads and power lines, and in recreation sites.
- Re-assessing areas for new hazards as tree mortality continues.
- Compiling a toolbox of tools and resources for federal, private, and state landowners and managers to assist in managing affected areas and support decision-making on the best course forward.
- Providing public education via a number of media (both print and electronic) and acting as a key participant in the Governor's Tree Mortality Task Force.
- Assessing California's wood processing capacity and helping to develop biomass energy markets that are responsive to changing needs.
- Reducing tree density and restoring resilience against forest pests and wildfires.

Caltrans Tree Mortality Program

As part of its participation in the Tree Mortality Task Force, Caltrans is identifying dead and dying hazardous trees that could affect the safety of the traveling public along highways and marking trees for removal. The 2017 Incident Action Plan of the Tree Mortality Task Force identified ten high hazard zones (in the counties of Kern, Tulare, Fresno, Madera, Mariposa, Tuolumne, Calaveras, Amador, Placer, and El Dorado), where tree mortality directly coincides with critical infrastructure. The Tree Removal Program is underway in counties in high hazard areas in Northern and Central California.

[307] https://www.gov.ca.gov/2018/05/10/governor-brown-issues-executive-order-to-protect-communities-from-wildfire-climate-impacts/

Since marked trees along highways may be on federal, state, county, or private property, Caltrans is in the process of obtaining written permission from all affected landowners to perform tree removal work. As part of this effort, Caltrans has mailed "permission to enter" forms to land owners and established an electronic "permission to enter" process online.

Caltrans has created a website that provides project maps, regulatory background, and public outreach information: http://www.dot.ca.gov/treemortality/.

CAL FIRE State Responsibility Area Fire Prevention Fund and Tree Mortality Grant Program

CAL FIRE awarded over $15 million in grants under the State Responsibility Area Fire Prevention Fee (SRAFPF) and Tree Mortality Grant Program for 2016 to 2017. Local entities receiving the grants include local governments, fire districts, community services districts, water districts, and special districts with State Responsibility Areas (SRAs) within their jurisdiction, along with local conservation corps, Fire Safe Councils, and other non-profit organizations. The grants support local efforts to remove dead and dying trees that pose a threat to public health and safety and projects that reduce the wildfire threat to habitable structures within SRAs.

Fire Safe Council Risk Reduction Activities Grants

The California Fire Safe Council selected 21 local projects in at-risk communities for the 2017 Grants Clearinghouse State Fire Assistance Program. These projects received $2.1 million in federal grant funds to support wildfire risk reduction activities and hazardous fuels reduction projects, including removal of dead and dying trees.

9.2 SOCIOTECHNICAL/TECHNOLOGICAL HAZARDS

Sociotechnical or technological hazards are events caused by either human error in controlling technology or a malfunction of a technology system.

9.2.1 HAZARDOUS MATERIALS RELEASE

Identifying Hazards Due to Release of Hazardous Materials

A hazardous material is defined in California's State Hazardous Materials Incident Contingency Plan (1991) as "a substance or combination of substances which, because of quantity, concentration, physical, chemical, or infectious characteristics may: cause, or significantly contribute to an increase in deaths or serious illnesses; and/or pose a substantial present or potential hazard to humans or the environment."[308] Hazardous materials are one or more of the following: flammable, corrosive or an irritant, oxidizing, explosive, toxic (poisonous or infectious), thermally unstable or reactive, or radioactive. See *Section 9.2.4* for discussion of radiological accidents.

Hazardous materials are ubiquitous in modern society and may be found at all stages of production, consumption, and disposal. Federal and state laws permit the intentional release of some hazardous materials into the environment, typically in quantities, in a form, and/or in locations such that the risk to human health and the environment is thought to be acceptable. However, sometimes releases are unintentional, resulting from leaks, accidents, or natural hazards. This section focuses on accidental or unintentional releases. Deliberate sabotage or terrorism are not covered here; see instead *Section 9.3.1, Terrorism*.

During the past two decades or so, increasing attention has been given to hazardous materials releases resulting from natural disasters. The term "natech" (an abbreviation for "natural disaster that triggers a technological accident") is generally used to refer to such releases. As pointed out by various authors including Lindell and Perry (1996), Young, Balluz, and Malilay (2004), and Steinburg, Sengul, and Cruz (2008), natechs are of particular concern because:

- They may have a simultaneous effect on many industrial facilities, overwhelming the capacity for response.
- Mitigation measures may fail (e.g., an outer containment system constructed to contain a release from within may itself be damaged so badly that it allows the hazardous material to escape).
- There may be cascading disasters, resulting in a "domino effect" (e.g., a fire in one facility may cause an explosion in a neighboring facility, which in turn damages a third facility, and so on).
- Response personnel typically focus on search and rescue first and give attention to the presence of hazardous materials only secondarily, if at all.
- Response may be hindered by a disaster's impact on the physical environment (e.g., roadways may be cut or blocked; power lines and communication towers may be toppled).
- Determining the appropriate response may be difficult (e.g., it may not be obvious whether, following an earthquake, people should shelter in place for protection against a chemical release or be evacuated to avoid being harmed by aftershocks).

Profiling Hazardous Materials Release and Toxic Substance Hazards

Accidental hazardous materials releases occur many times during any given day. Most incidents are minor, but some do cause significant impacts such as injuries, evacuation, and the need for cleanup.

For example, in Roseville, California, on April 28, 1973, a railroad accident focused national attention on the hazards of munitions involved in fires. A hot brake shoe ignited the oak-wood floor of a Department of Defense boxcar carrying 250-pound bombs filled with Tritonal (TNT/aluminum). The bombs were being transported from the Naval

[308] Note that the term "toxic substance" is sometimes used interchangeably with "hazardous material." However, toxicity is only one of many characteristics that may cause a material to be hazardous. In this section, the more general term "hazardous material" will be used except where reference to toxicity in particular is intended.

Ammunition Depot in Hawthorne, Nevada, to the ship load-out port facility at the Naval Weapons Station in Concord, California. The train had just entered the yard in Roseville when a fire was observed coming from one of the boxcars. The fire department was summoned but, before they could act, a large explosion demolished a boxcar and spread the fire. Over a period of approximately 32 hours, 18 boxcars exploded in succession. The railroad yard was essentially destroyed.

Fortunately, no one was killed; however, later local newspaper reports suggest that about 100 people were injured. There was about $24 million in property damage to the railroad yard and the surroundings. The litigation that followed lasted for several years and cost the government millions of dollars.

For more information about the Roseville explosion, see: http://www.oesnews.com/month-cal-oes-history-1973-railroad-explosion/.

More recently, on August 6, 2012, following a leak and the subsequent ignition of diesel fuel, a series of explosions and fires occurred at Chevron's refinery in Richmond, California. Thousands of East Bay residents were ordered to stay in their homes (shelter in place) with the windows and doors closed. Fortunately, there were no fatalities, but one refinery worker suffered burns to his wrist and was treated at the onsite clinic.

Much of the knowledge about the occurrence and impacts of natechs is anecdotal, although information has been reported with greater regularity in recent years, especially in relation to events involving earthquakes and tsunamis. Precise data can be difficult to obtain, as company managers may be reluctant to divulge the nature and extent of releases. Table 9.R lists examples of what has been reported by various authors.

While not related to natechs, a recent release of methane gas in Aliso Canyon, California illustrates the vulnerabilities of gas storage and risk to residential areas.

Table 9.R: Examples of Hazardous Materials Releases Triggered by Natural Disasters

Date	Location	Disaster	Reported Releases of Hazardous Materials	Citation(s)
1964	Alaska	Earthquake (magnitude 9.2) and tsunamis	Standard Oil Company's storage tanks toppled; break in hose connections to tanker loading diesel fuel; fire; rail cars exploded; Texaco bulk oil storage yard ignited.	Lindell and Perry, 1996
1971	San Fernando	Earthquake (magnitude 6.6)	100 natural gas leaks responded to by fire departments; one-third caused fires; also 18 hazardous materials leaks, 12 of which caused fires.	Perkins and Wyatt, 1990; Lindell and Perry, 1996
1983	Coalinga	Earthquake (magnitude 6.7)	Many natural gas line breaks; at least nine hazardous materials releases, including a spill of strong acids and bases at a community college; one caused a fire.	Ibid.
1987	Whittier Narrows	Earthquake (magnitude 6.1)	1,411 natural gas line breaks, 3 of which caused fires; 30 hazardous materials releases.	Ibid.
1989	Loma Prieta	Earthquake (magnitude 6.7)	Hundreds of natural gas leaks; over 300 releases of hazardous materials, including asbestos.	Ibid.

Date	Location	Disaster	Reported Releases of Hazardous Materials	Citation(s)
1994	Northridge	Earthquake (magnitude 6.8)	More than 15,000 natural gas leaks; over 200 fires; hazardous materials problems at 134 locations; 60 incidents requiring offsite hazardous materials response; fires and hazardous materials releases at California State University (CSU) Northridge science laboratory complex.	Lindell and Perry, 1996; Lindell and Perry, 1997
1999	Kocaeli, Turkey	Earthquake (magnitude 7.4)	Eight percent of facilities handling hazardous materials suffered earthquake-triggered releases of hazardous materials.	Cruz and Steinberg, 2005
2002	Czech Republic	Floods	Release of over 400 kilograms of chlorine from Spolana Chemical Works Company at Neratovice, north of Prague.	European Commission, 2002; Cruz and Okada, 2008
2004	Sumatra, Indonesia	Earthquake (magnitude 9.1) and tsunami	Leakage of 8,000 cubic meters of oil from Pertamina oil depot in Banda Aceh.	UNEP, 2005; Cruz and Okada, 2008
2008	Sichuan (Wenchuan), China	Earthquake (magnitude 8.0)	Leaks of ammonia, sulphuric acid, and other substances; also fires and explosions.	Krausmann, Cruz, and Affeltranger, 2010
2011	Tohoku, Japan	Earthquake (magnitude 9.0) and tsunami	Extensive damage to facilities handling hazardous materials; several documented major fires, explosions, spills.	Krausmann and Cruz, 2013
2012	East Coast, United States	Superstorm Sandy (80 to 90 mile-per-hour winds and sea-levels more than 14 feet above normal)	Diesel spill at the Motiva Refinery in Sewarren, New Jersey; biodiesel spill at the Kinder Morgan terminal in Carteret, New Jersey; fuel oil spill at the Phillips 66 Refinery in Linden, New Jersey; and smaller spills throughout New Jersey and New York.	National Oceanic and Atmospheric Administration (NOAA)– Office of Response and Restoration, 2012
2013	Estancia, Philippines	Super Typhoon Haiyan (Yolanda)	850,000 liters of bunker oil leaked onto coastline near Estancia after tanker pushed ashore during typhoon. 1,042 families at risk.	World Health Organization, 2013

Source: Multiple sources listed in "References" Appendix P.

Public Health Concerns Related to Hazardous Materials Releases

Hazardous materials released during and following industrial accidents and natural disasters pose risks to first responders, the impacted community, and the environment. While many of these incidents may be of a localized nature, they can cause both short- and long-term health and environmental impacts. Recent California examples include the 2016 Aliso Canyon methane gas leak, which caused evacuation of nearby residents, many of whom experienced temporary health problems such as difficulty breathing and eye irritation; and the 2016 Fruitland metal recycle plant fire in Maywood, which released heavy metals such as lead, magnesium, copper, aluminum, antimony, calcium, iron, sulfur, tin, potassium, and zinc. Other chemicals including bromine and chlorine were also released during the Maywood fire. Health effects from exposure to these metals included short-term symptoms such as irritation to the eyes, nose, throat, and lungs. This incident prompted a notice regarding "Health Related Information for First Responders and Workers" to be issued jointly by the U.S. EPA and Los Angeles County, including the county public health and county fire departments.

Implications of Hazardous Materials Releases Resulting from Primary Hazard Events

Natural disasters, including earthquake, flood, and fire also pose risks to public health and the environment. For example, following the Northridge Earthquake, California State University (CSU) Northridge laboratories and chemical storage rooms experienced multiple chemical spills. Such incidents, triggered by a natural disaster, pose a significant risk to students, faculty, staff, and first responders. Any educational institution with a science lab might be at risk for a chemical spill leading to adverse health outcomes.

In a severe flood event, floodwaters are often contaminated with hazardous materials posing a threat to public and animal health, groundwater, and other parts of the environment. These hazardous materials may be released from damaged or flooded underground tank sites (e.g., gas stations or chemical storage facilities), propane tanks, manure or human waste handling facilities, fertilizer and pesticide storage, agricultural sites, and household hazardous waste.

Following the October 2017 Northern California firestorms, which destroyed approximately 6,000 residences and burned entire neighborhoods to the ground, public health concerns delayed the initial steps of fire recovery, including reopening burned areas to residents and initiating debris removal activities. As part of the daily fire briefings held in Sonoma and Napa Counties, residents were advised of the public health issues related to post-fire cleanup, specifically the dangers of coming into contact with toxic substances due to the presence of synthetic and hazardous materials. In Sonoma County, the Public Health Officer and Environmental Health Director issued a local health emergency proclamation for debris removal. A "toxic sweep" managed by CalEPA identified and removed hazardous materials from all burned residential properties.

Employers performing cleanup and other work in areas damaged or destroyed by fire are required to identify and evaluate these hazards, correct any unhealthful conditions and provide training to employees. For worker safety and health during fire cleanup, information provided by California Division of Safety and Health includes guidelines related to:

- Safety hazards (fire and fire byproducts, electricity, flammable gases, unstable structures, demolition, sharp or flying objects, excavations)
- Health hazards (carbon monoxide ash, soot and dust; asbestos; hazardous liquids; other hazardous substances; heat illness)
- Confinement hazards

Details can be found at http://www.dir.ca.gov/dosh/wildfire/Worker-Health-and-Safety-During-Fire-Cleanup.html.

Assessment of State Vulnerability and Potential Losses

There is no comprehensive statewide vulnerability assessment available at this time. Validated historical data on which to base a model of vulnerability and potential losses from natechs (for example) are scarce, although a PC-compatible diskette of nearly 400 hazardous materials problems in 32 past earthquakes, including over 150 problems

from the Loma Prieta Earthquake, was made available in 1990 by the Association of Bay Area Governments (ABAG). It is likely that many such hazardous materials releases have received little attention in the past because public authorities, the media, and the public have overlooked them in the rush to address and recover from immediate disaster threats.[309] Furthermore, responsible parties may have an incentive to understate the extent of releases or not to report them at all.

With regard to earthquakes, as pointed out by Lindell and Perry (1997), historically there appears to have been no correlation between earthquake magnitude and the number of earthquake-triggered hazardous materials releases reported. Such releases depend not only on event magnitude but also on soil conditions, the number and structural characteristics of hazardous materials facilities in the area, and the seismic resistance of building contents. Lindell and Perry point out that "the Northridge experience establishes that (releases) may occur even when structural damage is minimal or absent, which indicates that chemical containment systems are more fragile than the buildings in which they are housed."

Assessment of Local Vulnerability and Potential Losses

Information related to vulnerability and loss assessments for California communities may be found in Local Hazard Mitigation Plans.

Current Hazardous Materials Release and Toxic Substance Mitigation Efforts

Many federal and state laws regulate hazardous materials in terrestrial, aquatic, and atmospheric environments. At the federal level, these laws include (as amended) the Clean Air Act; the Occupational Safety and Health Act; the Clean Water Act; the Hazardous Materials Transportation Act; the Resource Conservation and Recovery Act; the Toxic Substances Control Act; the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund); and others. Brief descriptions of some of the most relevant federal and state legislative and regulatory provisions are provided below.

Emergency Planning and Community Right-to-Know Act

Title III of the federal Superfund Amendments and Reauthorization Act, also known as the Emergency Planning and Community Right-to-Know Act (EPCRA), was established to encourage and support emergency planning efforts at the state and local levels and to provide the public and local governments with information concerning potential chemical hazards present in their communities in the wake of the Bhopal Disaster in India in 1984. The 2013 explosion of a fertilizer plant in West Texas that killed 15 people (including 12 first responders), injured 100s, and demolished buildings within a five-block radius, serves as a reminder of the importance of EPCRA. There was a lack of knowledge within the first responder community and among the nearest neighbors about what was being stored at the West Texas facility. The U.S. Chemical Safety and Hazard Investigation Board investigation report can be found at: http://www.csb.gov/file.aspx?DocumentId=732.

The law requires facilities to furnish information about the quantities and health effects of chemicals that they use and to promptly notify local and state officials whenever a significant release of hazardous materials occurs. Broadly representative Local Emergency Planning Committees (LEPCs) have been appointed for each of six Emergency Planning Districts, which have the same boundaries as the Mutual Aid Regions. There is one LEPC for each of the more than 3,000 designated local emergency planning districts. Membership of these committees, at a minimum, must include elected officials; emergency services professionals; environment, transportation, and hospital officials; facility representatives; and representatives from community groups and the media.

In carrying out the community right-to-know requirements of EPCRA, the committees provide a forum for emergency management agencies, responders, industry and the public to work together to evaluate, understand, receive training on, coordinate, and communicate chemical hazards in the community and develop regional hazardous materials emergency plans. Local plans, developed with stakeholder participation, are reviewed annually and provide information about chemicals in the community to citizens, government agencies, and emergency

[309] Breslin, 1993; Young, Balluz, and Malilay, 2004

responders. For more information on LEPCs, visit: https://www.epa.gov/epcra/local-emergency-planning-committees and http://www.caloes.ca.gov/FireRescueSite/Pages/Local-Emergency-Planning-Committee.aspx.

California's Unified Program

California law established the Unified Program, which consolidates, coordinates, and makes consistent the administrative requirements, permits, inspections, and enforcement activities of the following environmental and emergency response programs: the Aboveground Petroleum Storage Act (APSA) Program, Area Plans for Hazardous Materials Emergencies, the California Accidental Release Prevention (CalARP) Program, the Hazardous Materials Release Response Plans and Inventories (Business Plans), Hazardous Material Management Plan (HMMP) and Hazardous Material Inventory Statement (HMIS) requirements (California Fire Code), the Hazardous Waste Generator and Onsite Hazardous Waste Treatment (tiered permitting) Programs, and the Underground Storage Tank Program.

The state agencies responsible for these programs include the California Environmental Protection Agency (CalEPA), the Department of Toxic Substances Control (DTSC), the California Governor's Office of Emergency Services (Cal OES), the CAL FIRE Office of the State Fire Marshal, and the State Water Resources Control Board. These agencies set the standards for their programs while local governments implement and enforce the standards. CalEPA oversees the implementation of the Unified Program as a whole (California Code of Regulations, Title 27, Division I, Subdivision 4, Chapter 1, Sections 15100-15620).

The Unified Program is implemented at the local level by government agencies certified by the Secretary of CalEPA. These Certified Unified Program Agencies (CUPAs) have typically been established as a function of a local environmental health or fire department. Some CUPAs also have contractual agreements with one or more other local agencies, "participating agencies" (PAs) that implement one or more program elements under the oversight of the CUPA. Members of the California CUPA Forum, a partnership between CUPAs and PAs, have established the Unified Program Administration Advisory Group (UPAAG). The UPAAG addresses policy decisions, education, and problem solving. The goals and objectives of the UPAAG are listed in the UPAAG Strategic Plan, available on the CalEPA web page: http://calepa.ca.gov/cupa/about/.

At the state level, Hazardous Materials Business Plans/Emergency Response Plans (California Health and Safety Code, Chapter 6.95) seek to prevent or minimize the damage to public health and safety and the environment from a release or threatened release of hazardous materials and to satisfy community right-to-know laws. This is accomplished by requiring businesses that handle hazardous materials in quantities equal to or greater than 55 gallons, 500 pounds, or 200 cubic feet of gas or extremely hazardous substances above the threshold planning quantity (40 Code of Federal Regulations [CFR], Part 355, Appendix A) to:

- Inventory their hazardous materials;
- Develop an emergency plan; and
- Implement a training program for employees.

Most hazardous materials facilities in the state are regulated by a Hazardous Materials Business Plan. The state contains many such the Cal OES Hazardous Materials Business Plan program, visit: http://www.caloes.ca.gov/cal-oes-divisions/fire-rescue/hazardous-materials/hazmat-business-plan.

Map 9.X shows locations of certified hazardous material teams in California.

Map 9.X: Certified Hazardous Materials Teams in California

California Accidental Release Prevention (CalARP) Program

The California Accidental Release Prevention (CalARP) Program is intended to prevent accidental releases of substances that can cause serious harm to the public and the environment, to minimize the damage if releases do occur, and to satisfy community right-to-know laws. This is accomplished by requiring businesses that handle more than a threshold quantity of a regulated substance listed in the regulations to develop a Risk Management Plan (RMP). An owner or operation or a stationary source that has more than a threshold quantity of a regulated substance (listed in Tables 1-3 of Title 19 Section 2770.5) in a process may have to complete and submit an RMP. An RMP is a detailed engineering analysis of the potential accident factors present at a business and the mitigation measures that can be implemented to reduce this accident potential. The RMP may address:

- Regulated substances held onsite at the stationary source
- Offsite consequences of an accidental release of a regulated substance
- The accident history at the stationary source
- The emergency response program for the stationary source
- Coordination with local emergency responders
- Hazard review or process hazard analysis
- Operating procedures at the stationary source
- Training of the stationary source's personnel
- Maintenance and mechanical integrity of the stationary sources physical plant
- Accident investigation

Various mitigation efforts relating to the transport of hazardous materials are required and implemented as the result of federal and state regulations. The CalARP Program ensures that businesses carry out mitigations required by federal and state regulations for transport of hazardous materials, including the following:

- Placards and labeling of containers
- Proper container established for material type
- Random inspections of transporters
- Safe-handling policies and procedures
- Hazard communications
- Training for handlers
- Permitting
- Transportation flow studies (e.g., restricting the transportation of hazardous materials over certain routes)

California's Source Reduction Requirement

California's Hazardous Waste Source Reduction and Management Review Act of 1989, also known as Senate Bill 14, requires hazardous waste generators to seriously consider source reduction as the preferred method of managing hazardous waste. Source reduction is preferable to recycling and treatment options because source reduction avoids waste generation costs and management liability. Source reduction also provides the best protection for public health and the environment. Facilities generating more than 12 kilograms of hazardous waste or 12 kilograms of extremely hazardous waste are required to do source reduction planning. Hazardous waste generators subject to Senate Bill 14 are required to prepare various documents, including a Source Reduction Evaluation Review and Plan.

Additional Hazardous Materials Release and Toxic Substance Hazard Mitigation Opportunities

Mitigating Natech Risks

Steinberg, Sengul, and Cruz (2008) have identified several approaches to mitigating the risks posed by natechs. Similar approaches may be used to mitigate hazardous materials risks more generally. The identified approaches are:

- Design criteria (e.g., more stringent building codes so that structures containing hazardous materials are better protected against earthquakes and other likely hazards)
- Chemical process and facility safety measures (e.g., consideration of potential natural disaster-triggered process failures in safety management and planning for chemical processing plants, required every five years by the U.S. Occupational Health and Safety Administration – 29 CFR Section 1910.119)
- Land use planning (e.g., restriction of development in high risk areas, relocation of exposed elements, etc.)
- Local hazard mitigation planning (e.g., consideration of natechs in Local Hazard Mitigation Plans)
- Adoption of sustainable industrial processes (e.g., substitution of less hazardous raw materials and intermediate products for those that are more hazardous)

The authors acknowledge that California is ahead of many other states in the extent to which action has already been taken to address natechs and other hazardous materials releases. For example, the CalARP Program, mentioned above, specifically requires industry to analyze seismic events in the hazard review. Nevertheless, it is evident that much more could be done in this area.

Refinery Safety

Following the 2012 fire at Chevron's Richmond refinery, an Interagency Working Group on Refinery Safety was formed, composed of 13 state agencies and departments and the Governor's office. The working group met over eight months to examine ways to improve public and worker safety through enhanced oversight of refineries, and to strengthen emergency preparedness in anticipation of any future incident. Regular internal meetings were informed by meetings with a wide variety of stakeholders, including those from industry, labor, community and environmental groups, academic institutions, and local emergency response units. The working group's draft report, issued in July 2013, includes an assessment of the current state of refinery safety with input from stakeholders, a study by the RAND Corporation, and findings by the Division of Occupational Safety and Health (Cal/OSHA), the U.S. Chemical Safety Board, and Chevron's own internal investigation. As of 2017, two significant regulations regarding refinery safety have been changed: 1) the California Accidental Release Prevention (CalARP) Program administered through the California Governor's Office of Emergency Services (Cal OES), and 2) the Process Safety Management (PSM) regulations administered through Cal/OSHA, within the Department of Industrial Relations (DIR). The PSM regulations are largely focused on minimizing risks to employees, and the CalARP Program is designed to protect the safety and health of the community.

Recommendations of the working group most relevant to mitigation include 1) the creation of an Interagency Refinery Task Force, housed within CalEPA, to coordinate agencies' activities and carry out the recommended actions; 2) the strengthening of existing regulations, and the development of new regulations and practices to address the underlying causes of safety problems, including but not limited to creating inherently safer systems requiring periodic assessments of safety culture, completing root-cause analysis after significant accidents or releases, and accounting for "human factors" to manage and reduce error; and 3) enhanced enforcement and increased worker involvement in improving the methods and culture of safety at refineries.

The Interagency Refinery Task Force has since been established and met for the first time in August 2013. Although initially it will address safety issues relating to refineries, members have agreed that its focus should subsequently be expanded to other high risk facilities, including but not limited to those covered by the CalARP Program.

Other Opportunities

There are many other opportunities for enhanced mitigation of hazardous materials releases in California. Increased research into the potential risks associated with various hazardous materials, coupled with greater public awareness, may lead to additional regulatory requirements and personal choices regarding the use of certain chemicals and other substances identified as potentially harmful themselves or manufactured from (or using) other materials that are hazardous.

Product designers often have opportunities to minimize impacts on human health and the environment long before products reach the marketplace. California's proposed Safer Consumer Products Regulation, nearing adoption at the time of this writing, would create a predictable process for reducing toxic ingredients in products. In its simplest terms, the regulation would require manufacturers whose consumer product contains a toxic ingredient to ask: "Is this ingredient necessary? Is there a safer alternative? Is that alternative ingredient feasible?" In addition, by listing the chemicals that the State of California will be examining in consumer products, the regulation would give manufacturers the opportunity to "design out" the use of those chemicals ahead of time.

9.2.2 OIL SPILLS

Identifying Oil Spill Hazards

An oil spill is a release of liquid petroleum into the environment due to human activity that results in pollution of land, water, and air. Oil releases also occur naturally through oil seeps either on land or under water. Oil spills can result from the release of crude oil from offshore oil platforms, drilling rigs, wells, pipelines, tank trucks, and marine tank vessels (tankers). Refined petroleum products such as gasoline, diesel, and heavier fuels such as bunker fuel used by cargo ships are also sources of potential oil spill releases. According to NOAA, oil spills can be caused by people making mistakes or being careless, by equipment breaking down, by natural disasters, and by deliberate acts of terrorism, vandals, or illegal dumpers.[310]

During and oil spill, the oil floats on saltwater and often floats on freshwater. Depending on the type of oil, oil can sink in freshwater but usually, oil spreads out across a large area and is called an oil slick. As the oil slick spreads and convers a larger area, it becomes thinner and is called an oil sheen.[311] Depending on the origin, size, and duration of the release, an oil spill can have serious impacts on air and water quality, public health, plant and animal habitat, and biological resources. Spill clean-up and remediation activities may cost millions of dollars and impacts can last for years. The California Department of Fish and Wildlife Office of Spill Prevention and Response (OSPR) (Oiled Wildlife Division) treats countless thousands of oiled birds and other wildlife annually. Oil slicks and spills (as well as naturally occurring oil plumes) have a devastating impact on wildlife. Together with University of California Davis, the OSPR operates the Oiled Wildlife Care Network, which works to identify wildlife impacts and wildlife response needs.[312]

In 2014, OSPR's mission was expanded by Governor Brown to cover all state surface water at risk to oil spills from any source. These sources may include pipelines, production facilities, and shipments of oil transported by railroads.[313] The mission of the OSPR is to provide best achievable protection of California's natural resources by preventing, preparing for, and responding to spills of oil and other deleterious materials, and by restoring and enhancing affected resources. OSPR staff participated in Deepwater Horizon oil spill among many others. For more information about the OSPR, visit: http://www.dfg.ca.gov/ospr/.

The environmental impacts of oil spills contribute to short- and long-term effects on economic activities in the affected areas. Moratoriums may be temporarily imposed on fisheries, and tourism may decline in beach communities, resulting in economic hardship on individuals dependent on those industries for their livelihood and on the economic health of the community as well.

Profiling Oil Spill Hazards

The complex array of petroleum-related industries and distribution networks throughout California makes the majority of the state vulnerable to oil spills. As of early 2018, there are 26 production platforms, 1 processing platform, and 6 artificial oil and gas production islands located in the waters offshore of California. Of the 27 platforms, 4 are located in state waters offshore of Santa Barbara and Orange Counties, and 23 are located in federal waters offshore of Santa Barbara, Ventura, and Los Angeles Counties. There are 31 marine terminals in state waters and numerous land-based oil production, transportation, and storage facilities. In 2017, it was announced that that Platform Holly, located offshore of Santa Barbara County, will be dismantled and will be the first to be removed in over 20 years, leaving 26 offshore oil platforms remaining offshore of California (source). An executive order issued by President Trump in April 2017 mandates the United States Secretary of the Interior and cabinet members to review federal rules and regulations regarding offshore oil drilling. This action could open areas off the coast of California to drilling, increasing the oil spill risk.

[310] https://response.restoration.noaa.gov/training-and-education/education-students-and-teachers/how-do-spills-happen.html
[311] https://response.restoration.noaa.gov/training-and-education/education-students-and-teachers/how-do-spills-happen.html
[312] https://www.wildlife.ca.gov/OSPR/About
[313] https://www.wildlife.ca.gov/OSPR/About

The platforms and artificial islands off California each have multiple wells, the number of which varies from fewer than 10 to more than 50. The amount of oil produced by each structure varies from a few hundred to more than 20,000 barrels per day. According to the California Division of Oil, Gas, and Geothermal Resources (DOGGR), a total of 28 counties in California produce oil, and offshore oil production accounts for 16.3 percent of the state's total production.[314]

Platforms in federal waters are regulated by the U.S. Department of the Interior's Minerals Management Service (MMS). Facilities located in state waters less than 3 nautical miles from shore are regulated by the California State Lands Commission and the DOGGR, which under the jurisdiction of the California Department of Conservation. As of 2017, the DOGGR was updating its Renewal Plan for Oil and Gas Regulation. The first Renewal Plan was released in 2015, and the update will highlight the DOGGR's progress in the regulatory overhaul of California's oil and gas industry. More information on the Renewal Plan can be found at: http://www.conservation.ca.gov/dog/Documents/renewal-plan2017-onesheet.pdf.

A report prepared by the now dissolved U.S. Department of the Interior MMS in 2003 states that "based on the amount of offshore oil expected to be produced in California over the next 28 years and the number of spills that have occurred in the past, the risk of a spill of 1,000 bbl (oil barrel unit) or greater occurring during that period is estimated at 41.2 percent for federal operations and 8.4 percent for state operations."

Under the Lempert-Keene-Seastrand Oil Spill Prevention and Response Act, the State Lands Commission exercises oversight for the prevention of oil spills from offshore oil platforms and onshore and offshore marine oil terminals. At these marine facilities, large oceangoing tank vessels and smaller barges transfer oil between shore and the tank vessel. Due to numerous interfaces and interactions, there is great propensity for human-caused oil spills, fire, and/or explosion. Government Code Section 8670.28 requires the operator of each marine facility to conduct hazard and operability studies to identify hazards associated with operations of the facility, due to operating error (organizational factors), equipment failure, and external events like natech (a natural disaster that triggers a technological accident). These studies form the basis for permitted operations of oil production, handling, transportation, and preparedness for contingencies.

The DOGGR maintains data sets on the number, location, owner/operator, lease, and other characteristics of oil and gas wells. As of 2017, the data catalog has information on nearly 190,000 oil, geothermal, and gas wells in California.

The following is a discussion of historic oil spills that have either occurred in California or have contributed to environmental legislation and regulatory requirements for the oil industry. A summary of significant oil spills is included in Table 9.S at the end of this section.

Kern County

Known as the Lakeville Gusher, this incident involved an oil well that blew out on March 15, 1910. The oil well was being drilled at 2,440 feet below the surface in Kern County between the towns of Taft and Maricopa. The well was drilled into a high-pressure oil-bearing zone. The uncontained oil blew much of the steel casing out of the well and resulted in an estimated 9 million barrels of crude oil pouring from the ground. This was considered the largest documented oil spill in history and has only recently been surpassed by the Deepwater Horizon Oil Spill in the Gulf of Mexico.

To mitigate the spread of oil, workers circled the well with sandbags and built an earthen dam 20 feet high and 50 feet thick in the canyon mouths above the well to prevent flash flooding from further dispersing the oil. The well ultimately caved in and sealed itself on September 9, 1911, nearly 18 months after it blew. The site is designated as California Historical Landmark Number 485.

[314] http://www.conservation.ca.gov/dog/Pages/statistics.aspx#2004_offshore_production

Santa Barbara

In 1953, Congress enacted legislation authorizing the federal leasing of submerged Outer Continental Shelf (OCS) lands. The first lease sale was conducted in 1966 and resulted in the installation of the first platform in federal waters offshore of Santa Barbara County in 1967. Additional lease sales were conducted the following year; in September 1968, Union Oil Platform A was installed in 188 feet of water approximately 5 miles offshore of Summerland. By January 1969, four wells had been drilled and work began on a fifth well. Union Oil asked the U.S. Geological Survey to waive various well casing requirements and the waiver was approved.

Drilling began on January 14 and continued for two weeks until January 28 when drilling was halted for evaluation and maintenance. Pressure built up in the 3,500-foot-deep well as a pipe was being extracted. A burst of natural gas blew out the drilling mud that was being pumped into the well, split the steel casing, and caused cracks to form in the sea floor surrounding the well. The large volume of oil and gas being released caused a "blowout" of the well, releasing approximately three million gallons of oil over an 11-day period. Workers pumped chemical mud down the 3,500-foot shaft at a rate of 1,500 barrels an hour. It was then topped by a cement plug. Although capped, gas continued to escape and another leak sprung up weeks later, releasing oil for several more months. Union Oil drilled a relief well and pumped cement into a leaking well bore, thereby killing it. However, small amounts of oil continue to leak from fractures in the sea floor to this day. Platform A is still in operation.

The cause of the blowout and spill was attributed to the inadequate protective casing allowed by the U.S. Geological Survey waiver. Investigators postulated that more steel pipe sheathing inside the drilling hole would have prevented the rupture.

The incident received international attention and was a major catalyst in the development of modern environmental law in the United States. The spill influenced the passage of major state and federal legislation, such as the National Environmental Policy Act (NEPA), Clean Water Act, California Environmental Quality Act (CEQA), California Coastal Initiative in 1972 (Proposition 20), and California Coastal Act of 1976. Pursuant to these and other statutes, development permits for onshore or offshore oil and gas facilities cannot be issued without provisions to protect terrestrial, marine, visual, recreational, and air resources.

Exxon Valdez

Although the 1989 Exxon Valdez oil spill in Prince William Sound, Alaska did not directly affect the California environment or economy, it is significant for several reasons. First, it highlights the interconnectivity of oil production and distribution systems. The Exxon Valdez was en route from the Alyeska Pipeline Terminal to Long Beach, California when it ran aground, rupturing 8 of the 11 cargo tanks holding crude oil. Secondly, although in size the spill is no longer listed in the top 50 international oil spills, it is still considered to be one of the largest in terms of environmental damage. Finally, because of the environmental impacts, the Exxon Valdez oil spill resulted in landmark environmental legislation and more rigorous oil industry regulations.

American Trader

On February 7, 1990, off Huntington Beach, California, the oil tanker American Trader ran over its anchor, puncturing its hull and spilling an estimated 416,598 gallons of crude oil. An estimated 3,400 birds and an unknown number of fish were killed, and recreational beach use was seriously disrupted. The biological component of the resulting litigation was settled out of court for $3.45 million for bird- and fish-related injuries, plus an additional $360,000 for water monitoring projects, while the recreational component was eventually settled, following a jury trial, for $11.6 million. For more information, visit: https://www.wildlife.ca.gov/OSPR/NRDA/american-trader.

Guadalupe Dunes

The Guadalupe Dunes oil spill typifies another variety of oil spill that can occur in California. The Guadalupe-Nipomo Dunes, located along the southern coast of San Luis Obispo County, is one of the largest dune complexes along the California coast, measuring approximately 15,500 acres.

Oil exploration and production began in the area in the late 1940s. By 1953, Unocal Corporation was producing up to 2,000 barrels of oil per day from 34 wells. Oil field operations continued until March 1990 with gradual expansion to 215 wells producing approximately 4,500 barrels per day. Because of the highly viscous nature of the oil being extracted from the field, diluent (a diesel-like crude oil thinner) was introduced in the 1950s to assist in the production and transportation of the heavy crude. A 145-mile network of pipelines was built across the dunes to carry the diluent. Over the years, the pipelines rusted and became buried in the shifting sands, where they sprang leaks in 80 to 90 places, releasing as much as 12 million gallons of diluent into the dunes, beach, groundwater, and the Pacific Ocean.

The spill came to the attention of state officials when an oily sheen was noticed by surfers and sea lions and seals began washing up dead on the shore. On March 23, 1994, a lawsuit was filed by the California State Attorney General, the California Department of Fish and Wildlife, the California Regional Water Quality Control Board Central Coast Region, the California Department of Toxic Substances Control, and the Coastal Conservancy against Union Oil Company of California. The state plaintiffs alleged in this action that on numerous occasions since Unocal began using diluent at the Guadalupe oil fields, oil had leaked from the pipelines and storage tanks at numerous locations into the groundwater, surface water, and marine water. An agreement was reached between the parties in July 1998, for $43,800,000, of which $9 million was allocated for dune restoration activities. Six state and federal agencies now oversee the cleanup activities. Unocal has dismantled and removed the pipelines, storage tanks, and other infrastructure related to the oil field operations.

Cosco Busan

This San Francisco oil spill occurred on November 7, 2007, as a result of a container ship, the M/V Cosco Busan, striking the fender surrounding a footing of the western span of the San Francisco Bay Bridge. The collision caused no substantial damage to the bridge and the ship hull ruptured, causing medium-grade fuel oil to leak from its tank. Unlike oil tankers, container and cargo ships are not required to have double hulls, a regulation that was adopted following the Exxon Valdez oil spill discussed earlier.

Numerous local jurisdictions border the bayfront coastline and were affected by the oil spill. Local proclamations were issued by the counties of Alameda, Contra Costa, Marin, San Francisco, San Mateo, Solano, and Sonoma; the cities of Albany, Berkeley, and Oakland; and the East Bay Regional Park District. The Governor's proclamation covered the City and County of San Francisco and the counties of Alameda, Contra Costa, Marin, San Mateo, Solano, and Sonoma. The incident period for the event closed nearly one year following the oil spill on October 31, 2008.

Numerous state and federal agencies were involved in the oil spill response, cleanup, and subsequent investigations, including the United States Coast Guard (USCG), California Department of Fish and Wildlife Office of Oil Spill Prevention and Response (OSPR), and California Environmental Protection Agency (CalEPA) Office of Environmental Health Hazard Assessment (OEHHA). The 226 identified affected shoreline sites were ranked based on spill specifics such as the location of the release, nature of the release, volume of the release, and other established criteria. (For details on the oil spill response organization and activities, please see the Cosco Busan San Francisco Bay Area Oil Spill After Action/Corrective Action Report published by the California Emergency Management Agency, now Cal OES.)

Two new response and cleanup initiatives were developed as a result of this oil spill: the Department of Fish and Wildlife developed Shoreline Cleanup and Assessment Techniques (SCAT) teams to oversee beach and shoreline cleanup, and, OSPR has taken a lead role in expanding its convergent volunteer program to include opportunities outside of wildlife rehabilitation.

Gulf of Mexico

The Deepwater Horizon oil spill occurred in the Gulf of Mexico on April 20, 2010, as a result of an explosion that killed 11 platform workers and injured 17 others. It is the largest offshore marine oil spill in United States history. After releasing approximately 4.9 million barrels of crude oil, the leak was stopped by capping the wellhead. The spill caused extensive damage to marine and wildlife habitats as well as the Gulf's fishing and tourism industries.

While a six-month moratorium on offshore drilling was imposed after the explosion, the moratorium was lifted shortly thereafter by the United States District Court. Investigations into the causes of the explosion and spill were conducted by the United States Coast Guard (USCG), Minerals Management Service (MMS), National Academy of Engineering, National Commission on the BP Deepwater Oil Spill and Offshore Drilling, United States House Committee on Energy and Commerce, and others.

Table 9.S: Summary of California and Other Significant Oil Spills

Spill	Date	Area Affected	Estimated Amount	Wildlife Impacts (including estimated deaths)	Estimated Costs
Lakeville Gusher - Kern County	May 14, 1910–September 1911	Not available	378,000,000 gallons (9,000,000 barrels)	Unknown	Unknown
Santa Barbara	January 28, 1969–February 8, 1969	35 miles mainland coastline;800-square mile slick	3,000,000 gallons (102,620 barrels)	3,600 birds, seals, dolphins, fish, intertidal invertebrates	$17 million in lawsuit settlements for property damage
Exxon Valdez	March 24, 1989	1,300 miles of shoreline	11,000,000 gallons (257,000 barrels)	250,000 seabirds, 2,800 sea otters, 300 harbor seals, 250 bald eagles,33 killer whales, billions of salmon and herring eggs	$2.1 billion for clean-up by Exxon
American Trader	February 7, 1990	About 13 miles of coastline plus offshore area	416,598 gallons	3,400 birds; fish	$3.45 million settlement for bird and fish-related injuries; $360,000 for water monitoring projects; $11.6 million for recreational damage
Guadalupe Oil Field - San Luis Obispo	1950s–1994	2,700 acres	9,000,000-12,000,000 gallons (212,570 barrels)	Soil and water contamination; impacts on dune habitat, wetlands, groundwater, intertidal habitat	$44 million in penalties to Unocal, including $9 million for restoration
Cosco Busan - San Francisco Bay	November 7, 2007	200 miles of coastline	58,000 gallons (1,375 barrels)	2,225 birds, seals, herring eggs	$2.1 million for ship damage, $1.5 million for bridge damage, $70 million for cleanup
Deepwater Horizon - Gulf of Mexico	April 20, 2010–July 15, 2010	2,500-square-mile slick	180,000,000 gallons (4,900,000 barrels)	4,642 birds, 540 sea turtles, 75 mammals, (as of August 22, 2010)	To be determined; $20 billion response fund established by BP
Refugio Oil Spill – Plains All America Pipeline	May 19, 2015	Approximately 7 miles of coastline	123,000 gallons	202 birds, primarily brown pelican, common murre, and Pacific loon; 99 mammals, primarily California sea lion	$150 million in cleanup cost

Source: Multiple sources listed in "References" Appendix P.

Refugio

On May 19, 2015, a 24-inch subterranean pipeline owned and operated by Plains All America Pipeline ruptured on the Gaviota Coast, west of Refugio State Park. Much of the crude oil spilled ran down a storm drain and into a ravine under the freeway and entered the ocean. The size of the spill ranged from 100,000 to 140,000 gallons, covering the Santa Barbara County coastline and extending nearly 9 miles out into the ocean. Various agencies, including local, county, state, and federal partners, were involved in response and recovery efforts, with the participation of approximately 1,300 field and 325 incident command post personnel. Notifications from the county to state and federal partners were aligned with the Santa Barbara Operational Area Oil Spill Contingency Plan and Los Angeles-Long Beach Area Contingency Plan. The incident command post remained operational for the first 13 days of the incident.

Interagency field teams conducted a National Resource Damage Assessment to document dead fish, invertebrates, and other wildlife in the oiled areas following the spill. NOAA and its state and federal natural resource co-trustees investigated the extent to which the incident may have caused harm to birds (brown pelicans, common murres, Pacific loons, snowy plovers), marine mammals (including California sea lions), fish (especially surf perch and grunion), and marine invertebrates along with their habitats. The spill also shut down fisheries, closed multiple beaches, and affected recreational uses such as camping, non-commercial fishing, and beach visits.

Nearly one year after the spill, Plains All America Pipeline was indicted by the Santa Barbara County grand jury on 46 criminal counts related to the spill, after which the county filed criminal charges. Another three years elapsed before the trial date was set for February 5, 2018, with jury selection beginning in April 2018. The outcome of the trial will not be known for several months.

Three bills were signed into law in response to the spill. Under a new law, the California Fire Marshal will be required to review the oil pipelines conditions every year, while federal regulations only mandate a review every five years. Another new law provides for making oil spill response times faster and more effective. The third will force intrastate pipelines to use the best-known technology such as automatic shut-off valves.

Assessment of State Vulnerability and Potential Loss to Oil Spill Hazards

In his testimony to the U.S. House of Representatives Natural Resources Committee on May 27, 2010, California Congressman John Garamendi stated that the coastal environment of California provides $22 billion in annual economic activity and employs 369,000 people. According to the California Ocean Protection Council (OPC), California's ocean economy is valued at more than $40 billion per year and supports a multi-billion-dollar tourist industry. This is in addition to the immeasurable wealth and value that are difficult to quantify relative to the coastal environmental assets, including land, water, wildlife, and habitat. While even a catastrophic oil spill such as the recent Deepwater Horizon explosion and spill in the Gulf of Mexico would affect only a portion of these economical and aesthetic assets, the potential impacts could be sizeable and long-lasting.

Current Oil Spill Hazard Mitigation Efforts

The 1969 oil spill off the coast of Santa Barbara was a pivotal event in the history of offshore oil safety. Since 1969, a number of preventive measures have been initiated, including stringent regulations covering OCS operational and environmental safety, a rigorous MMS inspection program in the Pacific OCS Region, continuous evaluation, and improvement in OCS facilities' oil spill response, and the development of a highly organized oil spill response structure.

Following the Exxon Valdez oil spill in Alaska in 1989, both the United States and California governments enacted laws to prevent oil spills. The International Safety Management Code, enforced since 1998, requires ships entering U.S. ports to meet certain standards, including procedures for reporting accidents and requiring qualified crew. In 1990, the U.S. enacted the Oil Pollution Act, which requires that oil tankers be double-hulled and that existing single-hull tankers be phased out (see: https://www.epa.gov/laws-regulations/summary-oil-pollution-act). A double hull further protects a ship from damage to its cargo tank, reducing the risk of oil spilling during an accident. California

enacted the Lempert-Keene Seastrand Oil Spill Prevention and Response Act in 1990, which established the Office of Spill Prevention and Response (OSPR) within the (now) California Department of Fish and Wildlife (see: https://www.wildlife.ca.gov/OSPR). The OSPR is authorized to direct spill response, cleanup, and natural resource damage assessment activities, as well as regulate all private vessels over 300 gross tons (672,000 pounds) that enter California ports. The act also gave oversight of all marine oil terminals in the state to the California State Lands Commission, with the mandate to protect the public health, safety, and the environment by preventing spills at these facilities.

The OSPR also is tasked with preparation of the California State Oil Spill Contingency Plan. The latest (2017) version of this plan addresses discharges of oil to all marine or inland surface waterways of California and spills on land. State and local agencies must carry out spill response activities consistent with this plan and other applicable federal, state, or local spill response plans.

Non-tanker vessels (like the container ship that spilled oil in San Francisco) have their own regulations, which are less stringent than those for tanker vessels. California requires a Non-Tank Vessel Contingency Plan and Certificate of Financial Responsibility, which means vessels must prove to the OSPR that they have a plan in case of an oil spill and that they carry an insurance policy to cover the cost of a spill. Non-tank vessels over 300 gross tons must carry $300 million of insurance, while the requirement for tanker vessels is $1 billion.

The State Lands Commission has prevention programs for exercising the oversight at all oil platforms and oil terminals under the Lempert-Keene-Seastrand Oil Spill Prevention and Response Act. Under the authority of this act, the State Lands Commission exercises oversight over the oil production operation on oil platforms and oil transfer operations between the ships and the shore. Each production activity generates its risk to the public and the environment. The State Lands Commission is charged with oversight responsibility under the act. The oversight is exercised by the Commission staff on oil production work, to ensure adequate precautions are taken by industry. This is done through a comprehensive regulatory framework of performance standards. The Commission staff periodically inspects and regularly monitors the operations at oil platforms and in marine oil terminals for conformance to performance standards.

Oil Spill Response Plans and Procedures

Local Marine Oil Spill Contingency Plans

Local Marine Oil Spill Contingency Plans are developed by local governments that have marine waters within their borders. A local government may develop or update a Local Oil Spill Contingency Plan, consistent with state policy, as a supplement to its Area Plan. Although not required, most local governments have undertaken this planning process.

Harbor Safety Plans

Harbor Safety Plans are created pursuant to California Government Code Section 8670.23.1. Harbor Safety Committees were created in each of the major active port areas in the state to address oil spill prevention issues in those regions. The plans created by the committees are designed to ensure safe navigation and operation of vessels within each harbor. The California Department of Fish and Wildlife Office of Spill Prevention and Response (OSPR) is charged for developing regulations for the plans, which are found in 14 California Code of Regulations (CCR) Section 802.

Region IX Mainland Regional Contingency Plan

The Region IX Mainland Regional Contingency Plan is designed to coordinate timely and effective responses by various federal and state agencies and other organizations to discharges of oil and releases of hazardous substances, pollutants, and contaminants to protect public health, welfare, and the environment. It is meant to ensure that the roles and responsibilities of federal, state, local, and other responders are clearly defined. The plan also describes the Regional Response Team (RRT) organization and its relationship to other contingency plans. The RRT oversees the response operations and removal and remedial actions for hazardous substances, the use of chemical countermeasures such as dispersants and surface washing agents, state-specific response information, notification

procedures, and natural resource trustee contacts. The Region IX Mainland Regional Contingency Plan is supplemented by marine area plans and inland sub-area plans, which provide detailed information on areas of environmental or special economic importance. The plan also identifies the minimum components of an Inland Area Contingency Plan that best support first responders. (See discussion of marine and inland area planning below.)

Marine Contingency Plans
Marine Contingency Plans are required by Section 311(j) of the federal Clean Water Act. They are developed and maintained by Area Committees comprised of qualified personnel of federal, state, and local agencies. Area Committees, under the direction of a Federal On-Scene Coordinator, are responsible for preparing Marine Contingency Plans as described in National Contingency Plan (NCP) Section 300.210(c). Although Area Plans are "owned" by their Area Committees, the lead federal agency for marine area plans is the United States Coast Guard (USCG) and for inland area plans it is the U.S. Environmental Protection Agency (EPA). Area Committees are also responsible for working with appropriate federal, state, and local officials to enhance the contingency planning of those officials and to assure pre-planning of joint response efforts.

In California, there are six geographical marine areas and Area Committees along the coast and three Area Contingency Plans. Each Area Committee, chaired by the USCG and co-chaired by the OSPR, is comprised of a diverse group of participants from federal, state, and local agencies with expertise in environmental and response issues, as well as industry representatives and special interest groups.

Inland Geographic Response Plans
Inland Geographic Response Plans are updated and developed by the OSPR in collaboration with other federal, state, and local government, industry, and other partners for priority inland waters of the state with high oil spill risk. Inland Geographic Response Plans are also vetted through regional Local Emergency Planning Committees (LEPCs) that are made up of industry representatives; federal, state, and local government agencies; public health agencies; tribal representatives; and other stakeholders.

The California Oil Spill Contingency Plan
The California Oil Spill Contingency Plan is the state oil spill and marine oil spill contingency plan required pursuant to California Government Code Sections 8574.1 and 8574.7. The OSPR combined the California State Oil Spill Contingency Plan and the Marine Oil Spill Contingency Plan into one plan.
The latest 2017 version is available from the OSPR website at: https://www.wildlife.ca.gov/OSPR/Contingency

National Oil, Hazardous Substances, Pollutants, and Contaminants Contingency Plan
The National Oil, Hazardous Substances, Pollutants, and Contaminants Contingency Plan (NCP) is the nation's main hazardous materials emergency response plan. It is promulgated in Title 40, CFR, Part 300. The NCP is designed to provide for efficient, coordinated, and effective action to minimize adverse impact from oil discharges and hazardous substance releases. The NCP contains the national response strategy that provides the framework for notification, communication, logistics, and responsibility for response to discharges of oil, including worst-case discharges, and discharges that pose a substantial threat to the public health or welfare of the United States. The NCP is supported by the Region IX Regional Contingency Plan and Marine and Inland Area Contingency Plans.

Industry Contingency Plans – Marine and Inland
Effective September 2015, emergency regulations governing the development of oil spill contingency plans and financial responsibility for inland facilities, pipelines, refineries, and railroads became effective. Industry members affected by the regulations had until January 2016 to submit facility contingency plans and Certificates of Financial Responsibility to ensure compliance with inland regulations.

Oil Spill Technical Advisory Committee (TAC)

The Oil Spill Technical Advisory Committee (TAC) was established to provide public input and independent judgment of the actions of the OSPR Administrator. The TAC consists of 14 appointed members, 8 of whom are appointed by

the Governor, 3 by the Speaker of the Assembly, and 3 by the Senate Rules Committee. These appointees must have experience, knowledge, and expertise in the following areas:

- Public representation
- Marine transportation
- Local government
- State government
- Petroleum industry
- Oil spill response and prevention programs
- Environmental protection and the study of ecosystems
- Dry cargo vessel
- Railroad
- Oil production

The TAC meets as often as necessary, but at least twice a year. The TAC has the following responsibilities:

- The TAC provides recommendations to the OSPR Office of the Administrator, State Lands Commission, California Coastal Commission, San Francisco Bay Conservation and Development Commission, the DOGGR, Office of the State Fire Marshal, and California Public Utilities Commission on any provision of the act, including the promulgation of rules, regulations and policies according to Government Code Section 8670.54-8670.56.1.
- The TAC may study, comment, or evaluate any aspect of oil spill prevention and response in the state, coordinated with ongoing studies by the federal government, the OSPR Administrator, State Lands Commission, State Water Resources Control Board (SWRCB), and other state and international entities.
- The TAC may attend any drills, or any oil spills pursuant to Government Code Section 8670.10
- The TAC reports biennially to the Governor and the Legislature on its evaluation of oil spill response and preparedness programs within California. It may prepare and send any additional reports it determines to be appropriate to the Governor and the Legislature.

Progress Summary 9.L: Management and Control of Risks in Marine Oil Transportation System

Progress as of 2018: Tank ships calling at California ports must comply with the International Safety Management Code (ISM Code) in accordance with the international regulations in Chapter 9 of the International Maritime Organization's Safety of Life at Sea Conventions. The ISM Code requires ship operators to ensure that tank ships comply with the international regulation. The ISM Code requires ship owners to have an effective safety management system that addresses systemic risks attributable to catastrophic oil spills, petroleum fires, and/or explosions when ships are berthed at marine terminals. In accordance with Title 2, California Code of Regulations, Section 2340(c)(19), operators of marine terminals must verify that tank ships are compliant.

The international regulations do not apply to domestic tank barges. The tank barges are now required by the United States Coast Guard to manage systemic risks and demonstrate compliance with 46 Code of Federal Regulations (CFR) Subchapter M, Parts 136-144. This federal regulation requires tank barges owners to adopt and show compliance with a Towing Vessel Safety Management System. During oil transfer, the terminal and the ship or barge must form a temporary unified system for safe conduct of oil cargo operations.

There is no equivalent regulatory requirement for shoreside marine oil terminals, where ships and barges berth to transfer petroleum products and crude oil. This is a residual risk in the maritime oil transportation system.

The 2015-2020 Strategic Plan of the California State Lands Commission (Strategy 1.5) has a goal that requires the commission staff to develop regulatory requirements for identifying systemic risks at marine oil terminals in California ports. In 2017, the safety management system is the best achievable technology for controlling and mitigating systemic risks in marine oil terminals. The Oil Companies International Marine Forum developed guidelines ("Marine Terminal Management and Self-Assessment") as an industry initiative to control systemic risks. These guidelines have a four-stage maturity model for organizational development and control of risks.

Additional Opportunities for Oil Spill Hazard Mitigation

Oil Spill Prevention – Loss of Containment

West Coast Ocean Protection Act

In response to the Deepwater Horizon oil spill in the Gulf of Mexico in 2010, Senators Barbara Boxer and Dianne Feinstein from California joined senators from Oregon and Washington to introduce a bill known as the West Coast Ocean Protection Act that would prohibit offshore oil and gas drilling off the West Coast of the United States. The bill was a companion to a House bill introduced by California Representative John Garamendi. The 2010 bills were not enacted; however, after another unsuccessful attempt in 2011, Senators Boxer and Feinstein re-introduced their bill once again in 2013. The 2013 bill was again not enacted, but Senator Feinstein re-introduced the bill once again in 2017. The bill is a companion to a House bill introduced by California Representative Jared Huffman. In 2017, the West Coast Ocean Protection Act was reintroduced in the Senate to amend the Outer Continental Shelf Lands Act to prohibit the Bureau of Ocean Energy Management from issuing a lease for exploration, development, or production of natural gas in any area of the Outer Continental Shelf, specifically in California, Oregon, or Washington. The bill has been referred to the Committee on Energy and Natural Resources. For more information, visit: https://www.congress.gov/bill/115th-congress/senate-bill/31/all-info.

The future of mitigation efforts in preventing catastrophic oil spills lies in the oil industry adopting systems safety approaches to build a culture of safety, which in turn would build organizational resilience to withstand and manage these catastrophic events. The systems safety approach balances production goals with public expectation of risk management as a result of that production. It encompasses managing the socio-technical risks at the interfaces of human beings, organization, and engineered systems. In the recommendations of the Deepwater Horizon incident of April 2010, the National Academy of Engineers and the National Research Council (Recommendation 5.5) stated that "…Industry should foster an effective safety culture through consistent training, adherence to principles of human factors, system safety, and continued measurement through leading indicators."

Removal of Structures from the Surf Zone

The surf zone along the coastline of Santa Barbara and Ventura Counties contains many hazards that are caused by the remnants of past oil and gas development and/or are the result of development along the coastline. These hazards consist of old oil pier remnants, H-beam piles, and old oil well caissons. The remnants are generally sharp, protruding spikes that can cause severe injury to the beach users. As the underlying fee owner with exclusive jurisdiction over sovereign lands of the state, the California State Lands Commission is responsible for structures located on tidal and submerged lands pursuant to Public Resources Code Section 6301 et seq. Failure to provide for public safety exposes the state to tort liability in the event of an accident involving injury or death resulting from public use of the facility. A single loss could exceed the cost of repairs. The state is aware of the hazard and the fact that failure to remediate could result in a determination of negligence. These lands are held in trust to be used for public purposes such as commerce, navigation, fishing, recreation, and environmental open space and habitat. The hazards represent derelict structures that impede these uses and pose a potential threat to public health and safety.
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9.2.3 NATURAL GAS PIPELINE HAZARDS

Identifying Natural Gas Pipeline Hazards

The United States is heavily dependent on transmission pipelines to distribute energy and fuel sources. Virtually all natural gas, which accounts for about 29 percent of energy consumed annually, is transported by transmission pipelines according to the U.S. Energy Information Administration.[315] Energy demand in the United States continues to increase. Although California is a leader in exploring and implementing alternative energy sources such as wind and solar, the expansion of traditional energy sources, such as natural gas, continues. Increased urbanization is resulting in more people living and working closer to existing gas transmission pipelines that were placed prior to government agencies adopting and implementing land use and other pipeline safety regulations.

Compounding the potential risk is the age and gradual deterioration of the gas transmission system due to natural causes. Significant failure, including pipe breaks and explosions, can result in loss of life, injury, property damage, and environmental impacts. Causes of and contributors to pipeline failures include construction errors, material defects, internal and external corrosion, operational errors, control system malfunctions, outside force damage, subsidence, and seismicity. Growth in population, urbanization, and land development near transmission pipelines, together with addition of new facilities to meet new demands, may increase the likelihood of pipeline damage due to human activity and the exposure of people and property to pipeline failures.

Profiling Natural Gas Pipeline Hazards

California's Natural Gas Pipeline System

Most of the natural gas used in California comes from out-of-state natural gas basins. It is delivered to California via the interstate natural gas pipeline system. In 2016, natural gas accounted for 49.86 percent of in-state energy generation and 36.48 percent of California's power mix. Natural gas contributed 105,992 gigawatt hours (GWh) to the state's energy mix.[316]

Natural gas transported via the interstate pipelines, and some of the California-produced natural gas, is delivered into the Pacific Gas and Electric Company (PG&E) and Southern California Gas (SoCal Gas) intrastate natural gas transmission pipeline systems (commonly referred to as California's "backbone" natural gas pipeline system). Natural gas on the utilities' backbone pipeline systems is then delivered into the local transmission and distribution pipeline systems, or to natural gas storage fields. PG&E and SoCal Gas own and operate several natural gas storage fields that are located in Northern and Southern California.[317]

Map 9.Y shows the location and ownership of the natural gas pipeline system. Many of the pipelines are located in areas with high seismic activity, crossing the San Andreas and other active faults. To view in more detail, download a PDF copy of this map at: http://www.energy.ca.gov/maps/infrastructure/Natural_Gas_Pipelines.pdf.

Generally speaking, transmission lines are large-diameter steel pipes carrying natural gas at high pressure and compressed to provide higher carrying capacity. Transmission lines are both interstate and intrastate, with the latter connecting to smaller distribution lines delivering gas directly to homes and businesses.

Data compiled by the Pipeline and Hazardous Materials Safety Administration (PHMSA) report a total of 212,621 miles of gas pipelines in California, of which 12,416 miles are classified as gas transmission lines, 161 miles are gas-gathering lines, and the majority, 200,045 miles, are for gas distribution.

[315] https://www.eia.gov/energyexplained/index.cfm?page=natural_gas_use
[316] California Energy Commission, http://www.energy.ca.gov/almanac/electricity_data/total_system_power.html
[317] California Public Utilities Commission, http://www.cpuc.ca.gov/natural_gas/

Map 9.Y: California Natural Gas Pipelines

Source: California Energy Commission, http://www.energy.ca.gov/maps/infrastructure/Natural_Gas_Pipelines.pdf

Incidents and Losses from Pipeline Accidents

Overview

PHMSA tracks significant incidents and losses as a result of pipeline accidents occurring on gas transmission lines and gas distribution lines. Significant incidents are those reported by pipeline operators with either 1) a fatality or injury requiring in-patient hospitalization, or 2) $50,000 or more in total costs, measured in 1984 dollars.

From 2013 to 2017, a total of 85 incidents were reported on California distribution lines, resulting in a total of six fatalities, seven injuries, and $53,010,856 in property damage. For that same period, a total of 43 incidents were reported on gas transmission lines, resulting in two fatalities, 15 injuries, and $28,563,740 in property damage.[318] These incidents are summarized in Table 9.T.

Table 9.T: Gas Distribution and Local Transmission Line Incidents, 2013 to 2017

Year	Number of Incidents	Fatalities	Injuries	Total Cost of Damages
Gas Distribution Lines				
2013	14	0	0	$3,490,587
2014	18	2	2	$18,683,512
2015	14	2	2	$1,546,593
2016	16	0	1	$3,061,979
2017	23	2	2	$26,228,185
Total Gas Distribution Line Incidents	***85***	***6***	***7***	**$53,010,856**
Gas Transmission Lines				
2013	6	0	0	$2,324,207
2014	13	0	0	$10,344,591
2015	9	2	15	$9,633,537
2016	6	0	0	$2,052,778
2017	9	0	1	$4,208,740
Total Gas Transmission Line Incidents	**43**	**2**	**15**	**$28,563,853**

Source: Pipeline and Hazardous Materials Safety Administration, https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages

San Bruno Gas Transmission Line Explosion

Given the extensive gas transmission and distribution systems in place in California, annual average losses of approximately $1 million may not seem of concern. However, the potential for serious damage and loss of life from a single pipeline explosion can be substantial. On September 9, 2010, a 30-inch steel natural gas transmission pipeline owned and operated by PG&E ruptured and exploded in a residential neighborhood in San Bruno, California. The rupture produced a crater about 72 feet long by 26 feet wide. The section of pipe that ruptured, which was about 28 feet long and weighed about 3,000 pounds, was found 100 feet south of the crater. PG&E estimated that 47.6 million standard cubic feet of natural gas was released. The released natural gas ignited, resulting in a fire that destroyed 38 homes and damaged 70. There were eight confirmed deaths and 66 reported injuries. Cal OES has identified preliminary damage estimates at $15.4 million, including $2.5 million for debris removal, $10.2 million for protective measures, $2.1 million for roads and bridges, and $0.6 million for utilities and other facilities.

A report issued by the National Transportation Safety Board (NTSB) in August 2011 determined that the probable cause of the accident was PG&E's 1) inadequate quality assurance and quality control in 1956 during its Line 132 relocation project, which allowed the installation of a substandard and poorly welded pipe section with a visible seam weld flaw that over time grew to a critical size, causing the pipeline to rupture during a pressure increase stemming from poorly planned electrical work at the Milpitas Terminal; and 2) an inadequate pipeline integrity management program, which failed to detect and repair or remove the defective pipe section.

[318] Pipeline and Hazardous Materials Safety Administration, https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages, Data retrieved March 6, 2018

Contributing to the accident were the California Public Utilities Commission (CPUC) and the U.S. Department of Transportation (US DOT) exemptions of existing pipelines from the regulatory requirement for pressure testing, which likely would have detected the installation defects. Also contributing to the accident was the CPUC's failure to detect the inadequacies of PG&E's pipeline integrity management program. Contributing to the severity of the accident were the lack of either automatic shutoff valves or remote control valves on the line and PG&E's flawed emergency response procedures and delay in isolating the rupture to stop the flow of gas.

The NTSB report included a series of recommended actions to be undertaken by federal and state government agencies and PG&E. These recommendations and resulting legislation are discussed in subsequent sections.

Assessment of State Vulnerability and Potential Losses

No comprehensive statewide seismic hazard vulnerability inventory for pipeline networks exists in California. However, it can be logically assumed that any state facility in close proximity to a natural gas transmission pipeline is at risk. This risk is heightened if the facility is also located in an area of high seismicity, where multiple gas line failures and resulting fires can be expected.[319]

In 2017, the California Energy Commission's Climate Change Center conducted research assessing the state's natural gas pipeline vulnerability to climate change and hazards resulting from climate change. The study used modeling to assess the potential for damage to California's natural gas transmission system by inundation that may occur as a result of sea-level rise. The CEC assessment report is available at: http://www.energy.ca.gov/2017publications/CEC-500-2017-008/CEC-500-2017-008.pdf.

Assessment of Local Vulnerability and Potential Losses

Individual Local Hazard Mitigation Plans may include information on pipeline vulnerability pertinent to their communities, if this information is known. Earthquake planning scenarios produced by the California Geological Survey and others are the best source of information on potential disruptions, length of outages, and estimates of post-earthquake fire. For a discussion of vulnerability of gas and other pipelines to earthquake, see *Chapter 6, Section 6.1.4.2* under the heading "Pipeline Networks – Oil and Natural Gas."

Specific information on pipeline vulnerability is maintained by owners/operators such as PG&E and SoCal Gas. This information is not always readily available to local government planners. PG&E monitors system status in real time on a 24-hour basis and regularly conducts leak inspections, surveys, and patrols of all its natural gas transmission pipelines to identify issues to be addressed immediately. PG&E also uses the data it collects to help plan and set priorities for future work. One of the tools PG&E uses is a risk management program that inventories and evaluates each of the 20,000 segments within PG&E's natural gas transmission pipeline system. A pipeline segment may be identified for further study and long-range planning based on any of the following factors:

- Potential for third-party damage
- Potential for corrosion
- Potential for ground movement
- Physical design and characteristics
- Overall, did not score high in any one factor, but scored moderately high in more than one factor

PG&E also considers proximity to high-density populations, potential reliability impacts, and environmentally sensitive areas. Based on these factors, PG&E determines which segments warrant further evaluation, monitoring, or other future action. PG&E also creates a list of the "Top 100" segments to help inform future work plans. As conditions change from year to year, PG&E reevaluates the segments included on the list.[320]

[319] NTSB Number: PAR-11-01
[320] Gas Transmission Pipeline Long Range Planning http://www.pge.com/myhome/customerservice/response/pipelineplanning/

As a result of the 2010 San Bruno gas pipeline explosion, PG&E has launched a website application with an interactive map that individuals can use to learn more about the gas pipelines in their neighborhoods. The website can be found at: https://www.pge.com/en_US/safety/how-the-system-works/natural-gas-system-overview/gas-transmission-pipeline/gas-transmission-pipelines.page.

Current Gas Pipeline Hazard Mitigation Efforts

Mitigation for gas pipelines is accomplished primarily through federal regulation and safety standards. The federal government establishes minimum pipeline safety standards under 44 CFR, Title 49 "Transportation," Parts 190-199. The Office of Pipeline Safety (OPS), within the U.S. Department of Transportation (US DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA), has overall regulatory responsibility for hazardous liquid and gas pipelines under its jurisdiction in the United States. The Natural Gas Pipeline Safety Act of 1968 as amended (NGPSA) authorizes US DOT to regulate pipeline transportation of natural (flammable, toxic, or corrosive) gas and other gases.

State and Federal Regulatory Activities

In 2015, PHMSA and FEMA released a new hazard mitigation guidance document titled "Hazard Mitigation Planning: Practices for Land Use Planning and Development Near Pipelines." This document outlines best practices to reduce risk from pipeline incidents, including those caused by natural hazards. This document is available through the FEMA website at: https://www.fema.gov/media-library-data/1422297186422-e43ce828d6821027c258e96eae10fd6d/PIPA_Hazard_Mitigation_Primer_Final.pdf.

Through certification by OPS, the State of California regulates and inspects facilities and enforces intrastate gas and liquid pipeline safety requirements. By signed agreement with OPS, the State of California also enforces interstate liquid pipeline safety requirements. The California Office of the State Fire Marshal (OSFM) performs this work. State of California regulations can be found at: http://osfm.fire.ca.gov/pipeline/pipeline.

The California Public Utilities Commission (CPUC) regulates natural gas utility service for approximately 10.7 million customers that receive natural gas from PG&E, SoCal Gas, San Diego Gas & Electric (SDG&E), Southwest Gas, and several smaller natural gas utilities. The CPUC also regulates independent storage operators Lodi Gas Storage and Wild Goose Storage. The CPUC regulates the California utilities' natural gas rates and natural gas services, including in-state transportation over the utilities' transmission and distribution pipeline systems, storage, procurement, metering, and billing. The CPUC has regulatory jurisdiction over utility-owned natural gas pipelines, which transported 82 percent of the total amount of natural gas delivered to California's gas consumers in 2012.[321]

Operator compliance with state and federal pipeline safety regulations is monitored through a comprehensive inspection and enforcement program. The program is comprised of field inspections of operations, maintenance, and construction activities; programmatic inspections of operator procedures, processes, and records; incident investigations and corrective actions; and direct dialogue with operator management.

The OSFM and CPUC work in partnership with the federal Pipeline and Hazardous Materials Safety Administration (PHMSA) to assure pipeline operators are meeting requirements for safe, reliable, and environmentally sound operation of their facilities. Data on probable violations discovered and compliance actions taken are reported annually by the state to PHMSA. Information on enforcement actions taken by PHMSA is available at the Pipeline Safety Enforcement Program homepage: http://primis.phmsa.dot.gov/comm/reports/enforce/Enforcement.html?nocache=7044.

OPS is authorized to reimburse a state agency up to 80 percent of the actual cost for carrying out its pipeline safety program, including the cost of personnel and equipment. The actual amount of federal reimbursement depends upon the availability of appropriated funds and state program performance. OPS also provides grant funding to state partners to improve communication among excavators and owners of underground facilities. The PIPES Act of

[321] California Public Utilities Commission http://www.cpuc.ca.gov/natural_gas/

2006 also authorizes grants to state authorities, designated by the Governor, to create or augment effective state damage-prevention programs. For more information, go to Grants to States for One-Call and Damage Prevention.

Guidance for Local Land Use Planning

To reduce risk to public safety posed by natural gas transmission lines, local governments rely on zoning ordinances and control of easements. To better understand issues related to land use planning, PHMSA, in conjunction with the Federal Energy Regulatory Commission (FERC), sponsored a comprehensive study of land use practices, zoning ordinances, and preservation of environmental resources on transmission pipeline rights-of-way.

In an October 2004 report, the Transportation Research Board (TRB) recommended that PHMSA "develop risk-informed land use guidance for application by stakeholders." In response, the Pipelines and Informed Planning Alliance (PIPA), representing a wide spectrum of stakeholders, developed recommended practices related to protecting communities and pipelines. Approximately 130 stakeholder participants undertook the work to develop the PIPA recommended practices.

The final report, "Partnering to Further Enhance Pipeline Safety In Communities Through Risk-Informed Land Use Planning," was released in November 2010. The report includes recommended practices for local governments, property developers and owners, transmission pipeline operators, and real estate boards to be aware of and to implement as appropriate. PHMSA plans to continue working with stakeholders to ensure that a sound implementation strategy is developed and that the PIPA recommended practices are communicated to and understood by those that need to adopt them.

Lessons learned from implementation of these practices are expected to lead to improvement and expansion of the practices. The most current version of this information will be available on PHMSA's Pipeline Safety Stakeholder Communications website.

Gas Pipeline Safety Laws

Three gas pipeline safety bills were introduced into the California legislature as a result of the 2010 San Bruno gas pipeline explosion. On September 23, 2010, all three were signed into law by Governor Jerry Brown. A brief description of each bill is outlined below. Full text of the laws can be found at: http://leginfo.legislature.ca.gov/.

AB 578 (2010)
This bill requires the California Public Utilities Commission (CPUC) to adopt gas pipeline safety recommendations made by the National Transportation Safety Board (NTSB). If the CPUC opts not to adopt the standards, it must submit reasons for that decision in writing.

AB 861 (2010)
This bill prohibits a public utility from either cutting spending on operations and maintenance or increasing rates to recover expenses that were used to pay executive bonuses.

AB 1546 (2010)
This bill requires the CPUC to adopt performance metrics for pipeline safety and evaluate the state's gas utilities against those metrics. The bill allows the CPUC to levy penalties on the utility for poor performance.

Gas Safety Action

The California Public Utilities Commission (CPUC) created a comprehensive, high-level, Gas Safety Action Plan to guide and promote the CPUC's shift in culture from the traditional compliance model to a regulatory structure that sets, monitors, and enforces rules for regulated utilities based on risk assessment and risk management. The Gas Safety Action Plan also tracks the CPUC's implementation of improvements responsive to recommendations made by the Independent Review Panel and the National Transportation Safety Board (NTSB) in response to the PG&E San Bruno pipeline explosion that occurred on September 9, 2010. As part of the plan, the CPUC engages in an in-depth review of its current practices and procedures to seek areas for improvement in gas pipeline safety.

The Gas Safety Action Plan categorizes the efforts of the CPUC into four basic goals that embrace the elements of the CPUC's overall mission to protect the public and utility workers from unsafe practices and events involving gas pipeline facilities in California:

1. Ensuring the safety of the existing gas system
2. Upgrading and replacing the gas system to make it safer
3. Reforming the CPUC, making safety its first priority
4. Instilling safety culture in gas operators

To accomplish these goals, the plan's focus is to:

- Proactively identify, evaluate, and mitigate risks
- Verify compliance with rules, standards, and risk mitigation measures
- Propose and litigate enforcement actions
- Develop policies and procedures to assess the safety culture of natural gas pipeline operators
- Educate operators to promote the elements of the plan
- Review and improve CPUC policies, practices, and procedures

The Gas Safety Action Plan is designed to be a living document that will drive the CPUC's overarching strategies to improve its Gas Pipeline Safety Program. This "safety action plan" concept will not be limited to the CPUC's Gas Pipeline Safety Program, as the CPUC is also in the process of developing similar plans for the Electric and Railroad Safety Programs with innovative safety measures and methods with the goal of instilling a culture that inspires the values of utility safety and reliability throughout California, and the nation.

The Natural as Safety Action Plan can be viewed at: http://www.cpuc.ca.gov/General.aspx?id=2496.

Progress Summary 9.M: Pacific Gas and Electric Pipeline Safety

Progress as of 2018: Pacific Gas and Electric Company (PG&E) validated the safe operating pressure of an additional 194 miles of natural gas transmission pipeline in 2012, through hydrostatic pressure testing and rigorous records validation. These activities were completed in areas throughout Northern and Central California as part of PG&E's Pipeline Safety Enhancement Program (PSEP) Since PSEP projects were launched in 2011, PG&E has successfully tested a total of 409 miles of gas transmission pipeline.

In late 2013, PG&E completed construction on a state-of-the-art gas control center at its new gas operations headquarters in San Ramon, California. The control center serves as a central location from which PG&E will monitor the safe and reliable operation of its 7,000 miles of transmission pipeline and 42,000 miles of smaller-diameter distribution mains, enabling PG&E to more quickly assess and resolve gas system issues.

In 2017, PG&E developed a Gas Safety Plan that reports on the progress PG&E makes in assessing threats to energy assets, setting priorities for addressing risks, ensuring safety for employees and contractors, and resourcing the workload for future demand. The plan is available at: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Safety/Natural_Gas_Pipeline/Plans_and_Reports/2017%20Gas%20Safety%20Plan.pdf.

Additional Gas Pipeline Hazard Mitigation Opportunities

The NTSB's Pipeline Accident Report for the San Bruno gas pipeline explosion resulted in a series of recommendations to improve the nation's and California's gas pipeline safety practices. At the federal level recommendations were made to the U.S Secretary of Transportation, the Pipeline and Hazardous Materials Safety Administration, the American Gas Association (PHMSA) and the Interstate Natural Gas Association of America. Additional details regarding NTSB's recommended actions to these agencies can be found at: https://www.ntsb.gov/investigations/AccidentReports/Pages/PAR1101.aspx.

Recommendations specific to the State of California, quoted directly from the NTSB report, were as follows:

To the Governor of the State of California:

- Expeditiously evaluate the authority and ability of the pipeline safety division within the California Public Utilities Commission to effectively enforce state pipeline safety regulations, and, based on the results of this evaluation, grant the pipeline safety division within the California Public Utilities Commission the direct authority, including the assessment of fines and penalties, to correct noncompliance by state regulated pipeline operators

To the California Public Utilities Commission:

- With assistance from the Pipeline and Hazardous Materials Safety Administration, conduct a comprehensive audit of all aspects of Pacific Gas and Electric Company operations, including control room operations, emergency planning, record-keeping, performance-based risk and integrity management programs, and public awareness programs
- Require the Pacific Gas and Electric Company to correct all deficiencies identified as a result of the San Bruno, California, accident investigation, as well as any additional deficiencies identified through the comprehensive audit, and verify that all corrective actions are complete
- Develop an implementation schedule for the requirements of safety recommendations to Pacific Gas and Electric Company (PG&E) and ensure, through adequate oversight, that PG&E has aggressively and diligently searched documents and records relating to pipeline system components, such as pipe segments, valves, fittings, and weld seams, for PG&E natural gas transmission lines in class 3 and class 4 locations and class 1 and class 2 high consequence areas that have not had a maximum allowable operating pressure established through prior hydrostatic testing as outlined in safety recommendations to PG&E. These records should be traceable, verifiable, and complete; should meet your regulatory intent and requirements; and should have been considered in determining maximum allowable operating pressures for PG&E pipelines
- If such a document and records search cannot be satisfactorily completed, provide oversight to any spike and hydrostatic tests that Pacific Gas and Electric Company is required to perform
- Through appropriate and expeditious means, including posting on your website, immediately inform California intrastate natural gas transmission operators of the circumstances leading up to and the consequences of the September 9, 2010, pipeline rupture in San Bruno, California, and the National Transportation Safety Board's urgent safety recommendations to Pacific Gas and Electric Company so that pipeline operators can proactively implement corrective measures as appropriate for their pipeline systems

To the Pacific Gas and Electric Company:

- Revise your work clearance procedures to include requirements for identifying the likelihood and consequence of failure associated with the planned work and for developing contingency plans
- Establish a comprehensive emergency response procedure for responding to large-scale emergencies on transmission lines; the procedure should (1) identify a single person to assume command and designate specific duties for supervisory control and data acquisition staff and all other potentially involved company employees; (2) include the development and use of trouble-shooting protocols and checklists; and (3) include a requirement for periodic tests and/or drills to demonstrate the procedure can be effectively implemented

- Equip your supervisory control and data acquisition system with tools to assist in recognizing and pinpointing the location of leaks, including line breaks; such tools could include a real-time leak detection system and appropriately spaced flow and pressure transmitters along covered transmission lines.
- Expedite the installation of automatic shutoff valves and remote control valves on transmission lines in high consequence areas and in class 3 and 4 locations, and space them at intervals that consider the factors listed in Title 49 Code of Federal Regulations 192.935(c)
- Revise your post-accident toxicological testing program to ensure that testing is timely and complete
- Assess every aspect of your integrity management program, paying particular attention to the areas identified in this investigation, and implement a revised program that includes, at a minimum, (1) a revised risk model to reflect the Pacific Gas and Electric Company's actual recent experience data on leaks, failures, and incidents; (2) consideration of all defect and leak data for the life of each pipeline, including its construction, in risk analysis for similar or related segments to ensure that all applicable threats are adequately addressed; (3) a revised risk analysis methodology to ensure that assessment methods are selected for each pipeline segment that address all applicable integrity threats, with particular emphasis on design/material and construction threats; and (4) an improved self-assessment that adequately measures whether the program is effectively assessing and evaluating the integrity of each covered pipeline segment
- Conduct threat assessments using the revised risk analysis methodology incorporated in your integrity management program, as recommended in safety recommendations, and report the results of those assessments to the California Public Utilities Commission and the Pipeline and Hazardous Materials Safety Administration
- Develop, and incorporate into your public awareness program, written performance measurements and guidelines for evaluating the plan and for continuous program improvement
- Aggressively and diligently search for all as-built drawings, alignment sheets, and specifications, and all design, construction, inspection, testing, maintenance, and other related records, including those records in locations controlled by personnel or firms other than Pacific Gas and Electric Company, relating to pipeline system components, such as pipe segments, valves, fittings, and weld seams for Pacific Gas and Electric Company natural gas transmission lines in class 3 and class 4 locations and class 1 and class 2 high consequence areas that have not had a maximum allowable operating pressure established through prior hydrostatic testing. These records should be traceable, verifiable, and complete.
- Use the traceable, verifiable, and complete records located by implementation of Safety Recommendation P-10-2 (Urgent) to determine the valid maximum allowable operating pressure, based on the weakest section of the pipeline or component to ensure safe operation, of Pacific Gas and Electric Company natural gas transmission lines in class 3 and class 4 locations and class 1 and class 2 high consequence areas that have not had a maximum allowable operating pressure established through prior hydrostatic testing
- If you are unable to comply with safety recommendations to accurately determine the maximum allowable operating pressure of Pacific Gas and Electric Company natural gas transmission lines in class 3 and class 4 locations and class 1 and class 2 high consequence areas that have not had a maximum allowable operating pressure established through prior hydrostatic testing, determine the maximum allowable operating pressure with a spike test followed by a hydrostatic pressure test
- Require your control room operators to notify, immediately and directly, the 911 emergency call center(s) for the communities and jurisdictions in which your transmission and/or distribution pipelines are located, when a possible rupture of any pipeline is indicated.

9.2.4 RADIOLOGICAL ACCIDENTS

This hazard risk assessment covers only accidental or unintentional radiological events. Intentional radiological/nuclear threats are discussed in the terrorism hazard risk assessment *in Section 9.3.1*.

Identifying Radiological Accident Hazards

Overview

The wide use of radioactive and nuclear material in research, education, medicine, and industry, as well as the potential for terrorism, requires all levels of government to be prepared for response, mitigation, and recovery efforts should a radiological or nuclear emergency occur.

Radioactive materials are routinely transported in California. These materials include the medical and industrial sources described below, as well as wastes that have radioactive components. Many of the radioactive waste shipments come from research and cleanup efforts at national laboratories and military bases undergoing the BRAC process. Other radioactive waste shipments are generated from the oil and gas industry.

Examples of potential radiological releases include:

- Releases or loss of control at facilities that handle radioactive materials;
- Releases during the transportation of radiological materials;
- Discovery of uncontrolled, unlicensed, or unidentified radiological materials;
- Nuclear power plant incidents; or
- Terrorist acts involving radiological or nuclear materials e.g. radiological dispersion device (RDD) or an improvised nuclear device.

Nuclear Power Plants in California

Diablo Canyon Power Plant in San Luis Obispo County is the only operating nuclear power plant in California. Pacific Gas and Electric Company (PG&E) has submitted a joint proposal to phase out nuclear power production at the plant. Under the proposal, which is pending approval by the California Public Utilities Commission (CPUC), Diablo Canyon Power Plant would be retired in 2025 at the end of its current Nuclear Regulatory Commission operating licenses, which expire in 2024 and 2025.

California is home to three decommissioning nuclear power plants: San Onofre Nuclear Generating Station in San Diego County, Humboldt Bay Power Plant in Humboldt County, and Rancho Seco Nuclear Generating Station in Sacramento County. These sites are non-operational but have spent fuel stored onsite.

The accidental or intentional release of radiological materials or radiation may threaten public health, property, and the environment.

Profiling Radiological Accident Hazards

Radiological accidents that result in the release of radioactive materials may result in long-term health risks and contamination of the state resources, including air, water supply, groundwater, and agricultural lands.

Due to strict regulation of nuclear power plants in the United States, significant nuclear power incidents that can cause harm to the public have low probability of occurrence, and none have occurred to date in California. The probability of a catastrophic event involving a nuclear power plant is low and these plants are extremely well protected. However, as evidenced by the March 2011 events at the Fukushima Daiichi plant in Japan, caused by the Tohoku Earthquake and Tsunami, the consequences of a severe accident or a successful terrorist attack on a nuclear power plant that results in a release of radioactive materials could be very significant.

State and local governments having jurisdiction within Emergency Planning Zones (EPZs) of an operating nuclear power plant in the U.S. must plan, train for, and conduct emergency exercises annually in accordance with federal regulations. Detailed emergency plans are maintained by each affected agency. Four Emergency Classification Levels (ECLs) have been established in federal regulations to characterize the severity of the emergency and the response actions required. The ECLs must be used as the foundation for emergency response planning, training, and exercises, as described in Table 9.U.

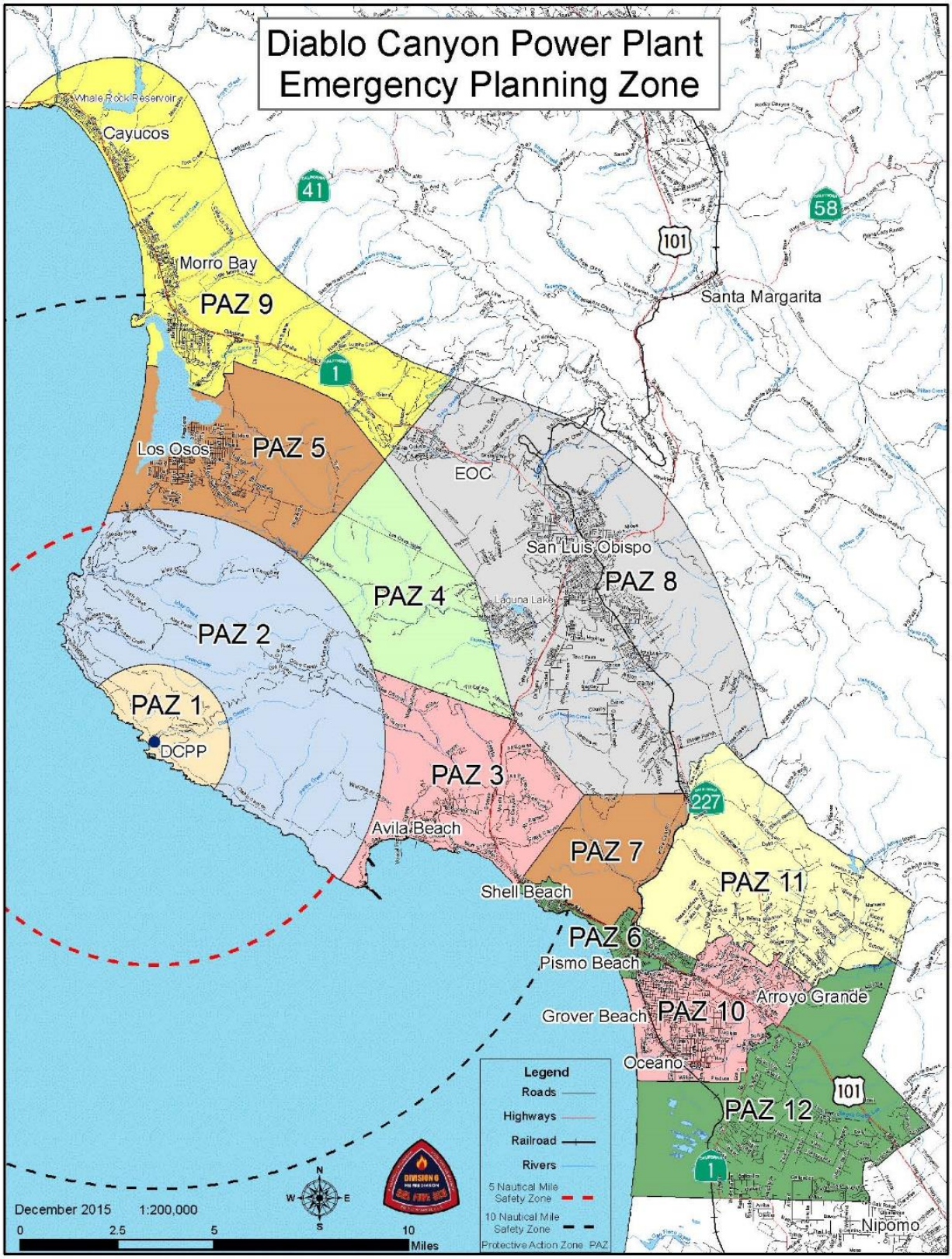
Table 9.U: Levels of Nuclear Power Plant Emergencies

Emergency Classification Level (ECL)	ECL Description and Purpose	Populations Affected*	Occurrences in California
Notification of Unusual Event	Issued when events are in progress or have occurred that indicate a potential degradation of the level of safety of the plant or indicate a security threat to facility protection has been initiated. No releases of radioactive material requiring offsite response or monitoring are expected unless further degradation of safety systems occurs.	Onsite only	Average 1-2 per year
Alert	Issued when events are in progress or have occurred that involve an actual or potential substantial degradation of the level of safety of the plant or a security event that involves probable life threatening risk to site personnel or damage to site equipment because of hostile action. Any releases are expected to be limited to small fractions of the U.S. Environmental Protection Agency (EPA) Protective Action Guides (PAGs).	Onsite only	3 declared. Note: All 3 were rescinded after further investigation
Site Area Emergency	Issued when events are in progress or have occurred that involve actual or likely major failures of plant functions needed for protection of the public or hostile action that results in intentional damage or malicious acts 1) toward site personnel or equipment that could lead to the likely failure of, or 2) that prevent effective access to, equipment needed for the protection of the public. Any releases are not expected to result in exposure levels that exceed EPA PAG exposure levels beyond the site boundary.	Designated areas within the Emergency Planning Zone	0
General Emergency	Issued when events have occurred that involve substantial core degradation or loss of containment integrity. Radioactive releases are expected to exceed federal exposure guidelines.	Designated areas within the Emergency Planning Zone	0

**Includes only populations with special planning and response operations.*
Source: U.S. Nuclear Regulatory Commission, https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/emerg-classification.html; California Governor's Office of Emergency Services (Cal OES) Nuclear Power Preparedness Program

The Emergency Planning Zone (EPZ) for the Diablo Canyon Power Plant is shown in Map 9.Z. The Nuclear Regulatory Commission (NRC) requires an approximate 10-mile radius EPZ around each plant site. California and local governments around Diablo Canyon Power Plant established an EPZ that follows the coastline and extends 18 miles to the north and 22 miles to the south. The EPZ size is established to provide for substantial reduction in early severe (acute) health effects in the event of a worst-case core melt accident.

MAP 9.Z: Emergency Planning Zones (EPZs) for Diablo Canyon Power Plant



Source: San Luis Obispo County Emergency Services

Assessment of Local Vulnerability and Potential Losses

For information on community vulnerability and loss, see Local Hazard Mitigation Plans.

Current Radiological Accident Mitigation Efforts

Cal OES Radiological Preparedness Unit

The Radiological Preparedness Unit (RPU) in Cal OES plans for, prepares for, responds to, mitigates, and assists in the recovery from radiological incidents that threaten public health and safety, property, and the environment. The goal of the RPU is to protect the public, property, and the environment from the possible harmful effects of radiation from incidents during transportation, at nuclear power plants and other fixed facilities, and from acts of terrorism. The RPU provides an effective and efficient emergency management system for radiological incidents by coordinating private entities and federal, state, and local government organizations.

The RPU is responsible for two programs:

- The California Radiological Emergency Preparedness (CalREP) Program
- The Nuclear Power Plant Program

Radiological programs are covered under the California Radiological Emergency Preparedness Plan. These programs address nuclear power plant incidents, transportation accidents involving radiological materials and wastes, other radiological emergencies, and nuclear terrorism (discussed in the terrorism hazard risk assessment in *Section 9.3.1*).

The California Radiological Emergency Preparedness Plan provides a framework outlining how local, state, and federal governments will respond and coordinate in anticipation of and immediately following a radiological emergency in the state.

California Department of Public Health Radiologic Health Branch

The California Department of Public Health (CDPH) Radiologic Health Branch (RHB) regulates the use of radioactive material through licensing and compliance programs under Health and Safety Code, sections 114960-115270 designed to protect the public, radiation workers, and the environment from the harmful aspects of radiation. This includes licensing of radioactive materials, certification of medical and industrial X-ray and radioactive material users, inspection of facilities that use radiation, investigation of radiation incidents, and surveillance of radioactive contamination in the environment.

RHB conducts routine monitoring of radioactive materials in the environment, including radioactive materials in media such as air, milk, food, and water. Routine air sampling occurs at nine fixed locations within California: Eureka, Richmond, Livermore, San Luis Obispo, Diablo Canyon, Baldwin Park, Long Beach, San Onofre, and San Diego.

The RHB Radioactive Materials Licensing and Inspection Program provides accountability and control for the use of radioactive material in California and licenses approximately 1,850 users of radioactive materials. The RHB Radiation Machine Registration, Professional Certification and Inspection Program registers approximately 85,000 radiation tubes used in approximately 32,000 facilities statewide that include uses in mammography, oncology, dental, and fluoroscopy radiation machines and computed tomography scanners. The program certifies approximately 78,000 physicians, technologists, and technicians (medical professionals) in possession of 118,000 individual certificates or permits who operate radiation machines and 87 radiation technology schools with more than 1,000 affiliated clinical sites that provide instruction and training to individuals seeking to become a medical professional qualified to operate radiation machines.

Operators of facilities or transport vehicles that handle radiological materials are responsible for ensuring the safety and security of the materials within their facilities or as carried by their transport vehicles and minimizing the hazard posed to the public. Facilities that handle radiological materials that are licensed by CDPH are required to notify

RHB when a reportable release occurs. RHB maintains staff and equipment capable of providing technical assistance in support of local response to radiological/nuclear emergencies in California.

RHB supports the California Preventative Radiological/Nuclear Detection initiative, which seeks to establish a statewide architecture to prevent the use of any radiological materials as a terrorist weapon within California through monitoring, detection, and intervention.

Nuclear Power Plant Safety

Nuclear power plants are designed with two principal safety objectives in mind:

1. To contain fission products to prevent offsite health effects.
2. To ensure that heat generated by the reactor, including heat generated by the decay of fission products after reactor shutdown, is removed.

If the decay heat is not continually removed from the reactor following shutdown, this heat could cause a failure of the system that is designed to contain the fission products. The fission products generated in the reactor core are highly radioactive; thus, releasing significant amounts of them to the environment could be quite harmful. Great care has been taken to prevent such a release through the defense-in-depth approach used in the design of nuclear power plants. The defense-in-depth approach ensures that any release of hazardous amounts of radioactive materials will be extremely unlikely. This approach uses three barriers to prevent the release of fission products from the reactor core to the environment:

- Fuel rods (fuel pellet and fuel cladding)
- Reactor vessel and primary coolant system
- Containment

The chance of any single barrier failing is unlikely. The chance of all three failing simultaneously is, therefore, extremely remote. A meltdown does not have to occur for sufficient fission products to be released from the fuel to pose a threat. What must occur is the loss of the many redundant systems designed to keep the core covered and cool (by removing the decay heat). These systems are designed to maintain cooling even under severe accident conditions such as a total break in the largest pipe in the system. Numerous systems and backup emergency core cooling systems are provided to ensure that reactor cooling water continues to flow through the reactor core to remove decay heat, even after the reactor has been shut down and the fission process has stopped. Control and safety systems within the plant are designed to overlap for safety. Automatic systems have the ability to shut down the reactors within seconds if monitoring devices detect unusual conditions, such as an excessive heat buildup. Should any individual safety component fail, there are backup systems that take over immediately.

The Nuclear Regulatory Commission (NRC) has resident inspectors assigned to each plant site. The inspectors oversee plant operations and ensure compliance with regulations governing operational and occupational safety. There are automatic communications systems that contact the State Warning Center in Sacramento if certain conditions, such as an earthquake or certain plant conditions, occur. The State Warning Center will be able to contact key personnel needed in an emergency.

Nuclear Power Plant Emergency Preparedness

Planning, preparing, and training for nuclear power plant emergencies are also part of the safeguards. Federal, state, and local emergency management agencies work with the utilities to ensure that nuclear power plants are safe and that each agency and utility has an effective emergency plan describing the actions to be taken in response to an emergency. Residents and businesses near a nuclear power plant should prepare a disaster plan for all emergencies, including nuclear power plant emergencies, and become familiar with the emergency preparedness information. Information regarding nuclear power plant safety issues, in general, is available from the NRC at: www.nrc.gov. As a federal agency, the NRC has primary jurisdiction over nuclear facilities in the United States and works closely with state and local emergency agencies.

Planning Zones

A series of zones has been established around each nuclear power plant to clearly identify the required activities in the event of an accident. Although three specific zones are identified, efforts to protect public health and safety and the environment are made without regard to whether particular areas are inside or outside of these zones. The three zones are as follows:

- The Emergency Planning Zone (EPZ) for which plans are in place to protect people, property, and the environment from the effects of exposure to a radioactively contaminated plume. As noted earlier, the EPZ around Diablo Canyon Power Plant follows the coastline and extends 18 miles to the north and 22 miles to the south.
- The Ingestion Pathway Zone. For Diablo Canyon Power Plant, this zone covers an approximate 50-mile radius around the plant. In this zone, plans are in place to mitigate the effects of radioactive contamination to agriculture, as well as food processing and distribution.
- The Public Education Zone, which includes areas approximately 35 miles from the plant. In this zone educational materials are distributed to inform the public about how the nuclear power plant operates, what to expect in the event of an accident, and what plans are in place for public protection. The utilities that operate the power plants are required to publish and disseminate information for residents and transient populations.

The CDPH Nuclear Emergency Response Program (NERP) protects the environment, and the health and welfare of the public from the consequences of a radiation release at a nuclear power plant. NERP plans and participates in graded exercises with local, state, and federal personnel to prepare for a nuclear power plant incident or terrorist attack. Without this program, Diablo Canyon Power Plant would not be able to maintain its U.S. Nuclear Regulatory Commission (NRC) licensure and, therefore, would be unable to operate.

Radiological Waste Transportation

Since 1989, the staff of the California Energy Commission has represented California on two western state groups: the Western Governors' Association Waste Isolation Pilot Plant (WIPP) Transportation Advisory Group and the Western Interstate Energy Board's High-Level Radioactive Waste Committee. Both groups work with the U.S. Department of Energy and other state and regional groups to develop accident prevention and emergency response plans for major federal non-classified shipments of radioactive waste. Staff also coordinates the California Nuclear Transport Working Group that develops and updates accident prevention and emergency response plans for federal shipments of transuranic waste to the WIPP in New Mexico.

To mitigate disaster, federal regulations require that 1) radiological materials transported by train use special packaging based on the hazard of the shipment, 2) there is extensive worker training and documentation, 3) vehicles and packages of radioactive materials are inspected, and 4) the waste travels via specific, controlled routes. More information about radiological waste transportation can be found on Cal OES's radiological transportation web page, at the following link: http://www.caloes.ca.gov/cal-oes-divisions/planning-preparedness/waste-isolation-pilot-plant-program.

Radiological Exposure and Public Health

CDPH RHB tracks information from generators of low level radioactive waste. These generators are required to submit annual reports to RHB concerning low level radioactive waste shipped and stored. California's risk mitigation strategy for radiological sources includes participation in the Department of Energy Cesium Irradiator Replacement Program that provides financial incentives to California hospitals and medical facilities that remove and replace cesium-137 irradiators with X-ray technologies.

Additional Radiological Accident Hazard Mitigation Opportunities

The nuclear power plant mitigating strategies currently in place were developed in the context of a localized event that was envisioned to challenge portions of a single unit. The events at Fukushima, however, demonstrate that "beyond-design-basis" external events (i.e., events that were not allowed for in a plant's design because they were

considered too unlikely) may adversely affect 1) more than one unit at a site with two or more units, and 2) multiple safety functions at each of several units located on the same site.

Nuclear plants are typically designed with multiple independent and redundant layers of defense to compensate for potential human and mechanical failures so that no single layer, no matter how robust, is exclusively relied upon. This "defense in-depth" strategy includes the use of access controls, physical barriers, redundant and diverse key safety functions, and emergency response measures. However, the events at Fukushima further highlight the possibility that extreme natural phenomena could challenge even this approach to prevention, mitigation, and emergency preparedness.

To address the uncertainties associated with beyond-design-basis external events, the NRC is now requiring a three-phase approach for mitigating such events. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities. The transition phase requires providing sufficient portable onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from offsite. The final phase requires obtaining sufficient offsite resources to sustain those functions indefinitely. Additionally, the NRC has initiated studies to learn more from the events at Fukushima. These studies will likely result in further changes in requirements for mitigation, preparedness, and response at U.S. nuclear power plants.

9.2.5 TRAIN ACCIDENTS RESULTING IN EXPLOSIONS AND/OR TOXIC RELEASES

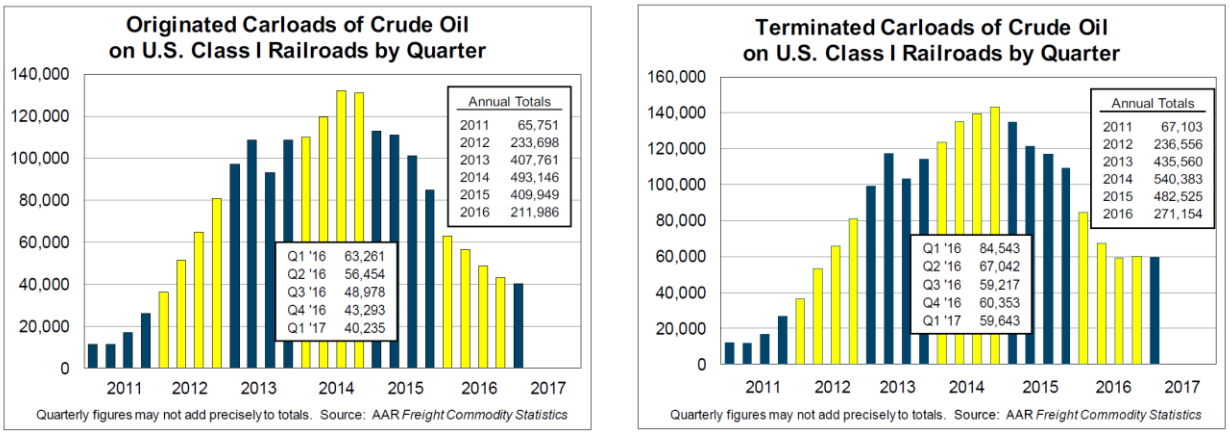
Identifying Train Accidents Resulting in Explosions and/or Toxic Releases

Train accidents are generally localized, and the incidents result in limited impacts at the community level. However, if there are toxic, volatile, or flammable substances on the train and the train is in a highly populated or densely forested area, death, injuries, and damage to homes, infrastructure, and the environment, including forest fires, can occur.

One of the most significant concerns in rail accidents is related to oil trains, or the transport of largely crude oil by rail. Due to the sharp rise in U.S. crude oil production, much of the increased oil product output is transported by rail. In 2008, U.S. Class I railroads originated 9,500 carloads of crude oil and by 2014, this number had increased by an estimated 5,100 percent to 493,146 carloads.

The majority of traditional crude oil refineries are located in production areas, such as Texas, Oklahoma, and Louisiana. Therefore, the product must be transported to areas where it can be processed and/or transferred to marine tankers. These facilities are generally located in coastal areas such as California, the state of Washington, New England, and the Gulf of Mexico. Railroads have helped fill the gap in transportation of crude oil as the traditional pipeline network linking refineries has reached capacity. After peaking in 2014, carloads of crude oil transported by rail have fallen sharply from 540,383 loads to 59,643 loads in 2016. Chart 9.C demonstrates the decrease in crude oil transportation by rail in the United States since 2014.

Chart 9.C: Crude Oil Transportation by Rail in the United States, 2011-2017



Source: Association of American Railroads, https://www.aar.org/todays-railroads/what-we-haul/crude-oil-by-rail

According to a 2014 report to the California Joint Legislative Committee on Emergency Management, crude-oil-by-rail imports into California were projected to increase as much as 25-fold by 2016, driven by increasing domestic production in the United States as well as Canada. This raised serious safety concerns due to a string of train derailments occurring in North America in 2013 and 2014. Of greatest concern were oil trains transporting Bakken oil, a lighter, highly flammable crude oil produced in the Bakken region of North Dakota and derived from tar sands in Canada.

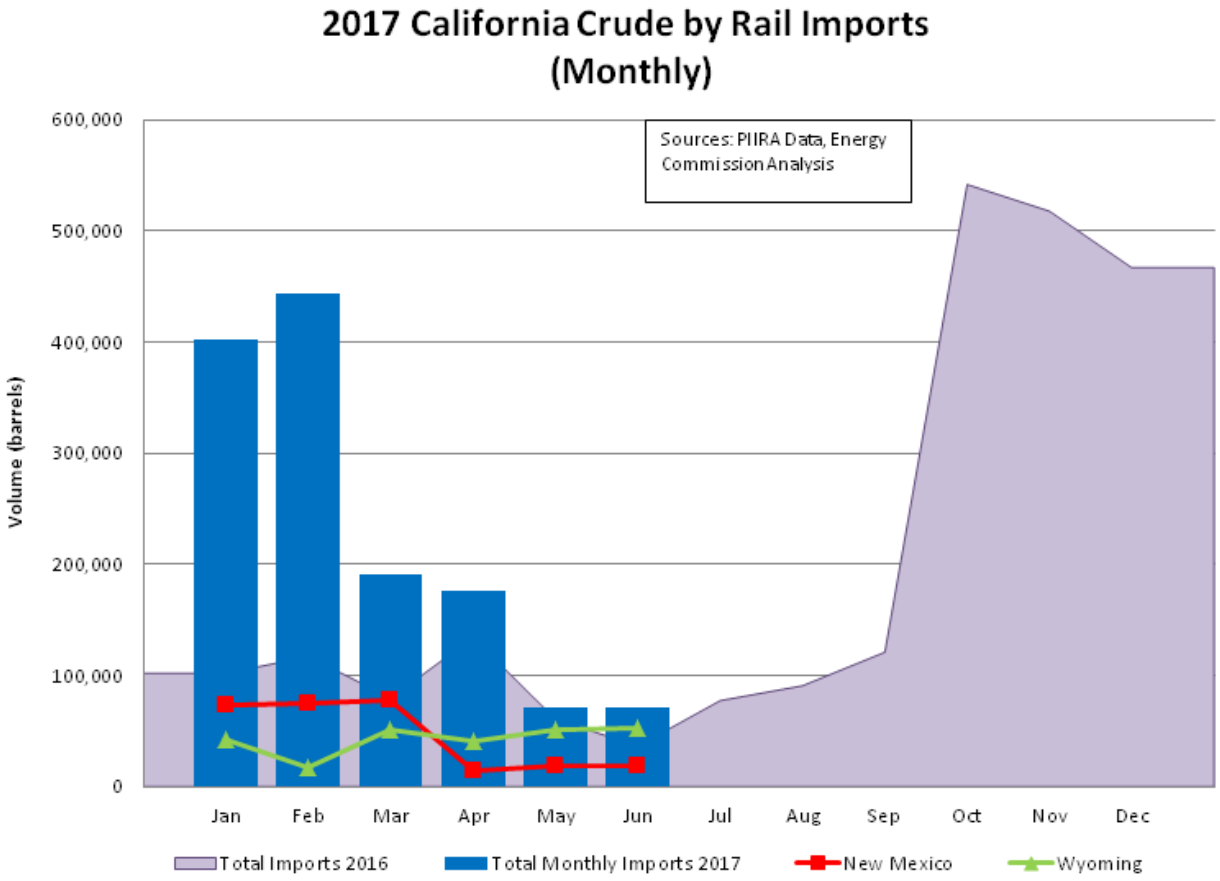
In 2014, 100-car Bakken oil trains originating in North Dakota traveled through the Feather River Canyon and midtown Sacramento once or twice a week en route to Richmond in the San Francisco Bay Area. By 2016, however, the number of those oil trains had diminished greatly due to economic factors leading to a decline in the need for importing crude oil to the Richmond refinery.

Several more oil trains were proposed to be initiated in 2015, including the Valero Refining Company's plan to run two 50-car oil trains a day through Sacramento to its plant in Benicia, and Phillips 66's plan to run oil trains five days a week into its refinery in San Luis Obispo County, some from the north and some via southern routes. Political and community opposition to the proposed new oil train routes, based on safety and environmental concerns, resulted in lengthy delays to those projects into 2017, when both the Valero and Phillips 66 projects were ultimately stopped by local governing body votes to deny the necessary permits to move forward with construction.

As of 2017, there are only two active crude-by-rail facilities in the state. The most active continues to be the Plains All American facility in Bakersfield. The other is the Kern Oil Refining facility, also in Bakersfield. The Kinder Morgan facility that operated for a short time in Richmond has been shuttered.[322]

Although the projections for increased Bakken oil trains never materialized, economic recovery and the increased demand for crude oil have produced an upswing in the number of crude rail imports into California. As can be seen in Figure 9.D, imports increased significantly during the fourth quarter of 2016, continued through the first quarter of 2017, and again declined during that summer.

Figure 9.D: Crude-by-Rail Imports into California, 2016 and 2017



Profiling Train Accidents Resulting in Explosions and/or Toxic Releases

According to Cal OES, there have been 14 train accidents affecting 12 communities since 1950. Several significant train accidents, derailments, fires and hazardous material releases have occurred in California in the past 40 years that resulted in multiple deaths, numerous injuries, and property damage and have, thus, stimulated changes in land

[322] CPUC, Rail safety report to the legislature. 2016.

use and rail safety regulations. Rail incidents involving oil in California increased from 3 in 2011 to 36 in 2013 and to 28 by mid-2014.[323]

Roseville Train Explosion

A dramatic example in California history was the major explosion and chemical plume release that occurred in April 1973 in the Roseville railroad yard when 6,000 bombs on a train bound for the Concord Naval Weapons Stations detonated after a car caught fire. Although no one was killed, the blast reportedly injured about 100 people and damaged 5,500 buildings, some more than a mile away.[324]

Duffy Street Derailment, San Bernardino

On May 12, 1989, a six-locomotive/69-car Southern Pacific freight train picked up speed while descending down the Cajon Pass in Southern California. The train reached a speed of 110 miles per hour on a curve at Duffy Street in San Bernardino designed for no more than 40 miles per hour. The train derailed and plowed into a residential area on Duffy Street. The conductor, head-end brakeman, and two residents were killed in the crash. Seven homes were destroyed, as was the entire train.

During the cleanup effort, an underground 14-inch high-pressure gasoline transit pipeline suffered undetected damage. On May 25, 13 days after the train derailment, the pipeline burst, showering the neighborhood in gasoline and igniting a large fire that killed two people and destroyed 11 more homes. The total property damage was $14.3 million. Many residents moved after this, and homes are no longer allowed to be built next to the rail lines.

Investigations determined several causes that contributed to the derailment: a miscalculation of the weight of the freight, which was underestimated by 40 percent; lack of dynamic brakes on three of the six locomotives; and train engineer error in activating the emergency brake, which cancelled the dynamic brakes on the functioning three locomotives.

Cantara Loop Spill, Upper Sacramento River

On the night of July 14, 1991, a Southern Pacific train derailed into the upper Sacramento River at a sharp bend of track known as the Cantara Loop, upstream from Dunsmuir, California, in Siskiyou County. Several train cars made contact with the water, including a tank car that initially appeared to be undamaged; however, a small rupture below the water line allowed its contents to be released into the river. Early the following morning, it became apparent that the tank car had ruptured and spilled approximately 19,000 gallons of metam sodium, a potent herbicide and pesticide used primarily to sterilize soil for agricultural purposes.

When mixed with water, metam sodium breaks down into several highly toxic compounds having varying toxicities and half-lives in the aquatic environment. Though some are highly toxic, all dissipate in a matter of hours or weeks and do not linger long-term. Some of the compounds volatilized into the air, creating a toxic cloud above the river as the chemical plume moved downstream. Efforts to determine the extent of damage to aquatic life from the metam sodium spill were delayed 12 to 48 hours due to the hazard of fume exposure.

Ultimately, over a million fish and tens of thousands of amphibians and crayfish were killed. Millions of aquatic invertebrates, including insects and mollusks, which form the basis of the river's ecosystem, were destroyed. Hundreds of thousands of willow, alder, and cottonwood trees eventually died. Many more were severely injured. The chemical plume left a 41-mile wake of destruction, from the spill site to the entry point of the river into Shasta Lake. Traveling at just under 1 mile per hour on average, the plume entered Shasta Lake on the morning of July 17, 1991. Dilution and evaporation of the metam sodium, combined with continued aeration, reduced the chemical to undetectable levels in the lake by July 29, 1991.

[323] IEPR Workshop, June 25, 2014
[324] Roseville Local Hazard Mitigation Plan, 2004; Wikipedia

In July 1992, a lawsuit was filed by the State of California and the federal government against Southern Pacific Railroad and other parties considered responsible for the Cantara spill. The lawsuit was on behalf of the natural and biologic resources damaged or destroyed by the spill. The basis of the lawsuit was to recover damages for those injured resources. An out-of-court agreement was reached in 1994, and the entire settlement process was completed by August 1995. The plaintiffs were awarded $38 million in damages, reimbursements, and restoration funds, $14 million of which was to be administered by the Cantara Trustee Council for restoration activities, land acquisition and protection, research, and public education. The Cantara Trustee Council operated for a period of 12 years, from 1995 to 2007. For additional details on the activities and projects funded by the Cantara Trustee Council, see: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=17248&inline=true.

The severity of this spill and the long-term effects on the surrounding ecosystem prompted the California Public Utilities Commission (CPUC) to conduct a statewide risk assessment which identified 19 hazardous rail sites within the state.

Glendale Derailment

On January 26, 2005, a southbound Metrolink commuter train collided with a sport utility vehicle (SUV) that had been abandoned on the tracks near the Glendale-Los Angeles city boundary. The train jackknifed and struck trains on both sides of it, one a stationary freight train and the other a northbound Metrolink train traveling in the opposite direction. The collisions resulted in 11 deaths and 100 to 200 injuries. The driver of the SUV left the vehicle before the crash and was later charged and convicted of 11 deaths and arson.

Subsequent criticism focused on the issue of train configuration. Many commuter trains use a “pusher configuration” to avoid turnaround maneuvers and facilities required to reverse a train’s direction. This means the trains are pushed from the back by the locomotive. There were assertions that this type of configuration made the accident worse and claims that if the engine had been in the front, the train might not have jackknifed and caused the second Metrolink train to derail.

To increase rider safety, Metrolink temporarily roped off the first cars in all of their trains and allowed passenger seating in the second car and beyond. Metrolink gradually modified this policy. As of 2007, the line permitted passengers to sit in a portion of the first car when the train is in "push mode," but did not allow seating in the forward-most section of the first car.

Chatsworth Derailment

The September 12, 2008 Chatsworth train accident, resulting in 25 deaths and injuring more than half the train’s passengers, spawned significant changes to national rail safety standards. The head-on collision occurred in Chatsworth, a neighborhood of Los Angeles located at the western edge of the San Fernando Valley, and involved a Metrolink commuter train and a Union Pacific freight train. All three locomotives, the leading Metrolink passenger car, and seven freight cars derailed. According to the National Transportation Safety Board (NTSB), the Metrolink train engineer most likely caused the collision because he was distracted by sending text messages while on duty. He failed to obey a red stop signal that indicated it was not safe to proceed from the double-track into the single-track section and, thus, collided head-on with the freight train that was traveling on the same single-track section from the opposite direction.

The NTSB also believed that deployment of a positive train control (PTC), which is a safety backup system that can automatically stop a train and prevent train collisions, could have avoided the disastrous collision and derailment. Although not required at the time of the Chatsworth accident, PTCs have been a high priority for the NTSB following similar collisions since the mid-1980s, and voluntary implementation has been uneven and incremental across the country since that time, primarily due to the high costs associated with installation and maintenance. Following the Chatsworth collision, Metrolink expanded the existing automated train stop system used on 30 miles of Metrolink track in Orange County across its 350-mile system. Metrolink's automated train stop system will automatically apply the brakes to stop a train if the engineer fails to respond to a warning within 8 seconds.

Feather River Canyon Derailment

On November 25, 2014, 11 cars carrying corn derailed adjoining a portion of the Feather River about 50 miles northeast and upstream of Lake Oroville, releasing kernels and husks into the river. Most of the corn landed on the hillside above the river. Although this was not considered a toxic spill, it raised concerns among state and local officials because the rail track routinely carried trains transporting hazardous materials, including 100-car Bakken crude oil trains. At the time, the number of crude oil trains entering the state via mountain passes and river canyons was expected to jump substantially in the next several years as coastal refineries planned to purchase Bakken oil from fields in North Dakota, Canada, Colorado and Texas. As a result of this spill and others occurring in Canada, Virginia, and Pennsylvania, representatives of the CPUC and Cal OES provided testimony for U.S. Department of Transportation (US DOT) hearings regarding rail tank safety standards.

Roseville Derailment

On January 6, 2015, a westbound freight train departing the Union Pacific Railroad Davis Yard in Roseville derailed before it was able to leave the yard. Of the seven cars that derailed, three were upright, two were leaning, and two were on their side. The two rail cars that were on their sides included a tank car containing hazardous materials. The tank car sustained substantial damage to its outer shell, but the inner shell was not breached and consequently there was no release of hazardous material. Due to damage to the hazardous material car and initial uncertainty about a possible release, the Union Pacific Railroad initially set up a half-mile evacuation zone. The Union Pacific Railroad's initial report stated the cause was a broken rail on the lead track of the departure yard. This was substantiated by CPUC staff.

Train derailments involving hazardous materials where track defects are the primary cause are of particular concern. In locations where such statistics highlight this concern, CPUC staff will often monitor and mentor the railroad maintenance personnel, focusing on each employee's competency and ability to perform effective regular inspections. Mentorship and observations in the field allow CPUC inspectors to discuss training needs and other remedies with local railroad managers.[325]

[325] http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/2016%20Rail%20Safety%20Report%20to%20the%20Legislature%202016%20FINAL.pdf

Assessment of State and Local Train Accident Vulnerability

Increasing concerns regarding the rail transport of crude oil within the state prompted the Governor of California to convene an Interagency Rail Safety Working Group in January 2014 to examine safety concerns and recommend actions the state and others should take in response to this emerging risk.

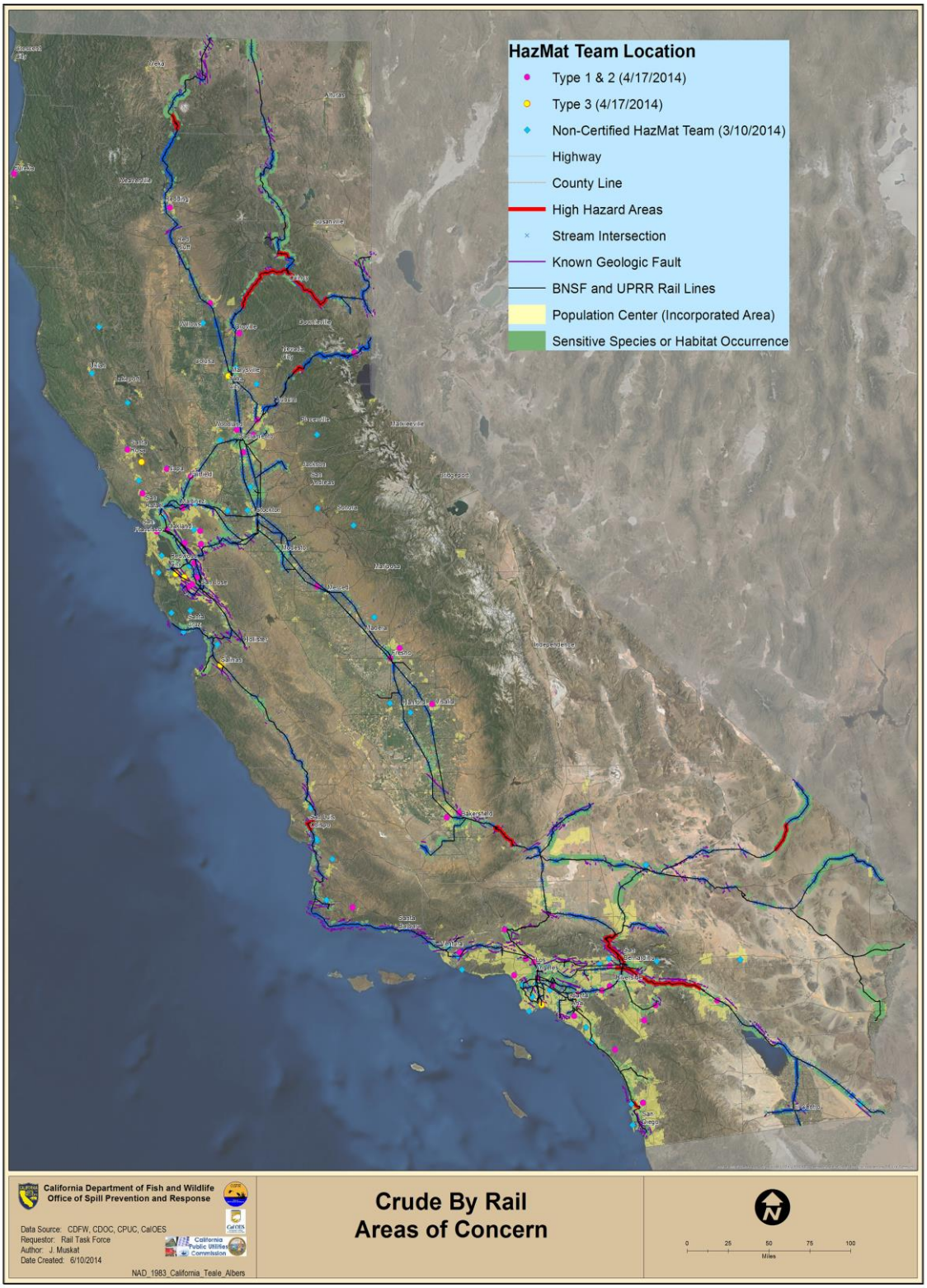
According to the Working Group, trains transporting crude oil are expected to travel along the Feather River or Donner Pass to the Bay Area, through the Tehachapi Pass to Bakersfield, or into Los Angeles. As a result, they will travel through some of the state's most densely populated areas, as well as some of the most sensitive ecological areas, since rail lines frequently operate near or over rivers and other sensitive waterways in the state. Agencies in the Working Group collaborated to identify and map areas along rail routes with potential high vulnerability, and to identify the locations of emergency response teams relative to the vulnerabilities. Map 9.AA and Map 9.BB provide an overview of oil train routes and potential high hazard sites, as well as the location of certified and non-certified hazardous materials response teams. Specifically, the mapping exercise found the following:

- High hazard areas for derailments are primarily located in the mountains, with at least one such site along every rail route into California. Some high hazard areas are also located in more urban areas, such as in the San Bernardino-Riverside and San Luis Obispo regions. Overall, high hazard areas represent an estimated 2 percent of track and 18 percent of the derailments that have occurred. This means that 82 percent of derailments have occurred in a wide range of other locations. The high hazard areas do not reflect the locations of other types of rail accidents (e.g., collisions). Therefore, while the highlighted areas are important, they are not the only sites where accidents may occur.

- Areas of vulnerable natural resources are located throughout the state, including in urban areas. A rail accident almost anywhere in California would place waterways and sensitive ecosystems at risk. The high hazard areas for derailments are generally located in areas with high natural resources vulnerability and nearby waterways (e.g., Dunsmuir, the Feather River Canyon).

- Emergency hazardous material response ("hazmat") teams in California have generally good coverage of urban areas, but none are located near the high hazard areas in rural Northern California. Some areas such as Yuba City and Monterey only contain "Type III Hazmat" teams—units that are equipped to perform only in a support role rather than lead role during a major chemical or oil incident.

Map 9.AA: Oil Train Routes and Potential High Hazard Sites



Map 9.BB: High Hazard Designations for Oil by Rail

Source: Cal OES, http://caloes.ca.gov/cal-oes-divisions/fire-rescue/hazardous-materials/hazmat-by-rail

Current Mitigation Efforts for Train Accidents Resulting in Explosions and/or Toxic Releases

There are numerous federal and State of California regulations aimed at preventing and mitigating rail accidents with the potential to cause death, injuries, and property and environmental damage. In general federal law as it relates to rail preempts state action on the subject. Federal regulations focus on design standards and safety technologies, while state and local regulations address areas of inspection, enforcement, preparedness, and response.

Notable Rail Safety Regulations

As with other hazards discussed in this SHMP, improved rail safety regulations have been implemented following specific destructive events, or in recognition of a significant risk.

Positive Train Control System Requirements

One such case is the development of regulations requiring the use of a positive train control (PTC) system designed to automatically stop a train to prevent a collision. In May 2007, prior to the Chatsworth collision, a bill requiring the installation and operation of PTC systems was introduced in the U.S. House of Representatives. The bill was passed by the House in October 2007 and moved on to the U.S. Senate, where it was being heard at the time of the Chatsworth collision. Following testimony by California Senator Boxer and others regarding the Chatsworth crash and the potential for avoidance of similar events through the mandatory deployment of PTC systems, the Senate passed the bill in October 2008. The legislation signaled that, despite the implementation costs, railroad employee and general public safety warranted mandatory and accelerated installation and operation of PTC systems.

The Railroad Safety Improvement Act of 2008 (RSIA08) requires the installation and operation of PTC systems on 1) all main lines, meaning all intercity and commuter lines, with limited exceptions; and 2) freight-only lines when they are part of a Class I railroad system, carrying at least 5 million gross tons of freight annually, and carrying any amount of poison-by-inhalation (PIH) or toxic-by-inhalation (TIH) materials. The RSIA08 mandated that widespread implementation of PTC systems across a major portion of the U.S. rail industry be accomplished by December 31, 2015. Each subject railroad was required to submit to the Federal Railroad Administration, by April 16, 2010, an implementation plan indicating where and how it intended to install PTC systems by December 31, 2015.[326]

Final Rule for Rail Transportation of Flammable Liquids

More recently, concerns over "oil trains," particularly those transporting the highly flammable Bakken crude oil throughout the United States, spawned new federal regulations. The Federal Railroad Administration, one of 10 agencies under the U.S. Department of Transportation (US DOT), has primary jurisdiction over railroad safety, covering the safety of track, grade crossings, rail equipment, operating practices, and movement of hazardous materials. US DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA) and the U.S. Department of Homeland Security's Transportation Security Administration (TSA) issue safety standards for railways. The National Transportation Safety Board (NTSB), an independent federal agency, is responsible for making recommendations to prevent future incidents. Unlike the Federal Railroad Administration, the NTSB has no regulatory authority, although the Federal Railroad Administration often agrees with the recommendations provided by the NTSB.

In an effort to improve safety and reduce the potential for rail spills, government agencies in the U.S. and Canada have adopted additional safety standards and issued new regulations for crude oil railcars. US DOT, for instance, issued an emergency order in May 2014 that requires railroad operators to notify local emergency responders whenever oil shipments travel through their states. Canada has also announced that it will phase out the use of older rail cars used to transport oil by May 2017.

In May 2015, US DOT announced a Final Rule to strengthen safety standards for transportation of flammable liquids by rail. The Final Rule, "Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains," was issued by the PHMSA and the Federal Railroad Administration. The rule applies to "high-hazard flammable trains" which means "a continuous block of 20 or more tank cars loaded with a flammable liquid or 35 or more tank

[326] http://www.fra.dot.gov/Page/P0395

cars loaded with a flammable liquid dispersed through a train." The rule establishes a variety of new standards, including enhanced tank car standards, new braking standards, new testing and sampling requirements to determine product stability, and new operational protocols, such as risk assessments of routing requirements, speed restrictions, and procedures for informing local agencies of oil train shipments.

A major provision of the Final Rule was the requirement that all tanker cars that transport crude oil or other flammable liquids meet "DOT 117" specifications that are designed to meet higher safety standards. A timeline was established for the retrofit of existing tanker cars. The January 1, 2017 date would trigger a reporting requirement, and shippers would have to report to DOT the number of tank cars that they own or lease that have been retrofitted, and the number that have not yet been retrofitted.[327]

Major State Agency Areas of Responsibility

Although the federal government has primary authority over railroad safety, the State of California enforces federal requirements, as well as state-specific rules, and state and local agencies have the lead in the areas of emergency planning, preparedness, and response. States additionally can help ensure that federal and voluntary industry actions are adequate given the risks posed by oil by rail.

California Public Utilities Commission (CPUC) Responsibilities

The CPUC is the state agency that oversees rail safety in California. This oversight can be broken down into three areas:

1. *Railroad Safety.* The CPUC employs federally certified inspectors to ensure that railroads comply with both federal and state railroad safety regulations.
2. *Rail Transit Safety.* The CPUC has safety and security regulatory authority over all rail transit agencies in California and works in cooperation with the Federal Transit Administration and transit agencies to enhance public safety and security.
3. *Rail Crossing Safety.* The CPUC is the state agency with exclusive jurisdiction over rail crossings in California. CPUC engineers evaluate the safety of rail crossings and review proposed construction where roadways or pathways cross railroad or rail transit tracks.

The CPUC Railroad Safety Division is required by the California Public Utilities Code to prepare an Annual Railroad Safety Report to the California State Legislature that chronicles the operations of the CPUC Railroad Operations and Safety Branch (ROSB). The ROSB mission is to ensure that California communities and railroad employees are protected from unsafe practices on freight and passenger railroads by promoting and enforcing rail safety rules, regulations, and inspection efforts and by carrying out proactive assessments of potential risks before they create dangerous conditions.

Findings of the 2016 ROSB Annual Report can be found at: http://www.cpuc.ca.gov/rosb/.

California Department of Fish and Wildlife, Office of Spill Prevention and Response (OSPR) Responsibilities

The California Department of Fish and Wildlife, Office of Spill Prevention & Response (OSPR) is the lead state agency for oil spill preparedness and response. The OSPR was established as part of the 2014 Budget Act. It creates an integrated marine-inland spill prevention, preparedness, and response program; provides funds to pay for oil spill cleanup; addresses preparedness for rail, pipeline, and production industries; and, promotes effective, timely spill response, cleanup, and restoration of resources damaged by spills.

Additional details about OSPR may be found at: https://www.wildlife.ca.gov/OSPR.

[327] http://www.ncsl.org/research/energy/transporting-crude-oil-by-rail-state-and-federal-action.aspx#Timeline

California Governor's Office of Emergency Services (Cal OES) Responsibilities
The Hazardous Materials (HazMat) Section, under the Cal OES Fire and Rescue Division, coordinates statewide implementation of hazardous materials accident prevention and emergency response programs for all types of hazardous materials incidents and threats, including hazardous materials transported by rail.

Rail Safety Working Group Recommendations
As noted earlier, in January 2014, the Governor's Office convened a Rail Safety Working Group to examine safety concerns and recommend actions that the state and others should take in response to the emerging risk posed by increased shipments of crude oil by rail into California.

The Working Group included representatives from the CPUC; Cal OES; California Environmental Protection Agency (CalEPA); Department of Toxic Substances Control (DTSC); California Energy Commission (CEC); California Natural Resources Agency (CNRA); California Office of the State Fire Marshal (OSFM); Department of Oil, Gas, and Geothermal Resources (DOGGR); and Office of Spill Prevention and Response (OSPR). The Working Group published a Preliminary Findings and Recommendations Report on June 10, 2014.

The Working Group report recommended the following:
- Increase the number of CPUC inspectors (and inspections)
- Expand the OSPR program to cover inland oil
- Provide additional funding for local emergency responders
- Post an interactive, public website depicting rail lines and potential vulnerabilities
- Monitor industry compliance with items in an industry Voluntary Agreement
- Review state and federal emergency response plans
- Request "Worst-Case Scenario" plans from railroads
- Call on the federal government to enhance safety requirements

Senate Bill 84 (2015)
In 2015, the California Legislature passed Senate Bill (SB) 84 which addressed the following rail safety issues:
- Creating the Regional Railroad Accident Preparedness and Immediate Response Force in Cal OES, consisting of stakeholders
- Authorizing the Force as being responsible for providing regional and onsite response capabilities in the event of a release of hazardous materials from a railcar or a railroad accident involving a railcar designated to transport hazardous material commodities
- Requiring Cal OES, in consultation with stakeholders, to develop a state regional railroad accident preparedness and immediate response plan that would be an annex to the State Emergency Plan
- Requiring the Force and OSPR to coordinate in their respective authorities and responsibilities to avoid any duplication of effort, ensure cooperation, and promote the sharing of information regarding the risk of discharge of petroleum by rail into state waters
- Requiring the Cal OES Director to establish a schedule of fees to be paid by a person owning any of the 25 most hazardous material commodities that are transported by rail in California
- Requiring the Cal OES Director to create an industry advisory committee to advise the director on setting the fee and other policy matters
- Requiring every person who operates a railroad that transports hazardous materials by railcar to register with the board and to remit the fees to the board pursuant to the Fee Collection Procedures Law
- Creating the Regional Railroad Accident Preparedness and Immediate Response Fund

9.2.6 WELL STIMULATION AND HYDRAULIC FRACTURING HAZARDS

Identifying Well Stimulation and Hydraulic Fracturing Hazards

Hydraulic fracturing, commonly called "fracking," is a process that involves high-pressure injection of water, sand, and chemical additives to cause fracturing of sub-surface rock resulting in release of gas or oil trapped inside.

As defined in California state statute, hydraulic fracturing means a well stimulation treatment that, in whole or in part, includes the pressurized injection of hydraulic fracturing fluid or fluids into an underground geologic formation in order to fracture or with the intent to fracture the formation, thereby causing or enhancing the production of oil or gas from a well.[328]

Fracking is a type of well stimulation treatment that is known to boost oil and gas production. Another type of well stimulation treatment also used to increase oil and gas production is acid well stimulation, which introduces one or more acids (applied at any pressure) to a well or geologic formation, either alone or in combination with hydraulic fracturing treatments.

The California oil and gas industry uses a large number of hazardous chemicals during hydraulic fracturing and acid treatments. The use of these chemicals underlies all significant potential direct impacts of well stimulation in California.[329]

Hazards and environmental impacts that could result from fracking and well stimulation include 1) contamination of groundwater with chemicals, 2) air pollution from dispersion of chemicals and gases, and 3) contamination of sub-surface rock formations from the injected chemicals. These concerns exist anywhere fracking is used as a gas and oil extraction method.

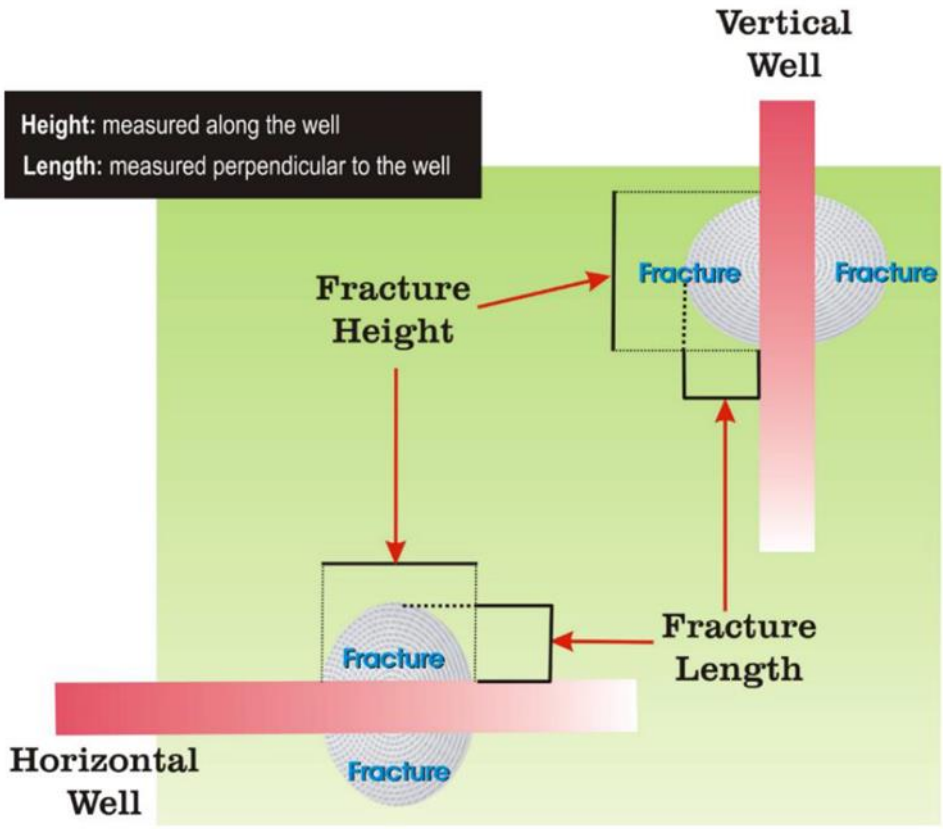
Profiling Well Stimulation and Hydraulic Fracturing Hazards

The more wells that are drilled, the higher the likelihood of some environmental damage, although the amount of damage is unknown. Fracking has been used in the gas and oil business for some time in California, with the majority of wells (approximately 90 percent) being found in Kern County on diatomite-type soils.

Newer technologies, however, allow for possible expansion of the practice to other areas, such as Los Angeles and Monterey Counties. Between July 2015 and June 2016, 579 well stimulations were performed, over 80 percent of them in diatomite formations. Wells in diatomite formation are generally shallow; average fracture height was 150 feet, average length was 76 feet, and average depth was 1,220 to 1,991 feet in 2016.[330] Less water is used in California wells than in wells outside of California. Related well dimensions are shown in Figure 9.E.

[328] Added by Statute 2013, Ch. 313, Sec. 2. Effective January 1, 2014
[329] California Council on Science and Technology 2015
[330] Division of Gas Oil and Geothermal Resources. Well Stimulation Treatment Annual Report, July 1, 2015-June 30th, 2016

Figure 9.E: Use of Height and Length in Describing Well Stimulation Treatment Fractures in California.



Source: Division of Gas Oil and Geothermal Resources. Well Stimulation Treatment Annual Report, July 1, 2015-June 30th, 2016.

As a result of these discoveries and the potential increase in fracking activities in the Central Valley (as well as elsewhere in California), the state legislature passed Senate Bill (SB) 4, which is intended to regulate well stimulation treatments, including fracking. SB 4, which was signed by the Governor in September 2013, amends the Public Resources Code as well as the Water Code.

Current Mitigation Efforts for Well Stimulation and Hydraulic Fracturing Hazards

As more wells were being developed nationally and public awareness of the risk to potable groundwater supplies grew, concern about fracking in California increased.

SB 4, signed by the Governor in September 2013, is intended to regulate well stimulation procedures and encourage development of new science information related to impacts. SB 4 directly supports 2018 SHMP Goal 3*: Protect the environment*.

As part of the SB 4 requirements, the California Natural Resources Agency conducted an independent study on well stimulation treatments that was completed in 2015. This report can be reviewed at the following website: https://ccst.us/projects/hydraulic_fracturing_public/SB4.php

SB 4 provides for oversight in several ways. The following five state agencies and a national lab now are involved in oversight and regulatory activities:

- Division of Oil, Gas, and Geothermal Resources (DOGGR)
- Office of Environmental Health Assessment
- Department of Toxic Substances Control (DTSC)
- State Water Resources Control Board (SWRCB)
- California Air Resources Board (CARB)
- Lawrence Berkeley/Livermore National Laboratories

The collective objectives of these agency efforts are to lower the probability of well failure and to identify any contamination problems quickly and act on measures to limit contamination impacts. The utilization of many state agencies also provides an integrated approach to addressing the threat of well failure and contamination, which directly supports SHMP Goal 4: *Promote community resilience through integration of hazard mitigation with public policy and standard business practices.*

Generally, the contamination of groundwater with chemicals is within the purview of the SWRCB and DOGGR. Contamination of sub-surface rock formations from the injected chemicals is also within the purview of DOGGR. DOGGR developed a set of permanent regulations for well drilling permitting that went into effect in September 2016, replacing an interim regulation process that was in place from July 2015 to June 2016.

DOGGR regulations for acquiring a permit call for review and oversight at three stages: during preliminary stimulation, during stimulation, and after stimulation. The applicant must include a water management plan and a groundwater monitoring plan in the application and obtain California Environmental Quality Act (CEQA) review from the lead agency (generally the local county government).

DOGGR serves as the responsible agency conducting the secondary review. As needed, other state agencies (such as the SWRCB and CARB) can provide additional agency reviews as needed. By addressing well drilling permitting as a three-stage process, consistent information is developed and shared, and the resources of many state agencies can be called upon to address this man-made threat to the environment. As part of the permitting process, DOGGR must post issued permits on the publicly accessible portion of its website.

SWRCB involvement occurs when a well site is close to an area of protected water (greater than 10,000 total dissolved solids). Under those conditions, a water monitoring plan is required to track any potential contamination and to quickly address any occurrences. The regulations are found in Section 10783 of the Water Code.

Air pollution from dispersion of chemicals and gases is the purview of CARB. CARB presently samples some well areas for air pollution related to chemical particulates. In the future, all new well fields developed will be fully monitored for air quality.

The DTSC is concerned with the chemicals and fluids used and their interaction and impact on sub-soil formations.

For the complete text of SB 4, go to:
http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB4

9.3 THREAT AND DISTURBANCE HAZARDS

While of great importance, the human-caused hazard risk assessments included in this section are less comprehensive in scope and content than those included in preceding sections, because threat and disturbance hazards typically affect a smaller geographic area than the hazards addressed in preceding sections.

9.3.1 TERRORISM

Identifying Terrorism Hazards

Technological hazards and terrorism are human-caused hazards. These are distinct from natural hazards in that they originate from human activity. The term "technological hazards" refer to the origins of incidents that can arise from human activities such as the manufacture, transportation, storage, and use of hazardous materials. For the sake of simplicity, this SHMP assumes that technological emergencies are accidental and that their consequences are unintended.

The term "terrorism" refers to intentional, criminal malicious acts. There is no single, universally accepted definition of terrorism, and the term can be interpreted in many ways. This SHMP uses the federal definition found in the Code of Federal Regulations (28 CFR, Section 0.85): "...the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives."

For the purposes of this SHMP, terrorism refers to the use of weapons of mass destruction, including biological, chemical, nuclear, and radiological weapons; arson, incendiary, explosive, and armed attacks; industrial sabotage and intentional hazardous materials releases; and cyber terrorism. (Cyber threats are discussed in more detail in *Section 9.3.2*.)

The process of identifying and mitigating hazards before they become disasters is similar for both natural and man-made hazards. Whether dealing with natural disasters, threats of terrorism, or hazardous materials accidents, a four-phase mitigation process should be used: 1) identify and organize resources, 2) conduct a risk assessment and estimate potential losses, 3) identify mitigation actions, and 4) implement the actions, evaluate the results, and keep the plan up to date.

Profiling Terrorism Hazards

Terrorist events have continued to occur in California. From 2001 to 2011, there were 207 terrorist attacks in the United States. California was the leading state with 40 attacks, followed by 19 in New York State. The leading cities were New York (12), Washington, DC (9), and Los Angeles (8). The most common weapons used in the 207 terrorist attacks in the United States from 2001 to 2011 were incendiary devices and explosives. From 2001 to 2011, the most common targets of terrorists in the United States were businesses (62 attacks), private citizens and property (59 attacks), and government (43 attacks). Table 9.V summarizes terrorist events from 2006 to 2016.

Table 9.V: Terrorist Events in California, 2006 to 2016

Date	Location	Description
June 30, 2006	Los Angeles	Attempted firebombing of private home
June 24, 2007	Los Angeles	Attempted firebombing of private home
October 20, 2007	Los Angeles	Flooding of a private home
February 5, 2008	Los Angeles	Arson at a private home
February 17, 2008	Eureka	Arson at a Planned Parenthood facility
April 25, 2008	San Diego	Bombing of a FedEx facility
August 2, 2008	Santa Cruz	Simultaneous firebombing of two separate private homes
March 7, 2009	Los Angeles	Firebombing of a private vehicle

Date	Location	Description
July 3, 2009	Huntington Beach	Racially motivated stabbing of a man
November 16, 2010	Los Angeles	Razor blade booby trap mailed to a private home
April 23, 2011	Stockton	Arson at a mosque
January 8, 2012	Coalinga	Arson at a feedlot
November 1, 2013	Los Angeles	Active shooter targeting Transportation Security Administration (TSA) at Los Angeles Airport
November 4, 2014	Coachella	Drive-by shooting at a mosque
December 7, 2014	Los Angeles	Arson at an apartment complex
September 30, 2015	Thousand Oaks	Arson at a Planned Parenthood facility
November 4, 2015	Merced	Stabbing of students
November 6, 215	Inglewood	Racially motivated assault of a man
December 2, 2015	San Bernardino	Active shooter murder of 14 people
December 11, 2015	Coachella	Firebombing of a mosque
December 26, 2015	Tracy	Firebombing of a mosque
February 28, 2016	Los Angeles	Racially motivated attack of three people
May 25, 2016	Modesto	Firebombing of a Planned Parenthood facility

Source: California Governor's Office of Emergency Services (Cal OES) Homeland Security Division

In addition to the events listed in Table 9.V, there have been numerous crimes by like-minded groups that do not meet terrorism criteria, as well as dozens of terrorism plot disruptions by law enforcement.

Terrorist threats are difficult to predict. Many different groups use terrorist attacks for various reasons. Two things are clear from the perspective of hazard mitigation: the most often used weapons of terrorists in California are incendiary bombs, and the greatest potential for loss is from active shooters or weapons of mass destruction. Additional concerns include the use of chemical and biological weapons.

Assessment of State Vulnerability and Potential Losses

The following infrastructure (listed in order of terrorist attention in their internet messaging) has been identified as meeting one or more state significance criteria and vulnerable to attack from domestic and international terrorists:

- *Transportation Sector*: 50,000 lane miles of highways, 246 public use airports (30 of which provide scheduled passenger service), over 170,000 miles of public roads, more than 12,000 bridges, and 11 seaports (California handles nearly half of all the port traffic in the United States), with 22 assets analyzed as high risk
- *Commercial Facilities Sector*: 236 office and apartment buildings, retail centers, convention centers, and others, 41 of which are analyzed as high risk
- *Government Facilities Sector*: 124 federal, state, and local buildings, 13 of which are analyzed as high risk
- *Communications Sector*: 49 assets including wireline, wireless, satellite, cable, and broadcasting capabilities, with 9 assets analyzed as high risk
- *Energy Sect*or: 114 identified assets comprising 500 power plants, a 25,000-circuit-mile "electron highway," more than 115,000 miles of pipelines, 20 refineries, and over 100 terminal facilities, with 20 assets analyzed as high risk
- *Banking and Finance Sector*: 14 banks and financial institutions, 2 of which are analyzed as high risk
- *Critical Manufacturing Sector*: 27 assets involved in a complex array of manufacturing processes, with 4 analyzed as being high risk
- *Emergency Services Sector*: 47 assets housing California's first responder communities, 8 of which are analyzed as high risk
- *Chemical Sector*: Approximately 100 "high risk" facilities

The vulnerability of various assets to particular threats can change over time. Tracking the vulnerability of different components may be done using various programs and systems, including the National Critical Infrastructure Prioritization Program (NCIPP), California Baseline Infrastructure Prioritization Initiative Project, and other tools that can be used to determine which assets, systems, or networks are nationally critical, state critical, or locally critical based on current risk profiles.

Assessment of Local Vulnerability and Potential Losses

At the local level, law enforcement and public safety agencies designate Terrorism Liaison Officers (TLOs) who are trained in reviewing and assessing local reporting and conducting outreach to other public safety agencies, critical infrastructure operators, and community groups. The TLO is the local agency point of contact for all terrorism-related alerts, requests for information, warnings, and other notifications from regional, state, or federal homeland security agencies. Through a single web-based state terrorism website, the TLO and his or her agency will have access to all available terrorism alerts, notices, information, and documents through a searchable database and daily information exchange with key federal, state, and local agencies.

Vulnerability and loss assessments from terrorism for individual California communities may be found in Local Hazard Mitigation Plans, if the jurisdiction chooses to include them.

Current Terrorism Mitigation Efforts

Homeland Security and the Homeland Security Strategy

Cal OES is California's lead state organization for gathering and disseminating information critical to protecting state assets, creating the state's comprehensive security strategy, and designing and implementing critical state, regional, and local infrastructure protection programs.

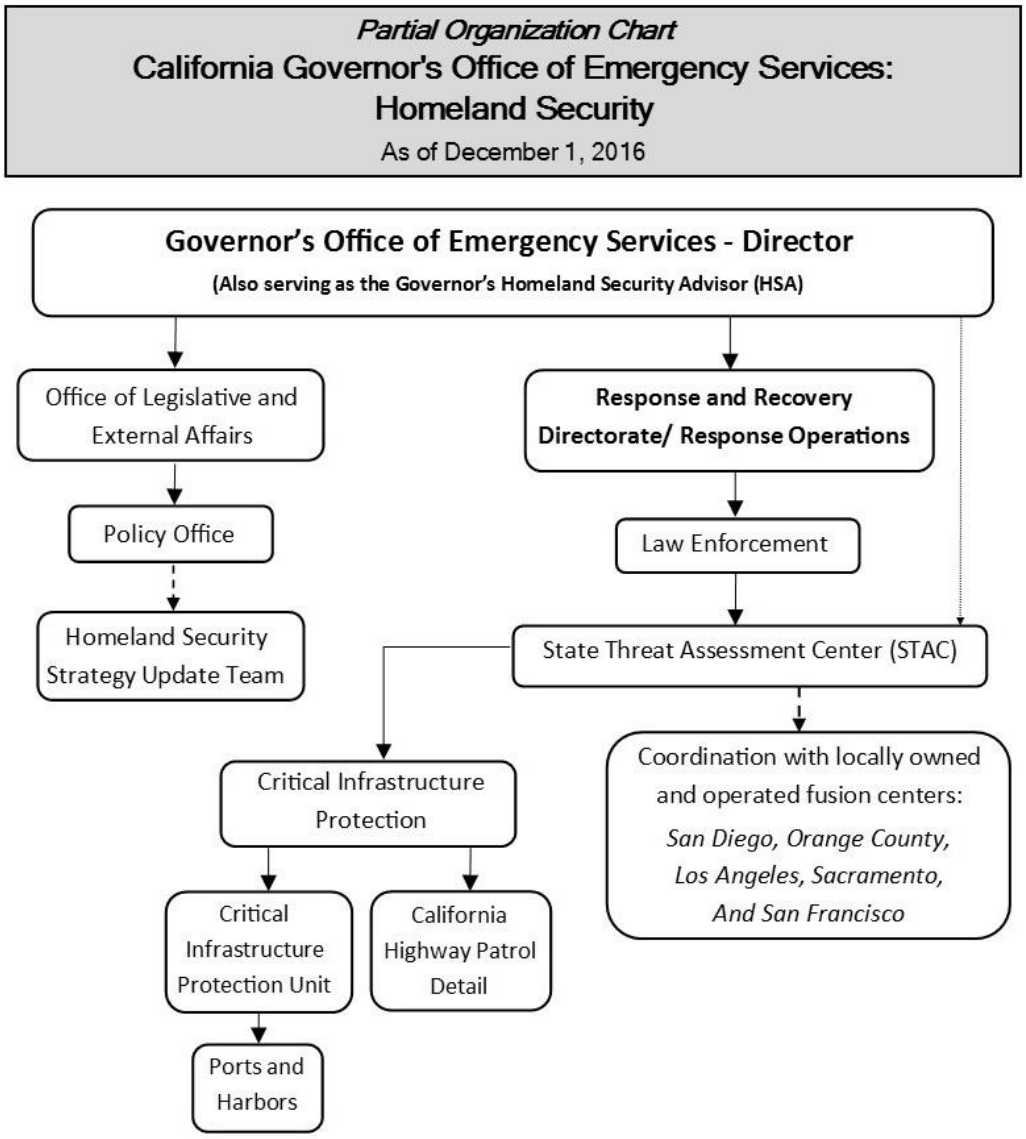
Homeland security is a statewide mitigation strategy to reduce the impact of human-made disaster events. This coordinated effort is focused on capacity-building for public agencies at the state and local level to prepare to prevent, protect against, mitigate, respond to, and recover from threats and acts of terrorism, and other human-made disasters or catastrophes. To carry out this effort, the state uses a risk management process to ensure that California has the right capabilities in place to manage those hazards that pose the greatest risk to its people, its critical infrastructure, and its key resources.[331] Reducing terrorism injury to the citizens of California and protecting vital infrastructure are key factors in the overall effort.

Between 2012 and 2016 Cal OES administered more than $500 million in federal grant funds at the state, regional, and local levels to significantly improve physical security at critical sites, upgrade equipment, and conduct training and exercises.

The Cal OES director is the Governor's Homeland Security Advisor. In 2016, the Homeland Security Advisory Committee (HSAC) was created to advise the Cal OES director on a 2017-2020 Homeland Security Strategy, which is the strategy that guides security activities in the state, as of February 2018. This inclusive committee is composed of federal department representatives, state cabinet members, and state associations (sheriffs, association of counties, etc.). The integration of federal, state, regional, and local entities ensures that the 2017-2020 strategy is a statewide coordinated effort and reflects the input from the main stakeholder groups, consistent with the SHMP strategy to strengthen inter-agency coordination actions, including state, regional, tribal, and local linkages.

[331] http://www.caloes.ca.gov/ICESite/Pages/Homeland-Security.aspx

Figure 9.F: Cal OES Homeland Security Organizational Structure



The HSAC developed 12 goals to guide the new Homeland Security Strategy and its associated objectives and then used 10 working groups to conduct a gap analysis and establish the associated objectives. The Homeland Security Strategy's goals that are closely related to terrorism and infrastructure are:

- Protect Critical Infrastructure and Key Resources from All Threats and Hazards
- Prevent Violent Extremism Through Multi-Jurisdictional/Inter-Jurisdictional Collaboration and Coordination
- Enhance Multi-Jurisdictional/Inter-Jurisdictional All-Hazards Incident Catastrophic Planning, Response and Recovery Capabilities

The 2017-2020 Homeland Security Strategy provides a framework for operating the main homeland security funding programs: Emergency Management Grant Programs, Homeland Security Grant Programs, and Infrastructure Protection Grant Programs. The Homeland Security Strategy also provides guidance to operational units within Cal OES such as the State Threat Assessment Center (STAC), the Cal OES Preventing Violent Extremism Program, and the Critical Infrastructure Protection (CIP) Unit. The organizational structure for this policy and operational effort is shown in Figure 9.F.

State Threat Assessment System

The State Threat Assessment System (STAS) is a key component of California's Homeland Security Strategy. The Cal OES' director, as California's Homeland Security Advisor, created the STAS to provide a framework for cooperative and effective work among federal, state, local, and tribal public safety agencies; criminal intelligence agencies; other state agencies; and critical infrastructure and key resource operators. The STAS assists in the detection, prevention, investigation, and response to criminal and terrorist activity; and disseminates intelligence to and facilitates communications among state, local, federal, and tribal agencies and private sector partners, to help them take action on threats and public safety issues.

The STAS is comprised of the STAC, four Regional Threat Assessment Centers, and one Major Urban Area Intelligence Center. The STAC serves as the state-level partner of the locally owned and operated fusion centers in Sacramento, San Francisco, Los Angeles, Orange County, and San Diego. Specific information about each can be found at the following links:

- STAC: http://www.caloes.ca.gov/cal-oes-divisions/state-threat-assessment-center
- Central California Intelligence Center: https://sacrtac.org
- Joint Regional Intelligence Center: https://www.jric.org
- Northern California Regional Intelligence Center: https://ncric.org
- San Diego Law Enforcement Coordination Center: https://sd-lecc.org
- Orange County Intelligence Assessment Center: https://ociac.ca.gov

The State Threat Assessment Center (STAC), is a partnership of the California Highway Patrol (CHP), California Department of Justice, and Cal OES and has connectivity with and participation of a number of state and federal agencies. The STAC acts as the California statewide information clearinghouse to aid in the prevention, preparation for, and response to strategic threats while preserving individual privacy and constitutional rights. The STAC develops intelligence products, including sector-specific critical information threat bulletins, for the state and local law enforcement, fire, and emergency management communities.

The STAC focuses on analyses of the following threats:

- International and domestic terrorism
- Transnational crime (including countering illicit narcotics trafficking and human trafficking)
- Criminal gangs
- Criminal domestic extremist movements
- Cyber crimes (including threats from state and non-state actors)
- Threats to California's critical infrastructure and key resources
- Threats developing from emerging and disruptive technologies

The Cal OES Preventing Violent Extremism Program

Cal OES established a Preventing Violent Extremism (PVE) Program in order to coordinate a statewide effort aimed at supporting and enriching community resilience against domestic and internationally inspired violence, beginning in January 2017.

The Cal OES PVE Program leverages existing state, federal, and private/non-profit partner resources in order to support community-led preventing violent extremism programs and to encourage further engagement in prevention efforts. As part of this effort, Cal OES has identified and assessed relevant trainings, funding opportunities, social service programs, global networks, and education initiatives offered by state, federal, and private partners in California.

This assessment of trainings, grants, social service programs, education initiatives, and PVE global networks throughout California was a necessary step in coordinating a statewide program aimed at connecting communities to the resources that meet their unique needs. The program has enhanced these five resources in order to meet

gaps in community needs and services and assist communities in building their own locally led prevention or intervention frameworks.

Further, the Cal OES PVE Program manages a website, equipped with a resources database and a Community Portal, which is an interactive platform that facilitates information sharing of best practices, knowledge, program models, and challenges among practitioners and communities. This website also hosts a virtual training aimed at assisting interested local governments in building program frameworks to enhance local resiliency against all forms of violence, at no cost to participants.

Additionally, Cal OES will fund non-profit pilot projects that support the PVE objectives outlined in the 2017-2020 Homeland Security Strategy. The PVE Non-Profit Pilot Grant Program supports five projects that will develop innovative and sustainable products by the end of the 18-month performance period, which will be completed in April 2020. This funding opportunity also aims to strengthen partnerships between community organizations and local, regional, and state government.

Protecting Critical Infrastructure

Since 9/11, California has worked closely with the federal Department of Homeland Security to enhance protection of California's complex and interdependent critical infrastructure and key resources.

Tactical security improvements must be rapidly implemented to deter, mitigate, or neutralize potential attacks. To facilitate the accomplishment of Homeland Security Presidential Directive 7 (HSPD-7), California's Critical Infrastructure Protection Objectives, described in the State's Homeland Security Strategy, are three-fold. California is committed to:

- Identifying and assuring the protection of infrastructures and assets deemed most critical in terms of consequences of terrorist attacks or natural disasters that impact California's public health and safety, governance, economic and national security, and public confidence
- Providing timely warning and assuring the protection of infrastructure and assets that face a specific, imminent threat
- Assuring the protection of other infrastructure and assets that may become terrorist targets over time by pursuing specific initiatives and enabling a collaborative environment in which federal, state, and local governments and the private sector can better protect the infrastructures and assets they control

On February 12, 2013, President Barack Obama signed the Presidential Policy Directive-21 (PPD-21). This directive, which superseded HSPD-7, advances a national unity of effort to strengthen and maintain secure, functioning, and resilient critical infrastructure. PPD-21 emphasizes that critical infrastructure must be secure and able to withstand and rapidly recover from all hazards.

The Cal OES Critical Infrastructure Protection (CIP) Unit works to address emerging issues related to the many varied aspects of infrastructure protection. The CIP Unit provides a mechanism to foster relationships and facilitate coordination between public-private partnerships throughout infrastructure sectors. The CIP Unit's key initiatives and services include critical infrastructure identification and prioritization, physical security and vulnerability assessments, information sharing, geospatial information systems analysis and mapping, and Threat and Hazard Identification and Risk Assessment (THIRA).

In 2010, the CIP Unit undertook an effort designed to establish criteria for defining "state significant" infrastructure, to identify assets meeting those criteria, and to perform a baseline risk analysis and prioritization. The CIP Unit collected data through open source research and subject matter expert collaboration, and analyzed the data by applying a risk scoring methodology to each asset. The end result was a risk-informed list of California's most significant infrastructure across 15 sectors.

California chooses to recognize the following critical infrastructure sectors: Chemical and Hazardous Materials; Commercial Facilities; Communications; Critical Manufacturing; Dams; Defense Industrial Base; Emergency Services; Energy; Financial Services; Food and Agriculture; Government Facilities; Healthcare and Public Health; Information Technology; Nuclear Reactors, Materials, and Waste; Transportation Systems; and Water and Wastewater Systems.

California accounts for assets in one remaining federal sector, Defense Industrial Base, within the Manufacturing sector. The CIP Unit's effort allows the state to make informed decisions related to the vast amount of critical infrastructure that exists. The CIP Unit used the Department of Homeland Security's MSHARRPP+V system of determining risk and vulnerability[332] as its risk-informed prioritization tool to focus on physical security and human-caused threat. This tool allows for systematic ranking of infrastructure by overall risk, or by any of its components. The outcomes can be used to make mitigation investments in the 15 critical infrastructure sectors. For example, the outcomes using this approach show the Commercial Facilities and Transportation Systems sectors having the highest risk scores, while the lowest risk scores are in Emergency Services; Nuclear Reactors, Materials, and Waste; and Food and Agriculture.[333]

Nuclear Detonation Response Program

Cal OES is California's lead agency in preparing the state for an attack using nuclear weapons. The spread of scientific and technical information has increased the risk that terrorists possessing sufficient nuclear material may attempt to develop their own improvised nuclear device. The national planning scenario for nuclear terrorism presumes an improvised nuclear device with a yield of 10 kilotons detonated at ground level in a major U.S. city.

The possibility also exists that a nation-state with nuclear capability may launch a nuclear attack against the United States. California, with its large population, substantial economic value, strategic military bases, and land and maritime border, represents a significant potential target. A nation-state with a dedicated nuclear program might develop weapons with higher potential yields, up to 100 kilotons or more.

The purpose of the Nuclear Detonation Response Program is to develop the State Nuclear Detonation Response Plan (NDRP). The NDRP provides a framework that describes how local, state, and federal partners will respond and coordinate following a nuclear detonation in California. The primary focus of the NDRP is the prompt execution of actions that will save lives and reduce injuries. The NDRP focuses on the immediate response phase, beginning with the notification of an attack or nuclear detonation and continuing through approximately 72 hours, at which point it is expected that state and federal resources will have begun integrating into a unified response organization.

Development of the NDRP began in 2017 with the drafting of the Base Plan. The Base Plan includes the actions the state will take in the first 15 minutes, 24 hours, and 72 hours in the event of a nuclear detonation. These actions include focusing on communicating with the public the risks of dangerous fallout from a nuclear blast. In 2018, continued NDR planning efforts include creating tactical level procedures and checklists for key state agencies and organizing a coordinated communications plan for alerting and messaging with state and local officials. Socialization of the plan and media outreach to the public will begin in late 2018.

Maritime Security

The California Maritime Security Council (CMSC) was created by Executive Order S-19-06 to enhance port security through statewide collaboration and information sharing. The CMSC works directly inside of the STAC operations to analyze seaport threats and develop a statewide maritime security strategy. There are maritime operatives assigned to Southern and Northern California and co-located with U.S. Naval and Coast Guard Intelligence. They are embedded in Port Security and/or U.S. Coast Guard Law Enforcement. There are also Area Maritime Security Committees that focus on the same duties as the CMSC, but at a regional level.

[332] MSHARRPP+V stands for: Mission, Symbolism, History, Accessibility, Recognizability, Recoverability, Population, Proximity,+ vulnerability. It is a systematic approach to assign a numerical score to each asset based on nine characteristics.
[333] Cal OES CIP Baseline Infrastructure Prioritization Initiative Report, June 30,2015.

Protecting the Food Supply

Collaboration continues among the Western Institute for Food Safety and Security (WIFFS), California Department of Food and Agriculture (CFDA), California Department of Public Health (CDPH), and UC Davis. The WIFFS is built on the functional relationships of these organizations and the private sector on the challenges of preventing intentional and unintentional contamination of food.

Grants Management

The Homeland Security Grant Section is responsible for the overall grant management of California's State Homeland Security Grant Program, Urban Security Initiative, Metropolitan Medical Response System, and Citizen Corps Program Grant Program.

The Homeland Security Grant Section conducts grant management and grant application workshops throughout the state. Programs addressed in the workshops include the following:

- Emergency Management Grant Programs
- Homeland Security Grant Programs
- Infrastructure Protection Grant Programs

California has made significant investments in homeland security. Table 9.W shows homeland security grant expenditures for the 2012-2016 period.

Table 9.W: Homeland Security Grant Program (HSGP) Expenditures, 2012-2016

HSGP Year	Solution Area					
	Planning	**Organization**	**Equipment**	**Training**	**Exercise**	**Total**
2012	$21,766,785	$12,365,244	$86,127,500	$10,264,394	$2,204,314	**$132,728,237**
2013	$20,368,513	$21,762,571	$76,308,843	$15,383,801	$2,864,492	**$136,688,220**
2014	$25,513,892	$25,912,786	$88,345,926	$15,770,284	$3,332,749	**$158,875,637**
2015	$13,118,333	$15,207,438	$34,517,803	$6,038,832	$2,172,832	**$71,054,868**
2016	$79,251	$84,415	$1,507,486	$158,559	$75,024	**$1,904,735**

Source: State of California, Automated Ledger System (ALS)

9.3.2 CYBER THREATS

Identifying Cyber Threats

Cyber threats are attempts by cyber criminals to attack a government, organization, or private party by damaging or disrupting a computer or computer network, or by or stealing data from a computer or computer network for malicious use.

A recent survey by the United States Government Accountability Office found that "agencies having high-impact systems identified cyber-attacks from 'nation-states' as the most serious and most frequently-occurring threat to the security of their systems."[334]

Profiling Cyber Threats

Nationally, cybersecurity incidents such as financial fraud and government database breaches have increased from 5,503 in 2006 to 67,168 in 2014.[335] This increase raises the question of whether there is a cybersecurity threat in California. Between 2012 and 2015, 50 million records of Californians were breached, and the majority of these breaches resulted from security failures, with malware and hacking; physical breaches constituted three quarters of all events.[336] As use of digital information expands, Californians will increasingly become more vulnerable to the slow-moving, potential technological hazard of cyber damage.

Assessment of State and Local Vulnerability and Potential Losses

Overview

Cyber vulnerability can occur in a variety of ways, including:

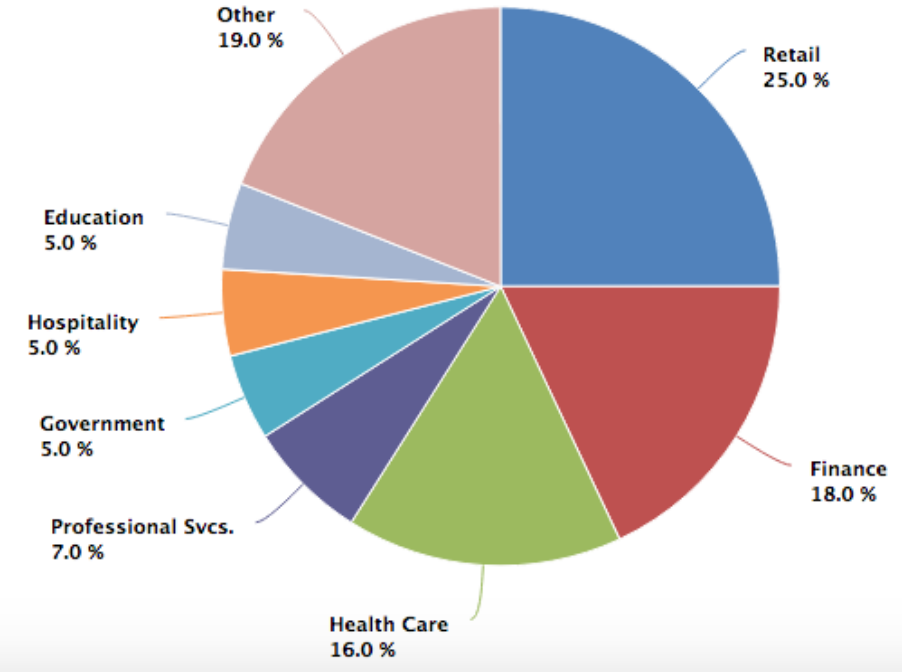
- Loss or theft of computer resources, assets, and funding
- Inappropriate access to and disclosure of personal and secure information
- Disruption of services
- Damage to networks
- High cost of remediation
- Disruption of essential operations supporting critical infrastructure needed for emergency management

Figure 9.G shows that there are cyber threats in all sectors of California's private and public life; with the retail, finance, and health sectors being most affected.

The state collects and processes data on a continuous basis (e.g., from motor vehicle records, through sales taxes) and is thus subject to all types of cyber threats. In 2016, the California Department of Technology (CDT) success rate in preventing unauthorized access to critical and sensitive data in the state data center was 99 percent, while there were 30 data breaches of personally identifiable information.[337]

[334] http://www.gao.gov/products/GAO-16-501?utm_source=blog&utm_medium=social&utm_campaign=watchblog, visited March 8, 2017
[335] Government Accountability Office, GTA -10-758T
[336] California Data Breach Report, California Department of Justice, February 2016
[337] California Department of Technology 2016 Annual Report

Figure 9.G: California Business Sectors Affected by Cyber Threats



Source: California Department of Justice, California Data Breach Report, February 2016. Figure 12, Breaches by Sector).

Assembly Bill 670 and Annual Vulnerability Assessment

Information security policy plays a critical role in the State of California and is vitally important to state government operations and service delivery. The CDT is the primary state government authority responsible for establishing policies for confidentiality, integrity, and availability of state systems and applications. It guards public data, is a leader in information technology services and solutions, and has broad responsibility and authority over all aspects of technology in California state government, including policy formation, inter-agency coordination, and advocacy. For more information about CDT, visit: https://cdt.ca.gov/about/.

To remain at the forefront, CDT adopted a Program Management Framework that shifts the state from a compliance-based practice to one that protects the highest-value assets through a management and risk-based approach. This approach provides a simplified set of 30 objectives mapped to 12 domains that security practitioners can use as focus areas for building a security program. The framework also allows state entities to assess, manage, and mature their security posture.

Assembly Bill (AB) 670 (Irwin, 2015) requires CDT to coordinate 35 vulnerability assessments each calendar year. State agencies will undergo these independent security assessments every two years based upon CDT's assessment criteria. The primary provider for this service is the California Military Department, through the Cal Guard Computer Network Defense Division. The resultant data are presented to the assessed state entity and CDT to allow them to implement and track remediation efforts.

CDT initiated an Information Security Audit Program to measure the effectiveness of its statewide policy and guidelines. The driver for the audit program is the need to assure that state entities are implementing appropriate administrative, operational, and technical information security safeguards. In 2016, this program was piloted in six state entities. Over time this audit may be used by all California levels of government to conduct vulnerability assessments.

Current Cyber Threat Mitigation Efforts

Certain mitigation efforts require cross-agency collaboration such that multiple agencies come together and work as a group toward specific mitigation goals. The State of California pursues a unified multi-department and partnering effort in addressing cyber threats. Many departments participate in four areas of activities:

- Threat monitoring
- Incidence response
- Prevention
- Education

State Emergency Plan, Cal OES, and Cyber Security

The 2017 State Emergency Plan (SEP) adds cyber security as a new California Emergency Support Function category (CA-ESF 18) and assigns Cal OES as the lead agency. Adding cyber security to the Emergency Support Function list is a recognition that cyber threats are a real and ongoing hazard. Unlike natural hazards, for which historical data are available and future events can be modeled, cyber threat is an emerging hazard, which can be more challenging to anticipate.

The SEP defines cyber security as "the protection of data and systems in networks that are connected to the Internet, including measures to protect critical infrastructure services. These services may include essential communications such as voice, email, and Internet connectivity,"

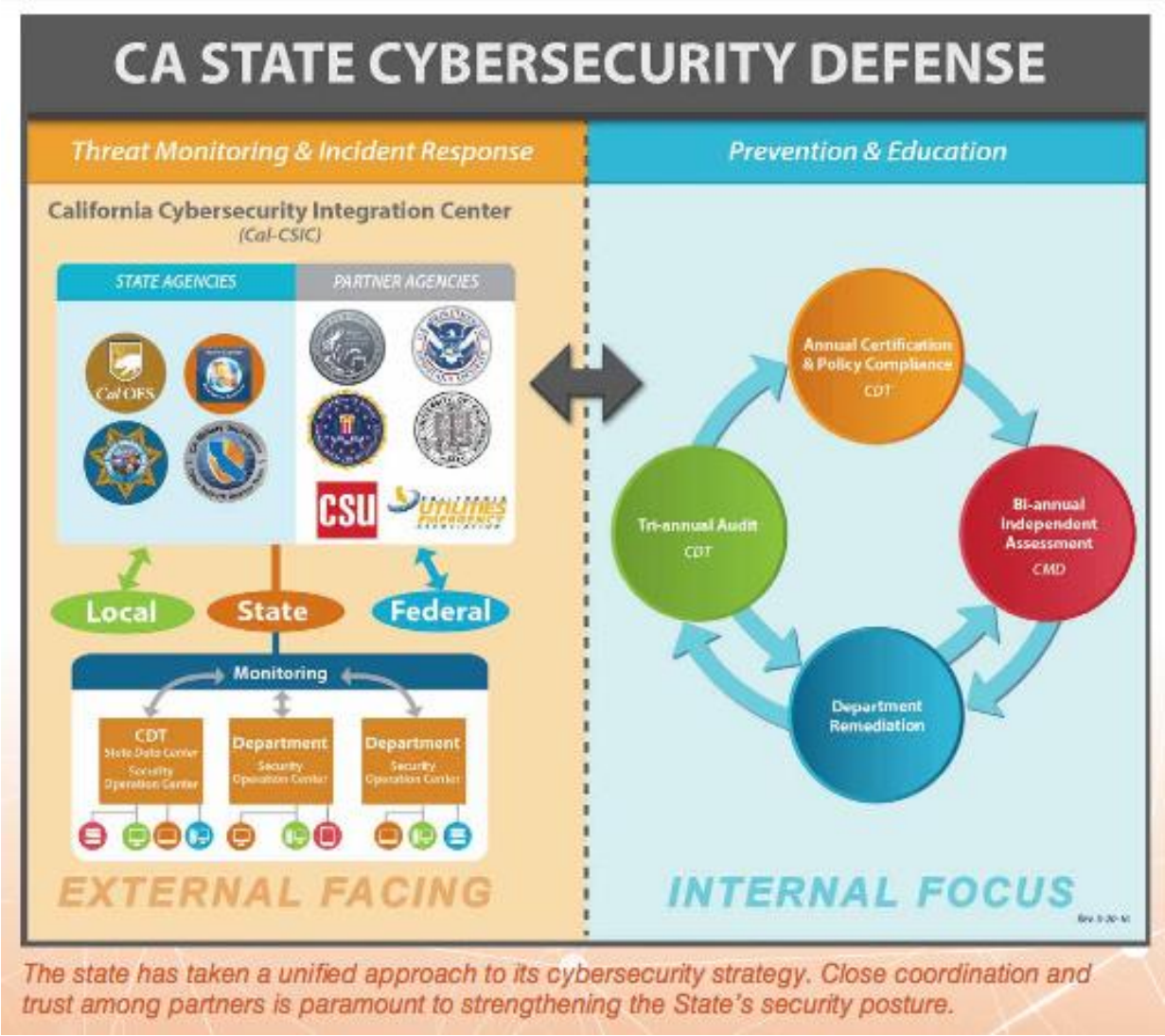
Since cyber attacks have the potential to occur on any day at any time, they are an ongoing, instantaneous threat, and integrated efforts are needed to prepare for, mitigate, respond to, and recover from these attacks. This integrated cyber security effort is led by Cal OES. In the lead agency role for cyber security defined by the SEP, Cal OES coordinates with other state agencies designated as support agencies and manages and operates the California Cybersecurity Integration Center (Cal-CSIC).

California Cybersecurity Integration Center and California Cybersecurity Task Force

The major cyber security efforts are conducted by CDT, Cal OES, the California Military Department, and the CHP, with those efforts grouped into two sectors—external facing and internal focus—as shown in Figure 9.H. The external-facing actions are coordinated through the work of the California Cybersecurity Integration Center (Cal-CSIC).

In 2013, Cal OES and CDT initiated the Cybersecurity Task Force to address the growing need for integrated action. In 2015, through Executive Order B-34-15, the Governor designated Cal OES to lead the Cal-CSIC.

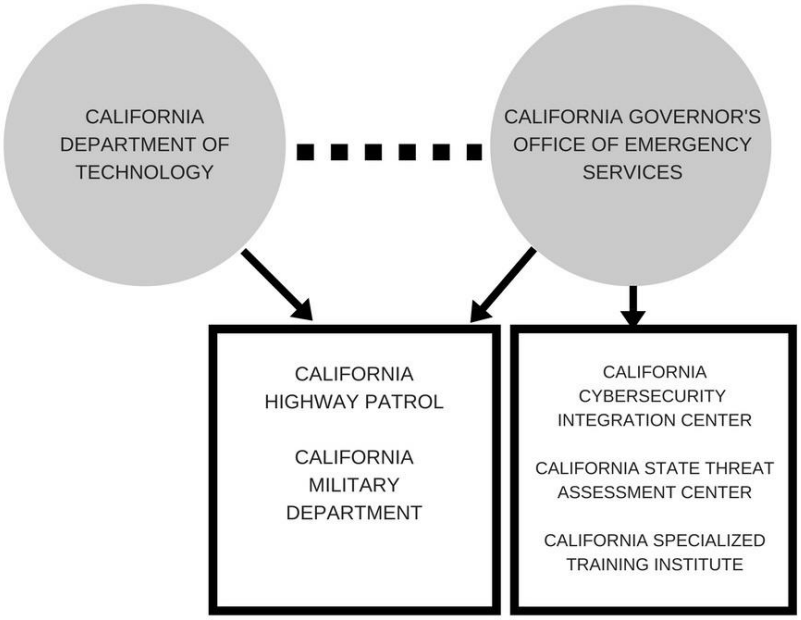
Figure 9.H: California Cyber Defense



Source: 2016 Annual Report California Department of Technology, p 9).

The Cal-CSIC's primary mission is to reduce the likelihood and severity of cyber incidents that could damage California's economy, its critical infrastructure, or public and private sector computer networks. The Cal-CSIC serves as the organizing hub of state government's cyber security activities and coordinates information sharing with local, state, and federal agencies, tribal governments, utilities and other service providers, academic institutions, and non-governmental organizations. Figure 9.I shows how the Cal-CSIC is linked to other agencies. This work directly puts into practice integration and thus addresses SHMP Goal 4: *Promote community resilience through integration of hazard mitigation with public policy and standard business practice*.

Figure 9.I: California Cybersecurity Integration Center (Cal CSIC) Linkage to Other Agencies



As nearly 95 percent of the nation's entire critical infrastructure is owned and operated by private industry, partnerships with California's private sector are critical to enhancing the cyber threat intelligence picture and state government's ability to respond effectively to significant cyber incidents.

The Cal-CSIC encourages private sector partnerships and hopes to foster a community of information sharing and mutual aid. Part of this effort is the California Cybersecurity Task Force, a statewide partnership comprised of key stakeholders, subject matter experts, and cyber security professionals from California's public sector, private industry, academia, and law enforcement.

The Task Force serves as an advisory body to State of California senior administration officials in matters related to cyber security. The Task Force is made up of the following seven subcommittees, each created to address specific Task Force goals and to support integration:

1. Cyber Risk Management Subcommittee
2. Information Sharing Subcommittee
3. Workforce and Education Development Subcommittee
4. Economic Development Subcommittee
5. Critical Infrastructure Subcommittee
6. High Tech and Digital Forensics Subcommittee

For more information about the Task Force and its subcommittees, visit: http://www.caloes.ca.gov/for-individuals-families/cybersecurity-task-force and http://www.caloes.ca.gov/for-governments-tribal/plan-prepare/cybersecurity-task-force/task-force-subcommittees

The Cal-CSIC is charged with a series of activities:

- *Operate* in close coordination with the California State Threat Assessment System and the U.S Department of Homeland Security - National Cybersecurity and Communications Integration Center, including sharing cyber threat information that is received from utilities, academic institutions, and private companies;

- *Establish* a Cyber Incident Response Team to serve as California's primary unit to lead cyber threat detection, reporting, and response in coordination with public and private entities across the state;
- *Provide* warnings of cyber attacks to government agencies and non-governmental partners;
- *Coordinate* information sharing among these entities, and assess risks to critical infrastructure and information technology networks;
- *Prioritize* cyber threats and support public and private sector partners in protecting their vulnerable infrastructure and information technology networks, and enable cross-sector coordination and sharing of recommended best practices and security measures;
- *Support* cyber security assessments, audits, and accountability programs that are required by state law; and
- *Develop* a statewide cyber security strategy, informed by recommendations from the California Cybersecurity Task Force. The cyber security strategy will be developed to improve how cyber threats are identified, understood, and shared in order to reduce threats to California government, businesses, and consumers.

Four primary Cal-CSIC outcomes are envisioned:

- *Actionable Intelligence:* The use of timely, accurate, and relevant intelligence to enhance decision-making and security of the state networks.
- *Network Resiliency:* The ability to disseminate security controls and alerting rules directly to partner networks and increase their resilience.
- *Incident Monitoring and Response*: Visibility into incidents affecting the state, and the ability to provide support coordination to critical incidents as they arise.
- *Security Solutions Engineering:* The ability to support partners by integrating Cal-CSIC security solutions into their infrastructures.

State Threat Assessment System and State Threat Assessment Center

In April 2016, Cal OES started the Cal-CSIC alongside the State Threat Assessment Center (STAC), California's information sharing clearinghouse of strategic threat analysis and situational awareness reporting. This co-location ensured immediate collaboration across the State Threat Assessment System (STAS), California's intelligence community.

The STAS helps safeguard California communities by serving as a dynamic security nexus comprised of the state, four Regional Threat Assessment Centers, and a major urban area fusion center. The STAS assists in the detection, prevention, investigation, and response to criminal and terrorist activity, and disseminates intelligence to and facilitates communications among state, local, federal, and tribal agencies and private sector partners to help them take action on threats and public safety issues. (See additional discussion of the STAS in *Section 9.3.1*)

Since April 2016, Cal-CSIC representatives from Cal OES, CDT, the California Military Department, and the CHP have been pooling resources to implement cyber vulnerability assessments and develop intuitive cyber threat alerts for the end user.

In July 2016, the Cal-CSIC hosted a Cyber Workshop where cyber security professionals from state government and the STAS met to discuss significant milestones in state cyber security and identify solutions to enhance cyber intelligence and incident response capabilities. Three primary goals stemmed from the workshop:

1. Collaborative development of a secure communications capability across STAS cyber elements
2. The standardization of intelligence tools and information streams, guaranteeing continuity and regional situational awareness
3. An education and professional development program to promote lateral training and enhance cyber capabilities for each fusion center

The STAS members include:

- California State Threat Assessment Center (STAC)
- Central California Intelligence Center (CCIC)
- Joint Regional Intelligence Center (JRIC)
- Northern California Regional Intelligence Center (NCRIC)
- Orange County Intelligence Assessment Center (OCIAC)
- San Diego Law Enforcement Coordination Center (SD-LECC)

The State Threat Assessment Center (STAC) is California's state primary fusion center, as designated by the Governor of California, and is operated by the CHP, Cal OES, and the California Department of Justice. Fusion centers are intended to assimilate cyber threat information from various sources, analyze acquired information for threat implications, and disseminate the information to various state, local, tribal, and private sector entities, and law enforcement.

In 2009, the STAC formalized its partnership through a Memorandum of Understanding between the California Department of Justice, Cal OES, and the CHP; the latter is vested with the day-to-day command and management of the STAC.

The STAC produces tailored all-source strategic intelligence designed to alert and inform California's policymakers and other public safety personnel on the numerous threats facing the state every day. Among the STAC threat domains are 1) cyber crimes (including threats from state and non-state actors), 2) threats to California's critical infrastructure and key resources, and 3) threats developing from emerging and disruptive technologies.

For more information regarding the STAC, visit: http://www.caloes.ca.gov/cal-oes-divisions/state-threat-assessment-center.

Evolving Training: California Cyber Training Complex

In 2017, the California Cyber Training Complex (CCTC) began as a multi-agency effort to protect California through enhanced cyber crime forensics and statewide tactical response training.

The CCTC is located centrally within California at Camp San Luis Obispo. This is close to the second largest fiber hub in the United States, allowing for high bandwidth communication and collaboration on data-intensive problems. Multiple law enforcement agencies already train at Camp San Luis Obispo, which serves as a base for the National Guard's Cyber Protection Team.

The mission of this unique program is to prepare law enforcement agencies and the nation's future cyber workforce in making California the most proactive state in the nation in addressing cyber threats. The CCTC includes a crime field training complex, a digital forensics lab, a cyber-academic training center and a test range and experimental laboratory. For the next few years the focus is on training local law enforcement, and California agency personnel (such as the CHP). In June 2017, the CCTC held a cyber-challenge event for high school students to develop interest in the cyber issues facing California.

Protecting Critical Power Grid Infrastructure

To protect power grid integration from cyber threats in California, the California Public Utilities Commission (CPUC) has funded a cyber-information sharing program, California Energy Systems for the 21st Century (CES-21). The research and development being pursued in this program has the potential to change the way utilities protect their critical assets.

CES-21, launched in 2014, aims to provide accurate and fast communication of cyber threats and the development of automated response capabilities to be executed prior to critical infrastructure damage. This initiative includes a team of technical experts from California's three largest public utilities —Pacific Gas and Electric Company (PG&E),

Southern California Edison and San Diego Gas and Electric (SDG&E)—and the Lawrence Livermore National Laboratory that will perform research in power grid cyber security.

The 2016 report on CES -21 related to cyber security states:

> *Given that 2015 was the startup year for the program, the learnings regarded the coordination of different utilities and national labs, as well as initial technical development. Model fidelity as a decision point for utilities working to produce models that are both extensible and actionable. If a model (and the language used to encode it) is too specific, it cannot be used by utilities with different equipment or configurations. If it is too vague, the results of the model are not actionable or applicable for a single utility.*
>
> *Finding the effective compromise between these extremes is an important step toward producing a model that can be productized by the private sector and used by utilities across the country. The work to automate the grid's cyber threat responses is nascent but fast growing. California is at the forefront of a research area that is attracting increased funding at the state and federal level for machine-assisted threat detection for industrial control systems.*

9.3.3 CIVIL DISORDER IN CALIFORNIA

The term "civil disorder" is defined by 18 U.S. Code Section 232 as any public disturbance involving acts of violence by assemblages of three or more persons, that causes an immediate danger of or results in damage or injury to the property or person of any other individual.

Civil disorders occur in California sporadically, and last from a few days to months. There are various causes, all man-made. All begin as local events; therefore, mitigation measures need to be planned and carried out locally and be supported by mutual aid agreements from near-by agencies. Extensive loss of life and loss of property have occurred in the last 25 years.

As summarized in the Table 9.X, there have been several significant civil disorders in the state since 1965 and more recently. These disorders have all taken place in metropolitan areas.

Table 9.X: Summary of Significant Civil Disorders in California

Disturbance	Location	Year	Deaths	Injuries	Damage
2016 Election Protests–*Protests against the election of Donald Trump. Thirty protesters were arrested, and three officers were injured.*	Oakland	2016	0	3	n/a
2016 Civil Disorder–*A rally of left-wing protesters and white nationalist groups outside the California State Capitol on June 26, 2016. Ten people were hospitalized for stabbing and laceration wounds.*	Sacramento	2016	0	10	n/a
2014 Oakland Riots–*A series of riots and civil disturbances following the decision of a Grand Jury in St. Louis not to charge Darren Wilson in the shooting death of black teenager Michael Brown in Ferguson, Missouri.*	Oakland	2014			n/a
2013 Oakland Riots–*Riots that occurred when protesters took to the streets on July 13, 2013, following the acquittal of George Zimmerman in the shooting death of Trayvon Martin.*	Oakland	2013	0	2	n/a
2012 Anaheim Police Shootings and Protests–*Two fatal shootings by police officers and subsequent public protests.*	Anaheim	2012	0	6	n/a
2011 Occupy California Protests–*Protests in 50 large and small cities and college campuses, along with 50,000 people participants in Occupy Oakland.*	Various	2011	0	1	$2.4 million
1992 Los Angeles Riots–*Riots that lasted six days and were a response to the acquittal of police officers for the beating of Rodney King*.	South Los Angeles	1993	50	Over 2,000	More than $1.0 billion
1965 Watts Riots–*ace riots that took place in the Watts neighborhood of Los Angeles.*	South Central Los Angeles	1965	34	1,032	$40 million