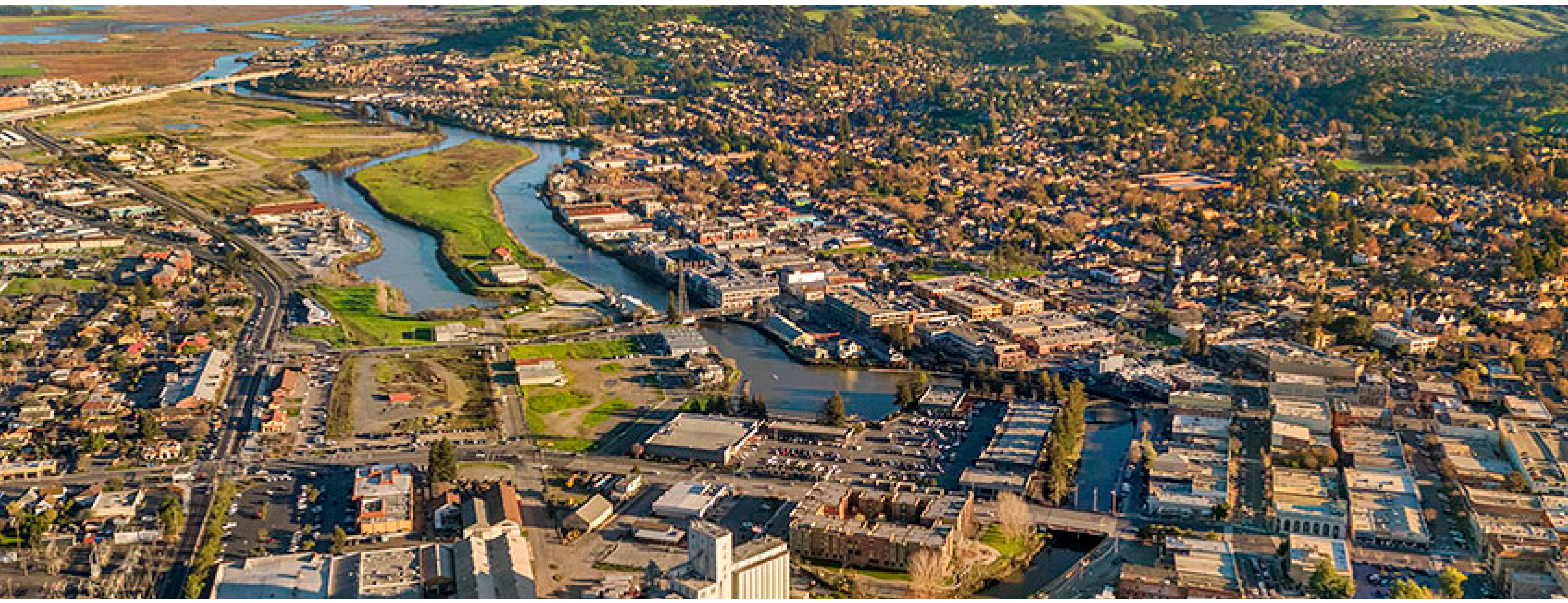
City of Petaluma

Local Hazard Mitigation Plan



Final Plan Update | November 2020

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Executive Summary

The purpose of hazard mitigation is to reduce or eliminate long-term risk to people and property from hazards. The City of Petaluma developed this Local Hazard Mitigation Plan (LHMP) update to make the City and its residents less vulnerable and more resilient to future hazard events. This plan was prepared pursuant to the requirements of the Disaster Mitigation Act of 2000 so that Petaluma would be eligible for the Federal Emergency Management Agency's (FEMA) Pre-Disaster Mitigation and Hazard Mitigation Grant programs.

The City followed a planning process prescribed by FEMA, which began with the formation of a hazard mitigation planning committee (HMPC) comprised of key City representatives, and other regional stakeholders. The HMPC conducted a risk assessment that identified and profiled hazards that pose a risk to the City of Petaluma, assessed the City's vulnerability to these hazards, and examined the capabilities in place to mitigate them. The City is vulnerable to several hazards that are identified, profiled, and analyzed in this plan. Floods, wildfires, severe weather, and earthquake hazards are among the hazards that can have a significant impact on the City.

Based on the risk assessment review and goal setting process, the HMPC identified the following five goals, which provide the direction for reducing future hazard-related losses within the City of Petaluma Planning Area:

- **Goal 1:** Minimize loss of life,property and economic damage, and protect people and property from hazards;
- **Goal 2:** Preserve and protect Petaluma's natural environment as an efficient resource to build;

  community resilience against natural hazards;
- **Goal 3:** Educate and build community awareness on natural hazard risks and the importance of resiliency and emergency preparedness;
- **Goal 4:** Enhance City staff coordination, training, and response during disasters and ensure City facilities and infrastructure are operational and provide safe places for the community to shelter during hazard events; and
- **Goal 5**: Implement and regularly update the LHMP as an integrated planning mechanism to prepare the City for natural, human-caused, and climate change-related hazards.

To meet identified goals, the plan recommends 34 mitigation actions, which are summarized in the table that follows. This plan has been formally adopted by the City and will be updated every five years at a minimum.

Table ES.1: Mitigation Action Summary Table

Mitigation Action Title	Priority	Addresses Current Development	Addresses Future Development
Dam Incidents			
Assess downstream impacts associated with dam incidents	Low	X	X
Drought			
Groundwater supply augmentation for drought resiliency	Medium	X	X
Sustainable Groundwater Management Planning	Low	X	X
Cyber Threats			
Develop a Water Infrastructure Vulnerability Risk and Resilience Plan and Emergency Response Plan that addresses cyber sufficiency	Low	X	X
Earthquake			
Implement Seismic Retrofits at Petaluma Historic Library and Museum	Medium	X	
Seismic Retrofit Analysis of City buildings	High	X	
Flooding			
Enhance structural flood mitigation projects to reduce near annual floods on north end of City	High	X	X
Floodplain property protection, acquisition, and relocation	Low	X	
Continue annual stream and creek channel maintenance	Low	X	X
Higher Regulatory Standards for Flood Protection	Medium	X	X
Improve National Flood Insurance Program Community Rating System Class Rating	Medium	X	X
Hazardous Material Releases			
Evacuation Planning	Low	X	X
Sea Level Rise			
Explore natural protection with wetland enhancement, marshland protection, and restoration project implementation in the Petaluma River and San Pablo Bay transition zone	Low	X	X
Continue Petaluma River Dredging Program to enhance flood resilience	Medium	X	X
Open space preservation in areas prone to sea level rise along the Petaluma River	Medium	X	X

Mitigation Action Title	Priority	Addresses Current Development	Addresses Future Development
Map and assess vulnerability to sea level rise and integrate the information with the City GIS mapping capabilities to educate the community and help them gain awareness of the potential impacts and actions the City is taking to plan and adapt	Medium	X	X
Assess sea level rise modelling for use in the LHMP and how those projections can be routinely re-evaluated in subsequent climate adaptation planning efforts	Low	X	X
Update City Implementing Zoning Ordinance (IZO) to manage development in high risk areas	Low	X	X
Severe Weather: Heavy Rains/Thunderstorms/Hail/Lightning/Dense Fog			
Replace aging generator and plan for severe weather by obtaining backup generators at City critical facilities, including the Communications Center	Medium	X	
Severe Weather: Extreme Heat			
Establish a resiliency hub at City Community Center to be used during severe weather events involving heat waves and wildfires	Medium	X	X
Severe Weather: High Wind			
Enhance local building code to incorporate wind-resistant design features that address high wind hazards	Low	X	X
Develop a PSPS toolkit for local businesses	Low	X	X
Wildfire			
Defensible space funding program	Medium	X	X
Develop a City-wide Fire Suppression Master Plan	Medium	X	X
Evaluate the WUI Zone in the City Limits	Medium	X	X
Install Fire Protection System in all City facilities	Medium	X	
Wildland Urban Interface Pre-Fire Plan	High	X	X
Multi-Hazard			
Evacuation Alert and Warning System and Periodic Testing	High	X	X
Periodically assess the need for new or relocated fire or police stations and other emergency facilities, changes in staffing levels, and need for supplies, equipment, technologies, and in-service training classes	Low	X	
Develop and maintain a system of interoperable communications for first responders from local, state, and federal agencies	High	X	X

Mitigation Action Title	Priority	Addresses Current Development	Addresses Future Development
Update the City Emergency Operations Plan	High	X	X
Emergency Operations Center replacement and upgrades	High	X	X
Expand Community Emergency Pre Program	Low	X	X
Community Emergency Preparedness Webpage	Low	X	X

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Acronyms

ABAG	Association of Bay Area Governments
APG	Adaptation Planning Guide
ASCE	American Society of Civil Engineers
AWIA	America Water Infrastructure Act
BAAQMD	Bay Area Air Quality Management District
BCM	Basin Characterization Model
BFE	Base Flood Elevation
CAC	Climate Action Commission
CalARP	California Accidental Release Prevention Program
Cal FIRE	California Department of Forestry and Fire Protection
Cal OES	California Office of Emergency Services
CBC	California Building Code
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CDPH	California Department of Public Health
CEQA	California Environmental Quality Act
CERT	Community Emergency Response Team
CIS	Community Information System
COPE	Citizens Organized to Prepare for Emergencies
CoSMoS	Coastal Storm Modelling System
CRHR	California Registry of Historic Resources
CUPA	Certified Unified Program Agency
CWD	Climate Water Deficit
CWPP	Community Wildfire Protection Plan
DHS	Department of Health Services
DOF	Department of Finance
DOT	Department of Transportation
DTSC	Department of Toxic Substances Control
DWR	Department of Water Resources
EAP	Emergency Action Plan
EIR	Environmental Impact Report

EOC	Emergency Operations Center
EOP	Emergency Operations Plan
ERP	Emergency Response Plan
FEMA	Federal Emergency Management Agency
FHSZ	Fire Hazard Severity Zone
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMP	Floodplain Management Plan
FRAP	Fire and Resource Assessment Program
GCM	Global Climate Model
GIS	Geographic Information Systems
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HMBP	Hazardous Materials Business Plan
HMPC	Hazard Mitigation Planning Committee
HSC	Health and Safety Code
IBC	International Building Council
ICC	International Code Council
IPCC	Intergovernmental Panel on Climate Change
IVT	Integrated Water Vapor Transport
IZO	Implementing Zoning Ordinance
LAL	Lightning Activity Level
LHMP	Local Hazard Mitigation Plan
LOMA	Letter of Map Amendment
LOMR	Letter of Map Revision
LRA	Local Responsibility Area
MDD	Maximum Daily Demand
NBRP	North Bay Reuse Program
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NFHL	National Flood Hazard Layer
NOAA	National Oceanic Atmospheric Association

NPMS	National Pipeline Mapping System
NRC	National Response Center
NRHP	National Registry of Historic Places
NWS	National Weather Service
OPC	Ocean Protection Council
OSHA	Occupational Safety and Health Administration
PG&E	Pacific Gas and Electric
PRC	Public Resources Code
PSPS	Public Safety Power Shutoff
RCPA	Regional Climate Protection Authority
RCRA	Resource Conservation and Recovery Act
RGMS	Residential Growth Management System
RMP	Risk Management Plan
RTK NET	Right-to-Know Network
SBA	Small Business Administration
SCAPOSD	Sonoma County Agricultural Preservation and Open Space District
SFHA	Special Flood Hazard Area
SGMA	Sustainable Groundwater Management Agency
SHMP	State Hazard Mitigation Plan
SLR	Sea Level Rise
SRA	State Responsibility Area
STAPLEE	Social, Technical, Administrative, Political, Legal, Economic, Environmental
UGB	Urban Growth Boundary
URM	Unreinforced Masonry
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UWMP	Urban Water Management Plan
WERC	Western Ecological Research Center
WRCC	Western Regional Climate Center
WRFP	Water Recycling Funding Program

WSCP	Water Shortage Contingency Plan
WUI	Wildland Urban Interface

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1 Introduction

The City of Petaluma prepared this Local Hazard Mitigation Plan (LHMP) to guide planning efforts to better protect the people and property of the City from the effects of hazardous events. It serves as a tool to help decision makers direct mitigation activities, to coordinate city resources, and to be eligible for State and Federal funding. This plan updates the City's previous hazard mitigation plan that was developed as part of a regional effort. This plan also demonstrates the City's commitment to reducing risks from hazards to the community.

1.1 Background and Scope

Each year in the United States, natural disasters take the lives of hundreds of people and injure thousands more. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. These monies only partially reflect the true cost of disasters because additional expenses to insurance companies and nongovernmental organizations are not reimbursed by tax dollars. Many natural disasters are predictable, and much of the damage caused by these events can be alleviated or even eliminated.

Hazard mitigation is defined by FEMA as "any sustained action taken to reduce or eliminate long-term risk to human life and property from a hazard event." The results of a three-year, congressionally mandated independent study to assess future savings from mitigation activities provides evidence that mitigation activities are highly cost-effective. On average, each dollar spent on hazard mitigation saves society an average of $6 in avoided future disaster costs (National Institute of Building Sciences 2018).

Hazard mitigation planning is the process through which hazards that threaten communities are identified, likely impacts of those hazards are determined, mitigation goals are set, and appropriate strategies to lessen impacts are determined, prioritized, and implemented. This plan documents the City of Petaluma's hazard mitigation planning process and identifies relevant hazards and vulnerabilities and strategies the City will use to decrease vulnerability, and increase resiliency and sustainability in Petaluma.

1.2 Previous Plan

In 2005 the Association of Bay Area Governments (ABAG) prepared a regional multi-jurisdictional LHMP for the San Francisco Bay Area referred to as *Taming Natural Disasters.* In 2010 the plan was updated and covered numerous jurisdictions in the Bay Area consisting of seven counties, 76 cities including the City of Petaluma, five school districts, 12 transit agencies, 13 water districts, and five special-purpose districts. The goal of the regional multi-jurisdictional LHMP was to maintain and enhance a disaster-resistant region by reducing the potential loss of life, property damage, and environmental degradation from natural disasters, while accelerating economic recovery from those disasters. The City participated in the original plan and update by preparing an annex that was approved by FEMA and adopted by resolution in 2012 by the Petaluma City Council as the City of Petaluma 2010 LHMP Annex. Today ABAG is no longer managing the update of the multi-jurisdictional LHMP and the 2010 *Taming Natural Disasters* plan has expired.

The City's 2019 LHMP supersedes the 2010 LHMP Annex prepared by ABAG. This new LHMP is a single jurisdictional stand-alone plan for the City of Petaluma that geographically covers everything within the City of Petaluma's jurisdictional boundaries and its Urban Growth Boundary (UGB) (hereinafter referred to as the Planning Area). The single jurisdictional and stand-alone plan is tailored to better suit the needs and capabilities of the City and their planning partners. The updated 2019 LHMP differs from the 2010 ABAG plan as follows:

- The single jurisdictional and stand-alone plan focuses only on the City of Petaluma rather than being a subset of a larger regional and multi-jurisdictional planning effort.
- The risk assessment addresses natural and human-caused hazards specific to the City and includes a vulnerability assessment that evaluated property within the City's Planning Area, critical facilities and infrastructure, and City-owned facilities and infrastructure, specifically water and wastewater systems.
- The plan integrates best available data and tools, including information on climate change impacts and sea level rise in a detailed risk and vulnerability assessment.
- The planning process was aligned with FEMA's National Flood Insurance Program (NFIP) Community Rating System (CRS) in order to maximize credits, improve the City's CRS rating, and ultimately reduce flood insurance premiums.
- The City and planning committee participants (referred to as the Hazard Mitigation Planning Committee) collaborated and involved the public through a coordinated outreach strategy targeted for both socially vulnerable and disadvantaged communities. The planning process involved the circulation of two online public surveys to better understand the community's perception of natural and human-caused hazard risks and to engage and solicit input on risk reduction through mitigation actions for the whole community.
- The planning process involved review of mitigation activities and strategies identified in various City planning documents, such as the 2025 General Plan, 2015 Floodplain Management Plan, and 2010 LHMP Annex.
- The plan includes a more detailed and tailored mitigation action strategy than the previous 2010 ABAG plan.
- The City and planning committee identified specific mitigation actions that are best suited for the City of Petaluma and can be funded under HMA grants and state funding programs in order to meet multiple objectives.

1.3 Regulatory Authority

1.3.1 Federal

This plan was prepared pursuant to the requirements of the Disaster Mitigation Act of 2000 (Public Law 106-390) and the implementing regulations set forth by the Interim Final Rule published in the Federal Register on February 26, 2002, (44 CFR §201.6) and finalized on October 31, 2007. (Hereafter, these requirements and regulations will be referred to collectively as the Disaster Mitigation Act or DMA of 2000.) The DMA of 2000, also commonly known as "The 2000 Stafford Act Amendments," constitutes an effort by the Federal government to reduce the rising cost of disasters. The Act stresses the importance of coordinated mitigation planning and disaster preparedness prior to an event and emphasizes the need for mitigation planning.

Section 322 of the regulations established the requirements that LHMPs must meet in order for a local jurisdiction to be eligible for certain Federal disaster assistance and hazard mitigation funding under the Robert T. Stafford Disaster Relief and Emergency Act (Public Law 93-288). To facilitate implementation of the DMA 2000 and the Stafford Act Amendments, FEMA created an Interim Final Rule (the Rule), published in the Federal Register in February of 2002 in Section 201 of 44 CFR (44 CFR §201.6). The Rule spells out the mitigation planning criteria for States and local communities.

In March 2013 FEMA released *The Local Mitigation Planning Handbook* (Handbook) as the official guide for local governments to develop, update and implement local mitigation plans. The Handbook complements and references the October 2011, *FEMA Local Mitigation Plan Review Guide* (Guide) in order to help "Federal and State officials assess Local Mitigation Plans in a fair and consistent manner." Local jurisdictions must demonstrate that proposed mitigation actions are based upon a sound planning process that accounts for the inherent risk and capabilities of the individual communities as stated in Section 201.5 of the Rule. The Handbook and Guide were routinely reviewed during the development of the City's 2019 LHMP for the purpose of ensuring thoroughness, diligence, and compliance with the DMA of 2000 planning requirements. The City also reviewed the Adaptation Planning Guide (APG) among other state-focused planning guides to information the climate vulnerability assessment and development of climate-specific adaptation goals and strategies.

This plan was also developed so the City can be eligible for certain federal disaster assistance, specifically, the FEMA Hazard Mitigation Assistance (HMA) grants including the Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM) program, and the Flood Mitigation Assistance (FMA) program. Additional FEMA mitigation funds include the HMGP Post Fire funding associated with Fire Management Assistance Grant (FMAG) declarations and the Building Resilient Infrastructure and Communities (BRIC) funding associated with the 2018 Disaster Recovery Reform Act (DRRA).

1.3.2 State and Local

During the development of the City's LHMP, City staff initiated a review of their 2025 General Plan Health and Safety Element to ensure consistency with hazards and mutually reinforcing policies. Following approval of the City's LHMP, the City intends to formally update the City's 2025 General Plan Health and Safety Element. In addition to following the DMA requirements the development of the 2019 LHMP addressed California Government Code Section 65302 (g) and the following State of California legislation requirements that relate to the General Plan and LHMP:

- Senate Bill (SB) 379 requires inclusion of climate adaptation strategies in the General Plan Safety Element and encourages a climate change discussion in LHMP updates;
- SB 1000, the Planning for Healthy Communities Act requires environmental justice and social equity considerations in the General Plan update upon the next revision of two or more elements concurrently on or after January 1, 2018 or the next revision of a LHMP; these considerations were addressed in the social vulnerability and disadvantaged communities summary of the community profile in Chapter 2 and again in the mitigation action prioritization criteria detailed in Chapter 5.
- Assembly Bill (AB) 2140 requires adoption by reference or incorporation of the LHMP into the Safety Element of the General Plan, following LHMP approval.

Information in this plan will be used to guide and coordinate mitigation activities and decisions for local land use policy in the future. Proactive mitigation planning will help reduce the cost of disaster response and recovery to communities and their residents by protecting critical community facilities, reducing liability exposure, and minimizing overall community impacts and disruptions. The City of Petaluma's Planning Area has been affected by hazards in the past and is committed to reducing future impacts from hazard events, building community resilience to future disasters, and becoming eligible for mitigation-related federal funding.

1.4 Plan Organization

The City of Petaluma's LHMP is organized as follows:

- Chapter 2: Community Profile
- Chapter 3: Planning Process
- Chapter 4: Risk Assessment
- Chapter 5: Mitigation Strategy
- Chapter 6: Plan Adoption
- Chapter 7: Plan Implementation and Maintenance
- Appendices

2 Community Profile

The City of Petaluma is located approximately 40 miles north of San Francisco. Petaluma is a unique community, geographically defined by the surrounding hillsides and a reputation for maintaining a "small town" atmosphere as the City has grown in population.

Today the City's proximity to the San Francisco Bay Area and the well-preserved historic downtown continues to make it an attractive place for home buyers. Petaluma has experienced steady growth since suburbanization in the 1950s and the adoption of the Urban Growth Boundary (UGB). In 2018 The City's population was projected to reach 62,700 in four years, making Petaluma the seventh-fastest growing city of Sonoma County's nine major cities (Sonoma County 2018).

2.1 Location and Geography

The City of Petaluma is located at the southern end of Sonoma County. The City is comprised of 13.9 square miles of land and one-tenth of a square mile of water consisting mostly of the Petaluma River. U.S. Highway 101 bisects the City easily connecting locals and visitors to the surrounding Bay Area region.

Petaluma's boundaries have been defined mostly by the surrounding natural landscape. The City is within the Petaluma River Valley, which is defined by Sonoma Mountain to the northeast and hills extending from Burdell Mountain on the west (City of Petaluma 2012). The City is surrounded by the unincorporated communities of Penngrove to the north and Lakeville to the south.

The City was built on the northern banks of the navigable end of the Petaluma River, a tidal estuary that flows south to the San Pablo Bay.

2.2 Land Use Distribution

The City of Petaluma's land use pattern has been defined by historical growth and land use regulations (City of Petaluma 2012). In 1998, Petaluma voters approved a 20-year UGB as part of Measure I. In 2010, voters approved the expansion of the UGB to include an additional 330 acres and extended the UGB until December 31, 2025. According to the City's revised 2012 General Plan (2025 General Plan) the UGB has not affected growth management numbers but did confine the growth and physical development of the City until 2018. The Hazard Mitigation Planning Committee (HMPC) selected the UGB as the Planning Area for this plan because it represents the City's boundaries at the planned buildout. This Planning Area is shown in Figure 2-1.

It should be noted that the "planning area" defined in the Local Hazard Mitigation Plan (LHMP) is different than the "planning area" defined in the City's General Plan. State law allows cities to identify a planning area during their General Plan process. This is typically an area outside of city boundaries and generally outside the UGB. It is designed to act as a signal to the County and other nearby local authorities that Petaluma recognizes that development may occur within these areas. The most common land use classification in the City of Petaluma is residential with 50 percent of parcels being designated as residential single-family homes. The remaining land uses include primarily mixed-use, business parks and commercial (17 percent), multifamily (1 percent), open space (8 percent), education (3 percent), and agricultural (1 percent). A detailed breakdown of land use in the City is summarized in Table 2-1. These land uses are shown in Figure 2-2.

Table 2-1: City of Petaluma Land Uses by Acreage

Land Use Description	Acres	Percentage of Total
Right of Way Private	0.62	0.01%
Agriculture Support Industrial (CPSP)	7.91	0.09%
Proposed City Park	44.64	0.50%
Agriculture	46.13	0.52%
Right of Way	46.30	0.52%
River Dependent Industrial (CPSP)	47.95	0.54%
Neighborhood Commercial	91.59	1.04%
High Density Residential (18.1-30.0 hu/ac)	97.93	1.11%
Mobile Homes (8.0-18.0 hu/ac)	117.29	1.33%
Floodway	136.46	1.54%
Industry	180.56	2.04%
Community Commercial	198.36	2.24%
City Park	242.42	2.74%
Regional Park	255.93	2.89%
Rural Residential (0.1-0.5 hu/ac)	268.21	3.03%
Education	268.22	3.03%
Medium Density Residential (8.1-18.0 hu/ac)	360.62	4.08%
Diverse Low Density Residential (6.1-12.0 hu/ac)	369.39	4.18%
Business Park	516.09	5.84%
Mixed Use	536.55	6.07%
Very Low Density Residential (0.6-2.0 hu/ac)	568.87	6.43%
Open Space	737.72	8.34%
Public/Semi-Public	1,182.87	13.38%
Low Density Residential (18.1-30.0 hu/ac)	2,518.26	28.48%
Total	8,840.89	100%

Source: City of Petaluma 2019

Figure 2-1: City of Petaluma Planning Area

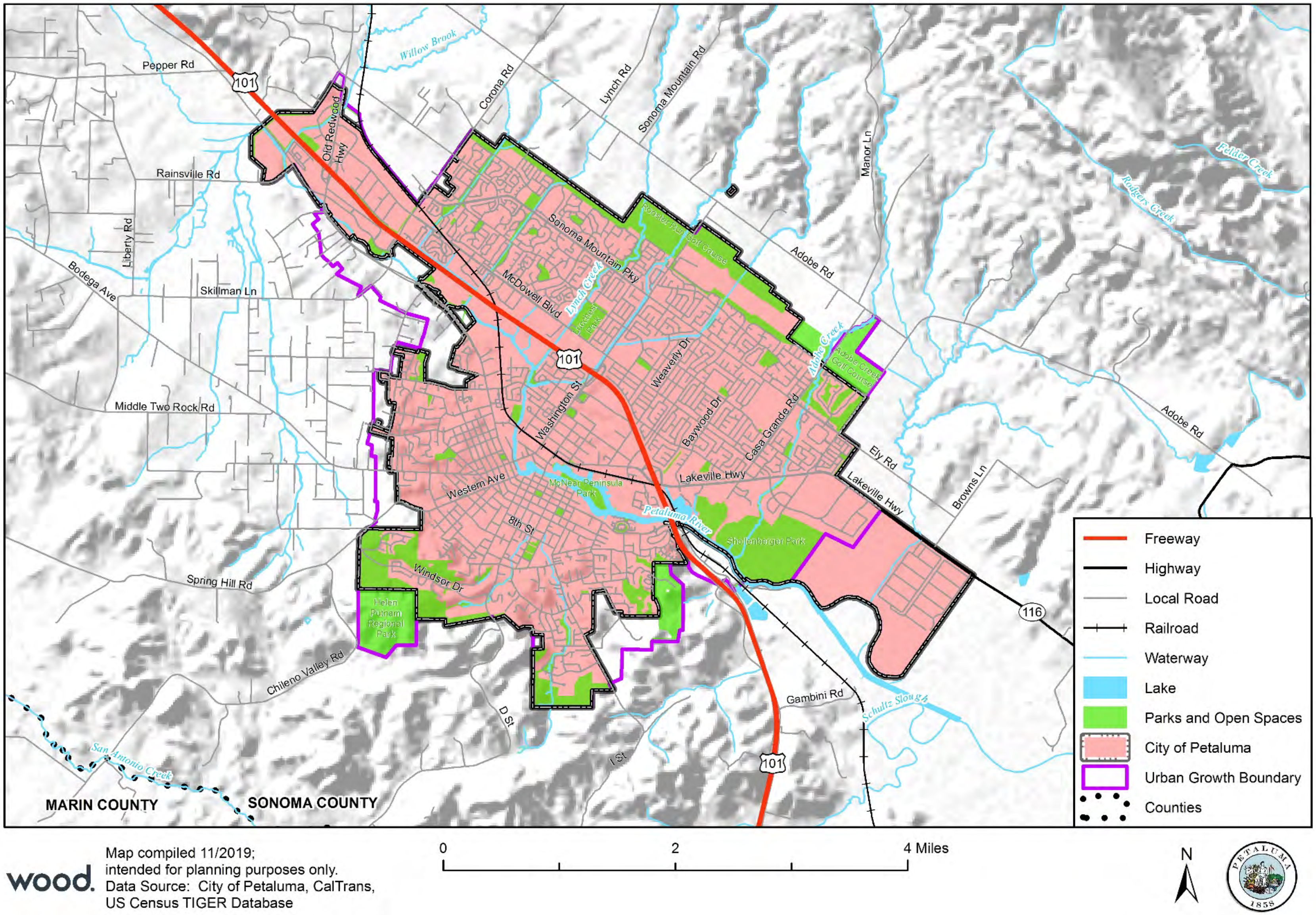
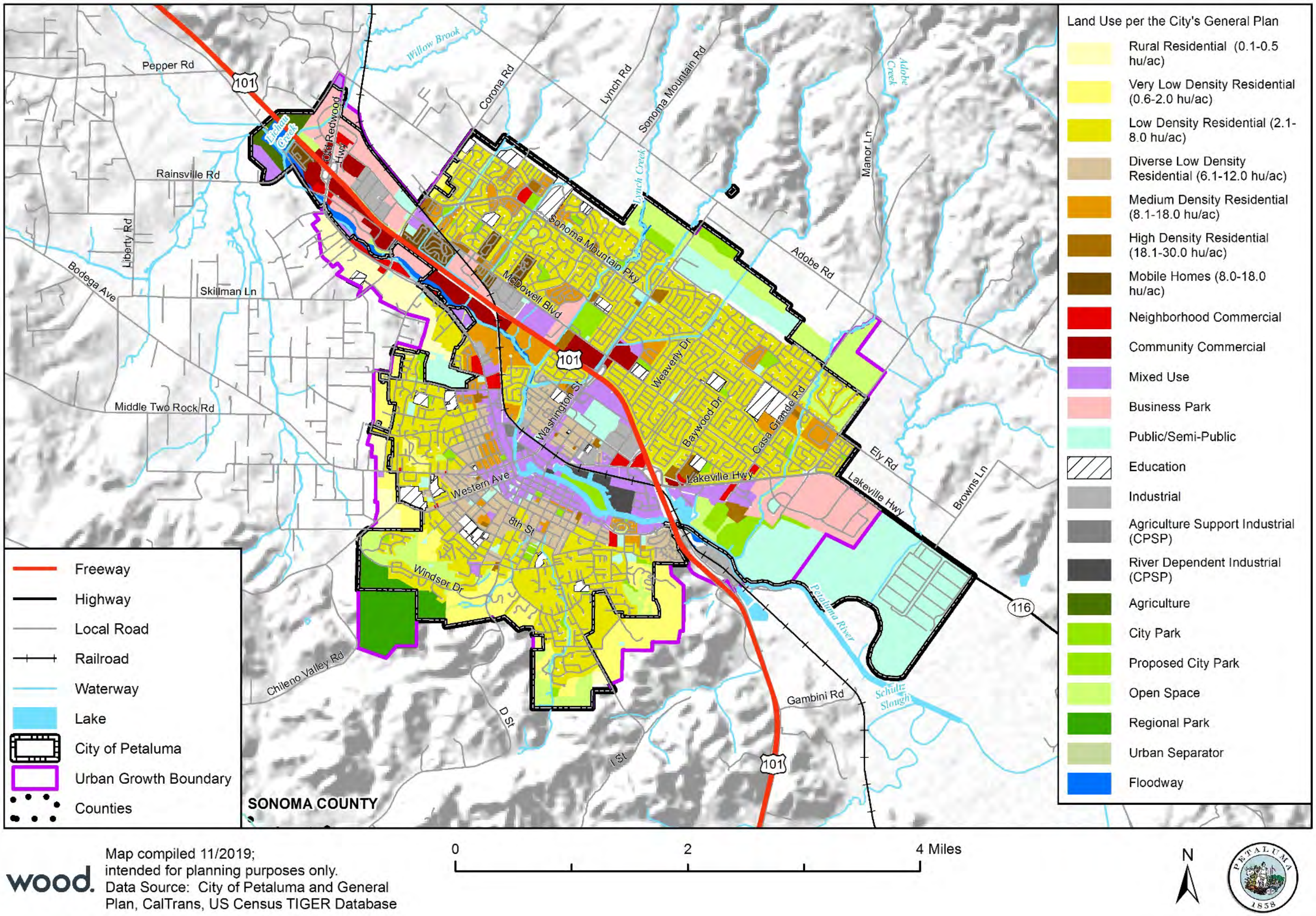


Figure 2-2: City of Petaluma Land Use Distribution



2.3 History

The Coast Miwok originally inhabited the area of modern day Petaluma and southern Sonoma County. The name "Petaluma" is a transliteration of the Coast Miwok phrase "péta lúuma," which means hill backside and was the original name of a Miwok village located east of the Petaluma River near the present day borders of the City. The City and the prominent waterways were also an attractive place for Mexican settlers in the early 1800s, and later settlers from Europe, Asia, and the Middle east in the mid-1800s.

In 1850 a group of hunters established a primitive hunting camp on the west of bank of the Petaluma River. The camp quickly developed along the Petaluma River and became a trading post for the growing San Francisco area. After incorporation of the City in 1858, downtown Petaluma began to develop along the southwest bank of the Petaluma River, along what is now Petaluma Boulevard North (City of Petaluma 2012). With the arrival of the railroad in 1870 the City became a thriving commerce center for the region. Agriculture dominated as an industry not only in Petaluma but throughout Sonoma County. By 1908, 75 percent of the county's population raised poultry (Visit Petaluma 2017). By the end of World War I, the City's egg industry was in trouble and in 1918 the City's Chamber of Commerce hired a well-known Public Relations consultant to rebrand Petaluma as "The World's Egg Basket" leading to a surge in industry until the 1940s when cost of production became too high for many farmers.

In 1937 with the completion of the Golden Gate Bridge, the City transformed into a bedroom community and experienced the post-World War II suburbanization similar to many small U.S. communities during that time. The completion of U.S. Highway 101 in the 1950's provided quick access to San Francisco which led to the arrival of families and the continued growth of Petaluma. In this timeframe residential and commercial areas expanded east of U.S. Highway 101. The City's proximity to the San Francisco Bay Area has consistently made it an attractive place for home buyers and the City has experienced steady growth since suburbanization in the 1950s.

The City of Petaluma was not impacted by the 1906 San Francisco Earthquake that devasted neighboring communities but served as a refuge for evacuees and survivors (Sommer 2017). Because of this many well-preserved historic buildings still exist in the Petaluma's downtown including several theaters and opera houses. Historic preservation of these building continues to be a priority for the City of Petaluma.

2.4 Demographics

Comprehensive data on the City of Petaluma's demographics was obtained from the U.S. Census Bureau's American Community Survey (ACS) five-year estimates (2013-2017) and the California Department of Finance population estimates.

2.4.1 Population and Growth Projections

Between 2010 and 2018 the population of Petaluma increased by 4,310 persons (6.8 percent) (DOF 2019) as shown by Table 2-2 reported by the California Department of Finance Population Estimates. During the same time period, the state of California population increased by 6.2 percent and Sonoma County's population increased by 3.7 percent. This growth trend demonstrates that the City of Petaluma has grown at approximately the same pace State and slightly faster than the surrounding region (US Census 2010; California DOF 2018).

The Sonoma County Economic Development Board is projecting the City of Petaluma will grow by 3.2 percent by 2022, outpacing the state and nation in five-year growth projections. The City's General Plan buildout estimates an additional 15,500 residents in the City by 2025.

The key land use changes noted in the City's General Plan buildout are increases in residential and mixed-use land areas. The City is estimating the buildout will result in 6,000 additional housing units for a total of 27,949 units, a 27 percent increase in housing units in the City (City of Petaluma 2012). The nonresidential growth is projected to increase by 36 percent with the addition of 6.1 million square feet of non-residential space and 23 million square feet of non-residential floor area by 2025 (City of Petaluma 2012).

Table 2-2: City of Petaluma Populations Changes (counts), 2010-2019

Year	Total Population
2019	62,247
2018	62,251
2017	61,124
2016	60,757
2015	60,237
2014	59,829
2013	59,241
2012	58,412
2011	58,123
2010	57,941

Sources: California DOF 2019

Table 2-3 breaks down Petaluma's demographics for select characteristics.

Table 2-3: City of Petaluma's Demographic and Social Characteristics, 2013-2017

Characteristic	
Gender/Age	
Median Age	41.8
Male, percentage	48.8%
Female, percentage	51.2%
Under 5 Years, percentage	5.6%
Under 18 Years, percentage	21.8%
65 Years and Over, percentage	16.1%
Race/Ethnicity	**Percentage**
White	78.8%
Hispanic or Latino (Any Race)	21.6%
Asian	6.2%
Some Other Race	12.4%
Black or African American	1.3%
American Indian/Alaska Native	1.3%
Native Hawaiian and Other Pacific Islander	0.6%
Education**	**Percentage**
High School Graduate or Higher	88.6%

Characteristic	
Bachelor's Degree or Higher	37.9%

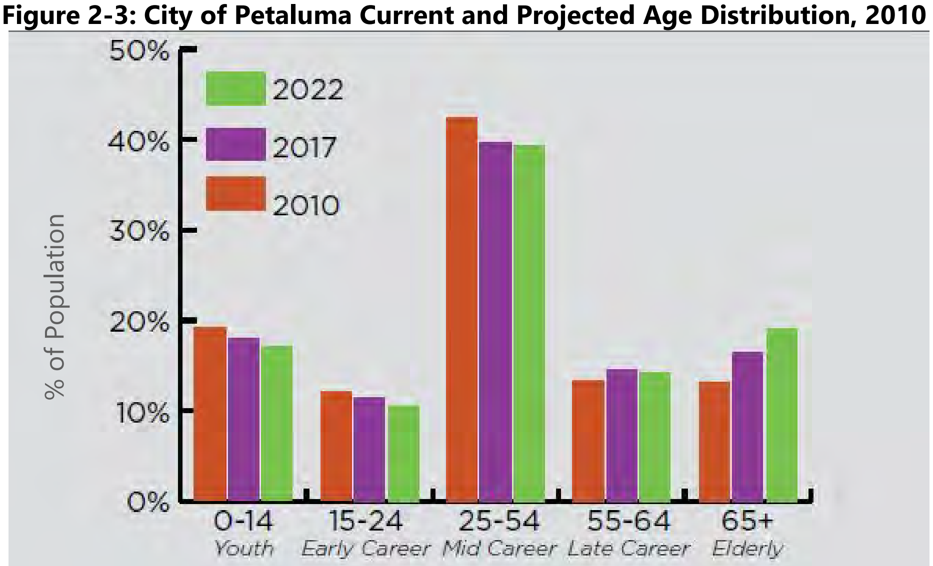
Source: U.S. Census Bureau American Community Survey, 2013-2017, www.census.gov/

**California DOF estimates

2.4.2 Age

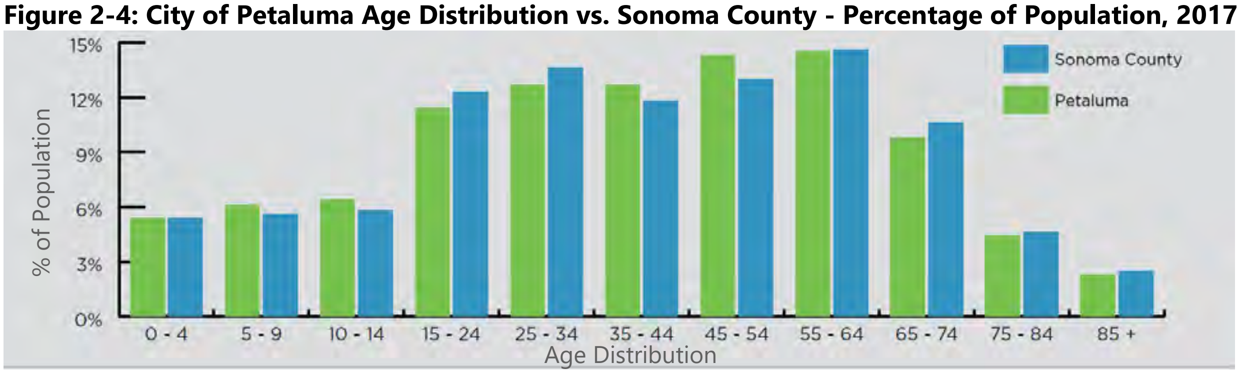
As noted in Table 2-3, the median age of Petaluma residents was 41.8 years old in 2017. According to the 2018 Petaluma City Profile Report from the Sonoma County Economic Development Board, Petaluma is ranked fifth of the County's nine incorporated cities in terms of age, and older than the median age of California (36). The City's labor force is older than the state but younger than the county overall. The City is projected to continue to age with the greatest increase by 2022 being individuals 65 years and older. Figure 2-3 and Figure 2-4 show the age distribution as of 2017 and projected for 2022.

Figure 2-3: City of Petaluma Current and Projected Age Distribution, 2010 – 2022



Source: Petaluma City Profile Report, Sonoma County Economic Development Board 2018

Figure 2-4: City of Petaluma Age Distribution vs. Sonoma County - Percentage of Population, 2017



Source: Petaluma City Profile Report, Sonoma County Economic Development Board 2018

2.4.3 Housing

Housing tenure for City of Petaluma was also obtained through the U.S. Census Bureau ACS and shows the majority of residents live in a home they own. Table 2-4 breaks down the differences in housing tenure.

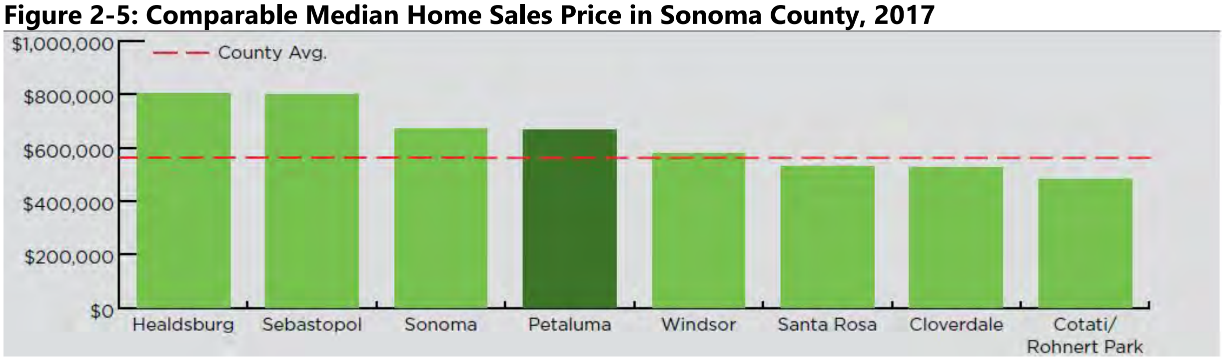
Table 2-4: City of Petaluma Housing Tenure, 2013-2017

Characteristic	Estimates
Occupied Housing Units	22,202
Owner Occupied	14,671
Renter Occupied	7,531

Source: U.S. Census Bureau American Community Survey, 2013-2017, www.census.gov/

Median home prices in the City of Petaluma as of 2017 was $667,750, which is $91,750 (or around 15.9%) higher than the County's median home sales of $576,000. Of the nine incorporated communities in Sonoma County, Petaluma has the fourth highest median home sale price in the county. In the past five years alone, Petaluma's median home sales prices have risen by 76 percent (Sonoma County 2018). Figure 2-5 compares Petaluma's median home sale prices to the other incorporated communities in Sonoma County.

Figure 2-5: Comparable Median Home Sales Price in Sonoma County, 2017



Source: 2018 Petaluma City Profile Report, Sonoma County Economic Development Board

The City of Petaluma Housing Department also manages an affordable housing program that has built or improved 1,336 housing units for low income families, which equates to 22 percent of all housing units built in the City over the past 15 years (City of Petaluma 2019). This program ensures affordable and stable housing services are provided to a broad spectrum of the community's low and moderate-income residents.

2.4.4 Race and Ethnicity

Table 2-5 shows the comparative demographic estimates between 2008 and 2017. The racial and ethnicity makeup of the City is similar to the County. Petaluma is less diverse in terms of race and ethnicity compared to the state.

Table 2-5: City of Petaluma Race and Ethnicity, 2008-2012 vs. 2013-2017

Race/Ethnicity	2008-2012			2013-2017		
	Petaluma	County	California	Petaluma	County	California
White	69.1%	66.3%	40.1%	69.4%	63.8%	37.9%
Black	1.4%	1.5%	5.8%	0.7%	1.4%	5.5%
American Indian and Alaska Native	0.7%	0.7%	0.4%	0.1%	0.5%	0.4%
Asian	5.6%	4.0%	13.0%	4.2%	3.9%	13.9%

Native Hawaiian and Other Pacific	0.3%	0.3%	0.4%	0.0%	0.3%	0.4%
Other	0.3%	0.2%	0.2%	1.3%	0.5%	0.2%
Hispanic	20.7%	24.8%	37.6%	21.6%	26.4%	38.8%

Source: U.S. Census Bureau American Community Survey, Comparative Demographic Estimates, 2008-2012 and 2013-2017 estimates,www.census.gov/

2.4.5 Income and Poverty

Individual households are commonly expected to use private resources and funds to prepare for, respond to and recover from disasters. This means that households living in poverty are disadvantaged when confronting natural and human-caused hazards. Households living in poverty may also occupy poorly built or inadequately maintained housing. These housing types may be more susceptible to damage in earthquakes or flood events than other types of housing. In urban areas, such as the City of Petaluma, households living in poverty may also live in older houses and multi-family housing that is constructed of un-reinforced masonry, a building type that is susceptible to damage during earthquakes. Further, residents living below the poverty level are less likely to have insurance to compensate for the losses incurred from natural disasters.

Persons under 18 years old in Petaluma can also be disproportionately affected by poverty. According to the 2013-2017 ACS data, 9.6 percent of the City's total residents under the age of 18 were living in poverty and 10.5 percent of the City's total residents under the age of 18 were living in poverty based on the 2018 ACS data (see Table 2-6 below), compared to the 5.7 and 6.0 percent of all families in the City, respectively. As shown in Table 2-6, the percentage of residents in poverty in Petaluma has decreased between 2008 and 2017, but gradually increased in 2018. The income brackets of $50,000 to $75,000 is estimated to shrink by 2.2 percent while the income bracket of $200,000 and more is estimated to grow by 2.1 percent by 2022 (Sonoma County 2018).

Table 2-6: City of Petaluma's Comparative Economic Characteristics, 2008, 2017, and 2018

	City of Petaluma		
Characteristic	**2008**	**2017**	**2018**
Families below Poverty Level	5.6%	5.7%	6.0%
All People below Poverty Level (under 18 years)	12.8%	9.6%	10.5%
All People below Poverty Level (18 years and over)	7.9%	8.5%	8.9%
Median Household Income	$82,259	$84,949	$87,708
Per Capita Income	37,450	40,784	$42,868
Population in Labor Force	70%	66.2%	66.3%
Population Employed*	64.8%	62.9%	63.0%
Unemployment	7.2%	3.3%	11.9%**

Source: U.S. Census Bureau American Community Survey, 2013-2017, obtained by California Office of Finance. 2018 ACS data added in July 2020.
*Excludes active duty armed forces

**Unemployment rate is based on June 19, 2020 data.

The City of Petaluma also had the second-highest median household income in the County as the average household income in 2017 was $84,949 and in 2018 increased to $87,708 according to the California Department of Finance. During the 2017, the median household income in Sonoma County at $71,769 while household incomes in nearby counties ranged higher from $104,703 to $79,637 (Marin and Napa counties). The median household income for the State in 2017 was $67,169 and the 11.1 percent of families were living below the poverty line (DOF 2019; U.S. Census Bureau ACS 2017). Based on this comparison, while the City of Petaluma has a higher median household income than the County and State, there are small segments of the City's population that are low income and disadvantaged, and in turn socially vulnerable and expected to be more susceptible to natural disasters and less likely to recover at the same pace as the rest of the community.

Additional demographic data and information on income, social vulnerability, and disadvantaged communities in the Petaluma Planning Area are summarized below in Section 2.5 Social Vulnerability. Information on growth is summarized in Section 2.8 Growth and Development Trends.

2.5 Social Vulnerability

Social vulnerability considerations were included in the development of this plan to identify populations across the City's Planning Area that might be more vulnerable to hazard impacts based on a number of factors. Hazard events can have very different impacts for different segments of a community, even if the hazard effects the entire City of Petaluma. The combination of socioeconomic status, household composition, physical disabilities, age, race and ethnicity, education level, primary language, housing, and transportation barriers can alter the way communities prepare for and respond to hazard events. For example, as stated in the previous section, families with lower household incomes may not be able to renovate their home to be more resilient to flooding and earthquakes, and as a result these households may be disproportionately affected by a flood or earthquake event. The elderly population may have limited mobility due to age and physical disabilities, which could lead to less accessibility during hazard events. It may also be more time-intensive for this population to receive hazard information and respond in the event of a hazard. Similarly, for those segments of the population where English is not their native language, it may take these individuals and families more time to prepare and respond during a hazard event.

The social vulnerability considerations in this plan cover household income, ethnicity, English proficiency, senior population, disabled population, single-parent households metrics. The considerations in this plan are broad in scope and are based on best available data and mapping information from the following source:

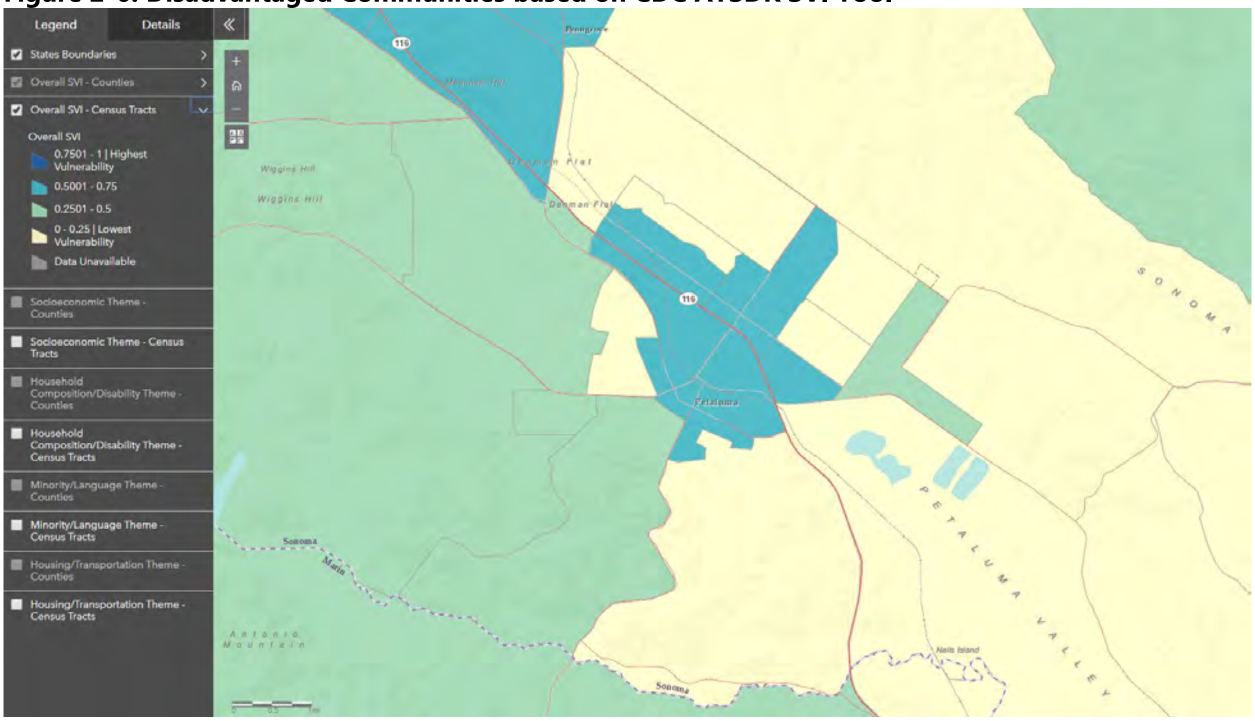
- Center for Disease Control's (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI).

CDC Agency for Toxic Substances and Disease Registry Social Vulnerability Index

A social vulnerability index (SVI) was developed by the Center for Disease Control's (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) and their Geospatial Research, Analysis & Services Program, as a way to portray communities' capacities to prepare for and respond to natural and man-made disasters. The SVI provides information on vulnerable populations to assist emergency response planners and public health officials in the identification of communities more likely to require additional support before, during, and after a hazardous event. The CDC's SVI includes county- and state-level maps that show relative vulnerability, provide key socially and spatially relevant information on communities' populations, and the maps compare the SVI based on Census Tracts. This SVI index combines four main themes of vulnerability: socioeconomic status; household composition and disability; minority status and language; and housing and transportation. The information from the SVI data informs the vulnerability of people, as qualitatively discussed in the vulnerability assessment for each hazard in Section 5.

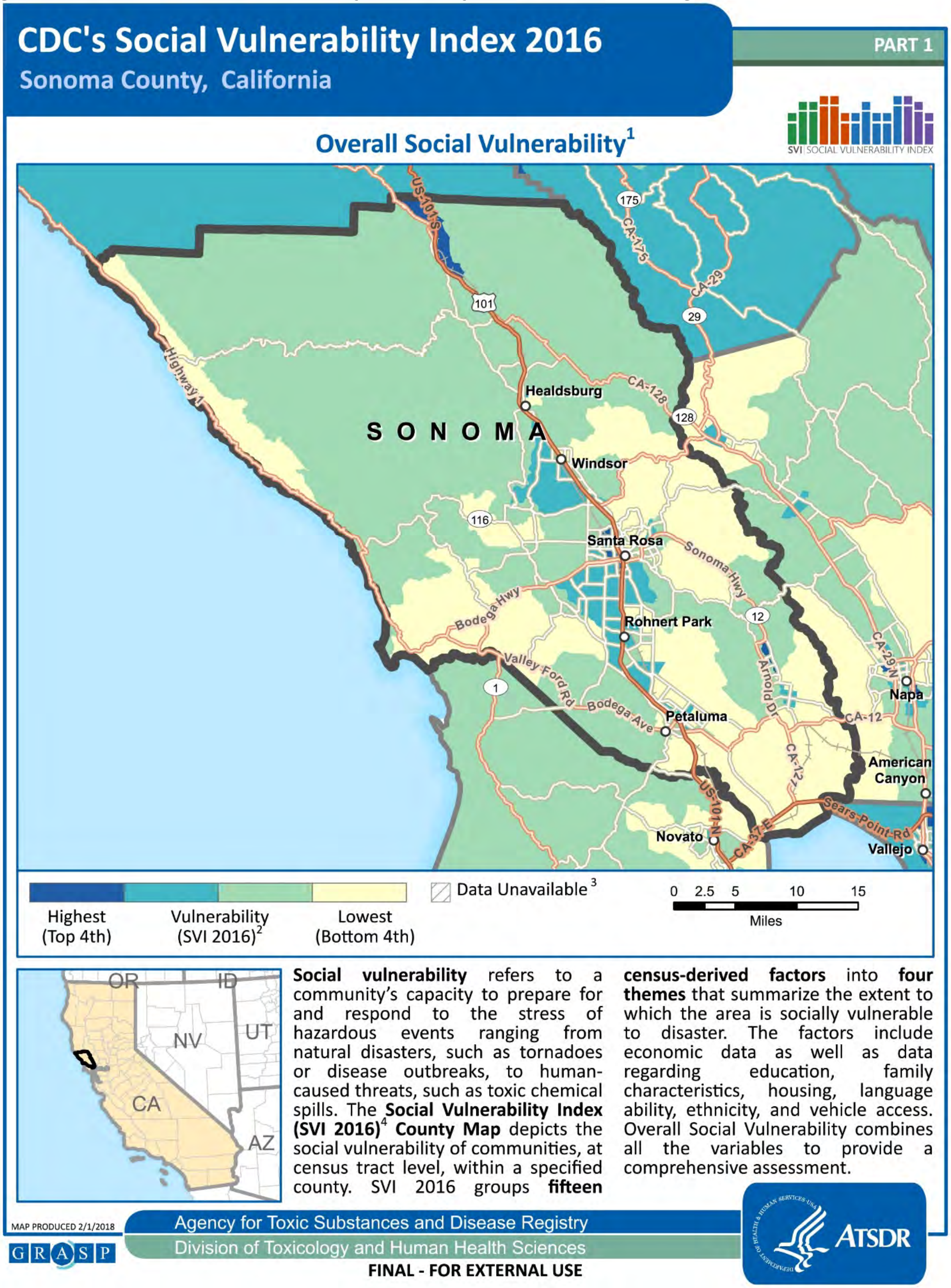
An overview of social vulnerability for the City's Planning Area is shown in Figure 2-6 based on CDC SVI data aggregated to Census Tracts. The SVI map depicts that within the City there is one census tract in the central portion with population with a higher vulnerability to disasters (in blue) and a portion of another census tract to the north with population with high vulnerability. The census tracts shaded in green and yellow have moderate to low vulnerability to disasters. The overall social vulnerability in the surrounding unincorporated portion of Sonoma County based on the SVI data is shown in Figure 2-7. Additional maps using the four main vulnerability themes of the SVI, including socioeconomic vulnerability, household composition and disability, minority status, language vulnerability, and housing and transportation are provided on the CDC's SVI online materials and maps at https://svi.cdc.gov/.

Figure 2-6: Disadvantaged Communities based on CDC ATSDR SVI Tool



Source: CDC ATSDR 2019

Figure 2-7: Overall Social Vulnerability in the City of Petaluma Planning Area based on SVI Data



2.5.1 Environmental Justice

Certain low-income residents, communities of color, and immigrant communities in California have disproportionately experienced greater environmental burdens and related health problems than other communities. The inequity is a result of many factors, including, but not limited to inappropriate zoning, discriminatory housing, limited political and economic power among certain demographics, and development patterns that tend to concentrate pollution in in certain communities (CEJA 2018). When combined with a lack of economic resources and unjust policy making, these residents and communities, also known as disadvantaged communities (DACs) or environmental justice (EJ) groups can face significant barriers to their overall health, livelihood, and resiliency to hazard events. With the support of community-based organizations, planners, local governments, and public health advocacy groups, recent legislation in California was developed to create healthier cities and counties and prioritize the needs of DACs.

SB 1000 Requirements §65302(h)(1)
The environmental justice element, or related environmental justice goals, policies, and objectives integrated in other elements, shall do all of the following: (A) *Identify objectives and policies to reduce the unique or compounded health risks in disadvantaged communities by means that include, but are not limited to, the reduction of pollution exposure, including the improvement of air quality, and the promotion of public facilities, food access, safe and sanitary homes, and physical activity.* (B) *Identify objectives and policies to promote civil engagement in the public decision making process.* (C) *Identify objectives and policies that prioritize improvements and programs that address the needs of disadvantaged communities.*

In 2016 California passed Senate Bill 1000 (SB 1000), the Planning for Healthy Communities Act, which mandates that cities and counties to adopt EJ elements or integrate EJ goals and policies into the elements of their General Plans when they are updating two or more elements of their General Plan concurrently on or after January 1, 2018. Environmental justice is defined by state law as "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies" (Gov. Code § 65040.12(e)). According to the California Environmental Protection Agency (EPA), SB 1000, and pursuant to Section 39711 of the California Health and Safety Code a DAC is a low-income area that is disproportionately affected by environmental pollution and other hazards that can lead to negative health effects, exposure, or environmental degradation.

Cities and counties are individually responsible for identifying EJ communities within their jurisdictions and incorporating the SB 1000 requirements into their planning processes. The City of Petaluma incorporated these requirements into the LHMP, as this plan will be incorporated into their General Plan in accordance with Government Code Section 65302.10 (Assembly Bill [AB] 2140). The City meets these requirements by identifying DACs and socially vulnerable communities, promoting engagement in the public decision-making process and in socially vulnerable communities through the implementation of an outreach strategy, addressing EJ considerations to a degree in the vulnerability assessment, and by considering prioritization criteria, such as social equity during the development of mitigation actions. For example, during the HMPC meeting, prioritization criteria included social equity and the HMPC discussed applying a higher priority to actions that related to social equity that benefited DACs or socially vulnerable communities. The HMPC also broadly addressed vulnerable and sensitive populations. The following sections summarize additional information on DACs within the City of Petaluma Planning Area based on various state and local sources.

2.5.2 Disadvantaged Communities

DACs refer to areas in California that suffer the most from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, the presence of hazardous wastes and the high incidence of asthma and other health diseases. DACs have been identified across the state, region, and Sonoma County using various criteria. The social equity considerations in this plan regarding DACs cover household income, ethnicity, English proficiency, senior population, disabled population, and single-parent households metrics. The considerations in this plan are broad in scope and are based on best available data and mapping information from the following state and local sources:

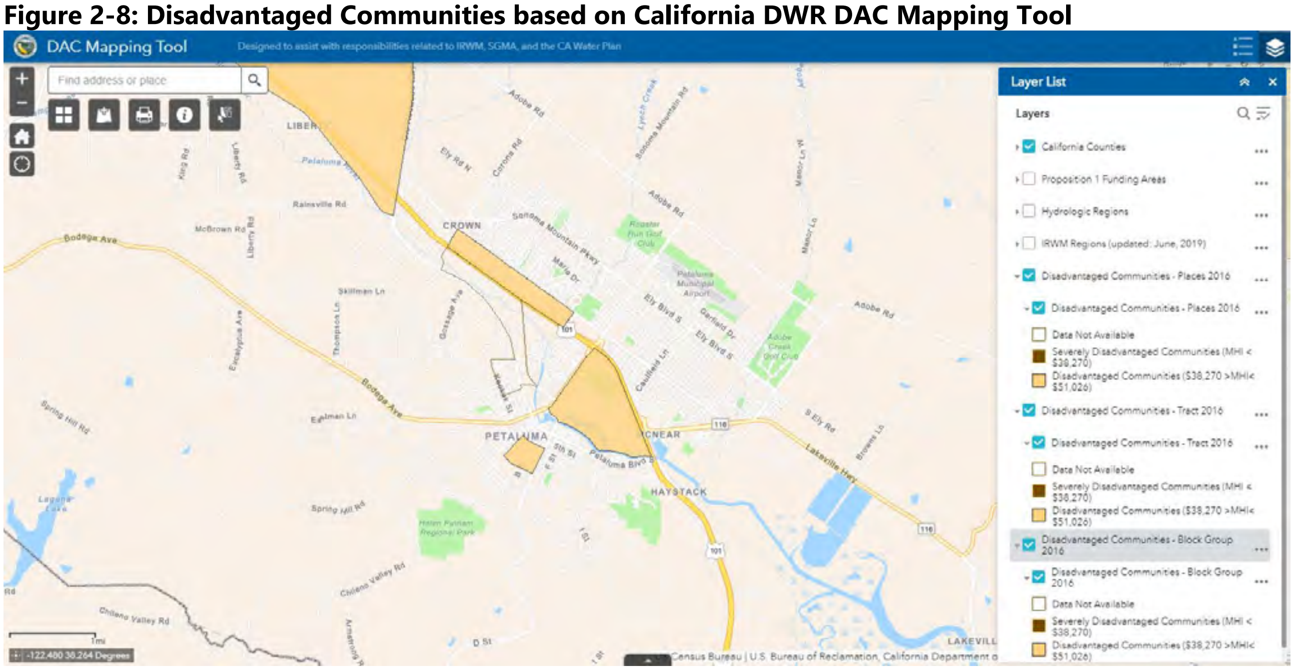
- California Department of Water Resources (DWR) Disadvantaged Communities (DAC) Mapping Tool,
- California Office of Environmental Health Hazard Assessment's (OEHHA) CalEnviroScreen Tool, and
- Sonoma County's Disadvantaged Communities Online Mapping Tool.

The metrics and methodology applied by each federal, state, and local source is summarized below, followed by a "snapshot" of the social vulnerability metrics and information available for the population in the City according to each tool.

California DWR Disadvantaged Community (DAC) Mapping Tool

California DWR defines DACs as a community with an annual median household income (MHI) that is less than 80 percent of the statewide annual MHI (Public Resources Code 7500(g)). Census geographies within an annual MHI less than 60 percent of the statewide annual MHI are considered "severely disadvantaged communities." Figure 2-8 shows DACs within the City's Planning Area.

Figure 2-8: Disadvantaged Communities based on California DWR DAC Mapping Tool



Source: California DWR 2019

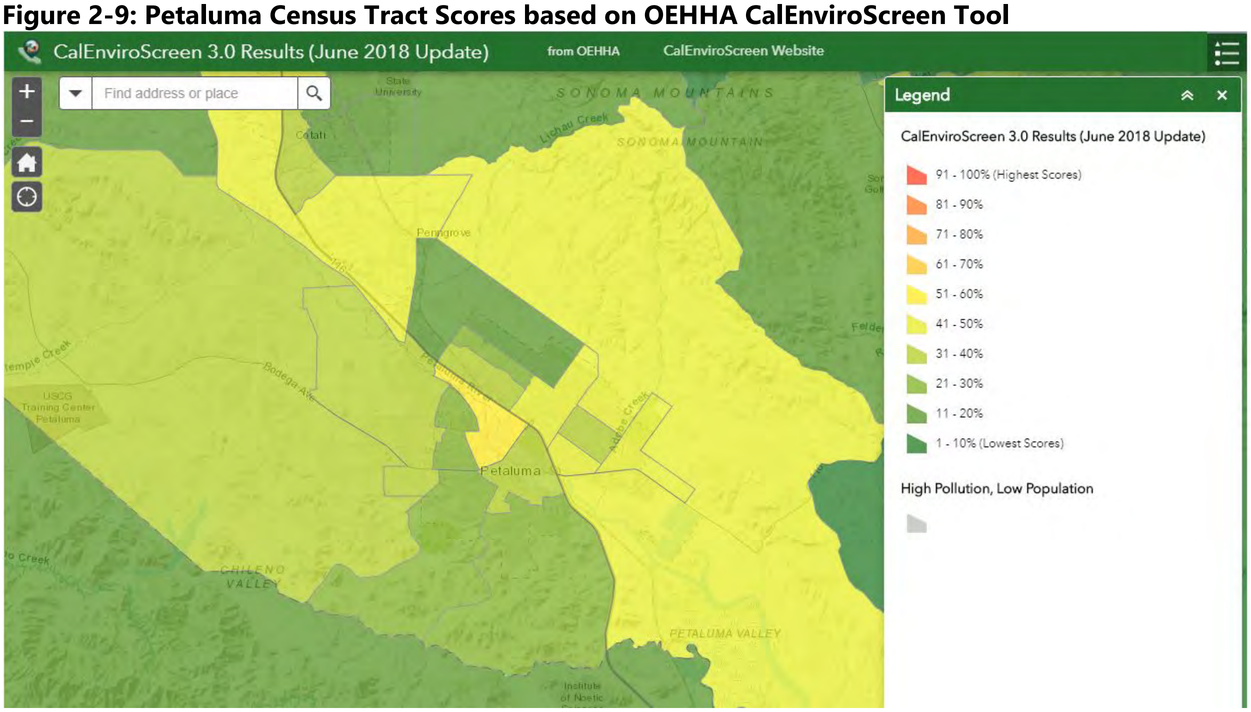
As shown in Figure 2-9 there is one census tract on the north end of Petaluma identified as a DAC that extends to Cotati and the western portion of Rohnert Park. There are three block groups identified in downtown Petaluma identified as a DAC with approximately 4,418 residents within 1,627 households.

California OEHHA CalEnviroScreen Tool

California's OEHHA uses the CalEnviroScreen Tool to identify California communities by census tract that are disproportionately burdened by, and vulnerable to, multiple sources of pollution. CalEnviroScreen is a science-based mapping tool that uses environmental conditions such as proximity to solid waste sites, clean-up sites, etc.; personal health (sensitive populations with asthma, cardiovascular disease, etc.), and socioeconomic (poverty, unemployment, educational attainment, etc.) information to produce a numerical score for each census tract in the state. A census tract with a high score (orange to red) is a community that experiences higher pollution burden and vulnerability than census tracts with low score (yellow to green).

California's Global Warming Solutions Act of 2006 (Assembly Bill 32) implemented a cap-and-trade program as one of several strategies in California to reduce greenhouse gas emissions that cause climate change. In 2012 the Legislature passed Senate Bill 535 that directed 25 percent of the proceeds from the Greenhouse Gas Reduction Fund (GHGRF) go to projects that provide benefit to DACs. As a result, the legislation gave California's EPA responsibility for identifying those communities. California EPA identified the 25 percent highest scoring CalEnviroScreen census tracts as DACs. The designation then lead to AB 1550 that requires 25 percent of the proceeds from the GHGRF be spent on project located in DACs. As shown in Figure 2-10 there are no environmentally burdened or vulnerable communities with high scores in the City of Petaluma.

Figure 2-9: Petaluma Census Tract Scores based on OEHHA CalEnviroScreen Tool



Source: California Office of Environmental Health Hazard Assessment 2018

Sonoma County's DAC Online Mapping Tool

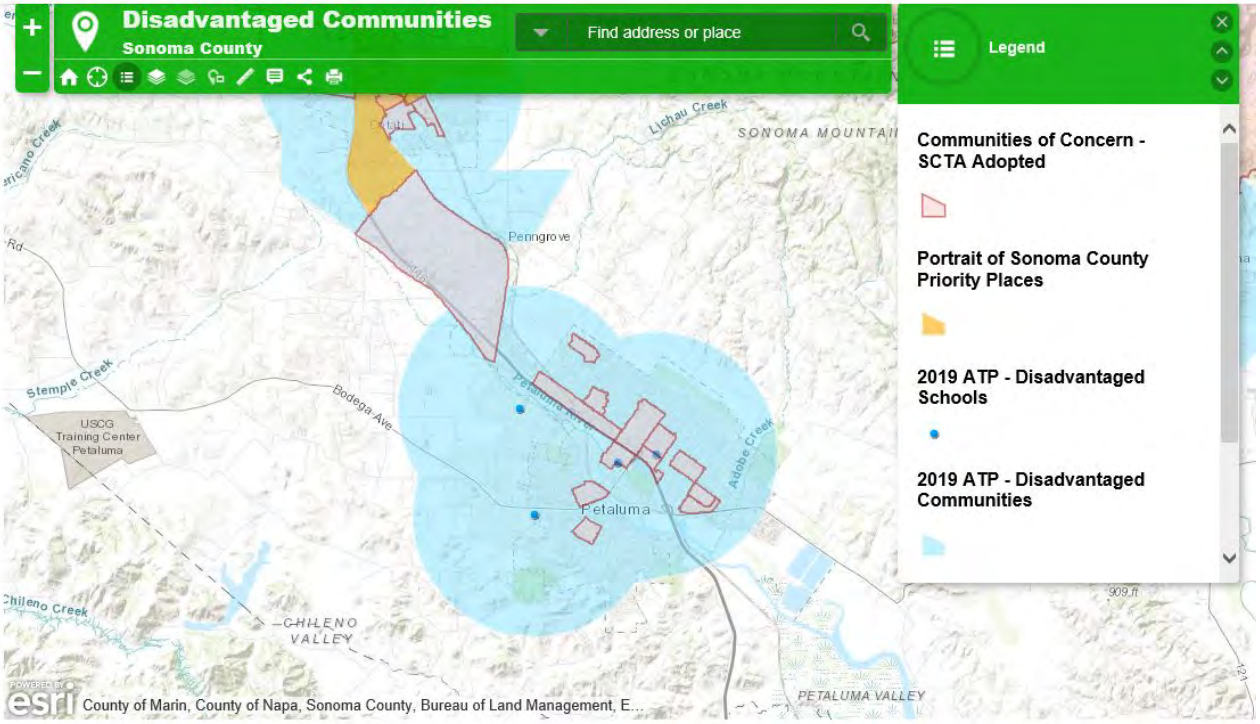
The Sonoma County Transportation Authority (SCTA) functions as the countywide planning and fund programming agency for transportation projects. The SCTA was created in 1990 as a result of federal and state legislation to address regional planning, specifically the implementation of transportation improvement projects. The SCTA Board of Directors also coordinates countywide climate protection activities through its other role as the Sonoma County Regional Climate Protection Authority (RCPA).

SCTA defines DACs using different identification criteria than the tools developed by other state agencies. The following DAC designations are defined in the SCTA Disadvantaged Communities mapping tool, including whether the DAC designations occur within the City of Petaluma:

- **MTC Adopted Communities of Concern (COC):** MTC identified regional COCs use demographic variables including ethnicity, income, English proficiency, senior population, disabled population, single-parent households, zero-vehicle households, and overburdened renters using Census Tract data from the 2005-2009 and 2010-2014 ACS 5-Year Average. These CoCs were adopted as part of Plan Bay Area and are currently being revised as part of the Plan Bay Area update that is underway. There are no MTC Adopted COCs within the City of Petaluma Planning Area.
- **SCTA Defined COCs:** SCTA Defined COCs use poverty level data (i.e., 30 percent of the census block group households earning 200 percent or less of the federal poverty level) and a more detailed level of census geography. Using census block groups allows better accuracy when identifying pockets of poverty in Sonoma County, especially in areas that are located in large census tracts, or that are adjacent to affluent areas. There are 12 census block groups that are within the City of Petaluma Planning Area, and a portion of a large census block group that intersects with the Planning Area towards the north end of the City. The 12 census block groups identified as SCTA-defined COCs comprise approximately 13,903 residents (22.3 percent of population) within 5,104 households.
- **2019 Caltrans Active Transportation Program (ATP) DACs:** The Caltrans ATP defines DACs using income, tribal lands, and proximity to disadvantaged schools. Disadvantaged schools are those where 75 percent of the students are eligible to receive free or reduced meals. The majority of the City's Planning Area was identified as a 2019 ATP DAC.
- **Portrait of Sonoma County Priority Places.** Portrait of Sonoma County considers life expectancy, education, and income of county residents and combines the variables into a single Human Development Index (HDI), which can be used to identify disadvantaged communities and disparities among Sonoma County neighborhoods. The 20 census tracts in the County with the lowest HDI are identified as DACs and included in the mapping tool. There were no census tracts that met this criteria in the City of Petaluma Planning Area.

Figure 2-10 shows the SCTA-defined COCs and 2019 Caltrans ATP DACs in the Planning Area.

Figure 2-10: SCTA-Defined Disadvantaged Communities in Petaluma



Source: SCTA 2019

2.6 Economy and Employment

The most comprehensive economic data available for the City of Petaluma comes from the U.S. Census Bureau ACS data and the California Department of Finance. Select estimates of economic characteristics for the City of Petaluma are summarized below.

As of 2017, Petaluma had the lowest unemployment rates of the cities in Sonoma County (Sonoma County 2018). The ACS 5-year estimates show a 3.3 percent unemployment rate, lower than the county (3.8 percent), and statewide rates (4.8 percent) and even nationwide (4.4 percent); this reflects an exceptionally strong economy and demand for labor in Petaluma. Table 2-6 above summarizes the City's general economic characteristics. Unemployment rates have increased in the past three years based on the most recent ACS data and California Department of Finance data.

Table 2-7 illustrates the breakdown of employment by industry in the City of Petaluma from 2013-2017, as well as the number of people employed by each industry, and Table 2-8 lists the City's major employers and approximate number of employees.

Table 2-7: City of Petaluma's Employment by Industry, 2013-2017

Industry	# Employed	% Employed
Agriculture, Forestry, Fishing, Mining	588	1.9
Construction	2,210	7.2
Manufacturing	2,146	7.0
Transportation and warehousing, and utilities	1,098	3.6
Information	931	3.1
Wholesale Trade	982	3.2
Retail Trade	3,539	11.6
Finance, Insurance, Real Estate and rental and leasing	2,094	6.9

Arts, entertainment, and recreation, and accommodation, and food services	3,267	10.7
Educational services and Health care and social assistance	6,781	22.2
Professional, scientific, and management, and administrative and waste management services	3,952	13.0
Other services	1,443	4.7
Public Administration	1,460	4.8
Totals	30,491	100

Source: U.S. Census Bureau American Community Survey, 2013/2017 www.census.gov/
*Civilian population 16 or older

Table 2-8: City of Petaluma's Major Employers

Employer	# of Employees
Petaluma School District	1,347
Petaluma Poultry Processors	561
Petaluma Valley Hospital	507
City of Petaluma	372
Enphase Energy Inc.	338
Lagunitas Brewing Company	346
Santa Rose Junior College	300
Hansel Auto	268
Olde Adobe Union School District	256
Clover Stornetta Farms	256

Source: City of Petaluma, California Comprehensive Annual Financial Report For the Year Ended June 30,2017, City of Petaluma Finance Department http://cityofpetaluma.net/finance/pdf/cafr/CAFR-FY2017.pdf

2.7 Commuter Population

Based on ACS five-year estimates data for 2013-2017, nearly 33.7 percent of Petaluma's workforce travelled to another county for employment while 65 percent worked within Sonoma County. Of those traveling outside the county for work, nearly 36 percent drove alone while 41.5 percent carpooled. Nearly 72 percent of those traveling outside the county used public transportation compared to 22 percent of those who travel within Sonoma County for work. Commuting patterns can increase congestion on U.S. Highway 101 and local county and city roads. Commute congestion can also affect the City's transportation infrastructure, as well as how the City responds to hazard events that may limit the commuting population's ability to travel to work and safely return to Petaluma after an event.

2.8 Growth and Development Trends

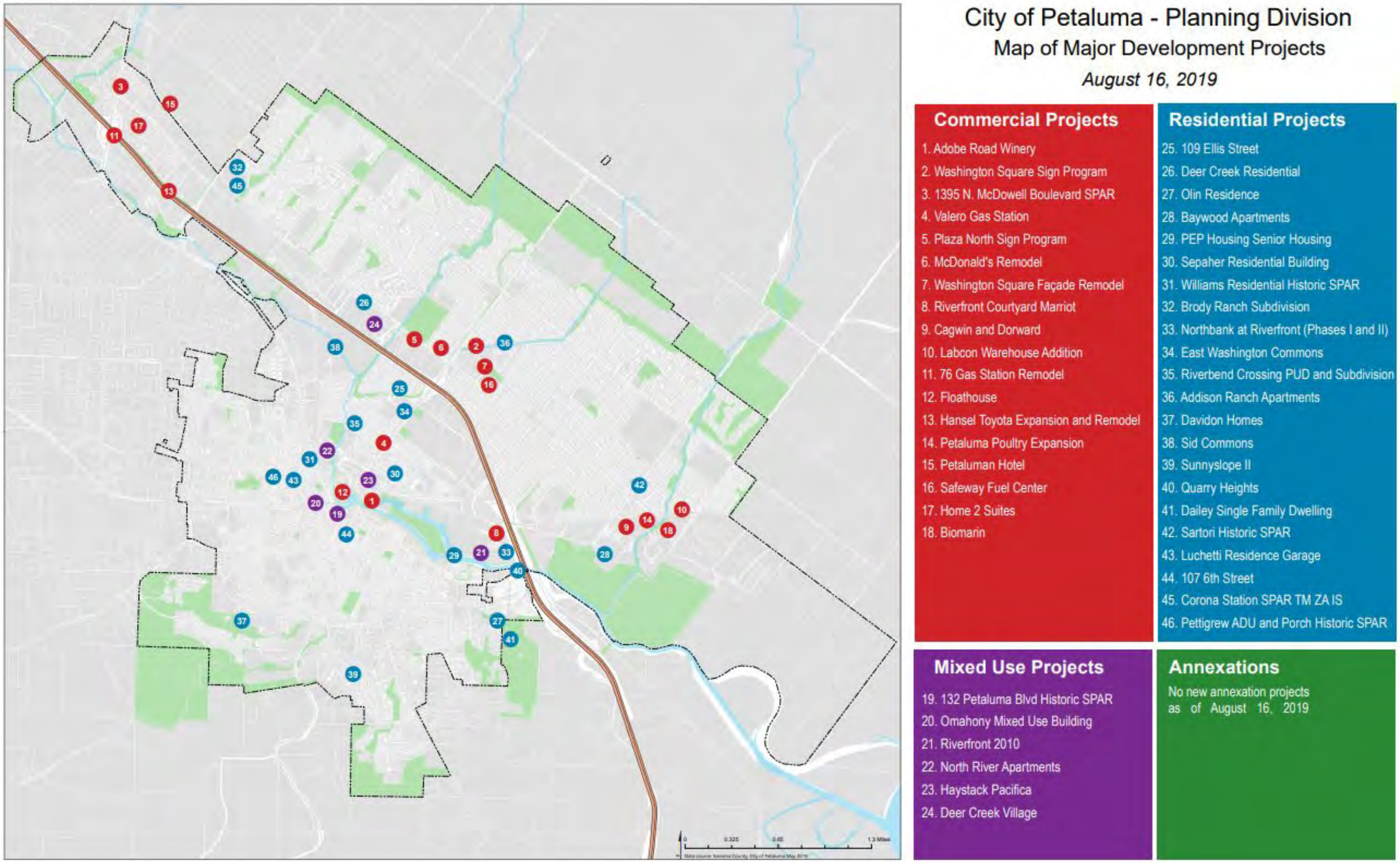
By the 1960's, after years of post-World War II suburbanization that resulted in sprawling subdivisions, the City of Petaluma experienced pressures on city infrastructure, increasing environmental concerns, and the increasing pressures on the local economy as growth edged toward the agricultural and dairy lands. There were also increasing concerns over the divide between the growing commuter-oriented east side and the older west side of the city, as retail businesses began to move away from downtown to the east side. As a result of these growth pressures the City implemented a system of controls to slow the pace of the new residential construction. The City of Petaluma General Plan lists the following milestones in the City's growth management history:

- **1961 General Plan** - The 1961 General Plan recognized the importance of compact development patterns and cost-effective provision of public services and infrastructure. It provided a framework for development within Downtown, expansion of industrial areas, new parks, residential neighborhoods, commercial areas, schools, and the roadway network.

- **Environmental Design Plan of 1972** - This served as a short-range strategic plan, limiting housing construction to a not-to-exceed rate of 500 dwelling units per year for the five-year period 1972 to 1977. It also established an urban separator (then called greenbelt).
- **Residential Growth Management System (RGMS) -** As part of the 1972 Plan (see above), the RGMS established the criteria to distribute 500 annual housing unit permits. The review process included a Council appointed citizen committee to review all residential development proposals prior to the Council granting of allocations. Although the allocation process is no longer utilized, the cap of 500 housing units is still monitored.
- **Environmental Design Plan of 1978** - This reiterated the city's UGB (then called Environmental Design Plan boundary) and extended its effective date through 1985. It identified an optimum population of approximately 70,000 to 90,000 residents.
- **Urban Limit Line (ULL)** - The 1987 General Plan designated a ULL for the period 1987 to 2005 that identified the outer edge of allowable urban development, encompassing 10,300 gross acres. General Plan population projections for buildout were "between 60,000 and 67,000 persons." Buildout was, at the time, expected to be reached by 2008.
- **Urban Growth Boundary (UGB)** - Placed on the ballot by the City Council in 1998, city voters overwhelmingly adopted a fixed urban edge, which for the most part was coterminous with the 1987 ULL. Although the UGB did not affect the growth management numbers, it confined the growth and physical development of the City until 2018. In 2010, the City Council placed a ballot measure before the voters extending the UGB to 2025.

According to the General Plan, between 1985 and 2005 the City grew at an average annual rate of 1.8 percent. Currently the city has two growth management programs in place, the RGMS and the UGB. Development on the western side of the City is constrained by the hilly topography and the UGB, while the east side is constrained by the UGB until 2025. As of August 16, 2019, the City has forty-six major development projects going through the planning process with the Planning Division. A majority of the projects (22) are residential developments, followed by commercial projects (18), and mixed use (6) projects. The major development projects are located throughout the City with a majority being concentrated near downtown Petaluma. Figure 2-11 shows the location of each development project in the Planning Area.

Figure 2-11: City of Petaluma Major Development Projects – As of August 16, 2019



Source: City of Petaluma Planning Division 2019

Table 2-9 shows the City's land use acreages at complete General Plan buildout.

Table 2-9: City of Petaluma Land Use Acreages at Plan Buildout

Land use	Land Area (acres)
Residential Land	**4,348**
Rural	268
Very Low Density	604
Low Density	2,520
Diverse Low	363
Medium Density	377
High Density	99
Mobile Homes	117
Commercial Land	**290**
Neighborhood Commercial	88
Community Commercial	202
Mixed Use	**542**
Business Park	**512**
Industrial Land	**188**
Industrial	**180**
Agricultural Support Industrial (CPSP)	8
Public and Educational	**1,447**
Public/Semi-Public	1,179
Education	268
Parks and Open Space	**1,594**
City Parks	308
County Parks	256
Agricultural	77
Open Space	953
Total	**8,921**

Source: City of Petaluma General Plan 2008-2025

Additional information on development trends in the City's Planning Area can be found in the Future Development section of each hazard profile in the Section 5.

2.9 Mitigation Capability Assessment

During the development of this plan the City's HMPC completed a mitigation capability assessment to understand what loss prevention mechanisms are already in place. When combined with the risk assessment the mitigation capability assessment this results in the City's "net vulnerability" to disasters, and more accurately focuses the goals and proposed actions of this plan. For this planning effort, a representative from most departments where the City had in-house staff available, participated on the HMPC.

The HMPC used a two-step approach to conduct the capability assessment for the City. First, an inventory of common mitigation activities was made through the use of a matrix. The purpose of this effort was to identify policies and programs that were either in place, needed improvement, or could be undertaken if deemed appropriate. Second, the HMPC conducted an inventory and review of existing policies, regulations, plans, and programs to determine if they contributed to reducing hazard-related losses or if they inadvertently contributed to increasing such losses.

Similar to the HMPC's effort to describe hazards, risks, and vulnerability of the City of Petaluma, this mitigation capability assessment describes the City's existing capabilities, programs, and policies currently in use to reduce hazard impacts or that could be used to implement hazard mitigation activities. It also identifies select state and federal departments/agencies that can supplement the City's mitigation capabilities. This assessment is divided into four sections: regulatory mitigation capabilities, administrative and technical mitigation capabilities, fiscal mitigation capabilities, and mitigation outreach and partnerships.

2.9.1 City of Petaluma's Regulatory Mitigation Capabilities

Table 2-10 lists planning and land management tools typically used by local jurisdictions to implement hazard mitigation activities and indicates those that are in place in the City of Petaluma. Excerpts from applicable policies, regulations, and plans and program descriptions follow to provide more detail on existing mitigation capabilities.

Table 2-10: City of Petaluma's Regulatory Mitigation Capabilities

Regulatory Tool (ordinances, codes, plans)	Yes/No	Comments
General Plan	Yes	The City's General Plan was last updated and amended in 2012. The Housing Element was last updated and amended in 2018. Both planning documents are the City's most comprehensive land use and development tools. Together, they establish the vision for the buildout of the City of Petaluma through 2025. They also include a set of broad-based goals and objectives to guide development in the City. Upon adoption of the LHMP, the City should update the General Plan Safety Element and amend the General Plan to include the LHMP.
Zoning Ordinance	Yes	The City's Implementing Zoning Ordinance (IZO) replaced the City's 1973 zoning ordinance. It guides current development through standards and regulations relating to allowable land uses consistent with the General Plan, conditionally allowable land uses, height, setbacks, parking, and signage. The IZO also addresses Hillside Protection, Tree Preservation, Floodway and Floodplain districts.
Subdivision Ordinance	Yes	Title 20 of the Petaluma's Municipal Code contains the City's subdivision provisions and Chapter 4 of IZO has procedural requirements, tentative subdivision maps, parcels maps, dedications, and improvements. It also outlines streets, alleys, and other public right-of-way or easements for emergency access.
Growth Management Ordinance	Yes	The City adopted RGMS in 1972; an ULL was designated in 1987. An UGB was approved by voters in 1998 and then extended in 2010.
Floodplain Ordinance	Yes	Chapter 6 of the Petaluma IZO contains the City's Floodplain Regulations. Special flood hazard areas in the City are based on the August 1979 Flood Insurance Study (FIS) for the City of Petaluma and recent Flood Insurance Rate Map (FIRM). It limits development of projects in the flood hazard zone unless the project demonstrates flood management facilities will protect the project to the urban level of flood protection, implements conditions on the permit or project entitlement that protect the project to standard flood protection standards.

Regulatory Tool (ordinances, codes, plans)	Yes/No	Comments
		Chapter 6.070 summarizes the standards of construction for new projects, and new construction or substantial improvements shall have the lowest floor elevation, including basements, elevated at least 12 inches above the level of the base flood elevation (BFE). Upon completion of construction, the elevation of the lowest flood shall be certified by a registered professional engineer or verified by the community building inspector. The certification shall be provided to the Floodplain Administrator.
Other special purpose ordinance (e.g., stormwater, steep slope, wildfire)	Yes	Chapter 16 Hillside Protection of the Petaluma's IZO contains the City's provisions for development and altering properties in hillside and ridgeline areas. The purpose is to preserve the essential scenic and natural resources that define the character of Petaluma and minimize potential for geologic failures, fires and floods. Section 16.070 ensures hillside subdivisions are designed to avoid development on steep slopes exceeding 10 percent as determined by the City's Average Slope Formula. Title 17, section 17.30 provides information on Storm Drainage. The Unreinforced Masonry (URM) Building Ordinance, Petaluma Ordinance No. 1882, Section 17.34.110, contains details related to resolution No. 92-48 N.C.S. from the City, originally initiated in 1992. The URM Ordinance requires URM buildings in the City to be retrofitted by the year 2017. This retrofitting process should be complete as of 2019.
Building Code	Yes	The City adopted the 2016 California Building Code (CBC). Adoption and reference to the 2016 CBC is outlined in Title 17, section 17.04.
Fire department Insurance Services Office (ISO) rating	Yes	ISO rating of 3
Erosion or Sediment Control Program	Yes	Title 17, section 31 of the Petaluma Municipal Code grading and erosion control and section 17.30 contains storm drainage.
Storm Water Management Program	Yes	They City complies with requirements under MS4 Order No. 2013-0001-DWQ, which was updated in 2013 as part of the second Phase II Small MS4 General Permit (adopted July 2013). They City is implementing a Storm Water Management Plan that contains processes that will be used to meet mandatory requirements under the updated order.
Site Plan Review Requirements	Yes	Discretionary projects involve site plan review as part of the planning and approval process conducted by the City's Planning Divisions. The Development Engineering Division of the Public Works Department provides review and permit processing. This division reviews subdivision maps, construction plans, public improvement, and grading plans for all residential, commercial, and industrial projects.

Regulatory Tool (ordinances, codes, plans)	Yes/No	Comments
Capital Improvements Plan	Yes	The Capital Improvement Division of the Public Works and Utilities Department is responsible for the planning, designing and renovating of all City of Petaluma CIP projects. These include projects, such as construction, repair, and improvements of public streets, utility pipelines, pump stations, bridges, bike paths, public buildings, and public parks. The Capital Improvement Division follows design standards, and standard plans and specifications for all street, utility, parks, streetscape, and storm water projects. The Division also maintains a Pavement Management System database of all the City street with a uniformly calculated numeric rating of the condition of pavement.
Economic Development Plan	Yes	The Economic Development Division contains various business development and incentive and program resources for commercial, retail, and property owners. Oversight of the Community Block Grant (CDBG) and Housing Program are functions of the City Manager's Office.
Local Emergency Operations Plan	Yes	The City of Petaluma adopted their Emergency Operations Plan (EOP) in 2007.
Other special plans	Yes	The City of Petaluma Floodplain Management Plan (FMP) (October 2015) describes the natural and magnitude of flooding the City has experienced in the past, floodplain management activities implemented, additional alternative remedies, and a plan for future action to address current floodplain problems. The City of Petaluma has participated in the CRS Program since 1991 and has a Class Rating 6.
Flood Insurance Study or other engineering study for streams	Yes	The City joined the NFIP on February 15, 1983. The City began implementing their NFIP floodplain regulations in 1980. The most recent FIS for the City was completed on March 7, 2017.
Elevation certificates	Yes	See Chapter 4 of this plan, and the City's 2015 Flood Management Plan. The City digitally tracks all of the elevation certificate records and has records dating back to 1991 when the City joined the CRS Program.
Other	Yes	Urban Water Management Plan (2015); River Enhancement Plan; Fire Sprinkler Ordinance for all new construction and existing building remodels.

Source: HMPC Data Collection Guide

As indicated in the table above, the City of Petaluma has several plans and programs that guide the City's development in hazard-prone areas. Starting with the City of Petaluma's General Plan, which is the most comprehensive of the City's plans when it comes to mitigation, these relevant plans and programs are described in more detail below.

City of Petaluma General Plan 2025 (2008)

The City's General Plan provides a comprehensive and long-term blueprint for the future by establishing a framework for how Petaluma should grow and change over the next two decades (Year 2025). The General Plan contains goals, objectives, policies, and actions that empower the City and community to achieve their future vision. The General Plan is the City's principal policy and planning document to guide future conservation, enhancement, and development in the City. It addresses all aspects of development organized in 12 chapters or elements, including six required by State Planning law and four elements prepared to meet local needs and concerns. The seven mandatory elements include the Land Use Element, Housing Element, Circulation Element (Mobility), Open Space Element, Conservation Element, Safety Element, and Noise Element. The five remaining elements include the Community Character Element, Economic Development Element, Public Facilities and Services Element, Water Resources Element, and Air Quality Element. The City of Petaluma's General Plan also has a section on Historic Preservation.

The following four elements have goals, policies, and implementation programs related to hazards and hazard mitigation, as detailed below:

- Community Facilities, Services, and Education Element
- Water Resources Element
- Health and Safety Element

Each of these elements include goal statements relating to different aspects of the issues addressed in the element. The summary below tracks the organization of each relevant element, with topically-focused goals.

Community Facilities, Services, and Education Element

This element lists all city-owned public facilities in Petaluma, including those that will be assessed in the LHMP. It summarizes broad policies that ensure adequate public facilities and services exist and are maintained to meet the needs of the community. Relevant public facilities and services and fire protection goals are outlined in Table 2-11.

Table 2-11: City of Petaluma Public Facilities, Services, and Fire Protection Goals

Goal	Goal Description
Goal 7-G-1	Ensure adequate public facilities and services exist and are maintained to meet the needs of the community for an array of high-quality services and programs.
Goal 7-G-5	Protect lives, property, and the environment by providing the highest quality of service in prevention, fire protection, emergency medical services, and community preparedness.

Water Resources Element

The water resources element summarizes four components: water supply and demand, recycled water, wastewater, and surface water. This element covers flood hazards, groundwater supply, and drought issues, as they relate to water conservation. Relevant flood and stormwater conveyance goals are outlined in Table 2-12.

Table 2-12: City of Petaluma Flood and Stormwater Conveyance Goals

Goal	Goal Description
Goal 8-G-8	Provide surface drainage and flood protection facilities to meet the community's needs of reducing flood hazards and potential property damage.
Goal 8-G-9	Preserve the design conveyance capacity of the surface water drainage system.

Health and Safety Element

Planning for growth and development requires the consideration of a wide range of public safety issues. Many of the safety risks associated with development, including risks to buildings and infrastructure, can be avoided through siting decisions made at the planning stages of development, while others may be lessened through the use of mitigation measures in the planning and land use review process. The City's Health and Safety Element aims to minimize risks posed by environmental hazards, including geologic and seismic hazards, noise, and hazardous materials and waste. The element also addresses emergency preparedness. Relevant natural hazard and emergency preparedness goals are outlined in Table 2-13.

Table 2-13: City of Petaluma Natural Hazard and Emergency Preparedness and Management Goals

Goal	Goal Description
Goal 10-P-1	Minimize risks of property damage and personal injury posted by natural hazards.
Goal 7-G-5	Protect lives, property, and the environment by providing the highest quality of service in prevention, fire protection, emergency medical services, and community preparedness.
Goal 10-P-2	Protect the community from risks associated with seismically induced surface ruptures, ground-shaking, ground failure, slope instability leading to mudslides and landslides, subsidence, liquefaction, and other seismic, geologic, and fire hazards.
Goal 10-P-3	Protect public health and welfare by eliminating or minimizing the effects of existing noise problems, and by minimizing the increase of noise levels in the future.
Goal 10-P-4	Minimize the risk to life and property from the production, use, storage, and transportation of hazardous materials and waste by complying with all applicable state and local regulations.

City of Petaluma 2015 – 2023 Housing Element

The City prepared the latest Housing Element in 2015 and revised it in 2018. The Housing Element is one of the seven mandatory elements of the General Plan. The Housing Element provides a long-term comprehensive plan to address the housing needs for all economic segments of the community. It addresses existing and projected housing demand and establishes goals, objectives, policies, and actions to assist the City in implementing the plan in accordance with other General Plan policies. The 2015-2023 Housing Element was prepared under a separate timeline and under different detailed State criteria.

City of Petaluma Urban Water Management Plan (2015)

The City's Urban Water Management Plan (UWMP) is prepared to meet the requirements of the California Water Code, which requires "every urban water supplier providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually to adopt and submit an UWMP every five years" (City of Petaluma 2015). The purpose of the plan is to evaluate the required potable and recycled water system facilities required to serve the buildout of the City's General Plan. It includes several objectives designed to help the City meet their future water demands and develop performance and operational criteria. It also presents the City's capital improvement program for recommended potable and recycled water system facilities. These range from costs associated with land acquisition, storage reservoir development, groundwater wells, booster pump stations, new pipelines, and interconnection facilities. Several of the objectives and the sustainability principles outlined in the plan will help the City minimize drought hazards.

Floodplain Management Regulations and NFIP Participation (1983)

The City of Petaluma has participated in the National Flood Insurance Program (NFIP) since 1974 through emergency entry and regular entry since 1983 by administering floodplain management regulations that meet the minimum requirements of the NFIP. The purpose of these regulations is to promote the public health, safety, and general welfare and to minimize public and private losses due to flood conditions in specific areas. These regulations apply to all areas of special flood hazards within the jurisdiction of Petaluma identified in FEMA's most recent FIS completed for Sonoma County on March 7, 2017. The Special Flood Hazard Area (SFHA), also known as the base flood, 100 year flood (1 percent annual chance flood) in the City is mapped as Zone A or AE.

Floodplain management is administered through the City's Public Works and Utilities Department. The City maintains records of BFE certificates for the properties within the SFHA and the NFIP is administered by the City Engineer (Floodplain Administrator) within the Public Works and Utilities Department.

Community Rating System (CRS) Program Participation

The City of Petaluma has participated in the Community Rating System (CRS) since 1991 as one of its efforts to reduce potential losses due to flooding for its citizens. This program, created by the NFIP, encourages communities to become proactive in their flood management planning activities. Under this program, participating communities, such as the City receive a point rating reflective of their efforts in undertaking these activities. The CRS ratings result in reduced flood insurance premiums to floodplain residents and property owners.

According to the 2015 FMP, the NFIP has conducted annual audits of the City's floodplain management efforts for over two decades and awarded the City a Class 6 rating, reducing flood insurance premiums to policy holders located in the SFHA throughout the City by approximately 20 percent and 10 percent for those who have standard X-Zone policies. According to FEMA, as of June 30, 2015, there were approximately 393 flood insurance policies currently in effect, with an annual premium of over $418,774 (City of Petaluma 2015). It is estimated that the City's participation in the CRS program saves insured residents $83,755 per year (City of Petaluma 2015). Potential opportunities to improve the City's class rating are described below in Section 3.1.5.

City of Petaluma Floodplain Management Plan (2015)

The City of Petaluma FMP was developed in an open public process and is considered a living document that is subject to revisions that reflect the City's change in policy or the state and/or federal regulations. This plan describes the magnitude of past flood events in the City and its purpose is to describe floodplain management activities implemented to date; additional alternative remedies; and a plan for future action to address the current flooding problems. The objective of the plan is to quantify flooding problems and propose solutions when funding becomes available (City of Petaluma 2015). The specific mitigation actions described in FMP were integrated into this LHMP in the mitigation strategy.

City of Petaluma Storm Water Management Plan (2003)

The City's Storm Water Management Plan describes actions and efforts that include best management practices that will address the reduction of nutrients, pathogens, and sediment in the City's stormwater. The plan also includes measurable goals and timetables for the minimum control measures. The City Water Resources and Conservation Division of the Public Works Department is responsible for implementing the plan and the City's Storm Water Program.

City of Petaluma Emergency Operations Plan (2007)

The City's EOP was updated in 2007. It includes a basic plan that addresses the City of Petaluma's responsibilities in emergencies associated with natural disaster, human-caused emergencies, and technological incidents. It provides a framework for coordination of response and recovery efforts within the City and in coordination with local, state, and federal agencies. The EOP contains the following goals:

- Provide effective life safety measures
- Reduce property loss and damage to the environment
- Provide for the rapid resumption of impacted government, community and business services;
- Provide accurate documentation and records required for cost recovery.

The plan establishes emergency organization staff to direct and control operations during a period of emergency by assigning responsibilities to specific personnel. The scope of the plan addresses earthquakes, hazardous materials emergencies, flooding, and wildfires. It includes procedures for emergencies that may or may not require the full or partial activation of an Emergency Operation Center (EOC). The City's response to an emergency incident is coordinated through the EOC and the City Manager serves as the Emergency Operations Director. The EOC also utilizes the Incident Command System (ICS) and the Standardized Emergency Management System/National Incident Management System (SEMS/NIMS) for unity of command and span of control.

2.9.2 City of Petaluma Administrative/Technical Mitigation Capabilities

Table 2-14 identifies the City personnel responsible for activities related to mitigation and loss prevention in the City of Petaluma.

Table 2-14: City of Petaluma's Administrative and Technical Mitigation Capabilities

Personnel Resources	Yes/No	Department/Position
Planner/engineer with knowledge of land development/land management practices	Yes	Community Development / Planning Manager
Engineer/professional trained in construction practices related to buildings and/or infrastructure	Yes	Community Development / Chief Building Official
Planner/engineer/scientist with an understanding of natural hazards	Yes	City Public Works and Utilities Department staff
Personnel skilled in GIS	Yes	Information Technology/GIS Technician
Full-time building official	Yes	Building Division / Chief Building Official
Floodplain manager	Yes	Public Works and Utilities Department / City Engineer
Emergency manager	No	Economic Development and Open Government Manager
Grant Writer	Yes	Handled within each department/program
GIS data—Hazard areas	Yes	GIS Specialist
GIS data—Critical facilities	Yes	GIS Specialist
GIS data—Building footprints	Yes	GIS Specialist
GIS data—Land use	Yes	GIS Specialist
GIS data—Assessor's data	Yes	GIS Specialist
Warning Systems/Service (Reverse 911, cable override, outdoor warning signals)	Yes	Flood alert system; Nixle; WEA; EAS; IPAWS; SoCo Alert

Source: HMPC Data Collection Guide

City Departments/Agencies

The City of Petaluma government consists of a City Council with six members and the Mayor. The City Council appoints the City Manager. The City Manager is the chief administrative officer for the City with all City employees with the exception of the City Attorney and City clerk reporting to the City Manager.

City Attorney's Office

The City Council appoints a City Attorney, which is staffed by one Assistant City Attorney, one Deputy City Attorney, and one legal secretary. The City Attorney's office provides legal advice to the City Council, Commissions, and City staff. They attend all City Council and Planning Commission meetings. They also assist in the preparation of legal documents, ordinances, and resolutions; prepare negotiations and contracts, and prosecute code violations.

City's Clerk Office

The City Clerk's office provides a variety of administrative services in support of the City Council. The office prepares City Council agendas and minutes, maintains the City's official records, recruits for City Council appointed boards and commissions, and the City Clerk serves as a filing officer.

City Manager's Office

The City of Petaluma's City Manager's Office provides general management, oversight and direction to all the City's departments and programs and provides administrative support to the Mayor and Council. The City Manager is responsible for organizing the departments within the City for efficient and effective delivery of services. The Manager also acts as the City's Personnel, Budget, and Purchasing Officer and provides strategic planning for anticipated future needs.

The City Manager department provides oversight to the following five divisions.

- **Building Division.** The Building Division is dedicated to improving the safety of the residents of Petaluma through professional and technical services. This department implements and enforces building and fire codes, conducts site plan and building permit review, and coordinates daily development review, permit issuance, and inspections.
- **Planning Division.** The City's Planning Division is currently managed by an outsourced planning contractor. The contracting team is responsible for implementing City policies that direct the physical development and community character of the City. Implementation of City development policies involves analysis and establishing conformance to local implementing plans, including various Specific Plans, the Zoning Ordinance, the Growth Management Ordinance and Guidelines, PUDs, and the City's Design Guidelines. Project development and approvals also involve environmental analysis to determine environmental impacts, as required by the California Environmental Quality Act.
- **Economic Division.** The Economic Development Division promotes and pursues commercial, industrial, and office development within the City to create a diversified and sustainable economic base for the community. This base provides a stable tax revenue structure for the City, as well as a full range of retail shopping, services, and employment opportunities for its residents.
- **Housing Division.** The Housing Division implements the City's Housing Program and administers funding through two sources: the fee collected in-lieu of providing units and the commercial linkage fee collected to mitigate the housing impacts of new changed or expanded commercial retail or industrial development.
- **Information Technology Division.** This Division supports all systems and enterprise systems within the City. GIS is within the IT Division and created GIS web applications and updates all GIS data through Open Data Petaluma.

Finance Department

The Finance Department is responsible for City budget preparation and compliance, accounting and financial reporting, debt issuance and management, accounts payable, City employee payroll preparation, utility billing, business licensing, accounts receivable, cashiering and sales. The department also ensures the fiscal foundation necessary to deliver community services.

Fire Department

The City of Petaluma fire, rescue and emergency medical services provides services within the city limits of Petaluma, Southern Sonoma County and a portion of Marin County; covering 184 square miles and 70,000 persons. The Department consists of 58 personnel, with 48 divided among 3 platoons that work 24-hour rotating shifts.

Human Resources Department

The Human Resources Department supports City training and development programs. The Department also oversees and manages the Risk Management Division.

Parks and Recreation Services Department

The Parks and Recreation Department oversees the City's parks and community facilities, public transportation system and bikeways, library, and other recreational programs.

Police Department

The Police Department ensures Petaluma is a safe place to live and work and is "proactive in Community Oriented Policing Philosophy" The Department covers 13 square miles and serves nearly 60,000 persons. There are 85 full time employees within the Department including three (3) K-9 Officers, Traffic Unit, Motorcycle Patrol, SWAT Team, Investigations Unit, FTP Program and Reserve Community Service Officer Program.

Public Works and Utilities Department

The Public Works Department provides maintenance services for streets, trees, traffic control systems, parks, landscape maintenance districts, City buildings and vehicles, graffiti removal, solid waste, and recycling. The department also maintains water distribution, sewer collection and drainage systems. The Department oversees the operation and maintenance of several facilities including the Ellis Creek Water Recycling Facility and is responsible for maintenance, repairs, and replaces mechanical and electrical plant equipment. The Department is also responsible for administrating the City's floodplain regulations.

The Public Works and Utilities Department is comprised of the following seven divisions:

- Capital Improvements
- Environmental Services
- Transit
- Public Works Operations
- Airport/Marina
- Development Engineering
- Parks/Facilities Maintenance

2.9.3 City of Petaluma Fiscal Mitigation Capabilities

Table 2-15 identifies financial tools or resources that the City could potentially use to help fund mitigation activities.

Table 2-15: City of Petaluma's Fiscal Mitigation Capabilities

Financial Resources	Accessible/Eligible to Use (Yes/No)	Comments
Community Development Block Grants	Yes	The City is an Entitlement Jurisdiction under the CDBG Program. A majority of CDBG allocation is for housing development and housing-related services. Because of the Entitlement status the both HOME and Emergency Shelter funds are also available to the City. The funds, granted through the U.S. Department of Housing and Urban Development (HUD) target programs and/or projects geared towards assisting low and moderate-income persons by providing decent housing, a suitable living environment, and expanding economic opportunity.
Capital Improvements Project funding	Yes	Grants like FEMA or Cal OES
Authority to levy taxes and assessments for specific purposes	Yes	Tax assessment for a specific mitigation project
Fees for water, sewer, services	Yes	Utility fees can be used for hazard mitigation of water and sewer projects
Impact fees for new development	Yes	The City oversees a comprehensive development impact fee program.
Incur debt through general obligation bonds	Yes	
Incur debt through special tax bonds	Yes	
Incur debt through private activities	Yes	
Withhold spending in hazard prone areas	No	

2.9.4 Mitigation Outreach and Partnership Capabilities

Sonoma County Community Wildfire Protection Plan (2016)

The Sonoma County Community Wildfire Protection Plan (CWPP) consists of three components: a collaborative effort of input from various agencies and community members, the identification of prioritized treatment areas and mitigation strategies, and the recommendation of measures to reduce ignitability of structures. The plan was developed with Fire Safe Sonoma, Cal Fire, and Sonoma County. The Sonoma County Board of Supervisors unanimously approved the Fire Safe Sonoma's 2016 CWPP.

Regional Climate Protection Authority Climate Action Plan (2016)

The Regional Climate Protection Authority (RCPA) is governed by a twelve member Board of Directors comprised of representatives from the Sonoma County Board of Supervisors and Council Members from each of the nine cities – Cloverdale, Cotati, Healdsburg, Petaluma, Rohnert Park, Santa Rosa, Sebastopol, Sonoma and Windsor. The RCPA coordinates climate protection activities countywide and performs a variety of important related functions including advocacy, project management, planning, finance, grant administration, and research. The Climate Action 2020 and Beyond, Sonoma County's Regional Climate Action Plan published in 2016 was a collaborative effort between Sonoma County and all nine cities within the County. The Plan is specific to the reduction of countywide Greenhouse Gas (GHG) emissions. The Plan sets forth near-term actions to be implemented through 2020 to achieve a 25 percent reduction in countywide GHG emissions. Although this plan is still referenced as it relates to the County's GHG emissions inventory and targets, it was not formally adopted by the County.

City of Petaluma Climate Emergency Resolution (2019)

In May 2019 the Petaluma City Council became the first city in Sonoma County to pass a Climate Emergency Resolution. The goal of the resolution is to frame climate as an urgent crisis and to engage action at the local government level. During the planning process for this LHMP and for future planning efforts related specifically to the Climate Emergency Resolution, the City Council also appointed seven members to the newly formed Climate Action Commission (CAC) to discuss and make recommendations to the Petaluma City Council on climate policy.

Climate Action Commission (2019)

The Petaluma City Council established a CAC through Ordinance No. 2689 on September 5, 2019. The City established the CAC in response to the declaration of the Climate Emergency Resolution enacted earlier in the year and to take action regarding climate change and to elevate climate change issues to the highest priority in its goal-setting process. This includes giving precedence to climate mitigation and adaptation when evaluating policies, planning projects, and allocating City resources. The CAC is also responsible for reducing citywide GHG emissions (in accordance with Executive Order [EO] B-55-18) and accelerating climate adaptation and resilience strategies.

The CAC consists of seven appointed Commissioners that will serve a four-year term. The CAC first convened in November 2019. Initial meetings held in 2019 focused on the establishment of ad-hoc committees, greenhouse gas (GHG) emission reduction activities, and review of the RCPA'S 2025 initiatives associated with decarbonization, carbon sequestration, and climate resilience, as outlined in Sonoma County's Regional Climate Action Plan (please note the formal plan was not adopted and review was for informational purposes only).

Sonoma County Operational Area Hazard Mitigation Plan (2016)

The Sonoma County HMP assesses the County's vulnerabilities to hazards and presents a mitigation strategy of actions intended to reduce the disruption to life, property, and economy that might result from a natural disaster. The HMP focuses on earthquake, flood, wildland fire, and landslide hazards, as they were considered to constitute the greatest risk to the County based on past disaster events, future probabilities, and vulnerability. Within the HMP risk assessment, secondary and tertiary are addressed, such as winter storms, coastal erosion, bluff failure, tsunamis, and post fire erosion.

Sonoma Water Local Hazard Mitigation Plan (2018)

Sonoma Water, previously referred to as Sonoma County Water Agency, is a wholesale provider of potable water that serves nine municipal customers in Sonoma and Marin counties. The water agency maintains a water transmission system that provides naturally filtered Russian River water, builds variety of flood protection projects, manages the county sanitation zones and districts that provide wastewater collection and treatment and recycled water distribution, and produces recycled water from its wastewater treatment plants to offset surface water drawn from the Russian River.

Sonoma Water also implements the Sustainable Groundwater Management Act (SGMA) in Sonoma County and is actively working to protect the basins throughout the region. The water agency adopted a LHMP in 2018 to comprehensively assess the natural hazard risks and vulnerabilities facing the agency's infrastructure, and to articulate a plan to address the vulnerabilities. The plan includes three tailored mitigation strategies focusing on water supply and distribution, sewer and sanitation, and flood control projects.

Petaluma's Power Shutoff Webpage (2019)

Following the unprecedented 2018 wildfire season in California, Pacific Gas & Electric (PG&E) announced it will be conducting Public Safety Power Shutoffs (PSPS) when there are high winds and dry conditions and generally a heightened fire risk forecast. The outages could last several days, and PG&E has suggested customers be prepared for outages that could last longer than 48 hours. A majority of Sonoma County could be affected by the power outages including almost the entirety of the City of Petaluma. PG&E has a plan in place to install a resource area at the Sonoma-Marin Fairgrounds within 24 hours of a PSPS, and will offer power, air conditioners and updates for local residents. In 2019 the City began planning for the shutoffs, including evaluating where vulnerable populations are located in the City, and how infrastructure and relationships with other agencies could be affected.

The first major shutoff occurred on October 8, 2019 impacting 30 counties in northern and central California including Sonoma County. Additional shutoffs took place throughout the month of October 2019 due to severe high winds and increasing fire danger. The City was proactive and created a website dedicated to share information on the PSPS, both before they took place and after PG&E announced the shutoffs. Snapshots of the City's webpages are shown in Figure 2-12 and Figure 2-13. Information on the website is provided in both English and Spanish and includes information such as tips for citizens to prepare and make plans for their families, the opening of community shelters, school closures and which areas of the City are impacted.

Figure 2-12: City of Petaluma Public Safety Power Shutoff Webpage

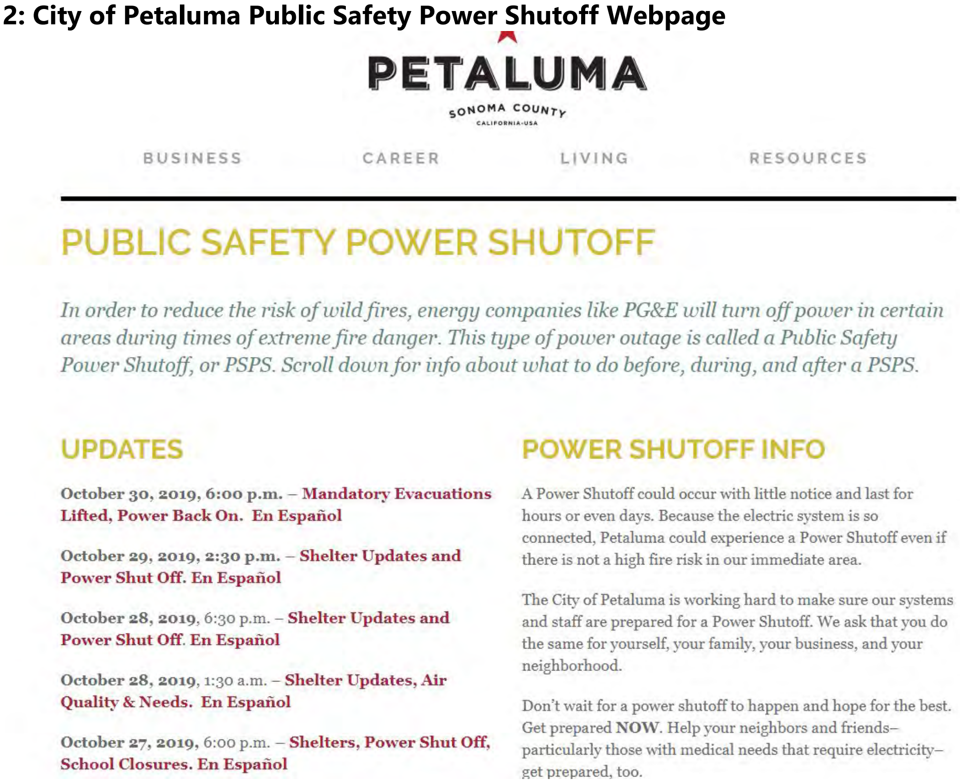
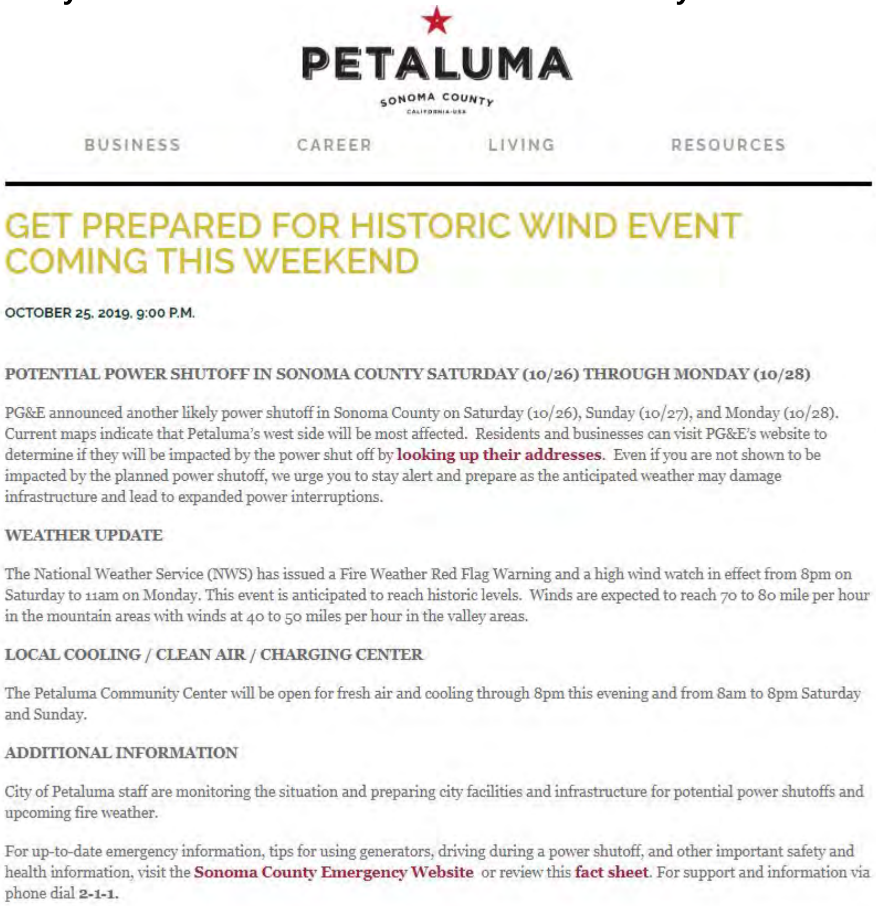


Figure 2-13: City of Petaluma Public Information on Public Safety Power Shutoffs



PETALUMA

SONOMA COUNTY

BUSINESS CAREER LIVING RESOURCES

GET PREPARED FOR HISTORIC WIND EVENT COMING THIS WEEKEND

OCTOBER 25, 2019, 9:00 P.M.

POTENTIAL POWER SHUTOFF IN SONOMA COUNTY SATURDAY (10/26) THROUGH MONDAY (10/28)

PG&E announced another likely power shutoff in Sonoma County on Saturday (10/26), Sunday (10/27), and Monday (10/28). Current maps indicate that Petaluma's west side will be most affected. Residents and businesses can visit PG&E's website to determine if they will be impacted by the power shut off by **looking up their addresses**. Even if you are not shown to be impacted by the planned power shutoff, we urge you to stay alert and prepare as the anticipated weather may damage infrastructure and lead to expanded power interruptions.

WEATHER UPDATE

The National Weather Service (NWS) has issued a Fire Weather Red Flag Warning and a high wind watch in effect from 8pm on Saturday to 11am on Monday. This event is anticipated to reach historic levels. Winds are expected to reach 70 to 80 mile per hour in the mountain areas with winds at 40 to 50 miles per hour in the valley areas.

LOCAL COOLING / CLEAN AIR / CHARGING CENTER

The Petaluma Community Center will be open for fresh air and cooling through 8pm this evening and from 8am to 8pm Saturday and Sunday.

ADDITIONAL INFORMATION

City of Petaluma staff are monitoring the situation and preparing city facilities and infrastructure for potential power shutoffs and upcoming fire weather.

For up-to-date emergency information, tips for using generators, driving during a power shutoff, and other important safety and health information, visit the **Sonoma County Emergency Website** or review this **fact sheet**. For support and information via phone dial **2-1-1**.

Community Shelters

On October 23, 2019 the Kincade Fire started in northeastern Sonoma County and once contained the fire had burned 77,758 acres. The fire did not directly impact the City of Petaluma, and because of this the City was able to open its community shelters from evacuees from neighboring communities in Sonoma County. Eight shelters were open in Petaluma, including the Sonoma-Marin Fairground which opened in partnership with the Red Cross. The Petaluma Community Center and the Veterans Building provided support for over 1,000 evacuees, as a total of 200,000 people were ordered to evacuate from northern Sonoma County (Argus Courier 2019).

Other Planning Capabilities (Ongoing)

The HMPC noted the following additional mitigation outreach efforts during planning sessions:

- **Sonoma County Regional Water Supply Resiliency Plan.** The City has participating in planning process and outreach efforts for this plan.
- **Fire Department – COPE.** COPE stands for Citizens Organized to be Prepared for Emergencies. The Fire Department holds a quarterly seminar on preparedness and encouraging neighborhood organization through "Map Your Neighborhood."
- **Police Department.** The City's Police Department has participated in disaster preparedness education with the City's Fire Department and Sonoma County, especially since the 2017 wildfire events.

- **City's Website.** The City of Petaluma's website provides public information and resource. Including information on water conservation efforts and information related to the PG&E PSPS. The City's social media accounts (Twitter, Facebook) are used to disseminate public information.

2.9.5 Opportunities for Enhancement

Based on the capabilities assessment, the City of Petaluma has several existing mechanisms in place that already help to mitigate hazards. In addition to these existing capabilities, there are also opportunities for the City to expand or improve on these policies and programs to further protect the community. Required future opportunities for enhancement comply with Assembly Bill 2140 include amending the City's General Plan Health and Safety Element to include the LHMP. The City can update other plans, such as the City's Capital Improvement 5 Year Plans to include hazard mitigation actions and climate adaptation strategies that relate to infrastructure resiliency. Other future improvements may include providing hazard training for staff or hazard mitigation grant funding in partnership with Sonoma County and Cal OES.

CRS Program Class Rating Improvements

The City of Petaluma currently has a Class 6 rating under the NFIP CRS Program. As previously mentioned, this Class 6 results in a 20 percent discount to policy holders in the SFHA and 10 percent reduction for those who have standard X-Zone policies. According to Table 2-16, the City currently has 2,125 credit points which are listed below by CRS activities.

Table 2-16: City of Petaluma Credit Points under the Community Rating System Program

Activity	Description	Year[1]	Total
C310	Elevation Certificates	2016	38
C320	Map Information	2016	90
C330	Outreach Projects	2016	96
C340	Hazard Disclosure	2016	15
C350	Flood Protection Information	2016	29
C360	Flood Protection Assistance	2016	55
C370	Flood Insurance Promotion	2016	0
C410	Floodplain Mapping	2016	0
C420	Open Space Preservation	2016	1137
C430	Higher Regulatory Standards	2016	241
C440	Flood Data Maintenance	2016	144
C450	Stormwater Management	2016	70
C510	Floodplain Management Planning	2016	177
C520	Acquisition and Relocation	2016	33
C530	Flood Protection	2016	0
C540	Drainage System Maintenance	2016	0
C610	Flood Warning and Response	2016	0
C620	Levees	2016	0
C630	Dams	2016	0

[1] – Year the City of Petaluma floodplain management activities were audited by the Insurance Services Office (ISO). ISO works on behalf of FEMA and insurance companies to review recertification applications and verify communities credit points under the CRS program. The next verification cycle will occur in 2021.

Source: FEMA Community Information System (CIS) 2019

The City will need 280 more points of credit to reach a CRS Class 5 and a 25 percent reduction in the cost of flood insurance. To reach a Class 5, the following activities of credit can be modified:

- Activity 330 Outreach Projects where a maximum of 200 points of credit are available for Outreach Projects. The City only has 96 points currently.

- Activity 510 Floodplain Management Planning where a maximum of 382 points are available and the City currently has 177 points for its current plan.
- Activity 540 Drainage System Maintenance where the maximum credit is 470 points and the City currently does not have any credit assigned. Taking credit for Problem Site Maintenance and the City's Capital Improvement Program could add 120 points under this activity.

Modifying these three activities may be enough credit for the City to reach a CRS Class 5 and savings of more than $106,264 each year and an average annual policy discount of $259. See Table 2-17 for savings.

Table 2-17: Cost Savings by Policy and by Community under CRS Class 5

CRS Class	Description	Total	SFHA	X-STD/AR/A99
9	Per Policy	$55	$97	$40
	Per Community	$22,628	$20,336	$2,292
8	Per Policy	$105	$195	$40
	Per Community	$42,964	$40,672	$2,292
7	Per Policy	$154	$292	$40
	Per Community	$63,300	$61,008	$2,292
6	Per Policy	$210	$389	$79
	Per Community	$85,928	$81,344	$4,584
5	Per Policy	$259	$487	$79
	Per Community	$106,264	$101,680	$4,584
4	Per Policy	$309	$584	$79
	Per Community	$126,600	$122,016	$4,584
3	Per Policy	$358	$681	$79
	Per Community	$146,936	$142,352	$4,584
2	Per Policy	$408	$778	$79
	Per Community	$167,272	$162,688	$4,584
1	Per Policy	$458	$876	$79
	Per Community	$187,608	$183,024	$4,584

[1] – SHFA includes Zones A, AE, A1-A30, V, V1-V30, AO, and AH; discount varies depending on class.
[2] – SFHA includes Zones A99, AR, AR/A, AR/AE, AR/A1-A30, AR/AH, and AR/AO; 10 percent discount for Classes 1-6; 5 percent discount for Classes 7-9
Source: CRS 2019

Other Opportunities

Additional training opportunities will help to inform City staff members on how best to integrate hazard information and mitigation projects into their departments. Continuing to train City staff on mitigation and the hazards that pose a risk to the City of Petaluma will lead to more informed staff members who can better communicate this information to the public.

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3 Planning Process

44 U.S. Code of Federal Regulations Requirements §201.6 Local Mitigation Plans (b) and §201.6(c)(1): An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include:

1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;

2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia, and other private and nonprofit interests to be involved in the planning process; and

3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

[The plan shall document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

3.1 Background on Mitigation Planning in the City of Petaluma

This multi-hazard, single-jurisdiction Local Hazard Mitigation Plan (LHMP) Update is a revised, detailed plan tailored for the City of Petaluma. The City's previous plan, "Taming Natural Hazards," adopted in 2005, was a regional, multi-jurisdictional LHMP for all nine counties within the Bay Area prepared on behalf of the City by the Association of Bay Area Governments (ABAG). The City annexed the regional plan in 2010 which has since expired in 2015. ABAG is no longer managing the update of the multi-jurisdictional LHMP which requires the City to create a single-jurisdiction update to the plan.

The increasing cost of disaster recovery in the nation and the State of California over the past decades, and specifically from the recent wildfires in 2017 and in 2019, has prompted a renewed interest in determining effective and holistic approaches to minimize natural hazards. Hazard mitigation planning plays an important role in building community resilience through the identification of hazards, assessment of vulnerabilities, and the development of mitigation actions. The City of Petaluma recognized the importance of developing a new, updated LHMP and was responsible for initiating its development in 2019. The goal of the LHMP is to develop practical, attainable, and cost-effective mitigation actions to reduce vulnerability to the identified hazards and reduce human, property, and economic losses from hazard events. The City contracted with Wood Environment & Infrastructure Solutions, Inc. (Wood) to facilitate and develop the plan. Wood's role was to:

- Assist in establishing the Hazard Mitigation Planning Committee (HMPC) as defined by the Disaster Mitigation Act (DMA) of 2000 (Public Law 106-390) commonly known as the 2000 Stafford Act Amendments;
- Meet the DMA requirements as established by federal regulations and follow the Federal Emergency Management Agency (FEMA) planning guidance;
- Facilitate the entire planning process based on a Community Engagement Strategy;
- Identify the data requirements for the HMPC and conduct the research and documentation necessary to augment that data;
- Perform risk assessments that identify, evaluate, and prioritize natural and human-caused hazards that could impact the City;

- Conduct a vulnerability assessment to identify the hazard's impacts on the City's critical facilities, infrastructure, property, and future development;
- Assist in facilitating the public input process;
- Integrate the risk and vulnerability assessment to help the City determine appropriate mitigation goals and objectives to minimize long-term vulnerabilities to the identified hazards;
- Produce draft and final plan documents; and
- Coordinate with California Office of Emergency Services (Cal OES) and FEMA Region IX plan reviews.

The original plan developed by ABAG broadly covered natural hazards and vulnerabilities in the City of Petaluma. This new, updated plan expands on the multi-jurisdictional LHMP and is tailored to address the natural and human-caused hazards in the City, the identified hazard impacts specific to Petaluma's critical facilities and infrastructure, and the development of a locally attainable mitigation strategy. The new LHMP will involve adopting, implementing, assigning responsibility, monitoring, and reviewing the mitigation actions over time to ensure the goals and objectives of the plan are being achieved and the plan remains relevant. The remainder of this chapter provides a narrative of the steps taken to prepare the LHMP.

3.2 Local Government Participation

The LHMP Update is a single-jurisdictional plan that covers the City of Petaluma Planning Area, which is the same boundary as the City's Urban Growth Boundary (UGB). The DMA planning regulations and guidance stress that each local government seeking FEMA approval of their mitigation plan must participate in the planning effort in the following ways:

- Participate in the process as part of the HMPC
- Identify potential mitigation actions; and
- Formally adopt the plan.

For the City of Petaluma's HMPC, "participation" was defined at the outset of the planning process as the following:

- Providing facilities for meetings;
- Attending and participating in the HMPC meetings;
- Completing and returning the Wood Environment & Infrastructure Solutions, Inc. Data Collection Guide;
- Collecting and providing other requested data (as available);
- Managing administrative details;
- Engaging stakeholders and facilitating a formal Stakeholder's Workshop;
- Making decisions on plan process and content;
- Identifying mitigation actions for the plan;
- Reviewing and providing comments on plan drafts;

- Informing the public, local officials, and other interested parties about the planning process and providing opportunity for them to comment on the plan;
- Advertising, coordinating, and participating in the public input process; and
- Coordinating the formal adoption of the plan by the City Council.

The City of Petaluma met all FEMA's requirements for plan participation. The City brought together a local planning team with representatives from each City of Petaluma department to help collect data, identify mitigation actions and implementation strategies, and review and provide data on plan drafts. The City engaged several federal, state, regional, and local stakeholder representatives from various agencies and municipalities in the region. In most cases, one or more representatives from each City department and each agency attended the HMPC meetings described in Table 3-2.

The preparation of the updated LHMP was also intended to assist the City of Petaluma in reducing its risk from natural and man-made hazards by identifying resources, information, and strategies for risk reduction. For the City's HMPC, the intention of the plan is to help guide and coordinate mitigation activities throughout the City's various departments, as this is their first stand-alone LHMP since the multi-jurisdictional regional LHMP prepared by ABAG. As a result, the HMPC set out to develop a plan that would meet the objectives summarized below.

- The plan would meet or exceed program requirements specified under the DMA of 2000.
- The plan would not only meet Cal OES and FEMA requirements, but also the needs of the City.
- The plan would coordinate existing and ongoing plans and programs already established at the City so that high priority initiatives and projects to mitigate possible disaster impacts would be funded and implemented.
- The plan would create a linkage between the LHMP and established plans such as the City's 2011 General Plan 2025, 2015 Floodplain Management Plan, Water and Infrastructure Master Plans, Capital Improvement Plans and projects, and the City's 2007 Emergency Operation Plan so that existing planning mechanisms can be integrated to help the City achieve successful mitigation.

Given plan integration is a key strategy in the success of LHMP implementation, the HMPC focused on consistency between plans and programs at the City of Petaluma, including the City Council's 2019-2020; 2020-2021 Goals and Priorities Strategic Plan. The HMPC also focused on ensuring each department representative consulted with their individual departments in between meetings to ensure existing capabilities were adequately documented in the LHMP and that mitigation actions were thoroughly reviewed and developed by a range of department leads throughout the City of Petaluma. Appendix A provides additional information and documentation of the planning process.

3.3 The 10-Step Planning Process

Wood established the planning process for the City of Petaluma's LHMP Update using the DMA planning requirements and FEMA's associated guidance. This guidance is structured around a four-phase process:

1) Organize Resources
2) Assess Risks
3) Develop the Mitigation Plan
4) Implement the Plan and Monitor Progress

Into this process, Wood integrated a more detailed 10-step planning process used for FEMA's Community Rating System (CRS) and Flood Mitigation Assistance (FMA) programs, as Petaluma participates in the CRS. Thus, the modified 10-step requirements of the Hazard Mitigation Assistance grants (HMA, including Hazard Mitigation Grant Program, HMGP; Pre-Disaster Mitigation program, PDM; Flood Mitigation Assistance, FMA), CRS, and the flood control projects authorized by the U.S. Army Corps of Engineers (USACE) are addressed. FEMA's March 2013 Local Mitigation Planning Handbook recommends a nine step process within the four-phase process. Table 3.1 summarizes the four-phase DMA process, the detailed CRS planning steps and work plan used to develop the plan, the nine handbook planning tasks from FEMA's 2013 Local Mitigation Planning Handbook, and where the results are captured in the Plan. The sections that follow describe each planning step in more detail, including information on the LHMP schedule and general timeframe of activities that took place to develop the plan.

Table 3-1: Mitigation Planning Processes Used to Develop the City of Petaluma's LHMP

FEMA 4 Phase Guidance Phases	Community Rating System (CRS) Planning Steps	2013 FEMA Local Mitigation Planning Handbook Steps (44 CFR Part 201)	Location in LHMP
Phase 1: Organize Resources	Step 1. Organize Resources	1: Determine the Planning Area and Resources	Chapters 1, 2, and 3
		2: Build the Planning Team 44 CFR 201.6(c)(1)	Chapter 3, Section 3.3.1
	Step 2. Involve the public	3: Create an Outreach Strategy 44 CFR 201.6(b)(1)	Chapter 3, Section 3.3.1
	Step 3. Coordinate with Other Agencies	4: Review Community Capabilities 44 CFR 201.6(b)(2) & (3)	Chapter 2, Section 2.2; Chapter 3, Section 3.3.1
Phase 2: Identify Hazards and Assess Risks	Step 4. Assess the hazard	5: Conduct a Risk Assessment 44 CFR 201.6(c)(2)(i) 44 CFR 201.6(c)(2)(ii) & (iii)	Chapter 4, Sections 4.1 through 4.3
	Step 5. Assess the problem		Chapter 4, Sections 4.1 through 4.3
Phase 3: Develop a Mitigation Strategy	Step 6. Set goals	6: Develop a Mitigation Strategy 44 CFR 201.6(c)(3)(i); 44 CFR 201.6(c)(3)(ii); and 44 CFR 201.6(c)(3)(iii)	Chapter 5, Section 5.2
	Step 7. Review possible activities		Chapter 5, Section 5.3
	Step 8. Draft an action plan		Chapter 5, Section 5.4
Phase 4: Implement and Monitor the Plan	Step 9. Adopt the plan	8: Review and Adopt the Plan	Chapter 6, Appendix C
	Step 10. Implement, evaluate, and revise	7: Keep the Plan Current	Chapter 7
		9: Create a Safe and Resilient Community 44 CFR 201.6(c)(4)	Chapter 7

3.3.1 Phase 1: Organize Resources

Planning Step 1: Organize the Planning Effort

With the City's commitment to develop the plan, Wood worked with the City's Public Works and Utilities Department to establish the framework and organization for the planning process. Organizational efforts were initiated with the City to inform and educate the plan participants of the purpose and need for the City, single-jurisdictional LHMP update. Wood held an initial call on May 28, 2019 to discuss the organizational aspects of this planning process with City's Public Works and Utilities Department project manager, who took the lead on this project. On June 12, 2019 the City circulated the HMPC invitee list. The schedule of subsequent planning activities is summarized in Table 3-2.

Table 3-2: Local Hazard Mitigation Plan Schedule of Planning Activities

Project Task	Meeting Date(s)
Project Kick-Off Meeting	May 28, 2019
Circulate Draft HMPC Invitee List	June 12, 2019
Submit HMPC Meeting #1 Agenda	July 2, 2019
HMPC Meeting #1	July 8, 2019
Submit Draft Community Engagement Strategy	July 30, 2019
City and HMPC Review of Community Engagement Strategy	August 9, 2019
Submit Final Community Engagement Strategy	August 12, 2019
HMPC Meeting #2	October 7, 2019
Prepare Hazard Identification and Risk Assessment	October 7, 2019
1st Public Workshop	October 8, 2019
Develop Goals and Objectives	October 8, 2019
HMPC Meeting #3	October 8, 2019
Compile Mitigation Action Worksheets	December 1, 2019
Submit Sea Level Rise Vulnerability Assessment (part of Risk Assessment)	December 4, 2019
Submit 1st Administrative Draft LHMP	January 17, 2020
City and HMPC provides consolidated comments on 1st Administrative Draft LHMP	January 31, 2020
Submit 2nd Administrative Draft LHMP	February 14, 2020
Complete FEMA Region IX Review Tool: Elements A through D	February 18, 2020
Circulate Public Review Draft LHMP	April 15, 2020
Public Review Ends (30-day public review)	May 15, 2020
HMPC Meeting #4	May 20, 2020
Submit Final Draft LHMP to Cal OES for review (45-day review period)	June 29, 2020
Submit Final Draft LHMP to FEMA Region IX for review	August 12, 2020
City Council Hearing*	TBD

**City Council Meetings are held on the first and third Tuesdays of each month.*

Invitations to the kick-off meeting were extended to key City departments, and federal and state agencies, Sonoma County, neighboring municipalities, and key stakeholders. Using FEMA planning guidance, representatives from each City of Petaluma department established the base membership for the HMPC stakeholder committee. The HMPC also included multiple representatives from federal, state, and local agencies, and stakeholders from local school districts, community hospitals, and other organizations. Key representatives from neighboring communities included staff from the Sonoma County Department of Emergency Management, City of Sebastopol, and Sonoma County Water Agency (Sonoma Water). The list of agencies and individuals invited to participate is included in Appendix A.

The HMPC was established as a result of this effort, as well as through interest generated through outreach conduced for this project, which is outlined in more detail in the Community Engagement Strategy. The HMPC collectively developed the plan with leadership from the City and facilitation by Wood. The HMPC meetings also had participation from other agency stakeholders with an interest in hazard mitigation, which are described in Planning Step 3. Representatives from the following City departments and other agencies participated on the HMPC:

City of Petaluma

- City Manager's Office
  - Building Division
  - Planning Division

- Economic Division
- Housing Division
- Information Technology Division

- City Clerk Office
- City Attorney's Office
- Finance Department
- Fire Department
- Human Resources Department
- Parks and Recreation Services Department
- Police Department
- Public Works and Utilities Department
    - Capital Improvements
    - Environmental Services
    - Transit
    - Public Works Operations
    - Airport/Marina
    - Development Engineering
    - Parks/Facilities Maintenance

Sonoma County

- Department of Emergency Management

Other Agency and Organization Stakeholders

- City of Sebastopol
    - Building Department
    - Planning Department

A list of participating HMPC representatives is included in Appendix B. This list includes all HMPC members that attended one or more HMPC meetings detailed in Table 3-2. The City also utilized the support of other City staff in order to collect and provide requested data and to conduct timely reviews of draft documents. Note, that the core HMPC group was also supplemented by input from other government and stakeholder representatives that contributed to the planning process as identified in Planning Step 3: Coordinate with Other Department and Agencies.

The planning process officially began with a kick-off meeting on July 8, 2019. The meeting covered the scope of work and an introduction to the DMA requirements. Participants were provided with a Data Collection Guide, which included worksheets to facilitate the collection of information necessary to support development of the plan. Using FEMA guidance, Wood designed these worksheets to capture information on past hazard events, identify hazards of concern to the jurisdiction, quantify values at risk to identified hazards, inventory existing capabilities, and record possible mitigation actions. A copy of Wood's Data Collection Guide for this project is included in Appendix A. The City completed and returned the worksheets in the data collection guide to Wood staff for incorporation into the plan.

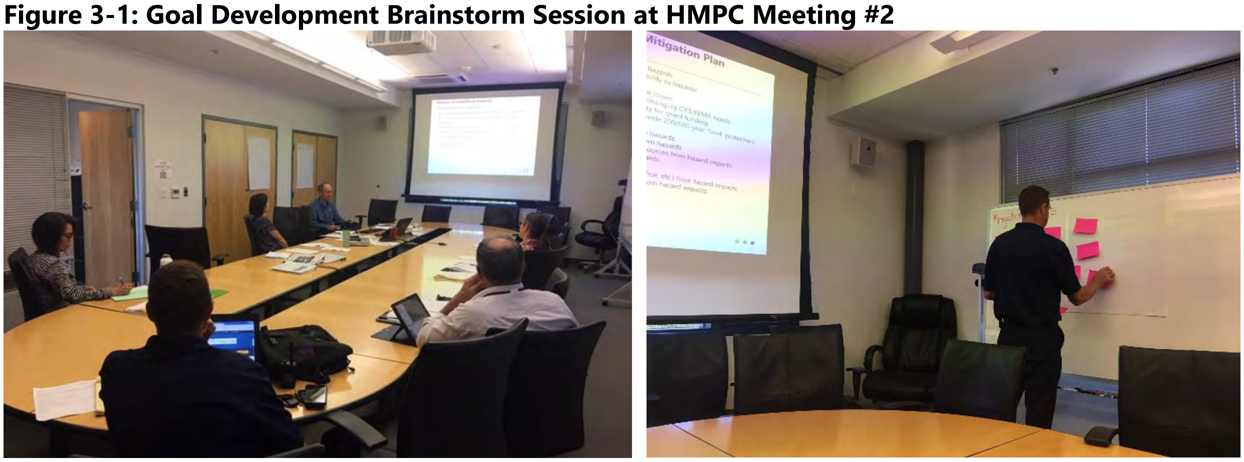
During the planning process, the HMPC communicated through face-to-face meetings, email, and monthly telephone conversations, and added information to the City's LHMP Webpage. Draft documents were distributed via email to the City's project manager and then distributed to the HMPC stakeholders. The HMPC met three times during the planning period (July 8, 2019 through October 8, 2019).

The dates and purposes of these meetings are described in Table 3-3. The HMPC also met internally in between meetings to help the City's Public Works and Utilities Department project manager track deliverables, worksheet materials, and public outreach documentation. Agendas for each of the meetings and lists of attendees are included in Appendix A. Figure 3-1 is from HMPC Meeting #2.

Table 3-3: Schedule of Planning Meetings

Meeting Type	Meeting Topic	Meeting Date(s)
HMPC Meeting #1	Kick-off meeting: introduction to DMA, the planning process, and hazard identification	July 8, 2019
HMPC Meeting #2	Risk assessment overview and work session on goal development	October 7, 2019
HMPC Meeting #3	Development of mitigation actions; selection and prioritization of mitigation recommendations	October 8, 2019
HMPC Meeting #4	Discuss public comments received on the Public Review Draft LHMP	May 20, 2020

Figure 3-1: Goal Development Brainstorm Session at HMPC Meeting #2



At HMPC Meeting #1, the planning process scope and schedule were discussed, along with the list of hazards addressed in the plan, followed by a presentation that summarized hazard vulnerability. The group was asked what hazards presented the greatest concern. HMPC Meeting #2 focused on the findings from the Risk Assessment and the specific vulnerabilities to the City's critical assets and infrastructure that need to be addressed in the mitigation strategy. The HMPC also developed broad goals and objectives during HMPC Meeting #2. This led to further discussion and the prioritization of mitigation actions developed at the HMPC Meeting #3. Figure 3-2 is from HMPC Meeting #3. Meeting #4 was held to review public comments and revise the Draft LHMP prior to submittal to Cal OES.

Figure 3-2: Mitigation Strategy Brainstorm Session at HMPC Meeting #3

Planning Step 2: Involve the Public

Early discussions with the City of Petaluma established the initial plan for public involvement. At the kick-off meeting, the HMPC discussed options for public involvement and agreed to an approach using established public information mechanisms and resources within the community. This approach was outlined in the project's Community Engagement Strategy (Appendix C). The approach was also supported and implemented by the City's Public Works and Utilities Department project manager.

Public outreach was initiated during the plan development process with an informational press release to notify the public of the purpose of DMA and the hazard mitigation planning process for the City of Petaluma. The City Public Works and Utilities Department project manager coordinated an interview with the local newspaper, the Petaluma-Argus Courier prior to the first public workshop. Public involvement activities included the development of the project webpage, organization of public workshops, and circulation of press releases and an online survey. The City compiled public comments received during the first public workshop and based on the first online survey.

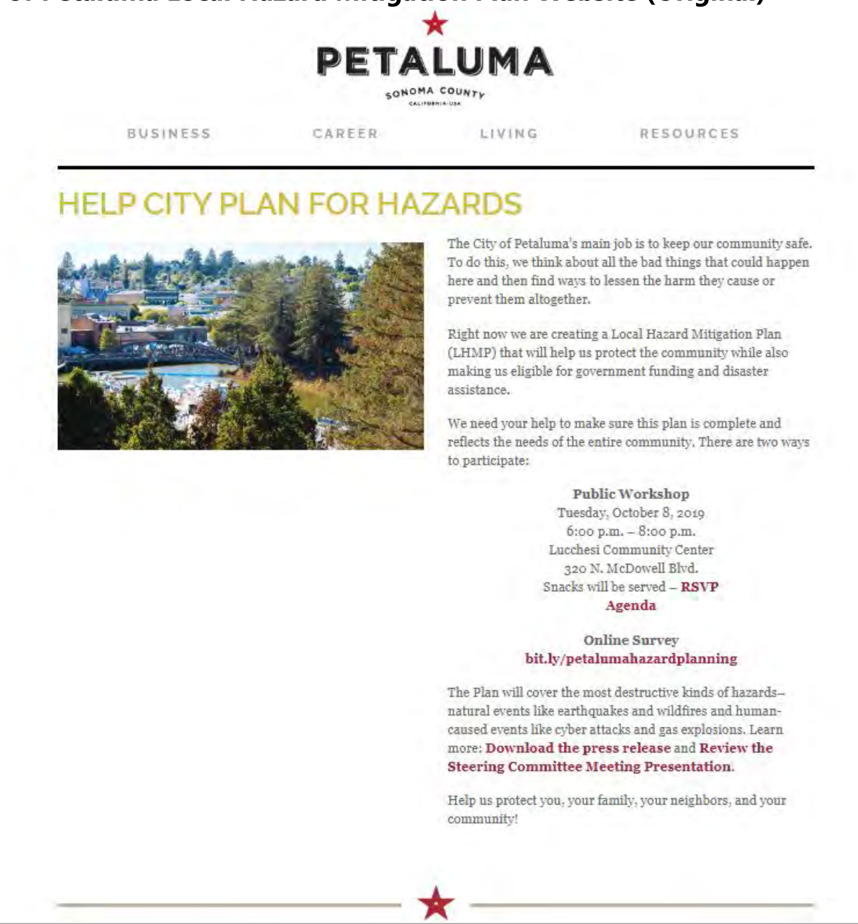
The City also compiled public comments on the planning process, hazard profiles, risk assessment, and the Draft LHMP during a second public workshop and based on a second online survey. During this time formal comments on the draft plan circulated during public review were compiled and organized. These comments were submitted by email and through the second online survey. The City received a total of four public comments on the plan. A summary of these comments and the comment-response matrix is included in Appendix A. The City incorporated public input by reviewing the comments and revising the LHMP prior to submittal to Cal OES and FEMA Region IX.

The City also took public comment during the second public workshop. The second public workshop was held as a virtual webinar. The City notified the project stakeholders and public about the second public workshop via email, the circulation of press releases, newspaper notices, and social media postings. The second public workshop was also advertised on daily and weekly City of Petaluma news updates. The City received one public comment during the second public workshop.

Project Webpage

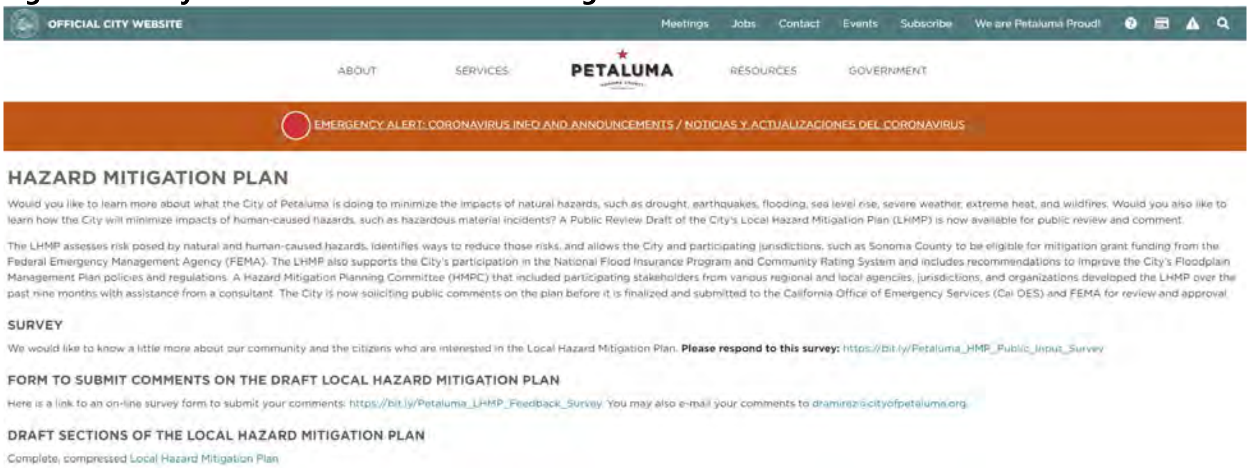
At the beginning of the planning process, the City Public Works and Utilities Department and City Manager's Economic Division created a LHMP Webpage linked to the City's Main Website to keep the public informed on hazard mitigation, the development of the LHMP and the planning process, and as a place to solicit public input. The LHMP Webpage include a background section on hazard mitigation planning and the DMA. It also highlighted recent natural hazard events that have occurred in the City of Petaluma and adjacent unincorporated Sonoma County. The LHMP Webpage publicized on all media releases, mailings, newsletters, surveys, and public meeting advertisements. It also has a sidebar with the meeting agenda's, minutes, sign-in sheets, and presentations from the various HMPC meetings and public workshops. The City also intends to keep the LHMP Webpage active after the plan is completed to keep the public informed about the status of the mitigation actions. Figure 3- and Figure 3-4 show the City of Petaluma LHMP Webpage at the time of the first public workshop and the second public workshop. The City of Petaluma website was being updated during the planning and outreach process for this project, and as a result the design of the project webpage changed. The City made the Public Review Draft LHMP available on the LHMP Webpage in April 2020 and was initially available here: https://petalumastar.com/hazards/.

Figure 3-3: City of Petaluma Local Hazard Mitigation Plan Website (Original)



The City also circulated the Public Review Draft LHMP on the updated LHMP Webpage here: https://cityofpetaluma.org/hazard-mitigation-plan-2/.

Figure 3-4: City of Petaluma Local Hazard Mitigation Plan Website



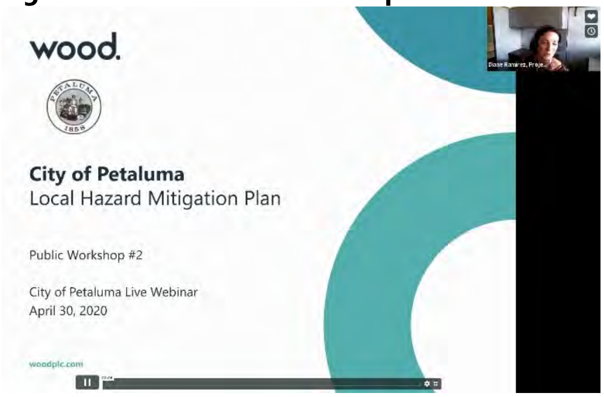
Public Workshops

Public meetings were held during the draft-plan development process and prior to finalizing the plan as further described in Table 3-4. The first public workshop was held on October 8, 2019. Figure 3-5 is from the first public workshop.

Figure 3-5: 1st Public Workshop

The second public workshop was held via a livestream webinar workshop on April 30, 2020. Figure 3-6 are two screenshots of the second public workshop.

Figure 3-6: 2nd Public Workshop



Where appropriate, stakeholder and public comments were incorporated into the final plan, including the sections that address mitigation goals and strategies. Comments submitted during the first public workshop addressed the proposed mitigation actions, specifically the need to include actions related to human-caused hazards associated with hazardous material releases (e.g. natural gas pipelines), wildfire prevention, and emergency preparedness. Detailed comments are summarized below.

All press releases and website postings are on file with the City of Petaluma Public Works and Utilities Department (see Figure 3- for an example of a press release published in a local newspaper). The public outreach activities described here were coordinated and fully supported by the City of Petaluma. The two Public Workshops scheduled and organized by the City are detailed in Table 3-4.

Table 3-4: Public Workshops

Meeting Topic	Meeting Dates	Meeting Locations
1st Public Workshop	October 8, 2019	Lucchesi Community Center
2nd Public Workshop	April 30, 2020	Livestream Webinar Workshop

The first Public Workshop was held to solicit public and stakeholder input during draft development of the plan. Public outreach included an email distribution with a notice of the public meeting to the HMPC with direction to share with other associations, boards and committees and postings around the workplace. The meeting notice was also posted on the City of Petaluma LHMP Webpage. The City of Petaluma Public Works and Utilities Department project manager also interviewed with the local newspaper to spread the word about the LHMP and the first public workshop. Ten people attended the public workshop. Sign-in sheets and other workshop materials are included in Appendix A.

There were several clarification comments during a presentation on the need to update the existing LHMP regarding coordination with Sonoma County and how the plan relates to emergency preparedness. One participant asked for information about the existing plan prepared by ABAG, why it expired, and inquired on the timing for the new or updated plan. Another participant indicated there were several man-made hazards in the City, such as gas pipelines that need to be addressed in the updated LHMP. A third attendee asked about fire prevention activities that may benefit the City but are located outside the city limits. Given the timing of the public workshop, all participants were also provided the opportunity to review the mitigation actions developed at the HMPC Meeting #3 that occurred during the afternoon. They were provided colored dot stickers and asked to place a green sticker on mitigation actions they think should be prioritized and a red sticker on mitigation actions they think should not be carried forward for further consideration. They were also provided different color sticky notes and asked to share a mitigation action related to the various action categories (e.g. flooding, earthquakes) displayed across the wall.

Where appropriate, stakeholder and public comments and recommendations were incorporated into the final plan, including the risk assessment and sections that address mitigation goals and strategies. Comments submitted during the second public workshop and during public review will be summarized in this chapter. A summary of the meeting will also be shared with the HMPC and is included in Appendix A.

Prior to finalization of the plan a draft will be made available on the City's LHMP Webpage for a 30-day public comment period. The Public Review Draft LHMP update was circulated on April 15, 2020 through May 15, 2020. The City posted an electronic form with the plan on the City's LHMP Webpage to capture electronic comments (see Appendix A).

Online Survey

During the planning process and drafting stage, two web-based public surveys were developed as tools to gather public input. The survey was for the public to provide feedback to the HMPC on topics related to hazard concerns and reducing hazard impacts. The survey provided an opportunity for public input during the planning process and prior to finalization of the plan. The survey gathered public feedback on concerns about wildfires, floods, earthquakes, climate change, and other hazards and solicited input on strategies to reduce their impacts. The first survey was released as an online tool on October 22, 2019 and closed on May 15, 2019 (6-month comment period). The HMPC provided links to the public survey by distributing it using social media, email, posting the link on the City's LHMP Webpage, and making it available on tablets at informational booths. As of May 15, 2020, 30 responses were received on the first survey. This information was shared with the HMPC to inform the process.

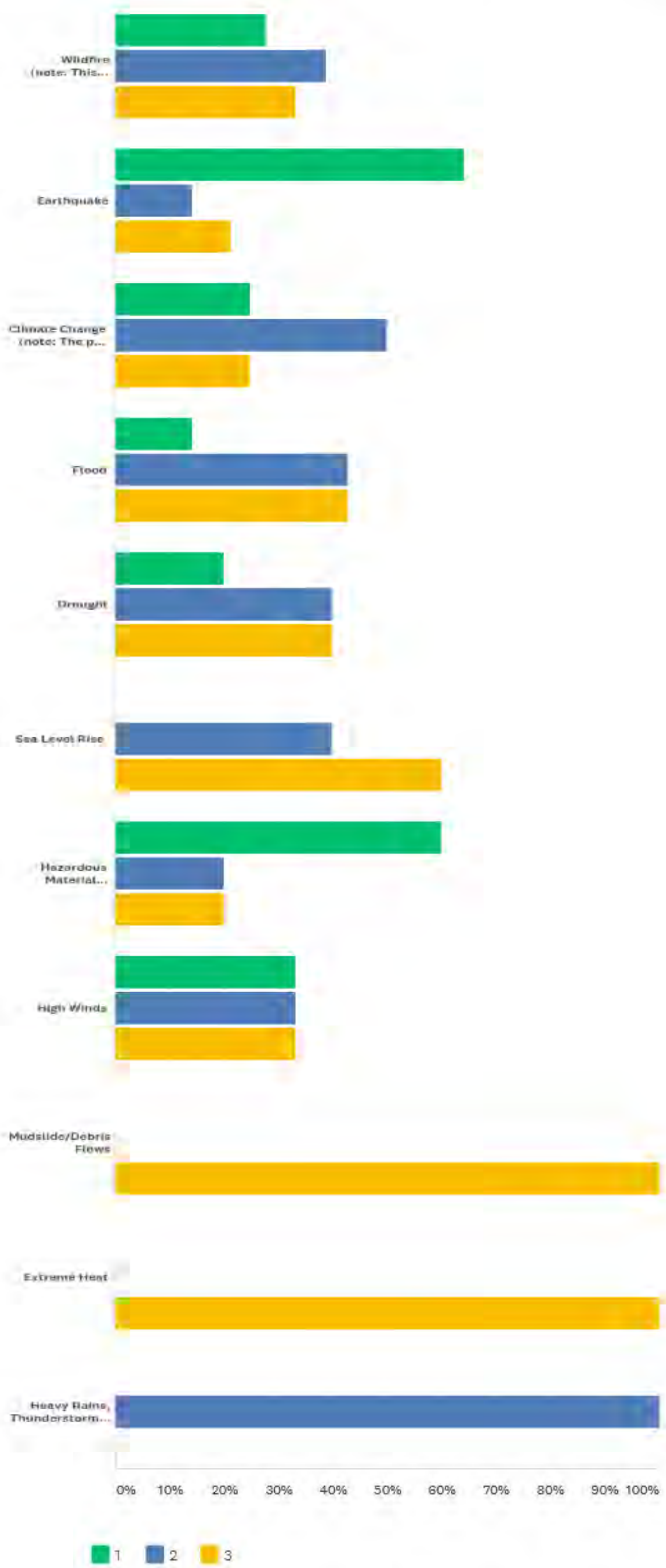
The survey included a total of 18 questions. There was a short section of questions on demographics, specifically on whether participants were residents of the City or the unincorporated portion of Sonoma County. These questions also inquired about homeownership, insurance, and commute patterns. The next section included questions on ranking hazard significance. The results generally track with the significance levels noted in Chapter 4 of this plan, with earthquake, flooding, wildfires, and climate change being considered the most significant. Drought, sea level rise, and high wind events also ranked highly in significance based on the public input. The last section of the survey focused on questions related to mitigation actions that the City should consider in the plan. The results indicated that public education/awareness, planning/zoning, critical facilities protection, stormwater drainage improvements, indoor/outdoor warning systems, and wildland fuels treatment projects were popular topics to the public. These results were shared with the HMPC and considered during the planning process.

The second public survey was developed to gather public input specific to the Public Review Draft LHMP. This second public survey was posted on the City's LHMP Webpage on April 15, 2020. It included a total of five questions designed to solicit input and provide an electronic comment form and format for the public to submit comments on the Draft LHMP. Two responses were received on the second survey. This information was also shared with the HMPC to inform the process.

Figure 3- shows an example of one of the public survey responses from the survey. The full results of the survey are included in Appendix A.

Figure 3-7: Example of Public Survey Response

Q7 The hazards addressed in the Hazard Mitigation Plan are listed below. Please choose the top 3 hazards of most concern to you. Number 1 represents highest concern.



Social Media

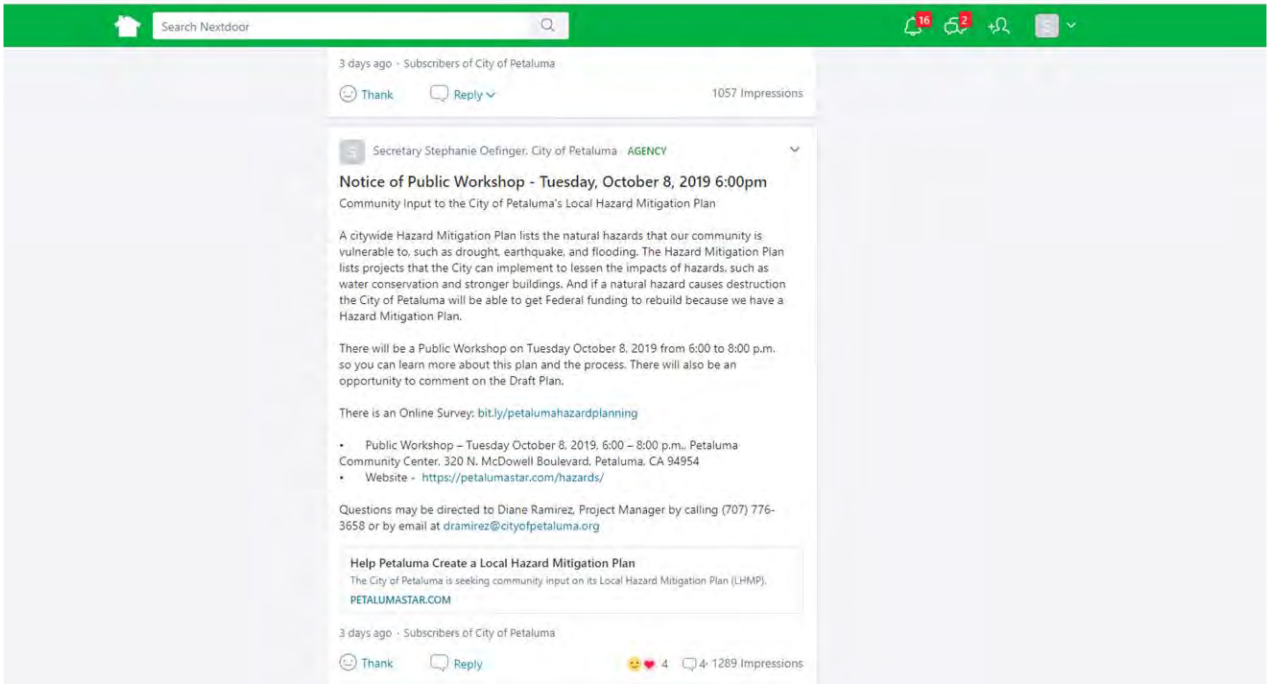
The City of Petaluma used the following social media platforms to circulate information on the LHMP:

- City Facebook (6,000+ followers);
- City Twitter (2,500+ followers); and
- City Nextdoor (1,500+ followers).

The three social media platforms announced the kick-off of the LHMP planning process, advertised the City's LHMP Webpage and other events, included a link to the online survey, notified the public about meetings and workshops, and announced the availability of the plan for public input and comment. Figure 3- and Figure 3-9 are examples of a news feed from two social media platforms: the City's Facebook and Nextdoor social media pages that advertise the first public workshop. 3-10 and Figure 3-11 advertise the availability of the Draft LHMP.

Figure 3-8: Example of Social Media Announcement on City's Facebook Page

Figure 3-9: Notice of Public Workshop on City's Nextdoor Page


Search Nextdoor

3 days ago · Subscribers of City of Petaluma

Thank Reply 1057 Impressions

Secretary Stephanie Oefinger, City of Petaluma AGENCY

Notice of Public Workshop - Tuesday, October 8, 2019 6:00pm

Community Input to the City of Petaluma's Local Hazard Mitigation Plan

A citywide Hazard Mitigation Plan lists the natural hazards that our community is vulnerable to, such as drought, earthquake, and flooding. The Hazard Mitigation Plan lists projects that the City can implement to lessen the impacts of hazards, such as water conservation and stronger buildings. And if a natural hazard causes destruction the City of Petaluma will be able to get Federal funding to rebuild because we have a Hazard Mitigation Plan.

There will be a Public Workshop on Tuesday October 8, 2019 from 6:00 to 8:00 p.m. so you can learn more about this plan and the process. There will also be an opportunity to comment on the Draft Plan.

There is an Online Survey: bit.ly/petalumahazardplanning

- Public Workshop – Tuesday October 8, 2019, 6:00 – 8:00 p.m., Petaluma Community Center, 320 N. McDowell Boulevard, Petaluma, CA 94954
- Website - https://petalumastar.com/hazards/

Questions may be directed to Diane Ramirez, Project Manager by calling (707) 776-3658 or by email at dramirez@cityofpetaluma.org

Help Petaluma Create a Local Hazard Mitigation Plan

The City of Petaluma is seeking community input on its Local Hazard Mitigation Plan (LHMP).

PETALUMASTAR.COM

3 days ago · Subscribers of City of Petaluma

Thank Reply 4 4 1289 Impressions

Figure 3-10: Social Media Announcement on City's Twitter Page on Availability of Draft LHMP

Figure 3-11: Notice of Availability of Draft LHMP on City's Facebook Page

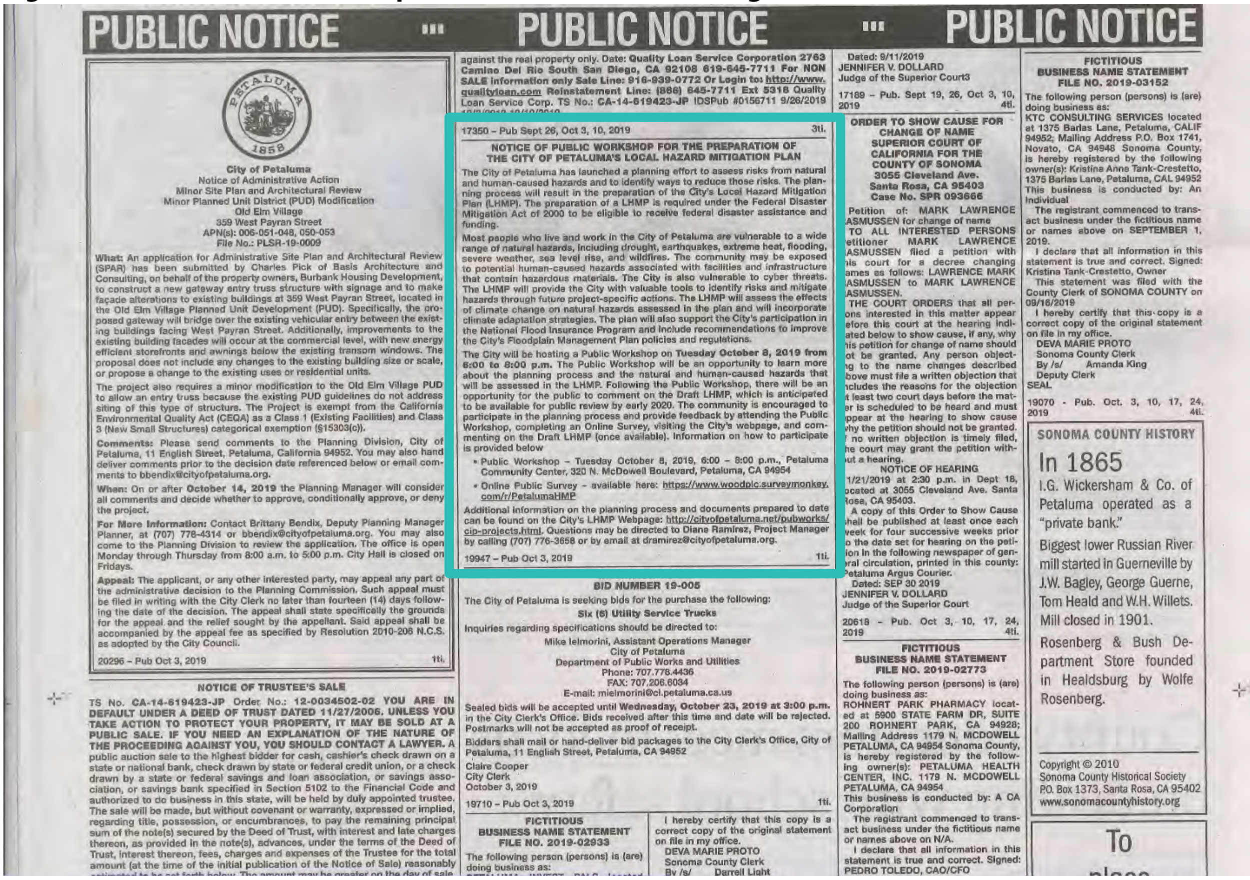
Newspapers

The following regional and local print newspapers were used to circulate and advertise information on the LHMP, specifically the announcement of the public workshop:

- Petaluma Star News
- Petaluma-Argus Courier
- Sonoma County Gazette
- Sonoma Index-Tribune
- Sonoma West Times & News; and
- Press Democrat.

Figure 3- and Figure 3-13 are examples of a press release published in the Petaluma-Argus Courier on the first and second public workshops.

Figure 3-12: 1st Public Workshop Notice in the Petaluma-Argus Courier



PUBLIC NOTICE PUBLIC NOTICE PUBLIC NOTICE

17350 – Pub Sept 26, Oct 3, 10, 2019 3ti.

NOTICE OF PUBLIC WORKSHOP FOR THE PREPARATION OF THE CITY OF PETALUMA'S LOCAL HAZARD MITIGATION PLAN

The City of Petaluma has launched a planning effort to assess risks from natural and human-caused hazards and to identify ways to reduce those risks. The planning process will result in the preparation of the City's Local Hazard Mitigation Plan (LHMP). The preparation of a LHMP is required under the Federal Disaster Mitigation Act of 2000 to be eligible to receive federal disaster assistance and funding.

Most people who live and work in the City of Petaluma are vulnerable to a wide range of natural hazards, including drought, earthquakes, extreme heat, flooding, severe weather, sea level rise, and wildfires. The community may be exposed to potential human-caused hazards associated with facilities and infrastructure that contain hazardous materials. The City is also vulnerable to cyber threats. The LHMP will provide the City with valuable tools to identify risks and mitigate hazards through future project-specific actions. The LHMP will assess the effects of climate change on natural hazards assessed in the plan and will incorporate climate adaptation strategies. The plan will also support the City's participation in the National Flood Insurance Program and include recommendations to improve the City's Floodplain Management Plan policies and regulations.

The City will be hosting a Public Workshop on **Tuesday October 8, 2019 from 6:00 to 8:00 p.m.** The Public Workshop will be an opportunity to learn more about the planning process and the natural and human-caused hazards that will be assessed in the LHMP. Following the Public Workshop, there will be an opportunity for the public to comment on the Draft LHMP, which is anticipated to be available for public review by early 2020. The community is encouraged to participate in the planning process and provide feedback by attending the Public Workshop, completing an Online Survey, visiting the City's webpage, and commenting on the Draft LHMP (once available). Information on how to participate is provided below

- Public Workshop – Tuesday October 8, 2019, 6:00 – 8:00 p.m., Petaluma Community Center, 320 N. McDowell Boulevard, Petaluma, CA 94954
- Online Public Survey – available here: https://www.woodplc.surveymonkey.com/r/PetalumaHMP

Additional information on the planning process and documents prepared to date can be found on the City's LHMP Webpage: http://cityofpetaluma.net/pubworks/cip-projects.html. Questions may be directed to Diane Ramirez, Project Manager by calling (707) 776-3658 or by email at dramirez@cityofpetaluma.org.

19947 – Pub Oct 3, 2019 1ti.

BID NUMBER 19-005

The City of Petaluma is seeking bids for the purchase the following:

Six (6) Utility Service Trucks

Inquiries regarding specifications should be directed to:

Mike Ielmorini, Assistant Operations Manager
City of Petaluma
Department of Public Works and Utilities

SONOMA COUNTY HISTORY

In 1865

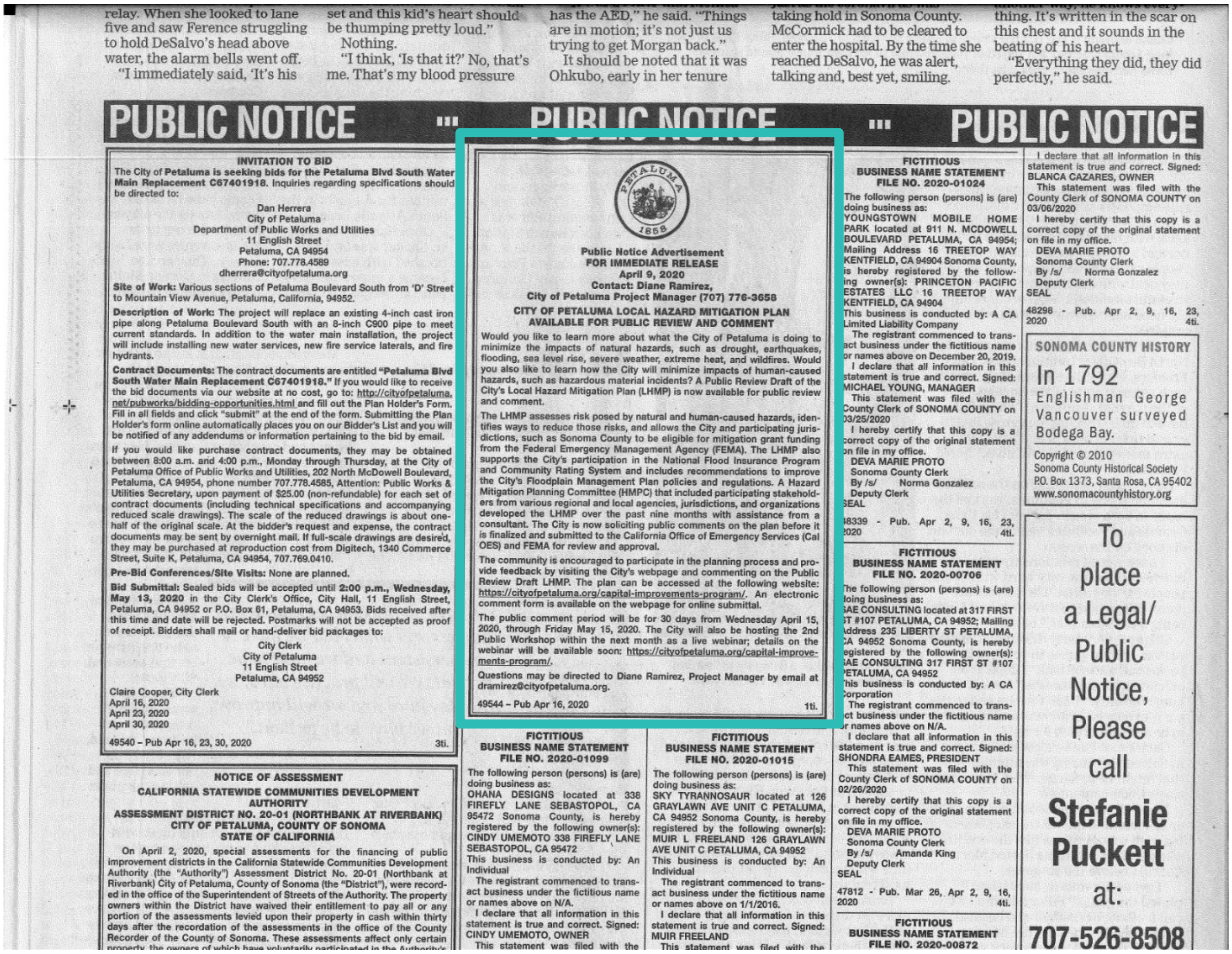
I.G. Wickersham & Co. of Petaluma operated as a "private bank."

Biggest lower Russian River mill started in Guerneville by J.W. Bagley, George Guerne, Tom Heald and W.H. Willets. Mill closed in 1901.

Rosenberg & Bush Department Store founded in Healdsburg by Wolfe Rosenberg.

Copyright © 2010
Sonoma County Historical Society
P.O. Box 1373, Santa Rosa, CA 95402
www.sonomacountyhistory.org

Figure 3-13: 2nd Public Workshop Notice in the Petaluma-Argus Courier



PUBLIC NOTICE

Public Notice Advertisement
FOR IMMEDIATE RELEASE
April 9, 2020
Contact: Diane Ramirez,
City of Petaluma Project Manager (707) 776-3658

CITY OF PETALUMA LOCAL HAZARD MITIGATION PLAN
AVAILABLE FOR PUBLIC REVIEW AND COMMENT

Would you like to learn more about what the City of Petaluma is doing to minimize the impacts of natural hazards, such as drought, earthquakes, flooding, sea level rise, severe weather, extreme heat, and wildfires. Would you also like to learn how the City will minimize impacts of human-caused hazards, such as hazardous material incidents? A Public Review Draft of the City's Local Hazard Mitigation Plan (LHMP) is now available for public review and comment.

The LHMP assesses risk posed by natural and human-caused hazards, identifies ways to reduce those risks, and allows the City and participating jurisdictions, such as Sonoma County to be eligible for mitigation grant funding from the Federal Emergency Management Agency (FEMA). The LHMP also supports the City's participation in the National Flood Insurance Program and Community Rating System and includes recommendations to improve the City's Floodplain Management Plan policies and regulations. A Hazard Mitigation Planning Committee (HMPC) that included participating stakeholders from various regional and local agencies, jurisdictions, and organizations developed the LHMP over the past nine months with assistance from a consultant. The City is now soliciting public comments on the plan before it is finalized and submitted to the California Office of Emergency Services (Cal OES) and FEMA for review and approval.

The community is encouraged to participate in the planning process and provide feedback by visiting the City's webpage and commenting on the Public Review Draft LHMP. The plan can be accessed at the following website: https://cityofpetaluma.org/capital-improvements-program/. An electronic comment form is available on the webpage for online submittal.

The public comment period will be for 30 days from Wednesday April 15, 2020, through Friday May 15, 2020. The City will also be hosting the 2nd Public Workshop within the next month as a live webinar; details on the webinar will be available soon: https://cityofpetaluma.org/capital-improvements-program/.

Questions may be directed to Diane Ramirez, Project Manager by email at dramirez@cityofpetaluma.org.

49544 – Pub Apr 16, 2020 1ti.

Press Releases

The City was encouraged to distribute and circulate press releases over the course of the LHMP development. The City's project manager and Wood staff also encouraged HMPC participants and stakeholders to distribute press releases during the project. Press releases were distributed as informational flyers, advertisements, posters, and public notices handed out during community events. These communication platforms were used to spread the news about the LHMP and invite the public to participate in the process.

Advertisements and press releases announced the kick-off of the LHMP planning process, advertised the City's LHMP Webpage and other events, included links to the public survey, notified the public about meetings and workshops, and announced the availability of the plan for public input and comment. Press releases were distributed to multiple print news agencies.

Figure 3- and Figure 3- are examples of a press releases and newspaper articles used to announce the public workshop in October 2019 and to notify the public about the LHMP update.

Figure 3-14: Press Release Newspaper Article published prior to the 1st Public Workshop

PETALUMA ARGUS-COURIER • THURSDAY, SEPTEMBER 26, 2019

City seeks feedback on emergency plan

\BETH GHIGLIERI

Oct. 7 workshop a chance for public to weigh in on plan

ARGUS-COURIER STAFF

The City of Petaluma has launched a planning effort to assess risks from natural and human-caused hazards and to identify ways to reduce those risks. The planning process will result in the preparation of the City's Local Hazard Mitigation Plan, a requirement under the Federal Disaster Mitigation Act to be eligible for federal disaster assistance and funding.

Petaluma is vulnerable to a wide range of natural hazards, including drought, earthquakes, extreme heat, flooding, and wildfires. The plan will provide the City with tools to identify risks and mitigate hazards through future actions. The plan will assess the effects of climate change on natural hazards assessed in the plan and will incorporate climate adaptation strategies, and will include recommendations to improve the City's Floodplain Management Plan policies and regulations.

The City will be hosting a public workshop on Monday Oct. 7 from 6 to 8 p.m. The workshop will be an opportunity to learn more about the planning process and the natural and human-caused hazards that will be assessed in the plan.

Following the workshop, there will be an opportunity for the public to comment on the draft plan, which is anticipated to be available for public review by early 2020.

The community is encouraged to participate in the planning process and provide feedback by attending the public workshop, completing an online survey, visiting the City's webpage, and commenting on the draft plan, once available.

The public workshop will be at the Petaluma Community Center, 320 N. McDowell Blvd.

Figure 3-3: Newspaper Article published prior to 1st Public Workshop

PETALUMA ARGUS-COURIER • THURSDAY, OCTOBER 3, 2019

Petaluma prepares for emergency

On fire anniversary, city agencies drill for disaster with federal funding at stake

By YOUSEF BAIG
ARGUS-COURIER STAFF

Petaluma officials have been addressing disaster readiness in earnest in recent weeks, starting the process for a new federal hazard plan that will help fortify the city in the future, while also undergoing annual operations training to prepare for a major crisis.

As the two-year anniversary of the North Bay fires approaches, officials are creating a local hazard mitigation plan that would assess what aspects of the city are susceptible to a broad range of natural disasters, like an earthquake or wildfire, or human-caused events like a cyberattack, and then identify ways to reduce those risks.

Once it's adopted, Petaluma would ostensibly become more competitive for grant funds to address those vulnerabilities. The city would also be eligible for the highest tier of federal assistance if an emergency occurred, said Diane Ramirez, project manager for the Public Works and Utilities Department.

She pointed to vital undertakings like the Denman Reach flood control projects that have used more than $40 million in outside funding to strengthen one of Petaluma's most susceptible natural hazards.

"It's to get the city prepared in case something happens, and what can we do in advance that would mitigate anything that happens in the city," Ramirez said. "More preparation makes us more resilient and able to rebound more quickly."

Petaluma's previous hazard mitigation plan was adopted seven years ago as part of a regional consortium with the Association of Bay Area Governments.

The rules for the plans have changed, though, and now federal regulators are calling for one in every jurisdiction, Ramirez said.

The scope of hazards officials believe the city is vulnerable to are broad, including drought, earthquakes, extreme heat, flooding, sea level rise and wildfires, according to a press release. Infrastructure contamination and cyber threats were also listed. So was climate change and its impact on natural hazards.

City officials are hosting a workshop at the Petaluma Community Center next week to get feedback on what hazards residents are seeing, and provide more information on the process for adopting the plan.

"We have a lot of base knowledge, but we want to hear from our community what they hear is important," Ramirez said. "There's some prioritization in terms of where we might put funding and projects first based on how the community responds to our preparation."

After the workshop, officials will create a draft that the public can comment on. It then has to get approved by FEMA and eventually the city council before it's adopted.

Ramirez anticipates it'll be in place by spring 2020, and would be subject to future amendments should the science or technology change, she said.

While the hazard plan would serve as a guiding document to reinforce the Petaluma's weaknesses in the future, city employees have to be ready for the worst right now.

Department heads and some of the senior-most public officials across the entire agency met for a mandatory, two-hour training session last week at the Petaluma Police Department headquarters, the site of the city's emergency operations center in a disaster.

Petaluma's EOC was triggered in October 2017 when the city became a refuge for fire victims and a staging ground for the response efforts throughout Sonoma County.

With several new officials like City Manager Peggy Flynn and Director of Human Resources Charlie Castillo onboard, the city shuffled roles and drilled into the minutia of what was learned in the fire's aftermath.

Departments are sorted into sections like management, logistics, intelligence and operations with responsibilities doled out to ensure public safety and continuity of government, said Petaluma Assistant Fire Chief Jeff Schach.

City officials went over details like what sort of communication is possible with ham radios, record-keeping for federal reimbursement and the nuances of volunteer activation. They later broke into groups to meet with their sections and go over their chain of command and what the new roles are when an EOC is activated.

"This is my favorite day of the year," Schach said. "When you raise your right hand" to serve as a government employee, "that's what comes with the territory."

Nancy Sands, Economic Development Specialist, described the collaboration across the city's divisions as an effective measure to help ensure every element of service is addressed.

"They are all connected in that they all affect the city's infrastructure," she said. "What I see as a city employee is that we're all working together cross-departmentally, and that's really helpful in making sure that nobody misses anything."

(Contact News Editor Yousef Baig at yousef.baig@arguscourier.com or 776-8461, and on Twitter @ YousefBaig.)

CRISSY PASCUAL / ARGUS-COURIER STAFF

City officials, police and fire departments came together for disaster preparedness training.

MORE INFORMATION

What: Public workshop for the preparation of Petaluma's Local Hazard Mitigation Plan

When: Tuesday, Oct. 8 from 6-8 p.m.

Where: Petaluma Community Center, 320 N. McDowell Blvd.

More information: visit petalumastar.com/hazards. Residents who cannot attend the workshop are encouraged to participate in the online survey at bit.ly/petalumahazardplanning

Public Review and Comments on the Draft LHMP

The City circulated the Public Review Draft LHMP for 30 days; it was be posted on the City's LHMP Webpage and circulated from April 15, 2020 through May 15, 2020. The City solicited public input on the Draft LHMP by collecting and reviewing comments received during the public review period. Comments submitted during public review are summarized in this chapter and incorporated in the revised version of the Draft LHMP submitted to Cal OES and FEMA Region IX. A detailed comment-response matrix addressing the public comments is included in Appendix A. This matrix also summarizes how the Draft LHMP was revised based on public comments.

Planning Step 3: Coordinate with Other Departments and Agencies

Early in the planning process, the HMPC determined that data collection, mitigation strategy development, and plan approval would be greatly enhanced by inviting state and federal agencies and organizations to participate in the process. Based on their involvement in hazard mitigation planning, their landowner status in the County, and/or their interest as a neighboring jurisdiction, representatives from the following agencies were invited to participate on the HMPC:

- U.S. Geological Survey Pacific and Coastal Marine Center
- Sonoma County Department of Emergency Management
- City of Sebastopol
- CAL FIRE
- Petaluma Health Care District
- Sonoma County Water Agency
- Petaluma Community Access
- Petaluma People Services
- Petaluma Visitor's Center
- Petaluma Chamber of Commerce
- City of Petaluma Climate Action Commission

Wood in coordination with the City and the HMPC also used technical data, reports, and studies from the following agencies and groups:

- American Red Cross
- California Department of Finance
- California Department of Fish and Game
- California Department of Forestry and Fire Protection (Cal Fire)
- California Department of Parks and Recreation Office of Historic Preservation
- California Department of Public Health
- California Department of Water Resources
- California Emergency Management Agency
- California Geological Survey
- Sonoma County Department of Health Services Environmental Health and Safety Division
- U.S. Army Corps of Engineers
- U.S. Center for Disease Protection
- U.S. Bureau of Land Management
- U.S. Bureau of Reclamation
- U.S. Fish and Wildlife Service
- U.S. Forestry Service
- U.S. Geological Survey
- U.S. Census Bureau
- Federal Emergency Management Agency
- National Weather Service
- National Oceanic and Atmospheric Administration, National Climatic Data Center
- National Resource Conservation Service

Several opportunities were provided for the above groups to participate in the planning process. At the beginning of the planning process, invitations were extended to the first group to actively participate on the HMPC and as a stakeholder representative to support the DMA planning process and to maximize credits under the NFIP CRS program. Specific participants from these groups are detailed in Appendix C.

The Sonoma County Department of Emergency Management staff worked closely with the City of Petaluma and HMPC. The City also provided various opportunities for Sonoma County and other neighboring communities, such as the City of Sebastopol to participate in the City of Petaluma LHMP development. Others assisted in the process by providing data directly as requested in the Data Collection Guide or through data contained on their websites or as maintained by their offices. These groups were also invited to participate through the public outreach process, which included public workshops as previously described. Further as part of the HMPC and public outreach processes, all groups were invited to review and comment on the plan during public review and prior to submittal to Cal OES and FEMA.

Other Community Planning Efforts and Hazard Mitigation Activities

Coordination with other community planning efforts is paramount to the success of this plan. Hazard mitigation planning involves identifying existing policies, tools, and actions that will reduce a community's risk and vulnerability to hazards. The City of Petaluma uses a variety of comprehensive planning mechanisms, such as general plans and ordinances, to guide growth and development. Integrating existing planning efforts and mitigation policies and action strategies into this plan establishes a credible and comprehensive plan that ties into and supports other community programs. The development of this plan incorporated information from the following existing plans, studies, reports, and initiatives listed in Table 3-5. Other related planning efforts were inventoried in the capability assessment in Chapter 2.

Table 3-5: Incorporated Planning Mechanisms

City of Petaluma Plans	How Plan is Incorporated in LHMP
FY 2019-2020; FY 2020-2021 City of Petaluma Goals and Priorities Strategic Plan	• The City of Petaluma Goals and Priorities for 2019 through 2021 outline objectives and workplan items that ensure the City operates efficiency and sustainably and provides valued services promptly and professionally engages the community. • The goals and priorities include objectives and workplan items related to environmental stewardship, river and open space protection, and the encouragement of sustainable development. • There are numerous goals and priorities outlined as objectives and workplan items related to enhanced public safety, emergency preparedness, and resiliency in a section titled, "A Safe Community that Thrives." • Other workplan items that support hazard mitigation include maintaining current staffing levels and response times, evaluating city facilities for replacement, creating an EOC, assisting the community with special needs, improving public safety and fire prevention activities, promoting emergency preparedness and resiliency strategies, and promoting improved community engagement and multilingual outreach.
City of Petaluma General Plan 2025 (2008)	• Incorporated relevant hazard information from the Safety Element into the LHMP. • Reviewed the Community Facilities, Services and Education Element goals and objectives in HMPC Meeting #2 and integrated them into the LHMP • Reviewed the Water Resources Element goals and objectives in HMPC Meeting #2 and integrated them into the LHMP. • Reviewed the Health and Safety Element goals and objectives in HMPC Meeting #2 and integrated them into the LHMP.

City of Petaluma Plans	How Plan is Incorporated in LHMP
	• Reviewed the 5-year planning mechanisms for the General Plan to determine if plan updates occurred, when, how often, and whether the next update can integrate the LHMP into the Safety Element. • Discussed whether a General Plan Advisory Group (or GPAC) could participate and provide a consistency review with the City's General Plan Health and Safety Element (and other elements covering water resources and fire prevention). • Assembly Bill 2140 requires the adoption of LHMPs into the General Plan Safety Element after LHMP Approval; this topic was discussed during each HMPC meeting. • The LHMP emphasizes need to ensure General Plan is amended to include the LHMP after it is approved by City Council; this information is included in the chapter on the adoption process.
NFIP Participation (1980)	• The City of Petaluma has participated in the NFIP since 19780 by administering floodplain management regulations; the current effective map date is October 12, 2015. • The LHMP integrates information in the risk assessment on the most recent Flood Insurance Study (FIS) completed for Sonoma County on March 7, 2017. • Reviewed DFIRMS and base flood elevation (BFE) data for critical facilities and properties identified within the flood hazard zones. • Reviewed NFIP and CRS related audits of the City's floodplain management efforts over two decades; the City has a Class 6 rating in the CRS. • The City plans to maintain an electronic record of the base flood elevations (BFE) certificates for properties within the Special Flood Hazard Area (SFHA); this information was summarized in the risk assessment and taken into consideration during the development of the mitigation strategy.
Community Rating System (1991)	• This City has participated in the CRS program since 1991 as a way to reduce potential losses due to flooding. • As of July 10, 2019, there were approximately 415 flood insurance policies in effect in the City. • The LHMP discusses several potential opportunities to improve the City's class rating in the Capability Assessment. • The LHMP specifically discusses activities of credit the City could consider to reach a Class 5 rating, including outreach, floodplain management planning, and drainage system maintenance.
Floodplain Management Plan (2015)	• The LHMP summarizes the Floodplain Management Plan (FMP) in detail in the Risk Assessment (Chapter 4) and the Capabilities Assessment (Chapter 2). • The HMPC reviewed the goals and strategies from the 2015 FMP and cross-referenced them during the development of the LHMP goals and objectives. • The HMPC and City re-reviewed these goals again during the development of the mitigation actions, as several actions in the LHMP came from the FMP, as they related to flood control projects (i.e. floodwall) and climate adaptation strategies. • The HMPC provided updates on specific strategies from the FMP, as these were referenced as goals and strategies in the City of Petaluma 2010 Annex to the ABAG plan, and updates were required as part of the DMA planning process.

City of Petaluma Plans	How Plan is Incorporated in LHMP
City of Petaluma Residential Growth Management System Ordinance (1972)	• City's RGMS ordinance is summarized in the Community Profile in Chapter 2 and as it relates to growth and development trends in the City's Planning Area • The City's RGMS is also summarized in the City's Capability Assessment in Chapter 2 as a tool to ensure new development integrates appropriate site specific measures to reduce natural hazards • The LHMP also discussed the UGB as a tool to manage growth and development. • The discussion on growth management in the LHMP illustrates that most major commercial and residential development projects in the City are within the city limits.
City of Petaluma Urban Water Management Plan (2015)	• The UWMP evaluates the required potable and recycled water system facilities required to serve the buildout of the City's General Plan. • Integrates availability and reliability information on the City's existing and future water supplies into the LHMP. • Cross references goals and projects outlined in the UWMP, specifically those related to new groundwater water facilities as similar mitigation actions were prioritized by the HMPC • Incorporates information on a shift in water demand from mostly surface water supplies to groundwater supplies • Integrates water conservation principles and strategies developed in the plan related to the City's capital improvement program and plans for potable and recycled water system facilities.
City of Petaluma Storm Water Management Plan (2003)	• Describes actions that address the reduction of nutrients, pathogens, and sediment in the City's stormwater. • The LHMP addressed this plan broadly, as it relates to flood hazards.
City of Petaluma Emergency Operations Plan (2007)	• The EOP is a basic plan that addresses the City of Petaluma's responsibilities in emergencies associated with natural disaster, human-caused emergencies, and technological incidents. It also provides a framework for coordination of recovery efforts within the City. • The EOP was discussed at most HMPC meetings given it was last updated in 2007 and needs to address current hazard issues in the City, especially because the Emergency Operation Center (EOC) has been activated several times over the past few years due to wildfires and planned public safety shutoffs (PSPS).
Sustainability Action Plan (2015)	• HMPC discussed the Regional Climate Protection Authority (RCPA) during meetings as it relates to climate change priorities and sea level rise. • The Sustainability Action Plan summarizes goals to reduce municipal greenhouse gas (GHG) emissions, reduce solid waste diversion in the City, provide 780 million gallons of recycled water by 2025, convert waste to energy at the Wastewater Treatment Facility, and install LED streetlights among many other goals. • Discussions regarding the City's Sustainability Action Plan at the HMPC meetings were general, the consultant team reviewed the broad goals and various action measures outlined in the plan to ensure any measures related to the LHMP mitigation actions were cross-referenced
Climate Emergency Resolution (2019)	• In May 2019 the City joined over 500 jurisdictions worldwide and declared a climate emergency by passing a Climate Emergency Resolution. • The resolution demonstrated that sustainability was a top priority for the City of Petaluma, as it faces a growing population, aging infrastructure, and climate change impacts.

City of Petaluma Plans	How Plan is Incorporated in LHMP
Climate Action Commission (2019 – 2022)	• The City Council appointed a seven-person Climate Action Commission (CAC) for a four-year term on September 5, 2019. The CAC is responsible for the development of a Climate Emergency Plan (now referred to as a Climate Action and Adaptation Plan [CAAP]) and establish ad-hoc committees to address climate mitigation, sequestration, and adaptation initiatives, engagement plan, and climate justice and equity goals and principles. • The City provided the CAC the Draft LHMP and requested input and direction on the risk assessment and mitigation strategy. They provided comments on the LHMP that were focused on social equity, outreach, the risk assessment, and climate adaptation strategies.
Other Plans	
Petaluma Municipal Services Review (2011)	• The City of Petaluma's 2011 Municipal Services Review (MSR) identifies the future needs for the extension of infrastructure and the provision of services from the City to new development within the planning horizon. • Wood reviewed this plan to ensure facility and infrastructure needs were integrated into the LHMP; the plan provides information on the City's facilities and infrastructure and staff could compare facility lists to understand what is include in the LHMP and what facility was not included and why • Based on findings from the City's MSR, it is structured to meet the needs of the development that is proposed within the SOI and UGB. • The LHMP notes that the City's ability to serve the anticipated growth within the UGB and the SOI is not anticipated to have any adverse effects on the City, as there are several mechanisms in place to effectively expand facilities and services.
Sonoma County Operational Area Hazard Mitigation Plan (2016)	• Hazard profile information from the 2016 Sonoma County Operational Area HMP was incorporated throughout the LHMP, where appropriate; this included information on flooding, landslides, and earthquake hazards. • HMPC reviewed the Sonoma County Operational Area HMP goals during the development of the City of Petaluma LHMP goals and objectives. • There are comparative tables on the hazards profiled in the state and county plan to those addressed in the Health and Safety Element of the City's General Plan. This information was helpful for the HMPC to compare which hazards to address and which to prioritize. • Sonoma County stakeholder from the Department of Emergency Management participated in the HMPC meetings and provided mitigation goals and action strategies to consider developing in the City's LHMP. • Sonoma County intends to update their plan in 2020; this provides the City with another opportunity to participate with hazard mitigation planning efforts in the region.
California State Hazard Mitigation Plan (2018)	• Reviewed goals and objectives in the State Hazard Mitigation Plan (SHMP) and noted the new and revised hazards related to community resilience • Reviewed the hazards profiled in the SHMP and compared those with the hazards summarized in the City's 2011 Health and Safety Element and the 2016 Sonoma County Operational Area HMP. • Integrated disaster declaration information and other key findings on major hazards from the SHMP into the City's LHMP Update. • Under 44 CFR Section 201.6, local hazard mitigation plans must be consistent with the state's hazard mitigation plan. In updating this plan,

City of Petaluma Plans	How Plan is Incorporated in LHMP
	HMPC and consultant staff reviewed California's SHMP to identify key relevant state plan elements. • Climate change is expected to intensify existing hazards in the City. Consistent with the organization of the 2018 California SHMP, the City and HMPC integrated a discussion of climate change hazards and considerations throughout the hazard profiles in the Risk Assessment.
Petaluma Valley Groundwater Sustainability Agency Draft Groundwater Sustainability Plan (2020)	• The 20-year Groundwater Sustainability Plan (GSP) ensures the sustainable use of groundwater within the Petaluma Valley Groundwater Basin. • The plan establishes standard groundwater management tools. • The plan also incorporates best available scientific and technical information by building on the technical foundation already established for the Petaluma Valley Basin. • The plan integrates the interests of many users and uses of groundwater resources within the Petaluma Valley Basin through public and community engagement.

Other documents were reviewed and considered, as appropriate, during the collection of data to support Planning Steps 4 and 5, which include the hazard identification, vulnerability assessment, and capability assessment. Appendix B References identifies additional documents and community planning efforts utilized in the development of this plan. Specific references relied on in the development of this plan are also sourced throughout the document as appropriate.

3.3.2 Phase 2: Assess Risks

Planning Steps 4 and 5: Identify the Hazards and Assess the Risks

Wood led the HMPC in a comprehensive research effort to identify and document all the hazards that have, or could, impact the City's Planning Area. Data collection worksheets were developed and used in this effort to aid in determining hazards and vulnerabilities and where risk varies across the Planning Area. Geographic information systems (GIS) were used to display, analyze, and quantify hazards and vulnerabilities. The HMPC also conducted a capability assessment to review and document the Planning Area's current capabilities to mitigate risk and vulnerability from hazards. By collecting information about existing government programs, policies, regulations, ordinances, and emergency plans, the HMPC could assess those activities and measures already in place that contribute to mitigating some of the risks and vulnerabilities identified. Using this information, Wood developed the risk assessment portion of the plan, which contained the hazard identification, the vulnerability assessment, and the capability assessment. Wood completed the risk assessment in October 2019 and the information was presented at the second HMPC meeting on October 7, 2019. A more detailed description of the risk assessment process and the results are included in Chapter 4 Risk Assessment. The risk assessment also included a vulnerability assessment on sea level rise and related flooding completed in November 2019.

3.3.3 Phase 3: Develop the Mitigation Plan

Planning Steps 6 and 7: Set Goals and Review Possible Activities

Wood facilitated brainstorming and discussion sessions with the HMPC on October 7, 2019, including a description of the purpose and process of developing planning goals, as well as discussion of a comprehensive range of mitigation alternatives, and a method of selecting and defending recommended mitigation actions using a series of selection criteria. Additional details of the process to develop goals and actions is included in Chapter 5 Mitigation Strategy. Documentation on the process the HMPC used to develop the goals and strategy is in Appendix C.

Planning Step 8: Draft an Action Plan

Based on input from the HMPC during the October 8, 2019 and from subsequent review of the draft risk assessment and the goals and activities identified in Planning Steps 6 and 7, Wood produced a complete first draft of the plan. This complete draft was internally circulated for HMPC review and comment via email in January 2020. HMPC and agency comments were integrated into the second draft in February.

Public Review Draft LHMP

The Public Review Draft LHMP was advertised and distributed to collect public input and comments. The City circulated the Public Review Draft LHMP for 30 days from April 15, 2020 through May 15, 2020. During this time, Wood integrated comments and issues from the public and stakeholders, as appropriate, along with additional agency and other stakeholder internal review comments. During the public review period, the City received four comments from the public. Public comments are briefly summarized in Table 3-6. Detailed responses to public comments are included in Appendix A. This appendix also includes comments from the City's CAC, which reviewed the Draft LHMP as a separate stakeholder group. The City's CAC made comments regarding climate change impacts, climate adaptation, and social equity.

Table 3-6: Summary of Comments Received during Public Review

Comment	Response
Oral Comment #1 (Oral comment received during Public Workshop #2)	
• Commenter inquired about the process and schedule for finalizing the LHMP.	• The City appreciates the inquiry about the public review process. The City and HMPC will review public comments after the close of the public review period on April 15, 2020 and update the Draft LHMP, if needed. Once updated, the City will submit the Draft LHMP to Cal OES for review. The State has 45 days to complete review. Once reviewed, Cal OES will forward the plan to FEMA Region IX for a 45-day review. City Council can consider the Draft LHMP for adoption once FEMA review is complete and they have approved the plan.
Written Comment #1 (Emailed Letter dated May 7, 2020)	
• Commenter explained that the LHMP is strong in many areas, but fails to adequately respond to the imminent risk of climate change and flooding, sea level rise, and wildfire risk in the City. The letter contains recommendations for various sections in the LHMP where the City should emphasize the high hazard significance of flood, sea level rise, and wildfire risk hazards. The letter also suggests prioritizing several related mitigation actions that address flooding and wildfire hazards has "high" in the Mitigation Strategy and recommends a mitigation action related to the development of a climate action program.	• The City appreciates the detailed comments on the Public Review Draft LHMP regarding flooding, climate change, and wildfire hazards. The Draft LHMP includes a discussion on climate change considerations in each hazard profile. The organization of this discussion aligns with the organization of the California State Hazard Mitigation Plan (SHMP), which discusses the effects of climate change within each hazard profile rather than a separate hazard profile. • The City revised sections of the Draft LHMP, including Chapter 4 – Risk Assessment to clarify the hazard risks associated with climate change and flooding, and to emphasize that climate change will intensify these hazards. This City also revised the mitigation actions included in the Mitigation Strategy. • The City's recognizes the imminent threat of climate change and established a CAC to focus on developing plans and policies to address the issue. As part of the CAC's workplan, they intend to prepare a CAAP in

Comment	Response
	coordination with the City. This plan will expand on the impacts of greenhouse gas (GHG) emissions and climate change, and will include climate adaptation strategies. • The City is also in the process of initiating a comprehensive update to the General Plan 2025, which will include incorporate this LHMP and include a detailed update to the General Plan Public Health and Safety Element consistent with California Government Code Section 65302(g).
Written Comment #2 (Electronic Comment Form dated May 11, 2020)	
• The commenter notes issues with prioritizing flood hazards as a medium priority, as flooding has been the biggest threat to the City based on historical flooding. The comment mentions development that has occurred in flood prone areas upstream of the Payran flood wall and states the City should incorporate higher regulatory standards for flood protection and prioritize the impacts of sea level rise and future flood hazards that would be more frequent due to climate change.	• The City appreciates the comment regarding prioritizing the significance flood hazards and recognizes the long history of flooding in the Planning Area, specifically around the Payran neighborhood. The Draft LHMP includes a discussion on these flood hazards in Section 4.3.5 of Chapter – Risk Assessment and on the repetitive loss properties (and around the Payran neighborhood) (see subsection "Insurance Coverage and NFIP Claims and Losses for Repetitive Loss Properties"). The Draft LHMP also includes a discussion on the impacts of future development in flood hazards areas in the Vulnerability Assessment in Chapter 4. • The City took these specific comments in to consideration and has revised the priority level of the mitigation actions included in Chapter 5 – Mitigation Strategy of the Draft LHMP. The City also revised the descriptions, alternatives, and timing of several of the mitigation actions.
Written Comment #3 (Electronic Comment Form dated May 11, 2020)	
• The commenter refers the City to their May 7, 2020 comment letter. This letter is the first comment letter summarized in Table 3-6.	• The City has reviewed the comments in the referenced May 7, 20202 comment letter. Please refer to the response to the May 7, 2020 comment letter in Table 3-6. This is the second letter summarized in this table.

Wood produced a final draft LHMP in June 2020 for Cal OES and FEMA Region IX staff to review and approve, contingent upon final adoption by Petaluma City Council.

3.3.4 Phase 4: Implement the Plan and Monitor Progress

Planning Step 9: Adopt the Plan

In order to secure buy-in and officially implement the plan, the plan will be reviewed by the Planning Commission and adopted by the Petaluma City Council on the dates included in the corresponding resolution in Appendix D: Adoption Resolution.

Planning Step 10: Implement, Evaluate, and Revise the Plan

The true worth of any mitigation plan is in the effectiveness of its implementation. In the previous steps of the planning process the HMPC's efforts have been directed at researching data, gathering information for the plan, and developing appropriate mitigation actions. Each recommended action includes key descriptors, such as a lead entity and possible funding sources, to help initiate implementation. An overall implementation strategy for the City's LHMP is described in Chapter 7 Plan Implementation and Maintenance.

Finally, there are numerous organizations within the City of Petaluma's Planning Area whose goals and interests interface with hazard mitigation. Coordination with these other planning efforts, as addressed in Planning Step 3, is key to the ongoing success of this plan and mitigation in the City of Petaluma and is addressed further in Chapter 7. A plan update and maintenance schedule and a strategy for continued public involvement are also included in Chapter 7.

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4 Risk Assessment

44 U.S. Code of Federal Regulations Requirement §201.6 Local Mitigation Plans (c)(2): [The plan shall include] A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

As defined by the Federal Emergency Management Agency (FEMA), risk is a combination of hazard, vulnerability, and exposure. "It is the impact that a hazard would have on people, services, facilities, and structures in a community and refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage."

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards, as well as the vulnerabilities of a community. The process allows for a better understanding of a jurisdiction's potential risk to hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

This risk assessment followed the methodology described in the FEMA publication "Understanding Your Risks—Identifying Hazards and Estimating Losses" (FEMA 386-2, 2002), which breaks the assessment into a four-step process:

1. Identify hazards
2. Profile hazard events
3. Inventory assets
4. Estimate losses

In other words, this risk assessment evaluates potential loss from hazards by assessing the vulnerability of the City's population; services; critical facilities; and buildings and infrastructure. Data collected through this process has been incorporated into the following sections of this chapter:

- **Section 4.1 Hazard Identification** profiles the natural hazards that threaten the City of Petaluma Planning Area (Planning Area) and describes why some hazards have been omitted from further consideration.
- **Section 4.2 Asset Summary** describes the methodology for determining vulnerability of the Planning Area to the identified hazards.
- **Section 4.3 Hazard Profiles and Risk Assessment** discusses the threat to the Planning Area and describes previous occurrences of hazard events and the likelihood of future occurrences. All the hazards identified in Section 4.1 are profiled and assessed individually in this section. Research and information from the City of Petaluma Hazard Mitigation Planning Committee (HMPC) is integrated into this section. This section also includes the identified vulnerability to each of the priority hazards, describing the impact that each hazard would have on the City. The vulnerability assessment quantifies (to the extent possible) using best available information, assets at risk to hazards and estimates potential losses.
- **Section 4.4 Human-Caused Hazards** identifies the hazards that threaten the Planning Area resulting from human actions.

- **Section 4.5 Hazards Summary** summarizes the results of the hazard identification and hazard profiles for the Planning Area based on the hazard identification data and input from the HMPC.

This risk assessment covers the entire geographical extent of the City of Petaluma, Urban Growth Boundary (UGB), and in some cases critical facilities within the City's water and wastewater service areas. This area is referred herein as the City's Planning Area. The HMPC agreed that the City's Planning Area for the Local Hazard Mitigation Plan (LHMP) should include the UGB.

This assessment qualitatively discusses critical facilities within the City's water and wastewater service areas to ensure that all the City's facilities are infrastructure are addressed in the risk assessment because some of these facilities were located outside the Planning Area. Given the location information of the City's water supply infrastructure is considered sensitive, this information was excluded from this assessment. Sensitive information included the City's water supply and distribution system (e.g. water pipelines, etc.). Instead the vulnerability of the potable water supply facilities is addressed more broadly and qualitatively compared to the level of detail considered for other facilities.

Additional information on the City's Planning Area as it pertains to this plan is provided in Chapter 2, Community Profile.

4.1 Hazard Identification: Natural and Human-Caused Hazards

44 U.S. Code of Federal Regulations Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

The first step in developing a risk assessment is identifying the natural hazards. The HMPC conducted a hazard identification study to determine the hazards that threaten the Planning Area. The identification of human-caused hazards is summarized in Section 4.4.

4.1.1 Methodology and Results

Using existing natural hazards data and input gained through planning meetings, the HMPC agreed upon a list of natural and human-caused hazards that could affect the City of Petaluma. Hazards data was examined to identify and assess the significance of these hazards to the Planning Area. The sources of data included information from the California Office of Emergency Services (Cal OES), FEMA, the National Oceanic and Atmospheric Administration (NOAA), Sonoma County Office of Emergency Management, and other sources as referenced in this assessment. The assessment also relied on the City's 2010 LHMP "Taming Natural Disasters" plan prepared by the Association of Bay Area Governments (ABAG) (referred to as the City's 2010 LHMP Annex), relevant City planning documents, such as the City's General Plan 2025 Health and Safety Element and 2015 Floodplain Management Plan (FMP), and adopted hazard mitigation plans in the region.

Table 4-1 below provides a crosswalk of the hazards identified in the General Plan 2025, 2010 ABAG LHMP Annex, 2016 Sonoma County Operational Area Hazard Mitigation Plan, 2018 Sonoma County Water Agency LHMP, and 2018 California State Hazard Mitigation Plan (SHMP). Numerous hazards were identified in the state and county plan, including five natural hazards identified in the City's General Plan 2025 Community Facilities, Services, and Education Element; Water Resources Element, and Health and Safety Element. Natural hazards discussed in these elements included flooding, groundwater supply and drought, earthquake and other seismic-related hazards (e.g. surface rupture, ground shaking, ground failure, slope instability), wildfire, and noise issues. Human-caused hazards discussed in these elements included the use, storage, and transport of hazardous materials. The crosswalk was used to develop a list of preliminary hazards for the HMPC to evaluate which were most relevant to the City's Planning Area.

The significance of each hazard was measured in general terms and focused on key criteria such as frequency and resulting damage, which includes deaths, injuries, and property and economic damage. The natural and human-caused hazards evaluated as part of this plan include those that occurred in the past or have the potential to cause significant human and/or monetary losses in the future.

Table 4-1: Crosswalk with Other Hazard Mitigation Plans

Hazard	City of Petaluma General Plan 2025 (2011)	ABAG LHMP City of Petaluma Annex Plan (2010)	Sonoma County Operational Area HMP (2016)	Sonoma County Water Agency LHMP (2018)	California SHMP (2018)
Natural, Human-Health, and Climate and Weather-Influenced Hazards					
Agricultural and Silvicultural Pests and Diseases					√
Air Pollution	√				√
Aquatic Invasive Species					√
Avalanches					√
Dam Incidents		√		√	
Drought and Water Shortage	√			√	√
Climate Change			√	√	√
Earthquake and Geologic Hazards (liquefaction, subsidence, landslides)	√	√	√	√	√
Energy Shortage and Energy Resiliency					√
Epidemic/Pandemic/Vector-Borne Disease					√
Flood: 100-, 200-, 500-Year Events	√	√	√	√	√
Sea Level Rise				√	√
Severe Weather: Extreme Heat		√		√	√
Severe Weather: Heavy Rain/Thunderstorm/Lightning/Hail/Fog		√		√	√
Severe Weather: Wind		√		√	√
Tree Mortality					√
Tsunami				√	
Volcano					√
Wildfire	√	√	√		√
Technological Hazards					
Hazardous Materials Release	√				√
Oil Spills	√				√
Natural Gas Pipeline Hazards					√

Radiological Accidents					√
Transportation Accidents					√
Threat and Disturbance Hazards					
Terrorism				√	√
Cyber Threats				√	√
Civil Disorder					√

1. Hazards listed is based on the natural, technological, and human-caused hazards in the California SHMP.

In alphabetical order, the natural hazards identified and investigated for the City of Petaluma 2019 LHMP include:

- Dam Incidents
- Drought and Water Shortage
- Earthquake
  - Surface Rupture
  - Ground Shaking
  - Liquefaction
  - Subsidence
  - Landslides/Mudslides
- Flood: 100/500-Year Flood
- Sea Level Rise
- Severe Weather: Heavy Rain/Thunderstorm/Hail/Lightning
- Severe Weather: Extreme Heat
- Severe Weather: Wind
- Wildfire

The human-caused hazards identified and investigated for the City of Petaluma 2019 LHMP include:

- Hazardous Materials: Hazard Material Releases, Chemical Facilities, Gas Pipelines
- Cyber Threats: Malware, Ransomware

Based on discussions at the early planning meetings and preliminary analyses, the following natural and human-health hazards were eliminated from further consideration in this risk assessment because of a lack of past occurrences in the City of Petaluma at the time or based on minimal potential impacts. For example, natural, human-caused, and human-health hazards were prioritized well before the City was aware that human-health hazards, such as the COVID-19 pandemic became a local, domestic, and global health emergency. As a result, the City in close coordination with Sonoma County and state partners, has been working diligently on the COVID-19 pandemic since this plan was circulated for public review. These City and County resources, guidelines, and updates are available on the City's main website.

Certain hazards were also eliminated based on separate State and Sonoma County regulatory programs and planning documentation that thoroughly addresses the hazard profile.

- Agricultural Hazards
- Air Pollution

- Aquatic Invasive Species
- Avalanches
- Energy Shortage and Energy Resiliency (integrated in the Extreme Weather: Winds vulnerability assessment)
- Epidemic/Pandemic/Vector-Borne Disease
- Tree Mortality
- Tsunami
- Volcano

Petaluma is an urban city surrounded largely by rural land uses in the unincorporated portion of Sonoma County that consist of both agriculture and open space. According to the General Plan 2025 and Petaluma General Plan Update Draft Environmental Impact Report (EIR), as of 2005 there were approximately 77 acres of designated agricultural land within the UGB (City of Petaluma 2005). Most of the designated agricultural land outside the City's UGB is within the Sonoma County Agricultural Preservation and Open Space District (SCAPOSD). Land within the SCAPOSD is designated as greenbelt agriculture, priority greenbelt, priority riparian corridors, wetland priority areas, and priority recreation areas. While land uses include farms, dairies, livestock ranches, and vineyards, the greenbelt land uses function as a separation between urban areas and active farming areas, thereby minimizing agricultural hazards and nuisances in the City.

Air quality and emissions within the Bay Area are generated by a variety of sources, including stationary sources, such as fireplaces and heating systems to mobile sources, such as vehicles and truck traffic. The Bay Area Air Quality Management District (BAAQMD) is the regional agency with the authority to develop and enforce regulations for the control of air pollution throughout the Bay Area. The Clean Air Plan is the BAAQMD's triennial plan for reducing air pollutant emissions in the Bay Area. The Bay Area is considered in "attainment" for all of the national standards of carbon monoxide, nitrogen dioxide, sulfur dioxide, lead, and particulate matter, with the exception of ozone. Given there are federal, state, and local laws and regulations in place for controlling air pollution, in addition to air quality management plans administered by the California Air Resources Board and BAAQMD, air pollution hazards and programs are not addressed in this plan.

Aquatic invasive species are non-indigenous species transported to new environments through human activities. The introduction of non-indigenous species into Petaluma's marine, estuarine, and freshwater environment can cause economic, human health, and ecological impacts. Invasive aquatic plants, such as water hyacinth has clogged the waterways in the California Delta, and the Petaluma River has a high percentage of introduced aquatic species (CDFG 2009). Known past occurrences related to aquatic invasive species in the City were mostly identified at Port Sonoma along the Petaluma River, but outside the Planning Area (CDFG 2009). Algae, also known as cyanobacteria can be normally found in water environments such as Petaluma River. When high temperatures and increased nutrient levels in the water occur, algae and other invasive species can grow, and some algal blooms can produce toxins that can be harmful to humans and animals. This hazard is currently addressed by the Sonoma County Department of Health Services (DHS), Environmental Health and Safety Public Health Division. The Division regularly tests water bodies in the County for aquatic invasive species, and specifically algae blooms at various beach and river park locations throughout the County. Given County monitoring programs are in place, this hazard was not addressed in this plan.

Avalanches and volcano hazards were not addressed in this plan. The City does not receive snowfall to have avalanche hazards. According to the 2018 California SHMP, only ten volcanic eruptions have occurred in California in the last 1,000 years and the likelihood of another eruption in the state is low (Cal OES 2018). Of the 20 volcanoes in the state, only a few are active and pose a threat (Cal OES 2018). Of these, the Clear Lake Volcano is the closest volcano to the City, and while it has been known for substantial geothermal activity, there are no past occurrences associated with the volcano. Given this volcanic field is approximately 80 miles to the north, volcano hazards were not addressed in this plan.

Energy shortage hazards can include energy disruptions related to electricity, renewable energy, natural gas, and gasoline and diesel fuels. Based on the energy types, electrical power outages, both planned and unscheduled disruptions can result in cascading hazards related to traffic, economic losses, other utility disruptions, and extreme heat and public health hazards. Climate change is also expected to bring more frequent and intense natural disasters, which could result in planned or unscheduled power outages or energy shortages. Given the PG&E's recent Public Safety Power Shutoff (PSPS) that began on October 9, 2019, energy shortage hazards are a major concern for the region and the City (City of Petaluma 2019c). Energy shortages are discussed as a secondary hazard impact and in the vulnerability assessment in the Severe Weather: Wind section of this chapter.

The City and the HMPC considered human-health hazards, such as epidemics, pandemics, and vector-borne disease hazards. Natural, human-caused, and human-health hazards were also prioritized well before the City was aware that human-health hazards, such as the COVID-19 pandemic would become a local, domestic, and global health emergency. These hazards are currently addressed by the Sonoma County Public Health Division Disease Control Unit, and the Safety Unit, Risk Management Division and therefore not addressed in this plan. Human-health concerns are also now addressed by the City's Emergency Operations Center.

Drought conditions can cause increased tree mortality associated with lack of moisture, pest infestations, and other drought-related issues. Tree mortality is discussed in more detail as a subsection of wildfire hazards and as a secondary hazard.

The City of Petaluma is situated approximately 15 miles upstream of the San Pablo Bay. Based on the U.S. Geological Survey (USGS) Tsunami Inundation Map for Emergency Planning (Cal EMSA, CGS, and USC 2009) the City Planning Area lies approximately three miles upstream from the northern extent of the tsunami inundation area along Twin House Ranch Road and the Petaluma River. Based on this information, tsunami and coastal erosion hazards were not further analyzed in this plan. Sea level rise is addressed in this chapter.

The City acknowledged natural gas pipeline hazards, oil spills, radiological incidents, as well as transportation accidents associated with these hazards. Gas pipeline hazards are addressed as a secondary hazard associated with earthquakes in the vulnerability assessment. Oil spill and radiological accidents were not further evaluated in this plan, as there are few oil pipelines or oil wells in the City, and few areas at risk to radiological accidents according to the HMPC. Other human-caused hazards, such as terrorism, and civil unrest or disturbances were considered and discussed during HMPC meetings, but because they are addressed in the Emergency Operations Plan (EOP), they were not discussed in detail in this plan.

The following technological and human-caused hazards were eliminated from further analysis in the City of Petaluma LHMP because they are either addressed as secondary impacts associated with other hazards (e.g. earthquakes) or because they are addressed in other City plan documents (e.g. General Plan 2025 Transportation Element):

- Natural Gas Pipeline Hazards
- Oil Spills
- Radiological Accidents

- Transportation Accidents
- Terrorism
- Civil Disorder

4.1.2 Overall Hazard Significance Summary

Overall hazard significance was based on a combination of geographic extent, probability of future occurrences, and potential magnitude/severity. Climate change considerations are discussed qualitatively in each hazard profile, specifically on whether it is anticipated to have a low, medium, or high influence on future impacts. The individual ratings shown in Table 4- **2** are based on or interpolated from the analysis of the hazards in the sections that follow.

Table 4- 2: City of Petaluma Hazard Significance Summary

Hazard	Geographic Extent	Probability of Future Occurrences	Magnitude/Severity	Overall Significance
Dam Incident	Limited	Unlikely	Limited	Low
Drought	Extensive	Likely	Limited	Medium
Earthquake	Extensive	Likely	Catastrophic	High
Flood	Limited	Likely	Limited	Medium
Sea Level Rise	Limited	Occasional	Negligible	Low
Severe Weather: Extreme Heat	Extensive	Likely	Limited	Low
Severe Weather: Heavy Rain/Thunderstorms/Hail/Lighting	Extensive	Likely	Limited	Medium
Severe Weather: High Winds	Extensive	Likely	Limited	Medium
Wildfire	Significant	Occasional	Critical	Medium
Hazardous Material Releases	Significant	Likely	Limited	Medium
Cyber Threat	Extensive	Occasional	Critical	Low

Geographic Extent / Probability of Future Occurrences	Magnitude/Severity / Overall Significance
Geographic Extent Limited: Less than 10% of planning area Significant: 10-50% of planning area Extensive: 50-100% of planning area **Probability of Future Occurrences** Highly Likely: Near 100% chance of occurrence in next year or happens every year. Likely: Between 10 and 100% chance of occurrence in next year, or a recurrence interval of 10 years or less. Occasional: Between 1 and 10% chance of occurrence in the next year or has a recurrence interval of 11 to 100 years. Unlikely: Less than 1% chance of occurrence in next 100 years or has a recurrence interval of greater than every 100 years.	**Magnitude/Severity** Catastrophic—More than 50 percent of property severely damaged; shutdown of facilities for more than 30 days; and/or multiple deaths Critical—25-50 percent of property severely damaged; shutdown of facilities for at least two weeks; and/or injuries and/or illnesses result in permanent disability Limited—10-25 percent of property severely damaged; shutdown of facilities for more than a week; and/or injuries/illnesses treatable do not result in permanent disability Negligible—Less than 10 percent of property severely damaged, shutdown of facilities and services for less than 24 hours; and/or injuries/illnesses treatable with first aid **Overall Significance** Low: minimal potential impact Medium: moderate potential impact High: widespread potential impact

FEMA's Hazus 4.0 Loss Estimation Tool

Hazus Multi-Hazard Loss Estimation tool (Hazus-MH) is FEMA's standardized method for modeling and estimating potential losses from earthquakes, floods, strong wind-caused events, and hurricanes. For the purposes of this plan, Hazus Version 4.0 was used with Geographic Information System (GIS) software to estimate economic and social impacts from the occurrence (or potential occurrence) of natural hazards (FEMA 2018a).

Hazus-MH provides tabular outputs as well as graphic and illustrative results of identified high-risk areas due to the profiled hazards of interest, with reports summarizing losses or damages from structures and critical facilities, populations affected or at risk, and debris generated from an event. Hazus 4.0 is a key component of the pre-disaster planning process and is used for mitigation and recovery, given its ability to estimate potential losses and damages on a city, county, and multi-regional context. For this LHMP, Hazus-MH was used to estimate effects from a probabilistic 2,500-year earthquake scenario as well as a USGS ShakeMap-based deterministic scenario, and the software is referenced in the dam incidents and flooding sections to point out methodologies applied to the vulnerability assessments as indicated in Hazus-MH loss calculation procedures (e.g. the FEMA flood depth damage functions per the Benefit Cost Analysis application) (FEMA 2018b). For more information on the earthquake scenarios processed with Hazus 4.0, refer to the Section 4.3.3 Earthquakes.

4.1.3 Disaster Declaration History

One method the HMPC used to identify hazards was researching past events that triggered federal and state emergency or disaster declarations in the Planning Area. Federal and state disaster declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Should the disaster be so severe that both the local and state governments' capacities are exceeded, a federal presidential emergency or disaster declaration may be issued allowing for the provision of federal assistance to help disaster victims, business, and public agencies.

The federal government may issue a disaster declaration through FEMA, the U.S. Department of Agriculture (USDA), or the Small Business Administration (SBA). FEMA also issues emergency declarations which are more limited in scope and without the long-term federal recovery programs of major disaster declarations (Farm Service Agency 2018). The quantity and types of damage are the determining factors in the type of declaration issued. This section focuses on state and federal disaster and emergency declarations.

The City of Petaluma is among many communities in California that are susceptible to disaster. Details on federal and state disaster declarations were obtained by the HMPC, FEMA, and Cal OES and compiled in chronological order in Table 4-3.

Table 4-3: City of Petaluma and Sonoma County State and Federal Disaster Declarations, 1950-2018

Event/ Hazard	Year	Disaster #	Declaration Type
Heavy Rains and Flooding	1964	183	Major Disaster Declaration
Severe Storms and Flooding	1969	253	Major Disaster Declaration
Drought	1977	3023	Emergency Declaration
Flood	1982	651	Major Disaster Declaration
Coastal Storm	1983	677	Major Disaster Declaration
Flood	1986	758	Major Disaster Declaration

Event/ Hazard	Year	Disaster #	Declaration Type
Freeze	1991	894	Major Disaster Declaration
Flood	1993	979	Major Disaster Declaration
El Niño - Fishing Losses	1994	1038	Major Disaster Declaration
Severe Storm(s)	1995	1044	Major Disaster Declaration
Severe Storm(s)	1995	1046	Major Disaster Declaration
Cavedale Fire	1996	--	Local Emergency
Severe Storm(s)	1997	1155	Major Disaster Declaration
Severe Storm(s)	1998	1203	Major Disaster Declaration
Severe Storm(s)	1999	--	Local Emergency
Severe Storm(s)	2002	--	Local Emergency
Geysers Fire	2004	2554	Fire Management
Flood	2005	--	State and Federal Disaster Declaration
Severe Storm(s)	2006	1646	Major Disaster Declaration
SF Oil Spill	2007	--	Gubernatorial Declaration
H1N1 Influenza Pandemic	2009	--	Local Emergency
Great Tohoku Tsunami	2011	--	Gubernatorial Declaration
Drought	2014-2016	--	Gubernatorial Declaration
South Napa Earthquake	2014	4193	Major Disaster Declaration
Severe Storm(s)	2014	--	Local Emergency
Valley Fire	2015	4240	Major Disaster Declaration
Severe Storm(s)	2017	4301	Major Disaster Declaration
Flood	2017	4308	Major Disaster Declaration
Wildfires	2017	4344	Major Disaster Declaration

Source: 2018 California State Hazard Mitigation Plan, FEMA, 2016 Sonoma County Hazard Mitigation Plan

Most disaster declarations are issued on a county-wide basis. In some limited instances a city or area within a county is specifically designated. Sonoma County has received 29 declarations between 1964 and 2017, 18 of which received federal disaster declarations, 4 received a Gubernatorial Declaration, 6 were local emergency declarations and 1 for fire management assistance. Of the 29 disaster declarations, 12 were associated with severe storms and heavy rain (also includes the 1 coastal storm event), 5 associated with flooding, and 4 declarations related to wildfires; freeze, earthquake and pandemic all received 1 declaration. The County also received 1 declaration related to fishing losses, 1 related to the Cosco Busan oil spill in San Francisco Bay, and 1 related to the 2011 Japan Tsunami.

Since 2012, there have been 13 drought declarations issued by the Secretary of Agriculture for Sonoma County, 8 of which were "Fast Track Secretarial Disaster" designations; refer to Section 4.3.2 on drought hazards for more details on previous occurrences of drought events. According to the Secretary of Agriculture, a Fast Track designation is for a severe drought and provides an automatic designation when any portion of the county meets the severe drought intensity value for eight consecutive weeks during the growing season.

This combined federal and state disaster history suggests that Sonoma County (and the City of Petaluma) experiences a major event worthy of a disaster declaration every 1.8 years. The County has a 55 percent chance of receiving a disaster declaration in any given year. Further, a review of these events helps the City identify risk reduction targets and ways to improve their capabilities to avoid large-scale hazard events in the future.

4.1.4 Climate Change Considerations Summary

Climate change is an increasingly important factor now affecting all phases of the disaster management cycle. The City of Petaluma and Sonoma County acknowledge that climate change is occurring and began to plan for it when the City Council declared a climate emergency in May 2019 and drafted the Climate Emergency Resolution. The City's focus on addressing climate policy was further underscored by the establishment of a Climate Action Commission (CAC) in October 2019. The Commission is an appointed seven-member body designated to address the City's impact on climate change, develop climate policies, and make recommendations to the Council.

What is Climate Change?
Climate change refers to distinct changes in weather conditions that result from increased atmospheric greenhouse gas (GHG) emissions. Monthly mean GHG levels now exceed 400 parts per million (ppm) for the first time in recorded history. This GHG increase has trapped heat in the atmosphere and is linked to an increase in average global temperature and these global temperature and GHG increases are resulting in a series of changes to the global climate. These changes include shifts in seasonal temperature patterns; altered precipitation timing, amount, and location; sea level rise due to melting glaciers and ice caps; ocean acidification due to increased carbon dioxide (CO_2) absorption; and altered wind and storm event frequency and severity, including more frequent and intense storms, droughts, and heat waves. Climate change is not a discrete event, but a long-term hazard that already affects communities in California.
Sources: NOAA 2017; IPCC 2018; SHMP 2018

Sonoma County initiated climate change efforts in 2009 by the establishment of a Regional Climate Protection Authority (RCPA). The RCPA was formed through locally sponsored state legislation to coordinate countywide climate protection efforts among Sonoma County's nine cities and multiple county agencies. The RCPA focuses on efficient buildings, clean energy, alternative transportation, and conservation and adaptation. In 2014, the RCPA prepared a climate hazard and vulnerability assessment, known as *Climate Ready Sonoma County: Climate Hazards and Vulnerabilities*. In 2016, the RCPA prepared Sonoma County's *Regional Climate Action Plan: Climate Action 2020 and Beyond* (referred to as the County's CAP). Although not formally adopted by the County, climate change projections summarized in the CAP are based on the Basin Characterization Model (BCM) prepared by scientists from the USGS and the University of California, Davis Center for Environment. The projections were developed by applying scaled-down models that identify watershed-level climate change impacts specific to Sonoma County; the projections represent the best available climate data for the County (RCPA 2016). The BCM projections and recent studies indicate that climate change could affect Sonoma County (and the City of Petaluma) in the following ways:

- **Higher Average Temperature and More Extreme Heat Events:** For scenarios with mitigated emissions, summer high temperatures are expected to rise by 1 to 2°F; scenarios with unmitigated emissions project average summer high temperatures will increase by up to 9 to 11°F by 2100.
- **More Frequent and Intense Droughts:** Three of the four climate scenarios examined indicate a rising climate water deficit (CWD), a numeric measure of drought stress, over this century, producing 10 to 20 percent drier soil conditions in the summer months. The greatest increases in soil dryness are projected to occur in the south and southeastern portions of the County (including Petaluma).
- **More Frequent and Intense Wildfire:** Wildfire risk will continue to rise due to increased dryness of vegetation compounded by the productivity of plants in the spring. By the end of the century, the chances of one or more fires during a 30-year period are projected to increase from 15 to 20 percent to 25 to 33 percent in the mountainous areas of the County.
- **Fewer Winter Nights that Freeze.** Projected winter low temperatures are expected to rise in the future. For scenarios with mitigated emissions, winter low temperatures are expected to rise by 1 to 2°F. In the two scenarios with unmitigated emissions, average winter low temperatures are projected to increase by up to 7 to 9°F by 2100.

- **Increased Risk of Extreme Floods:** Climate scenarios project increased seasonal variability of precipitation, runoff, and stream flows for Sonoma County, along with increased likelihood of "extreme" precipitation and drought events. There may be more years with more frequent storm events and occasional events that are much stronger than historical ones and the length of season over which storm events occur is predicted to increase.
- **More Frequent Coastal Flooding, Increased Erosion, and Saltwater Intrusion:** Sea levels are projected to rise between 16.5 and 65.8 inches by 2100. Rising sea levels combined with increased storm surge will lead to more frequent inundation of the low-lying areas, and flooding of homes, infrastructure, agricultural land, and natural areas on the shores of San Pablo Bay. The greatest impacts are anticipated during winter storms.

The important consideration for hazard mitigation is that climate change is exacerbating the hazards which are already identified and profiled in this plan. For example, it can be expected that coastal storm and wave surge and coastal flooding and erosion along the Petaluma River will become more of a threat as sea level rises. The City and California are also already experiencing the impacts of climate change including prolonged drought, increased flooding, increased average temperatures, shifts in the water cycle, and changes to precipitation patterns and the intensity of extreme events resulting from hazards, such as wildfires. Climate change not only results in progressive changes, such as shifting weather patterns, but also affects the frequency and severity of hazard events (SHMP 2018). Climate change also results in an increase in the variance of climate patterns and this increased variance creates challenges for hazards planning, which previously used historic recurrence rates to predict future events, and now must incorporate changes to the frequency, severity, and location due to climate change.

Risk assessment for hazards is built upon the frequency of past events and the assumption that historic occurrence rates are a good predictor of future event probability. With climate change; however, history is not an adequate predictor of the probability of future occurrences (SHMP 2018). Planning for climate change (and understanding the probability of future occurrences [see Section 4.3 below]) is therefore now based on understanding and integrating evolving climate change science and modeled projections that account for shifts in historic conditions due to climate change (SHMP 2018) into hazard mitigation planning.

Additional specifics associated with the hazards are discussed in the Climate Change Considerations subsection of each hazard profile. This section also summarizes whether climate change is anticipated to have a low, medium, or high influence on future hazards.

4.2 Asset Summary

As a starting point for analyzing the Planning Area's vulnerability to identified hazards, the HMPC used a variety of data, including data provided by Sonoma County (e.g. structure values, assessor data) to define a baseline against which all disaster impacts could be compared. If a catastrophic disaster were to occur in the Planning Area, this section describes significant assets exposed or at risk in the Planning Area. Data used in this baseline assessment included:

- Total assets at risk;
- Critical facility inventory;

- Cultural, historical, and natural resources; and
- Population statistics, land use, and growth/development trends.

Total Assets at Risk

A spatial parcel dataset containing attributes such as structure values and year of property construction was provided by the City of Petaluma GIS Department, alongside a building outline layer useful in counting buildings per parcel. Property type, valuation details, and other information contained in this plan are based on data from the Sonoma County Assessor's Office. This data provided the baseline for an inventory of the total exposure of developed properties within the City of Petaluma. This data helps to ensure that the LHMP can be updated over time to reflect changes in development. It is important to note that depending on the nature and type of hazard event or disaster, it is generally the value of the infrastructure or improvements to the parcels that are of concern or at risk. Generally, the land itself is not a total loss, but may result in a reduction in value. Thus, the parcel analysis excludes land value.

Once the dataset was reviewed and organized, the parcel layer was clipped to the boundaries of the City of Petaluma UGB. For the purpose of parcel analysis and exposure calculations only parcels with improved values were used, except for exempt or government properties (which may not include an improvement value per its categorization and is one limitation that results in the total improvement values underestimating the actual value). "Improved" parcels have an improvement value greater than zero. Contents values were also estimated, as a percentage of building value based on their property type, using FEMA/Hazus guidelines. Content value estimates are based on 100 percent of the structure value for commercial and agriculture structures, 150 percent of the structure value for industrial structures, and finally 50 percent for residential structures. Improvement values were added to contents values to calculate the total structure values for all properties in the parcel layer. The parcel layer, originally in the form of polygons, was then converted into points based on the center (or centroid) of a parcel to then used in overlay analysis with those hazards profiled in this plan that are available in spatial format (i.e. flood and fire). These outputs summarize the count and value of improved properties, contents, and total values for the property inventory, and the exposure values by property type for the City of Petaluma.

Table 4-4 summarizes the total improved parcel exposure by parcel type for the City of Petaluma.

Table 4-4: City of Petaluma Total Improved Parcel Exposure by Parcel Type

Parcel Type	Total Parcels	Improved Value	Content Value	Total Value
Agricultural	2	$12,473	$12,473	$24,946
Commercial	1,029	$1,268,444,699	$1,268,444,699	$2,536,889,398
Multi-Family	295	$525,362,102	$262,681,051	$788,043,153
Residential	17,569	$4,368,066,096	$2,184,033,048	$6,552,099,144
TOTAL	18,895	$6,161,885,370	$3,715,171,271	$9,877,056,641

Source: Wood analysis based on City of Petaluma and Sonoma County Assessor's Office Data 2019

Critical and City Facility Inventory

A critical facility is defined (within the context of this plan) as a facility that is essential in providing utilities or support either during the response to an emergency or during a recovery operation. The following four categories were used to differentiate critical assets and facilities in Petaluma based on FEMA's Hazus-MH program and other FEMA guidelines:

- **Emergency Services –** Facilities or centers aimed at providing for the health and welfare of the whole population (e.g., hospitals, police, fire stations, emergency operations centers, evacuation shelters, schools).
- **Lifeline Utility Systems –** Facilities and structures such as potable water, wastewater, oil, natural gas, electric power and communications systems.
- **Transportation Systems –** These may include railways, highways, waterways, airways and city streets to enable effective movement of services, goods and people. Particular examples for Petaluma include airports, historic drawbridges, and train or other transportation stations.
- **High Potential Loss Facilities –** These include nuclear power plants, dams, and levees.

The City of Petaluma also provided key facilities that it deems essential. Table 4-5 lists both critical facilities obtained from the Homeland Infrastructure Foundation-Level Data (HIFLD 2018), a federal dataset, as well as the City-provided structure data. Table 4-5 shows the City's critical facilities.

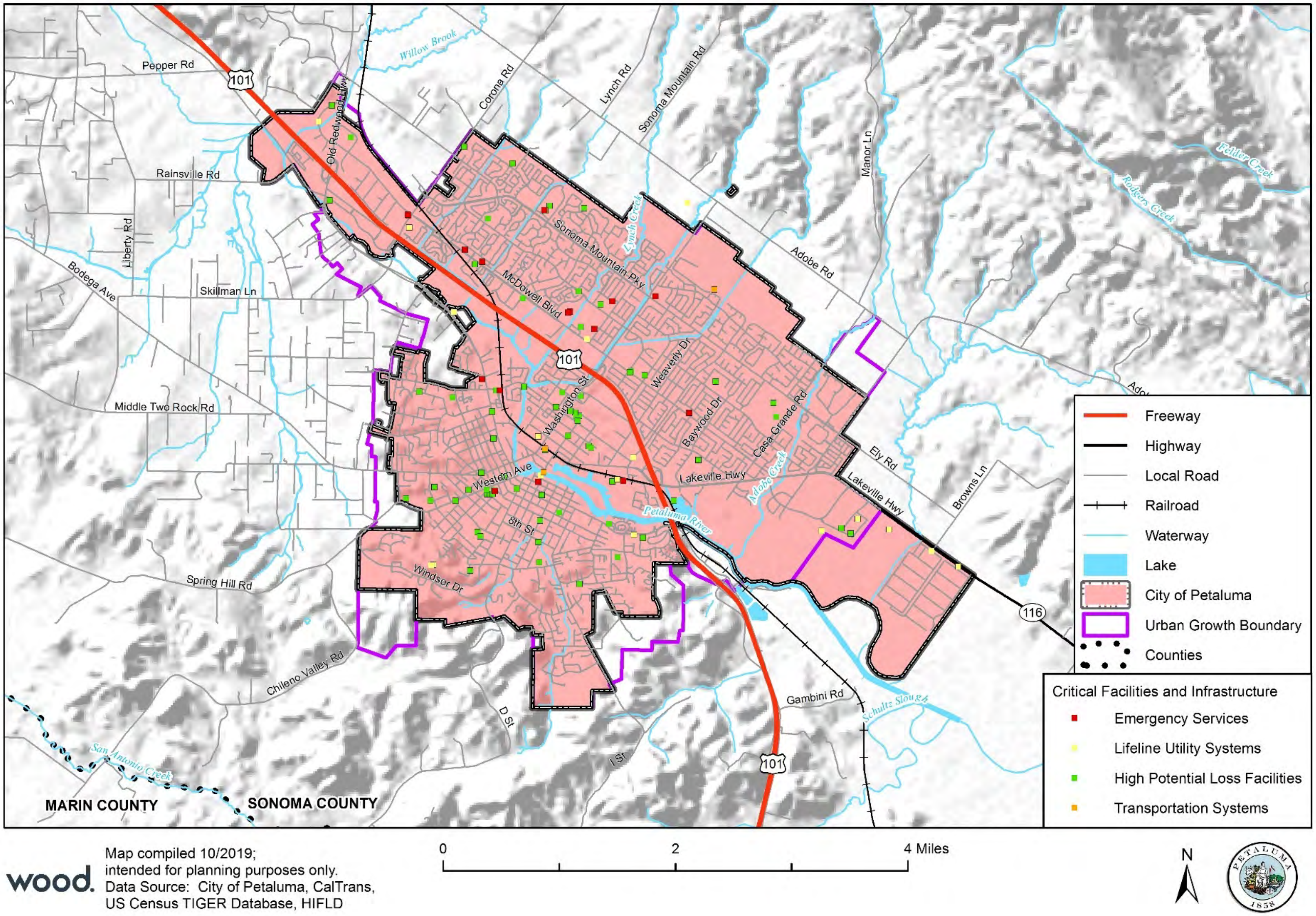
Table 4-5: Critical and City Facility Summary by Category and Type

Overall Category	Critical Facility Type	Total Critical Facilities
Emergency Services	Emergency Medical Service Station	2
	Fire Station	3
	Hospitals	1
	Law Enforcement	4
	Nursing Homes	4
	Senior Center	2
	Shelter Home	1
TOTAL		**17**
High Potential Loss Facilities	Community/Recreation Center	8
	Day Care Facilities	13
	Government/Admin	16
	Private School and Day Care	2
	Private Schools	4
	Public School and Day Care	4
	Public Schools	19
	Supplemental Colleges	2
TOTAL		**68**
Lifeline Utility Systems	AM Transmission Towers	1
	Electric Substations	3
	Microwave Service Towers	3
	Water Facility	8
	Wastewater Treatment Plant	2
TOTAL		**17**
Transportation Systems	Airport	1
	Historic Drawbridge	1
	Train Station	1
TOTAL		**3**
GRAND TOTAL		**105**

Sources: City of Petaluma, Homeland Infrastructure Foundation-Level Dataset

NOTE: The SMART Rail at Haystack Bridge in the City of Petaluma was not included as a critical facility because it is not owned by the City. This facility is owned and operated by Sonoma-Marin Area Rail Transit District.

Figure 4-1: Critical and City Facilities in Petaluma by Overall Category



Cultural, Historical, and Natural Resources

Assessing the City of Petaluma's vulnerability to disaster also involves inventorying the natural, historical, and cultural assets of the area. This step is important for the following reasons:

- The community may decide that these types of resources warrant a greater degree of protection due to their unique and irreplaceable nature and contribution to the overall economy.
- In the event of a disaster, an accurate inventory of natural, historical and cultural resources allows for more prudent care in the disaster's immediate aftermath when the potential for additional impacts is higher.
- The rules for reconstruction, restoration, rehabilitation, and/or replacement are often different for these types of designated resources.
- Natural resources can have beneficial functions that reduce the impacts of natural hazards, for example, wetlands and riparian habitat which help absorb and attenuate floodwaters and thus support overall mitigation objectives.

Cultural Resources

Historical resources are buildings, structures, objects, places, and areas that are eligible for listing in the National Register of Historic Places (NRHP), the California Register of Historic Resources (CRHR), or the City's List of Historic Resources, have an association with important persons, events in history, or cultural heritage, or have distinctive design or construction method.

For purpose of federal actions, a qualified historic resource is defined as a property listed in or formally determined eligible for listing in the NRHP before a disaster occurs. The NRHP is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect historic and archeological resources. Properties listed include districts (i.e. Petaluma Historic Commercial District), sites, buildings, structures, and objects that are significant in American history, architecture, archeology, engineering, and culture. The National Register is administered by the U.S. Department of the Interior National Park Service. Local and state agencies may consider a broader definition of qualified historic properties in the review, evaluation, and treatment of properties damaged during a disaster.

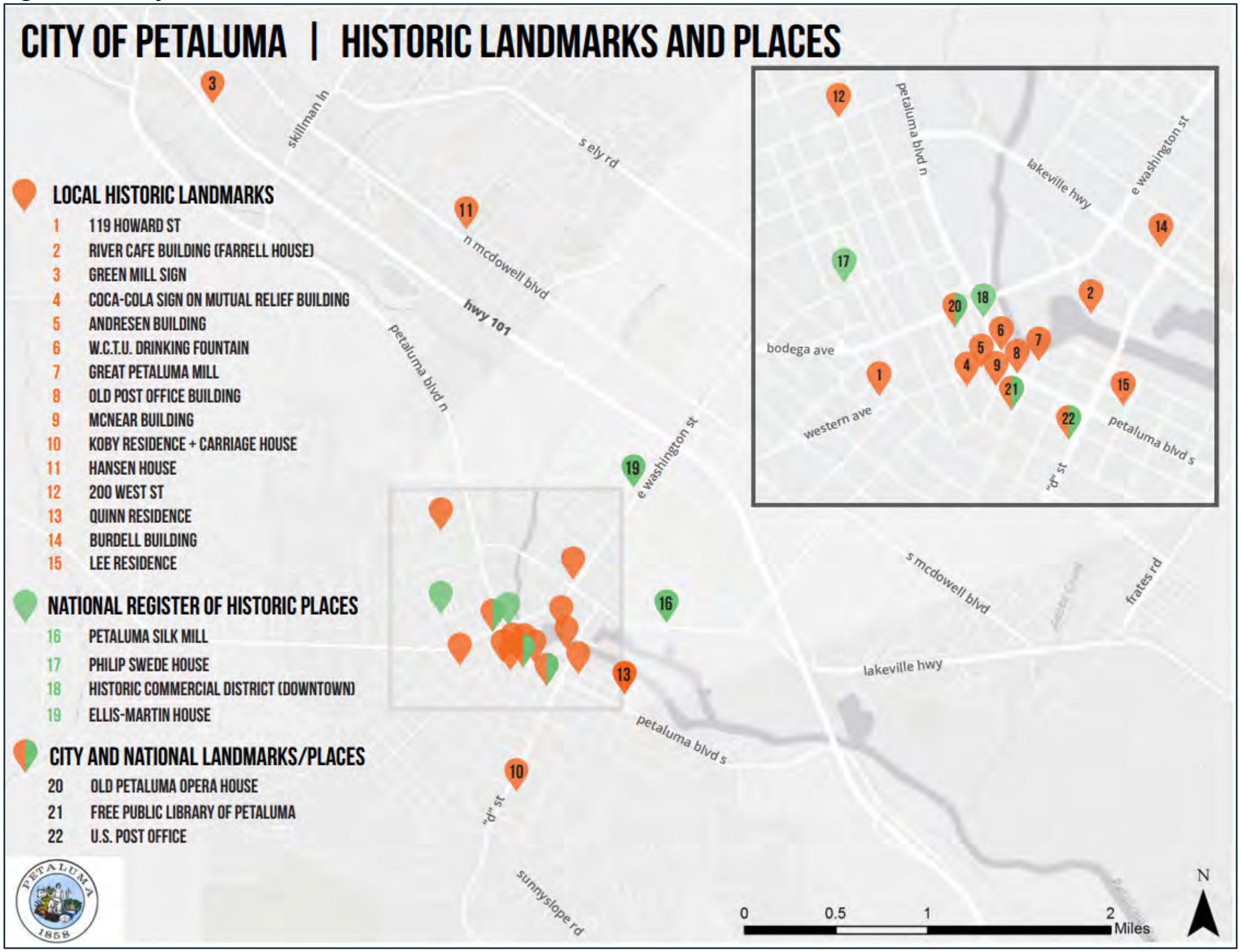
The State of California Office of Historic Preservation can provide technical rehabilitation and preservation services for historic properties affected by a natural disaster. Depending on the hazard, protection could range from emergency preparedness, developing a fire safe zone around sites susceptible to wildfires, or seismically strengthening or structurally reinforcing structures.

State and local registers of historic resources provide designated Historical Landmarks, Points of Historical Interest, and Historic Buildings. These resources include, but are not limited to:

- The California Register of Historical Resources (CRHR)
- The California Historical Landmarks
- The California Inventory of Historical Resources
- The California Points of Historical Interest

Historical resources designated by the City of Petaluma's Planning Division and Historic and Cultural Preservation group/chapter are provided in Figure 4-2. Table 4-6 summarizes the historic and cultural resources found in the National Register of Historic Places for the Petaluma area. Some of these historic and cultural places are duplicative in both the City and National databases and hence table and map.

Figure 4-2: City of Petaluma Historic Landmarks and Places



Source: City of Petaluma Planning Division – Historical and Cultural Preservation Division 2019

Table 4-6: City of Petaluma Historical Resources from the National Register of Historic Places

Historical Resource Name	Listed Date	Location	Other Names or Description
Petaluma Adobe	4/15/1970	4 miles East of Petaluma on Casa Grande Rd.	Rancho Petaluma Adobe
Old Petaluma Opera House	12/22/1978	147--149 Kentucky St.	The Maclay Building
US Post Office--Petaluma	1/11/1985	120 4th St.	Petaluma USPS Post Office; US Post Office in California 1900-1941 TR
Petaluma Silk Mill	3/6/1986	420 Jefferson St.	Carlson-Currier Silk Mfg. Co.; Belding-Heminway-Corticelli
Free Public Library of Petaluma	6/23/1988	20 Fourth St.	Old Carnegie Library; Petaluma Historical Library and Museum
Swede, Philip, House	6/18/1992	301 Keokuk St.	--
Petaluma Historic Commercial District	3/31/1995	Along Petaluma Blvd., between B and Prospect Streets	Old Petaluma Opera House
Ellis--Martin House	10/4/2006	1197 E. Washington St.	Martin House; Ellis, John D., House

Source: National Register of Historic Places, 2019

Lists of designated historical resources change periodically, and they may not include those currently in the nomination process and not yet listed. Additionally, as defined by the National Environmental Policy Act (NEPA), any property over 50 years of age is considered a historic resource and is potentially eligible for listing on the National Register. Thus, in the event that the property is to be altered, or has been altered, as the result of a major federal action, the property must be evaluated under the guidelines set forth by NEPA. Structural mitigation projects are considered alterations for the purpose of this regulation.

Cultural resources defined in California Environmental Quality Act (CEQA) Section 15064.5 include prehistoric and historic archaeological resources; historic-period resources (buildings, structures, area, place, or objects). Archaeological resources reflect past human activity extending from Native American prehistoric cultures throughout the early 20th century. The artifacts left by previous occupants may be encountered in small to large residential sites, or special use areas.

Many cultural and historical resources in the City are vulnerable to several hazards due to location and the nature of their construction. Some of these risks include earthquakes, wildfires, coastal storms, or adverse weather.

Tribal Cultural Resources

Tribal cultural resources are defined in Public Resources Code (PRC) Section 21074.1 as a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe. A Native American tribe is defined as "a federally recognized California Native American tribe or a non-federally recognized California Native American tribe that is on the contact list maintained by the Native American Heritage Commission". Traditional tribal cultural places are defined in PRC Sections 5097.9 and 5097.993 to include sanctified cemeteries, places of worship, religious or ceremonial sites, or sacred shrines, or any historic, cultural, or sacred site that is listed on or eligible for the CRHR including any historic or prehistoric ruins, burial grounds, or archaeological site. Cultural and tribal resources are governed primarily by federal, state, and local laws that regulate potential impacts to such resources. State regulations that were established to encourage the preservation and protection of traditional tribal cultural resources include:

- **Assembly Bill 52** (PRC Section 21080.3.1) mandates early tribal consultation prior to and during CEQA review to consider tribal cultural values in determination of project impacts and mitigation.
- **Senate Bill 18** (Government Code 655352.3) requires cities and counties to consult with Native American tribes early during broad land use planning efforts on both public and private lands, prior to site- and project-specific land use decisions. Consultation is intended to encourage preservation and protection of traditional tribal cultural places by developing treatment and management plans that might include incorporating the cultural places into designated open spaces.
- **State Executive Order B-10-11 (2011)** established the Governor's Tribal Advisor position and established Administration Policy to encourage State Agencies to communicate and consult with Californian tribes regarding tribal cultural resources.

Natural Resources

The City of Petaluma contains diverse in natural resources, exemplified by the creeks and rivers and salt marshes within its watershed that drain inland mountains to the confluence of the Petaluma River and San Pablo Bay.

Natural resources are important to include in benefit/cost analyses for future projects and may be used to leverage additional funding for mitigation projects that also contribute to community goals for protecting sensitive natural resources. Inventory and awareness of natural resource assets is vital to meeting conservation objectives. For example, protecting wetland areas provides sensitive habitat protection as well as floodwater conveyance and storage, which further enhances public safety.

Natural resources also exhibit varied levels of resiliency to anthropogenic impacts, climate change, and natural hazards such as flooding, drought, coastal storms or wildfire. Climate change is one of the most substantial threats to conserving the biodiversity and ecological habitat of the County (OPR 2019). Habitat resiliency is exemplified in coastal habitat migration to inland areas as a result to sea level rise, and recovery of burn areas following a wildfire.

Special Status Species

To further understand natural resources that may be particularly vulnerable to a hazard event, as well as those that need consideration when implementing mitigation activities, it is important to identify at-risk species (endangered and threatened species) potentially located in the City of Petaluma and its Planning Area. The US Fish and Wildlife Service (USFWS) maintains a list of federally-listed threatened and endangered species for the country, which can be queried at the state and county levels. The California Department of Fish and Wildlife (CDFW) also maintains species lists and accounts for threatened and endangered species. State and federal laws protect the habitat of these species through the environmental review process. Species of special concern may additionally include species that meets the State definition of threatened or endangered but has not been formally listed, experiences seriously population declines or habitat decline, or has naturally small populations exhibiting high susceptibility to population decline (CDFW 2019). Table 4-7 summarizes those special status animal species as indicated in the USFWS database that are located in Sonoma County and likely the areas surrounding the City of Petaluma Planning Area.

Table 4-7: Threatened and Endangered Species in Sonoma County and the City of Petaluma Area

Common Name	Scientific Name	Group	Status
California tiger Salamander	Ambystoma californiense	Amphibians	Endangered
California red-legged frog	Rana draytonii	Amphibians	Threatened
Short-tailed albatross	Phoebastria (=Diomedea) albatrus	Birds	Endangered
California least tern	Sterna antillarum browni	Birds	Endangered
California clapper rail	Rallus longirostris obsoletus	Birds	Endangered
Yellow-billed Cuckoo	Coccyzus americanus	Birds	Threatened
Western snowy plover	Charadrius nivosus	Birds	Threatened
Northern spotted owl	Strix occidentalis caurina	Birds	Threatened
Marbled murrelet	Brachyramphus marmoratus	Birds	Threatened
California freshwater shrimp	Syncaris pacifica	Crustaceans	Endangered
Conservancy fairy shrimp	Branchinecta conservatio	Crustaceans	Endangered
Vernal pool fairy shrimp	Branchinecta lynchi	Crustaceans	Threatened
longfin smelt	Spirinchus thaleichthys	Fishes	Candidate
Sonoma alopecurus	Alopecurus aequalis var. sonomensis	Flowering Plants	Endangered
Clara Hunt's milk-vetch	Astragalus clarianus	Flowering Plants	Endangered
White sedge	Carex albida	Flowering Plants	Endangered
Vine Hill clarkia	Clarkia imbricata	Flowering Plants	Endangered
Baker's larkspur	Delphinium bakeri	Flowering Plants	Endangered
Yellow larkspur	Delphinium luteum	Flowering Plants	Endangered
Contra Costa goldfields	Lasthenia conjugens	Flowering Plants	Endangered
Pitkin Marsh lily	Lilium pardalinum ssp. pitkinense	Flowering Plants	Endangered
Few-flowered navarretia	Navarretia leucocephala ssp. pauciflora (=N. pauciflora)	Flowering Plants	Endangered
Many-flowered navarretia	Navarretia leucocephala ssp. plieantha	Flowering Plants	Endangered
Slender Orcutt grass	Orcuttia tenuis	Flowering Plants	Threatened
Lake County stonecrop	Parvisedum leiocarpum	Flowering Plants	Endangered
Calistoga allocarya	Plagiobothrys strictus	Flowering Plants	Endangered
Napa bluegrass	Poa napensis	Flowering Plants	Endangered
Kenwood Marsh checker-mallow	Sidalcea oregana ssp. valida	Flowering Plants	Endangered
Sonoma sunshine	Blennosperma bakeri	Flowering Plants	Endangered
Sonoma spineflower	Chorizanthe valida	Flowering Plants	Endangered
Marin dwarf-flax	Hesperolinon congestum	Flowering Plants	Threatened
Burke's goldfields	Lasthenia burkei	Flowering Plants	Endangered
Sebastopol meadowfoam	Limnanthes vinculans	Flowering Plants	Endangered
Showy Indian clover	Trifolium amoenum	Flowering Plants	Endangered
Loch Lomond coyote thistle	Eryngium constancei	Flowering Plants	Endangered
Clover lupine	Lupinus tidestromii	Flowering Plants	Endangered
Pennell's bird's-beak	Cordylanthus tenuis ssp. capillaris	Flowering Plants	Endangered
Myrtle's silverspot butterfly	Speyeria zerene myrtleae	Insects	Endangered
San Bruno elfin butterfly	Callophrys mossii bayensis	Insects	Endangered
Callippe silverspot butterfly	Speyeria callippe	Insects	Endangered
Behren's silverspot butterfly	Speyeria zerene behrensii	Insects	Endangered
Salt marsh harvest mouse	Reithrodontomys raviventris	Mammals	Endangered
Point Arena mountain beaver	Aplodontia rufa nigra	Mammals	Endangered
Leatherback sea turtle	Dermochelys coriacea	Reptiles	Endangered
Leatherback sea turtle	Dermochelys coriacea	Reptiles	Endangered
Olive ridley sea turtle	Lepidochelys olivacea	Reptiles	Threatened
Short-tailed albatross	Phoebastria (=Diomedea) albatrus	Birds	Endangered
California least tern	Sterna antillarum browni	Birds	Endangered
California clapper rail	Rallus longirostris obsoletus	Birds	Endangered
Yellow-billed Cuckoo	Coccyzus americanus	Birds	Threatened

Source: USFWS – Environmental Conservation Online System, 2019

Population, Growth, and Development Trends

Between 2010 and 2018 the population of Petaluma increased by 4,310 persons (DOF 2019). The Sonoma County Economic Development Board is projecting the City of Petaluma will grow by 3.2 percent by 2022, outpacing the state and nation in five-year growth projections. The City's General Plan buildout plan also estimates an additional 15,500 residents in the City by 2025 and much of the growth is projected to occur within the UGB.

With the City's two growth management programs in place, the Regional Growth Management System and the UGB, development in the City has been managed or constrained to some degree. Development on the western side of the City is constrained by the hilly topography and the UGB, while the east side is constrained by the UGB until 2025. As discussed in Chapter 2, as of August 16, 2019, the City has forty-six major development projects going through the planning process with the Planning Division. A majority of the projects are residential projects with commercial projects the next most common. These major development projects are located throughout the City and most are located near downtown Petaluma. Additional information on population and growth and development trends are in Section 2.4 and Section 2.8 in Chapter 2.

4.3 Hazard Profiles and Risk Assessment

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Requirement §201.6(c)(2)(ii): [The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.

Requirement §201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas.

Requirement §201.6(c)(2)(ii)(B): [The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) of this section and a description of the methodology used to prepare the estimate.

Requirement §201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

The hazards identified in Section 4.1 Hazard Identification: Natural Hazards are profiled individually in this section. In general, information provided by HMPC is integrated into this section with information from other data sources. These profiles set the stage for the vulnerability assessment for each natural hazard that follow the detailed hazard profiles.

Each hazard is profiled in the following format:

- **Hazard Description** - This section gives a description of the hazard and associated issues followed by details on the hazard specific to the City of Petaluma Planning Area.
- **Location** – This section provides a spatial description of the potential locations or geographic areas in the City of Petaluma of where the hazard is expected to impact.
- **Extent (Magnitude/Severity)** - This section gives a description of the potential strength or magnitude of the hazard as it pertains to the City of Petaluma. Different hazards may have different measures of extent.
- **Previous Occurrences** - This section contains information on historical incidents, including impacts where known. The extent or location of the hazard within or near the Planning Area is also included in this subsection. Historical incident worksheets and other data sources were used to capture information on past occurrences.
- **Probability of Future Occurrence** - The frequency of past events is used in this section to gauge the likelihood of future occurrences. Where possible, frequency was calculated based on existing data. Frequency was determined by dividing the number of events observed by the number of years on record and multiplying by 100. This gives the percent chance of an event happening in any given year (e.g., three droughts over a 30-year period equates to a 10 percent chance of a drought in any given year). The likelihood of future occurrences is categorized into one of the following classifications:
  - **Highly Likely** - Nearly 100 percent chance of occurrence in next year or happens every year.
  - **Likely** - Between 10 and 99 percent chance of occurrence in next year or has a recurrence interval of 10 years or less.

- **Occasional** - Between 1 and 10 percent chance of occurrence in the next year or has a recurrence interval of 11 to 100 years.
- **Unlikely** - Less than 1 percent chance of occurrence in next 100 years or has a recurrence interval of every 100 years or greater.

The risk assessment for most hazards is built upon the frequency of past events and the assumption that historic occurrence rates are a good predictor of future event probability. With climate change; however, history is not an adequate predictor of the probability of future occurrences (SHMP 2018). Planning for climate change is based on understanding and integrating evolving climate change science and modeled projections that account for shifts in historic conditions due to climate change into hazard mitigation planning (SHMP 2018). For these reasons, the likelihood of future occurrences for climate change and sea level rise impacts is categorized into one of the four classifications, but this classification is based on climate change science and modeled projections.

- **Climate Change Considerations** – Climate change refers to a long-term change in the earth's temperature, precipitation, humidity, and seasons. This section addresses the probable effects of climate change qualitatively and as a secondary impact for each identified hazard. In other words, it describes the potential for climate change to affect the frequency and severity of natural hazards. Impacts can include water supply shortages, changes in the frequency, intensity, and extent of drought and extreme heat events, more precipitation and flooding risks, and increasing temperatures. This section also concludes whether climate change is anticipated to have a low, medium, or high influence on future hazard impacts.

The discussion relies on information from the Fifth Assessment Report from the Intergovernmental Panel on Climate Change (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* (IPCC 2018). It also relies on numerous California publications on climate change and climate adaptation including:

- *California's Fourth Climate Assessment* (California Natural Resources Agency 2018a);
- *Safeguarding California Plan: 2018 Update – California's Climate Adaptation Strategy* (Cal-Adapt 2018);
- *2014 Safeguarding California: Reducing Climate Risk* (California Natural Resources Agency 2014); and
- *2009 California Climate Adaptation Strategy* (CAS) (California Natural Resources Agency 2009).

The discussion integrates climate information from Cal-Adapt, a website that gathers data on how climate change might affect California at the local level based on the state's scientific and research community (CEC 2018). The climate change considerations subsections also summarizes climate change modelling and findings from the following two RCPA-prepared documents: *Climate Ready Sonoma County: Climate Hazards and Vulnerabilities* (2014) and *Sonoma County's Regional Climate Action Plan: Climate Action 2020 and Beyond* (2016). Climate change projections summarized in Sonoma County's CAP are based on BCM projections, which as previously mentioned were developed by applying scaled-down models that identify watershed-level climate change impacts specific to Sonoma County (RCPA 2016). Climate change is addressed in the plan as a secondary impact for each hazard.

Vulnerability Assessment – The vulnerability of the Planning Area to a specific natural hazard is assessed through the study of potential impacts to specific sectors:

- Property

- People
- Economy
- Critical Facilities and Infrastructure
- Historic, Cultural, and Natural Resources
- Future Development

Risk Summary – This is a summary of key findings and risk based on threat, vulnerability and consequences to the Planning Area from the specific hazard.

The significance of each hazard was determined based on the hazard profile, focusing on key criteria such as frequency and resulting damage, including deaths/injuries, and property and economic damage. This assessment was used by the HMPC to prioritize those hazards of greatest significance to the Planning Area thereby allowing the City to focus resources where they are most needed. The following sections provide profiles of the natural hazards, listed alphabetically that the HMPC identified in Section 4.1 Identifying Hazards. Human-caused hazards are addressed in Section 4.4.

4.3.1 Dam Incidents

Hazard Description

Dams are manmade structures built for a variety of uses, including flood protection, power generation, agriculture, water supply, and recreation. When dams are constructed for flood protection, they usually are engineered to withstand a flood with a computed risk of occurrence. For example, a dam may be designed to contain a flood at a location on a stream that has a certain probability of occurring in any one year. If prolonged periods of rainfall and flooding occur that exceed the design requirements, that structure may be overtopped and fail. Overtopping is the primary cause of earthen dam incidents and failure in the United States. Dam incidents can also result from any one or a combination of the following causes:

- Earthquake
- Inadequate spillway capacity resulting in excess overtopping flows
- Internal erosion caused by embankment or foundation leakage or piping or rodent activity
- Improper design
- Improper maintenance
- Negligent operation
- Failure of upstream dams on the same waterway

Water released by a failed dam generates tremendous energy and can cause a flood that is catastrophic to life and property. A catastrophic dam incident or failure could challenge local response capabilities and require evacuations to save lives. Impacts to life safety will depend on the warning time and the resources available to notify and evacuate the public. Major loss of life could result as well as potentially catastrophic effects to roads, bridges, and homes. Associated water quality and health concerns could also be issues. Factors that influence the potential severity of a full or partial dam failure or dam incident are the amount of water impounded; the density, type, and value of development and infrastructure located downstream; and the speed of failure.

Controlled release or spillway flooding: inadequate spillway capacity often results in excess overtopping flows, though the potential for flooding as a result of discharge from dam outlet structures or spillways could be expected during excessive rain events. However, controlled releases of water from dams is a measure that can prevent or minimize spillway flooding or structure failure, by regulating capacity in a managed way. Even controlled releases can lead to unwanted or unpredicted flooding, depending on environmental and weather conditions, or even human error.

In general, there are three types of dams: concrete arch or hydraulic fill, earth-rockfill, and concrete gravity. Each type of dam has different failure characteristics. A concrete arch or hydraulic fill dam can fail almost instantaneously: the flood wave builds up rapidly to a peak then gradually declines. An earth-rockfill dam fails gradually due to erosion of the breach: a flood wave will build gradually to a peak and then decline until the reservoir is empty. And, a concrete gravity dam can fail instantaneously or gradually with a corresponding buildup and decline of the flood wave.

Location

According to the U.S. Army Corps of Engineers' National Inventory of Dams database, last updated in 2018, there are three potential dams of concern upstream of the City of Petaluma. These and other nearby dams may have been constructed for flood control, irrigation storage, recreation, and stock watering purposes. Of these dams of concern, one is considered to pose a high hazard, one is of significant hazard, and the last is rated as posing a low hazard.

The La Crema Winery Dam is an earth-material structure located just east of the City of Petaluma, about a half mile away and north of the City's wastewater treatment facility. The dam storage capacity is 103 acre-feet. This is a high hazard dam owned by the Jackson Family Wines entity, with no active EOP, or Emergency Action Plan (EAP) in place. The Pinheiro Dam is in the significant hazard category and was built in 1967. It is owned by a private entity and is located just over two miles east of the City, along a tributary to the Petaluma River. The dam storage capacity is 83 acre-feet. Finally, the Lawler Dam is located close to North Creek, about three miles northeast of Petaluma. This is a low hazard dam owned by the City, built in 1910 on the north part of the Petaluma Reservoir and with a primary use of providing water supply. It has a storage capacity of 227 acre-feet.

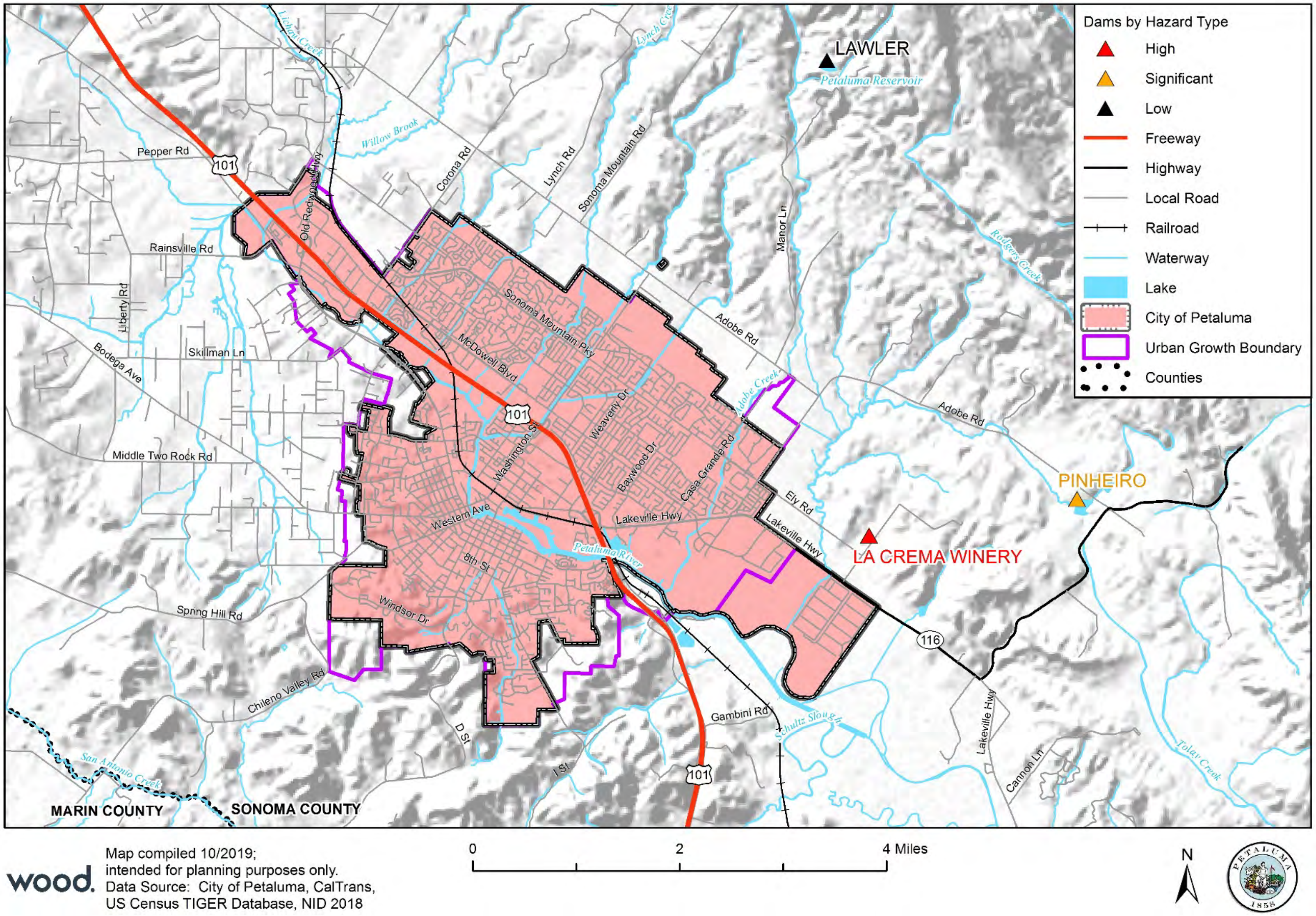
Table 4-8 below details these dams that could potentially affect the City of Petaluma given their close proximity and potential to inundate if either were to fail. **Figure 4-3** illustrates the locations of the two identified dams of concern near the City.

Table 4-8: Characteristics of the Dams of Concern Upstream of the City of Petaluma

Hazard Rating	Dam Name	River Drainage	Downstream Community	Dam Type	Dam Height (in Feet)	Storage Capacity (Acre-Feet)	Emergency Operations Plan	Dam Owner
Significant	Pinheiro	Tributary of Petaluma River	Petaluma	Earth	26	83	No	Private Entity
High	La Crema Winery	--	Petaluma	Earth	32	103	No	Jackson Family Wines
Low	Lawler	North Creek	Petaluma	Earth	40	227	No	City of Petaluma

Source: U.S. Army Corps of Engineers' National Inventory of Dams, 2018
Note: 1 acre-foot = 325,851 gallons

Figure 4-3: Dams of Interest Upstream of the City of Petaluma



Extent (Magnitude/Severity)

Limited – Standard practice among federal and state dam safety offices is to classify a dam according to the potential impact a dam failure (breach) or mis-operation (unscheduled release) would have on downstream areas. The hazard potential classification system categorizes dams based on the probable loss of human life and the impacts on economic, environmental, and lifeline facilities. Dams are classified into the following three categories which identify their potential hazard to life and property:

- High hazard indicates that a failure would most probably result in the loss of life;
- Significant hazard indicates that a failure could result in appreciable property damage;
- Low hazard indicates that failure would result in only minimal property damage and loss of life is unlikely; and
- Undetermined hazard dams have not been rated or their hazard rating is not known.

Since there are two potentially hazardous dams upstream of the City (one significant- and one high-rated hazard dam), there is some, though limited, potential for loss of life and/or property damage. Adjacent unincorporated portions of Sonoma or Marin Counties could also be affected by a dam failure upstream of the City, although the specific extent of impacts would depend on the nature of the failure, local emergency response capabilities, people and property found in the path of the dam inundation areas, and other such factors. However, based on the dam capacities of these the dams upstream of the Planning Area, it is unlikely that much risk would be imposed on those areas near Petaluma. Because the dam inundation maps are not currently available for the La Crema Winery and Pinheiro dams, it is difficult to determine the particular populations or properties at risk of a potential dam failure event on the City of Petaluma.

Previous Occurrences

There is no history of dam incidents or failures affecting the City.

Probability of Future Occurrences

Unlikely – The City remains at risk to upstream dam failures or incidents, particularly from the two that are classified as high or significant hazard structures. However, based on the lack of previous dam inundation events, HMPC input, and the fact that the dams posing risk to the City have relatively low storage capacities, dam failure and dam incidents are unlikely in the area. Nevertheless, the potential exists for future dam incidents in the City or portions of it, but the likelihood of this is low. Uncontrolled or controlled release flooding as well as spillway flooding below dams due to excessive rain or runoff are more likely to occur than failures.

Climate Change Considerations

The potential for climate change to affect the likelihood of dam failure and incidents is not fully understood at this point in time. With a potential for more extreme precipitation events a result of climate change, this could result in large inflows to reservoirs. However, this could be offset by generally lower reservoir levels if storage water resources become more limited or stretched in the future due to climate change, drought and/or population growth. For these reasons, climate change would have a “low” influence on dam incidents.

Vulnerability Assessment

A dam incident can range from a small, uncontrolled release to a catastrophic failure. Vulnerability to dam failures is confined to the areas and populations subject to inundation downstream of the facility. Secondary losses would include loss of the multi-use functions of the dam itself and associated revenues that accompany those functions, including potential potable water uses or critical irrigation for crops.

Property

In general, communities located below a high or significant hazard dam and along a waterway are potentially exposed to the impacts of a dam failure. For reference, high hazard dams threaten lives and property, significant hazard dams threaten property only. Inundation maps that identify anticipated flooded areas (which may not coincide with known floodplains) are often produced for all high hazard dams and are contained in the EAP required for each dam. The potential magnitude of a dam incident depends on the time of year and the base flow of the river when the incident or failure occurs. During the winter months, when the river flows are higher, the impact to the area would be much greater and evacuation times even shorter.

Due to the lack of dam inundation mapping for the dams upstream of the City, as well as the lack of EAPs, it is not well known how a potential dam failure could affect the City's property and infrastructure. Based on the location of the one high hazard dam and one significant hazard dam on the outskirts of the City in a sparsely populated area it appears the potential impacts to buildings and infrastructure downstream are minimal.

People

Persons located underneath or downstream of a dam are at risk of a dam failure, though the level of risk can be tempered by topography (specifically where populations are located within the inundation path of a dam but at higher elevations), amount of water in the reservoir/damming structure, and time of day of the breach. Injuries and fatalities can occur from debris, bodily injury, and drowning. Once a dam has breached, standing water presents all the same hazards to people as floodwater from other sources. People in the inundation area may need to be evacuated, cared for, and possibly permanently relocated. Impacts could include hundreds or thousands of evacuations and likely casualties, depending on the dam involved.

Due to the lack of dam inundation mapping for the three dams upstream of the City, as well as the lack of EAPs, it is not well known to what extent a potential dam failure could affect the City's population, nor the specific impacts on socially vulnerable or sensitive populations in the City's Planning Area.

Economy

Extensive and long-lasting economic impacts could result from a major dam failure including the long-term loss of water in a reservoir after a failure event. A major dam failure or incident and loss of water from the associate reservoir could include direct business and industry damages and indirect disruption of the local economy, including the disruption of irrigation water for crops or even water for livestock which may be key components of the local economy and its sectors.

Critical Facilities and Infrastructure

A total dam failure can cause catastrophic impacts to areas downstream of the water body, including critical infrastructure and essential facilities. Dam incidents may result is less severe downstream impacts, depending on the severity of the incident. Any critical asset located under the dam in an inundation area would be susceptible to the impacts of a dam incident. Of particular risk would be roads and bridges that could be vulnerable to washouts, further complicating response and recovery by cutting off impacted areas. Risk to specific facilities could be considered sensitive information, especially those such as water treatment facilities or water delivery systems which may provide potable water for the local population. Due to the lack of dam inundation mapping for the dams upstream of the City, as well as the lack of EAPs, it is not well known the extent to which a potential dam failure could affect the City's property and infrastructure. Based on location alone it does appear that the failure or a major incident at the La Crema Winery Dam, a high hazard dam could potentially impact the City's wastewater treatment infrastructure located downstream and near the drainage areas, but the actual risk is unknown due to data limitations.

Historic, Cultural, and Natural Resources

Dam failure effects on the environment would be similar to those caused by flooding from other causes. Water could erode stream channels and topsoil and cover the environment with debris. For the most part the environment is resilient and would be able to rebound from whatever damages occur, though this process could take years. Historic and cultural resources could be affected just as housing or critical infrastructures would, were a dam to fail and cause downstream inundation that could further erode surfaces or cause scouring of structural foundations. Given the high hazard dam outside the City lacks inundation mapping or an EAP, risks to historical and cultural resources is unknown.

Future Development

Areas slated for future development should take into consideration potential impacts from dam failure risk upstream and should attempt to overlay the existing dam inundation maps (if available) with proposed future development. In the case of a dam failure, inundation would likely follow some existing FEMA mapped floodplains, which contains development restrictions for areas in the one percent annual chance floodplain, but it could exceed those floodplains and affect areas that are not regulated for flood hazards. Also, development below a low or undetermined hazard dam such as the Lawler dam could increase its hazard rating. Finally, added development could compromise dams and reservoir resources if populations depend on them for critical needs such as potable water during or after a dam failure event.

Risk Summary

- The overall significance of dam inundation in the City of Petaluma is **Low**.
- There are three dams of concern that fall upstream of the City: La Crema Winery Dam, Pinheiro Dam, and Lawler Dam.
- La Crema Winery Dam is considered a high hazard dam and owned by the Jackson Family Wines entity. It is located about half a mile east of the City and its storage capacity of 103 acre-feet.
- The second dam of concern is the Pinheiro Dam and considered significant hazard dam and located just over 2 miles east of the City. It is owned by a private entity and located along a tributary of the Petaluma River. This significant hazard dam has a storage capacity of 83 acre-feet.
- The last potential dam of interest is the Lawler Dam, a low significance structure with a capacity of 227 acre-feet.
- All three of these dams are of earthen-constructed structures, and none have a current EAP on file
- Due to the lack of historic occurrence data on dam inundation, no dam inundation mapping available, and lack of EAPs, it is not well known how a potential failure of any of these dams could affect the City's populations, property, and critical infrastructure.

4.3.2 Drought

Hazard Description

Drought is a gradual phenomenon. Although droughts are sometimes characterized as emergencies, they differ from typical emergency events. Most natural disasters, such as floods or forest fires, occur relatively rapidly and afford little time for preparing for disaster response. Droughts occur slowly, many times over a multi-year period, and it is often not obvious or easy to quantify when a drought begins and ends.

Drought is a complex issue involving many factors; it occurs when a normal amount of moisture is not available to satisfy an area's usual water-consuming activities. Drought can often be defined regionally based on its causes or effects:

- **Meteorological** drought is usually defined by a period of below average water supply.
- **Agricultural** drought occurs when there is an inadequate water supply to meet the needs of the state's crops and other agricultural operations such as livestock.
- **Hydrological** drought is defined as deficiencies in surface and subsurface water supplies. It is generally measured as streamflow, snowpack, and as lake, reservoir, and groundwater levels.
- **Socioeconomic** drought occurs when a drought impacts health, well-being, and quality of life, or when a drought starts to have an adverse economic impact on a region.

The California Department of Water Resources (DWR) says the following about drought:

> "One dry year does not normally constitute a drought in California. California's extensive system of water supply infrastructure—its reservoirs, groundwater basins, and inter-regional conveyance facilities—mitigates the effect of short-term dry periods for most water users. Defining when a drought begins is a function of drought impacts to water users. Hydrologic conditions constituting a drought for water users in one location may not constitute a drought for water users elsewhere, or for water users having a different water supply. Individual water suppliers may use criteria such as rainfall/runoff, amount of water in storage, or expected supply from a water wholesaler to define their water supply conditions."

The drought issue in California is further compounded by water rights. Water is a commodity possessed under a variety of legal doctrines. The prioritization of water rights between farming and federally protected fish habitats in California is part of this issue.

Drought impacts are wide-reaching and may be economic, environmental, or societal. Also, during a drought, allocations go down, which results in reduced water availability. Voluntary water conservation measures are typically implemented during extended droughts. A reduction of electric power generation and water quality deterioration are also potential problems. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding.

Location

Drought is a regional hazard, and during severe drought conditions, it can affect the entire state of California with varying levels of dryness. In other words, drought affects all aspects of the economy and environment and the community simultaneously. The most significant impacts associated with drought in the City's Planning Area are those related to water intensive activities such as municipal usage and general water supply (e.g. irrigation for parks and open spaces), wildfire protection (including relief and response activities), commerce, agriculture, and tourism.

According to City of Petaluma's General Plan and the City's Water and Sewer Rate Study (City of Petaluma 2017), the City obtains its water from a mix of sources including water from the Russian River purchased from the Sonoma County Water Authority (SCWA) (also known as Sonoma Water), recycled water, and groundwater. The City also conserves water supplies through a standard management program and practices. These water supply sources and projected acre-feet (AF) available by 2025 are displayed in Table 4-9.

Table 4-9: Petaluma's Current Water Supply Sources and Projected Availability for 2025

Water Supply	2005 Usage	2025 Projected Availability
SCWA	11,799 AF	13,397 AF
Recycled Water	0	1,425 AF
Water Conservation	0	767 AF
Groundwater	0	186 AF
TOTAL	**11,799 AF**	**15,775 AF**

Sources: City of Petaluma General Plan 2008.

Notes:

2. One Acre-Foot = 43,560 cubic feet.
3. SCWA: Sonoma County Water Authority

The City purchases over 95 percent of its water supply on a wholesale basis from Sonoma Water and less than 5 percent is supplied by groundwater production from City wells. To aid in the overall conservation of water and reduction of use in the City for the coming years, the City built its first recycled water system in 1984 for irrigation of agricultural properties outside the City limits. The Ellis Creek Water Recycling Facility, built in 2009, takes wastewater subjected to additional high-level treatment and distributes the treated water for agricultural or landscape irrigation uses. The Ellis Creek recycled water facility treated 581 million gallons in 2019, but this amount varies year to year. The City is preparing to expand the recycled water treatment capacity in 2020, while increasing the distribution of recycled water incrementally through 2025. This City also applies a four-stage rationing plan during declared water shortages. This plan applies to catastrophic losses of water (City of Petaluma 2015). The rationing plan determines a consumption reduction of over 35 percent of the normal consumption depending on the cause, severity, and anticipated duration of the water supply shortage. Stage 1 involves minimal reductions of up to 15 percent of water supply conditions, stage 2 involves moderate reductions of 15 to 25 percent, stage 3 involves severe reductions of 25 to 35 percent, and stage 4 involves critical reductions greater than 35 percent (City of Petaluma 2015).

Sustainable Groundwater Management Act of 2014

Groundwater resources plays a significant role in the development, growth, and sustainability of the Petaluma Valley. Groundwater is the primary source for domestic and agricultural use by rural property owners in the Petaluma Valley Basin, while urban water supply to the City is primarily imported from Russian River surface water. The residents of Petaluma and all of California have been experiencing significant drought and water shortages since 2011 and only recently did the City and the majority of the state come out of drought. In January 2014 the Governor declared an emergency proclamation due to multiple years of drought. The proclamation called on citizens to reduce water use by 20 percent; with a subsequent executive order that directed urban water agencies to reduce water use by 25 percent. In September 2014, the Governor signed a three-bill package (California Senate Bills 1168 and 1319, and Assembly Bill 1739), known as the Sustainable Groundwater Management Act of 2014 (SGMA). The SGMA establishes local Groundwater Sustainability Agencies (GSAs) to manage groundwater sustainability within the groundwater sub-basins defined by DWR.

There are three GSAs in Sonoma County: Santa Rosa Plain, Sonoma Valley, and the Petaluma Valley. The Petaluma Valley groundwater basins spans 46,000 acres within the larger 93,440-acre Petaluma Valley watershed. Groundwater flows generally move from recharge areas in the mountains surrounding Petaluma Valley toward the City and then south towards San Pablo Bay. While groundwater data is currently being studied in the Petaluma Valley Basin, current groundwater elevation data suggests that elevations are relatively stable in the southern to central areas of Petaluma Valley, but exhibiting long-term declines in the northwest portion of the basin (Petaluma Valley GSA 2019). Historical occurrences of nitrate concentrations have been documented in the western portion of the Basin (DWR 1982). There have been other areas with poor water quality in the southern portion of the basin and saltwater intrusion from the tidally influenced portion of the Petaluma River (Petaluma Valley GSA 2019).

Extent (Magnitude/Severity)

Limited – Extent can be measured according to a scale developed by the United States Drought Monitor, which measures drought in five categories: "abnormally dry," "moderately dry," "severely dry," "extremely dry," and "exceptionally dry". The City of Petaluma is vulnerable to all levels of drought, which are further subject to the effects of climate change, precipitation trends, and wet and dry periods. Drought can have a widespread impact on the environment and economy in the Planning Area, but it typically does not result in loss of life or damage to property. Rather drought may have an impact on agriculture, business, and the movement of goods and services related to agricultural, commodities, tourism and recreation, and water supply sectors.

Given that the City of Petaluma's water users fall within the categories of residential (68 percent of water users) and commercial/office, industrial, and institutional (non-residential represents 32 percent of water users), it can be assumed that three main factors have an effect on water demands: climatic, demographic, and economic. These are described below and are expected to influence water demands in the future, as they have in the past.

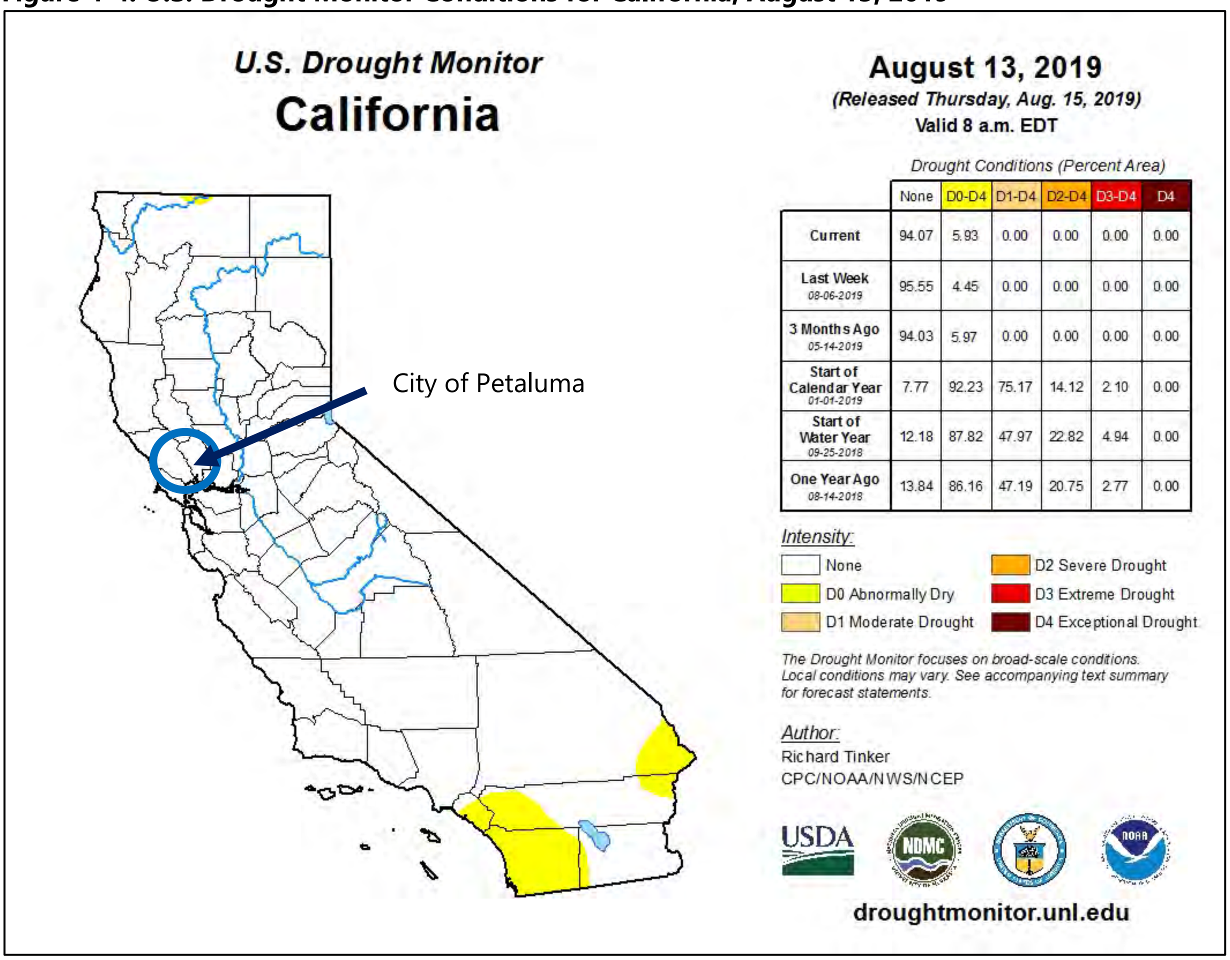
- **Climatic**. The weather in Petaluma is mild with a mean annual temperature of 70 degrees Fahrenheit. Average annual precipitation is about 25 inches. Climate has the most dramatic annual effect on water demands, and severe deviations from normal temperatures and average rainfall can increase or decrease annual water demands. Although Petaluma's municipal supply doesn't fully rely on surface water sources, precipitation shortages can have negative effects on what the City receives and can process for potable and other key uses.
- **Demographic**. Since water use is related to demographics and population change, an accurate description of population and housing stock in the service area serves as a basis for water planning activities described in the City's 2015 Urban Water Management Plan (UWMP) or other planning mechanisms. According the American Community Survey, the City's population was 60,210 in 2017. Population projections for the City indicate an increase from to 73,350 by 2040, or an increase of about 13,140 people per year (City of Petaluma 2015).
- **Economic**. Commercial water users have the second highest water demand after residential users (both single family and multi-family). According to the City's 2015 UWMP, commercial water users demand for potable and raw water is projected to increase from a volume of 930 to 1,048 by 2040.

Industrial users are expected to increase their demand for water by 64 percent by 2040. Although agricultural areas are outside of Petaluma, the City does supply recycled water to these areas with plans to expand services in the future.

The magnitude or severity of a drought across the City could vary and is difficult to predict. However, understanding the total population affected as well as economy and resources vulnerable provides insight on how to estimate potential losses and damages to the City's assets; drought related information can be obtained and measured from the National Drought Mitigation Center's Impact Reporter and Drought Monitor tools (United States Drought Monitor 2018; United States Drought Impact Reporter 2018).

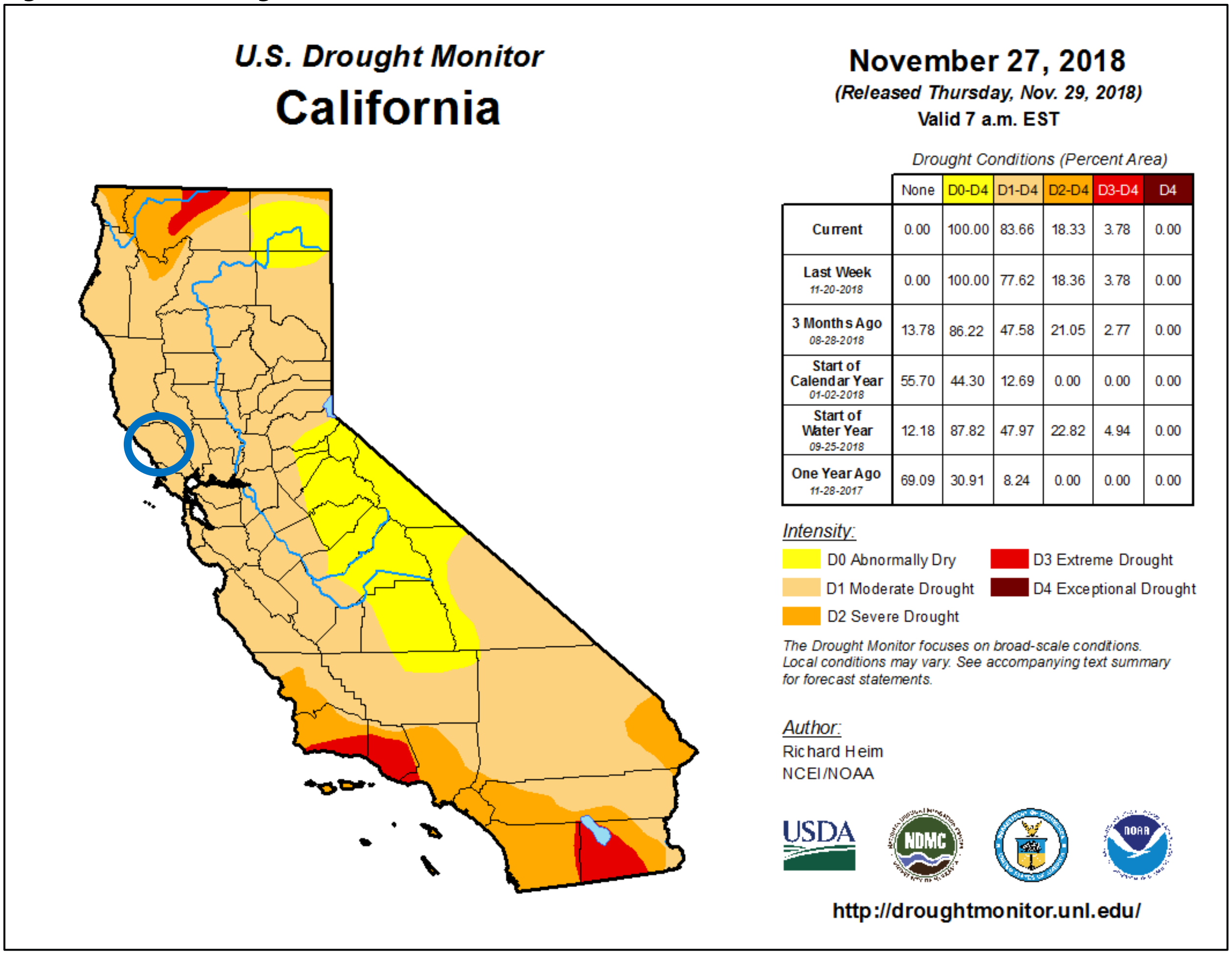
Figure 4-4, Figure 4-5, and Figure 4-6 provide "snapshots in time" of the drought conditions in California as of August 2019, November 2018, and August 2015 (during the period of the last multi-year drought in the state, from 2012- 2017). The snapshots selected are instrumental in depicting both the historic and potential change in drought's geographic range and severity in Sonoma County (circled in blue). These maps were extracted from the National Drought Mitigation Center and consider several factors including the Palmer Drought Index, Soil Moisture Models, U.S. Geological Survey (USGS) Weekly Streamflows, Standardized Precipitation Index, and Satellite Vegetation Health Index (United States Drought Monitor 2018).

Figure 4-4: U.S. Drought Monitor Conditions for California, August 13, 2019



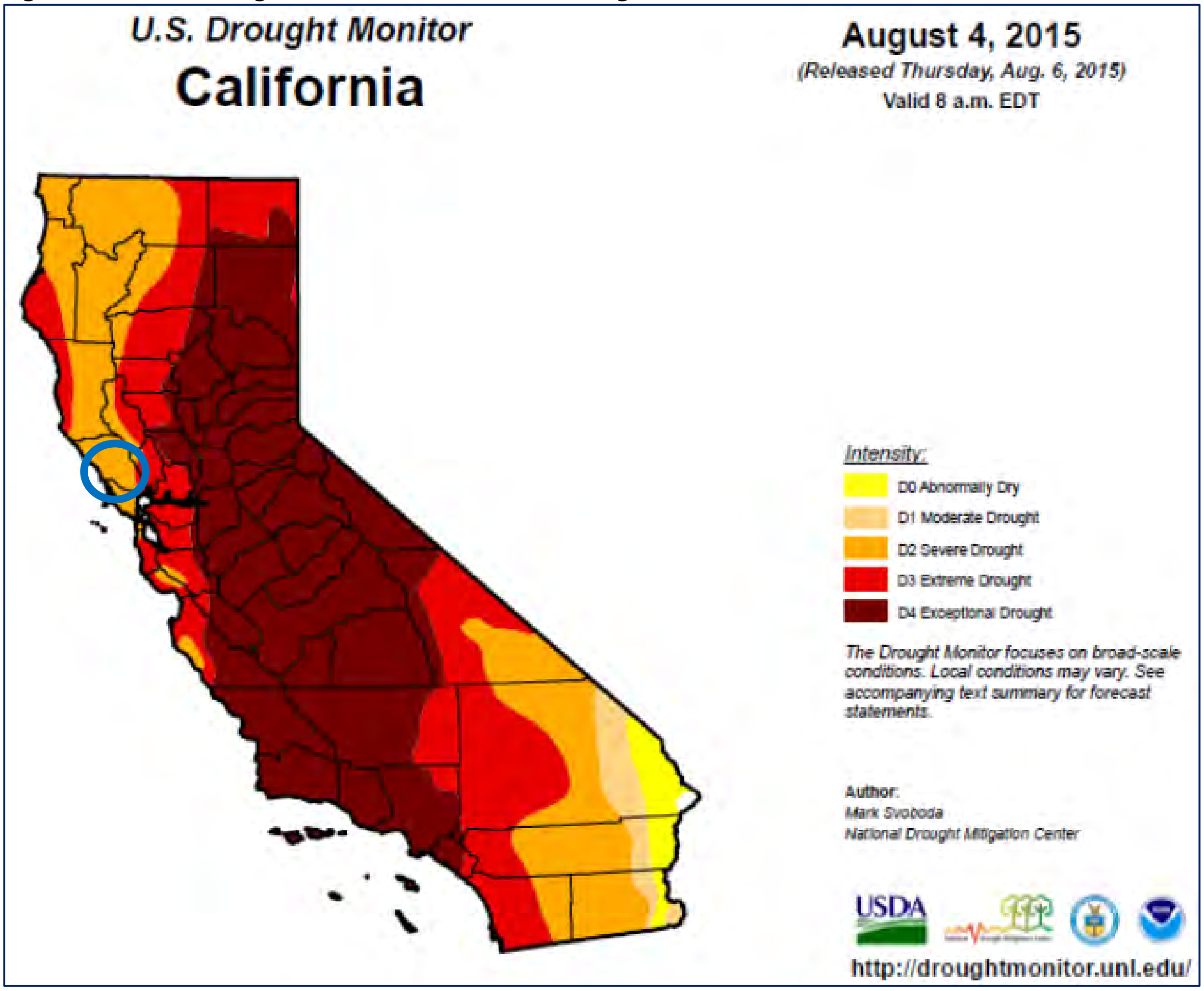
Source: National Drought Mitigation Center, 2018

Figure 4-5: U.S. Drought Monitor Conditions for California, November 29, 2018



Source: National Drought Mitigation Center, 2018

Figure 4-6: U.S. Drought Monitor for California: August 4, 2015

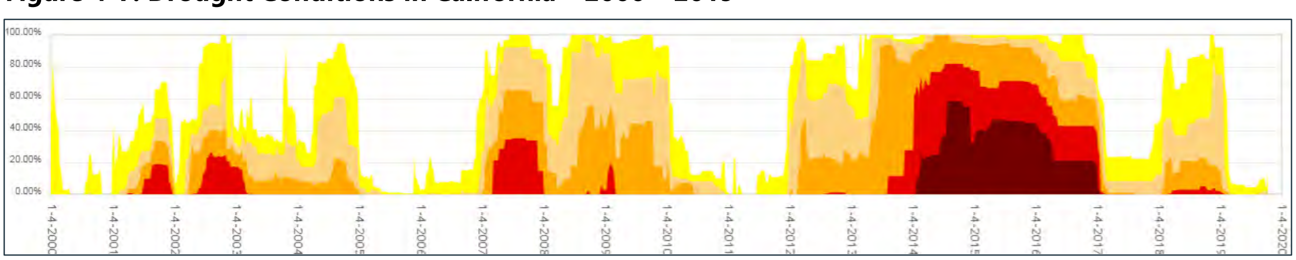


Source: National Drought Mitigation Center, 2018

Previous Occurrences

Historically, California has experienced multiple severe droughts. According to California's DWR, droughts exceeding three years are relatively rare in Northern California, the source of much of the state's developed water supply. The 1929-34 drought established the criteria commonly used in designing storage capacity and yield of large Northern California reservoirs. Figure 4-7 depicts California's multi-year historical dry periods from 2000-2019.

Figure 4-7: Drought Conditions in California – 2000 – 2019



Source: U.S. Drought Monitor https://droughtmonitor.unl.edu/Data/Timeseries.aspx

Since the year 2000 there have been several cases of multi-year droughts across California; these are described below:

2007-2009 – Water years 2007-2009 were the seventh driest three-year period in the measured record for state-wide precipitation and the fifteenth driest three-year period for DWR 8-station precipitation index (a rough indicator of potential water supply available to the State Water Project and Central Valley Project).

2012-2017 – The water years of 2012-14 stand out as California's driest three consecutive years in terms of statewide precipitation. The drought occurred at a time of record warmth in California, with new climate records set in 2014 for statewide average temperatures. On January 17, 2014, California declared a drought state of emergency and during this time the state assisted farmers and communities that were most impacted by the drought conditions and helped with drinking water shortages. The state also directed all state agencies to use less water and expand their water conservation campaigns. During this time, these factors have led to excessively dry conditions in the City of Petaluma and the surrounding areas than in past years, often requiring disaster declarations to be enacted to combat drought conditions. Sonoma County declared a Proclamation of Local Emergency Due to Drought Conditions from February 2015 to the end of 2015. On June 1, 2015 the Petaluma City Council imposed Stage 2 (mandatory) restrictions . From June 2015 to February 2016, the City as a whole was required to reduce its overall water use by 16 percent compared to 2013 consumption.

This drought period now marks the second time a statewide proclamation of emergency has been issued for this hazard. On April 17, 2017 Executive Order B-40-17 was issued, which officially ended the drought state of emergency in California, except for Fresno, Kings, Tulare, and Tuolumne counties. Table 4-10 summarizes the drought-related disaster declarations proclaimed for Sonoma County from 1976 through 2019. These declarations include those from FEMA, the USDA's Secretary of Agriculture, and events noted in the State of California's 2018 State Hazard Mitigation Plan.

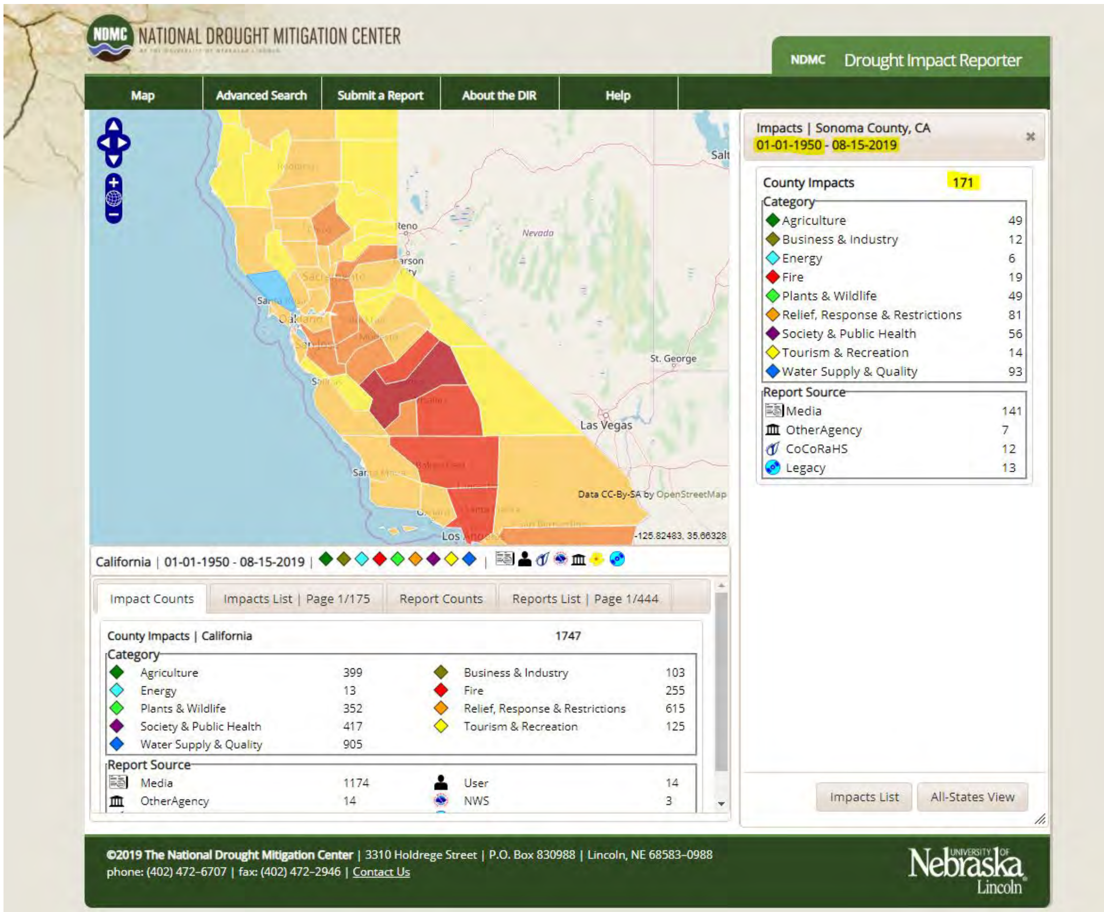
Table 4-10: Disaster Declarations and Proclamations Related to Drought in Sonoma County

Declaration or Order	Date
1976 Drought (State)	1976
EM-3023 (FEMA)	1/20/1977
S3248 (Secretary of Agriculture)	2012
S3452 (Secretary of Agriculture)	2012
S3565 (Secretary of Agriculture)	2013
S3569 (Secretary of Agriculture)	2013
S3637(Secretary of Agriculture)	2014
S3743 (Secretary of Agriculture)	2014
S3797 (Secretary of Agriculture)	2014
S3784 (Secretary of Agriculture)	2015
S3943 (Secretary of Agriculture)	2015
S3952 (Secretary of Agriculture)	2016
S3964 (Secretary of Agriculture)	2016
S4163 (Secretary of Agriculture)	2016-2017
S4144 (Secretary of Agriculture)	2017

Source: USDA Disaster Designations 2019; California SHMP 2018; FEMA

Figure 4-8 graphically displays the amount of drought-related reported impacts to Sonoma County (United States Drought Impact Reporter 2019). While it is difficult to extract the impacts specifically affecting Petaluma, a total of 171 reports were made within Sonoma County between January 1, 1950 and August 15, 2019. It is assumed that these drought-related impacts for areas across Sonoma County are likely to have also affected Petaluma at some point or to some extent. Based on the summary of negative effects to Sonoma County since 1950, the categories of water supply/quality have had the most reports, followed by relief, response, and restrictions operations and society and public health. Agriculture and plants and wildlife have also suffered the effects of drought, but to a lesser extent.

Figure 4-8: Drought Impact Reporter Summarizing Impacts at the County Level in Sonoma County, 1950-2019



Source: National Drought Mitigation Center Drought Impact Reporter, 2019

Probability of Future Occurrences

Likely – Historical drought data for California and more particularly the Sonoma County municipalities indicate there have been significant droughts and negative effects from water shortages in the past and the present. Based on this data, droughts are likely to affect the City's Planning Area and surrounding parts approximately every ten years; some of these droughts may persist for multiple years.

Climate Change Considerations

Scientific studies prepared for various California climate assessments and adaptations strategies show that drought conditions in California are likely to become more frequent and persistent over the next century due to climate change. Temperatures are warming, heat waves are more frequent, and precipitation has become increasingly variable (Natural Resources Agency 2018a). Water resources are also already experiencing the following stresses: population growth, poor water quality, groundwater overdraft, and aging water infrastructure.

The recent drought conditions over the past decade underscore the need to examine water supply and distribution management, conservation, and use policies. California and Sonoma County have experienced a succession of dry spells, and with warmer temperatures the impacts of drought conditions have increased (OEHHA 2018). In an average year, approximately 40 percent of the state's total water supply comes from groundwater, and during a dry year this increases to more than half of the state's water supply, with groundwater acting as a critical buffer against the impacts of drought and climate change (Natural Resources Agency 2018a). The City of Petaluma only uses groundwater in emergencies, but the Petaluma Valley Groundwater Basin has shown to have a reduction in groundwater levels due to the 2012-2015 drought period (City of Petaluma 2015).

According to California's Climate Adaptation Strategy, also referred to as *Safeguarding California Plan: 2018 Update*, climate change is likely to significantly diminish California's future water supply. As a result, the state must change its water management, as climate change will create greater competition for limited water supplies (California Natural Resources Agency 2018b). Similarly, as summarized in the Sonoma County CAP, climate change could result in hotter and drier weather, and more frequent and intense droughts. The CWA (numeric measure of drought stress that quantifies the extent to which plants need for water exceeds moisture available in soil) for the region is projected to increase over this century, producing 10 to 20 percent drier soil conditions in the summer months, leaving less water available for groundwater recharge or runoff into rivers and creeks (RCAP 2016). The greatest increases in soil dryness are projected in the south and southeastern portions of the County, near Petaluma (RCAP 2016). These water management concerns will also impact Sonoma Water, the City's main water supplier. For these reasons, climate change would have a "high" influence on drought hazards, as well as water shortages.

Vulnerability Assessment

Property

Drought impacts are wide-reaching and may be economic, environmental, and societal. The most significant impacts associated with drought in the City's Planning Area are those related to water intensive activities, such as agriculture, municipal water use, commerce, tourism, and recreation. The vulnerability of a water intensive activity to the effects of drought usually depends on its water demand, whether the demand is met, and what water supplies are available to meet the demand. For the City of Petaluma, water allocations go down during a drought, and the City's contractual surface water entitlements may be reduced. According to the 2015 UWMP, because the City relies more on surface water supplies from the Russian River they can also use available groundwater supplies as a buffer during drought conditions. Water restrictions and other conservation measures are typically implemented during extended droughts, and these can result in economic impacts on water utilities managed by the City of Petaluma. Drought conditions can also cause soil to compact and not absorb water efficiently, potentially making areas more susceptible to flooding.

According to the Drought Impact Reporter the Sonoma County recorded a total of 171 impacts to drought in the survey period between 1/1/1950 and 8/15/2019 (69-year period). Of these, the majority of the impacts were associated with Water Supply and Quality; and Relief, Response, and Restrictions. These statistics are shown in Figure 4-8 (above). While the Drought Impact Reporter data reflects impacts at the county-level, the data should be used to develop an ongoing record of drought impacts that can be more specifically tied to events that occur within the City's Planning Area to better understand city-specific vulnerable sectors and impacts.

People

According to the California Department of Finance (DOF) as of 2017 the City population was around 60,210. The City supplies a majority of its water (95 percent) to residential users. The population is expected to continue to increase in the future. This projected population growth would add additional strain to the surface water supplies. There are also several initiatives in the UWMP (and water contingency plan and groundwater management policies) that emphasize water conservation, and its planned expansion of the City's recycled water system is expected to reduce the water demand for irrigation water in the summer months. Water conservation will also ensure that the existing groundwater remains operational during severe drought conditions and readily available during emergencies.

Drought can also cause public health problems related to poor water quality, and health problems can become exacerbated due to dust. Generally, drought may require conservation of water resources, which means that water use is restricted to essential uses, which may reduce watering for landscaping. The community may also exhibit a range of abilities to prepare for, respond to, and recover from drought hazards, as these conditions impact populations with health-related issues related to heat-related illness, respiratory problems, and people who work outdoors. These conditions can also impact lower-income populations, as food and water prices increase. There are sensitive and socially vulnerable populations residing near the downtown area of the Planning Area that may be the most susceptible to water restrictions, and health-related illnesses. Socially vulnerable populations may also be sensitive to increases in water rates and in turn, food prices.

Economy

Drought impacts to the local and regional economy can be difficult to quantify but can be extensive and long-lasting depending on the circumstances during and after a severe drought event. If water resources are limited, effects would be more severe for industries that rely on large amounts of water, and any prolonged drought would intensify these impacts. Sectors critical to the economy such as commerce, distribution, agriculture, tourism, related environmental resources, municipal and industrial water supply, key city assets, energy generation, and even socioeconomic aspects can be affected due to lack of or reduced quality of water resources.

While there are few water intensive agricultural uses within the City's Planning Area, the City does supply agricultural areas outside the City with recycled water and plans to expand services in the future. Long lasting droughts can be indirectly detrimental to the City's water supply but may be mitigated through the expansion of the recycled water facility.

Critical Facilities and Infrastructure

The most direct impact of drought will be on the City's water supply. Drought can also directly affect the water storage, treatment, and distribution and conveyance systems. Landscaping around city facilities may no longer be maintained during water restrictions, but the risk within the Planning Area will be largely aesthetic.

Historic, Cultural, and Natural Resources

Severe, prolonged drought can impact the natural environment. Wildlife and natural habitats including the Petaluma River can be affected, including the shrinkage of habitat, habitat fragmentation, reduced food supply for wildlife, and possibly the migration of species in the nearby hillsides that define the City of Petaluma. Prolonged drought can also cause poor soil quality, loss of wetlands, tree mortality (along the periphery of the City's Planning Area), and increased soil erosion.

Tree mortality is identified as a cascading impact that can affect (or worsen) other hazards, such as wildfire and wind conditions. For example, drought-impacted trees can become susceptible to diseases and insect infestations that further exacerbate the risk of tree mortality. One of the most prevailing impacts of drought to the natural environment is the increased risk of wildfires, as seen during the 2017-2018 wildfire seasons. Wildfires now burn larger and more intensely during dry conditions and are happening outside the typical fire season. Lastly, drought conditions can cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding.

Impacts to the City's historic and cultural building inventory may be negligible. The City's open spaces and park and public lands can suffer during droughts, though the ability of the City to use recycled water for irrigation purposes can offset this vulnerability.

Future Development

Future development and water conservation are the focus of each update to the City of Petaluma's UWMP and this planning process specifically address drought conditions and water contingencies. In 2015, the City of Petaluma provided water to more than 61,798 customers, and the UWMP describes how current and future water resources and demands within the City's service area will be managed to provide adequate and reliable water supply.

As the population grows over time the City will have to revise their reliability and supply projections from the Sonoma Water. Sonoma Water may reduce water deliveries as water levels in major reservoirs decrease. Therefore, as new development occurs in the City's Planning Area it will be important to assess the availability and reliability of multiple water sources, such as groundwater and recycled water. The City currently supplies a majority of water supply to single family residents and is expecting demand for potable and raw water to increase by 70 percent by 2040. Consistent with Senate Bill 610, any proposed developments in the City are mandated to estimate future water uses and identify water supplies that may be used to meet their uses. This water supply assessment process is intended to ensure that adequate water supplies exist to support new growth.

Risk Summary

- There have been six multi-year droughts since 1950, three of which have occurred since 2000. The most recent drought lasted from 2012 to 2017 and resulted in a declared state of emergency.
- 171 drought impact reports were made within Sonoma County between 1950 and 2019.
- As of 2015, the City of Petaluma was supplying 6,744 acre-feet of water, the majority of which is supplied to single family residential properties. The City's 2015 UWMP projects that demand for potable and raw water will increase to 9,623 acre-feet, or by 70 percent by the year 2040.
- Population is expected to increase to 73,350 by 2040, or an increase of about 13,140 people per year; this projected growth would add additional strain to the water supply, particularly during future severe drought events.
- Climate change projections indicate the region will experience more frequent and intense droughts due to drier soil conditions in the summer months, leaving less water available for groundwater recharge.
- The enforcement of water conservation policies, regular updates to the UWMP, and the expansion of the City's recycled water facility will help ensure the City of Petaluma is more resilient to drought events in the future.
- Overall, the significance of extreme drought is **Medium.**

4.3.3 Earthquakes

Hazard Description

An earthquake is caused by a sudden slip on a fault. Stresses in the earth's outer layer push the sides of the fault together. Stress builds up, and the rocks slip suddenly, releasing energy in waves that travel through the earth's crust and cause the shaking that is felt during an earthquake. The amount of energy released during an earthquake is usually expressed as a magnitude and is measured directly from the earthquake as recorded on seismographs. Another measure of earthquake severity is intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface (see discussion in the Extent section). Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

Seismic Hazards

Earthquakes can cause structural losses, injury, and possibly death, as well as damage to infrastructure such as water, power, gas, communication, and transportation networks and systems. The degree of damage depends on many interrelated factors. Among these are the magnitude, focal depth, distance from the causative fault, source mechanism, duration of shaking, high rock accelerations, type of surface deposits or bedrock, degree of consolidation of surface deposits, presence of high groundwater, topography, and the design, type, and quality of building construction.

Primary hazards associated with seismic activity include surface rupture along faults, ground shaking, and associated building failure. Secondary hazards result from the interaction of ground shaking with existing ground instabilities or facilities and include liquefaction, settlement, debris flows, landslides, tsunamis and seiches, and perhaps flooding or wildfires from broken pipelines, gas, or electrical infrastructure.

Ground Shaking

When movement occurs along a fault, the energy generated is released as waves, which cause ground shaking. Ground shaking intensity varies with the magnitude of the earthquake, the distance from the epicenter, and the type of rock or sediment through which the seismic waves move. The geological characteristics of an area can be a greater hazard than the area's distance to the earthquake epicenter.

The City of Petaluma is situated within an area of high potential seismic activity (the San Francisco Bay Region), and so the fault systems within and around the City have the potential to produce earthquakes that could impact the City of Petaluma significantly (e.g. the San Andreas Fault System which is currently active). A high-magnitude earthquake on one of these faults could cause moderate to high ground shaking in the City. Figure 4-9 below is an earthquake shaking map for the City of Petaluma that is based on the two percent probability of occurrence in 50 years, per the USGS analyses of nearby faults. The probability of occurrence map represents a worst-case shaking scenario and shows that the City of Petaluma will experience strong ground shaking, which has the potential to be damaging.

Liquefaction Susceptibility

Liquefaction can be defined as the loss of soil strength or stiffness due to a buildup of pore-water pressure during a seismic event, and is associated primarily with relatively loose, saturated fine to medium-grained unconsolidated soils. Seismic ground shaking of relatively loose, granular soils that are saturated or submerged can cause the soils to liquefy and temporarily behave as a dense fluid. If this layer is at the surface, its effect is much like that of quicksand for any structure located on it. If the liquefied layer is in the subsurface, the material above it may slide laterally depending on the confinement of the unstable mass. Liquefaction is caused by a sudden temporary increase in pore-water pressure due to seismic densification or other displacement of submerged granular soils. Liquefiable soil conditions are not uncommon in alluvial deposits in moderate to large canyons and could also be present in other areas of alluvial soils where the groundwater level is shallow (i.e. 50 feet below the surface). Bedrock units, due to their dense nature, are unlikely to present a liquefaction hazard.

According to the USGS Earthquake Hazards Program data for liquefaction susceptibility, there are several areas of liquefaction susceptibility in the City of Petaluma and its Planning Area (see Figure 4-10 below). The majority of the city is in the moderate liquefaction susceptibility zone, while parts of it in the center and close to Highway 101 (near Washington Street and Western Avenue) are within more severe liquefaction susceptibility zones. Approximately 1,851 acres fall in the high liquefaction susceptibility areas within Petaluma and 559 acres in the very high liquefaction susceptibility areas. Most of these highly susceptible categories follow the Northwestern Pacific railroad, which is similar to the Petaluma River's general location as it flows from the northwest of the City, though the center and downtown area, then out through the center-east.

Earthquakes can also lead to secondary hazards including flooding, building structure failure, debris flows, and fire (among others). The City is at risk of flooding from dam or levee failure as well as risk of broken pipelines and critical structures such as the water treatment facility on the east of the City.

Figure 4-9: Potential Ground Shaking Probability in the City of Petaluma

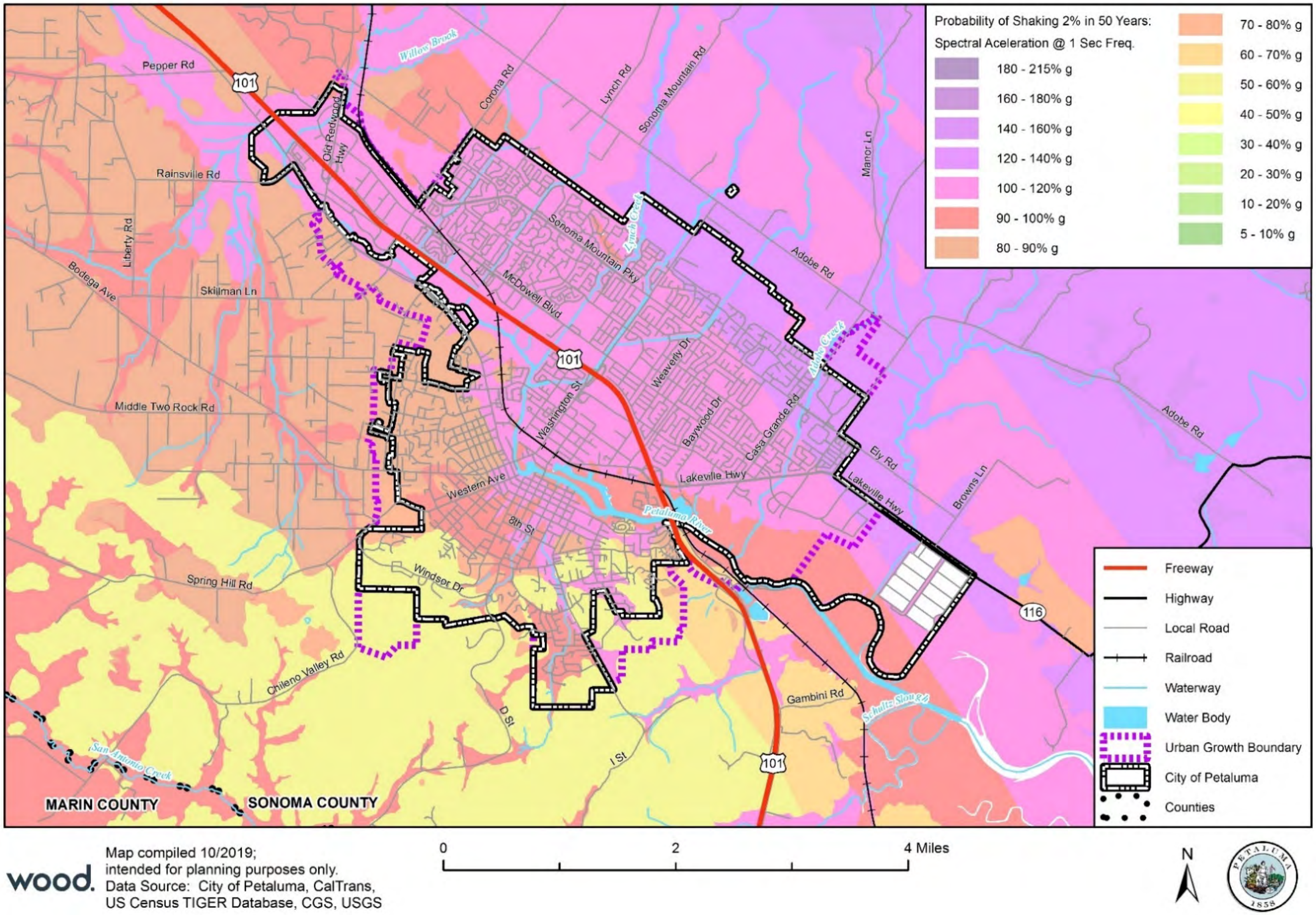
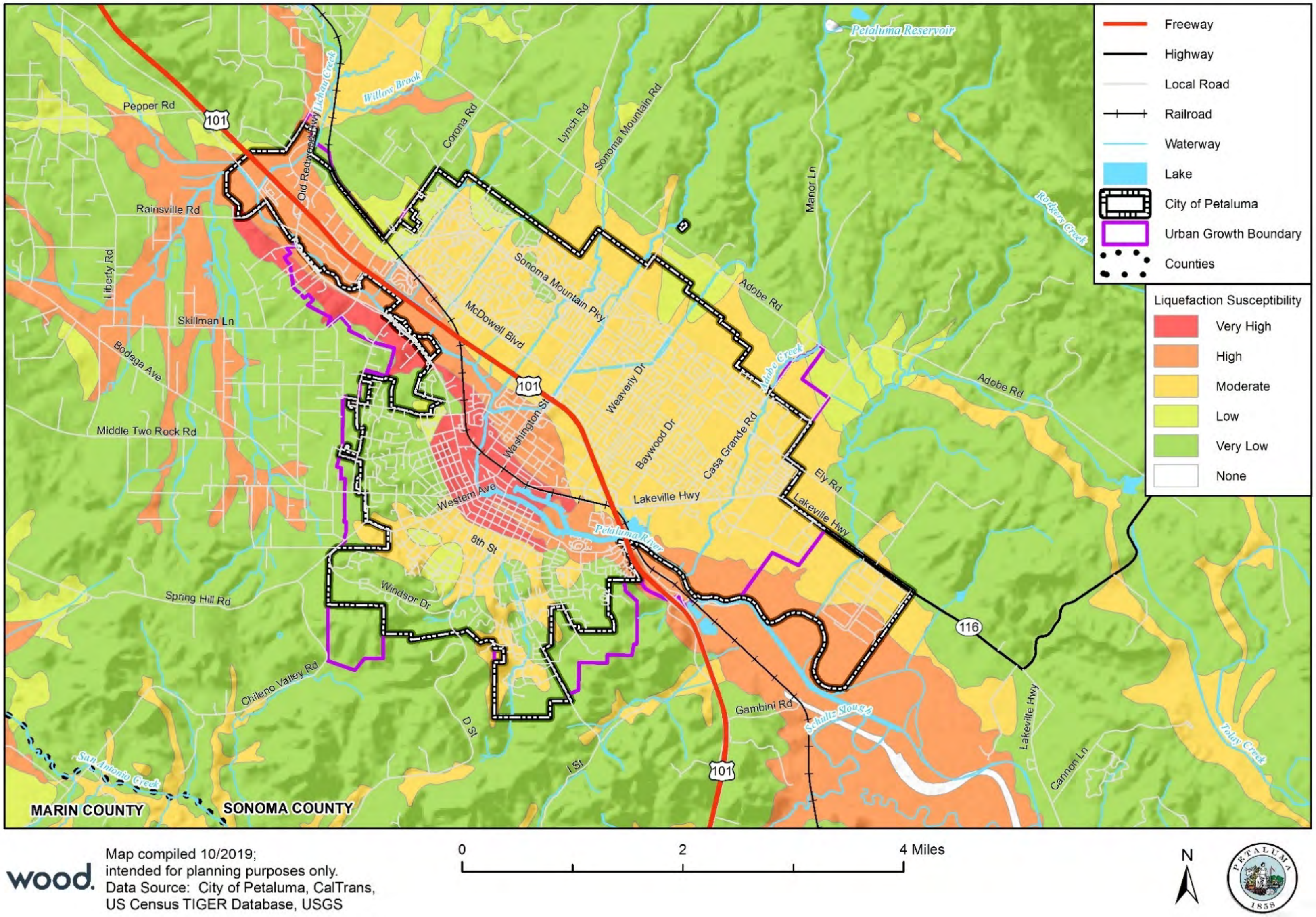


Figure 4-10: Liquefaction Susceptibility in the City of Petaluma



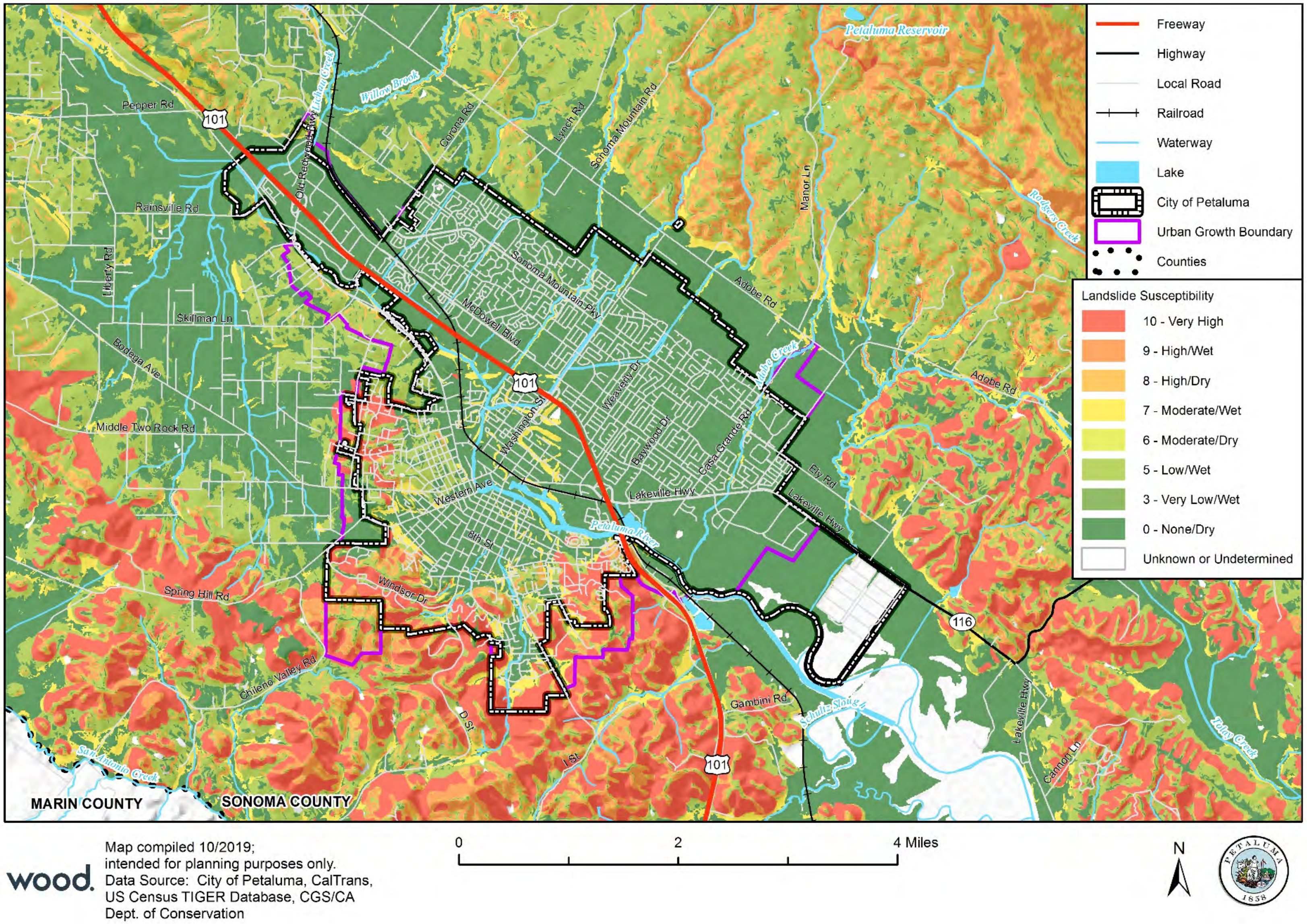
Landslide Potential and Susceptibility

A landslide is a geologic hazard where the force of gravity combines with other factors to cause earth material to move or slide down an incline. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly. Slopes with the greatest potential for sliding are between 34 degrees and 37 degrees. Although steep slopes are commonly present where landslides occur, it is not necessary for the slopes to be long.

There are predictable relationships between local geology and landslides. The down-slope movement of earth material as a landslide is part of the continuous, natural process of erosion. This process, however, can be influenced by a variety of causes that change the stability of the slope. Slope instability may result from natural processes, such as the erosion of the toe of a slope by a stream, or by ground shaking caused by an earthquake. Slopes can also be modified artificially by grading, or by the addition of water or structures to a slope. Landslide problems can be caused by land mismanagement, particularly in mountain, canyon, and coastal regions. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides and debris flows. As human populations expand over more of the land surface, these processes become an increasing concern. As such, development that occurs on a slope can substantially increase the frequency and extent of potential slope stability hazards. Knowledge of these relationships can improve planning and reduce vulnerability. Slope stability is dependent on many factors and their interrelationships, including rock type, moisture content, slope steepness, and natural or man-made undercutting.

The California Geological Survey (CGS) along with the California Department of Conservation have generated a landslide dataset that classifies susceptibility in California to various degrees, from Very High (the most potentially dangerous) to a none or dry category (the least risk). Unknown or undetermined areas exist as well, as displayed in Figure 4-11 below. In Petaluma the majority of the Planning Area is in the lower risk categories of landslide susceptibility, meaning that the local soils and geology are not very likely to lead to landslide activity. However, some higher landslide susceptibility areas fall inside the Planning Area’s boundary, such as in the west and south of the City where there is hilly terrain. During heavy rainfall events, added precipitation in soil can result in increased landslide potential and susceptibility in these higher landslide susceptible areas in the City.

Figure 4-11: Landslide Susceptibility in the City of Petaluma and Its Planning Area



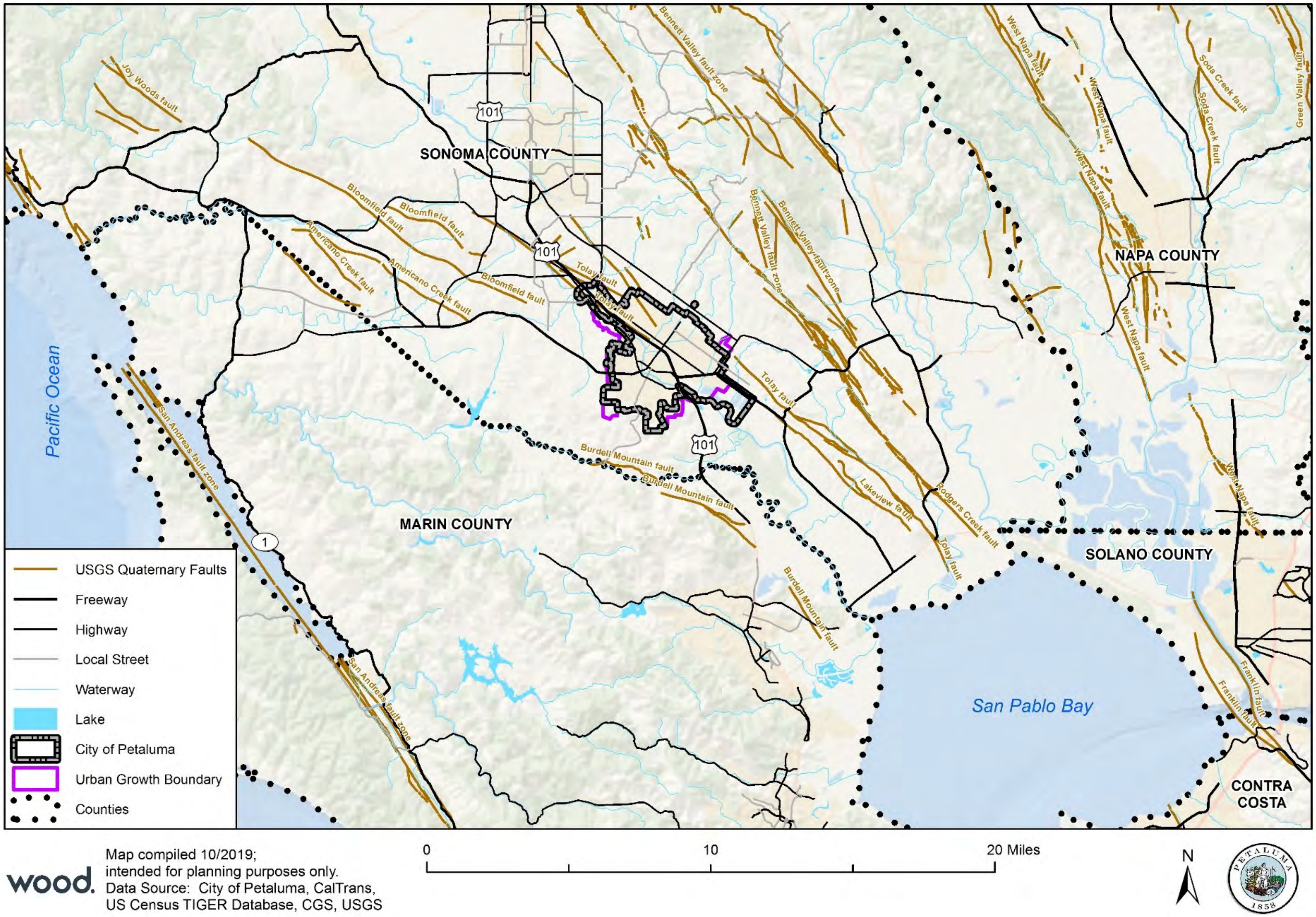
Faults

California is a seismically active area with numerous faults throughout the region. An active fault is defined by CGS as a fault that has had surface rupture or displacement within the last 11,000 years (Holocene times). This does not mean, however, that faults having no evidence of surface displacement within the last 11,000 years are necessarily inactive. Potentially active faults are those that have shown displacement within the last 1.8 million years (Quaternary period) but have not moved within the Holocene times. Any fault older than Pleistocene (>1.8 million years) is considered inactive and dormant. Although based on the history of fault movement and seismic activity in the area, it is known that the main faults posing risk to the City are the San Andreas Fault system and the Healdsburg-Rodgers Creek Fault (see the Location section of this chapter for additional details).

As shown in Figure 4-12, there are several earthquake faults classified as Quaternary (those which are recognized at the surface and which have shown activity in the past 1.6 million years, or during the geologic Quaternary epoch) in the Planning Area. Additional faults are present which are located farther from the City of Petaluma than is shown in the map (and could cause seismic activity in the future). The faults illustrated in Figure 4-12 are summarized below:

- Lakeview fault on the southeast of the City;
- Part of Tolay fault on the southeast of the City boundary, as well as reaching on the northwest portion of the City;
- Bennett Valley fault zone, to the northeast of the City but outside of its limits; and
- The Rodgers Creek fault, along Rodgers Creek to the northeast of the City but outside of the limits.

Figure 4-12: Earthquake Faults near the Planning Area



Location

There are two notable faults adjacent to the City of Petaluma, which are discussed in more detail below. Addition faults nearby the Planning Area are illustrated in Figure 4-12. There is one active fault (the San Andreas Fault) and potentially active fault (such as the Healdsburg-Rodgers Creek Fault) that fall outside the Planning Area but have historically been the source of earthquakes felt in Petaluma. These local and regional faults are described in more detail below based on information summarized in the Sonoma County Hazard Mitigation Plan from 2016 as well as the City of Petaluma General Plan.

San Andreas Fault. The San Andreas Fault is located approximately 20 miles west of the Planning Area. It is a shallow fault and is considered the most active fault in California. Historically, the San Andreas Fault system is the main fault responsible for earthquakes felt in the City and is also expected to continue being the source of future earthquake activity.

Healdsburg-Rodgers Creek Fault. The Healdsburg-Rodgers Creek Fault is an active fault associated with the Santa Rosa Plain, in Sonoma County. It is a strike slip fault, measuring around 117 kilometers in length. The most notable earthquake activity along this fault took place in 1969 during the Santa Rosa Earthquakes. These were a magnitude 5.6 and 5.7 strikes early October of that year, in Santa Rosa County to the north of the City of Petaluma.

Extent (Magnitude/Severity)

Catastrophic – Extent (meaning the severity of an earthquake) refers to the amount of energy released during an earthquake and is usually expressed in terms of intensity or magnitude. These metrics are measured directly from the earthquake as recorded on seismographs.

Intensity represents the observed effects of ground-shaking at any specified location, and earthquake shaking decreases with distance from the earthquake epicenter. Intensity is an expression of the amount of shaking at any given location on the ground surface based on felt or observed effects. Seismic shaking is typically the greatest cause of losses to structures during earthquakes. Intensity is measured with the Modified Mercalli Intensity (MMI) scale (see Table 4-11).

Magnitude represents the amount of seismic energy released at the hypocenter of an earthquake and is based on the amplitude of the earthquake waves recorded. Seismologists have developed several magnitude scales; one of the first was the Richter Scale, developed in 1932 by Dr. Charles F. Richter of the California Institute of Technology. The Moment Magnitude Scale is the current scale used to quantify the magnitude or strength of the seismic energy released by an earthquake.

Table 4-11 below compares magnitude and the felt effects associated with the MMI scale. Damage typically occurs in MMI of VII or above and based on Figure 4-9. The majority of the City is found in areas where spectral acceleration is expected to surpass the 70 percent g (or gravitational velocity); this means that there is a high probability of the City experiencing strong seismic movements in the next few decades.

Table 4-11: Magnitude and Mercalli Intensity Scale Measurements and Associated Characteristics

Magnitude	Mercalli Intensity	Effects	Frequency
Less than 2.0	I	Micro-earthquakes, not felt or rarely felt; recorded by seismographs.	Continual
2.0-2.9	I to II	Felt slightly by some people; damages to buildings.	Over 1M per year
3.0-3.9	II to IV	Often felt by people; rarely causes damage; shaking of indoor objects noticeable.	Over 100,000 per year
4.0-4.9	IV to VI	Noticeable shaking of indoor objects and rattling noises; felt by most people in the affected area; slightly felt outside; generally, no to minimal damage.	10K to 15K per year
5.0-5.9	VI to VIII	Can cause damage of varying severity to poorly constructed buildings; at most, none to slight damage to all other buildings. Felt by everyone.	1K to 1,500 per year
6.0-6.9	VII to X	Damage to a moderate number of well-built structures in populated areas; earthquake-resistant structures survive with slight to moderate damage; poorly designed structures receive moderate to severe damage; felt in wider areas; up to hundreds of miles/kilometers from the epicenter; strong to violent shaking in epicentral area.	100 to 150 per year
7.0-7.9	VIII<	Causes damage to most buildings, some to partially or completely collapse or receive severe damage; well-designed structures are likely to receive damage; felt across great distances with major damage mostly limited to 250 km from epicenter.	10 to 20 per year
8.0-8.9	VIII<	Major damage to buildings, structures likely to be destroyed; will cause moderate to heavy damage to sturdy or earthquake-resistant buildings; damaging in large areas; felt in extremely large regions.	One per year
9.0 and Greater	VIII<	At or near total destruction - severe damage or collapse to all buildings; heavy damage and shaking extends to distant locations; permanent changes in ground topography.	One per 10-50 years

Source: USGS

Previous Occurrences

In 2014 a 6.0 magnitude earthquake occurred in the southern portion of the City of Napa on the West Napa Fault. The event was the largest earthquake in the San Francisco Bay Area since the 1989 Loma Prieta earthquake. Total damage in the southern Napa and Vallejo areas ranged from $362 million to $1 billion. *Photo Credit: LA Times 2014*

Earthquakes have occurred nearby the Planning Area in the past (within Sonoma County and adjacent areas). According to the USGS, a recent earthquake event of a magnitude of 6.0 took place near South Napa, about 23 miles to the east of the City of Petaluma Planning Area. This event occurred the morning of August 24, 2014 and had a reported intensity of VII in the Mercalli scale. The earthquake was on the West Napa Fault, which was not mapped under the Alquist-Priolo earthquake fault hazard zone and was the largest event of this kind in the San Francisco Bay area since the 1989 Loma Prieta earthquake. The seismic activity of this event had an estimated 11.1 kilometers of depth. Thousands of structures across Sonoma County were damaged, and hundreds of people were injured during the quake across the affected areas in the County. One person was reported as being killed during the earthquake. Because of the extensive damages, the California Governor issued an emergency proclamation on August 24, 2014, and the U.S. President declared the incident a major disaster on September 11, 2014. Total economic losses were around $400 million, and state and federal assistance surpassed the $30 million mark. The Small Business Administration granted over $21 million in low-interest disaster loans to local businesses and other agencies affected by the event.

Other recent earthquake events in the area include smaller magnitude earthquakes such as:

- A magnitude 2.8 earthquake with reported intensity of III, on December 24, 2017. This event's epicenter was about 6 kilometers west of Temelec, near Sonoma. The depth of the event was of 1 kilometer.
- A magnitude 2.7 earthquake with reported intensity of II, on November 17, 2013. The epicenter of this incident was about 5 kilometers east-southeast of Penngrove, north of Petaluma. The depth of the event was of 4.4 kilometers.
- A magnitude 3.3 earthquake took place on July 25, 2011 and had a reported intensity of IV. Its depth was of 6.7 kilometers and the epicenter was located a few kilometers north-northwest of Petaluma.

Probability of Future Occurrences

Likely – Given the information presented herein as well as recent quake activity history, earthquake hazards are expected to be a likely occurrence in the City of Petaluma as well as in Sonoma County. It is estimated that similar seismic activity events may occur every 20 to 30 years in the Planning Area and the overall San Francisco Bay region (State of California Seismic Safety Commission).

The USGS noted in 2008 that there was a 63 percent probability of a strong earthquake (of magnitude 6.7 or greater) striking the San Francisco Bay Region (of which Petaluma is part) by 2032. The probability of having a strong earthquake (of this magnitude 6.7 or greater) generated from the Healdsburg-Rodgers Creek Fault was then estimated at about 27 percent while the San Andreas Fault had an estimated 21 percent chance of causing a strong earthquake by 2032 (USGS 2003). However, more recent information released in 2015 by the USGS new Uniform California Earthquake Rupture Forecast 3, or UCERF3, considers additional parameters and data. This new criteria and advanced technology, the updated results estimate that the actual chance of a strong earthquake of magnitude 6.7 or above is around 72 percent in the San Francisco Bay Region. The San Andreas fault now has a 33 percent chance of rupturing and causing earthquake activity, though the Rodgers Creek fault system's probability has decreased to about 15 percent chance of rupture (Uniform Earthquake Rupture Forecast Version 3 2014).

Climate Change Considerations

While climate change is not expected to directly affect earthquake frequency or intensity it could exacerbate indirect or secondary impacts of earthquakes. For example, climate change could increase the frequency and intensity of extreme precipitation events, in turn increasing the probability of landslides and liquefaction events during an earthquake if the earthquake coincided with a wet cycle. Increased precipitation due to climate change will also result in increased frequency of landslide potential, as the added weight of rain-saturated soils on steeper hill slopes and the weakening of slopes caused by the pressure groundwater exerts on porous hillsides could trigger slope failure (SHMP 2018). These impacts are more likely to occur along the southwestern edge of the City's Planning Area where there is higher landslide potential. For these reasons, climate change would have a "medium" influence on earthquake hazards, but specifically landslide susceptibility within the City.

Vulnerability Assessment

Ground shaking is the primary hazard related to earthquake activity. Many factors affect the survivability of structures and systems from earthquake-caused ground motions. These factors include proximity to the fault, direction of rupture, epicentral location and depth, magnitude, local geologic and soils conditions, types and quality of construction, building configurations and heights, and comparable factors that relate to utility, transportation, and other network systems. Ground motions become structurally damaging when average peak accelerations reach 10 to 15 percent of gravity, average peak velocities reach 8 to 12 centimeters per second, and when the MMI Scale is about VII, which is considered to be very strong (general alarm; walls crack; plaster falls).

Fault rupture itself contributes very little to damage unless the structure or system element crosses the active fault. In general, newer construction is more earthquake resistant than older construction because of improved building codes and enforcement. Manufactured housing is very susceptible to damage because rarely are the foundation systems braced for earthquake motions. Locally generated earthquake motions, even from very moderate events, tend to be more damaging to smaller buildings, especially those constructed of unreinforced masonry.

The HMPC noted that the City of Petaluma's unreinforced masonry building (URM) inventory was initiated in 1992 based on a resolution to strengthen and upgrade the City's URM buildings as required by local and state regulations (with more details available in the Petaluma Ordinance No. 1882, Section 17.34.110). The URM reinforcement resolution (No. 92-48 N.C.S. of the City of Petaluma), required the URM buildings to be retrofitted by the year 2017 (for Group IV, which was the last priority group), though the time limits varied by group types. Group I URM structures were at highest risk of failure, with Groups II, III, and IV to follow in terms of risk category so that Group IV was at lowest risk of failure. Based on the resolution, it was noted that 22 buildings in the City were categorized under Group I; 17 buildings were categorized under Group II; 27 buildings were categorized under Group III; and, 32 buildings were categorized under Group IV, for a total of 98 URM inventoried structures. Given this URM retrofit process, it is unlikely that the City of Petaluma continues to have URM structures susceptible to seismic movement events, which in turn reduces the City's overall structure exposure and risk.

Other common impacts from earthquakes include damage to infrastructure and buildings (e.g., crumbling of unreinforced masonry, failure of architectural facades, rupturing of underground utilities, and road closures). Earthquakes also frequently trigger secondary hazards, such as dam and levee failures, flooding, and fires that can become disasters themselves.

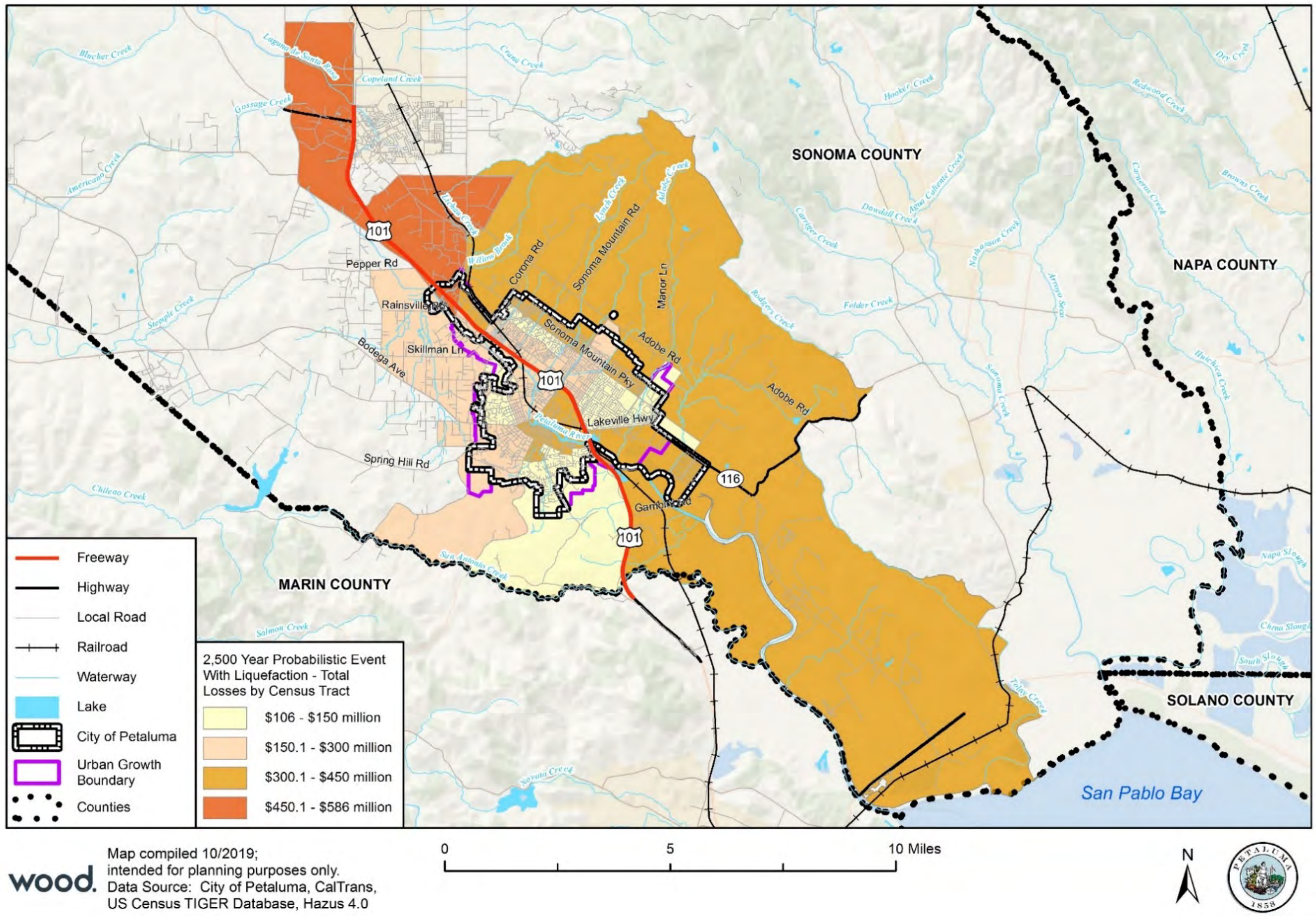
FEMA's loss estimation software, Hazus-MH (which originally stood for 'Hazards U.S.'), was used to analyze the City's vulnerability to earthquakes, at the census tract level (for 15 tract units that cover the City of Petaluma, displayed in Figure 4-13 below). Note that these census tract boundaries do not neatly line up with the City's boundary, and as such a slightly larger area than that covered in this planning context was necessary to include Petaluma. Because of these boundary differences, the damage and loss estimates may be slightly exaggerated (given the larger coverage of structures and population).

2,500-Year Probabilistic Earthquake Scenario

The 2,500-year probabilistic Hazus-based earthquake scenario results include liquefaction susceptibility. Loss estimates and vulnerability assessment discussions are based on the following subsections: property; people; the local economy; critical facilities and infrastructure; historic, cultural, natural resources; and future development in the Planning Area.

The total losses by census tract are shown in Figure 4-13. Refer to Section 4.1.1 and FEMA's Hazus 4.0 Loss Estimation Tool for more information on the Hazus tool and its analysis functions. This methodology was selected to support the vulnerability assessment, as it is a national standard for modelling earthquake loss. To evaluate potential losses associated with earthquake activity in the Planning Area, a Hazus 2,500-year probabilistic scenario including liquefaction susceptibility was run for the City's 15 census tracts, using a Magnitude of 7.0 as the parameter that would simulate a strong earthquake. Due to these inputs, this 2,500-year scenario with liquefaction susceptibility represents a worst-case level of shaking that considers multiple faults in the region. Hazus estimates the number of people displaced, the number of buildings damaged and their type (e.g. construction material, occupancy class), the number of causalities, and the damage to transportation systems and utilities (e.g. critical facilities).

Figure 4-13: Hazus 2,500 Year Probabilistic Earthquake Scenario with Liquefaction Susceptibility – Total Losses by Census Tract



A summary of the key losses based on the Hazus earthquake analysis results included the following:

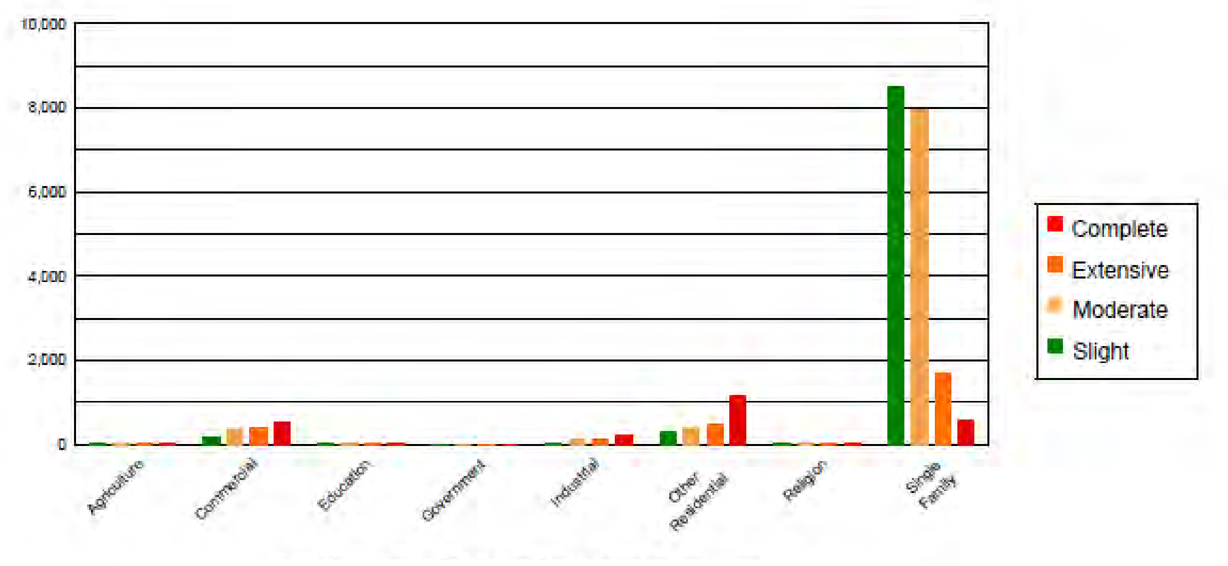
- Total economic loss estimated for the earthquake was $3.63 billion, which includes building losses and lifeline related losses based on the Hazus inventory for the Planning Area.
- Building-related losses, including direct building damages and business interruption losses, totaled $3.47 billion.
- $484.9 million in losses came from income related losses from wage-related, capital-related, rental properties, and relocation costs, while almost $3 billion came from capital stock losses related to structural, contents-based, and inventory property categories.
- 14 percent of the estimated losses were related to business interruptions.
- 14,179 buildings (53 percent of total in the region) would be at least moderately damaged; 2,545 of those buildings would be damaged beyond repair.
- Residential structures made up 47 percent of the total earthquake-induced losses.
- $78.8 million in losses are associated with transportation system economic damages and losses (e.g. highways, buses, airport facilities and related infrastructure).
- $89.4 million in losses are associated with utility and lifeline system economic damages and losses (e.g. potable water, wastewater, natural gas, oil systems, communications, and related infrastructure).
- The mid-day earthquake (2 p.m.) caused the most injuries and casualties: 2,131 injuries and 162 casualties.
- The model estimates that a total of 740,000 tons of debris will be generated. Brick and Wood structures comprise 31 percent of the total, with the rest being Reinforced Concrete and Steel materials.
- Around 25,875 households are expected to suffer from potable water or electric power losses, or both, in the first day of the earthquake event.
- Of the total 41 essential facilities considered by the Hazus earthquake scenario for the planning area (hospitals, schools, emergency operations centers, police stations, and fire stations), 7 will be at least moderately damaged.
- Before the earthquake, the region had 82 hospital beds available for use. On the day of the earthquake, the model estimates that only 23 hospital beds (28 percent) would be available for use by patients already in the hospital and those injured by the earthquake.

Property

Significant earthquakes can cause damages to buildings, private and public property, and other infrastructure. The number of properties at risk is also based on when the majority of development was constructed in the City's Planning Area and whether that development was developed after the City adopted the latest state seismic code. The California State Building Code (CBC) was modified several times since 1960, which resulted in code requirements that directly affected the structural integrity of development in California. According to the HMPC, the City of Petaluma adopted the 2016 CBC, which included the building and seismic code improvements, and most redevelopment in the City's Planning Area occurred during the past 40 years when the City enforced these new code requirements. The Hazus earthquake results also accounted for the improved seismic codes in the model.

Hazus estimates that 14,179 buildings (53 percent of the total buildings in the region) would be at least moderately damaged, while 2,545 of those buildings would be damaged beyond repair by the earthquake scenario. A majority of the buildings experiencing damage are residential structures, and wood frame construction makes up the majority of building/structure material in the planning area's inventory. Figure 4-14 summarizes the specific estimated damages to buildings based on occupancy and damage category.

Figure 4-14: Estimated Building Damage by General Occupancy Type and Damage Category



	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	8	0.24	22	0.24	32	0.36	23	0.83	30	1.17
Commercial	59	1.77	155	1.71	340	3.83	402	14.53	519	20.38
Education	5	0.16	12	0.14	18	0.20	12	0.45	12	0.49
Government	2	0.05	3	0.04	5	0.05	5	0.17	7	0.27
Industrial	14	0.43	42	0.47	111	1.25	141	5.10	197	7.72
Other Residential	116	3.49	304	3.36	398	4.49	493	17.82	1,172	46.05
Religion	5	0.16	13	0.15	21	0.24	19	0.70	25	0.99
Single Family	3,116	93.70	8,488	93.90	7,944	89.58	1,671	60.40	584	22.94
Total	3,326		9,040		8,868		2,766		2,545	

Source: Hazus 4.0

With a majority of the buildings in the Planning Area being residential, the Hazus model estimates that over 47 percent of the total losses incurred by this earthquake scenario are single family homes and other residential categories. The building inventory in the region varies in terms of construction types. A large number of buildings are also constructed of wood materials, though the building inventory includes URM buildings and manufactured housing. These types of wood, masonry, and manufactured housing structures are particularly vulnerable to ground shaking in an earthquake event. Table 4-12 describes the Hazus results of expected building damage by building type. Most buildings/structures found are expected to sustain slight to moderate damages.

Table 4-12: Expected Building Damage by Building Type (All Building Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	3,246	97.61	8850	97.90	8,283	93.40	1,742	62.97	623	24.47
Steel	8	0.23	23	0.25	91	1.03	158	5.69	212	8.33
Concrete	19	0.58	54	0.60	94	1.06	100	3.60	139	5.47
Precast	10	0.30	33	0.36	100	1.12	126	4.57	170	6.69
RM	41	1.25	68	0.75	171	1.93	214	7.73	233	9.14
URM	1	0.03	4	0.04	18	0.20	30	1.08	74	2.92
MH	1	0.02	8	0.09	111	1.25	397	14.35	1,094	42.98
Total	3,326		9,040		8,868		2,766		2,545	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Source: Hazus 4.0

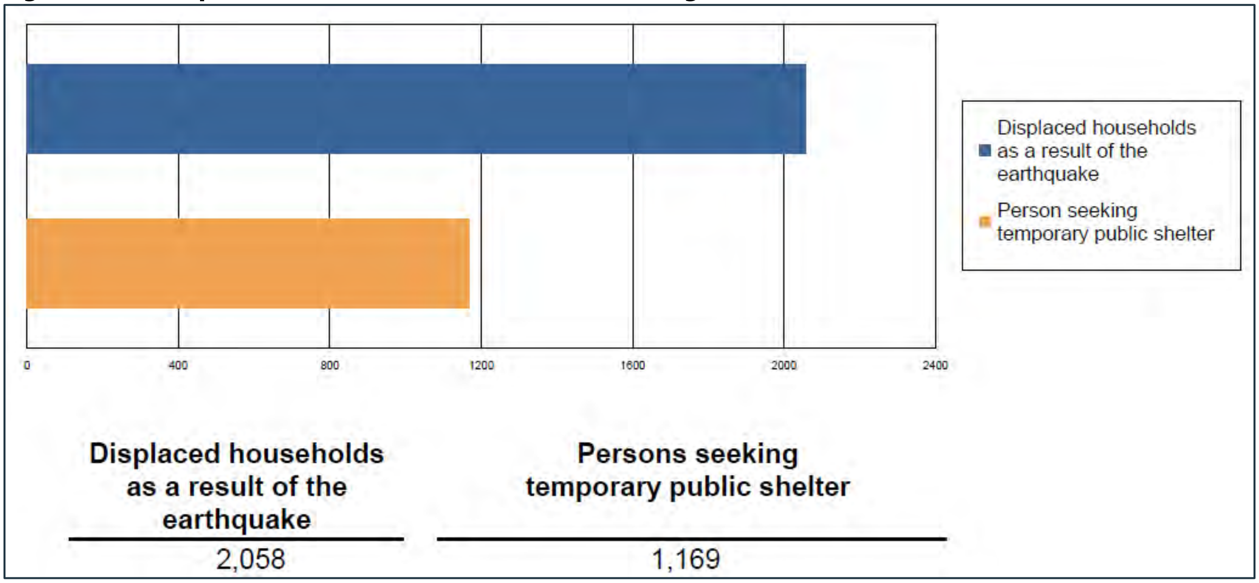
People

Hazus estimates the number of people that would be injured or killed by the 2,500-probabilistic earthquake scenario, which includes liquefaction susceptibility. The causalities are broken down into four severity levels. Level 1 means that injuries occur but do not need hospitalization (i.e. the lowest level, causing the least damages or injuries), through to Level 4, where victims are killed by the earthquake (i.e. the highest, or worst, of the levels). The estimates are also provided for three times of the day which represent the periods of a standard working day when different sectors of the community are likely at their peak occupancy loads (e.g. in business/office settings versus residing at home). As shown in Table 4-13 below, the highest number of injuries and casualties are estimated to occur in the early afternoon (2 p.m.) with the greatest impacts on the commercial and educational sectors when those sector loads are considered to be at their maximum. The 2 p.m. time has the greatest potential for fatalities, with an estimate of 162, followed by the 5 p.m. scenario which estimates 108 fatalities (more information below).

Some populations in the Planning Area may be more vulnerable to an earthquake event than others. For example, those with mobility issues as well as the elderly may have challenges with evacuating or traveling to a shelter without assistance if they cannot stay in their homes. Other vulnerable populations may be individuals whom English is not their native language. Of these socially vulnerable populations and according to the census tracts and block groups in the City, several of these populations are anticipated to reside within central Petaluma and within older housing that may have been constructed prior to the seismic code improvements.

According to 2013-2017 American Community Survey estimates, 24.3 percent of individuals in the City of Petaluma speak a language other than English in their home. These individuals may not receive or understand evacuation information including where shelters are located or where to receive resources to aid in the recovery process. These same individuals and households are designated as socially vulnerable populations, many which reside in the downtown Petaluma area. Figure 4-15 shows the Hazus report estimates for the total number of households expected to be displaced as result of the earthquake. The report estimates 2,058 households to be displaced, and of those, 1,169 individuals will be seeking temporary shelter. This does not take into account future population growth or other variables, such as populations increases due to tourism.

Figure 4-15: Displaced Households and Persons Seeking Shelter Estimates



Source: Hazus 4.0

Table 4-13 shows the Hazus estimates for total casualties and injuries.

Table 4-13: Casualty and Injury Estimates from Hazus Results

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	18	6	1	2
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	25	8	1	3
	Other-Residential	205	56	6	11
	Single Family	208	39	3	5
	Total	**456**	**108**	**11**	**20**
2 PM	Commercial	994	317	54	107
	Commuting	2	2	4	1
	Educational	297	96	17	33
	Hotels	0	0	0	0
	Industrial	184	57	9	18
	Other-Residential	39	11	1	2
	Single Family	40	7	1	1
	Total	**1,555**	**490**	**86**	**162**
5 PM	Commercial	694	220	38	74
	Commuting	32	43	72	14
	Educational	29	9	2	3
	Hotels	0	0	0	0
	Industrial	115	36	6	11
	Other-Residential	76	21	2	4
	Single Family	82	15	1	2
	Total	**1,027**	**345**	**120**	**108**

Source: Hazus 4.0

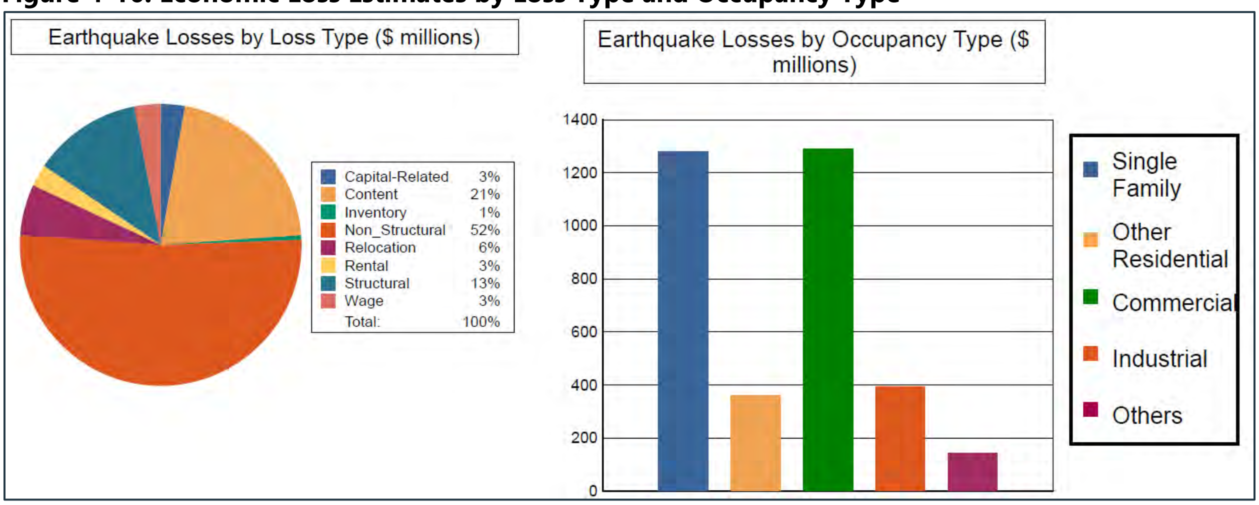
Economy

Earthquakes can have a severe impact on local and regional economies. Impacts can be both direct, such as damages to commercial and residential structures, as well as indirect such as cascading effects involving business interruptions due to employees being displaced from their homes. Another secondary or cascading impact an earthquake could have is causing damages to transportation infrastructure that is critical to employees and business activity. Based on the Hazus results, a magnitude 7.0 earthquake could potentially cause a total of $3.63 billion in economic losses. This amount includes both income losses (estimated to be $484.9 million) as well as capital stock losses ($3 billion).

Another secondary impact of an earthquake is business disruption and the resulting economic loss as a result of that disruption. Hazus describes business interruption losses as those losses associated with the inability to operate a business because of the damage sustained by the earthquake and includes the temporary living expenses for individuals displaced from their homes.

Hazus also estimates the total building-related losses. This includes business interruption losses and direct building losses (the estimated costs to repair or replace the damage caused to buildings and its contents) at $3.47 billion, 14 percent of which are related to business interruption in the region. As shown in Figure 4-16 and Table 4-14 below, the largest loss in this scenario was sustained by residential occupancies, making up 47 percent of total loss. The following figures and tables report the estimate of losses by loss type, occupancy type, and building-related loss.

Figure 4-16: Economic Loss Estimates by Loss Type and Occupancy Type



Source: Hazus 4.0

Table 4-14: Building-Related Economic Loss Estimates (Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	6.87	89.86	4.87	3.06	104.65
	Capital-Related	0.00	2.93	87.85	2.88	0.87	94.53
	Rental	27.10	16.57	43.85	1.82	1.26	90.60
	Relocation	96.75	14.22	63.65	8.40	12.12	195.14
	Subtotal	**123.85**	**40.58**	**285.21**	**17.97**	**17.31**	**484.92**
Capital Stock Losses							
	Structural	152.54	42.73	171.91	44.77	22.41	434.36
	Non_Structural	750.88	223.21	559.75	189.94	66.80	1,790.58
	Content	252.10	55.19	266.41	123.72	34.14	731.56
	Inventory	0.00	0.00	6.68	16.22	0.78	23.69
	Subtotal	**1,155.52**	**321.13**	**1,004.75**	**374.65**	**124.13**	**2,980.19**
	Total	**1,279.37**	**361.71**	**1,289.96**	**392.62**	**141.44**	**3,465.10**

Source: Hazus 4.0

In addition to economic losses experienced by building-related losses, Hazus estimates the economic losses as a result of transportation and utility lifeline losses and the direct repair cost for each component. As shown in Table 4-15 and Table 4-16 below it is estimated that $78.8 million will be lost as a result of damages to transportation components and $89.4 million are expected to be lost as result of utility system damages. The information in this table does not take into account an appraisal for the Ellis Creek Water Recycling Facility, which was recently appraised at $173 million (Walker 2020).

Table 4-15: Transportation System Economic Losses (Millions of Dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	761.20	$42.98	5.65
	Bridges	69.16	$22.13	32.01
	Tunnels	0.00	$0.00	0.00
	Subtotal	**830**	**65.10**	
Railways	Segments	50.25	$2.98	5.93
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**50**	**3.00**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0**	**0.00**	
Bus	Facilities	2.57	$1.85	72.09
	Subtotal	**3**	**1.90**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0**	**0.00**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0**	**0.00**	
Airport	Facilities	10.65	$7.75	72.80
	Runways	37.96	$1.11	2.92
	Subtotal	**49**	**8.90**	
	Total	**931.80**	**78.80**	

Source: Hazus 4.0

Table 4-16: Utility System Economic Losses (Millions of Dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	54.10	$20.56	38.01
	Subtotal	**54.08**	**$20.56**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	78.60	$49.77	63.33
	Distribution Line	32.40	$14.73	45.40
	Subtotal	**111.03**	**$64.51**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	21.60	$4.23	19.53
	Subtotal	**21.63**	**$4.23**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Communication	Facilities	0.10	$0.08	68.64
	Subtotal	**0.12**	**$0.08**	
	Total	**186.86**	**$89.37**	

Source: Hazus 4.0

Critical Facilities and Infrastructure

Large seismic events could have catastrophic effects on the City and surrounding areas, possibly damaging transportation and utility lifelines, bridges, railroads, and other critical facilities and infrastructure. Hazus estimates impacts to essential facilities including hospitals, schools, Emergency Operations Centers (EOCs), police stations, and fire stations. The Hazus analysis also takes into account four hazardous material sites, though zero nuclear power plants and zero military installations fall within the study area.

According to the earthquake analysis, there is one hospital with a total capacity of 82 beds, 32 schools, zero emergency operations facility, one police station, and seven fire stations in the study area. Hazus estimates that seven of these essential facilities are expected to suffer moderate damage. With regards to transportation systems, 65 will suffer at least moderate damage, and 5 will suffer complete damage. However, only two of the utility system facilities will suffer at least moderate damage, but zero of these types of facilities will suffer complete damage.

Table 4-17, Table 4-18, and Table 4-19 summarize the expected damages generated by the Hazus scenario for each type of transportation system and utility system, including pipelines in the area. Based on personal communication with the HMPC, the Ellis Creek Water Recycling Facility is expected to be able to resume operation within one week after an earthquake event (Walker 2020).

Table 4-17: Expected Damage to the Transportation Systems

System	Component	Number of Locations_				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	63	0	0	62	62
	Bridges	64	62	5	2	7
	Tunnels	0	0	0	0	0
Railways	Segments	16	0	0	16	16
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	2	2	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	1	1	0	0	0
	Runways	1	0	0	1	1

Source: Hazus 4.0

Table 4-18: Expected Utility System Facility Damage

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

Source: Hazus 4.0

Table 4-19: Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	2,704	3867	1282
Waste Water	1,622	2771	919
Natural Gas	1,082	795	264
Oil	0	0	0

Source: Hazus 4.0

Historic, Cultural, and Natural Resources

An earthquake in the City's Planning Area or in the surrounding region could cause cascading (secondary) effects, including dam or pipeline failure that would impact the natural environment in different ways, depending on the extent of the cascading hazard. For example, earthquake-induced landslides or debris flows could significantly damage habitat and re-route streams and waterways, causing water quality impacts. Other types of ground deformation could also result.

Future Development

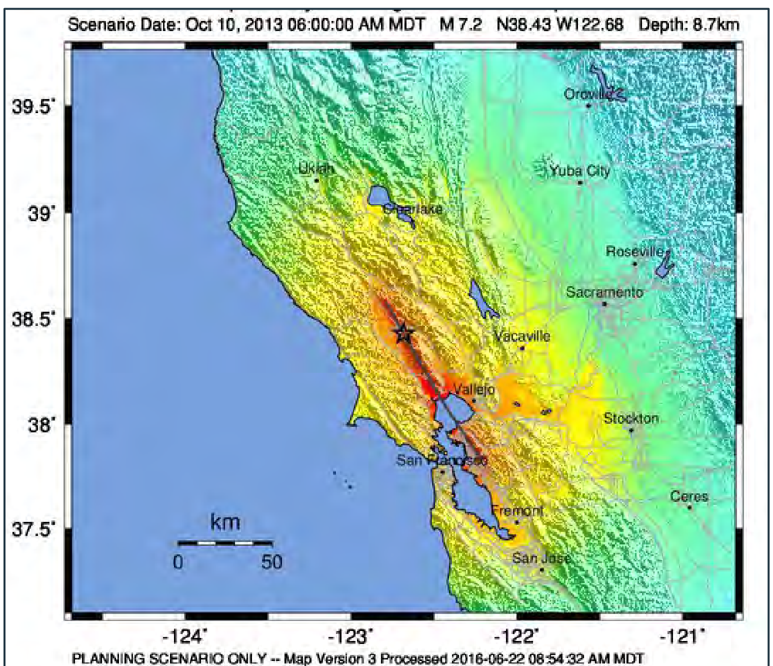
The Hazus scenario only estimates damage and causalities for existing building inventory and populations and does not take into account future development plans. The City of Petaluma has experienced growth in the past eight years (2010-2018) that is not expected to slow (Refer to Chapter 2 Community Profile for further discussion on demographics and population changes). The latest U.S. Census estimates show that 6.9 percent is the average percent change of population in the City, which went from having a little over 57,000 people in 2010 to almost 62,000 in 2018.

As more portions of the City and its vicinity are developed and infill areas in the City are redeveloped, it will be important for the City of Petaluma to meet its stated goal and objectives and ensure that risk reduction in the community is taken into account, particularly when dealing with earthquakes and other geologic hazards. The City of Petaluma General Plan of 2025 (adopted in 2008 and revised in 2012) and its Health and Safety Element establish standards and requirements for the protection from geologic and seismic hazards. Building and development will also be regulated through building standards.

Magnitude 7.2 Deterministic ShakeMap Earthquake Scenario

A second Hazus-based earthquake scenario was run for the Petaluma Planning Area using census tract units that was based on a deterministic model. A deterministic scenario relies on seismic data to predict the outcome of a specific earthquake event. This deterministic scenario used USGS provided ShakeMap datasets to model what a Magnitude 7.2 earthquake of the Hayward Rodgers Creek Faults would generate in terms of damages and losses for the chosen area of interest (i.e. the Petaluma Planning Area). These faults were selected because they are known to have caused seismic activity and pose a risk to the Petaluma and nearby communities. The M7.2 ShakeMap scenario datasets used to import into Hazus 4.0 include four USGS-provided key data layers in spatial format: peak ground velocity, peak ground acceleration, peak spectral acceleration for 0.3 seconds (0.3 % g, or gravitational velocity), and peak ground acceleration for 1.0 seconds (1.0 % g).The epicenter of this USGS modeled scenario is located at latitude 38.43 North and 122.68 West and had a depth of 8.7 kilometers. A fifth layer of liquefaction susceptibility was also included in the Hazus model, which is the same utilized in the previous 2,500-year probabilistic scenario to enhance the model with more accurate ground and soil conditions. Figure 4-17 includes the general location of the scenario's epicenter (marked with a start northeast of the San Francisco Bay area) as well as intensity information and reference to the USGS ShakeMap data.

Figure 4-17: USGS Generated ShakeMap Earthquake Scenario for the Hayward-Rodgers Creek Faults



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.1	0.5	2.4	6.7	13	24	44	83	>156
PEAK VEL.(cm/s)	<0.07	0.4	1.9	5.8	11	22	43	83	>160
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Wald, et al.; 1999

Source: USGS 2016, Weld, et al 1999

For more information on the USGS generated ShakeMap scenarios, modeling criteria, manual information, and overall catalog of available data refer to the USGS Earthquake Hazards Program ShakeMap information page.

This deterministic M7.2 scenario results included liquefaction susceptibility. Loss estimates and vulnerability assessment were completed based on the following subsections, similar to the previous scenario: property; people; the local economy; critical facilities and infrastructure; historic, cultural, natural resources; and future development of the Planning Area. The total losses by census tract from this M7.2 scenario are shown in Figure 4-18 and summarized in Table 4-20 below. Refer to Section 4.1.1 and FEMA's Hazus 4.0 Loss Estimation Tool for more information on the Hazus tool and its analysis functions. As stated in the previous section, Hazus is a loss estimation tool which derives totals on the number of people displaced, the number of buildings damaged and their type (e.g. construction material, occupancy class), the number of causalities, and the damage to transportation systems and utilities (e.g. critical facilities) given the input parameters, scenario type, and region/area of interest.

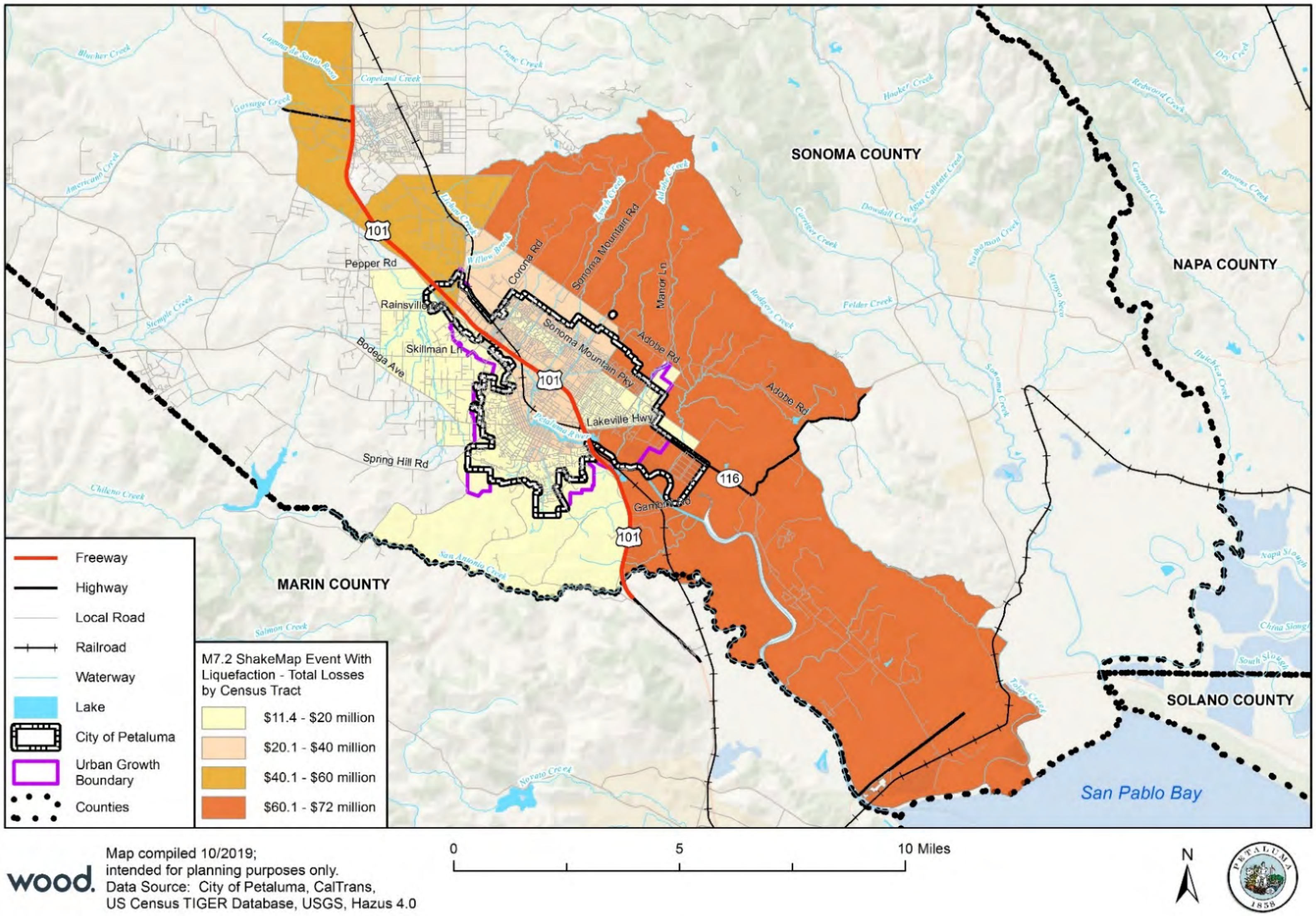
Table 4-20: Hazus 4.0 Deterministic M7.2 Earthquake Scenario Loss Estimations for Petaluma's Census Tracts

Type of Impact	Impacts to Planning Area
Total Buildings Damaged	Slight: 9,144 Moderate: 1,772 Extensive: 286 Complete: 25
Building and Income Related Losses	$ 395.2 million 54 % of damage related to residential structures 12 % of loss due to business interruption
Total Economic Losses (Includes building, income, and lifeline/critical facility losses)	$ 449.9 million
Casualties (Based on a 2 a.m. time of occurrence)	Without requiring hospitalization: 29 Requiring hospitalization: 2 Life threatening: 0 Fatalities: 0
Casualties (Based on a 2 p.m. time of occurrence)	Without requiring hospitalization: 58 Requiring hospitalization: 9 Life threatening: 2 Fatalities: 2
Casualties (Based on a 5 p.m. time of occurrence)	Without requiring hospitalization: 48 Requiring hospitalization: 17 Life threatening: 20 Fatalities: 5
Damage to Transportation Systems	0 damages to highway or bridges 0 damages to airport facilities or runways 0 damages to bus facilities 0 damages to light rail 0 damages to ferry and port facilities
Damage to Essential Facilities	0 damages to schools, police stations, fire stations, emergency operations centers, or hospitals
Damage to Utility Systems	0 of the following facilities will suffer damages: potable water; wastewater; natural gas; oil systems; electrical power; and communications. Potable water breaks: 277 Wastewater breaks: 198 Natural gas breaks: 57 Oil pipeline breaks: 0
Households without Power/Water Service (Based on 26,824 total households)	Power loss, Day 1: 1,028 Power loss, Day 3: 557

Type of Impact	Impacts to Planning Area
	Power loss, Day 7: 187 Power loss, Day 30: 30 Power loss, Day 90: 2 Water loss, Day 1: 12,510 Water loss, Day 3: 9,792 Water loss, Day 7: 3,352 Water loss, Day 30: 0 Water loss, Day 90: 0
Displaced Households	72
Persons Seeking Temporary Shelter	42
Debris Generation	60,000 tons

Source: Hazus 4.0, USGS ShakeMap M7.2 Scenario for Hayward-Rodgers Creek

Figure 4-18: Hazus M7.2 ShakeMap Deterministic Earthquake Scenario (Hayward-Rodgers Creek Faults) in Petaluma with Liquefaction Susceptibility – Total Losses by Census Tract



wood.

Property

The Hazus results for this M7.2 scenario indicate 2,082 buildings will be at least moderately damaged. This is over 8 percent of the total buildings in the region. However, approximately 25 buildings will be completely destroyed. The majority of these at least moderately damaged buildings are residential in nature, followed by commercial buildings and lastly industrial buildings. With a majority of the buildings in the Planning Area being residential, the Hazus model estimates that over 54 percent of the total losses incurred by this earthquake scenario are single family homes and other residential categories. Table 4-21 provides a detailed breakdown of these expected building damages based on the occupancy types.

Table 4-21: Expected M7.2 Earthquake Scenario Building Damages by Occupancy Type

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	56	0.37	36	0.40	17	0.98	4	1.49	1	2.34
Commercial	700	4.57	455	4.98	267	15.08	48	16.97	3	13.54
Education	34	0.22	18	0.19	7	0.40	1	0.46	0	0.33
Government	11	0.07	5	0.06	4	0.21	1	0.36	0	0.39
Industrial	209	1.36	157	1.72	112	6.30	25	8.77	2	9.39
Other Residential	688	4.49	794	8.68	817	46.11	173	60.42	11	45.82
Religion	44	0.29	25	0.28	12	0.69	3	0.90	0	0.89
Single Family	13,577	88.63	7,653	83.69	536	30.23	30	10.62	7	27.30
Total	**15,318**		**9,144**		**1,772**		**286**		**25**	

Source: Hazus 4.0, USGS ShakeMap M7.2 Scenario for Hayward-Rodgers Creek

The building inventory in the region varies in terms of construction types. A large number of buildings are also of wood materials, though the building inventory also includes unreinforced masonry buildings and manufactured housing. These types of wood, masonry, and manufactured housing structures are particularly vulnerable to ground shaking in an earthquake event. Most buildings/structures found are expected to sustain slight to moderate damages, with the wood and manufactured housing materials making up the largest percentages of the damaged building materials category.

People

Hazus estimates the number of people that would be injured or killed by the M7.2 ShakeMap earthquake scenario which includes liquefaction susceptibility. The causalities are broken down into four severity levels as described in the previous Hazus model summary (2,500-year probabilistic scenario). The estimates are provided for three times of the day which represent the periods of a standard working day when different sectors of the community are likely at their peak occupancy loads. The highest number of injuries and casualties are estimated to occur in the late afternoon (5 p.m.) with the greatest impacts on commercial sectors followed by commuting activities and residential areas as these sector loads are considered to be at their maximum in the late afternoon/early evening times. This 5 p.m. time has the greatest potential for fatalities, with an estimate of 5, followed by the 2 p.m. scenario which estimates 2 fatalities.

Some populations in the Planning Area may be more vulnerable to an earthquake event than others. Most vulnerable individuals who may not receive or understand evacuation information including where shelters are located or where to receive resources to aid in the recovery process would be at high risk of earthquakes. The Hazus report estimates 72 households to be displaced, and of those, 42 individuals will be seeking temporary shelter. It should be noted that this does not take into account future population growth or any other variables such as seasonal or weekend tourism to the region. An earthquake would have a disproportionate impact on socially vulnerable populations residing in the downtown area of Petaluma.

Economy

Earthquakes can have a severe impact on local and regional economies as previously discussed in the 2,500-year probabilistic Hazus analysis sub-section. Based on this Hazus M7.2 scenario, the modeled earthquake could potentially cause a total of $449.9 million in economic losses. This amount includes both income losses (estimated to be $46 million) as well as capital stock losses ($395.2 million).

Another secondary impact of an earthquake is business disruption and the resulting economic loss as a result of that disruption. Hazus describes business interruption losses as those losses associated with the inability to operate a business because of the damage sustained by the earthquake and includes the temporary living expenses for individuals displaced from their homes. Of the total $395.2 million in building-related losses, 12 percent are related to business interruptions in the region.

In addition to economic losses experienced by building-related losses, Hazus estimates the economic losses as a result of transportation and utility lifeline losses and the direct repair cost for each component. It is estimated that $30.7 million will be lost as a result of damages to transportation components while almost $24 million are expected to be lost as result of utility system damages from the M7.2 modeled ShakeMap scenario.

Critical Facilities and Infrastructure

Large seismic events could have catastrophic effects on the City and surrounding areas, possibly damaging transportation and utility lifelines, bridges, railroads, and other critical facilities and infrastructure. Hazus estimates impacts to essential facilities including hospitals, schools, EOCs, police stations, and fire stations. The Hazus analysis also takes into account four hazardous material sites. No nuclear power plants or military installations fall within the study area.

According to the earthquake analysis, there is one (1) hospital with a total capacity of 82 beds, thirty-two (32) schools, zero (0) emergency operations facility, one (1) police stations, and seven (7) fire stations in the study area. This M7.2 Hazus earthquake scenario estimates that none of these essential facilities are expected to suffer moderate or complete damage. With regards to transportation systems, no major roadways or other transportation infrastructure will suffer moderate or complete damage.

The only utility systems or structures that are expected to suffer site specific damages are shown in Table 4-22 and Table 4-23. These damage estimates are also summarized in the overall scenario summary table at the beginning of the section (Table 4-20).

Table 4-22: Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	2,704	671	277
Waste Water	1,622	481	198
Natural Gas	1,082	138	57
Oil	0	0	0

Source: Hazus 4.0, USGS ShakeMap M7.2 Scenario for Hayward-Rodgers Creek

Table 4-23: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	26,824	12,510	9,792	3,352	0	0
Electric Power		1,028	557	187	30	2

Source: Hazus 4.0, USGS ShakeMap M7.2 Scenario for Hayward-Rodgers Creek

Historic, Cultural, and Natural Resources

The same general impacts, potential risk, and cascading or secondary issues discussed for the 2,500-year probabilistic scenario's would apply to the Planning Area's historic, cultural, and natural resources based on this M7.2 modeled ShakeMap scenario which uses the Hayward-Rodgers Creek faults.

Future Development

The same general impacts, potential risk, and cascading or secondary issues discussed in the 2,500-year probabilistic scenario's would apply to the Planning Area's future development based on this M7.2 modeled ShakeMap scenario which focuses on the Hayward-Rodgers Creek faults as causing the seismic movements.

Risk Summary

- The overall risk significance of earthquake hazards to the City of Petaluma is **High**.
- Earthquakes and seismic activity are expected to have a probability of occasional occurrence in the future, given the local seismic conditions, past history, and input from the City.
- Two earthquake faults of concern can affect the City: the San Andreas Fault and the Healdsburg-Rodgers Creek Fault, although only the first is considered to be currently active and the fault that may lead to more damages or losses in the future.
- The majority of the Planning Area is found in moderate, high, or very high liquefaction susceptibility zones, with the downtown area being in high and very high liquefaction zones (and hence at high risk of potential seismic activity).
- Based on the first Hazus earthquake analysis, it is expected that a 2,500-year probabilistic earthquake with a magnitude of 7.0 and liquefaction susceptibility taken into account would cause $ 3.63 billion in total economic losses, and mostly affect residential buildings (since an estimated 14,179 buildings would be at least moderately damaged, with 2,545 completely destroyed).
- The Hazus scenario resulted in $78.8 million of losses to the transportation systems, while $89.4 million would be incurred in damages and losses to the utility and lifeline systems. Around 25,875 households would be affected by potable water or electric power losses from this earthquake scenario.
- The Hazus scenario also estimates that around 740,000 tons of debris would be generated, with brick and wood structures suffering the most.
- The potential for casualties during the worst-case scenario for which time of day of the earthquake might hit (the 2 p.m. scenario) would lead to 162 casualties and 2,131 injuries.
- Based on the second Hazus earthquake analysis, it is expected that a Magnitude 7.2 deterministic earthquake using the Hayward-Rodgers Creek faults and liquefaction susceptibility taken into account

would cause $ 449.9 million in total economic losses, and mostly affect residential buildings (since an estimated 2,082 buildings would be at least moderately damaged, with 25 completely destroyed).

- The Hazus scenario resulted in $ 30.7 million of losses to the transportation systems, while $24 million would be incurred in damages and losses to the utility and lifeline systems. Around 12,510 households would be affected by potable water or electric power losses from this earthquake scenario.
- The Hazus scenario estimates that around 60,000 tons of debris would be generated, with brick and wood structures suffering the most.
- The potential for casualties during the worst-case scenario for which time of day of the earthquake might hit (the 5 p.m. scenario) would lead to 5 casualties and 85 injuries.

4.3.4 Wildfire

Hazard Description

Wildfires are any uncontrolled fires that occur most often on undeveloped land and require fire suppression. They are caused by lightning or by human-activities such as smoking, arson, equipment misuse, and from electrical infrastructure. Wildfires are a significant concern throughout California. In recent years wildfires have occurred in vegetated areas in the vicinity of the City of Petaluma. Wildfires in surrounding areas, even a few counties away, can create significant impacts to the City such as those stemming from intense smoke, which can then lead to poor air quality, traffic visibility issues, and public health concerns. Generally, the fire season extends from June through October of each year during the hot, dry months. Fire conditions arise from a combination of high temperatures, intense sunlight, low rainfall, an accumulation of vegetation, and high winds.

Throughout California, communities are increasingly concerned about wildfire safety as increased development in the foothills and mountain areas and subsequent fire control practices have affected the natural cycle of the ecosystem. While wildfire risk is predominantly associated with wildland-urban interface (WUI) areas, significant wildfires can also occur in heavily populated areas. The WUI is a general term that applies to development adjacent to landscapes that support wildfire.

Location

Wildfires affect grass, forest, and brushlands, as well as any structures populations located within or surrounding them. Where there is human access to wildland areas the risk of fire increases due to a greater chance for human carelessness and historical fire management practices. In other areas, large concentrations of highly flammable brush and grasslands located in flat open spaces are also susceptible to wildfire.

The California Department of Forestry and Fire Protection's (CAL FIRE) Fire and Resource Assessment Program (FRAP) models map wildfire hazards using a science-based approach and computerized techniques to classify moderate, high, and very high fire severity zones in a Fire Hazard Severity Zone (FHSZ) dataset. The model uses existing CAL FIRE data and hazard information based on fuel, weather, and terrain, explained in more detail in the Extent (Magnitude/Severity) section below.

Figure 4-19 displays the fire hazard severity zones falling within State Responsibility Areas, or SRAs, around the City of Petaluma. Figure 4-20 shows these hazard severity zones but within Local Responsibility Areas, or LRAs, in and surrounding the City. Fire threat zones are displayed in Figure 4-21.

These three maps provide general indications of potential future fire behavior as well as where fire occurrence might take place. The south portions of the City, particularly south of the Petaluma River and near Windsor Drive show wildfire hazard areas based on fire threat data and the FHSZs mapped at both the SRA and LRA levels. Other potential areas of concern are along the edges of the City boundary, on the eastern and northern sides where moderate and high severity zones intermingle.

Figure 4-19: Fire Hazard Severity Zones in State Responsibility Areas (SRAs) Around the City of Petaluma

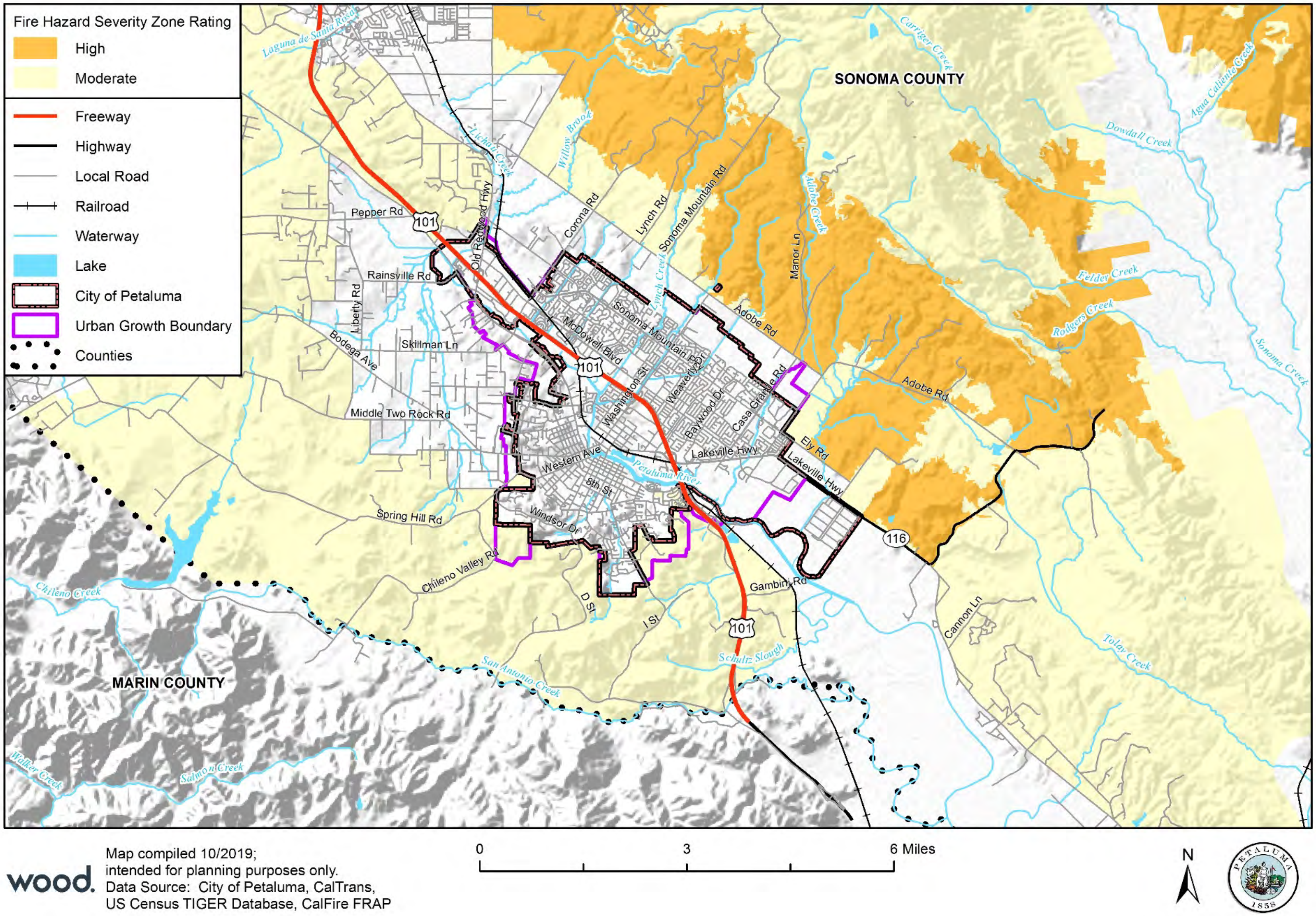


Figure 4-20: Fire Hazard Severity Zones in Local Responsibility Areas (LRAs) in Petaluma

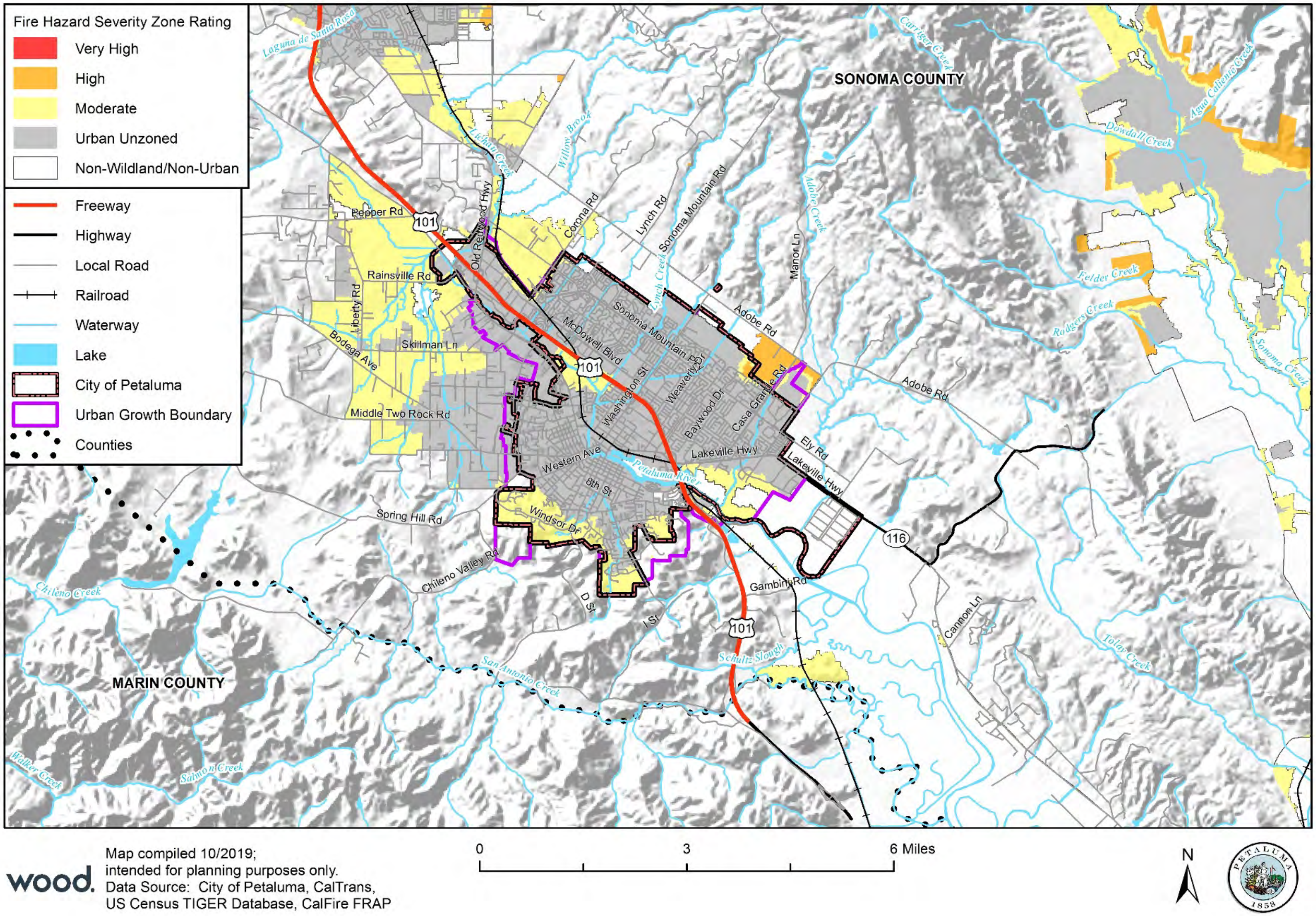
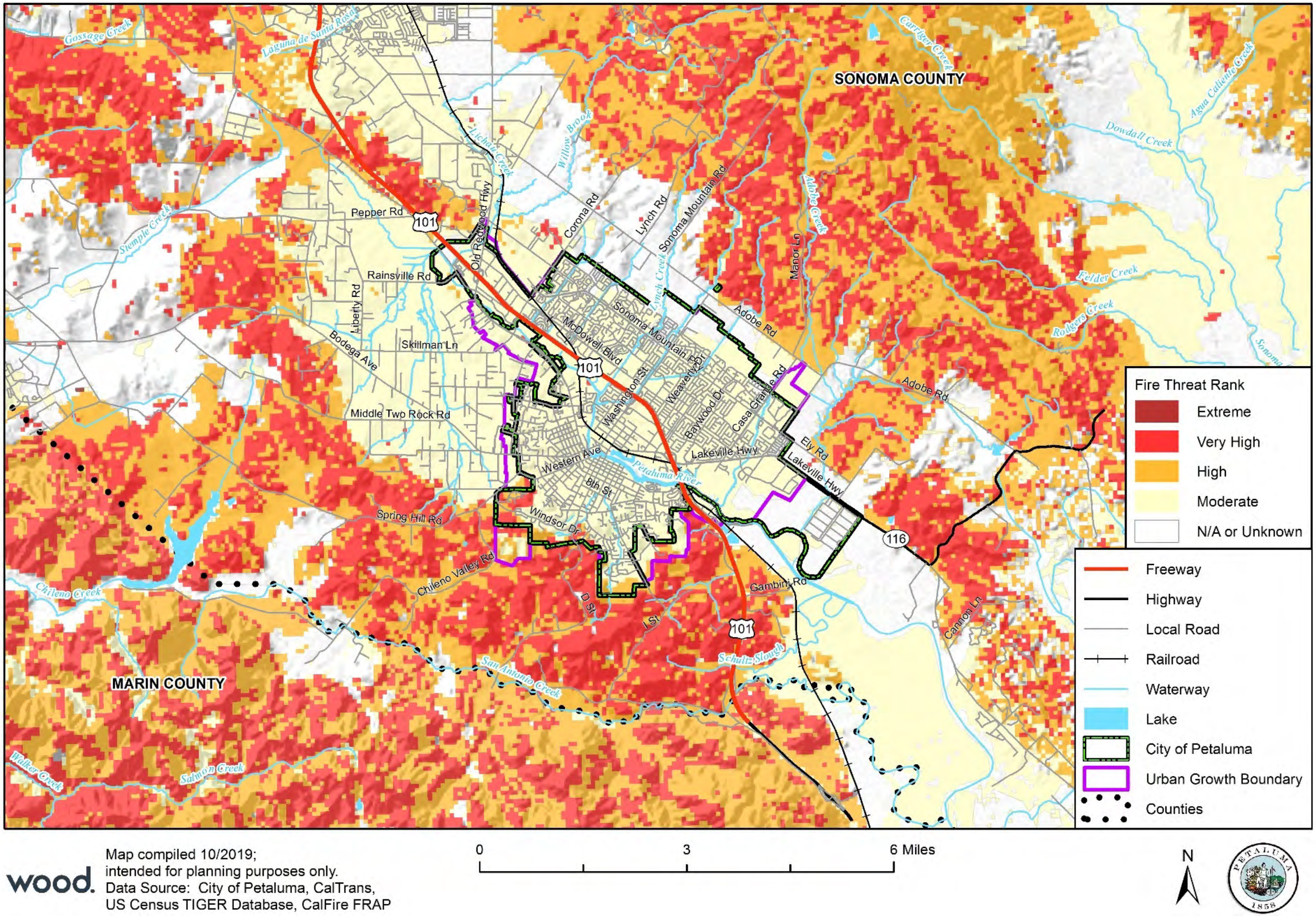


Figure 4-21: Fire Threat Zones in and Near the City of Petaluma



Extent (Magnitude/Severity)

Critical – Potential losses from wildfires include human life, structures and other improvements, natural and cultural resources, quality and quantity of water supplies, cropland, timber, recreational opportunities, and impacts to the community's way of life. Economic losses could also result from reduced tourism and visitation and generally impacted economic sectors. Smoke and air pollution from wildfires can be a severe health hazard. In addition, catastrophic wildfire can create favorable conditions for other secondary hazards such as flooding, landslides, and erosion during the rainy season. Typically, the potential for significant damage to life and property exists in areas designated as "wildland-urban interface" areas, or WUIs, where development is adjacent to densely vegetated area.

Generally, there are three major factors that sustain wildfires and predict a given area's potential to burn. These factors are fuel, topography, and weather, as described below.

- **Fuel** - Fuel is the material that feeds a fire and is a key factor in wildfire behavior. Fuel is generally classified by type and by volume. Fuel sources are diverse and include everything from dead tree leaves, twigs, and branches to dead standing trees, live trees, brush, and cured grasses. Manmade structures, such as homes and other associated combustibles are also fuel sources. The type of prevalent fuel directly influences the behavior of wildfire. Fuel is the only factor that is under human control. Fuel types within the City include seasonal grasses, and mature landscaping, such as deciduous and evergreen oaks, and conifers. Fuel types surrounding the City Planning Area include mainly seasonal grasslands and brush.
- **Topography** - An area's terrain and land slopes affect its susceptibility to wildfire spread. Both fire intensity and rate of spread increase as slope increases due to the tendency of heat from a fire to rise via convection. The arrangement of vegetation throughout a hillside can also contribute to increased fire activity on slopes.
- **Weather** - Weather components such as temperature, relative humidity, wind, and lightning also affect the potential for wildfire. High temperatures and low relative humidity dry out fuels that feed wildfires, creating a situation where fuel will more readily ignite and burn more intensely. Thus, during periods of drought, the threat of wildfire increases. Wind is the most treacherous weather factor. The greater a wind, the faster a fire will spread and the more intense it will be. Lightning can also ignite wildfires, often in difficult to reach areas for firefighters.

However, fires in the broader region (Sonoma County and bordering counties such as Mendocino or Napa) in recent years have resulted in the loss of property as well as human injuries or even deaths. The smoke and air pollution from wildfires are also severe health hazards particularly for sensitive populations including the elderly, children, and people with respiratory and cardiovascular diseases. Wildfires can also threaten the health and safety of those fighting the fires, so the overall magnitude or severity of fires can be wide-reaching and incur many types of impacts. Overall, wildfire severity can usually be quantified in terms of acres burned during an event, number and cost of properties/structures damaged (including critical facilities), money lost from disruption of services, and population affected by the fires (e.g. people displaced, injured or killed).

Previous Occurrences

Wildfires are a significant concern throughout California. According to CAL FIRE under the CAL FIRE system, vegetation fires occur across California on a regular basis; most can be controlled and contained early with limited damage. The foothills and mountain areas of California have experienced numerous devastating fires over the last 100 years, with the fire risk significantly increasing in recent years due to high fuel loads and expansion of development into the WUI areas. For those ignitions that are not readily contained and become wildfires, damage can be extensive. There are many causes of wildfire, from naturally caused lightning fires to human-caused fires linked to activities such as smoking, campfires, debris burning, equipment use, and arson. Recent studies conclude that the greater the population density in an area, the greater the chance of an ignition from human sources, as well as powerlines or other electrical or utility infrastructure.

Although not fully representative of annual fire activity, data from CAL FIRE supplemented with the Wildland Fire Occurrence databases from USGS (e.g. the Geospatial Multi-Agency Coordination, or GeoMAC) reported 26 fires affecting the vicinity of the City from 1941 to 2019. Table 4-24 below summarizes these fires that occurred around Petaluma, while Figure 4-22 displays the fires that have occurred close to the City. The fires have been organized in chronological order, with the oldest fire taking place in 1941 and the most recent of record in October 2019. In terms of larges fires, the Nuns Fire occurred in 2017 and burned 55,798 acres. The 37 Fire, which also took place in 201 burned 1,657 acres. Most recently, the Kincade Fire (not mapped) in Sonoma County north of Geyserville burned 77,758 acres.

The NOAA National Centers for Environmental Information (NCEI) database was also queried for past wildfire events in or near Petaluma. This NCEI query yielded a record of a “Dense Smoke” event related to the 2018 Camp Fire, dated November 9, 2018. This record specifically calls out Petaluma. As such, even events that take place elsewhere can affect the planning area as noted herein.

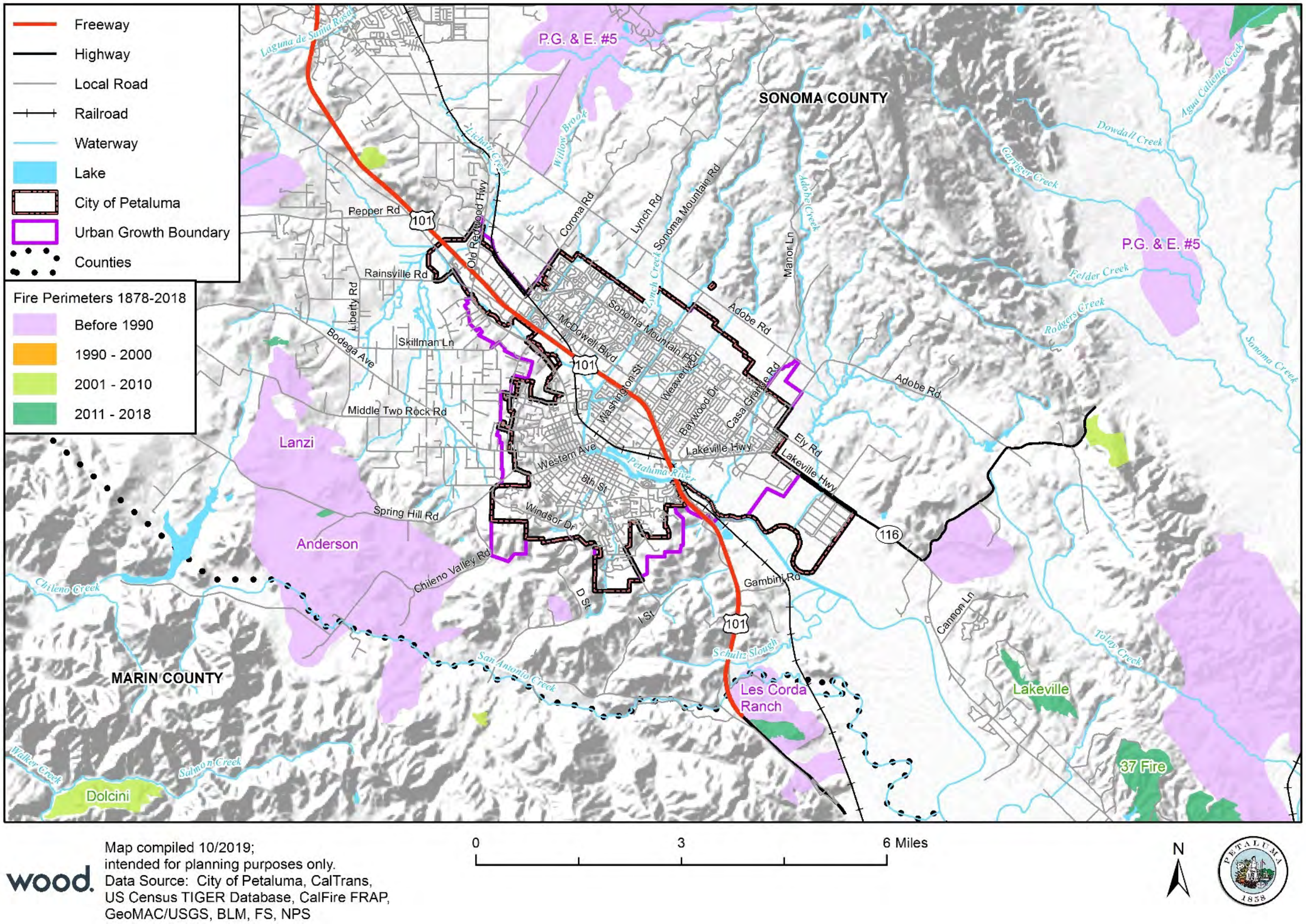
Table 4-24: Summary of Fire History Near the City of Petaluma

Fire Name	Year	Cause of Fire	Acres Burned	Details/Agency in Charge
Unknown	1941	Unknown / Unidentified	278	Contract County
--	1945	Unknown / Unidentified	602	California Department of Forestry and Fire Protection
--	1945	Unknown / Unidentified	526	California Department of Forestry and Fire Protection
--	1945	Unknown / Unidentified	500	California Department of Forestry and Fire Protection
P.G.&E. #5	1961	Unknown / Unidentified	825	California Department of Forestry and Fire Protection
Lanzi	1963	Unknown / Unidentified	377	California Department of Forestry and Fire Protection
Nuns Canyon	1964	Unknown / Unidentified	9,808	California Department of Forestry and Fire Protection
Anderson	1965	Unknown / Unidentified	4,954	California Department of Forestry and Fire Protection
P.G.& E.#5	1965	Unknown / Unidentified	3,250	California Department of Forestry and Fire Protection
Les Corda Ranch	1966	Unknown / Unidentified	588	Contract County

Fire Name	Year	Cause of Fire	Acres Burned	Details/Agency in Charge
--	1968	Unknown / Unidentified	4,554	California Department of Forestry and Fire Protection
D Street	1968	Unknown / Unidentified	63	Contract County
Olympali	1981	Unknown / Unidentified	212	Contract County
Les	1983	Unknown / Unidentified	57	Contract County
Dump	2001	Arson	144	California Department of Forestry and Fire Protection
Redhill	2001	Unknown / Unidentified	19	Contract County
Dolcini	2004	Unknown / Unidentified	365	California Department of Forestry and Fire Protection
Grade 2	2007	Unknown / Unidentified	60	California Department of Forestry and Fire Protection
Antonio	2012	Vehicle	95	Contract County
Lakeville	2013	Equipment Use	178	California Department of Forestry and Fire Protection
Nuns	2017	Unknown / Unidentified	55,798	California Department of Forestry and Fire Protection
37 Fire	2017	Unknown / Unidentified	1,657	California Department of Forestry and Fire Protection
Bodega	2017	Unknown / Unidentified	18	California Department of Forestry and Fire Protection
Spring	2017	Unknown / Unidentified	12	California Department of Forestry and Fire Protection
Unknown	--	Unknown / Unidentified	2,927	Contract County
Unknown	--	Unknown / Unidentified	303	Contract County
Kincade	2019	Unknown/Unidentified	77,758	California Department of Forestry and Fire Protection

Source, CalFire 2018, USGS/BLM/BIA/FS/NPS (from Federal Wildland Fire Occurrence database, 2019)

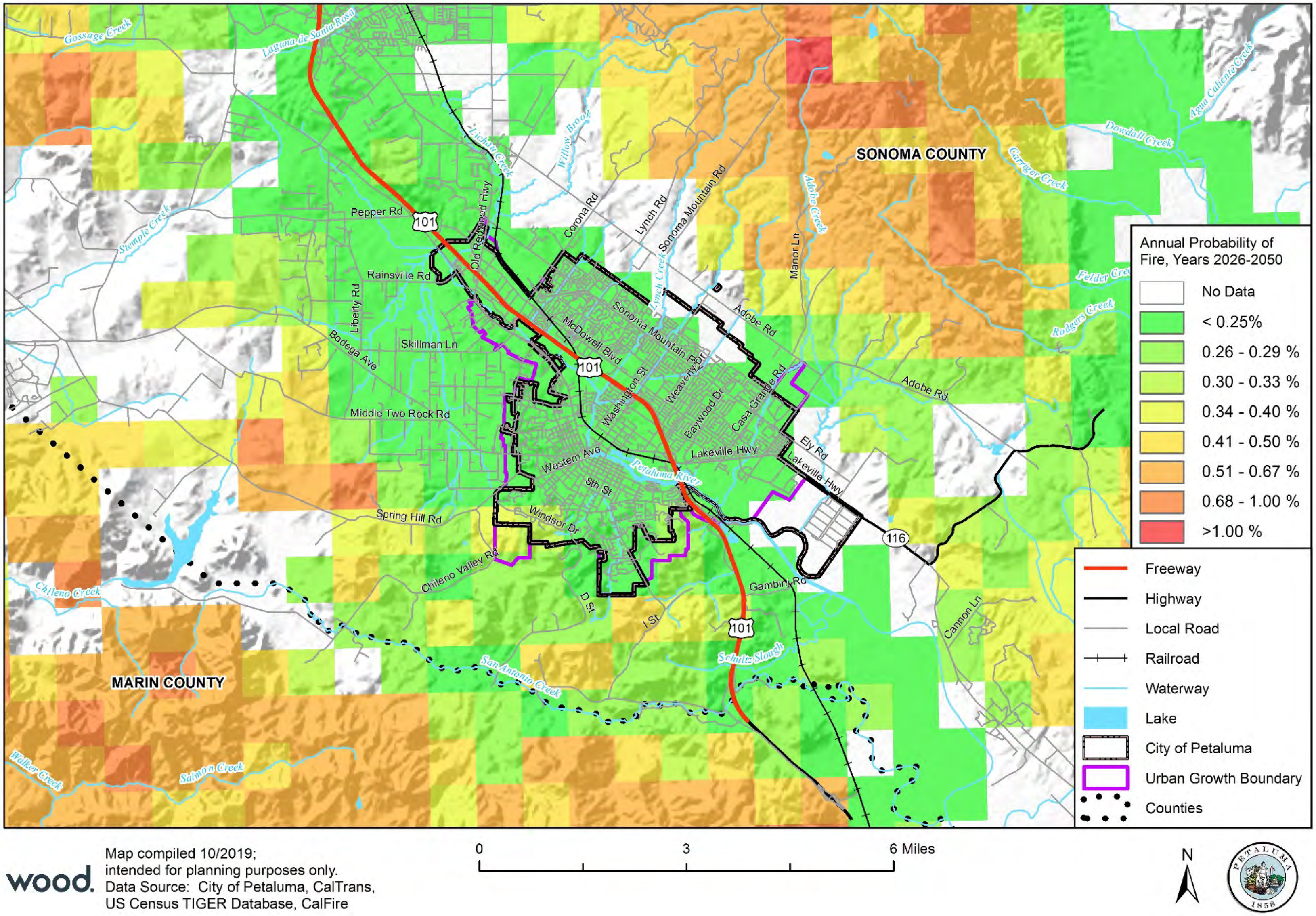
Figure 4-22: Fire History and Burn Perimeters near the City of Petaluma, 1878 to 2018



Probability of Future Occurrences

Occasional – Considering the local fuels, weather conditions, and the flat topography in the area combined with a lack of extensive WUI development means that fires may only occur occasionally in or immediately surrounding the City. A widely damaging wildland fire within the City is considered to be more unlikely, although changing issues and increasing record-high temperatures accompanied by low humidity, strong winds, and drought conditions could worsen the likelihood of fires in the Planning Area in the future. Based on the CAL FIRE Probability and Carbon Accounting mapping, which is based on Mann et al.'s projections for the years 2026-2050 (shown on Figure 4-23 below), the annual probability of fire occurrence is rather low for the most the City (CAL FIRE 2019). The south-southwest corner has a slightly higher probability, though based on the range of values shown in the figure even those 0.4-0.5 percent probabilities remain low compared to areas north and south of the City, within unincorporated portions of Sonoma and Marin Counties. However, due to the effects of climate change and because the probability of future occurrences outside the City's Planning Area ranges from likely to high likely, the City recognizes the probability of future occurrences of wildfires in the City's Planning Area would increase when taking into consideration climate change and wildfire risk in the region. Recent wildfires in various parts of Sonoma County and in the region have had significant impacts on the City, and in some instances required City residents to evacuate. These recent wildfires also caused many residents to temporarily evacuate due to poor air quality and smoke. For more information on this CAL FIRE probability mapping methodology and related resources, visit https://frap.fire.ca.gov/frap-projects/fire-probability-and-carbon-accounting/

Figure 4-23: Annual Fire Probability in the City of Petaluma for the Years 2026-2050



Climate Change Considerations

Increases in greenhouse gases coupled with population growth and development are expected to continue impacting California's forests and natural resources. Likewise, the effects of climate change will impact wildfire behavior, the frequency of ignitions, fire management, and fuel loads. Increasing temperatures will intensify wildfire threat and susceptibility to more frequent wildfires in the grasslands that surround the Planning Area, in addition to wildlands throughout Sonoma County.

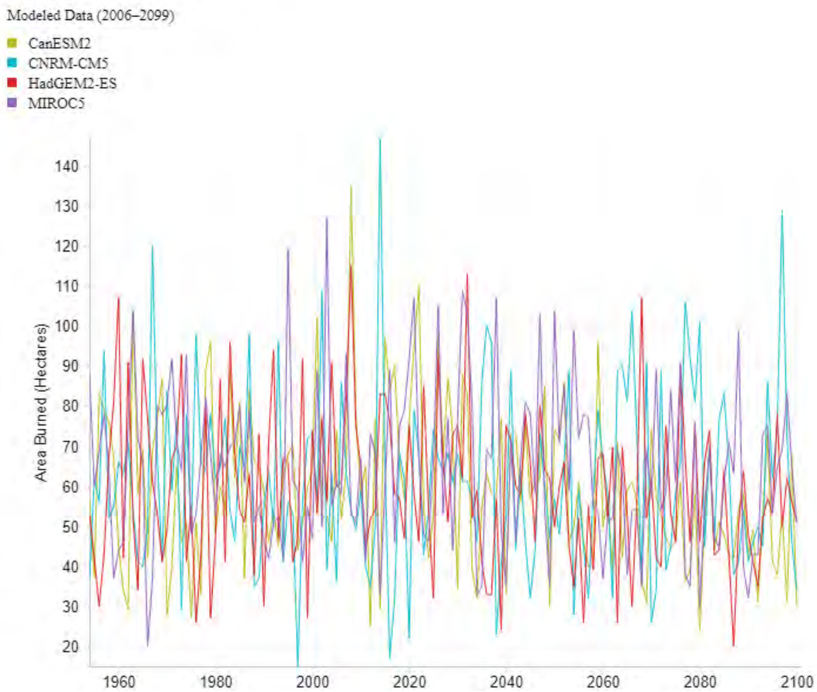
Uncertainty exists in how climate change will affect total precipitation, but models suggest that there is a tendency for wetter conditions in the northern part of the state and drier conditions in the south (California Natural Resources Agency 2018). Forests are also sensitive to variable precipitation events, and damaging droughts such as the multi-year event from 2012-2017 contributed to widespread tree mortality as warmer temperatures stressed trees and made them more susceptible to pests and pathogens (California Natural Resources Agency 2018). While the surrounding hillsides near the City's Planning Area consist of mostly grasslands, there are emerging studies that indicate that hot and dry winds can influence shrubland and grassland fires. Studies noted in California's Fourth Assessment report indicate climate change impacts on wind patterns may strongly affect forests, potentially serving as a trigger mechanism for conversion of forest to other types of vegetation (California Natural Resources Agency 2018).

Cal-Adapt conducted wildfire risk projections based on statistical modeling from historical data of climate, vegetation, population density, and fire history. The wildfire risk simulations were used in California's Fourth Climate Change Assessment and based on four models that produced a warm/dry simulation (HadGEM2-ES), cooler/wetter simulation (CNRM-CM5), average simulation (CanESM2), and a simulation that is most unlike the first three for the best coverage of different possibilities (MIROC5). These wildfire risk simulations are shown in Figure 4-24. The upper chart shows the modeled annual averages of area burned in Petaluma under the RCP 8.5 scenario, while the lower chart shows modeled annual averages of area burned for Petaluma under the RCP 4.5 scenario.

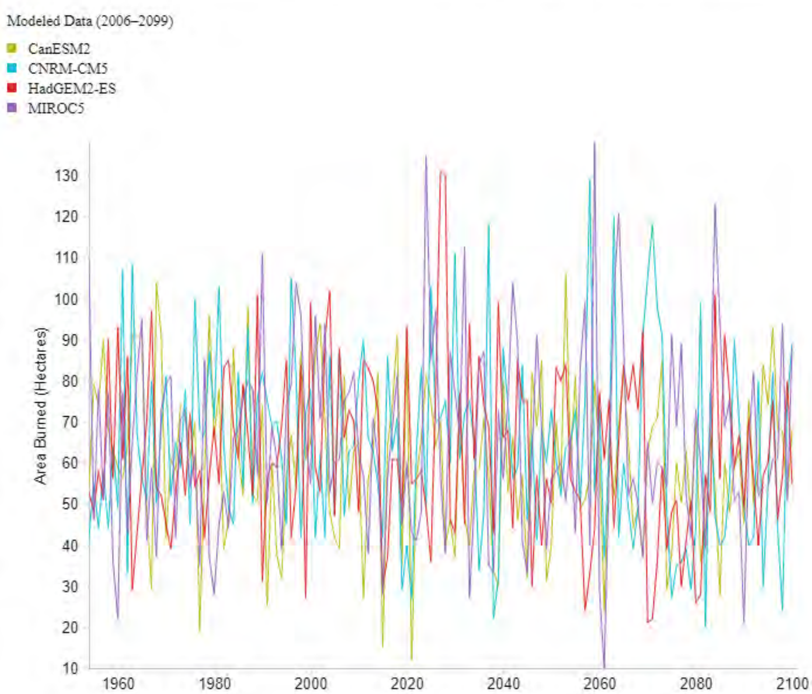
Figure 4-24: Future Annual Averages of Acres Burned in Petaluma under Low and High Emission Scenarios

Petaluma

Emissions continue to rise strongly through 2050 and plateau around 2100 (RCP 8.5). Central Population Growth Projections



Emissions peak around 2040, then decline (RCP 4.5). Central Population Growth Projections



Source: Cal-Adapt 2019

According to the Sonoma County's 2016 Regional CAP, climate change is expected to result in more frequent and intense wildfires. These risks are expected to continue to rise due to increased dryness of vegetation compounded by the productivity of plants in the spring. Based on the Regional CAP data, by the end of the century, the chances of one or more fires during a 30-year period are projected to increase from 15 to 20 percent to 25 to 33 percent in the mountainous areas of the County.

While the CAL FIRE program actively collaborates with state, local, and national agencies to reduce climate change impacts, current scientific models expect California will be affected by increased numbers of forest fires with added intensity due to longer warmer seasons, reduced distribution of biodiversity, lack of moisture, changes in ecosystems, drought impacts (e.g. pest diseases and continued spread of invasive species), and other such impacts in coming years. Due to these increasingly worsening and recurring issues, wildfire hazards should be carefully studied by the City with regards to future negative effects in or near the City Planning Area related to wildfire risk. For these reasons, climate change would have a "high" influence on wildfire hazards.

Vulnerability Assessment

The City's wildfire risk and vulnerability is a medium concern. Wildfires can affect major transportation roads, such as U.S. Highway 101 and Highway 116 by impeding commuters to get to and from their destinations (e.g. to the Bay Area), as well as potentially block emergency responders. As previously mentioned, wildfire can also damage or destroy property and infrastructure, injure people or even cause death. During the May to October fire season, the dry vegetation and hot sometimes windy weather, combined with a growing population, results in an increase in the number of potential ignitions. Any fire, once ignited, has the potential to quickly become a large, out-of-control fire. Fires that prevent essential goods or services from entering or leaving the City could negatively affect local residents and businesses by impacting the local economy and the community's livelihood (e.g. limited access to jobs, daycare, schools, resources, and residences).

The CAL FIRE-produced FHSZs within LRAs displayed in Figure 4-24 were used to assess general wildfire risk in the Planning Area, using methodology detailed below. The results are summarized in the tables and maps that follow.

The City's parcel layer was used as the basis for the inventory of parcels, while the CAL FIRE FHSZs in LRAs, ranked by severity, was used to intersect the parcels and determine general risk based on the severity rank categorization, all in GIS. Centroids were generated for each parcel for simpler overlay analysis, so that a parcel was either "in" a fire threat layer of type "moderate severity," "high severity," or "very high severity," or "out" of any of these fire threat categories (e.g. in Urban Unzoned or Non-Wildland/Non-Urban areas). For purposes of this analysis, it was assumed that every parcel with an improved value greater than zero was developed in some way, even those stated as "vacant." This specification ensures parcels such as rights-of-way are discarded for the purposes of determining vulnerability to fire, and to be able to aggregate valuations based on each parcel type (e.g. residential, commercial, agricultural). The assessor's office data calculates improved values based on the "annual structure value" which relates to the improvements of the parcel; this was the field used to determine improved values for each parcel.

Once parcels in the form of centroids are categorized by property type, next the content values were calculated as follows: a) residential and multi-family properties received contents valued at 50 percent of the parcel improved value; b) commercial and agricultural properties' contents were valued at 100 percent of the parcel improved value; and, c) vacant parcels (if applicable) received 0 percent content values. These valuation assignments are based on FEMA's methodology for estimating contents within their loss estimation software, Hazus-MH.

Properties falling in the FHSZs are listed in Table 4-25, along with a summary of all improved structure values, contents values, total values (which are the aggregated improved structure values plus the content values), loss estimates (equal to 100 percent of the total parcel values) and population at risk. As Figure 4-25 illustrates, the areas with parcels exposed to the FHSZs within the LRAs are found along the south, east of the Urban Growth Boundary, and near the central-west portions of the City (along Highway 101, northwest of Washington St. and south of McDowell Blvd.)

Property

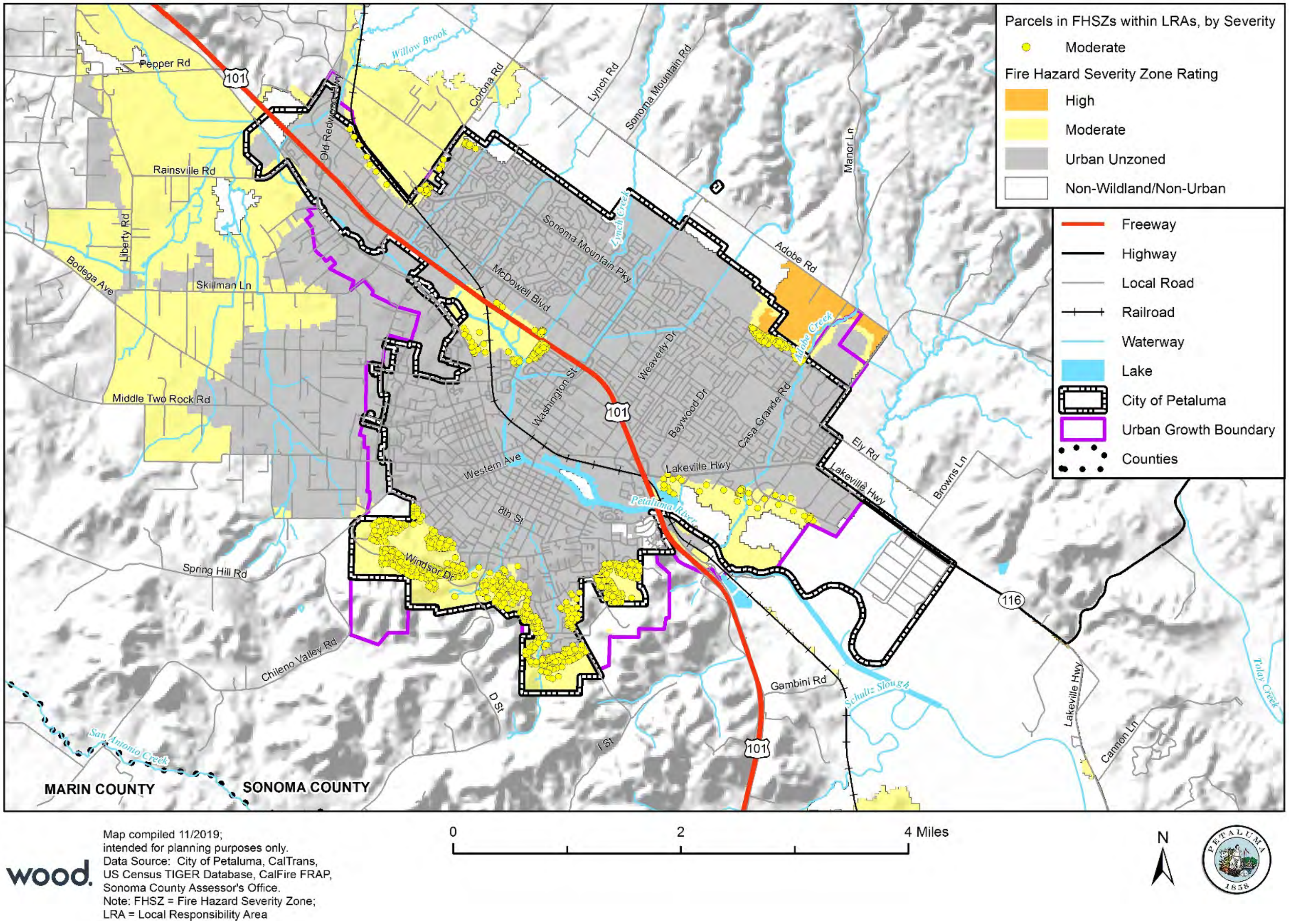
The fire severity zones and parcel overlay analysis yielded the following results below. The highest number of parcels at risk fall under the Residential category (with a total of 917 parcels), followed by the Commercial category (with 93 parcels), Multi-family (with 3 parcels), and finally Agricultural (with 2 parcels at risk). A total of $937.8 million in parcel value is at risk of being affected by potential fires, based on a $572.3 million improved structure value combined between all the parcel types, and $365.5 million in content values. The moderate fire hazard severity category contains all the parcels at risk, with 1,015. No parcels fall in the high or very high FHSZ areas. Figure 4-25 displays parcels located in the FHSZ areas.

Table 4-25: Parcels in Fire Hazard Severity Zones within Local Responsibility Areas in Petaluma

Fire Threat Ranking	Parcel Type	Total Parcels	Improved Structure Value	Contents Value	Total Value	Loss Estimate (100% of the Total Value)	Population at Risk
Moderate	Agricultural	2	$12,473	$12,473	$24,946	$24,946	--
	Commercial	93	$158,660,345	$158,660,345	$317,320,690	$317,320,690	--
	Multifamily	3	$49,818,964	$24,909,482	$74,728,446	$74,728,446	8
	Residential	917	$363,846,182	$181,923,091	$545,769,273	$545,769,273	2,458
TOTAL		**1,015**	**$572,337,964**	**$365,505,391**	**$937,843,355**	**$937,843,355**	**2,466**

Source: City of Petaluma GIS, Sonoma County Assessor's Office; CalFire; Wood Parcel Analysis; U.S. Census Bureau

Figure 4-25: Parcels in Fire Hazard Severity Zones in Local Responsibility Areas - City of Petaluma



People

Wildfire risk is of greatest concern to populations residing in the moderate, high, and very high wildfire threat zones. The 2018 U.S. Census estimates were used to show the average persons per household in the City of Petaluma, so that total persons at risk of each fire threat category could be calculated, based on property type. For each residential property type (i.e., general residential, multifamily), an average household value of 2.68 people per parcel was applied to roughly estimate potential population at risk. Table 4-25 above summarized the estimated population residing in each fire threat zone along with the parcel analysis summary by fire threat type. The results were estimated by multiplying the average persons per household in Petaluma times the number of residential parcels in each fire threat zone. Based on the analysis, the moderate FHSZ has 2,466 potential people at risk.

The Kincade Fire in northern Sonoma County started on October 23, 2019 and was not fully contained until November 6, 2019. It started near Geyserville and spread smoke toward Petaluma Valley and the surrounding Bay Area. The City opened the Petaluma Community Shelter for fire evacuees. During the same time, part of the City was without electricity due to the planned power shutoffs.
Photo Credit: San Francisco Chronicle 2019

Based on HMPC feedback, the Petaluma Fire Department has a program called Citizens Organized to be Prepared for Emergencies, or COPE, which holds quarterly seminars on preparedness. The COPE program stresses the importance of encouraging neighborhood organization through efforts such as the "Map Your Neighborhood." In future wildfire events this program could be useful in effectively engaging the local populations in avoiding damages to fires or evacuating before a fire, hence preventing injuries and losses. The City website also contains information and resources regarding these recent projects and efforts.

Economy

Wildfires can be incredibly destructive depending on the circumstances of the event, particularly the type of resources and populations they affect due to fire size, location, length of the burn, and ongoing or existing weather or hazard conditions. For example, damages to structures and properties are obvious impacts to the economy due to fire, though cascading negative effects on the economic sectors include road closures, lower revenue to the City based on reduced tourism and visitation, or excessive costs of firefighting and relocating people or natural and man-made resources (thus indirectly impacting city revenues). Transportation lifelines being closed and/or damaged could impede a majority of the population's ability to commute to nearby cities and the Bay Area. Additional direct or indirect impacts to the economy could be further exacerbated by existing hazard issues such as earthquakes, drought, or severe weather, if those make it difficult to control the fires or reestablish the economic drivers in the Planning Area.

Critical Facilities and Infrastructure

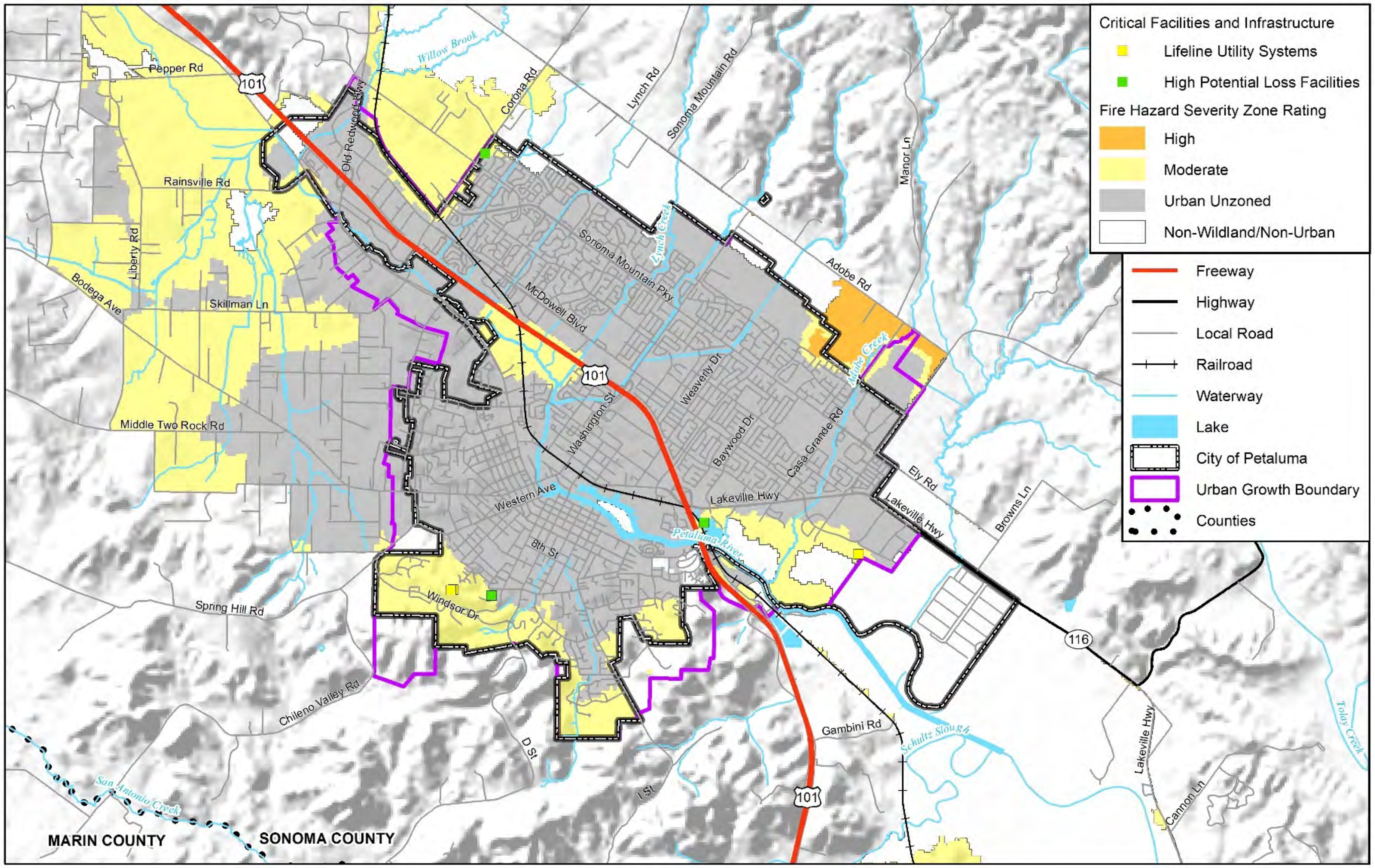
Critical facilities are those community components that are most needed to withstand the impacts of a disaster. An overlay analysis using GIS was performed to determine where critical facilities are located within FHSZs ranked moderate, high, or very high (within the LRAs as defined by CAL FIRE). Only those facilities located in these zones are noted as being at risk. Figure 4-25 shows those critical facilities located in the City that fall in the FHSZs, while Table 4-26 describes the facilities. Based on these results, a total of six critical facilities are found in zones of the type "moderate." No other fire threat zones contain critical facilities in the Planning Area. From these facilities, three are High Potential Loss Facilities, and the other three fall under the Lifeline Utility Systems category.

Table 4-26: The City of Petaluma's Critical Facilities at Risk to Wildfire based on FHSZs in LRAs

Fire Threat Zone	Critical Facility Category	Critical Facility Type	Critical Facility Total
Moderate	High Potential Loss Facilities	Community/Recreation Center	1
		Day Care Facilities	1
		Public Schools	1
	TOTAL		**3**
	Lifeline Utility Systems	Microwave Service Towers	1
		Water Facility	2
	TOTAL		**3**
	GRAND TOTAL		**6**

Source: City of Petaluma GIS; HIFLD; CalFire FRAP; Wood GIS Analysis

Figure 4-26: Critical Facilities and Infrastructure within Fire Threat Zones in the City of Petaluma



Map compiled 11/2019;
intended for planning purposes only.
Data Source: City of Petaluma, CalTrans,
US Census TIGER Database, HIFLD, CalFire
FRAP. Note: FHSZ = Fire Hazard Severity Zone;
LRA = Local Responsibility Area

According to California's Fourth Climate Assessment, wildfire may be the biggest immediate threat to California's transportation system, as vegetation fuel accumulation continues to increase (California Natural Resources Agency 2018). Wildfires can also lead to mudslides and debris flows, later resulting in the temporary transportation system closures or other key impacts to the community. Studies cited in the most recent climate assessment also found that a considerable amount of infrastructure is exposed to wildfire risk, with the highest risk being roads and highways, such as U.S. Highway 101 and Highway 116. Railroads may also be at risk of warping during wildfires, and transportation or freight activity disrupted, while smoke and fire-fighting operations can lead to temporary service disruptions that can additionally affect movement of goods and services (California Natural Resources Agency 2018).

Historic, Cultural, and Natural Resources

The City has eight cultural and historic resource places, as summarized under Section 4.2 of this plan. Since these structures are sensitive in nature and may not have been built according to the latest building codes due to their age, it is expected that they might be at risk of wildfires (e.g. because of their potential inability to withstand significant heat). However, other areas such as parks or natural spaces could also be at risk of a wildfire, but these places would need to be further studied to determine vulnerability and risk more specifically.

Future Development

Population growth and development in the City of Petaluma is increasing, as noted on the Petaluma City Profile Report released in 2018. Petaluma is expected to grow 3.2 percent by the year 2022, which results in an increase of 62,700 residents. The increasing urbanization of the Planning Area makes wildfire vulnerability a growing issue, as future development in the WUI will increase risk to this hazard citywide. WUI related risks can however be managed with strong land use regulations and building code requirements. For example, development in the WUI can be limited, or where permitted can require firebreaks between development and grasslands, as well as enforce that building construction be compliant with CBC Chapter 7A: Materials and Construction Methods for Exterior Wildfire Exposure. The City's General Plan 2025 and IZO can also be amended to address these land use regulations.

Risk Summary

- The overall risk significance of wildfire hazards to the City of Petaluma is **Medium**.
- The level of wildfire risk will likely increase in the future due to the effects of climate change, and as the City assesses and monitors the level of risk, they will adjust the emergency preparedness and hazard mitigation efforts accordingly.
- Wildfires are expected to have a probability of occasional occurrence in the future, given the local fuel, topography, and weather conditions and the extent of the WUI. Based on recent CAL FIRE future fire occurrence probability mapping, the City of Petaluma is mostly expected to have a low likelihood of fire from years 2026 to 2050.
- The areas of the City with high or very high fire threat, which in turn pose the highest risk to life and property, are located on the south- of the Planning Area, near Windsor Drive. However, all of the City's parcels falling fire hazard severity zones are in the "moderate" zone, with 1,015 parcels vulnerable to wildfire (within LRA as defined by CAL FIRE).
- Although the probability of future occurrence of wildfire risk is occasional within the City's Planning Area, the future occurrence outside the City is ranges from likely to highly likely, and must account for

areas where future occurrence of major wildfires will significantly affect the City through mandated evacuation and poor air quality, among other impacts.

- Approximately 2,466 people may be at risk of the moderate FHSZs within the LRA.
- Six critical facilities are in moderate fire threat areas within the City of Petaluma (no other facilities fall in any additional fire threat zones).
- Eight historic and cultural properties and places are exposed to wildfire risks, based on the NRHP database.
- Population growth is expected to be at 3.2 percent by 2022 in the City of Petaluma, so WUI development may become a larger issue into the future. Building to the current code with regards to materials and structures is recommended based these development trends.

4.3.5 Flood

Hazard Description

Floods are among the most frequent and costly natural disasters in terms of human hardship and economic loss. Flooding is usually the result of, or often exacerbated by, weather events. Floods can cause substantial damage to structures, landscapes, and utilities as well as life safety issues. Certain health hazards are also common to flood events; standing water and wet materials in structures can become breeding grounds for microorganisms such as bacteria, mold, and viruses. Standing water or affected infrastructure can in turn cause disease, trigger allergic reactions, and damage materials long after the flood. When floodwaters contain sewage or decaying animal carcasses, infectious disease also becomes a concern. Direct impacts such as drowning can be limited with adequate warning and public education about what to do during floods. Where flooding occurs in populated areas, warning and evacuation will be of critical importance to reduce life and safety impacts.

Floodplains are defined as the areas immediately adjacent to a channel from a river, stream, or other waterway. Floodplains are illustrated on inundation maps, which show areas of potential flooding and water depths. In its common usage and based on FEMA guidelines, the floodplain most often refers to the area that is inundated by the 100-year flood, or the flood that has a one percent chance in any given year of being equaled or exceeded. The 100-year flood is the national minimum standard to which communities regulate their floodplains through the FEMA National Flood Insurance Program (NFIP). The 500-year flood is the flood that has a 0.2 percent chance of being equaled or exceeded in any given year. A 500-year flood event would be slightly deeper and cover a greater area than a 100-year flood event. The potential for flooding can change and increase through various land use changes and changes to land surface, which then may result in a change to the floodplain. A change in environment can create localized flooding problems inside and outside of natural floodplains by altering or confining natural drainage channels. These changes are most often created by human activity.

The City of Petaluma is susceptible to various types of flood events as described below.

- **Riverine Flooding** - Riverine flooding, defined as the condition when a watercourse (e.g. river or channel) exceeds its "bank-full" capacity, generally occurs as a result of prolonged rainfall, or rainfall that is combined with already saturated soils from previous rain events. This type of flood occurs in river systems whose tributaries may drain large geographic areas and include one or more independent river basins. The onset and duration of riverine floods may vary from a few hours to many days. Factors that directly affect the amount of flood runoff include precipitation amount, intensity and distribution, the amount of soil moisture, seasonal variation in vegetation, snow depth, and water-resistance of the surface due to urbanization. In the Planning Area, flooding is largely caused by heavy and continued rains, increased outflows from upstream dams, and heavy flow from tributary streams. Local intense storms can overwhelm nearby waterways as well as the integrity of flood control structures. The warning time associated with slow rise floods assists in life and property protection.

- **Localized Flooding** - Flash flooding describes localized floods of great volume and short duration. This type of flood usually results from a heavy rainfall on a relatively small drainage area. Precipitation of this sort usually occurs in the winter and spring. Flash floods often require immediate evacuation. Related to this type of flooding is also localized flooding, which is often caused by flash flooding, severe weather, or an unusual amount of rainfall. Flooding from these intense weather events occurs in areas experiencing an increase in runoff from impervious surfaces associated with development and urbanization as well as inadequate storm drainage systems.
- **Dam or Levee Failure Flooding** – Potential inundation caused by failure or mis-operation of one or more upstream dams or water control structures such as levees is also a concern to the City of Petaluma. A catastrophic flood control or water retention structural failure could easily overwhelm local response capabilities and require evacuations towards the east of the City, which is in closest proximity to the two dams identified in this plan. Impacts to life safety will depend on the warning time and the resources available to notify and evacuate the public, as well as the magnitude of the event. Loss of life could potentially result, however, and there could be associated health concerns as well as negative effects to local buildings and infrastructure. Dam failure is addressed in more detail under Section 4.3.1 Dam Incidents, while levee failures and other aspects related to localized flood problem areas are discussed throughout this chapter.

Location

Flooding of various types may occur anywhere within the City's Planning Area. Details on local water features, watersheds, and flood control structures and systems are provided below.

City of Petaluma Watersheds and Waterways

The City of Petaluma is primarily located within the San Pablo Bay and the Petaluma River-Frontal San Pablo Bay Estuaries watersheds (under Hydrologic Unit Codes 1805000208 and 1805000206, respectively), both of which are part of the greater San Pablo Bay Watershed (Hydrologic Unit Code 18050002).

The City is located in the Petaluma Valley, a fairly flat alluvial plain with elevation ranging from sea level along the Petaluma River, to over 400 feet in the nearby hills. This valley is characterized by a Mediterranean climate with long and dry summers, followed by cool and wet winters. The mean annual precipitation over the valley is approximately 26 inches (City of Petaluma 2015).

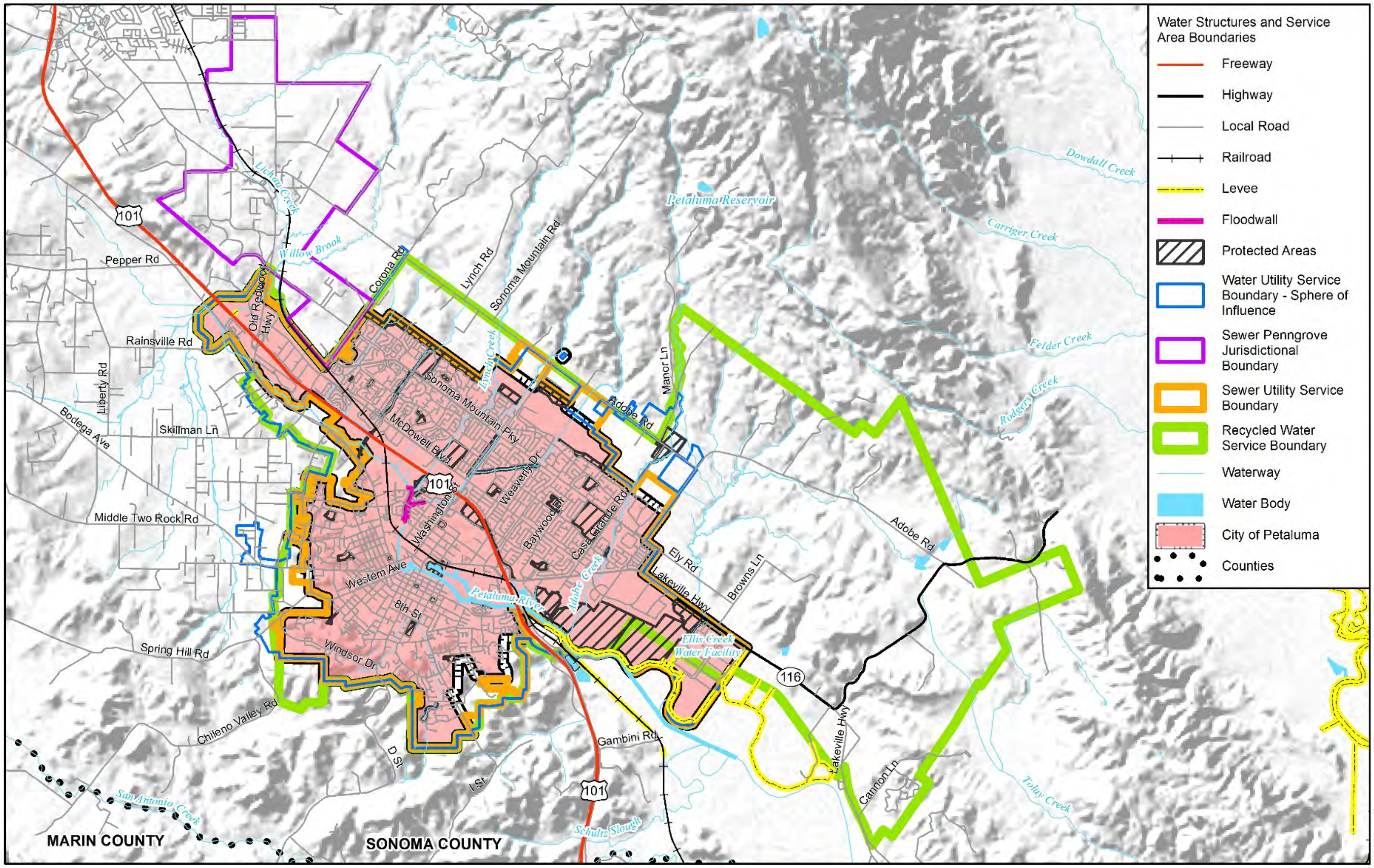
The main waterways in the City include the Petaluma River, Adobe Creek, Lynch Creek, Lichau Creek, and smaller branches or tributaries such as Willow Brook. The Petaluma River is historically important due to its key role in enabling exploration activities, settlement, and the development of the Petaluma and San Pablo Bay watersheds. Over the years, inundation and overtopping of the banks of the Petaluma River have caused siltation of the streambed, which in turn has had an effect on the water-carrying capacity and also navigability of the waterway (causing problems for many decades on the surrounding communities). The City's two watersheds are described below.

San Pablo Bay Watershed (HUC 18050002) - The larger San Pablo Bay Watershed covers approximately 1,227 square miles and spans the counties of Sonoma, Marin, Napa, Alameda, Contra Costa, San Francisco, and Solano, all within California. The San Pablo Bay watershed drains into the San Pablo and San Francisco Bays, and the main tributaries of this watershed are the Napa River, Petaluma River, and Sonoma Creek.

Figure 4-26 below illustrates general waterways and water features in the City, including FEMA NFHL levee centerlines and water service area boundaries (e.g. utilities, sewer, etc.). The main river present in the City is the Petaluma River, and the largest levee structure covers part of this river on the southern portion of the boundary, near the Ellis Creek Water Facility. Small portions of the Petaluma River and Lynch Creek are leveed, on the center and western portion of the City north of Washington Street. Some protected areas are also present on the south-southeast of the City, as portrayed in the Figure 4-26 with dark grey hash marks. The smaller San Pablo Bay Watershed, associated with HUC 1805000208, is displayed alongside the Petaluma River watershed (with HUC 1805000206) in Figure 4-27.

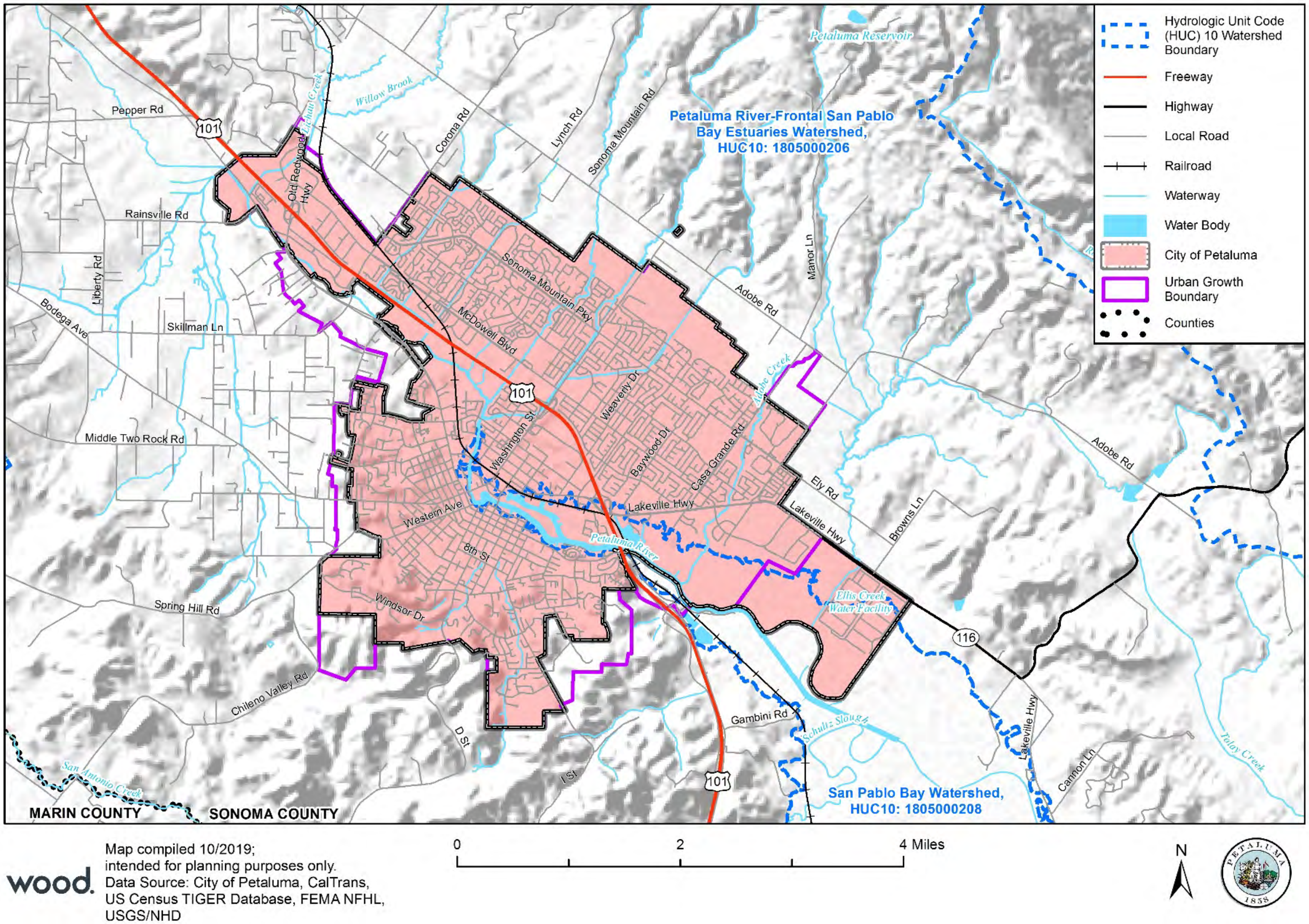
Petaluma River-Frontal San Pablo Bay Estuaries Watershed (HUC 1805000206) – This smaller watershed is located in the southern portion of Sonoma County, with some parts falling in Marin County. It is approximately 126,518 acres in size and it is the watershed which covers the majority of the City and its Planning Area. Tidal influences extend into the City and the watershed, with the confluence of Lynch Creek on the north-central portion of the City. The watershed contains salt marshes and wetlands.

Figure 4-27: City of Petaluma Water Service Areas and Flood Control Structures



Map compiled 9/2019; intended for planning purposes only.
Data Source: City of Petaluma, CalTrans, US Census TIGER Database, FEMA NFHL, USGS

Figure 4-28: Watersheds in the City of Petaluma and Its Planning Area



Local and Regional Drainage Facilities

Major drainage features within the Planning Area or managed by the City of Petaluma include:

- Petaluma River
- Adobe Creek
- Lynch Creek
- Lichau Creek
- Willow Brook
- Small unnamed branches and tributaries in the San Pablo Bay and Petaluma River-Frontal San Pablo Bay Estuaries watersheds
- Petaluma Water Aqueduct
- The Lawler structure/dam
- City and County stormwater drainage facilities (e.g. as indicated in the Petaluma Storm Water Management Plan)
- City water weir
- City pumps, tanks, lift, ditches, and other water structures/stations

Floodplain Mapping and Studies

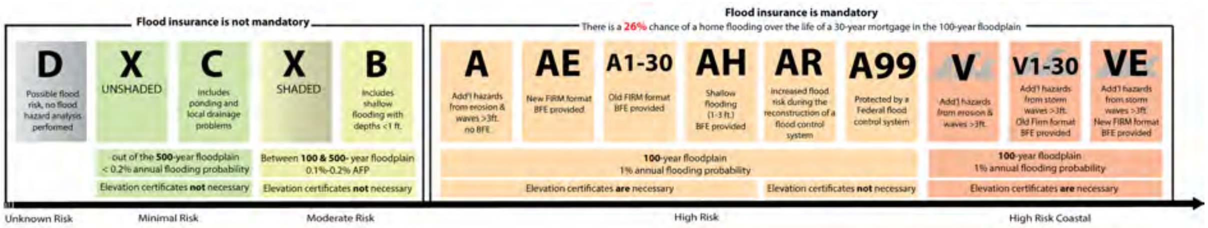
FEMA established standards for floodplain mapping studies as part of the NFIP (FEMA 2019). The NFIP makes flood insurance available to property owners in participating communities adopting FEMA-approved local floodplain studies, maps, and regulations. Floodplain studies that may be approved by FEMA include federally funded studies; studies developed by state, city, and regional public agencies; and technical studies generated by private interests as part of property annexation and land development efforts. Such studies may include entire stream reaches or limited stream sections depending on the nature and scope of a study. A general overview of floodplain mapping and related components is provided in the following paragraphs.

Flood Insurance Study (FIS) - The FIS develops flood-risk data for various areas of a community that are used to establish flood insurance rates and assist the community in its efforts to promote sound floodplain management. The latest FIS applicable to the City of Petaluma was included in a five-volume report along with other incorporated jurisdictions and unincorporated areas studied in Sonoma County; this recent report was last revised March 7, 2017.

Flood Insurance Rate Map (FIRM) - The FIRM is designed for flood insurance and floodplain management applications. For flood insurance, the FIRM designates flood insurance rate zones to assign premium rates for flood insurance policies. The designated flood zones are based on flood risk in the area. For floodplain management, the FIRM delineates 100- and 500-year floodplains, floodways, and the locations of selected cross sections used in the hydrology and hydraulic analyses and local floodplain regulations

Land areas that are high risk within the 100-year floodplain (meaning they have a one percent annual chance of flooding), are called Special Flood Hazard Areas (SFHAs) and are mapped as A or AE zones. The difference between A and AE zones are the level of detail in analysis and mapping, so that A zones are more general while AE contain additional detail and also display Base Flood Elevations, or BFEs. In communities that participate in the NFIP, mandatory flood insurance purchase requirements apply to Zones A and AE (i.e., those areas subject to a 100-year flood event).

What are flood zones?



Flood zones are geographic areas on a flood map that indicate flood risk. Zones are determined by assessing the expected height of a flood that has a 1 percent chance of occurring in any given year ("100-year flood"), as well as potential wave heights, the distance from the nearest water body, and the ground elevation. While there is only a 1 percent chance of a flood of such magnitude to occur every year, there is a 26 percent chance of such a flood to occur over the lifecycle of a 30-year mortgage. *Source: Wetlands Watch 2019*

The City of Petaluma FIRMs, as with most portions of California and larger developments across the U.S., have been replaced by new digital flood insurance rate maps (or DFIRMS) as part of FEMA's Risk Map and Map Modernization programs. DFIRMs and related datasets (e.g. cross sections used in floodplain studies and analyses, BFEs, etc.) are now delivered via National Flood Hazard Layer (NFHL) databases, accessible for free online at FEMA's Flood Map Service Center site.

These digital DFIRMs achieve the following purposes:

- Incorporate the latest flood study updates (LOMRs and LOMAs)
- Utilize community supplied data
- Verify the currency of the floodplains and refit them to community supplied base maps and base data
- Upgrade the FIRMs to a GIS database format to set the stage for future updates and to enable manipulation, storage, and support for GIS analyses and other digital applications
- Solicit community participation

The most current DFIRMs for the City of Petaluma and other jurisdictions or unincorporated areas within Sonoma County are included in the County's NFHL database. The latest effective date for studies in the County is March 7, 2017. The spatial features available in this NFHL database, such as floodplains and levees, were used for the analyses and mapping in this plan as they relate to flooding hazards.

Letter of Map Revision (LOMR) and Letter of Map Amendment (LOMA) - LOMRs and LOMAs represent separate floodplain studies dealing with individual properties or limited stream segments that update the FIS and FIRM data (as revisions or amendments) between periodic FEMA publications of the FIS and FIRM products.

Major Sources of Flooding

General rainfall floods, primarily associated with seasonal storms and thunderstorms, can occur in the City during winter and spring months. This type of flood results from prolonged heavy rainfall over tributary areas and is characterized by high peak flows of moderate duration. Flooding is more severe when antecedent rain has resulted in saturated ground conditions.

In the more urbanized areas of Petaluma, flood problems intensify because the immediate areas are developed and contain mostly impervious surfaces such as roads and paved structures. Because of this, the nearby open land available to absorb rainfall and runoff is often limited or difficult to access naturally.

In other words, the decrease in the amount of open land that can absorb precipitation increases the volume of water that must be carried away by waterways and developed infrastructure, causing localized flash flooding and stormwater issues.

The latest FEMA NFHL data indicate that 100- and 500-year floodplains are predominantly located on the south-southeast and north-northwest of the City, along the Petaluma River (see Figure 4-28). Other smaller flooding areas are also expected to occur along Lakeville Highway and Casa Grande Road, on the confluence of Adobe Creek with the Petaluma River, as well as east of Washington Street and McDowell Boulevard, on the confluences of Lynch Creek and nearby tributaries associated with the Petaluma River. The more upstream portions of Lynch Creek, near the north-northeast of the City are also affected by flooding, towards Adobe Road north of Sonoma Mountain Parkway.

The Sonoma Water authority was enabled, in 1958, to create several geographic zones encompassing major watersheds in the county, in order to finance development and maintenance of flood protection projects as flood control zones. The City of Petaluma falls in Zone 2A, named the Petaluma River Watershed area. Zone advisory committees exist which are in charge of prioritizing, managing, and approving zone related capital improvement plans and projects such as flood protection and drainage facility works, natural waterway maintenance, plan development, erosion and sedimentation control activities, and others also pertaining to Sonoma Water's goals and objectives. Petaluma's Zone 2A flood control area is represented in Figure 4-28 below including the zone's stream maintenance program focus areas along major waterways (i.e. primary sources of flooding) in the City.

Figure 4-29: FEMA Special Flood Hazard Areas for the 1% and 0.2% Annual Chance Flood Events in the City of Petaluma

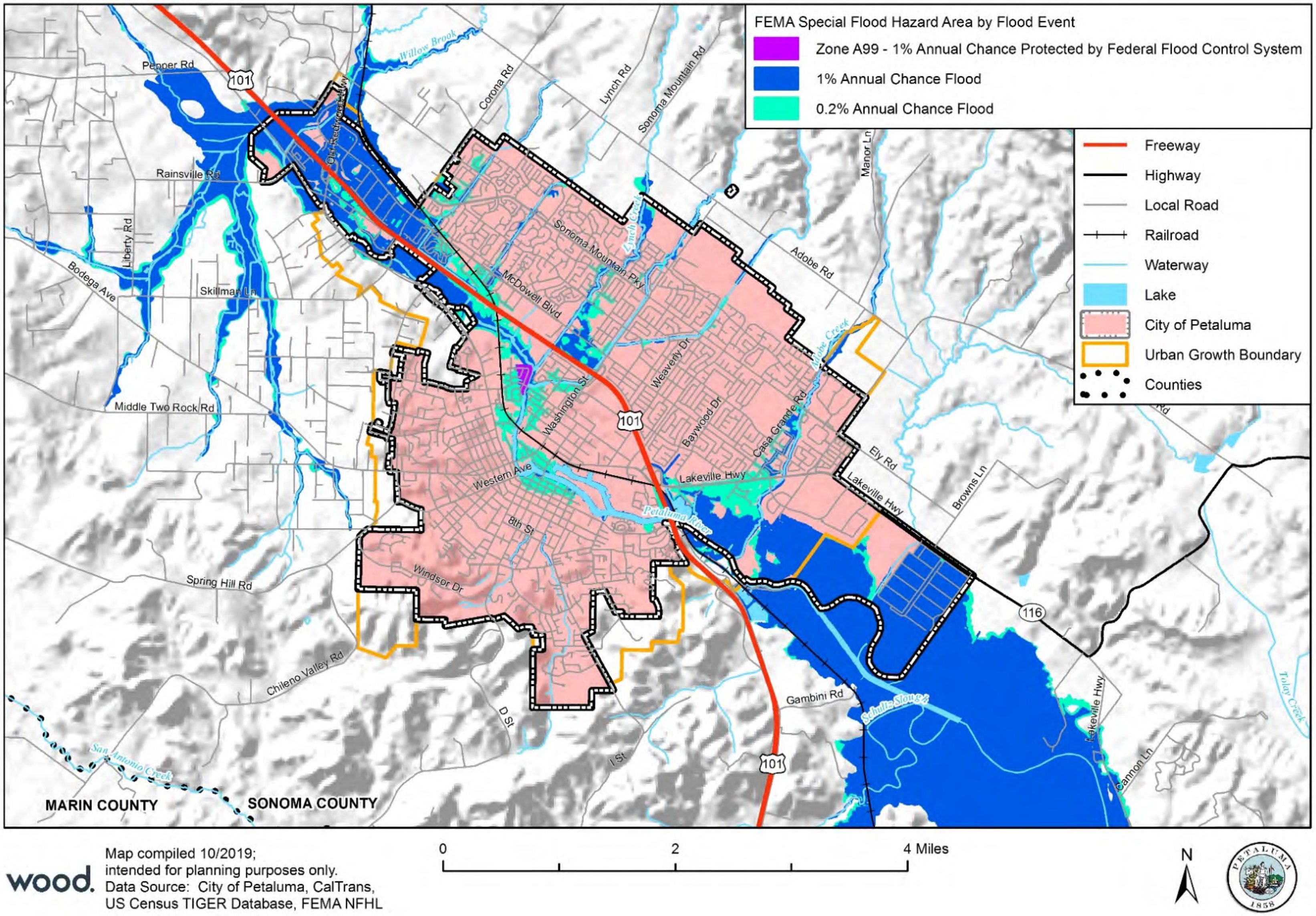


Figure 4-30: Petaluma Flood Control Zone 2A and Stream Maintenance Program Focus Areas

Localized Flooding Problem Areas

Based on historical occurrence data, the Payran neighborhood and nearby areas have been severely impacted by flooding from storms and flash floods compared to other communities in the City's Planning Area. This is the area where the two worst floods for Petaluma occurred and resulted in millions of dollars in damages and losses (i.e. the floods of 1982 and 2005). More information on heavily flood-affected areas is summarized in the Previous Occurrences subsection and the Vulnerability Assessment (including the Insurance Coverage and NFIP Claims and Losses subsection, information on repetitive loss properties and Community Information System records for Petaluma).

The Petaluma River Flood Control project is currently nearing completion, and the Payran levee project is part of this larger flood control project. Once constructed, this flood control project is expected to relieve flood risk and historic and repetitive flooding impacts to the Payran area. According to the City's FMP, the Petaluma has already been noticing a significant reduction in flooding related issues due to project implementation and construction (City of Petaluma 2015b).

Levees

In many locations in California, levees and flood control facilities have been built and are maintained by various public and private entities, including water, irrigation, and flood control districts; other state and local agencies; and private interests (National Levee Database 2018). Some of these facilities were constructed with flood control as secondary or incidental to their primary purpose. The City of Petaluma owns, operates, and maintains two floodwalls within the Planning Area, were both shown in Figure 4-30 as dark pink line features. The two flood control structures are located west of Washington Street along the Petaluma River, in the center-west portion of the Planning Area. However, other levees contained in the latest FEMA NFHL database cover the boundaries of the City and Planning Area; these are also located along the Petaluma River, but on the south-southeast portion of the Planning Area. The City of Petaluma pledged to pursue certification of several of these existing levees in order to better protect the City's infrastructure, including the wastewater treatment plant and wetland areas.

What is Levee Certification?

Levee certification is the process that deals specifically with the design and physical condition of levees, and is the responsibility of the levee owners or community in charge of the levee's operation and maintenance. Certification must be completed for the levee to be eligible for accreditation by FEMA. Certification consists of documentation signed and sealed by a registered Professional Engineer, as defined in 44 CFR Section 65.2. This documentation must state the levee meets the requirements of 44 CFR Section 65.10, the data is accurate to the best of the certifier's knowledge, and the analyses are performed correctly and in accordance with sound engineering practices. Levee certification does not guarantee performance, as it is the responsibility of the levee owner to ensure the levee is being maintained and operated properly.
Source: FEMA 2012 www.fema.gov/rm-main

A small portion of a Zone A99 is located in the Planning Area, as shown in Figure 4-29 by the purple polygon. This special flood designation is located in the Payran residential neighborhood, a few streets west of Washington Street and to the east of the railroad, in the central and western portion of the City. These A99 flood zones are 100-year floodplains that will be protected by federal flood control systems or structures, as their construction methods have reached specified legal requirements. The City of Petaluma submitted this A99 flood zone determination application in 2013, and on June 10, 2014 a LOMR using this flood zone classification became effective. It is expected that when construction has been fully completed the Payran levee project will be certified by the U.S. Army Corps of Engineers, and this zone will switch to a flood zone of type "X" (i.e. areas of minimal flood hazard) (City of Petaluma 2015b).

Extent (Magnitude/Severity)

Limited – Flood maps can be used as an indicator of flood extent. Flood depth and velocity also affect the extent of flood hazards and resulting damage. The deeper and faster flood flows become, the more damage they can cause in a community. However, shallow flooding with high velocities (e.g., such as a flash flood event caused by precipitation) can cause as much damage as deep flooding with a slow velocity (e.g., from a riverine flood event). This typically happens when a channel migrates over a floodplain and redirects flows and transports debris and sediment.

While cities can implement measures to prevent or reduce the severity and magnitude of flood hazards, some level of risk often remains. These types of threats include upstream dam failure, infrastructure failure, and severe flood events that exceed flood design standards or drainage capacity, leading to flash flooding. Flood severity can be determined by logging peak discharge flows. This information is tracked by both FEMA and the USGS. FEMA's BFE depth curve datasets can provide further insight as to how much gets flooded of a community and where exactly, enhancing the level of detail on the magnitude of flooding that can affect a particular community. Based on the most recent NFHL database from FEMA (which includes these BFEs), the City of Petaluma and its Planning Area is expected to experience the worst flooding conditions across the northeast and southeast, with pockets of deep inundation across the central portions of the Petaluma River near the downtown area, and north-northwest of Washington Street and north-northeast of Western Avenue (near the Payran neighborhood).

Based on a flood depth grid indicating the amount of feet that areas of the City could experience in terms of flooding amount, the City of Petaluma may experience one to two feet of flooding near Wickersham Park and the Theater District area, and two to four feet of flooding in small pockets of roads or lawn/field areas near the Norcal Paintball Park north of Payran Street. Other portions of the City may face deeper flooding (over 5 feet), such in the residential neighborhood's paved areas located between Caulfield Lane and S. McDowell Boulevard, east of U.S. Highway 101.

Other localized flooding from existing stormwater infrastructure, for example, is more difficult to estimate but could happen anywhere in the Planning Area and could be severe depending on the flood event itself and the conditions of the existing infrastructure. Table 4-27 below summarizes the general FEMA-available flood zones for context. Overall, while the historic extent of flooding hazards was likely critical, today, flooding hazards were rated by the City and HMPC as being limited in terms of magnitude or severity for the City of Petaluma. In other words, where flood hazards were previously expected to impact approximately 25 to 50 percent of the properties in the City's Planning Area, because of the construction of flood control projects, now approximately 10 to 25 percent of the property could be severely damaged.

Table 4-27: FEMA's Special Flood Hazard Area Zone Descriptions

Flood Zone	Definition
FEMA Special Flood Hazard Areas (SFHA) Subject to Inundation by the 100- or 500-Year Floods	
Zone A	100-year floodplain, or areas with a 1% annual chance of flooding. Because detailed analyses are not performed these areas, no depths or base flood elevations are shown in Zone A areas.
Zone AE	Detailed studies for the 100-year floodplain. The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 zones.
Zone AH	Areas with a 1% chance of shallow flooding, usually in the form of a pong with an average depth ranging from 1 to 3 feet. These are flood elevations derived from detailed analyses.
Zone AO	River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. Average flood depths derived from detailed analyses.

Flood Zone	Definition
Zone A99	100-year floodplain, areas with a 1% annual chance of flooding that will be protected by a federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones.
Other Flood Areas	
Floodway	A regulatory floodway is the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.
Zone X (shaded)	Areas with a 0.2% annual chance flooding (1 in 500 chance), between the limits of the 100-year and 500-year floodplains. This zone is also used to designate base floodplains of lesser hazards, such as areas protected by levees from the 100-year flood, shallow flooding areas with average depths of less than one foot, or drainage areas less than 1 square mile.
Zone X (unshaded)	500-year floodplain (0.2% annual chance). Area of minimal flood hazard.

Source: FEMA Flood Map Service Center, 2018

Previous Occurrences

The City of Petaluma has historically been impacted by flooding from sources such as general riverine and flash flooding from winter storms. Historical records are described below, but may not represent all historical events. The records below are from several sources, including: the NCEI database, which is managed by NOAA; 2016 Sonoma County Operational Area HMP; the 2018 California SHMP, 2015 Petaluma FMP; the U.S. Department of Agriculture's Secretarial Disaster Designations; and, the OpenFEMA Disaster Declaration dataset.

January 3-5, 1982 – This is the largest flood of record in the City. It led to approximately $28 million in damages, and the storm that caused the flooding is documented in an Army Corps of Engineers post-flood event report, reading as follows: "During the January 1982 storm, flooding occurred over a 50+ block area on both sides of the river through the City of Petaluma. Most of the 500 homes and the 100 commercial-industrial establishments in this area incurred flood damage. In many cases, water depth reached two to three feet inside the structure. The most severely hit area appears to be along Jess Avenue where most homes had four to five feet inside. Payran Street was also an area of major damage in which flooding reached over three feet inside the structure." (City of Petaluma 2015b).

February 14-17, 1986 - $1 million in damages were caused in the Petaluma River urbanized sections between the Lynch Creek confluence with the Lakeville Street Bridge. An article in the San Francisco Chronicle headlined "Petaluma Takes to the Boats" published February 15, 1986, noted how 400 homes were evacuated due to this flood in the Linda Del Mar subdivision, and how flood waters reached a depth of about 5 feet (City of Petaluma 2015b).

March 9, 1995 – This flood event led to about $9,000 of damage to the Petaluma Wastewater Treatment Plant as flood control structures were severely impacted. Hopper Street also experienced damage. In addition, seven schools were closed, and over 300 homes had to be evacuated for safety reasons. Another article in the San Francisco Chronicle was published on March 10, 1995 on this event, titled "Soggy Anger on the Street That Always Floods." The article discussed how Payran Street was impacted during this event and how that particular street and area commonly get flooded over the years.

February 1998 – The winter of 1997-1998 felt the effects of the El Niño storms, which caused great storms in the west coast that lead to the major flooding in Petaluma among other California coastal areas. Approximately $6 million were incurred from damages in the City, from both the early February event (2nd-3rd of the month) as well as the February 29, 2019 storms. State and federal governments declared the events as disasters (under the FEMA DR 1203 declaration). The Payran neighborhood and businesses in the Industrial Ave/Auto Center Drive area saw the worst effects, and oxidation ponds the City's wastewater treatment facility also were badly damaged. The San Francisco Chronicle published an article on February 20, 1998 titled "More Rain, More Havoc" about this event. The article reported that the Payran community got hit for the third time in three weeks with storms and flooding, and almost 50 homes needed evacuation. Around 30 seniors required evacuation as well, from a mobile home park north of the City.


The north end of the City of Petaluma experienced significant flooding on December 30, 2005 through December 31, 2005. Streets and buildings in the north end of the City had up to five feet of flooding and several houses and mobile homes were damaged on Petaluma Boulevard North and North McDowell Boulevard. The City also noted damage to business along Industrial Drive and Corona Road, near the Petaluma Outlets, and on Old Redwood Highway
Photo Credit: City of Petaluma Fire Department 2019

December 31, 2005 – The middle and northern areas of the City experienced significant flooding due to this New Year's Eve event, incurring $56 million in structural damages (affecting 53 structures). Flood waters also damaged streets and river channel banks, particularly within the Petaluma Factory Outlets, and at several commercial structures and mobile homes. This flood event led to a State and Federal Disaster Declaration.

January 25-26, 2008 - Very heavy rain caused flash flooding around Petaluma late Friday night, January 26, 2008. The Petaluma River near Corona Road went over its flood stage of 25.5 feet reaching nearly 30 feet. At least a dozen homes were flooded as were several businesses. A nearly stationary frontal band hung over parts of the Bay Area bringing intense rainfall for several hours. It is estimated that $800,000 was incurred in overall damages across all the storm-affected areas in the Bay Area (particularly coastal sections of Marin, San Francisco, and San Mateo Counties).

December 2, 2012 – Minor flooding was observed around Petaluma Sky Ranch/airport area, as water levels on Willow Brook were overtopped. Penngrove Park was also affected.

December 11, 2014 – The northern and southern portions of the City were affected by flooding, and waters inundated Industrial Avenue and nearby areas. Road closures were necessary along that Avenue as well as Auto Center Drive. Evacuations of businesses ensued. Residential neighborhoods near Corona Creek and near Ellis Creek were also hit. There were no reported damaged structures.

December 15, 2016 - Northbound State Route 121 closed due to flooding near the Junctions of Route 116 and 121 in Petaluma, though overall the flood event was minor.

Probability of Future Occurrences

Likely - The 100-year flood is the flood that has a one percent chance in any given year of being equaled or exceeded, while the 500-year flood is expected to have a 0.2 percent chance of occurring (or being exceeded) in any year, respectively. As such, it is likely that riverine flooding will occur in the future, though localized stormwater flooding and general flash flooding is also expected to take place especially during the wet months and heavy rain or storm events.

Climate Change Considerations

Emerging findings from California's Fourth Climate Assessment show that costs associated with direct climate change impacts by 2050 will be dominated by human mortality, coastal damage, and the potential for droughts and mega-floods (California Natural Resources Agency 2018). Scientific studies outlined in the same assessment also indicated shifts in California's precipitation regime, which show more dry days, more dry years, a longer dry season, mixed with increases in occasional heavy precipitation events and floods (i.e. a shift towards potentially less frequent but more extreme precipitation events). Studies also project great storm intensity with climate change, resulting in more direct runoff and flooding due to the flash flooding or precipitation nature of these expected events. As a result of fewer but more violent precipitation events, high frequency flood events will increase with climate change. Also, with wildfires already being a problem in California, increasing periods of drought and lack of precipitation are expected to exacerbate conditions for fires to occur, and in turn worsen the potential for runoff and flooding associated with burned areas due to increased impermeability and damage terrain and soils.

This Fourth Climate Assessment indicates that climate change is expected to alter built water supply systems, so that current management practices for flood control and water supplies across the state of California may need to be revised. Future revisions should aim to account for subsidence-prone infrastructure (e.g. levees), which coupled with rising sea levels and worsening storm conditions can lead to overtopping or failure of these flood control structures (California Natural Resources Agency 2018).

Based on Sonoma County's 2016 CAP and GHG emission modelling, climate change is projected to result in an increased risk of extreme flood, and an increased seasonal variability of precipitation, runoff, and stream flows for Sonoma County, along with increased likelihood of "extreme" precipitation and drought events. There may be more years with more frequent storm events and occasional events that are much stronger than historical ones and the length of season over which storm events occur is predicted to increase (SCTA 2016). Also, according to the CAP, more frequent coastal flooding and increased erosion is anticipated. In addition to flooding, sea levels are projected to rise between 16.5 and 65.8 inches by 2100. Rising sea levels combined with increased storm surge is anticipated to lead to more frequent inundation of the low-lying areas, and flooding of homes, infrastructure, agricultural land, and natural areas on the shores of San Pablo Bay. The greatest impacts are anticipated during winter storms. For these reasons, climate change would have a "high" influence on flooding hazards.

Vulnerability Assessment

Historically, the Planning Area has been at risk to flooding primarily on the north-northwest and south-southeast portion of the City. Normally, storm floodwaters are kept within defined limits by a variety of storm drainage and flood control measures (e.g. levees). But, occasionally, extended heavy rains result in floodwaters that exceed local drainage infrastructure capacity and cause damage.

Flooding has occurred in the past: within the 100-year floodplain and in other localized areas. In addition to damage to area infrastructure and City facilities, other problems associated with flooding include erosion, sedimentation, degradation of water quality, loss of environmental resources, certain health hazards, and the inconvenience or potential financial and accessibility issues that come with road closures and other such effects.

The City of Petaluma has mapped flood hazard areas as portrayed in the figures contained throughout this section. For the following vulnerability assessment, GIS was used to identify and quantify the possible impacts of flooding within the City's Planning Area. The following methodology was followed in creating these flood vulnerability maps and determining values at risk to the 100- and 500-year flood events.

Insurance Coverage and NFIP Claims and Losses for Repetitive Loss Properties

The City of Petaluma joined the NFIP (regular entry) on February 15, 1980. The current effective map date is from October 12, 2015. The City currently participates in the Community Rating System (CRS), holding a class rating of 6 as of May 1, 2019 (leading to a 20 percent discount rate for SFHAs). NFIP Community Information System (CIS) insurance data indicates that as of July 10, 2019 there were 415 policies in place in the City, resulting in $145,671,200 of insurance in effect. Since the City began participating in the NFIP there have been 373 total closed losses, amounting to $8,703,708 in payments. According to the 2018 California SHMP, in 2017, Sonoma County was the top-ranking county in state for Repetitive Losses, accounting for more than 48 percent of the total top 10 repetitive losses. The City of Petaluma's latest CIS report, released July 10, 2019, shows 30 Repetitive Loss buildings (13 of which are insured) as defined by FEMA. Repetitive loss properties have incurred 89 total losses, 43 of which were insured cases, and these accrued to $3,179,133 in payments from both building- and contents-related losses. The majority of these repetitive loss properties fell within AE, A, A1-A30, AO, AH flood hazard areas (FEMA 2019c). Table 4-28 below summarizes the repetitive loss information detailed in the City's latest CIS report, while Figure 4-31 displays the locations of these repetitive loss properties.

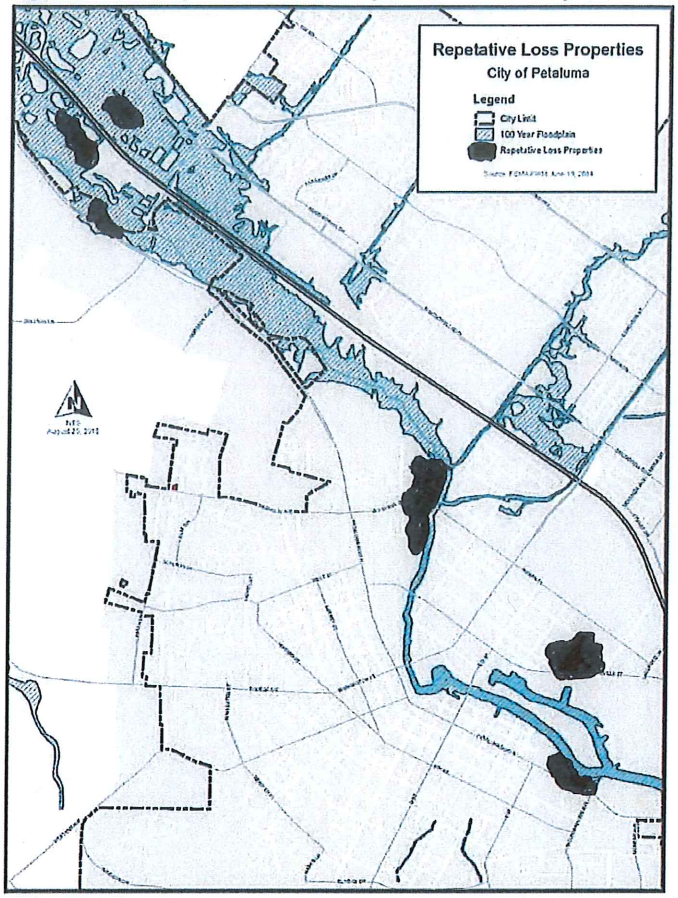
Table 4-28: City of Petaluma Parcels in Floodplains by Parcel Type and Flood Event

Repetitive Loss Component	Zones AE, A, A1-30, AO, AH	Zones B, C, X	Total
Total Buildings	28	2	30
Insured Buildings	13	0	13
Total Losses	84	5	89
Insured Losses	43	0	43
Total Payments	$3,119,975	$59,158	$3,179,133
Building related losses	$2,480,047	$43,565	$2,523,612
Contents related losses	$639,927	$15,593	$655,520
Insured Payments	$2,464,996	$0	$2,464,996
Building related payments	$2,019,948	$0	$2,019,948
Contents related payments	$445,048	$0	$445,048

Source: CIS Repetitive Loss report for the City of Petaluma (FEMA) 2019

Note: No repetitive loss information was noted for Zones VE, V, or V1-30; as such that column was excluded.

Figure 4-31: Repetitive Loss Properties in the City of Petaluma as of 2015



Source: City of Petaluma 2015

Property

This section summarizes the vulnerabilities to parcels and values at risk in the City. According to the information obtained via the GIS analysis, where the number and types of parcels falling in the 100- and 500-year floodplains was aggregated, Petaluma has 820 parcels with total values equating to $1.12 billion in both floodplains. A 25 percent damage factor was applied to the total value column of the tables below to estimate potential losses from flood related hazards to the City's parcels. 25 percent is the typical loss ratio associated with a 2-foot-deep flood, based on FEMA and Army Corp of Engineer depth-damage relationships. The total values were calculated by adding up the improved structure values of the parcels in the floodplains with the content values. These values were then estimated with the following formulas: a) residential and multi-family properties received contents valued at 50 percent of the parcel improved value; b) commercial and agricultural properties' contents were valued at 100 percent of the parcel improved value; and, c) vacant parcels received 0 percent content values. These valuation assignments are founded on FEMA's methodology for estimating contents within their loss estimation software, Hazus-MH.

Table 4-29 and Table 4-30 summarize the values at risk in the City's 100- and 500-year event floodplains. Figure 4-32 displays the location of these parcels in the flood areas. Overall, Petaluma has 200 parcels valued at roughly $424.4 million in the 100-year floodplain, $106 million of which is estimated to be a potential loss if a flood of this nature were to take place. 620 parcels valued at roughly $699.2 million are found in the 500-year floodplain, $174.8 million of which is estimated to be a potential loss if an event of this magnitude were to take place. Combined, the potential losses estimated from both events would total $280.9 million.

Table 4-29: City of Petaluma Parcels in Floodplains by Parcel Type and Flood Event

Flood Event	Parcel Type	Total Parcels	Improved Value	Contents Value	Total Value	Loss Estimate (25% of the Total Value)	Population at Risk
100-year	Residential	54	$9,994,745	$4,997,373	$14,992,118	$3,748,029	145
	Multi-Family	1	$63,059	$31,530	$94,589	$23,647	3
	Commercial	145	$204,698,304	$204,698,304	$409,396,608	$102,349,152	--
TOTAL		**200**	**$214,756,108**	**$209,727,206**	**$424,483,314**	**$106,120,829**	**147**
500-year	Residential	510	$118,374,972	$59,187,486	$177,562,458	$44,390,615	1,367
	Multi-Family	11	$122,909,517	$61,454,759	$184,364,276	$46,091,069	29
	Commercial	99	$168,655,657	$168,655,657	$337,311,314	$84,327,829	--
TOTAL		**620**	**$409,940,146**	**$289,297,902**	**$699,238,048**	**$174,809,512**	**1,396**
GRAND TOTAL		**820**	**$624,696,254**	**$499,025,108**	**$1,123,721,362**	**$280,930,340**	**1,544**

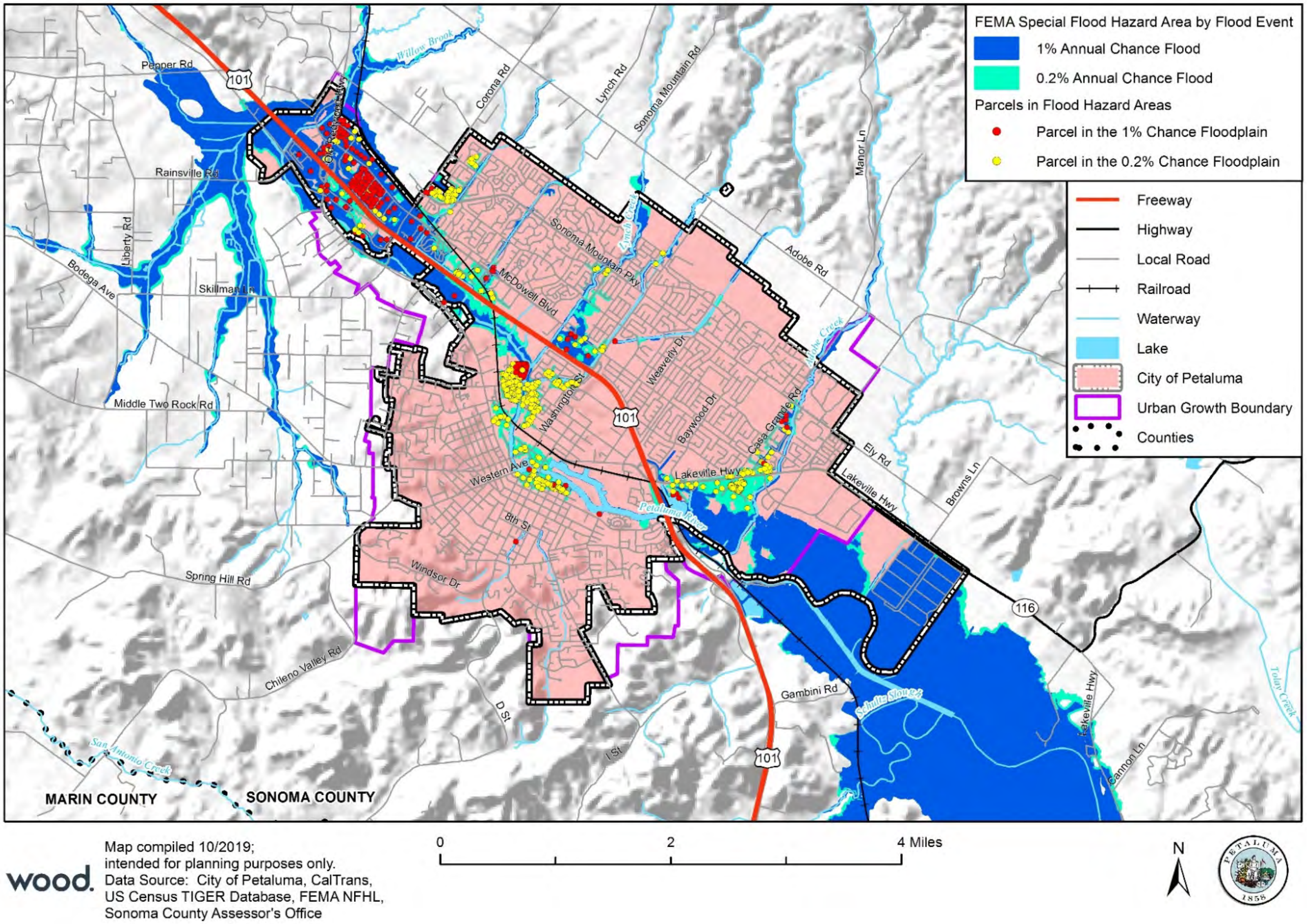
Sources: City of Petaluma GIS, Sonoma County Assessor's Office, FEMA NFHL, Wood Parcel Analysis

Table 4-30: City of Petaluma Flood Loss Estimates Summary by Parcel Type

Parcel Type	Total Parcels	Improved Value	Contents Value	Total Value	Loss Estimate (25% of the Total Value)	Population at Risk
Commercial	244	$373,353,961	$373,353,961	$746,707,922	$186,676,981	--
Residential	564	$128,369,717	$64,184,859	$192,554,576	$48,138,644	1,512
Multi-Family	12	$122,972,576	$61,486,288	$184,458,864	$46,114,716	32
TOTAL	**820**	**$624,696,254**	**$499,025,108**	**$1,123,721,362**	**$280,930,340**	**1,544**

Sources: City of Petaluma GIS, Sonoma County Assessor's Office, FEMA NFHL, Wood Parcel Analysis

Figure 4-32: City of Petaluma Parcels in the 1% and 0.2% Annual Chance Floodplains



People

Of greatest concern in the event of a flooding event is the potential for injury or loss of life. City of Petaluma 2018 U.S. Census Bureau estimates were obtained, which indicate the average persons per household for the City. The City's average household size is 2.68, and this metric was multiplied by the number of parcels of residential nature at risk of flooding to determine the total potential affected population. Population at risk estimates are summarized in the last column of Table 4-29 and Table 4-30 in the pages above, by flood event type and parcel type. The results were totaled for all the flood hazard zones. As the previous two tables indicate, there are around 1,544 people at risk of flooding caused by any of the flood events overlapping with residential properties, where 147 people are found in the 100-year floodplain and 1,396 people in the 500-year floodplain. Given the number of households and populations identified as socially vulnerable, disadvantaged, or sensitive in the City's planning area and the proximity of these census tracks and block groups to the flood zones, it is assumed that a portion of this population segment may also be disproportionately impacted during a flood event.

Economy

Similar to a dam inundation event which would affect infrastructure (e.g. roads), homes, and populations (possibly displacing families), impacts to the local economy could include business interruptions, lost or reduced wages from potential relocation of populations, infrastructure and resource downtime costs, and reduced city revenues from lack of tourism or inability to run/maintain certain services (like potable water based utilities). Other secondary hazard impacts such as reduced water quality or resource availability, which could in turn raise costs of water processing and distribution are also possible results from a severe flooding event, whether from riverine flooding, flash flooding, or an event caused by local stormwater/drainage infrastructure failures. Based on the history of flooding in Petaluma, the Payran neighborhood and nearby areas have historically been affected the most in terms of economic losses, which largely encompass damages to property (including disruption to business and commerce operations) and City infrastructure.

Critical Facilities and Infrastructure

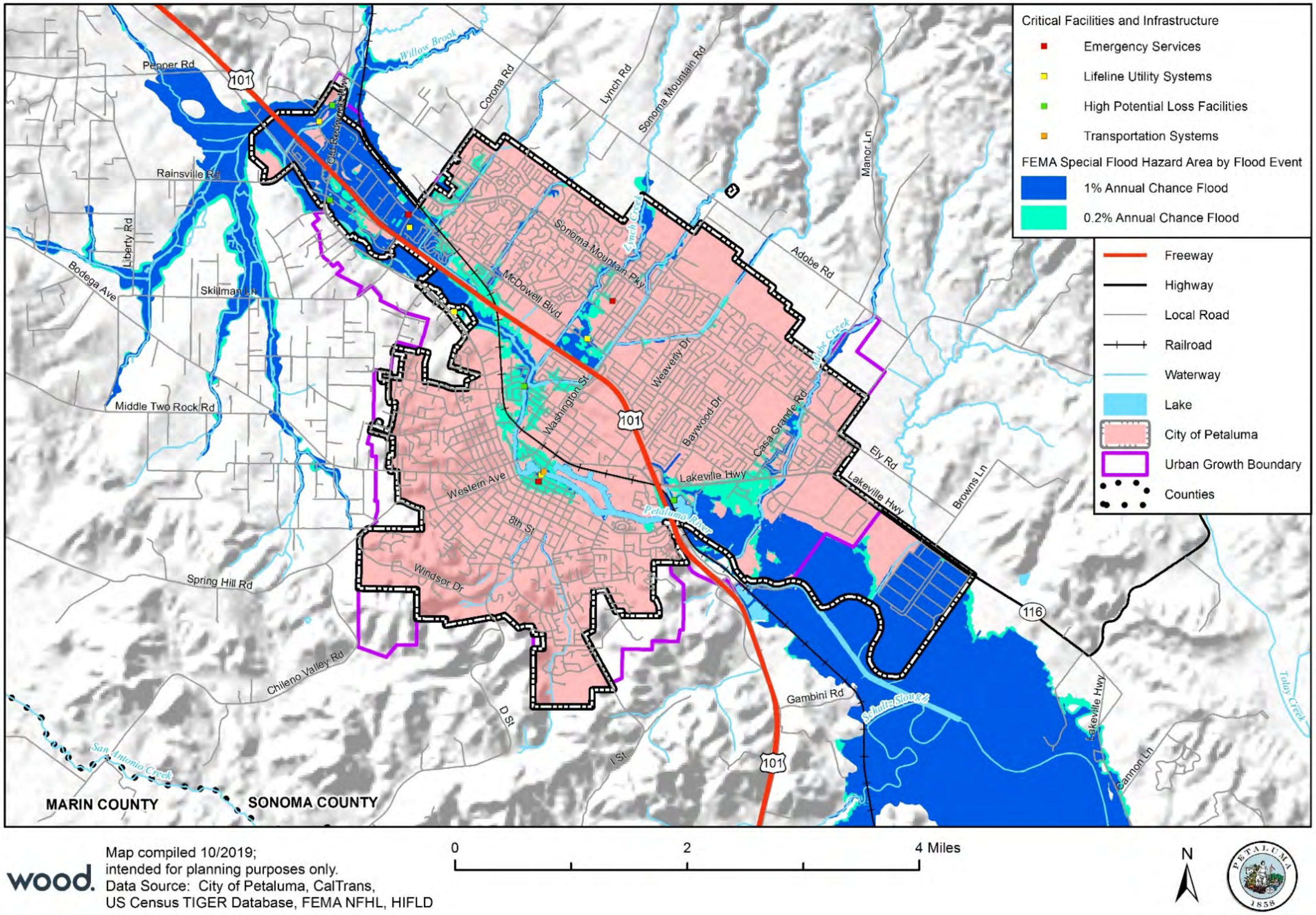
Critical facilities are those community components that are most needed to withstand the impacts of disaster as previously described. GIS was used to determine what City facilities and infrastructure occur within Petaluma's mapped flood hazard areas. The NFHL flood layers previously discussed were used to identify where the 100- and 500-year floodplains intersected with critical facilities. Figure 4-33 illustrates the locations of these critical facilities relative to the floodplains. Table 4-31 provides an inventory of the 15 facilities that occur within the floodplains. The impact to the community could be substantial if these critical facilities were damaged or destroyed during a flood event, particularly those which provide lifeline utilities or health/medical services. Overall, there are a total of five Emergency Service facilities in flooding areas, four High Potential Loss Facilities, five Lifeline Utility Systems, and one Transportation System found at risk in FEMA SFHAs.

Table 4-31: The City of Petaluma's Critical Facilities in the 100- and 500-Year Floodplains

Flood Event	Critical Facility Category	Critical Facility Type	Total Critical Facilities
100-year flood event	High Potential Loss Facilities	Day Care Facilities	1
		Government/Admin	1
	Lifeline Utility Systems	Electric Substations	1
		Water Facility	2
	Transportation Systems	Historic Drawbridge	1
TOTAL			**6**
500-year flood event	Emergency Services	Emergency Medical Service Station	2
		Fire Station	2
		Nursing Homes	1
	High Potential Loss Facilities	Community/Recreation Center	1
		Government/Admin	1
	Lifeline Utility Systems	Electric Substations	1
		Water Facility	1
TOTAL			**9**
GRAND TOTAL			**15**

Source: The City of Petaluma GIS, HIFLD, FEMA NFHL, Wood GIS Analysis

Figure 4-33: City of Petaluma Critical Facilities and Infrastructure in the 1% and 0.2% Annual Chance Floodplains



Historic, Cultural, and Natural Resources

The City of Petaluma has eight natural, historic, or cultural resources located in or nearby the Planning Area boundaries as previously described in Section 4.2 Asset Summary and Section 4.3.4 Fire: Urban and Wildland Fires, under the Historic, Cultural, and Natural Resources subsection. Climate change studies at the county and regional level indicate the likelihood that increasingly unpredictable flash flooding and uncertainty in storm occurrence will lead to a worsening in erosion and sedimentation conditions. However, natural areas within the floodplain often benefit from periodic flooding as a naturally recurring phenomenon, and these natural areas often reduce flood impacts by allowing absorption and infiltration of floodwaters. Nevertheless, other cultural or historical resources such as older buildings or districts may be more affected by these flooding hazards, given their likely older construction methods, weaker materials, and potential failure to meet current building code standards.

Future Development

The development trend in the City of Petaluma Planning Area is steady. The Petaluma City Profile Report published in 2018 notes the predicted population changes through the year 2022. The City is expected to grow around 3.2 percent in the next 5 years, to an estimated total of 62,700 people. Given these projections it is likely that the City will keep diversifying and expanding its economic base due to proximity to the San Francisco Bay area.

The potential for flooding may increase as stormwater is channelized due to land development. Such changes can create localized flooding problems inside and outside of natural floodplains by altering or confining natural drainage channels. Floodplain modeling and master planning should be based on buildout land use to ensure that all new development is properly designed and remains safe from future flooding. While certain local floodplain management and water quality regulations and policies exist, as well as specific regulatory control of building codes, flood insurance requirements, and other such aspects at the federal or state level, the cumulative effects of flood related hazards can have a negative impact on the floodplain and the community into the future. Water and flood control infrastructure such as dams and levees can additionally be stressed due to increased development and municipal water supply needs coupled with a changing environment which causes environmental and weather conditions to become more and more unpredictable (e.g. through storm events, climate change).

City floodplain management ordinances require that new construction be built with two feet of freeboard for first floor elevations above the BFE (per the General Plan 2025 Policy 8-P-37F). New development that complies with the mandated elevation requirements in addition to other requirements for maintaining elevation certificates, implementing stormwater program elements, and complying with erosion or sediment controls for all new development in the floodplain may protect new constructions from 100-year and possibly other floods events (refer to Section 2.9 Mitigation Capabilities in Chapter 2 – Community Profile for more information on the City's existing floodplain standards and regulations).

The amount of growth in the City and nearby communities can also strain the capacity of the water management system, which includes water supply in addition to water control. When flood drainage and control structures are overwhelmed, the result is not only severe flooding. Significant losses to the water supply system may also occur.

Risk Summary

- Overall the significance of flood hazards is **Medium**.

- Floods impacts will vary by location and severity and will likely only affect certain areas of the City Planning Area at any one time.
- Based on the risk assessment, floods will continue to have economic impacts to certain areas of the City's Planning Area, and the estimated losses for properties amounts to $280.9 million (with a total of 1,544 potential people at risk), in addition to the 15 critical facilities which fall in the floodplains.
- 200 properties valued at roughly $424 million are located in the 100-year floodplains. 620 properties were found at risk of the 500-year (0.2 percent annual chance) floodplain, roughly valued at $699 million.
- Six noteworthy flooding events have taken place in Petaluma since 1982. These caused significant damages and several required evacuations, though other minor flooding cases have taken place. The worst two events to record for the City are the January 1982 flood, which caused $28 million in damages, and New Year's Eve flood of December 2005, which led to an estimated $56 million in damages. Based on the history of flooding in Petaluma, the Payran neighborhood and nearby areas have historically been affected the most in terms of economic losses which encompass damages to property (including disruption to business and commerce operations) and City infrastructure.
- Impacts that are not directly quantified but could be anticipated in large future events include: 1) injury and loss of life; 2) disruption of and damage to public infrastructure; 3) disruption to trade, commerce, commuting, mobility, and other activities that may rely on the road networks; 4) health hazards associated with mold and mildew; 5) significant direct and indirect economic impact (jobs, sales, tax revenue) upon the community; and 6) negative impact on commercial and residential property values.
- The 2018 California SHMP noted that Sonoma County was the top-ranking area in California to log NFIP repetitive loss cases, accounting for more than 48 percent of the total top 10 repetitive losses (Cal OES 2018)
- NFIP CIS insurance data indicates that as of July 10, 2019 there were 415 policies in place in the City, resulting in $145,671,200 of insurance in effect. Since the City began participating in the NFIP there have been 373 total closed losses, amounting to $8,703,708 in payments. There are 30 Repetitive Loss buildings (13 of which are insured) in Petaluma. Repetitive loss properties have incurred 89 total losses, 43 of which were insured cases, and these accrued to $3,179,133 in payments from both building- and contents-related losses

4.3.6 Sea Level Rise

Hazard Description

Sea level rise is defined as the relative average rise in mean sea level. Global sea level rise refers to the long-term gradual increase of sea levels driven by the expansion of ocean waters as they warm, the addition of freshwater to the ocean from melting land-based ice sheets and glaciers, and extractions from groundwater. Regional and local factors such as tectonics and ocean and atmospheric circulation patterns result in relative sea level rise rates that can be higher or lower than the global average. Sea level rise also contributes to increased coastal flooding and more frequent and severe tidal inundation because there is less of a buffer between the ocean and coastal areas and infrastructure within these areas. This can exacerbate existing flood hazards from severe storms, as well as alter the function of the salt marsh and tidal flats near the confluence of Petaluma River and San Pablo Bay. Unlike flooding caused by severe storms, tidal inundation when combined with sea level rise would occur with predictable high tides and with some regularity. Tidal inundation and sea level rise combined with coastal storm events could also occur and result in greater impacts. Over time, existing low-lying tidal flat areas near the southern portion of Petaluma's Planning Area are expected to be semi-permanently inundated as a result of sea level rise.

Location

The southern portion of the City of Petaluma, the protected open space and marsh and tidal lands within Petaluma Marsh Wildlife Area, the areas located along Petaluma River, and existing urban development and natural resources in the City are already exposed to riverine and localized flooding, which will be exacerbated by sea level rise. The hazards in these areas are projected to become more severe when combined with sea level rise. The creeks and rivers that drain to the Petaluma River in confluence with San Pablo Bay result in an ecologically diverse range of low-lying habitats including coastal wetlands, tidal salt marsh, and mudflats. These ecological areas extend from the southern portion of the City Planning Area along Petaluma River and between U.S. Highway 101 and Highway 116 to outside the Planning Area near Point Sonoma and San Pablo Bay. The portion within the Planning Area where sea level rise may occur over time under the more extreme projections includes downtown Petaluma and a number of open space and recreation areas, such as Steamer Landing Park and Shollenberger Park. The southern portion of the City also contains the Petaluma Marina and Ellis Creek Water Recycling Facility. In summary, the geographic area of the City exposed to sea level rise is limited to a small portion of the entire planning area.

Extent (Magnitude/Severity)

Negligible – USGS, in collaboration with the Our Coast, Our Future (OCOF) project, has developed the Coastal Storm Modelling System (CoSMoS) to make detailed predictions of coastal storm (wave-driven) flooding, beach and cliff erosion, and sea level rise over a large geographic scale. In the City of Petaluma, sea level rise is projected to expand the flood zone under varying scenarios, but specifically in the low-lying areas along the Petaluma River and the coastal areas located south of downtown. The potential extent of flooding associated with sea level rise and various storm scenarios, such as the average annual tidal conditions, and 100-year wave event are summarized and depicted in the vulnerability assessment. It is worth noting that sea level rise modeling used for the vulnerability assessment assumes some level of shoreline protection or adaptation strategies, such as large-scale levees are in place (e.g. CoSMoS includes levee structures that are visible on LiDAR data and can be included in digital elevation models).

The California Ocean Protection Council (OPC) summarized the best available science on sea level rise in *Rising Seas in California: An Update on Sea Level Rise* report released in 2017, which was later used to update the OPC's guidance on sea level rise in 2018. This guidance is also referenced as the best available science in the California Coastal Commission (CCC) *Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Costal Development Permits* document last updated in November 2018 (CCC 2018).

The OPC Guidance projects sea level rise for various emission scenarios and uses a probabilistic approach to generate a range of projections at a given time horizon (Kopp et al. 2014). The CCC Sea Level Rise Policy Guidance recommends using projections associated with a high emissions scenario given that worldwide emissions are currently following the high emissions trajectory, whereas the OPC Guidance provides a risk decision framework that explains when to use a low or a high risk aversion in the planning process (CCC 2018; OPC 2018). With these frameworks, probabilistic projections inform decision-making processes regarding the likely extent of sea level rise rather than trying to estimate the exact rate or occurrence of sea level rise based on an individual scenario or projection.

For the 2050 time horizon the likely range of sea level rise is between 0.6 to 1.1 feet and there is a 66 percent probability that sea level rise will fall within this likely range (Kopp et al. 2014). The likely range of sea level rise at 2100 is 1.6 to 3.4 feet for a high emissions scenario. The upper end of the likely range is recommended to use as a projection for low-risk tolerance situations, where sea level rise impacts can be easily mitigated. The CCC recommends the high-risk tolerance range to be used when considering resources where the consequences of sea level rise are limited in scale. In other words, this would apply where there would be minimal disruption and where there would be a low impact on communities and critical infrastructure.

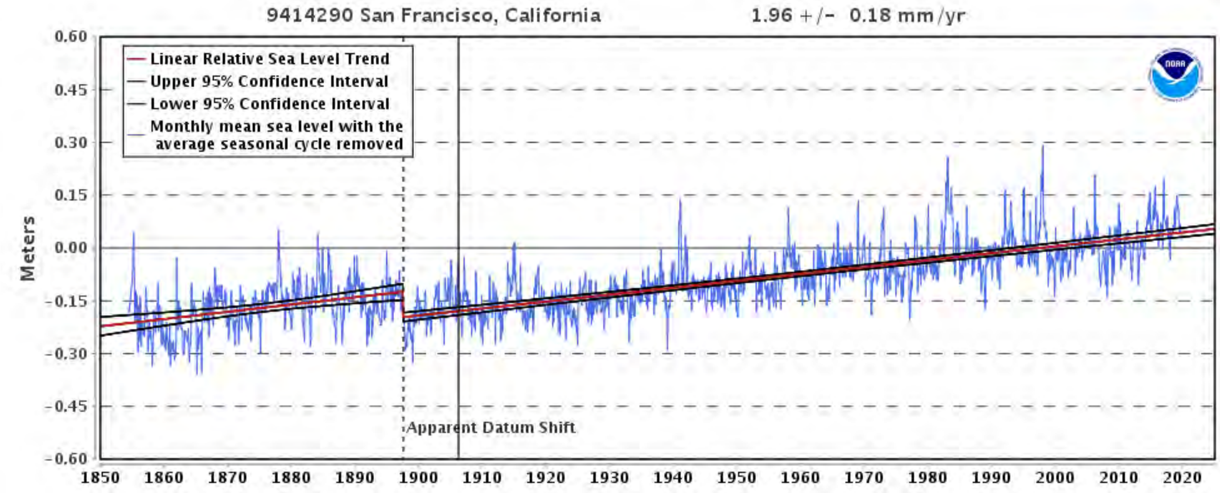
For medium-high risk tolerance situations, more conservative projections for sea level rise are recommended by the OPC Guidance. The medium-high risk aversion scenario projects 1.9 feet of sea level rise could occur by 2050, and 6.9 feet of sea level rise could occur by 2100. These projections have a 0.5 percent probability of occurring, or a 1 in 200 chance, at a given time horizon. These projections would be appropriate for projects where damage from coastal flood hazards exacerbated by sea level rise would result in higher consequences, or the community or project would have less ability to adapt. The medium-high risk tolerance situation may be applicable to residential and commercial development in Petaluma.

The OPC Guidance also includes a specific stand-alone scenario, referred to as H++, where up to 6.6 feet of sea level rise could occur by 2080, and 10.2 feet of sea level rise could occur by 2100. This scenario is based on scientific studies that predict the instability of the Antarctic ice sheet could make extreme sea-level rise outcomes more likely than predicted by other studies (Griggs et al., 2017). Based on the extreme uncertainty of the H++ scenario, it is most appropriate to consider when planning development that poses a high risk to public health and safety, natural resources, and critical infrastructure (OPC 2018).

Previous Occurrences

Sea levels are rising at different rates in different regions of the California due to local differences in tectonic uplift/subsidence and other factors such as tidal and wetland zones. Typically, the highest sea level readings along California's coastline and within the San Pablo Bay occur during periods of heavy rain that coincide with high tides, causing coastal flooding, such as those experienced during the 1982 to 1983 and 1997 and 1998 El Niño events. Sea level rise in the San Francisco Bay Area has risen seven to eight inches in the past century (NRC 2012; Heberger et al 2012). Sea level at the San Francisco tide gauge has also risen eight inches over the past century (NOAA 2018). While the Petaluma River already experiences flooding, sea level rise will exacerbate these natural events. The San Francisco Tide Gauge located north of Chrissy Field in the City of San Francisco reports the local sea level rise rate at approximately 1.96 (+/-0.18) millimeters per year (mm/year) based on mean sea level data from 1897 to 2018. This is equivalent to a change of 0.64 feet in 100 years (NOAA 2018), which equates to roughly 1.95 mm/year (see Figure 4-34). This rate compares to the global average annual rate of 3.2 mm/year (Griggs et. al. 2017) and the rate near the mouth of San Francisco Bay that has recorded approximately 7 inches in sea level rise variation over the past 100 years. The growth trend is projected to increase in future years (NOAA 2017).

Figure 4-34: Tide Record and Sea Level Rise Trend from San Francisco Tide Gauge (NOAA Station 9414190)



Source: NOAA 2018

Probability of Future Occurrences

Likely - Scientific understanding of sea level rise is advancing at a rapid pace; projections of future sea level rise continue to change as new studies become available. Future climate change is projected to particularly affect sea levels as the glaciers, polar ice packs, and ice sheets retreat. The predicted sea level rise over the course of this century varies widely. Since 1992, trends in sea level rise have been monitored by satellites and recorded by tide gauges. Given the variables involved, it is not yet possible to determine the actual rate of sea level increase. The OPC suggests that sea level rise in the San Francisco Bay Area could occur on the order of 0.5 to 1.0 foot by 2030, 1.1 to 2.7 feet by 2050, and 2.4 to 10.2 feet by 2100 (Table 4-32). In the next 5 years, or the timeframe until the next update of the City's LHMP this could equate to an "occasional" to "likely" probability of future occurrence that depends on the climate change models and sea level rise scenarios considered in this plan. The likely ranges discussed above fall within these sea level rise scenarios because they are based on various projections of global GHG emissions. The probabilities also take into account uncertainties related to each of these scenarios.

As previously discussed, the *Rising Seas in California: An Update on Sea-Level Rise Science* guidance document identifies an extreme sea level rise scenario (H++). This scenario projects 10.2 feet of sea level rise by 2100 based on a trajectory of high GHG emissions and an accelerated rate of Arctic and Antarctic ice sheet loss (Griggs et. al. 2017). There is a high level of uncertainty associated with the H++ scenario (as well as all the sea level rise projections and timing) and given the emerging nature of sea level rise science, these estimates are intended to be used as a guide only and are subject to refinement over time. If this extreme sea level rise scenario were to occur, the modeled elevations of sea level rise and associated hazards could be experienced substantially sooner than the projected horizon year.

Table 4-32: Sea Level Rise Projections for San Francisco Bay Area

Projected Horizon Year / Time	66% Probability SLR meets or exceeds	0.5% Probability SLR meets or exceeds	H++ Extreme SLR Scenario (no probability assigned)
2030	0.5 ft	0.8 ft	1.0 ft
2050	1.1 ft	1.9 ft	2.7 ft
2080	2.4	4.5	6.6 ft

2100	2.4-3.4 ft	5.7-6.9 ft	10.2.ft

Note: Probabilities based on projections by the OPC for both low and high GHG emissions scenarios at the San Francisco tide gauge (Griggs et. al. 2017).

Taking the current and best available climate science and projection information into account, the probability of future occurrence of rising sea levels is expected to increase over time from a 1 and 10 percent chance occurrence in the next year to between a 10 and 100 percent chance of occurrence in the subsequent planning cycle for this LHMP, particularly as the modelled and actual levels of sea level rise more rapidly in the next half century.

Climate Change Considerations

As ocean temperatures warm as a result of climate change, the water in the ocean expands and occupies more volume, resulting in a rise in sea levels. In addition, global sea levels rise from the additional volume of water added to the oceans from the melting of mountain glaciers and ice sheets on land. The rate at which sea levels will rise is largely dependent on the melting of the ice, which changes the land cover from a reflective ice surface to open ocean water; the ocean continues to absorb more of the sun's energy and subsequently increases the rate of ice melt. In other words, sea level rise is a direct consequence of climate change. However, the uncertainties associated with the rate at which ice melt occurs is largely responsible for the wide variation in sea level rise projections in the latter half of this century (i.e., between 2050 and 2100) and explain the H++ scenario.

The time scales for sea level rise are related to complex interactions between the atmosphere and the oceans, delays in stabilizing GHG levels in the atmosphere, and the dissolution of those gases into the ocean. The Intergovernmental Panel on Climate Change (IPCC) has published scientific evidence that sea levels will be rising for the next several thousand years due to the GHGs that have already been released into the atmosphere. Much of the scientific advancement in recent years has been in understanding the contribution and rate of ice melt to global sea levels. Studies also show the potential for extreme sea level rise resulting from rapid acceleration of ice melt as noted under the H++ scenario. In general, the higher the GHG emissions, the higher the temperature, the more rapid the ice melt, and the higher the rate of sea level rise. For these reasons, climate change would have a "high" influence on future sea level rise.

Vulnerability Assessment

The vulnerability to sea level rise within the City of Petaluma Planning Area relies on the best available science and modeling and methodology from a range of sources including FEMA and the *OPC 2018 State of California Sea-Level Rise Guidance Update* (OPC 2018). Data was derived from the USGS CoSMoS Version 2.1 model, and previous studies that quantify historic rates of coastal storms and provide evidence for future trends (NOAA 2019b; USGS 2018). This assessment is further guided by FEMA's *Local Mitigation Planning Handbook* (2013), which provides strategies to describe and quantify hazards risk in the context of individual jurisdictions. As previously discussed, sea level rise modeling used for the vulnerability assessment assumes some level of shoreline protection or adaptation strategies, such as levees or floodwalls are in place. Additional adaptation actions, such as floodplain management and engineering solutions could substantially change the flood extent associated with sea level rise.

For the vulnerability assessment, the City of Petaluma HMPC wanted to model the 30-year and 50-year sea level rise scenarios both with and without the 100-year coastal storm event. Given sea level rise projections linked to planning horizons can change with new scientific data, the sea level rise scenarios were selected based on sea level rise elevation. The probabilistic projections based on the high emissions scenario (business as usual) for 2050 and 2070 translates to 1.1 foot by 2050 and 1.9 feet by 2070 (or 2.4 feet by 2080 as shown in Table 4-31), both which have a 66 percent probability of occurrence. The conservative approach for 2050 and 2070 have a 0.5 percent probability of occurrence and translate to 1.9 feet by 2050 and 4.0 feet by 2070 (or 4.5 feet by 2080 as shown in Table 4-31). The City HMPC also considered one conservative scenario to assess potential future impacts to critical infrastructure. These projection recommendations roughly convert to the 25 cm (1 foot or 0.25 meters), 75 cm (2.7 feet or 0.75 meters), and 200 cm (6.6 feet or 2 meters) sea level rise datasets provided in the CoSMoS 2.1 model. As shown in Table 4-31, these can these three elevations could apply to a range of sea level rise projections and associated planning years.

A GIS overlay analysis was performed to determine parcels and critical facilities that may be affected by sea level rise based on three inundation layers from the CoSMoS 2.1 model. The GIS analysis conducted follows the same methodology used with other hazard layers assessed in this plan, where the hazard layer is overlaid with critical facilities or parcel centroids, all of which are shown as points. The parcel centroids are determined based on developed parcel polygons, so that each parcel or critical facility either falls in or outside of each hazard area based on the spatial analysis intersection performed.

For this overlay analysis the 25 cm, 75 cm, and 200 cm datasets of sea level rise inundation data were used, based upon currently available (November 2019) modeling representative of the best available science and on the CoSMoS Version applicable to the City of Petaluma area, which is version 2.1 (USGS CoSMoS 2.1). This dataset provides detailed projections of tidal inundation, which refers to the predicted average annual tidal inundation conditions. It also includes detailed projections of coastal flood hazards, which refers to the 100-year coastal flood event that accounts for coastal wave and storm surge intervals, for the area north of Golden Gate Bridge in San Francisco Bay.

Scenarios within this area of interest are consistent with the full spectrum of sea level rise (0 to 2 meters, 5 meters) and storms (daily to 100-year return) used on the outer coast. However, storm events used inside the Bay were derived from numerically modeled wind-wave heights driven by wind projections from one Global Climate Model (GCM) known as the Geophysical Fluid Dynamics Laboratory Earth System Model 2M (USGS 2019). These scenario and specification options allow flexibility for managers to specify degrees of risk tolerance based on future projections as well as geographic variability in the study areas on the coast. CoSMoS models all relevant physics of a coastal storm, such as tides, waves, and storm surges, which are then scaled down to local flood projections for use in community-level coastal planning and decision-making processes (USGS 2019). Also, rather than relying on historic storm records, the CoSMoS model uses wind and pressure from GCMs to project coastal storms under changing climatic conditions during the 21st century (USGS 2019).

CoSMoS Version 2.1 is the most recent version of the program modeling to date, and is based on GCMs developed by the IPCC which considers region-specific factors such as oceanographic conditions, backshore types (beach, bluff or estuarine), long-term changes in the shoreline, river and stream drainages, wind patterns, and seasonal changes. The CoSMoS modeling identifies areas along the coast where significant flooding may occur under both a non-storm scenario (i.e. average spring tide inundation) and 100-year coastal storm scenario (i.e. coastal wave-driven 100-year flooding). With CoSMoS data, for each modeled increase in sea level elevation, there is a minimum, average and maximum range of uncertainty that is accounted for in the model. The maximum uncertainty scenario was modeled, which includes conservative assumptions for marsh accretion, subsidence, and vegetation. The H++ scenario was also used for the purposes of this analysis, and effectively models a worst-case scenario for each given sea level rise scenario.

The analysis includes three ranges of sea level rise across the two scenarios used: one with 100-year coastal storm event flooding and one without it (i.e. no storm, equivalent to the average annual tidal inundation), to take into account the high degree of uncertainty associated with predicting when and at what rate sea level rise will occur. Sea level rise scenarios selected for the analysis are based on projections for the City of Petaluma and according to the OPC's *State of California Sea Level Rise Guidance* (OPC 2018) under a worst case, or extreme risk aversion scenario (H++ scenario within Table 4-32 above). The scenarios were selected for analysis as the intent is to identify infrastructure and critical facilities that could be irreversibly damaged by sea level rise, or would be significantly costly to repair, and hence carry considerable impacts to public safety, health, or environmental resources. The first phase of analysis models property and critical facility exposure to an average annual tidal inundation at the following increments:

- Area extent of average annual tidal inundation with 25cm (approximately 1.0 ft) increase in sea level rise
- Area extent of average annual tidal inundation with 75cm (approximately 2.7 ft) increase in sea level rise
- Area extent of average annual tidal inundation with 200cm (approximately 6.6 ft) increase in sea level rise[1]

These hazard zones show the projected maximum extent of what will be regularly flooded by average annual tidal movements under the selected sea level rise elevations. The three elevations in sea level rise (25, 75, and 200 cm) were also selected to apply to a range of sea level rise projections and their associated planning year.

The second scenario of analysis uses the same sea level rise elevations previously described but on top of it models the area extent of inundation associated with a 100-year coastal storm event (or 1 percent annual chance of a coastal flood, based on a wave storm surge event). The addition of the flooding worsens the extent of the overall inundation and represents how coastal and estuarine flooding will be exacerbated by sea level rise in the future.

- Area extent of flooding from 100-year coastal storm event with 25cm (approximately 1.0 ft) increase in sea level rise
- Area extent of flooding from 100-year coastal storm event with 75cm (approximately 2.7 ft) increase in sea level rise
- Area extent of flooding from 100-year coastal storm event with 200cm (approximately 6.6 ft) increase in sea level rise

An exposure analysis was performed to identify the counts of improved properties, values of those properties, and critical facilities located within the six scenarios. The number of parcels and critical facilities were then aggregated by parcel type or critical facility type and category. Improved value totals for parcels in Petaluma were calculated by adding the improved values of the parcels of each type, as summarized in the following tables. As a clarification, improved values are the values of the developments in the parcels, or improvements, not land value. The analysis does not predict damage loss, as property and content values may change in the future, and it is assumed that some property will eventually be relocated or removed prior to permanent inundation. The analysis also does not account for undeveloped parcels that might be permanently inundated by sea level rise in the future since there are not improvements accounted for with those parcels. The inundation events become progressively more extensive with the addition of the deeper sea level rise levels, thus a property or critical facility that is

[1] 6.6 feet of sea level rise under the H++ scenario is not projected to occur until 2080.

inundated in the 25 cm and 75 cm scenarios is also inundated in the 200 cm scenario (if applicable), and is totaled as such unless noted otherwise.

General Property

Public and private property vulnerable to sea level rise generally includes buildings and infrastructure built within the salt marshes in the central and eastern portions of the City's Planning Area. Vulnerable private development primarily includes residential and commercial buildings in, as well as some agricultural lands along Highway 116 towards the unincorporated community of Lakeville.

Table 4-33 and Table 4-34 depict the count of exposed parcels and values of improvements within the City's Planning Area on those parcels for the sea level rise scenarios, both with and without the 100-year coastal storm event for the 75 cm and 200 cm scenarios. There were no risks to parcels within the Planning Area under the 25 cm scenario with the average annual tidal inundation or the 100-year coastal storm event. Those parcels inundated by the provided scenarios are depicted in Figure 4-35 and Figure 4-36.

Table 4-33: Parcels Exposed to Average Annual Tidal Inundation with Sea Level Rise

Sea Level Rise Event	Parcel Type	Total Parcels	Improved Value	Content Value	Total Value	Population at Risk
25 cm	NA	0	0	0	0	0
75 cm	Commercial	1	$4,481,126	$4,481,126	$8,962,252	--
TOTAL		**1**	**$4,481,126**	**$4,481,126**	**$8,962,252**	**0**
200 cm	Commercial *	32	$64,260,591	$64,260,591	$128,521,182	
	Residential	56	$18,030,947	$9,015,474	$27,046,421	150
	Multi-Family	2	$26,118,842	$13,059,421	$39,178,263	5
TOTAL		**90**	**108,410,380**	**86,335,486**	**$194,745,866**	**155**
GRAND TOTAL		**90**	**$112,891,506**	**$90,816,612**	**$203,708,118**	**155**

* The 75 cm Commercial parcel is considered in the 200 cm category as well, since it overlaps with the larger inundation layer (meaning that this same parcel is inundated by both scenarios). Therefore, the grand total is the same as the total under the average annual tidal inundation with 75 cm of sea level rise scenario.

Source: CoSMoS v2.1, City of Petaluma, Sonoma County Assessor, U.S. Census, Wood Plc analysis

Table 4-34: Parcels Exposed to 100-Year Coastal Storm Event Inundation with Sea Level Rise

Sea Level Rise Event	Parcel Type	Total Parcels	Improved Value	Content Value	Total Value	Population at Risk
25 cm	NA	0	0	0	0	0
75 cm	NA	0	0	0	0	0
200 cm	Commercial	138	$197,452,315	$197,452,315	$394,904,630	--
	Multi-Family	17	$77,390,564	$38,695,282	$116,085,846	46
	Residential	228	$51,627,780	$25,813,890	$77,441,670	611
TOTAL		**383**	**$326,470,659**	**$261,961,487**	**$588,432,146**	**657**

Source: CoSMoS v2.1, City of Petaluma, Sonoma County Assessor, U.S. Census, Wood Plc analysis

According to the parcel analysis, there was little to no risk to existing development under both the 25 cm and 75 cm scenarios. The majority of the risk impacts were under the 200 cm scenario, which is considered the high-risk aversion situation. This scenario also did not account for adaptation actions in the analysis. For the risks under the 200 cm scenario, the greatest vulnerability from the sea level rise scenarios occurs along the Petaluma River in the central and eastern portions of the Planning Area and within downtown Petaluma. The highest number of parcels exposed to this hazard are residential (with a total of 58 of type "residential" and "multi-family" in the tidal inundation analysis, and 245 in the sea level rise plus the 100-year coastal storm event), followed by 32 commercial parcels in the tidal inundation scenario (1 of which falls in both 75cm and 200cm flooding extents), and 138 in the sea level rise plus the 100-year coastal storm event. The commercial parcels account for the highest total values at risk of sea level rise, with around $532 million between both tidal inundation and sea level rise plus the 100-year coastal storm event scenarios. Overall, there are $203.7 million at risk in the tidal inundation scenario, and $588 million at risk in the sea level rise plus the 100-year coastal storm event from parcel total values, as summarized in Table 4-33 and Table 4-34 above. As displayed in Figure 4-35 and Figure 4-36 below, there are parcels exposed to the sea level rise plus 100-year coastal flood event in the City's downtown area, to the east of Western Avenue, south of the Petaluma River.

The results of the parcel analysis are projected estimates based on available data and modeling results, which are subject to change according to the actual rate of sea level rise and the frequency and duration of coastal storms. They also do not account for the implementation of future adaptation actions, such as floodplain management activities or the construction of structural projects, such as floodwalls and levees. Sea level rise alone is not anticipated to be the primary cause of damage, but rather sea level rise as it exacerbates existing flood and coastal hazards, including damage caused by severe storms and the frequency, duration, and extent of tidal flooding. The implementation of future mitigation strategies may minimize these impacts.

Figure 4-35: Parcels Exposed to Average Annual Tidal Inundation with Sea Level Rise

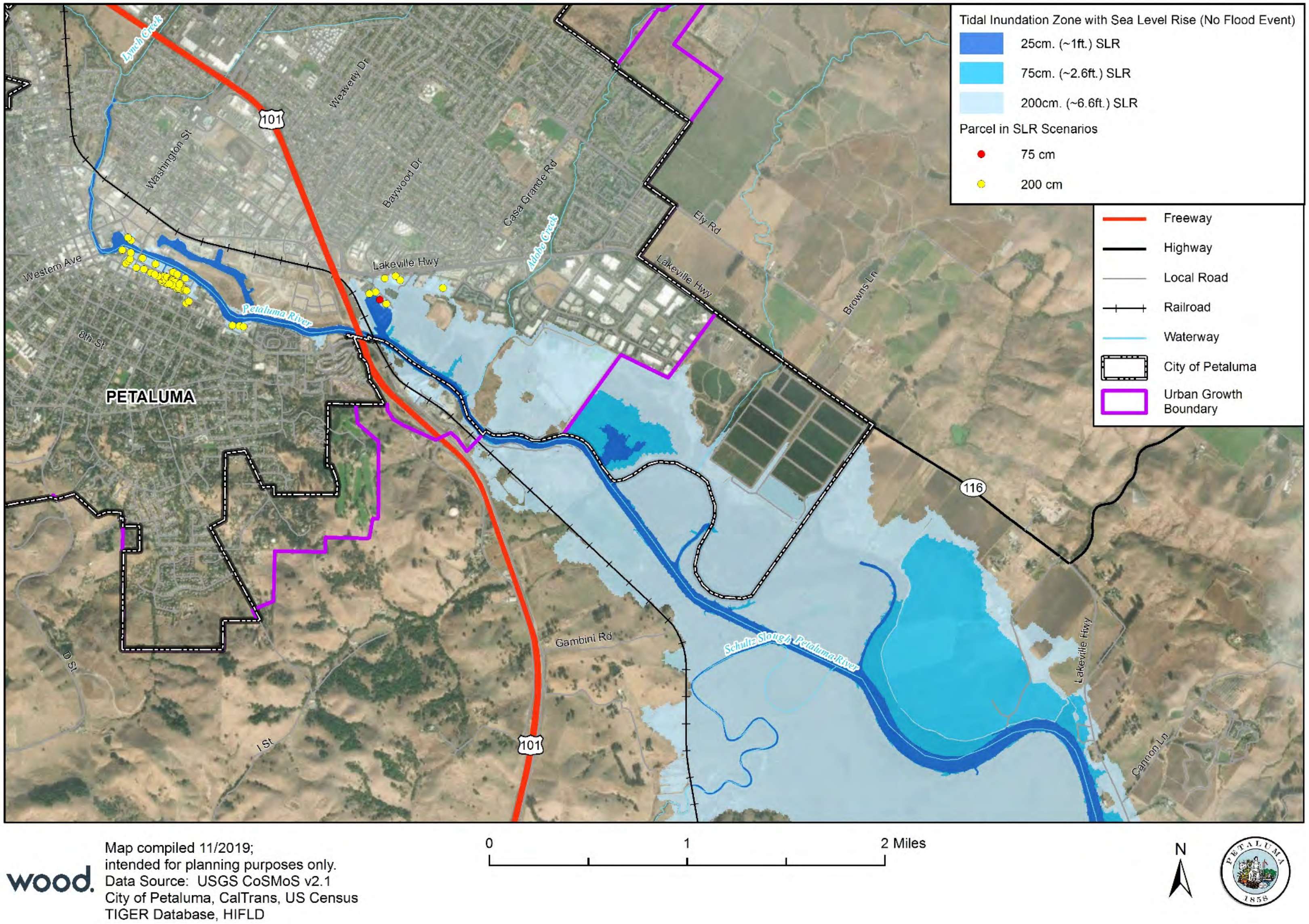
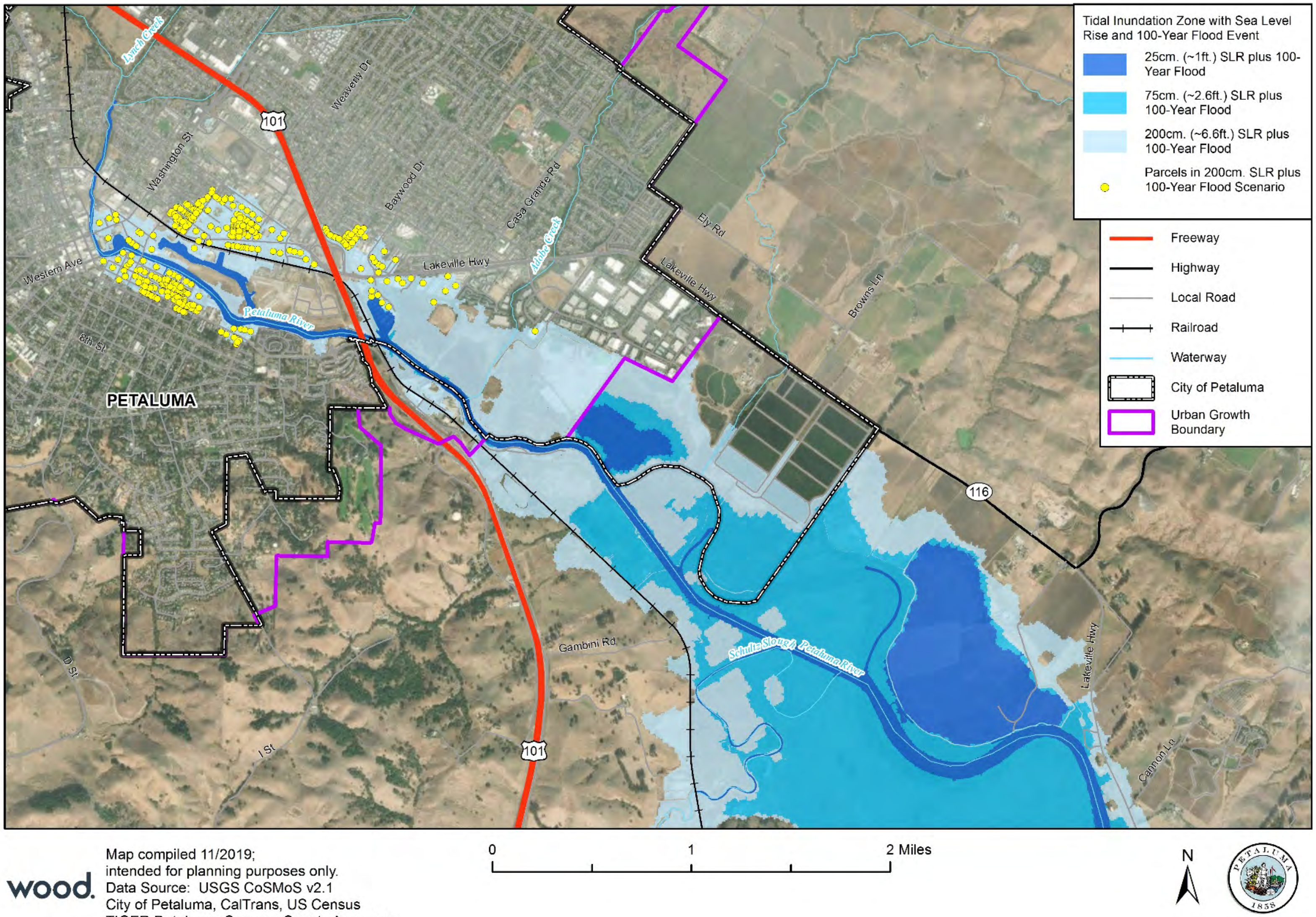


Figure 4-36: Parcels Exposed to 100-Year Coastal Storm Event Inundation with Sea Level Rise



Map compiled 11/2019;
intended for planning purposes only.
Data Source: USGS CoSMoS v2.1
City of Petaluma, CalTrans, US Census
TIGER Database, Sonoma County Assessor

People

Some populations are more vulnerable to flooding and sea level rise impacts due certain sensitivities, an increased likelihood of exposure, or a lower adaptive capacity (Public Health Institute Center for Climate Change and Health 2016). Demographic characteristics including health conditions that affect physical ability, or socioeconomic factors that amplify risk factors for poor health conditions, may affect the abilities of individuals or households to prepare for, respond to, and recover from coastal hazards (EPA 2017). Specific attributes may create additional stresses on individuals and communities resulting in reduced resiliency in the event of a flooding hazard event. Many of these factors may also be exacerbated by the specific, localized nature of flooding, erosion, and other impacts associated with sea level rise.

Based on the parcel analysis summarized in Table 4-33 and Table 4-34 above for the 75 and 200 cm scenarios, it estimated that a total of 155 people may be exposed to the tidal inundation with sea level rise scenario, while 657 people may be at risk under the 100-year coastal storm event with sea level rise. These population totals were estimated by multiplying the average persons per household value based on current U.S. Census figures (which is 2.68 per home) by the total parcels of residential nature in the City. Two people are at risk based on the “multi-family” category in the tidal inundation scenario, and 17 in the 100-year coastal storm event with sea level rise scenario; the remaining exposed populations fall under the general “residential” category, and 56 of those are found in parcels within the tidal inundation extents, while 228 fall in the 100-year coastal storm event with sea level rise scenario extents.

The downtown area of the City of Petaluma and areas along the Petaluma River with a high Social Vulnerability Index (SVI) inform which communities are more susceptible to adverse impacts of flooding and sea level rise. Based on the SVI data presented and discussed in Subsection 2.5, populations in downtown Petaluma are expected to be highly vulnerable to the hazards discussed herein. Again, these results do not account for adaptation actions under consideration by the City.

Critical Facilities and Infrastructure

Critical facilities that are vulnerable to sea level rise may include assets related to public transportation, wastewater treatment and water supply infrastructure, schools, law enforcement facilities, and community centers, among others. Essential education facilities such as the Valley Oaks Elementary and High School or the San Antonio High School may be subject to flooding exacerbated by future sea level rise. Law enforcement facilities in close proximity to the Petaluma River also prove vulnerable to flooding.

Regional and local-serving public and utility infrastructure vulnerable to sea level rise include roads, bridges, railroad lines and crossings, wastewater treatment plants, culverts, water lines, communication line and towers, stormwater outlets, bike lanes, bike facilities, airports, and fiber optic lines. Utility infrastructure containing hazardous materials that are vulnerable to sea level rise include hazardous material facilities, underground tanks, and the City’s Wastewater Treatment Plant (Hopper Street Sewer Plant). Facilities that are impacted by flood hazards that may be exacerbated by sea level rise could also result in a release of hazardous materials or deteriorating water or air quality, as well as disruption to key public and utility services to the wider community. Low-lying transportation infrastructure is vulnerable to the impacts of sea level rise, including City roads and state highways in the unincorporated portion of Sonoma County. Vulnerable roads may include short sections of U.S. Highway 101 and State Highway 116.

Based on the GIS overlay analysis conducted with the critical facility layer, the following nine facilities and structures were found to be vulnerable under the 200 cm sea level rise scenario with the 100-year coastal storm event (though several of those are also vulnerable to the average annual tidal inundation with sea level rise scenario, as indicated in the subsequent tables):

- Petaluma Fire Department Station Number 1 & Emergency Medical Service Station
- Fire Station 1 (Headquarters)
- San Antonio High School
- Valley Oaks Elementary and High School
- Petaluma Marina
- Parks and Recreation Maintenance Building
- Petaluma Station C
- Hopper Street Sewer Plant (specifically two of the storage ponds)
- D Street Bridge House

However, the inundation extent shown in the following two maps (Figure 4-37 and Figure 4-38) shows that that the Ellis Creek Water Recycling Facility ponds and other property assets may also be at risk of potential future damages. Wastewater treatment plants and related infrastructure located in low-lying areas along the Petaluma River and near the southern portion of the City's Planning Area may be vulnerable to projected sea level rise, but according to the HMPC only the Ellis Creek Water Recycling Facility storage ponds would be affected and the plant is expected to remain operation during flooding (Walker 2020). In the tidal inundation with sea level rise scenario there are five exposed facilities, including the Historic Drawbridge, which also falls in the 75 cm extent, and the others in the 200 cm event. In the 100-year coastal storm event plus sea level rise scenario there are nine facilities falling in the 200 cm extent, falling under all four of the facility categories (2 in the Emergency Services, 4 in the High Potential Loss Facilities, 2 in the Lifeline Utility Systems, and 1 in the Transportation Systems category). Results are displayed in Figure 4-37 and Figure 4-38.

Table 4-35 summarizes the critical facilities in the average annual tidal inundation with sea level rise extent for both the 75 cm and 200 cm scenarios, while Table 4-36 summarizes those nine facilities within the 100-year coastal storm event with sea level rise for both the 75 cm and 200 cm scenarios (which were previously included in the bullet list above, based on the facility name). No critical facilities were within the average annual tidal inundation with 25 cm of sea level rise or the 100-year coastal storm event with sea level rise scenarios.

Table 4-35: Critical Facilities Exposed to Average Annual Tidal Inundation with Sea Level Rise

Sea Level Rise Event	Critical Facility Category	Critical Facility Type	Total Critical Facilities
25 cm	NA	NA	0
75 cm	Transportation Systems	Historic Drawbridge	1
TOTAL			**1**
200 cm	Emergency Services	Emergency Medical Service Station	1
		Fire Station	1
	High Potential Loss Facilities	Community/Recreation Center	1
	Lifeline Utility Systems	Electric Substations	1
	Transportation Systems	Historic Drawbridge	1
TOTAL			**5**
GRAND TOTAL			**5**

Source: CoSMoS v2.1, City of Petaluma, HIFLD, Wood Plc analysis

Table 4-36: Critical Facilities Exposed to 100-Year Coastal Storm Event Inundation with Sea Level Rise

Sea Level Rise Event	Critical Facility Category	Critical Facility Type	Total Critical Facilities
25 cm	NA	NA	0
75 cm[1]	NA	NA	0
200 cm	Emergency Services	Emergency Medical Service Station	1
		Fire Station	1
	High Potential Loss Facilities	Community/Recreation Center	1
		Government/Admin	1
		Public Schools	2
	Lifeline Utility Systems	Electric Substations	1
		Wastewater Treatment Plant	1
	Transportation Systems	Historic Drawbridge	1
TOTAL			**9**

[1] - The Historic Drawbridge was subject to tidal inundation with 75 cm of sea level rise, but because the 75 cm with the 100-year coastal storm event is based on different CoSMoS model inputs the Historic Drawbridge was not within this sea level projection.

Source: CoSMoS v2.1, City of Petaluma, HIFLD, Wood Plc analysis

Figure 4-37: Critical Facilities Exposed to Average Annual Tidal Inundation with Sea Level Rise

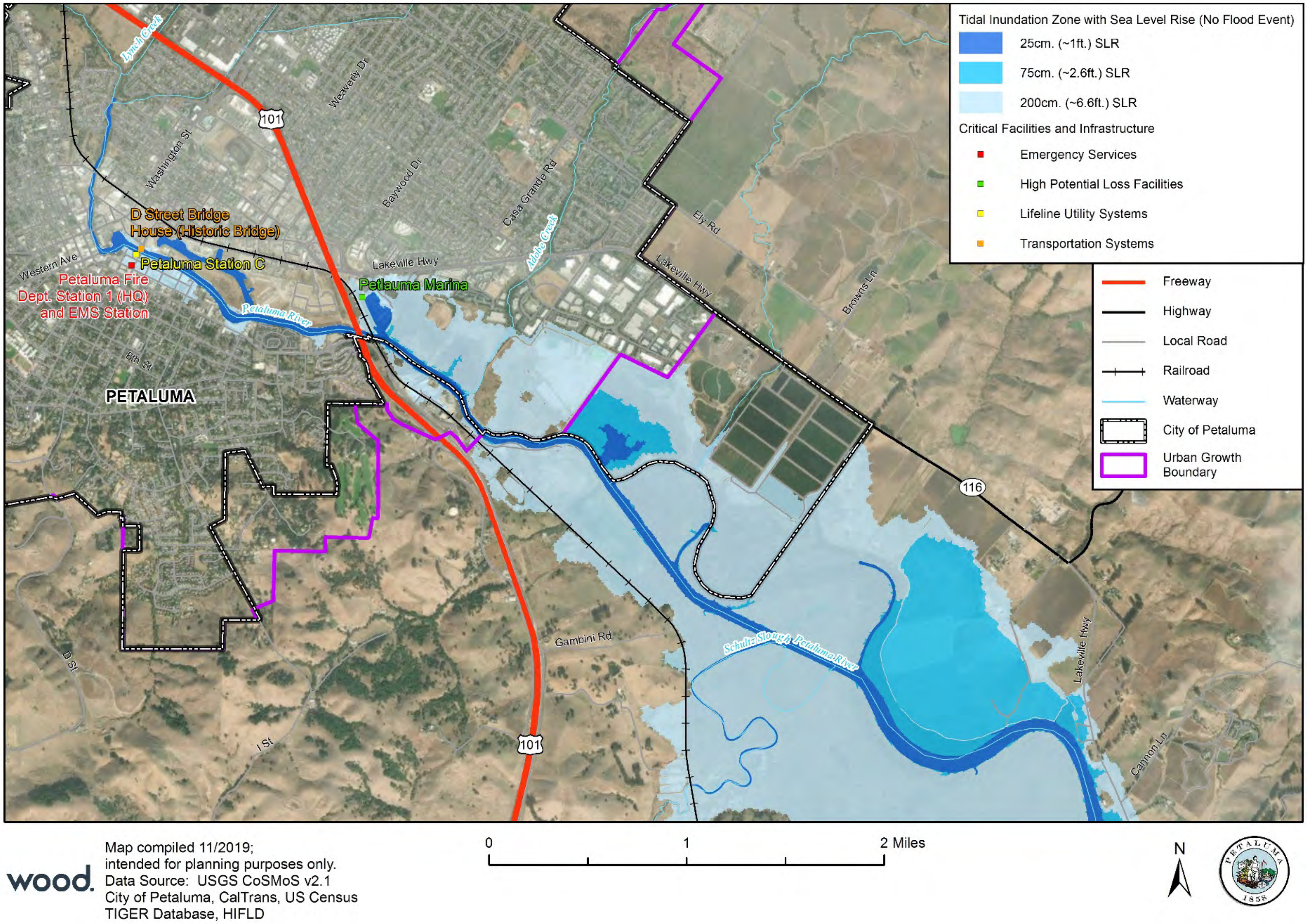
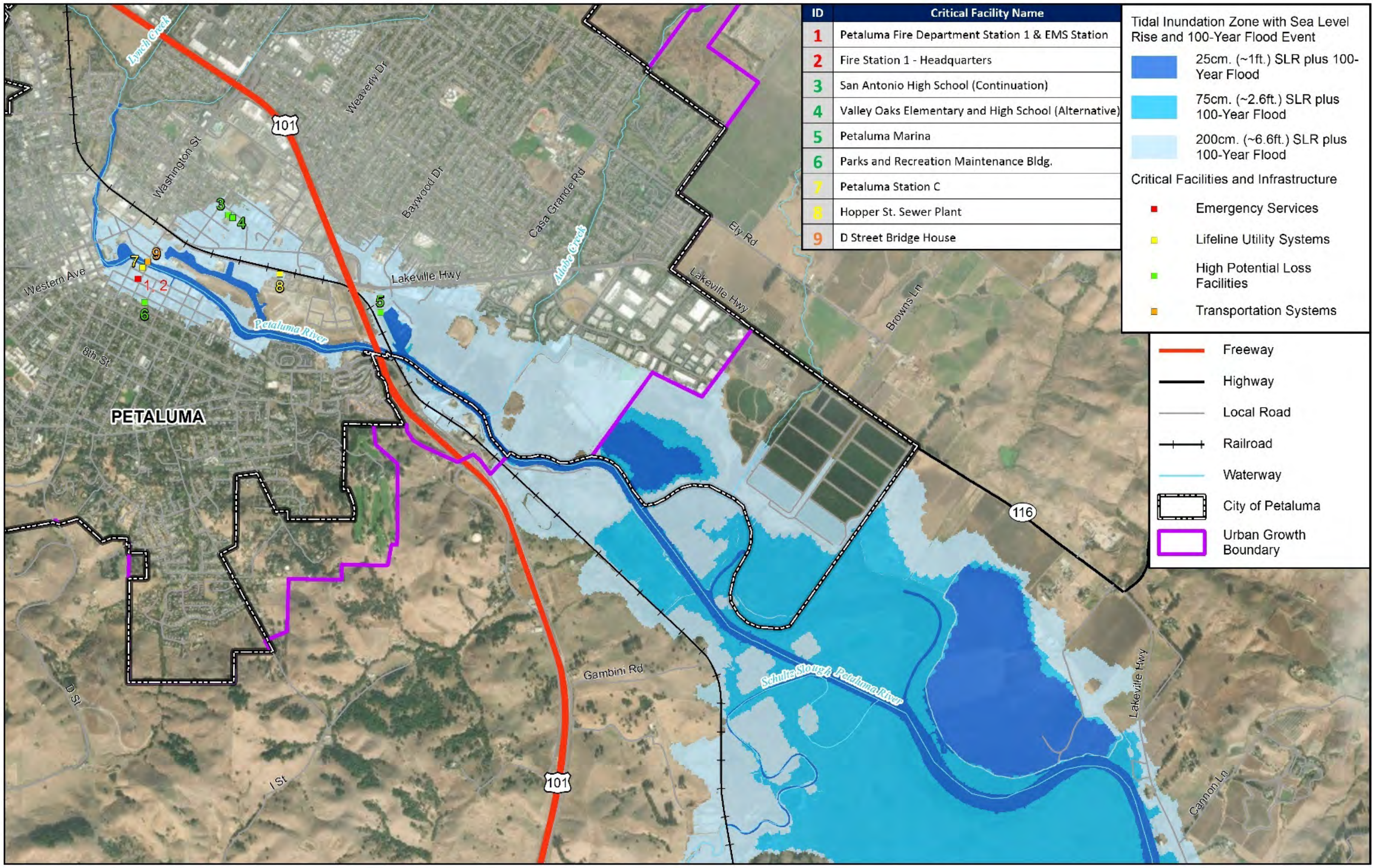


Figure 4-38: Critical Facilities Exposed to 100-Year Coastal Storm Event Inundation with Sea Level Rise



ID	Critical Facility Name
1	Petaluma Fire Department Station 1 & EMS Station
2	Fire Station 1 - Headquarters
3	San Antonio High School (Continuation)
4	Valley Oaks Elementary and High School (Alternative)
5	Petaluma Marina
6	Parks and Recreation Maintenance Bldg.
7	Petaluma Station C
8	Hopper St. Sewer Plant
9	D Street Bridge House

0 1 2 Miles

wood. Map compiled 11/2019; intended for planning purposes only.
Data Source: USGS CoSMoS v2.1
City of Petaluma, CalTrans, US Census
TIGER Database, HIFLD

Economy

The major economic industries in the City include retail; arts, entertainment, tourism accommodations and food services; and construction and manufacturing (ACS 2017). Developed areas in the City of Petaluma that are important to tourism include the historic downtown, as well as the Petaluma Marina. Undeveloped areas that are important to tourism include the park and open space areas, such as Steamer Landing Park and Shollenberger Park. Many Petaluma businesses depend on tourism and sales tax revenues. Flooding impacts to the historic downtown, to the north end of the City, and around the marina that are exacerbated by projected sea level rise could decrease economic activity and affect the local economy.

The Petaluma Marina is a popular access point for recreation activities, such as boating, water skiing, and fishing and may be impacted by rising sea levels, which could in turn also impact the local economy. *Photo Credit: Petaluma Star*

Historic, Cultural, and Natural Resources

Historic resources within Petaluma's downtown, include locally designated historic landmarks, nationally registered historic sites and landmarks, the historic commercial district, and important habitat resource areas. Historic resources close to Petaluma River include the historic commercial district, local historic residential homes, the Old Petaluma Opera House, and Public Library.

While sea level rise may have little effect on historic and cultural resources, the combination of sea level rise, shifting precipitation patterns, and the frequency and intensity of storms can have effects on coastal ecosystems, including salt marshes located within the southern portion of the City's Planning Area. However, the salt marshes located within the southern portion of the City are currently designated as open space and parks and restricted from future urban development. While these salt marshes may be semi-permanently inundated in the future, they will also provide a beneficial value, such as functioning as a natural buffer from tidal inundation that may reduce sea level rise impacts within the City. Nonetheless, the combined influence of sea level rise and flood hazards may also result in species and habitat impacts, specifically the migration of species to different elevations, or a transition to different habitat types, but more resilient species may adapt.

A study underway by USGS and Western Ecological Research Center (WERC) research ecologists has begun modeling sea level rise in the San Francisco Bay Estuary, including the San Pablo Bay National Wildlife Refuge. In 2009 and 2010, elevation and vegetation points survey points were collected in the salt marsh at 12 study sites around San Francisco Bay providing land owners with informative baseline data on current sea levels. Two of the twelve study sites are located along the Petaluma River, including the Gambinini and Petaluma marshes. Currently the percent of time the Gambinini and Petaluma Marsh is inundated varies throughout the year by season, with the most inundation during the winter (USGS 2018).

As part of the study, a marsh accretion model, referred to as WARMER, was developed to assess risk of sea level rise to salt marshes in San Francisco Bay. According to the WARMER model most salt marsh around San Francisco Bay could transition from high to mid marsh by 2040, to low marsh by 2060 and to mudflat by 2080, but the model accounts for variation around the Bay Area.

Future Development

The vulnerability of future development to rising sea levels would be similar to the vulnerability assessment findings discussed in flood hazards in Section 4.3.5. As mentioned in that section, the development trend in the City of Petaluma Planning Area is steady. The City is expected to grow by 3.2 percent in the next 5 years, to an estimated total of 62,700 people.

The potential for flooding may increase as stormwater is channelized due to land development, and it may be intensified due to sea level rise. Floodplain modeling should account for sea level rise projections and infill development and master planning should be based on buildout land use to ensure that all new development remains safe from future flooding. While certain local floodplain management and water quality regulations and policies exist, as well as specific regulatory control of building codes, flood insurance requirements, and other such aspects at the federal or state level, the cumulative effects of flood and sea level rise related hazards can have a negative impact on the floodplain and the community into the future. Water and flood control infrastructure such as dams, floodwalls, and levees and local storm drainage systems can become stressed due to increased development. Future development may also stress the municipal water supply needs when coupled rising sea levels and changing weather conditions that become more unpredictable.

Risk Summary

- Overall, the significance of sea level rise is **Medium** based on current and best available science that currently indicates this hazard is already a prominent hazard now and in the next half century.
- Future sea level rise may exacerbate flood hazards in the City's Planning Area and is projected based on the best available science and modeling.
- There is no risk to very low risk under the average annual tidal inundation with 25 cm and 75 cm of sea level rise and no risk to very low risk under the 100-year coastal storm event with 25 cm and 75 cm of sea level rise scenarios. This is largely due to the protection of the salt marshes located within the southern portion of the City's Planning Area.
- Average annual tidal inundation in combination of up to 200 cm in sea level rise would put 90 parcels at risk, with one falling in the 75 cm of sea level rise extent and the other 89 within the 200 cm of sea level rise extent, which is more extreme projection scenario. Most of these exposed parcels are residential in nature. The total values at risk amount to $203.7 million. The model and analysis assumed no adaptation strategies such as levees, floodwalls, or other floodplain management or engineering solutions would be in place. The implementation of adaptation actions would minimize impacts.
- Under the 100-year coastal storm event with 200 cm of sea level rise scenario, 228 single family residential and 17 multi-family parcels would be impacted by rising sea levels, followed by 138 commercial parcels (all of which fall in the 200 cm event extent). The commercial parcels account for the highest total values at risk of sea level rise, with $394.9 million. Overall there are $588.4 million at risk in parcel total values, including the residential and multi-family parcels.
- Approximately 155 people may be at risk under the average annual tidal inundation in combination with up to 200 cm of sea level rise scenario.
- A total of 657 people may be at risk of inundation under the 100-year coastal storm event with 200 cm of sea level rise scenario; these totals are based on multiplying the average persons per household value by the total parcels of residential nature in the City.

- Five critical facilities are exposed to the average annual tidal inundation with up to 200 cm of sea level rise, and nine would be exposed to flooding with a 100-year coastal storm event when combined with up to 200 cm of sea level rise. Facilities at risk include emergency services, high potential loss facilities, lifeline utility facilities, and transportation systems.
- Rising sea levels alone are not anticipated to be the primary cause of vulnerabilities and potential damages to resources, property and infrastructure within the City; rather impacts may be caused by severe coastal storm patterns that may increase in frequency and duration as a result of sea level rise and climate change.
- If sea levels continue to rise at higher projected rates, flooding impacts that already occur during large coastal storm events could become more frequent, as predictable high tides may regularly inundate low-lying tidal marsh areas located within the southern portion of the City Planning Area.
- Given the sea level rise vulnerability assessment does not account for the incorporation of adaptation actions, floodplain management programs and the implementation of structural adaptation projects, such as levees and floodwalls should minimize impacts.

4.3.7 Severe Weather: General

Severe weather is generally any destructive weather event, but usually occurs in the Planning Area as localized thunderstorms that bring heavy rain, hail, lightning, high winds, and dense fog. Severe weather can also include extreme heat events.

The NOAA NCEI has been tracking severe weather since 1950. Their Storm Events Database tracks severe weather events on a county basis and contains data on the following: all weather events from 1993 to current (except from 6/1993-7/1993); and additional data from the Storm Prediction Center, which includes tornadoes (1950-1992), thunderstorm winds (1955-1992), and hail (1955-1992). This database contains 225 severe weather events that occurred in Sonoma County between January 1, 1950, and July 31, 2019. Table 4-37 summarizes these events.

Table 4-37: NCEI Hazard Event Reports for the Sonoma County* 1950-2019

Type	# of Events	Property Loss ($)	Crop Loss ($)	Deaths	Injuries
Debris Flow	49	25,916	20,000	1	0
Dense Fog	3	100,000	0	0	2
Dense Smoke	3	0	0	0	0
Extreme Cold/Wind Chill	2	0	0	1	0
Flash Flood	44	8,018,000	164,000	1	1
Flood	169	208,097,400	6,150,000	1	0
Frost/Freeze	3	60,000	3,000,000	0	0
Funnel Cloud	1	0	0	0	0
Hail	15	0	0	0	0
Heat	5	0	0	1	0
Heavy Rain	22	383,500	20,000,000	1	2
High Wind	71	713,500	0	2	0
Landslide	6	1,132,000	0	0	0
Lightning	2	1,000,000	0	0	0
Strong Winds	140	3,141,200	0	3	5
Tornado	13	1,558,500	500	0	1
Wildfire	10	505,000	5,000	0	1

Type	# of Events	Property Loss ($)	Crop Loss ($)	Deaths	Injuries
Total**	**558**	**$224,735,016**	**$29,339,500**	**11**	**12**

Source: NOAA's National Centers for Environmental Information https://www.ncdc.noaa.gov/stormevents/

*Note any reference to a coastal type weather event for Sonoma County has been excluded from this table.

**Losses reflect totals for all impacted areas, inclusive of Sonoma County

The NCEI table above summarizes severe weather events that have occurred in Sonoma County. Only a few of the events resulted in state and federal disaster declarations. While the HMPC recognizes these inconsistencies, this data provides value in depicting the County's "big picture" hazard environment.

As previously mentioned, several state and federal disaster declarations including the City of Petaluma have been a result of severe weather. For this plan, severe weather is broken down as follows:

- Extreme Heat
- Heavy Rain/Thunderstorm/Hail/Lightning/Dense Fog
- High Winds

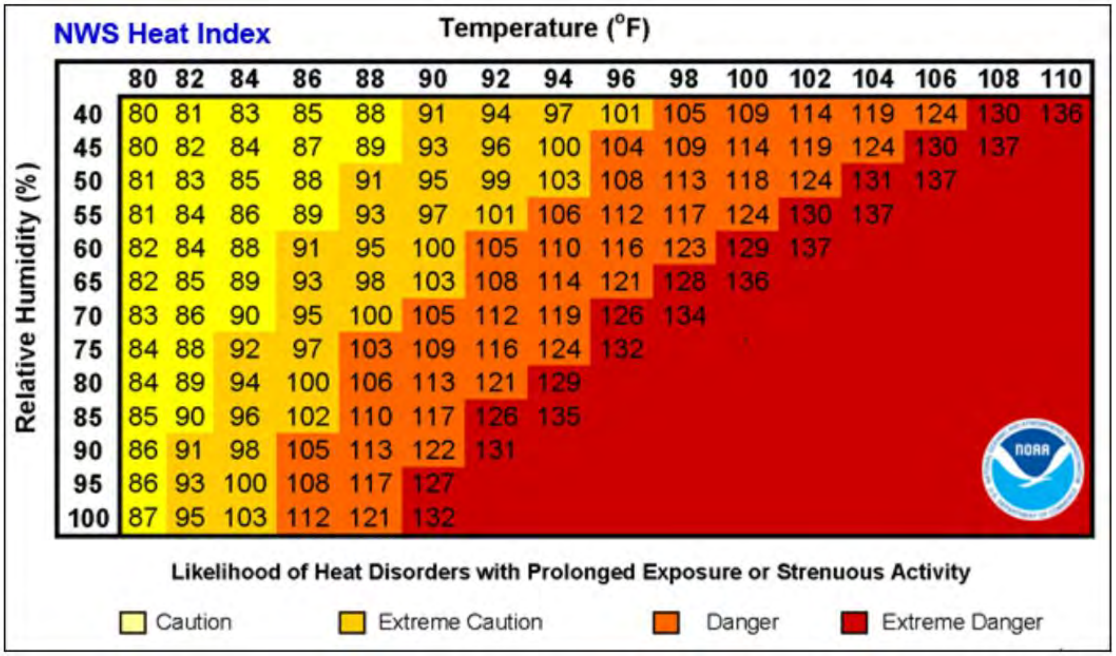
4.3.8 Severe Weather: Extreme Heat

Hazard Description

Extreme heat events can have severe impacts on human health and mortality, natural ecosystems, the agriculture sector and other economic sectors. According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. According to the National Weather Service (NWS), among natural hazards, only the cold of winter takes a greater toll nationally — not lightning, hurricanes, tornadoes, floods, or earthquakes. However, there are a lack of cold weather and extreme cold temperatures events in Sonoma County. During the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the heat wave of 1980, more than 1,250 people died. The 2018 California SHMP notes the heat wave during the summer of 2006 lead to 650 deaths in a 13-day period (Cal OES 2018), and in the past 15 years heat waves have claimed more lives in California than all other declared disaster events combined (California Climate Adaptation Strategy 2018).

Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating or a chemical (salt) imbalance caused by too much sweating. When heat gain exceeds the level the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise, and heat-related illness may develop. The elderly, small children, patients with chronic medical conditions, those on prescription medication therapy, and people with weight or alcohol problems are particularly susceptible to heat reactions, especially during heat waves in areas where moderate climate usually prevails. Figure 4-39 illustrates the relationship of temperature and humidity to heat disorders.

Figure 4-39: National Weather Service Heat Index



RH (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Source: National Weather Service

Note: Since heat index values were devised for shady, light wind conditions, exposure to full sunshine can increase heat index values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

Location

Severe weather events have the potential to happen anywhere in the Planning Area. According to the City and HMPC, extreme heat, occasional heavy rain and thunderstorms, and wind events have occurred in the City.

Extent (Magnitude/Severity)

Limited – The City of Petaluma begins to experience hot weather in June or July of each year, and the heat continues throughout the summer months. According to the Western Regional Climate Center (WRCC), the average high temperature for the City of Petaluma in July is 81.8°F. Temperatures that are 10 degrees above normal are considered excessive. The California OES Contingency Plan for Excessive Heat Emergencies (2014) indicates that through the use of historical weather and mortality data, the NWS and the California Department of Public Health (CDPH) have identified five major types of climate regions within California to account for climate differences among regions in order to recognize what constitutes an excessive heat event in each of the regions. When temperatures spike for two or more consecutive days without an adequate drop in nighttime temperature to cool the outdoor and indoor environments, there is a significant increase in the risk to vulnerable populations.

The NWS has in place a system to initiate alert procedures (advisories, watches, and warnings) when high temperatures are expected to have a significant impact on public safety. The expected severity of the heat determines which type of alert is issued. During past heat waves, the City of Petaluma has designated facilities as Cooling Centers. In 2017 the Petaluma Community Center at Lucchessi Park was designated as a City Cooling Center. The Center also accepted cats and dogs on leashes or inside appropriate pet carriers. In summary, extreme heat impacts would likely be limited in the Planning Area, with 10 to 25 percent of the Planning Area affected. Extreme heat will have an impact on vulnerable populations and could also impact livestock and crops if the event occurs during certain times of the year.

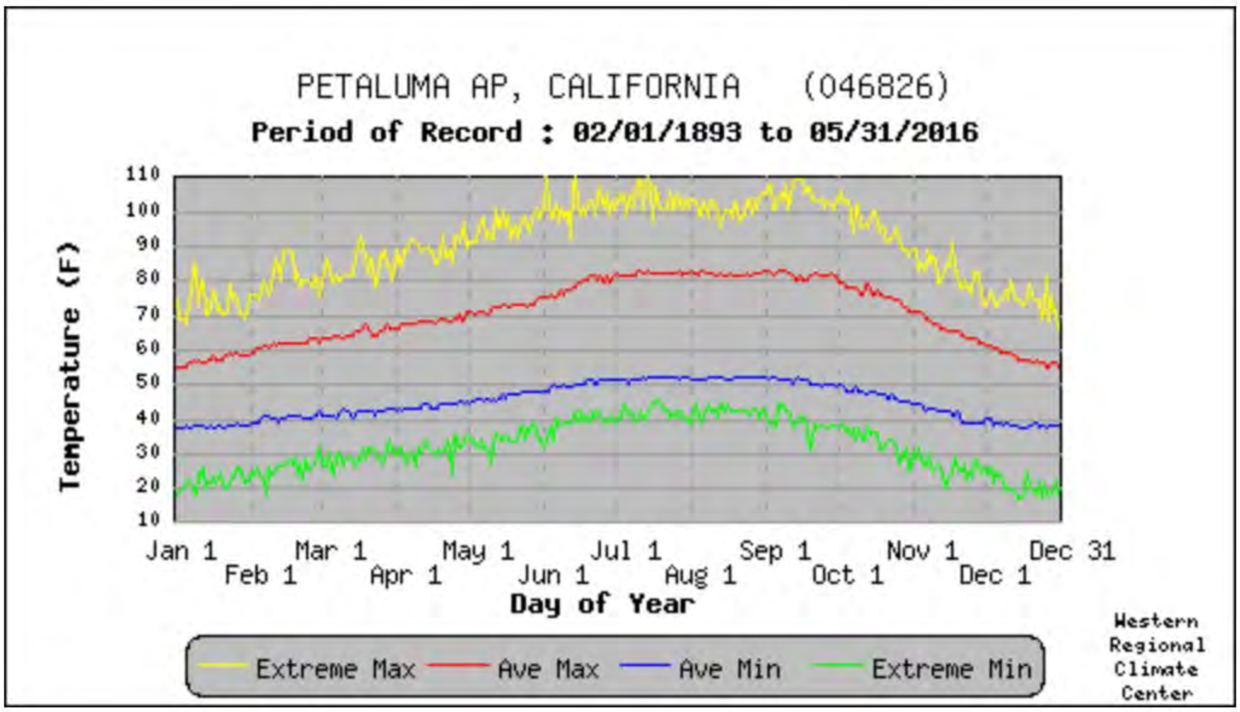
Previous Occurrences

Information from the closest weather station with the most comprehensive data, the Petaluma Fire Station 3 Weather Station (046826), is summarized below and in Figure 4-40 to illustrate daily temperature averages in the City's Planning Area.

The City of Petaluma (Petaluma Fire Station 3 Weather Station, Period of Record 1893 to 2016)

In the City of Petaluma, monthly average maximum temperatures in the warmest months (May through October) range from the mid-70s to the upper 80s. Monthly average minimum temperatures from November through April range from the upper 50s to mid-60s. The highest recorded daily extreme was 110°F on June 2, 1960. The lowest recorded daily extreme was 16°F on December 14, 1932. In a typical year, maximum temperatures do not exceed 81°F and minimum temperatures do not fall below 40°F.

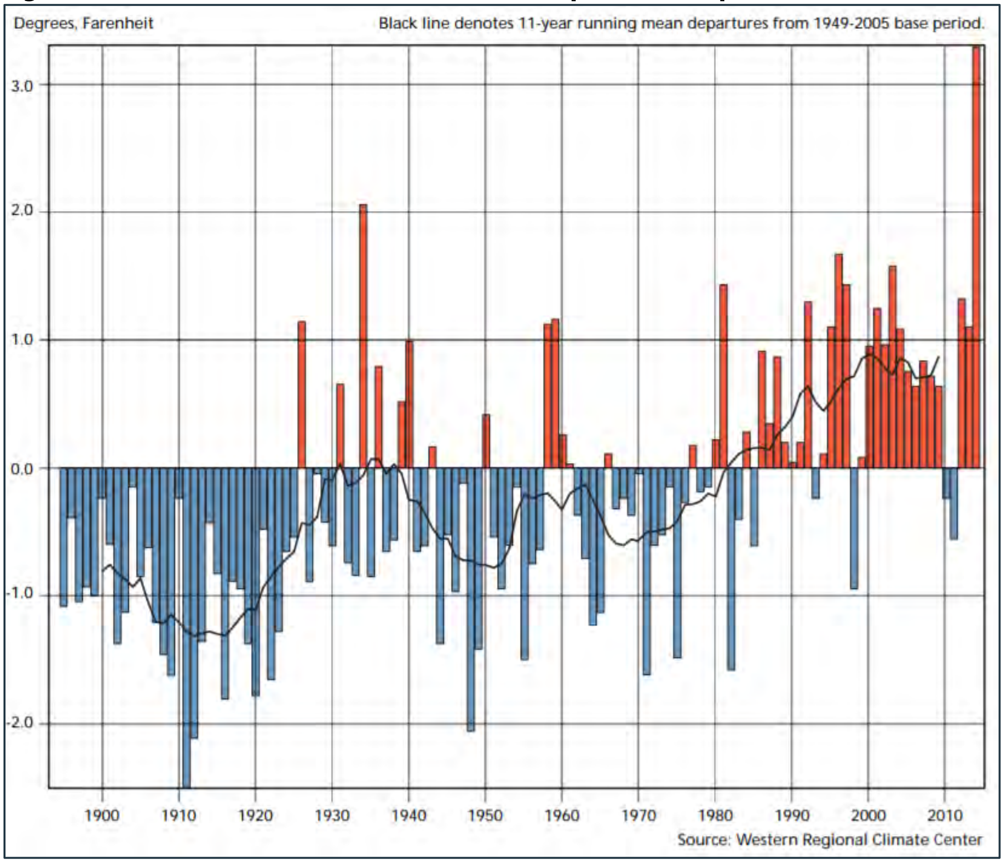
Figure 4-40: The City of Petaluma's Daily Temperature Averages and Extremes



Source: Western Regional Climate Center, www.wrcc.dri.edu/

The California statewide mean temperature departures from the 1900s to mid-2010s are displayed in Figure 4-41. This graphically highlights the general warming trend across the state, and how climate change can have significant implications in future water supply availability, higher mean temperatures.

Figure 4-41: California's Statewide Mean Temperature Departure, 1900-2014



Source: Drought in California Report (CA DWR; Natural Resources Agency; State of California, 2015)

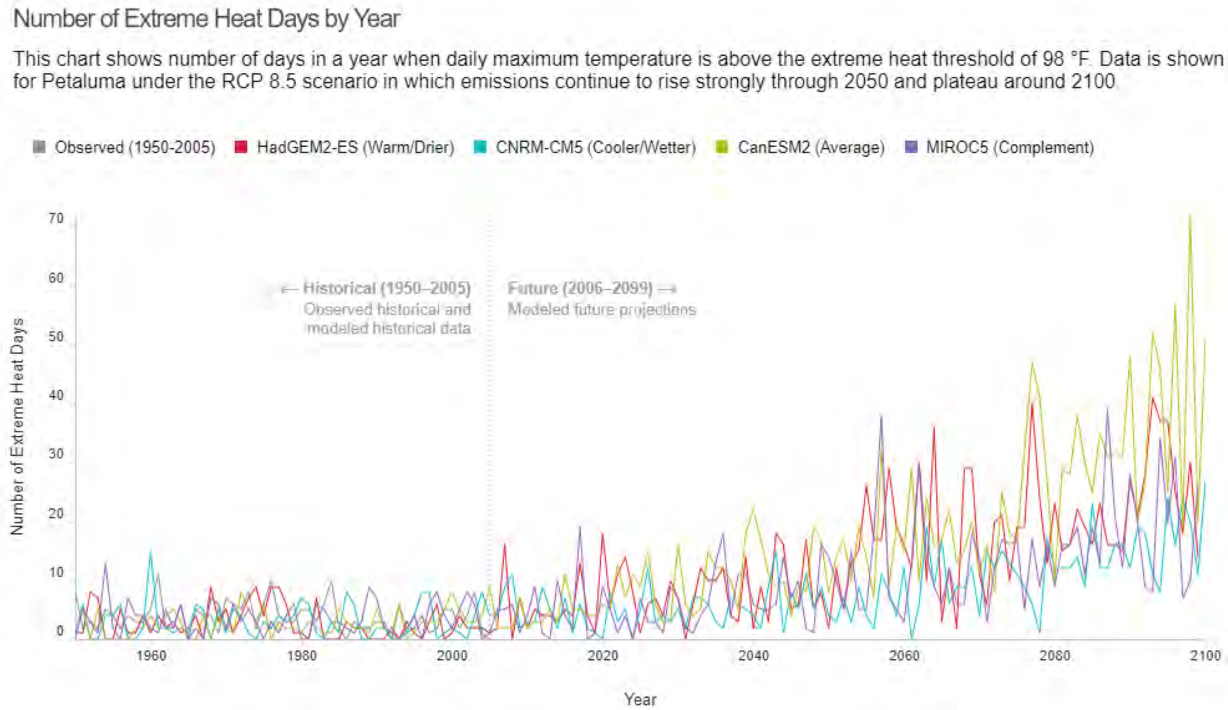
Probability of Future Occurrences

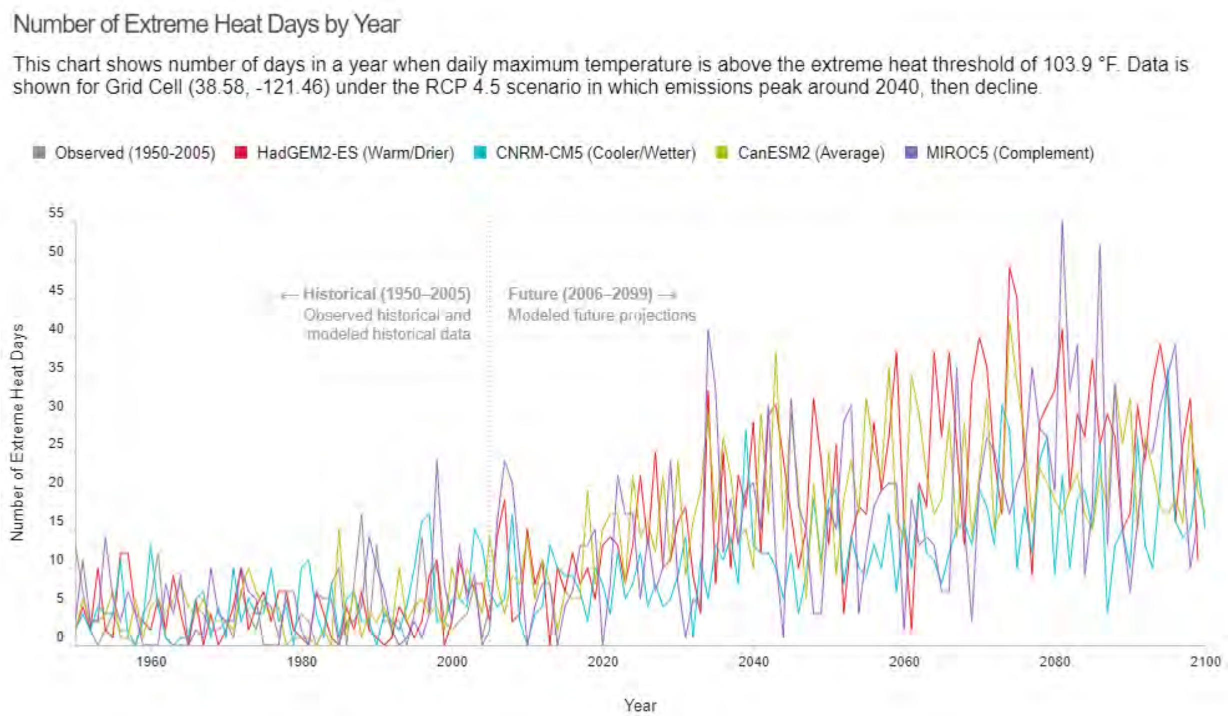
Likely – Temperatures of extreme heat are likely to continue to occur annually in the Planning Area.

Climate Change Considerations

Heat waves are likely to become more frequent, which will have direct impacts on human health in terms of heat related illness. With the general trend of increased warming of average temperatures, extreme high temperatures will likely also increase. Cascading impacts include increased stress on water quantity and quality, degraded air quality, and increased potential for more severe or catastrophic natural events such as heavy rain, droughts, and wildfire. Another cascading impact includes increased duration and intensity of wildfires with warmer temperatures. According to the 2013 document, *Preparing California for the Extreme Heat*, Cal-Adapt projects that throughout California urban and rural population centers will experience an average of 40 to 53 extreme heat days by 2050 and an average of 40 days by 2099 (Cal-Adapt 2013). This compares to a historical average of four days per year (Cal-Adapt 2013). Cal Adapt also projects that overall temperatures are expected to rise substantially throughout this century. Future temperature estimates from Cal Adapt for the City of Petaluma under high and low emission scenarios are shown in Figure 4-42. The top graph shows the number of days per year when daily maximum temperature is above the extreme heat threshold of 98°F under the RCP 8.5 scenario (business as usual). The bottom graph shows the number of days per year when daily maximum temperature is above the extreme heat threshold of 103.9°F under the RCP 4.5 scenario.

Figure 4-42: City of Petaluma – Future Extreme Heat Days in High and Low Emission Scenarios





Source: Cal-Adapt 2019

Extreme heat has also been shown to accelerate wear and tear on the natural gas and electrical infrastructure (California Natural Resources Agency 2018). Projected increases in summer demand associated with rising temperatures may increase risks to energy infrastructure and may exceed the capacity of existing substations and distribution line infrastructure and systems.

A recent study on extreme heat released by the Union of Concern Scientists in July 2019 analyzed three global climate scenarios associated with different levels of heat-trapping emissions and future warming. The results of the analysis showed that with no actions taken to reduce heat-trapping emissions by midcentury (2036-2065) the average number of days per year in the United States with a heat index above 100°F will double, while the number of days per year above 105°F will quadruple. The modeling completed for the study showed that the most dramatic transformations will be felt in areas where the climate has been temperate. The City of Petaluma could experience up to 11 more times as many days per year in which the heat feels like 90 degrees (KQED 2019). According to Cal-Adapt Climate Projections for the Bay Area Region as stated in the 2017 Climate Change Health Profile Report for Sonoma County, by 2100 the number of heat waves in the Bay Area Region is expected to be between 6 to 10 heatwaves per year.

Based on Sonoma County's 2016 CAP, climate change is also expected to result in higher average temperature and more extreme heat events. If future GHG emissions are mitigated or reduced over time, summer high temperatures are expected to rise by 1 to 2°F. Whereas, if GHG emissions are not mitigated average summer high temperatures will increase by up to 9 to 11°F by 2100 (RCAP 2016). For these reasons, climate change would have a "high" influence on extreme heat hazards.

Vulnerability Assessment

Property

Recent research indicates that the impact of extreme heat, particularly on populations, has been historically under-represented. The risks of extreme heat are often profiled as part of larger hazards, such as drought or wildfire. However, as temperature variances may occur independent of other hazards or outside of the expected seasons, but still incur large costs, it is important to examine them as stand-alone hazards. Extreme heat can overload demands for electricity to run air conditioners in homes and businesses during prolonged periods of exposure and presents health concerns to individuals who are outside.

Extreme heat may also be a secondary effect of droughts or may cause temporary drought-like conditions. For example, several weeks of extreme heat increases evapotranspiration and reduces moisture content in vegetation, leading to higher wildfire vulnerability for that time period even if the rest of the season is relatively moist. Extreme heat can cause infrastructure damage to roads. In summary, all property is vulnerable from extreme heat.

People

Traditionally, the very young and very old are considered at higher risk to the effects of extreme heat, but any populations outdoors during periods of extreme temperatures are exposed, including otherwise young and healthy adults and homeless populations. While everyone is vulnerable to extreme heat incidents, some populations are more vulnerable than others. Extreme heat poses the greatest danger to outdoor laborers, such as highway crews, police and fire personnel, and construction workers. The elderly, children, people in poor physical health, and the homeless are also vulnerable to exposure. Arguably, the young-and-otherwise-healthy demographic may also experience a higher vulnerability of exposure, due to the increased likelihood that they will be out in temperatures of extreme heat, whether due to commuting for work or school, conducting property maintenance such as lawn care, or for recreational reasons.

It is difficult to isolate the City's specific vulnerability to this hazard, as the impacts from extreme heat can be spread across an entire state or region. In general, all the population of the City can be considered at-risk to this hazard.

Economy

Extreme heat impacts on the economy may be more indirect compared to other hazards. Infrastructure such as roads could be damaged and lead to increased need for repaving. Critical facilities may be vulnerable to the indirect impact of prolonged excessive heat (i.e., electrical power outages), which may impact response capabilities or care capabilities for hospitals and clinics. Hospitals and clinics may see a surge in patients during the heat event as the exposed population suffers from the effects of the heat, but it is not anticipated that these increases will overwhelm the capacities of hospitals and clinics in Petaluma. Essential infrastructure, especially the electrical distribution system, is also posed to be stressed during extreme heat events as demand increases to run air conditioning. Peak demand exceeding the local utility's capacity for supply can lead to blackout or brownout conditions.

Critical Facilities and Infrastructure

Extreme heat can affect road infrastructure, but direct impacts to critical infrastructure is expected to be minimal. Critical infrastructure that relies on public utility systems that could be overloaded may result in impacts during extreme heat events. The loss of utilities or power outages during extreme heat events could also result in adverse secondary impacts to sensitive populations.

Historic, Cultural, and Natural Resources

Extreme heat may cause temporary drought-like conditions. For example, several weeks of extreme heat increases evapotranspiration and reduces moisture content in vegetation, leading to higher wildfire vulnerability for that time period even if the rest of the season is relatively moist. Changing heating and cooling patterns globally can have destructive secondary impacts, intensifying a variety of weather-related disasters that directly impact jurisdictions.

Future Development

Since structures are not usually directly impacted by severe temperature fluctuations, continued development is less impacted by this extreme heat than others in the plan. Continued development implies continued population growth, which raises the number of individuals potentially exposed to temperature variations. Public education efforts should continue to help the population understand the risks and vulnerabilities of outdoor activities, property maintenance, and regular exposures during periods of extreme heat.

Risk Summary

- The highest recorded temperature in Planning Area is 110°F on June 2, 1960.
- Extreme heat can have severe impacts on human health, the natural environment, and the economy.
- The very young, the elderly, people with poor physical health, and the homeless are more susceptible to the impacts of extreme temperatures.

- The average number of days per year in the United States with a heat index above 100°F will double, while the number of days per year above 105°F will quadruple if no actions to reduce heat-trapping emissions are taken.
- Climate change is expected to result in higher average temperature and more extreme heat events. In other words, climate change will have a "high" influence on the number of extreme heat days.
- Overall, the significance of extreme heat is **Medium.**

4.3.9 Severe Weather: Heavy Rain/ Thunderstorm/ Hail/ Lightning/ Dense Fog

Hazard Description

Severe storms in the Planning Area are generally characterized by heavy rain accompanied by strong winds, and lightning. Approximately 10 percent of the thunderstorms that occur each year in the United States are classified as severe. A thunderstorm is classified as severe when it contains one or more of the following phenomena: hail that is three-quarters of an inch or greater, winds in excess of 50 knots (57.5 mph), or a tornado.

Heavy Rain

Atmospheric rivers, a climate pattern that leads to adverse weather in the City, are responsible for up to 50 percent of California's precipitation annually and 65 percent seasonally (Arcuni, 2019). An atmospheric river (AR) is a long, narrow region of the atmosphere, like a river in the sky, that transports most of the water vapor outside of the tropics. ARs can be 300 miles wide, a mile deep and more than 1,000 miles long and carry an amount of water vapor roughly the same as the average flow of water at the mouth of Mississippi River (NOAA 2015). Warm water storms over the Pacific Ocean lead to evaporation and create a high concentration of moisture in the air, while prevailing winds create the distinctive river shape, which is often compared "to a fire hose pointed at California" (Arcuni 2019). When an atmospheric river reaches land, it releases the water vapor in the form of rain or snow. Atmospheric rivers play an important role in the global water cycle and are closely tied to both water supply and flooding risk.

Research suggests that atmospheric rivers contributed to the collapse of both Orville Dam spillways in February 2017 (NASA Global Hydrology Resource Center 2018), as well as the winter flooding in 1861-1862, which inundated Sacramento and is considered the worst flood event in California's history (Ingram 2013). When an atmospheric river forms in the tropical regions of the Pacific near Hawaii it is known as a "Pineapple Express". This type of atmospheric river can produce as much as five inches in one day (NOAA 2018). In 2018, two Pineapple Express ARs hit California causing significant heavy precipitation events throughout state.

Sonoma Water entered into a cooperative agreement with Scripps Institution of Oceanography and the Center for Western Extremes (CW3E) to advance the research in ocean science and meteorology. Three projects have come from the initial agreement: 1) research to help define the role of atmospheric rivers in filling Lake Mendocino and potentially offering predictability in retaining water without increasing flood risk; 2) a NOAA-funded climate program project to study the role of atmospheric rivers in ending droughts on the Russian River; and 3) cooperation in developing a feasibility assessment for potential use of forecast-informed reservoir operations for Lake Mendocino in cooperation with the U.S. Army Corps of Engineers.

Hail

Hail is formed when water droplets freeze and thaw as they are thrown high into the upper atmosphere by the violent internal forces of thunderstorms. Hail is sometimes associated with severe storms within the Planning Area. Hail falls when it becomes heavy enough to overcome the strength of the updraft and is pulled by gravity towards the earth. Hailstorms occur throughout the spring, summer, and fall in the region, but are more frequent in late spring and early summer. Hailstones are usually less than two inches in diameter and can fall at speeds of 120 mph. Hail causes nearly $1 billion in damage to crops and property each year in the United States. Hail is also one of the requirements which the NWS uses to classify thunderstorms as 'severe.' If hail more than ¾ of an inch is produced in a thunderstorm, it qualifies as severe. Severe hailstorms can be quite destructive, causing damage to roofs, buildings, automobiles, vegetation, and crops.

The NWS classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Table 4-38 under the Extent subsection below indicates the hailstone measurements utilized by the NWS.

Dense Fog

Fog results from air being cooled to the point where it can no longer hold all of the water vapor it contains. For example, rain can cool and moisten the air near the surface until fog forms. A cloud-free, humid air mass at night can lead to fog formation, where land and water surfaces that have warmed up during the summer are still evaporating water into the atmosphere. This is called radiation fog. A warm moist air mass blowing over a cold surface also can cause fog to form, which is called advection fog.

Sonoma County is made up of three major climactic zones, with the major climatic influence being the Pacific Ocean. The City of Petaluma falls within the marine zone, which is under direct ocean influence. The prevailing weather and winds tend to come from the Pacific Ocean from the northwest. Areas such as Petaluma tend to receive more precipitation in the fall and winter and more wind and fog in early morning of the summer months.

Lightning

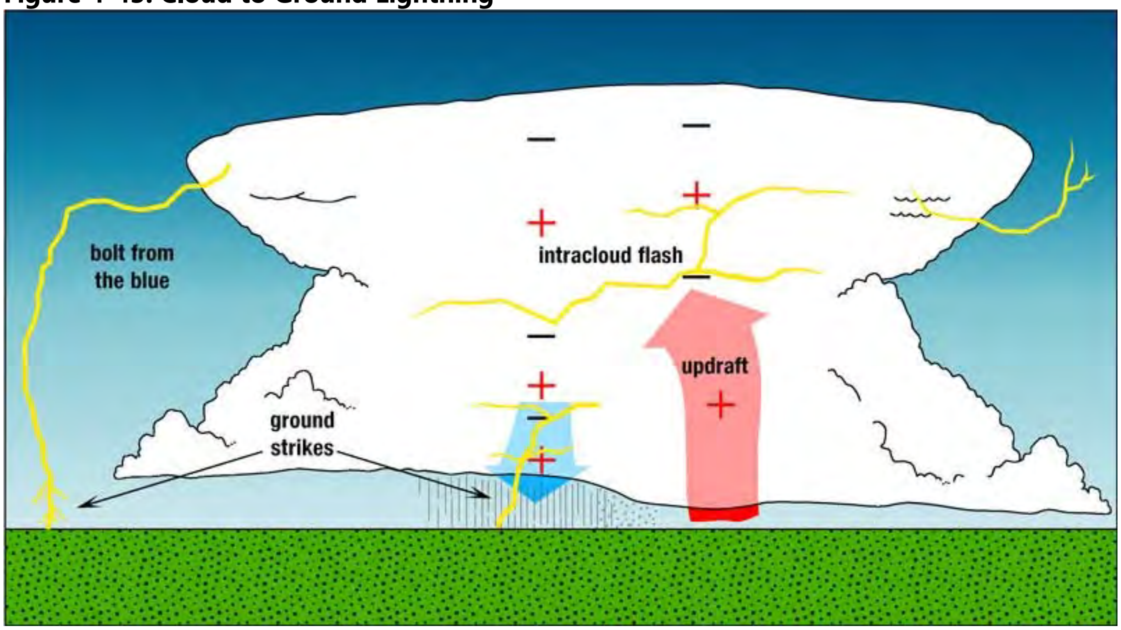
Lightning is an electrical discharge between positive and negative regions of a thunderstorm. A lightning flash is composed of a series of strokes with an average of about four. The length and duration of each lightning stroke vary, but typically average about 30 microseconds.

Lightning is one of the more dangerous weather hazards in the United States. Each year, lightning is responsible for deaths, injuries, and millions of dollars in property damage, including damage to buildings, communications systems, power lines, and electrical systems. Lightning also causes forest and brush fires, and deaths and injuries to livestock and other animals. According to the National Lightning Safety Institute, lightning causes more than 26,000 fires in the United States each year. The Institute estimates property damage, increased operating costs, production delays, and lost revenue from lightning and secondary effects to be in excess of $6 billion per year. Impacts can be direct or indirect. People or objects can be directly struck, or damage can occur indirectly when the current passes through or near it.

Intra-cloud lightning is the most common type of discharge. This occurs between oppositely charged centers within the same cloud. Usually it takes place inside the cloud and looks from the outside of the cloud like a diffuse brightening that flickers. However, the flash may exit the boundary of the cloud, and a bright channel, similar to a cloud-to-ground flash, can be visible for many miles.

Cloud-to-ground lightning is the most damaging and dangerous type of lightning, though it is also less common. Most flashes originate near the lower-negative charge center and deliver negative charge to earth. However, a large minority of flashes carry positive charge to earth. These positive flashes often occur during the dissipating stage of a thunderstorm's life. Positive flashes are also more common as a percentage of total ground strikes during the winter months. This type of lightning is particularly dangerous for several reasons. It frequently strikes away from the rain core, either ahead or behind the thunderstorm. It can strike as far as 5 or 10 miles from the storm in areas that most people do not consider to be a threat (see Figure 4-43). Positive lightning also has a longer duration, so fires are more easily ignited. And, when positive lightning strikes, it usually carries a high peak electrical current, potentially resulting in greater damage.

Figure 4-43: Cloud to Ground Lightning



Source: National Weather Service Pueblo Office

The ratio of cloud-to-ground and intra-cloud lightning can vary significantly from storm-to-storm. Depending upon cloud height above ground and changes in electric field strength between cloud and earth, the discharge stays within the cloud or makes direct contact with the earth. If the field strength is highest in the lower regions of the cloud, a downward flash may occur from cloud to earth.

Location

Heavy rains and severe storms have the potential to occur anywhere in the Planning Area.

Extent (Magnitude/Severity)

Limited – Extent for severe weather, particularly severe storms that involve heavy rain and hail, can be measured according to hail by diameter size, as it corresponds to everyday objects to define the severity to the population (Table 4-38).

Common problems associated with severe storms include the loss of utilities or immobility. Loss of life is uncommon but can occur during severe storms. Immobility can occur when roads become impassable due to dense fog, flooding, downed trees, ice, or a landslide. Fog specifically poses a risk to commuters and driving conditions as fog typically forms rapidly in the early morning hours. Nighttime driving in the fog is dangerous and multi-car pileups have resulted from drivers using excessive speed for the conditions and visibility.

Loss of utilities can occur when severe thunderstorms cause trees or tree limbs to fall and damage power lines. Lightning can also cause severe damage and injury, particularly when it causes wildfires.

The NWS classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Table 4-38 indicates the hailstone measurements utilized by the NWS.

Table 4-38: Hail Measurements

Average Diameter	Corresponding Household Object
.25 inch	Pea
.5 inch	Marble/Mothball
.75 inch	Dime/Penny
.875 inch	Nickel
1.0 inch	Quarter
1.5 inch	Ping-pong ball
1.75 inch	Golf-Ball
2.0 inch	Hen Egg
2.5 inch	Tennis Ball
2.75 inch	Baseball
3.00 inch	Teacup
4.00 inch	Grapefruit
4.5 inch	Softball

Source: National Weather Service

There is no clear distinction between storms that do and do not produce hailstones. Nearly all severe thunderstorms probably produce hail aloft, though it may melt before reaching the ground. Multi-cell thunderstorms produce many hailstones, but not usually the largest hailstones. In the life cycle of the multi-cell thunderstorm, the mature stage is relatively short so there is not much time for growth of the hailstone. Supercell thunderstorms have sustained updrafts that support large hail formation by repeatedly lifting the hailstones into the very cold air at the top of the thunderstorm cloud. In general, hail two inches (5 cm) or larger in diameter is associated with supercells (a little larger than golf ball size which the NWS considers to be 1.75 inch.). Non-supercell storms are capable of producing golf ball size hail.

In all cases, the hail falls when the thunderstorm's updraft can no longer support the weight of the ice. The stronger the updraft the larger the hailstone can grow. When viewed from the air, it is evident that hail falls in paths known as hail swaths. They can range in size from a few acres to areas 10 miles wide and 100 miles long. In some instances, piles of hail have been so deep that snow plows were required to remove them, and occasionally hail drifts have been reported.

Lightning is measured by the Lightning Activity Level (LAL) scale, created by the NWS to define lightning activity into a specific categorical scale. The LAL is a common parameter that is part of fire weather forecasts nationwide. The City of Petaluma is at risk to experience lightning in any of these categories. The LAL is reproduced in Table 4-39.

Table 4-39: Lightning Activity Level Scale

LAL 1	No thunderstorms
LAL 2	Isolated thunderstorms. Light rain will occasionally reach the ground. Lightning is very infrequent, 1 to 5 cloud to ground strikes in a five-minute period
LAL 3	Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a five-minute period.
LAL 4	Scattered thunderstorms. Moderate rain is commonly produced. Lightning is frequent, 11 to 15 cloud to ground strikes in a five-minute period.
LAL 5	Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and intense, greater than 15 cloud to ground strikes in a five-minute period.
LAL 6	Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag warning.

Source: National Weather Service

The heavy precipitation that is possible in the City of Petaluma and all of California is often the result of an atmospheric river. Atmospheric rivers are categorized by a unit of measurement known as the Integrated Water Vapor Transport (IVT), which takes into account the amount of water vapor in the system and the wind that moves it around. For a storm to be classified as an atmospheric river it has to reach an IVT threshold of 250 units; 1,000 IVT or more is considered to be “extreme” (Arcuni, 2019). In 2019 a system for categorizing the strength and impacts of atmospheric rivers was developed by the Center for Western Weather and Water Extremes (CW3E), out of the Scripps Institution of Oceanography at the University of California San Diego. The newly developed scale ranks ARs into five categorizes from weak to exceptional. Unlike the Fujita scale for tornadoes that focuses on potential damages, the AR scale accounts for both storms that may be hazardous and storms that can provide benefits to the local water supply. A category one AR is considered to be primarily beneficial, generally lasting only 24 hours and produces modest rainfall. On the other end of the scale, a category five AR is considered “exceptional” and primarily hazardous, lasting for several days and associated with heavy rainfall and runoff that may cause significant damages. Table 4-40 describes the scale further. The Center developed the scale as a tool for officials with an operational need to assess flooding potential in their jurisdictions before the storms makes landfall.

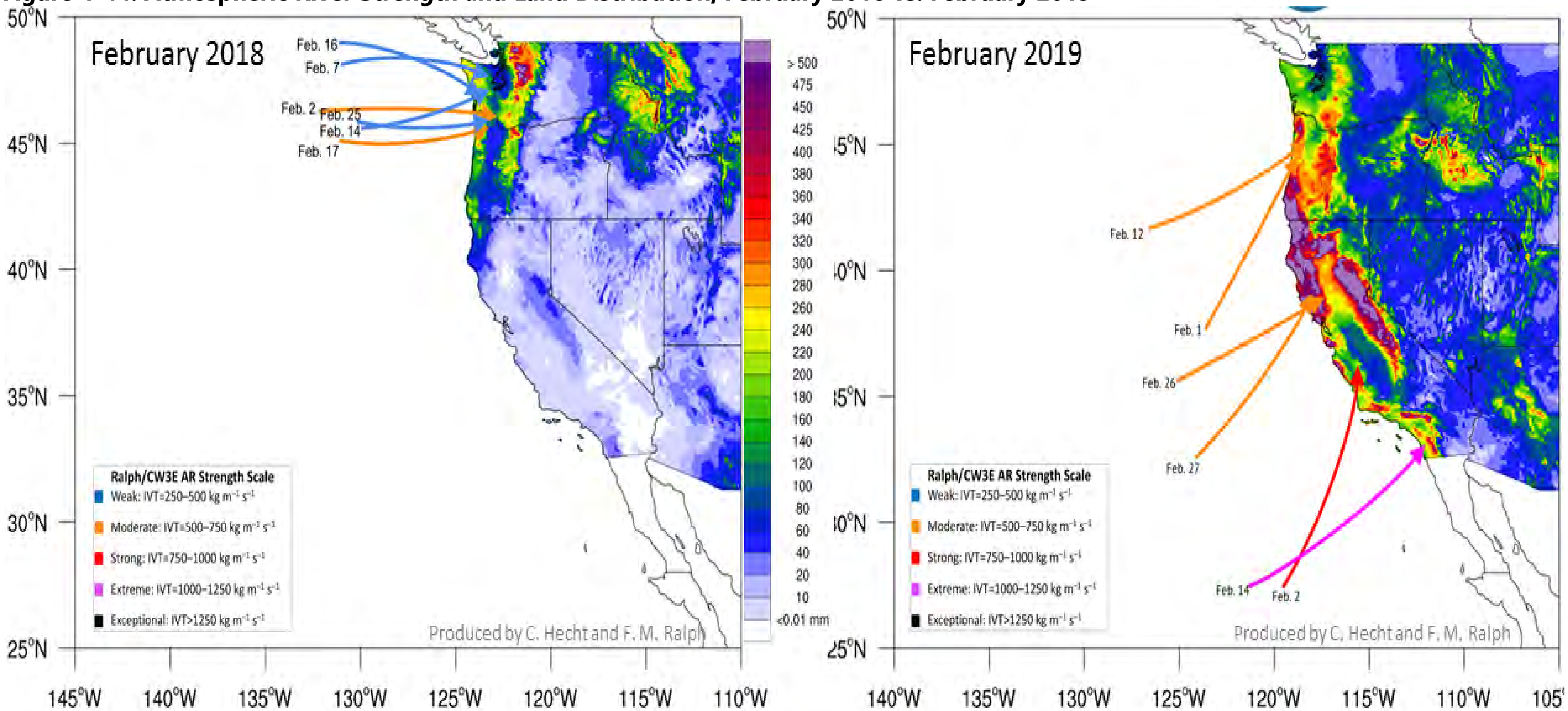
In both February 2018 and 2019 the West Coast experienced six atmospheric rivers. But as Figure 4-44 from the Center for Western Weather and Water Extremes shows, California experienced vastly different precipitation totals due to the location of where the atmospheric river made landfall as well as each atmospheric river’s IVT. Using the AR scale developed by CW3E, the ARs in February 2019 were all considered to be moderate to extreme and concentrated more on California, resulting in heavy precipitation.

Table 4-40: Atmospheric River Categories

Category	Potential Impacts
AR Cat 1: Weak	Primarily beneficial. For example, a Feb. 2, 2017 AR hit California, lasted 24 hours at the coast, and produced modest rainfall.
AR Cat 2: Moderate	Mostly beneficial, but also somewhat hazardous. An atmospheric river on Nov. 19-20, 2016 hit Northern California, lasted 42 hours at the coast, and produced several inches of rain that helped replenish low reservoirs after a drought.
AR Cat 3: Strong	Balance of beneficial and hazardous. An atmospheric river on Oct. 14-15, 2016 lasted 36 hours at the coast, produced 5-10 inches of rain that helped refill reservoirs after a drought, but also caused some rivers to rise to just below flood stage.
AR Cat 4: Extreme	Mostly hazardous, but also beneficial. For example, an atmospheric river on Jan. 8-9, 2017 that persisted for 36 hours produced up to 14 inches of rain in the Sierra Nevada and caused at least a dozen rivers to reach flood stage.
AR Cat 5: Exceptional	Primarily hazardous. For example, a Dec. 29, 1996 to Jan. 2, 1997 atmospheric river lasted over 100 hours at the Central California coast. The associated heavy precipitation and runoff caused more than $1 billion in damages.

Source: Center for Western Weather and Water Extremes, Scripps Institution of Oceanography at UC San Diego. Scale was developed by F. Martin Ralph Director of CW3E in collaboration with Jonathan Rutz of NWS

Figure 4-44: Atmospheric River Strength and Land Distribution, February 2018 vs. February 2019



Source: Center for Western Weather and Water Extremes, Scripps Institution of Oceanography at UC San Diego

Previous Occurrences

Heavy rains and severe storms occur in the Planning Area primarily during the late fall and winter. According to information obtained from the WRCC the majority of precipitation is produced by storms during January and other winter months. Precipitation during the summer months is in the form of rain showers and is rare. Snowstorms and ice storms occur infrequently in the City of Petaluma. The Storm Events Database records one snow event in the City, January 28, 2002 with one to two inches of snow falling in the vicinity of Petaluma; the Database notes this was "quite a rare event". The NCEI records 42 hail, heavy rain, lighting and dense fog events that have taken place in Sonoma County in the past 68 years (1950 –2018). Table 4-41 is a summary of the most significant severe weather events for Sonoma County. An asterisk (*) indicates events where the City of Petaluma was specifically mentioned.

Table 4-41: Severe Weather Events recorded in Sonoma County (1950-2018)

Hazard Type	Date	Hazard Description
Dense Fog	February 8, 2012	Dense fog is blamed in 11 crashes on Highway 37 near Skaggs Island Rd. There were 31 vehicles involved in the crashes. Two people suffered minor injuries. $100,000 in property damages were recorded.
	December 10-11, 2018	Widespread dense fog impacted the Bay Area blanketing the Bay and interior valleys. Numerous reports of dense fog with visibility less than 1/4 mile. A Dense Fog Advisory was issued for the North and East Bay Valleys as well as the San Francisco Peninsula and surrounding bay coastline. Fog caused numerous diverts at KSFO.
Hail	Jan. 19, 2018*	A cold front swept through the region late on the 18th. Small scattered thunderstorms were generated behind the front bringing pea sized hail (0.25 in.) to the region.
	Jan. 25, 2018*	Isolated thunderstorms developed behind a cold front that passed through the area on the 25th. These thunderstorms caused minor roadway flooding and small hail (0.25 in.)
	March 14, 2018*	The Press Democrat in Santa Rosa showed multiple reports of accumulating small hail in downtown Petaluma (0.25 in.); An upper level disturbance moved through the area on the afternoon of the 14th. This disturbance created scattered thunderstorms that resulted in lightning and accumulating hail in the North and East Bay areas.
Lightning	March 14, 2018*	The Press Democrat in Santa Rosa reported that lightning struck a PG&E circuit at 11 am the morning of the 14th causing a power outage for 25 Petaluma residents lasting through the evening. An upper level disturbance moved through the area on the afternoon of the 14th. This disturbance created scattered thunderstorms that resulted in lightning and accumulating hail in the North and East Bay areas.
Heavy Rain	December 15, 2008	Heavy rain caused a fatality of a 32-year-old man when his vehicle collided with another vehicle. Highways 116 and 121 were closed for about three hours after the collision. A cold core low pressure system produced winter storm conditions causing low elevation snow, minor flooding and isolated strong wind through the period December 15 through 17, 2009. $25,000 in property damages is recorded.
	December 22, 2012	A series of storm systems, part of a large Atmospheric River type of pattern, impacted the area during late December 2012. From the 21st through 26th of December, heavy rain, gusty winds, flooding, and mudslides occurred across the Bay Area in these consecutive events. Downed trees, powerlines, and flooded roadways impacted residents over

Hazard Type	Date	Hazard Description
		the Christmas holiday season. $30,000 in property damages were recorded.
	December 11, 2014	An Atmospheric River event brought heavy rain and gusty winds with a strong winter storm that impacted the Bay Area for several days in mid-December. Many locations around the entire Bay Area had flooding: urban flooding of streets and highways, flooding of creeks and even one large river in the North Bay. Eventually the NCFR (narrow cold frontal rainband) slowed around the Big Sur Coast. The stalling was likely due to another 'wave' in the atmosphere, farther to the southwest, riding along the boundary. The end result was to have the weakened NCFR lift back northward, almost like a quasi-warm front, producing another round of moderate to locally heavy rainfall around the Bay Area, compounding flooding concerns. The event was followed by several weaker storm systems that week that brought additional rainfall, continued flooding and mudslide concerns to the area.
	January 16, 2019	A moderate to strong atmospheric river impacted much of California in the middle of the month. A weak surface low developed off the coast on January 15th bringing moderate to heavy rainfall to portions of the region. Over the next 24 to 36 hours a second strong low-pressure system moved to the north and east bringing heavy rain, destructive winds, high surf, flooding, and thunderstorms to the Bay Area. Numerous reports were received of downed trees and power lines. Winds were recorded between 60 and 100 mph. Downed trees resulted in two fatalities.

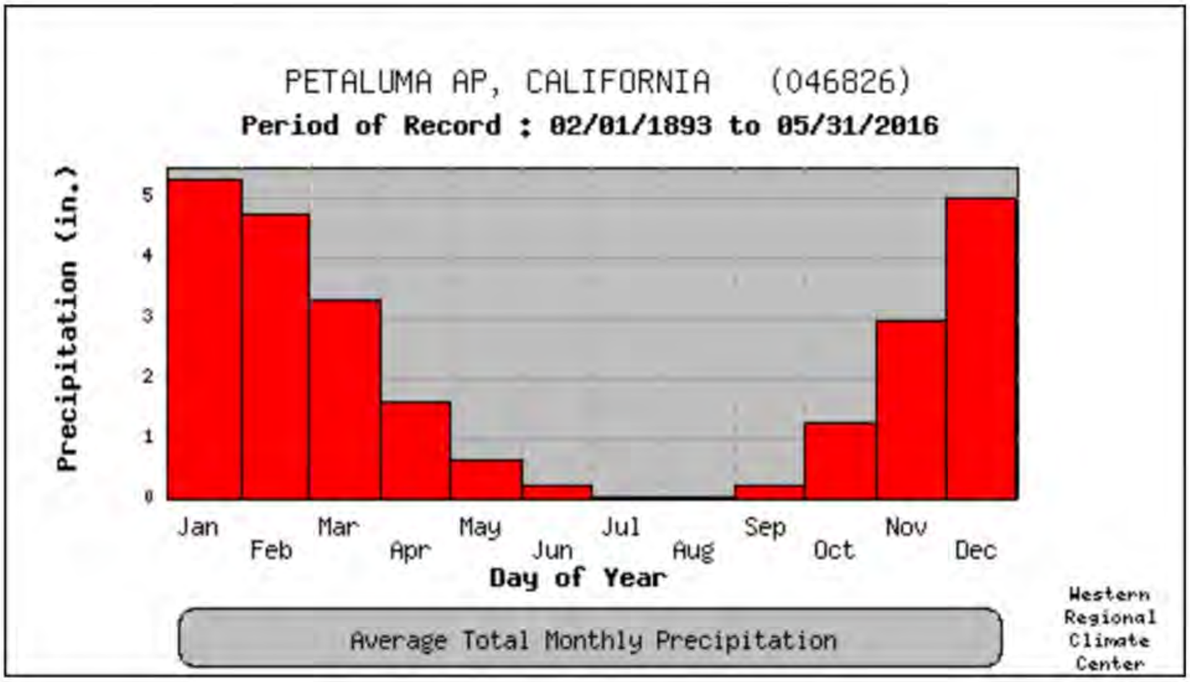
Source: National Centers for Environmental Information, Strom Events Database.

*Notes events that were specific to the City of Petaluma

City of Petaluma—Petaluma Fire Station 3 Weather Station (Period of Record 1893 to 2016)

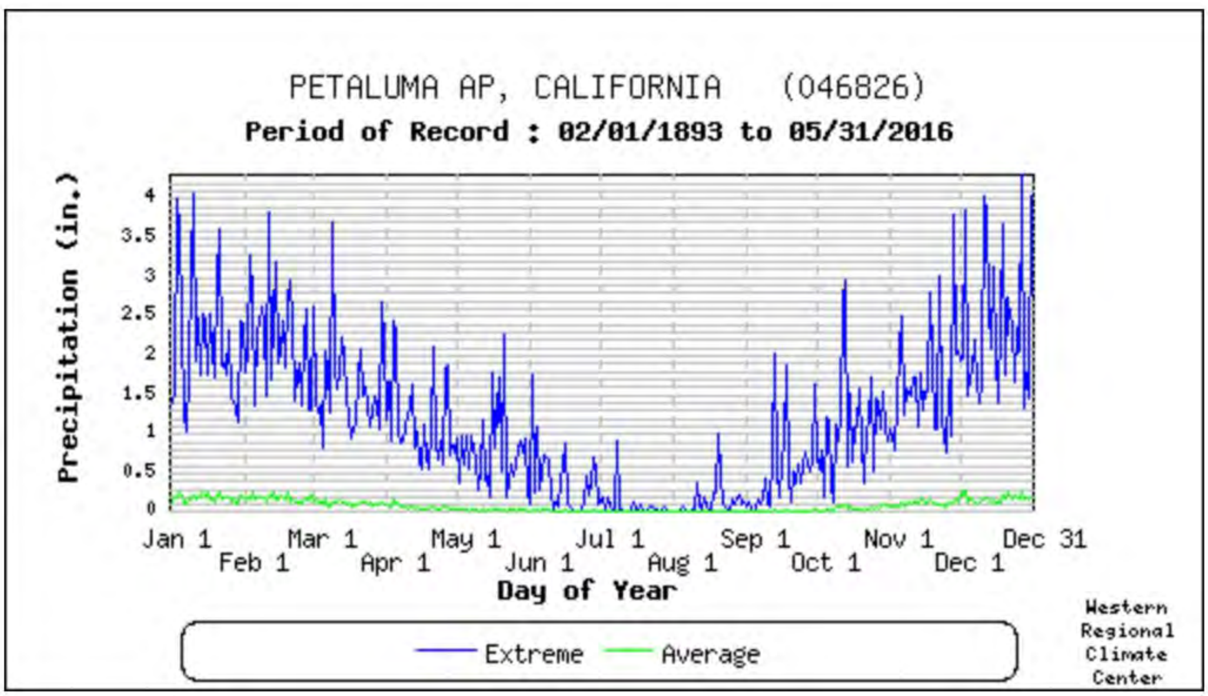
Information from the closest weather station with the most comprehensive data, the Petaluma Fire Station 3 Weather Station, is summarized below in Figure 4-45 and Figure 4-46. Average annual precipitation in the Planning Area is 24.89 inches per year. The highest recorded annual precipitation was 31.48 inches in 1998; the highest recorded precipitation for a 24-hour period is 4.29 inches on December 12, 2004. The lowest recorded annual precipitation was 8.98 inches in 1976.

Figure 4-45: The City of Petaluma's Monthly Average Total Precipitation



Source: Western Regional Climate Center, www.wrcc.dri.edu/

Figure 4-46: The City of Petaluma's Daily Average and Extreme Precipitation



Source: Western Regional Climate Center, www.wrcc.dri.edu/

Probability of Future Occurrences

Likely – Heavy rain, thunderstorms, hail, and lightning wind and fog events are well-documented seasonal occurrences that will continue to occur annually in the Planning Area.

Climate Change Considerations

As average temperatures increase over time, this generally will result in higher extreme temperatures and more warming in the atmosphere can trigger climate changes, which could result in more frequent extreme weather events. According to California's Fourth Climate Change Assessment, the number of days each year on which the atmospheric rivers bring "extreme" amounts of rain and snow to the region are expected to increase under the projected climate change for the state, possibly increasing more than a quarter. Pacific Northwest National Laboratory researchers found that atmospheric rivers will reach the West Coast more frequently if GHG emissions continue to rise under business as usual conditions. Currently, the West receives rain or snow from these atmospheric rivers between 25 and 40 days each year. By the end of this century, days on which the atmospheric rivers reach the coast could increase by a third this century, between 35 and 55 days a year. Meanwhile, the number of days each year on which the atmospheric rivers bring "extreme" amounts of rain and snow to the region could increase by more than a quarter.

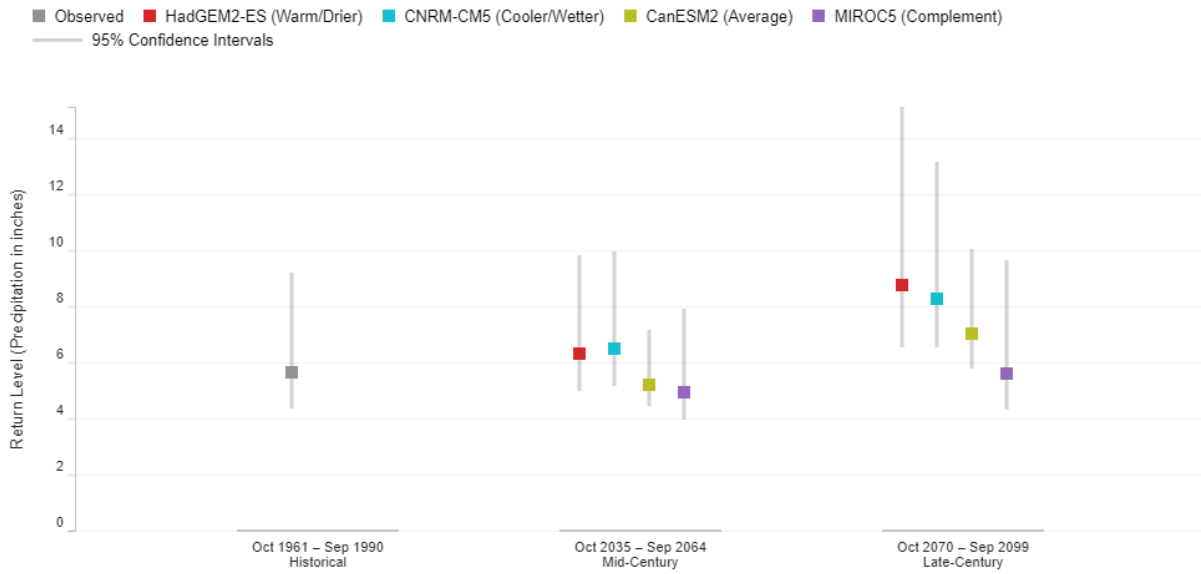
Cal-Adapt indicates that on average, projections show little change in total annual precipitation in California; however, the Mediterranean seasonal precipitation pattern is expected to continue, with most precipitation falling during the winter months from North Pacific storms. Cal-Adapt provides extreme future precipitation estimates that summarize the intensity and frequency of events. Future extreme precipitation estimates for the City of Petaluma are shown in Figure 4-47. The upper chart shows estimated intensity of extreme precipitation events under the RCP 8.5 scenario that are exceeded on average every 50 years and how it changes in a warming climate over historical, mid-century, and late-century time periods. This chart shows that emissions rise strongly through 2050 and plateau by 2100 and that extreme precipitation events are days during a water year (October – September) with 2-day rainfall totals above an extreme threshold of 1 inch. The lower chart also shows estimated intensity of extreme precipitation events but under the RCP 4.5 scenario that are exceeded on average every 50 years. This chart shows that emissions peak by 2040 and then decline and that extreme precipitation events are days during a water year (October – September) with 2-day rainfall totals above an extreme threshold of 1.53 inches.

Figure 4-47: City of Petaluma Future Precipitation Estimates in High and Low Emission Scenarios

Changes in Intensity of Extreme Precipitation Events

This chart shows estimated intensity (*Return Level*) of Extreme Precipitation events which are exceeded on average once every 50 years (*Return Period*) and how it changes in a warming climate over historical, mid-century and late-century time periods. Data is shown for Grid Cell (38.5937, -121.4687) under the RCP 8.5 scenario in which emissions continue to rise strongly through 2050 and plateau around 2100.

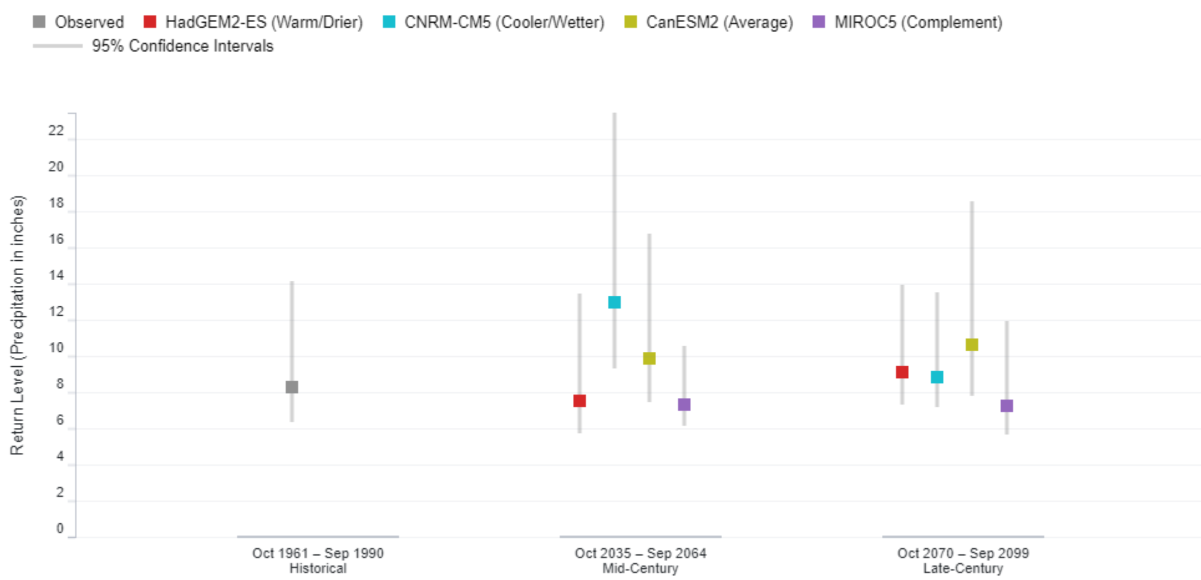
Extreme Precipitation events are days during a water year (Oct–Sep) with 2-day rainfall totals above an extreme threshold of 1 inches.



Changes in Intensity of Extreme Precipitation Events

This chart shows estimated intensity (*Return Level*) of Extreme Precipitation events which are exceeded on average once every 50 years (*Return Period*) and how it changes in a warming climate over historical, mid-century and late-century time periods. Data is shown for Petaluma under the RCP 4.5 scenario in which emissions peak around 2040, then decline.

Extreme Precipitation events are days during a water year (Oct–Sep) with 2-day rainfall totals above an extreme threshold of 1.53 inches.



Source: Cal-Adapt 2019

It is difficult at this point in time to predict the effects climate change will have on these hazards. However, as average temperatures increase over time, this generally will result in higher extreme temperatures. More warming in the atmosphere will trigger climate changes, which will result in more frequent extreme weather events. Much of the U.S. has already experienced prolonged periods of heavy downpours and severe flooding as a result of more extreme heavy rain and thunderstorm events. For these reasons, climate change would have a “high” influence on severe weather, specifically more heavy rainfall and precipitation events.

Vulnerability Assessment

Property

Based on historic information, these storms have not directly resulted in significant injury or damages to people and property, or the losses are typically covered by insurance. It is the secondary hazards caused by weather, such as floods, that have had the greatest impact on the City’s Planning Area. But while the primary effects may not result in significant injury or property damage, all property is vulnerable during sever weather events; properties in poor condition or closer to overhead power lines and large trees may be more vulnerable to damage.

People

Exposure is the greatest danger to people from severe thunderstorms. People can be hit by lightning, pelted by hail, and caught in rising waters. However, serious injury and loss of human life is rarely associated with hailstorms.

Reduced visibility is the greatest risk to people when heavy fog is prevalent. Particularly when fog is dense, it can be hazardous to drivers, mariners, and aviators and contributes to numerous accidents each year. To reduce injury and harm, people should avoid driving when dense fog is prevalent, if possible. If driving is pertinent, emergency services advise driving with lights on low beam, avoiding stopping on highways, and avoiding crossing traffic lanes.

While national data shows that lightning causes more injuries and deaths than any other natural hazard except extreme heat, there does not seem to be any trend in the data to indicate that one segment of the population is at a disproportionately high risk of being directly affected. Anyone who is outside during a thunderstorm is at risk of being struck by lightning. Aspects of the population who rely on constant, uninterrupted electrical supplies may have a greater, indirect vulnerability to lightning. As a group, the elderly or disabled, especially those with home health care services rely heavily on an uninterrupted source of electricity. Resident populations in nursing homes, residential facilities, or other special needs housing may also be vulnerable if electrical outages are prolonged. If they do not have a back-up power source, rural residents and agricultural operations reliant on electricity for heating, cooling, and water supplies are also vulnerable to power outages. Thunderstorms have the potential energy and strong winds to topple dead trees and injure people. As a result, power outages that occur from severe weather can be life threatening and these populations could face more exposure and could experience greater secondary effects of the hazard. Refer to the Vulnerability Assessment for Severe Weather: High Winds hazards below for analysis related to electricity dependent populations in the City of Petaluma.

Economy

Economic impacts of severe weather are typically short term. Lightning can cause power outages and fires. Hail can destroy exposed property; an example is car lots, where entire inventories can be damaged.

Generally, long-term economic impacts center around hazards that cascade from a severe thunderstorm, including wildfires ignited by lightning and flooding due to heavy rain.

Critical Facilities and Infrastructure

Due to the unpredictability of severe thunderstorm strength and path, most critical infrastructure that is above ground is equally exposed to the storm's impacts. According to historical data the Planning Area has experienced power outages in the past due to severe storms, but due to the random nature of these hazards, a more specific risk assessment was not conducted for this plan. Heavy rain and thunderstorms, particularly those that result in hail could significantly impact motorists travelling along U.S. Highway 101 and State Highway 116. Depending on the severity of the storm, these events could slow traffic, reduce visibility, and increase the likelihood of vehicle accidents along the highway, which may result in greater traffic delays. These effects are also likely to occur along highway segments in adjacent counties.

Fog can have devastating effects on transportation corridors in the City and throughout the County. Dense fog may increase the potential for transportation accidents along U.S. Highway 101 and State Highway 116 which could in turn cause longer traffic delays and timely movement of goods and services. Multi-car pileups have resulted from drivers using excessive speed for the conditions and visibility.

These accidents can cause multiple injuries and deaths and could have serious implications for human health and the environment if a hazardous or nuclear waste shipment were involved. Other disruptions from fog include delayed emergency response vehicles and school closures.

Historic, Cultural, and Natural Resources

Severe thunderstorms are a natural environmental process. Environmental impacts include the sparking of potentially destructive wildfires by lightning and localized flattening of plants by hail. As a natural process, the impacts of most severe thunderstorms by themselves are part of the overall natural cycle and do not cause long-term consequential damage.

Future Development

New critical facilities, such as communication towers should be built to withstand heavy rain, lighting, and hail damage. Population and commercial growth in the City will increase the potential for complications with traffic accidents and commerce interruptions associated with dense fog. Future development projects should also consider severe weather hazards at the planning, engineering and architectural design stage with the goal of reducing vulnerability. Storm water master planning and site plan review should account for building to withstand severe weather events and be considered for all new development. Future development in the City is not expected to be vulnerable to the hazard, but all development will be affected by severe weather and storm events and population growth will increase potential exposure to hazards such as lightning and hail.

Risk Summary

- Sonoma County has experienced 42 hail, heavy rain, lighting, and dense fog events in past 68 years.
- The average annual precipitation is 24.89 inches.
- The highest recorded annual precipitation was 31.48 inches in 1998.
- The highest recorded precipitation for a 24-hour period was 4.29 inches on December 12, 2004.
- Overall significance for severe weather hazards such as heavy rain, thunderstorms, hail, lightning, and dense fog is **Medium.**

4.3.10 Severe Weather: High Winds

Hazard Description

High winds, often accompanying severe thunderstorms, can cause significant property and crop damage, threaten public safety, and have adverse economic impacts from business closures and power loss. The wind patterns in Petaluma are strongly influenced by the Petaluma Gap, the region from the Estero Lowlands to San Pablo Bay (BAAQMD 2003). The predominant wind pattern is out of the northwest and tends to be light in the morning and windier in the afternoon when the sea breeze arrives.

Windstorms in the City of Petaluma are typically straight-line winds. Straight-line winds are generally any thunderstorm wind that is not associated with rotation (i.e., is not a tornado). These winds can exceed 100 miles per hour (mph) and are responsible for most wind damage related to thunderstorms. These winds can overturn mobile homes, tear roofs off houses, topple trees, snap power lines, shatter windows, and sandblast paint from cars. Other associated hazards include utility outages, arcing power lines, debris blocking streets, dust storms, and an occasional structure fire. Table 4-42 outlines the Beaufort scale, describing the damaging effects of wind speed.

Table 4-42: Beaufort Wind Scale

Wind Speed (mph)	Description—Visible Condition
0	Calm; smoke rises vertically
1-4	Light air; direction of wind shown by smoke but not by wind vanes
4-7	Light breeze; wind felt on face; leaves rustle; ordinary wind vane moved by wind
8-12	Gentle breeze; leaves and small twigs in constant motion; wind extends light flag
13-18	Moderate breeze; raises dust and loose paper; small branches are moved
19-24	Fresh breeze; small trees in leaf begin to sway; crested wavelets form on inland water
25-31	Strong breeze; large branches in motion; telephone wires whistle; umbrellas used with difficulty
32-38	Moderate gale whole trees in motion; inconvenience in walking against wind
39-46	Fresh gale breaks twigs off trees; generally, impedes progress
47-54	Strong gale slight structural damage occurs; chimney pots and slates removed
55-63	Whole gale trees uprooted; considerable structural damage occurs
64-72	Storm very rarely experienced; accompanied by widespread damage
73+	Hurricane devastation occurs

Source: NWS

High winds and tornadoes can cause damage to property and loss of life. Property damage can include damage to buildings, fallen trees and power lines, broken gas lines, broken sewer and water mains, and the outbreak of fires. Agricultural crops and industries may also be damaged or destroyed. Access roads and streets may be blocked by debris, delaying necessary emergency response.

Location

Strong winds have the potential to happen anywhere in the City's Planning Area. The resulting damage from wind events may be most severe in the downtown area of the City where there are more large trees, infrastructure, and higher density development.

Extent (Magnitude/Severity)

Limited – The prevailing winds in Petaluma come from the northwest and are strongly influenced by the Petaluma Gap helping to push marine air towards the City. Winds tends to be lighter in the morning and windier in the afternoon as the ocean air arrives.

Based on NCEI records between 1950 and July 31, 2019 there have been 211 high and strong wind events in Sonoma County, causing a total of $3,854,700 in property damage. The most damaging event took place on December 27, 2006 and was a 30 mph wind event that resulted in over $1 million of property damage to both commercial and residential structures. The highest magnitude event recorded occurred on February 14, 2019 and was in association with an atmospheric river that moved through the region. Recorded winds were as high as 80-mph and resulted in downed trees, power outages, and property damages.

High wind events in the County have led to five recorded fatalities and five injuries. Overall, high wind event impacts would likely be limited, with a majority of impacts being related to property damages caused by down trees as well as power outages. Overall, impacts from high wind events would likely be limited, with 10 to 25 percent of property severely damaged.

Previous Occurrences

Despite being nearly 20 miles from the coast of the Pacific Ocean, Petaluma's climate tends to be similar to coastal communities. Similar to a community along the coast, the City of Petaluma tends to experience wind events regularly. High wind events in Petaluma have also led to downed trees and power outages throughout the City. The following events are recorded in the NCEI Storm Events Database that are specific to the City of Petaluma Planning Area.

January 18, 2010 - Strong wind uprooted a large oak tree forcing it onto Bennett Valley Road near Enterprise Road in the hills east of Petaluma partially blocking one lane of traffic. The roots had grown under the roadway, and when they were torn out of the ground, they took about seven inches of asphalt with them leading to the closure of the eastbound lane. Also, in the hills east of Petaluma, another tree was reported to be uprooted on Sonoma Mountain Road at Pressley Road. Power outages across central Sonoma County numbered 3,584 customers.

April 8, 2013 - Strong wind blew down small tree branches and debris onto streets in the City. Strong and gusty northwest winds impacted much of the Bay Area resulting in downed trees, downed power lines, rough seas and even broken windows. The rather strong northerly pressure gradient helped to produce widespread wind gusts in excess of 35 mph with a few locations over 60 mph. Numerous reports of downed trees and power lines were received as a result of the strong winds.

November 21, 2013 - Strong winds gusted across the greater Bay Area during the evening and overnight hours of November 21 into the early morning of November 22. Numerous trees and power lines were knocked down by the winds, causing power outages for thousands of residents and even sparking wildfires across the North Bay. A tree was felled by strong winds onto a car driving on US Highway 101 in Petaluma, injuring the car's occupant.

December 30, 2014 - A strong windstorm struck the Bay Area on December 30 during the afternoon and evening hours. Strong winds brought down numerous trees and power lines across the area. The combination of recent heavy rains earlier in the month brought weakened ground conditions. Additionally, there were numerous dead trees across the area from years of ongoing drought. Major disruptions to the evening commute due to downed trees and the accidents they caused were observed. Wind gusts of 40 to 55 mph were widespread across the area. Despite most areas not reaching 60 mph, there was widespread wind damage and impacts due to the reasons above. A large tree was blown down and blocked both lanes of Old Redwood Highway near Petaluma.

February 6, 2015 - A strong winter storm impacted California following on nearly a month and a half of no rain and the driest January on record. The storm brought heavy rain, gusty winds, and damage to trees and power lines along with some minor flooding of urban areas. Impacts to the planning areas included a tree blown down across the roadway at Magnolia Avenue and Thompson lane about three miles west of Petaluma. Winds gusted 50 to 70 mph with the highest gusts in the mountains of the region.

October 23, 2019 - A series of offshore wind events plagued much of California towards the end of October 2019. Cut off lows (also known as insider sliders) moved into the Great Basin as an upper ridge sat over the eastern Pacific. Strong surface high pressure also building over the Great Basin and a trough along the California coast provided the set up for strong and dry offshore winds over the greater Bay Area. Two more events would go on to occur before the end of the month providing what would be historic critical fire weather conditions for the region. The first event brought strong north to northeast winds to the region, particularly the North Bay, where gusts of 50 to 70 mph were observed. Healdsburg Hills North Station had a peak gust of 76 mph the night of October 23rd. These conditions fed the rapid growth of the Kincade Fire that broke out late in the evening of October 23rd, and at the end of the month the Kincade Fire was still burning. Additionally, near record breaking high temperatures were observed in parts of the area on the 24th and 25th. Prior to the event on October 9th PG&E shut off power to roughly 1 million people across the state of California.

Probability of Future Occurrences

Likely – A total of 211 combined high and strong wind events have occurred in Sonoma County over 68 years of record keeping, which equates to an average of three events in a typical year. Historical wind activity within the Planning Area indicates that the area will likely continue to experience high wind events during adverse weather conditions. The actual risk of a wind event to the City is dependent on the nature and location and the magnitude of a high wind event.

Climate Change Considerations

There presently is not enough data or research to quantify the magnitude of change that climate change may have related to wind frequency and intensity. Studies referenced in California's Fourth Climate Assessment indicated that extreme fire weather, particularly in the form of hot and dry winds, can strongly influence shrub-land fire regimes. Strong winds have also been associated with severe forest fires in California, meaning climate change impacts on wind patterns may also affect forest health and wildfire susceptibility. Lastly, other ongoing research compiled in the recent climate assessment has resulted in different conclusions on the effect of climate change on wind regimes, particularly extreme wind events, such as the Santa Ana and Diablo winds that created some of the most devastating wildfires (California Natural Resources Agency 2018a). At this time, these changing factors are not well understood and are still being incorporated into state and regional research and risk analysis.

Vulnerability Assessment

Property

General damages from high wind events can be both direct and indirect. Direct impacts refer to what the wind physically destroys, while indirect impacts includes additional costs, damages and losses attributed to secondary hazards spawned by the event, or resulting from the direct damages caused by the wind event. Construction practices and building codes can help maximize the resistance of the structures to damage.

Secondary impacts of damage caused by wind events often result from damage to infrastructure. Downed power and communications transmission lines, coupled with disruptions to transportation, create difficulties in reporting and responding to emergencies. These indirect impacts of a wind event put tremendous strain on a community.

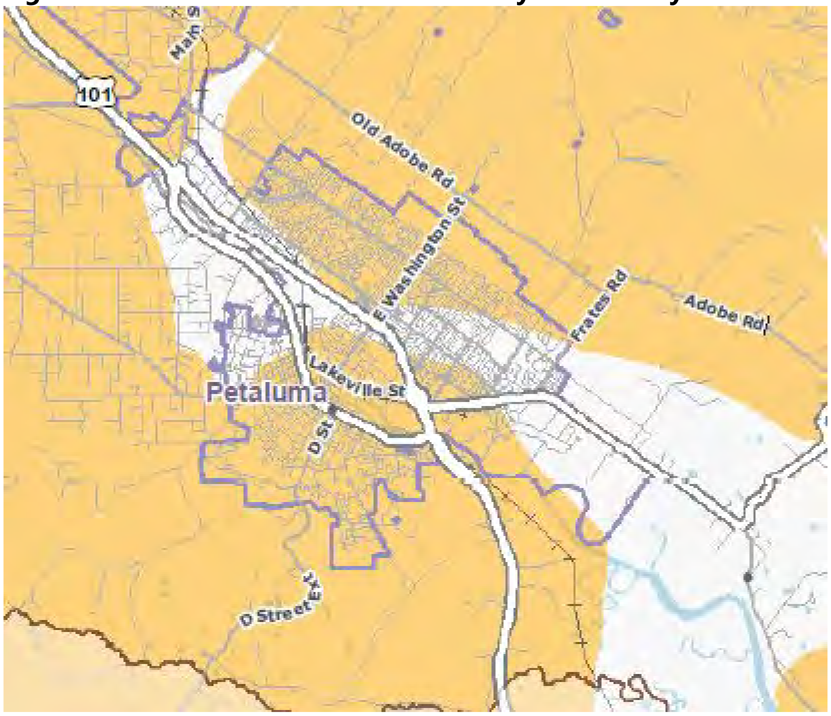
People

Community members are the most vulnerable to high wind events. However, there are also segments of the population that are especially exposed to the indirect impacts of high winds, particularly the loss of electrical power. These populations include the elderly or disabled, especially those with medical needs and treatments dependent on electricity. Nursing homes, community-based residential facilities, other special needs housing facilities, and other socially susceptible populations are vulnerable if electrical outages are prolonged since backup power generally operates only minimal functions for a short period of time.

The U.S. Department of Health and Human Services ePOWER Mapping tool (https://empowermap.hhs.gov/) provides information on Medicare beneficiaries who rely on electricity-dependent medical equipment such as ventilators to live independently in their homes. According to the tool there are 13,631 Medicare beneficiaries located in the City of Petaluma (within the zip codes of 94952 and 94954). Of these individuals, 382 are considered electricity dependent and are highly vulnerable to power outages as a result a high wind event.

Following the unprecedented 2018 wildfire season in California, Pacific Gas & Electric (PG&E) announced it will be conducting Public Safety Power Shutoffs (PSPS) when there are high winds and dry conditions and generally a heightened fire risk forecasted. The outages could last several days, and PG&E has suggested customers be prepared for outages that could last longer than 48 hours. A majority of Sonoma County could be affected by the power outages including almost the entirety of the City of Petaluma. Figure 4-48 shows the areas (orange) in the City of Petaluma that could potentially be impacted by the power outages. PG&E does have a plan to install a resource area at the Sonoma-Marin Fairgrounds within 24 hours of a PSPS, and will offer power, air conditions and updates for local residents.

Figure 4-48: Areas of Petaluma Potentially Affected by the PG&E Public Safety Power Shutoffs



Source: The Press Democrat https://www.pressdemocrat.com/news/9898428-181/pge-map-sheds-light-on?artslide=2

Economy

Winds typically don't have long-term impacts on the economy. The most common problems associated with high winds are loss of utilities. Downed power lines can cause power outages, leaving large parts of the City isolated, and without electricity, water, and communication. Damage may also limit timely emergency response and the number of evacuation routes.

In the event of a PSPS during red flag warnings, as described above, large portions of the City could be without power including several businesses. At this time, it is unclear what the economic impacts may be due to the PSPS, and it may depend on the length of the shutoff. However, given the recent planned PSPS in October 2019, economic impacts were reported across northern California as many businesses and restaurants and other tourism-based operations had to close due to limited to no power supply. In 2018, PG&E abruptly shut down the power in the Napa Valley region and the City of Calistoga reported that numerous small business lost tens of thousands of dollars in missed revenue and inventory (Argus-Courier 2019).

Critical Facilities and Infrastructure

Public gathering places such as schools, community centers, shelters, nursing homes, and churches may have increased impacts at certain times of day. Due to the random nature of the hazard, a more specific risk assessment was not conducted for this plan.

Historic, Cultural, and Natural Resources

High winds can cause massive damage to the natural environment, uprooting trees and other debris. This is part of a natural process, however, and the environment will return to its original state over time. Wind damage to historic or cultural resources on the other hand may result in more severe temporary and permanent damage that could temporarily impact the historic aesthetic of downtown Petaluma or require extensive restoration and rehabilitation of certain structures.

Future Development

As the City continues increasing in population, the number of people and housing developments exposed to the hazard increases. Proper education on building techniques and the use of sturdy building materials, basements, attached foundations, and other structural techniques may minimize the property vulnerabilities. Public shelters at parks and open spaces may help reduce the impacts of high wind events on the recreational populations exposed to storms.

Risk Summary

- Increase in post-failure or secondary hazards such as flooding, mudslides, landslides, and long-term power outages can occur.
- The U.S. Department of Health and Human Services lists 382 individuals in the City as electricity dependent, and highly vulnerable to power outages due to high wind events.
- Damage to natural resource habitats and other resources may result from severe weather associated wind.
- Severe wind events could result in the loss of water, communication lines, or power; closures to roads and transportation lifelines, which could impact, strand, and/or impair mobility for emergency responders and/or area residents.
- Economic losses (jobs, sales, tax revenue) associated with loss of commercial structures and/or inability to move through transportation lifelines could occur.
- Severe wind hazards could result in loss or damages to historic and cultural resources, which could severely impact the social fabric downtown Petaluma;
- Timely removal of debris, specifically downed trees must be addressed, as this can impact the severity of the severe weather events and the secondary impacts (e.g. localized flooding, loss of power).
- Overall the significance of severe weather associated with wind is **Medium.**

4.4 Human-Caused Hazard Profiles and Risk Assessment

The DMA does not require an assessment of human-caused hazards, but the City of Petaluma and HMPC decided to include human-caused hazards in this LHMP to several reasons. First, the City wants to inform the public about all hazards, including both natural and human-caused hazards. The City is also interested in the impact human-caused hazards could have on their community and on the daily movement of goods and services through the City. The City intends to take a proactive approach to disaster preparedness, and the HMPC feels that preparation for and response to a human-caused disaster involves the same training and commitment of City resources as a natural hazard. Lastly, the City recognizes that the likelihood of some human-caused hazard events in the Planning Area is greater than several of the natural hazard events identified in the plan.

The City also recognizes that while Sonoma County has several hazardous material management and planning procedures in place through their Certified Unified Program Agency (CUPA) administered through their Environmental Health Department, it is equally important to highlight the hazardous material hazards present in the City's Planning Area in this plan for the purpose of public education and awareness. The City wants to ensure that these hazards do not exacerbate secondary impacts associated with natural hazard events.

The following human-caused hazards are discussed in this plan:

- Hazardous Materials
- Cyber Threats

Other potential human-caused hazards, such as human-health hazards and terrorism threats were dismissed from further study. The City and HMPC noted that human-health hazards are adequately covered by the planning mechanisms administered by Sonoma County's Fire Prevention Division and Environmental Health Department.

4.4.1 Hazardous Materials

Hazard Description

Generally, a hazardous material is a substance or combination of substances which, because of quantity, concentration, or physical, chemical, or infectious characteristics, may either cause or significantly contribute to, an increase in mortality or an increase in serious, irreversible, or incapacitating reversible, illness. Hazardous materials may also pose a substantial present or potential hazard to human health or environment when improperly treated, stored, transported, disposed of, or otherwise managed. Hazardous material incidents can occur while a hazardous substance is stored at a fixed facility, or while the substance is being transported along a road corridor or railroad line or via an enclosed pipeline or other linear infrastructure.

The U.S. Department of Transportation (DOT), U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) all have responsibilities relating to the transportation, storage, and use of hazardous materials and waste. The Right-to-Know Network (RTK NET), maintained by the EPA's National Response Center (NRC), is a primary source of information on the use and storage of hazardous materials, as well as data regarding spills and releases. The California EPA and Department of Toxic Substances Control (DTSC) are authorized by the U.S. EPA to enforce and implement federal hazardous materials laws and regulations within the state. At the local level, Sonoma County's Fire Prevention Division and Hazardous Materials Division (also known as Permit Sonoma) is the approved CUPA responsible for administration of permitting, inspections, and enforcement for hazardous waste and hazardous materials programs. The CUPA administers the Hazardous Material Business Plan (HMBPs), California Accidental Release Prevention (Cal-ARP) program, and the Aboveground Storage Act, as well as permitting and inspection activities for hazardous waste generators, and onsite hazardous waste treatment facilities, and underground storage tanks.

Hazardous materials can be divided into the following classes:

- Explosives
- Compressed gases: flammable, non-flammable compressed, poisonous
- Flammable liquids: flammable (flashpoint below 141 degrees Fahrenheit) combustible (flashpoint from 141 - 200 degrees)
- Flammable solids: spontaneously combustible, dangerous when wet
- Oxidizers and organic peroxides
- Toxic materials: poisonous material, infectious agents
- Radioactive material
- Corrosive material: destruction of human skin, corrodes steel

It is also common to see hazardous materials releases as escalating incidents resulting from other hazards such as floods, wildfires, and earthquakes. The release of hazardous materials can greatly complicate or even eclipse the response to the natural hazards disaster that caused the spill.

The Safety Element of the City of Petaluma General Plan contains goals, policies, and implementation measures pertaining to hazardous materials. Additionally, Sonoma County has prepared and adopted the Sonoma County Operational Area Hazardous Materials Incident Response Plan, in accordance with the California Health and Safety Code (HSC) (Division 20, Chapter 6.95, §25500 et seq.) and California Code of Regulations (CCR) (Title 19, Article 3, §2270 et seq.). This plan describes the policies and procedures relating to hazardous materials emergency response throughout Sonoma County, and is reviewed and updated every three years.

Location

Hazmat incidents can occur at a fixed facility or during transportation. Hazardous materials facilities are identified and mapped by the counties they reside in, along with the types of materials stored there; facilities generally reside in and around communities. The Petaluma Fire Department and Hazardous Materials Division manages the prevention, control and mitigation of dangerous conditions related to hazardous materials and enforces state and local laws regulating the storage, use, dispensing and handling of hazardous materials. The Division is responsible for the enforcement of the regulatory-based HMBP Program, Hazardous Waste Program, Underground Storage Tank Program, Above Ground Petroleum Storage Tank Program, Accidental Release Program, and the portions of the California Fire Code that address hazardous materials. Inspections of businesses are conducted on a routine basis, and the Division.

Under Chapter 6.95 of the California Health and Safety Code and the Federal Resource Conservation and Recovery Act (RCRA), any business storing quantities of hazardous materials greater than 55 gallons of liquid, 500 pounds of solid or 200 cubic feet of some compressed gasses must file a HMBP annually that establishes incident prevention measures, hazardous material handing protocols and emergency response and evacuation procedures.

CalARP is a statewide initiative to reduce the likelihood and severity of consequences of extremely hazardous materials releases. CalARP requires certain facilities (referred to as "stationary sources") which handle specified chemicals (termed "regulated substances") to take specified actions to proactively prevent and prepare for chemical accidents. Because the CalARP program is implemented at the local government level by the CUPAs, they can work directly with regulated facilities. The Petaluma Fire Department administers CUPA and provide response and mitigation services to the City.

Some facilities contain extremely hazardous substances; these facilities are required to generate Risk Management Plans (RMPs) and resubmit these plans every five years. According to the RTK NET, the City of Petaluma Wastewater Treatment Plant is the only RMP facility located in the planning area. This site stores 18,000 pounds of chlorine, used as part of the sewage treatment process.

In transit, hazardous materials generally follow major transportation routes, including road, rail and pipelines, creating a risk area immediately adjacent to these routes. The City's nearby transportation network, primarily U.S. Highway 101, has the potential for hazardous material incidents. Railroad lines (nearby Northwestern Pacific Railroad Authority lines) and the Petaluma Municipal Airport may also transport hazardous materials.

According to the Federal Motor Carrier Safety Administration and the National Hazardous Materials Route Registry, U.S. Highway 101 running through Petaluma is designated as a hazardous materials route. However, local deliveries of hazardous materials can be found on any of the City's major roads.

Hazardous materials releases can also result from natural disasters, such as floods or earthquakes that may cause containment systems to fail. In summary, hazardous material incidents have the potential to occur in business and industrial areas (where fixed facilities are located). Often these facilities are concentrated in the Planning Area due to their manufacturing operations. Hazardous material incidents are also located in agricultural areas surrounding the Planning Area; these types of facilities typically use pesticides, fertilizers, and other agricultural chemicals that are harmful to people and the environment. Illegal drug operations and dumping sites have also been known to pose a hazardous threat.

Lastly, pipelines can transport large quantities of hazardous materials. The National Pipeline Mapping System (NPMS) shows the approximate location of multiple pipelines passing through the City, primarily transporting gas or fuels.

Extent (Magnitude/Severity)

Limited – Hazardous materials come in the form of explosives, flammable and combustible substances, poisons and radioactive materials. Hazards can occur during production, manufacturing, storage, transportation, use, or disposal. Numerous factors influence the impacts of a hazardous materials release, including method of release, the type of material, location of release, weather conditions, and time of day. This makes it difficult to predict precise impacts. Impacts from hazardous waste releases can include:

- Injury
- Loss of life (human, livestock, fish and wildlife)
- Evacuations
- Property damage
- Air pollution
- Surface or ground water pollution/contamination
- Interruption of commerce and transportation

CAL FIRE notes several additional factors that can contribute to the impact of hazardous materials releases from a fixed facility or transportation incident:

- Solid, liquid, and/or gaseous hazardous materials can be released from fixed or mobile containers either accidentally or on purpose.
- The resulting release can last for hours or for days.
- The substances released may be corrosive or otherwise damaging over time, and they may cause an explosion and/or fire.
- Contamination may be carried out of the incident area by people, vehicles, water, and/or wind.
- Weather conditions will directly affect how the hazard develops.
- The micrometeorological effects of buildings and terrain can alter travel and duration of agents.
- Shielding in the form of sheltering in place can protect people and property from harmful effects.
- Noncompliance with fire and building codes as well as failure to maintain existing fire protection and containment features can substantially increase the damage from a hazardous materials release.

The release or spill of hazardous materials also requires different emergency response depending on the amount, type, and location of the spill incident.

The Planning Area has energy pipelines, railroad tracks which carry many types of hazardous materials, and state highways running through its boundaries. A variety of hazardous materials originating in the Region or elsewhere are transported along these routes and could be vulnerable to accidental spills.

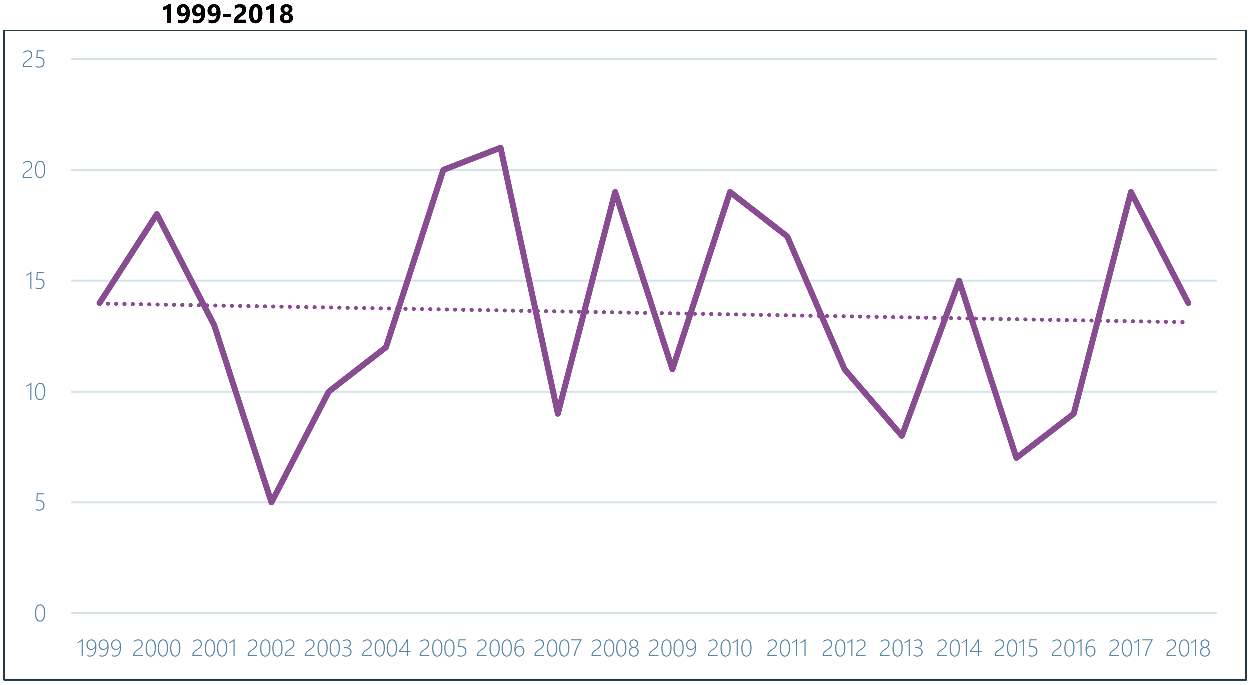
Consequences can vary depending on whether the spill affects a populated area versus an unpopulated but environmentally sensitive area.

Potential losses can vary greatly for hazardous material incidents. For even a small incident, there are cleanup and disposal costs. In a larger scale incident, cleanup can be extensive and protracted. There can be deaths or injuries requiring doctor's visits and hospitalization, disabling chronic injuries, soil and water contamination can occur, necessitating costly remediation. Evacuations can disrupt home and business activities. Large-scale incidents can easily reach $1 million or more in direct damages.

Previous Occurrences

The City of Petaluma experiences multiple hazardous materials incidents every year. The vast majority of these incidents are minor with very localized impacts. The Cal OES Warning Center reports 271 hazardous materials incidents in Petaluma from 1999 through 2018; this works out to an average of 13.6 incidents per year. Even this total likely excludes a large number of unreported minor spills. Figure 4-49 below shows the number of incidents within the City limits reported to Cal OES over the last twenty years. While the number of incidents can vary considerably from year to year, the number of hazardous materials spills or accidents in the City has remained steady over the last twenty years. This is in contrast to the statewide trend, which has seen hazardous materials incidents increase by 30 percent during the same time period.

Figure 4-49: Hazardous Materials Spills/ Accidents in the City of Petaluma Reported to Cal OES: 1999-2018



Source: Cal OES Spill Release Reporting (https://www.caloes.ca.gov/cal-oes-divisions/fire-rescue/hazardous-materials/spill-release-reporting), analysis by Wood

The vast majority of hazardous materials incidents have only minimal life safety impacts. Of the 271 incidents reported above, only seven (3 percent) result in any injuries, fatalities, or evacuations. This translates to an average of one damaging hazardous materials incident roughly every three years. In all, Cal OES records seven injuries, one fatality, and one evacuation are associated with those 271 incidents.

Probability of Future Occurrence

Likely – As discussed above, the City experiences anywhere from five to twenty reportable hazardous materials incidents per year, with various degrees of impact; there is effectively a 100 percent chance that the City will see a hazardous materials incident in any given year. However, hazardous materials incidents that cause deaths, injuries, or evacuations are far rarer, occurring once every three years on average. These can occur at any time and with little predictability given the presence of major transportation routes in the City's Planning Area.

Climate Change Considerations

There are no known effects of climate change on human-caused hazards, such as hazardous material incidents. However, hazmat incidents may indirectly increase the risk by increasing the frequency, severity, or range of other hazards, such as severe storms or fires. It is possible that an increase in these other hazards may increase the likelihood of an accidental hazardous materials release.

Vulnerability Assessment

Property

The impact of a fixed hazardous facility, such as a chemical processing facility, will likely be localized to the property where the incident occurs. The impact of a small spill (i.e. liquid spill) may also be limited to the extent of the spill and remediated if needed. A blanket answer for potential impacts is hard to quantify, as different chemicals may present different impacts and issues. Property within a half mile in either direction of designated hazardous materials routes are at increased risk of impacts. While cleanup costs from major spills can be significant, they do not typically cause significant long-term impacts to property.

People

People living near hazardous facilities in the Planning Area may be at a higher risk of exposure, however; few people live near these facilities as most industrial land uses are sited away from residential land uses. Still, people living downstream and downwind from a hazardous material facility (or hazardous material release) could be more vulnerable. For example, a toxic spill or a release of an airborne chemical in a populated area like the City of Petaluma could have a greater potential for loss of life, particularly if is spreads towards residential areas surrounding the downtown area.

In addition to the immediate health impacts of releases, a handful of studies have found long term health impacts such as increased incidence of certain cancers and birth defects among people living near certain chemical facilities. However, there has not been sufficient research done on the subject in the Planning Area to allow detailed analysis.

Critical Facilities and Infrastructure

Impacts from hazardous material incidents on critical facilities would be localized. That is, they will be limited to the area or facility where they occurred, such as at a transit station, airport, fire station, hospital, or railroad. Whereas hazardous material incidents to major transportation infrastructure would be localized to some extent, they may also be further reaching if they result in major delays in the movement of goods and services and if they result in long-term traffic delays and road closures. These incidents would be more severe if they result in traffic delays or road closures along U.S. Highway 101.

Economy

The primary economic impact of hazardous material incidents result in lost business, delayed deliveries, property damage, and potential contamination. Large and publicized hazardous material-related events can deter tourists and recreationists too. If incidents occur along major transportation corridors, they can temporarily close routes and result in traffic delays. Economic effects from major transportation corridor closures can be significant.

Historic, Cultural, and Natural Resources

Hazardous material incidents may affect a small area at a regulated facility or cover a large area outside such a facility. Widespread effects occur when hazards contaminate the groundwater and eventually the municipal water supply, or they migrate to a major waterway or aquifer.

Future Development

The City of Petaluma anticipates experiences the greatest growth in the downtown area. Future development in central Petaluma is close to major roads and local thoroughfares, as well as some operations that are known to store, handle, and transport hazardous materials. As a result, future development would be exposed to potential hazardous material releases to some extent. Careful review and management of HMBPs and implementation of Hazardous Materials Incident Response Plans during events should minimize major risks.

Risk Summary

- There is one RMP facility located within the City limits.
- Over the last twenty years the City has averaged 13.6 hazardous materials incidents per year. However, hazardous materials incidents that cause deaths, injuries, or evacuations are far rarer, occurring once every three years on average.
- Incidents at hazardous facilities will likely be localized to the property where the incident occurs.
- People living near, downstream, or downwind of hazardous facilities could be more vulnerable to airborne or water quality related contamination associated with a hazardous material incident.
- Hazardous materials releases can complicate response to and recovery from natural disasters such as foods and earthquakes.
- Hazardous Materials incidents can cause injuries and fatalities, as well as long term health problems like increased cancer risks.
- Impacted properties and infrastructure can require cleanup, but the effects are usually localized to the site of the release.
- Extended road closures can result in economic losses and impact tourism.
- Overall significance level for hazardous materials is **Medium.**

4.4.2 Cyber Threats

Hazard Description

The California SHMP identifies cyber threats as "attempts by cyber criminals to attack a government, organization, or private party by damaging or disrupting a computer or computer network, or by stealing data from a computer or computer network for malicious use." A recent survey by the United States Government Accountability Office (GAO) 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."

There are many types of cyber-attacks. Among the most common is a direct denial of service, or DDoS attack. This is when a server or website will be queried or pinged rapidly with information requests, overloading the system and causing it to crash.

Cyber-attacks use malicious code to alter computer operations or data. The vulnerability of computer systems to attacks is a growing concern as people and institutions become more dependent upon networked technologies. The Federal Bureau of Investigation (FBI) reports that "cyber intrusions are becoming more commonplace, more dangerous, and more sophisticated," with implications for private- and public-sector networks.

Malware, or malicious software, can cause numerous problems once on a computer or network, from taking control of users' machines to discreetly sending out confidential information. Ransomware is a specific type of malware that blocks access to digital files and demands a payment to release them. Hospitals, school districts, state and local governments, law enforcement agencies, businesses, and even individuals can be targeted by ransomware. One 2017 study found ransomware payments over a two-year period totalled more than $16 million. Even if a victim is perfectly prepared with full offline data backups, recovery from a sophisticated ransomware attack typically costs far more than the demanded ransom. However according to a 2016 study by Kaspersky Lab, roughly one in five ransomware victims who pay their attackers are still not able to retrieve their data.

Cyber spying or espionage is the act of illicitly obtaining intellectual property, government secrets, or other confidential digital information, and often is associated with attacks carried out by professional agents working on behalf of a foreign government or corporation. According to cybersecurity firm Symantec, in 2016 "…the world of cyber espionage experienced a notable shift towards more overt activity, designed to destabilize and disrupt targeted organizations and countries."

Major data breaches - when hackers gain access to large amounts of personal, sensitive, or confidential information - have become increasingly common. The Symantec report says more than seven billion identities have been exposed in data breaches over the last eight years. In addition to networked systems, data breaches can occur due to the mishandling of external drives, as has been the case with losses of some state employee data.

Cybercrime can refer to any of the above incidents when motivated primarily by financial gain or other criminal intent. The most severe type of attack is cyber terrorism, which aims to disrupt or damage systems in order to cause fear, injury, and loss to advance a political agenda.

The adopted City of Petaluma budget for FY2019 notes an increase in spending on cyber security measures, specifically to combat malware and ransomware.

Location

Cyber disruption events can occur or impact virtually any location where computing devices are used. Incidents may involve a single location or multiple geographic areas. A disruption can have far-reaching effects beyond the location of the targeted system; disruptions that occur far outside the state can still impact people, businesses, and institutions within the City of Petaluma.

Extent (Magnitude/Severity)

Critical –The extent of a cyber disruption event is variable depending on the nature of the event. A disruption affecting a small, isolated system could impact only a few functions and processes. Disruptions of large, integrated systems could impact many functions and processes, as well as many individuals that rely on those systems.

There is no universally accepted scale to quantify the severity of cyber-attacks. The strength of a DDoS attack is sometimes explained in terms of a data transmission rate. One of the largest DDoS disruptions ever, which brought down some of the internet's most popular sites on October 21, 2016, peaked at 1.2 terabytes per second.

Data breaches are often described in terms of the number of records or identities exposed.

Previous Occurrences

The City of Petaluma IT Department noted there are potential ransomware attacks on the City's IT system on a daily basis. Specific cyber incidents were not discussed.

Symantec reports there were a total of 1,209 data breaches worldwide in 2016, 15 of which involved the theft of more than 10 million identities. While the number of breaches has remained relatively steady, the average number of identities stolen has increased to almost one million per incident. The report also found that one in every 131 emails contains malware, and the company's software blocked an average of 229,000 web attacks every day.

The Privacy Rights Clearinghouse, a non-profit organization based in San Diego, maintains a timeline of 2,631 data breaches resulting from computer hacking incidents in the United States from 2005-2019. The database lists 522 data breaches in California during this timeframe, including attacks on private sector facilities, government agencies, schools and media entities. While none of those security breaches were specifically targeted at systems in the City of Petaluma, some of them included information on individuals who live in the community. Similarly, Petaluma residents were almost certainly affected by national and international data breaches.

While Petaluma itself has not been the victim of major cyber or ransomware attacks, examples from across the country show both the prevalence of cyber-attacks and potential impacts.

The City of Atlanta was also hit by a major ransomware attack in 2018, recovery from which cost a reported $2.6M, significantly more than the $52,000 ransom demand. A similar attack against the City of Baltimore in 2019 affected the city government's email, voicemail, property tax portal, water bill and parking ticket payment systems, and delayed more than 1,000 pending home sales.

Probability of Future Occurrences

Occasional – Cyber-attacks occur daily, but most have negligible impacts at the city level and are blocked by the city's existing cyber security systems. The possibility of a larger disruption affecting the City exists at all times, but it is difficult to quantify the exact probability due to such highly variable factors as the type of attack and intent of the attacker. Minor attacks against business and government systems have become commonplace occurrences but are usually stopped with minimal impact. Similar data breaches impacting the information of residents are almost certain to happen in coming years. Major attacks or breaches specifically targeting systems in the county are less likely but cannot be ruled out.

Climate Change Considerations

Climate change is not expected to have any direct impacts on the vulnerability of cyber systems to an attack.

Vulnerability Assessment

Property

While specific types of cyber-attacks can cause physical damage to systems and equipment, property damage from cyber-attacks is typically limited to computer systems.

People

Cyber-attacks can have a significant cumulative economic impact. Symantec reports that in the last three years, businesses have lost $3 billion due to spear-phishing email scams alone. A major cyber-attack has the potential to undermine public confidence and build doubt in their government's ability to protect them from harm.

Injuries or fatalities from cyber-attacks would generally be a cascading result of specific system failure (i.e. injuries or fatalities caused by secondary incidents due to a compromised traffic light system) or a compromised electrical grid. Refer to the Vulnerability Assessment under Section 4.3.10 High Winds for details on the number of Medicare beneficiaries that are electricity dependent in the City of Petaluma.

Economy

Economic impacts are entirely dependent on the types of successful attacks that occur, and what the specific attack's goals were. In an electronic-based commerce society, any disruption to daily activities can have disastrous impacts to the economy. Economic impacts from cyber threats around the world include disruptions in commerce, ransom demands, and restoration costs. McAfee notes that cyber threats cost the global economy as much as $600 billion in 2017.

Critical Facilities and Infrastructure

Critical facilities, infrastructure and systems can make inviting targets for cyber threats, with the potential to cause widespread and damaging impacts. Ultimate impacts of a cyber-attack depend on both the method and success of the attack, as well as the type of critical asset affected. Most attacks affect only data and computer systems. Sabotage of utilities and infrastructure from a major cyber terrorist attacks could potentially result in system failures that damage property on a scale equal with natural disasters. Facilities and infrastructure may become unusable as a result of a cyber-attack.

Future Development

Traditionally, cyber threats should not have any bearing on future development. The prevalence and evolution of cyber threats does require continued City efforts to upgrade security systems to meet evolving threats.

Risk Summary

- City systems are attacked multiple times a day; most attacks thwarted by existing security systems
- The City and surrounding county are proactive in cybersecurity and cyber prevention measures.
- Evolving cyber threats require a matching evolution in protection and deterrence techniques to match the threat.
- While the City of Petaluma hasn't suffered a specific, large-scale cyber infiltration, examples from around the world show how devastating these types of attacks can be on communities.
- Successful cyber incidents can have a variety of impacts, based on the targeted system(s), attack type, attack goals, and ultimate success of the attack.

- Overall the significance associated with cyber threats is **Medium.**

4.5 Hazard Summary

Table 4-43 summarizes the results of the hazard identification and hazard profiles for the Planning Area based on the hazard identification data and input from the HMPC. For each hazard profiled in Section 4.2 on natural hazards and in Section 4.3 on human-caused hazards, this table includes the likelihood of future occurrence and whether the hazard is considered a priority hazard for the Planning Area.

Table 4-43: Hazard Identification and Determination of Priority Hazard

Hazard	Priority Hazard
Natural Hazard	
Drought	Yes
Earthquake	Yes
Fire: Urban and Wildfire	Yes
Flood: 100-, 200-, and 500-Year Events	Yes
Sea Level Rise	Yes
Severe Weather: Extreme Heat	No
Severe Weather: Heavy Rain/Thunderstorm/ Hail/Lightning/Dense Fog	Yes
Severe Weather: Wind	No
Human-Caused Hazards	
Hazardous Materials	Yes
Cyber Threats	Yes

Source: HMPC 2018

The HMPC determined that drought, earthquake, flooding, sea level rise, heavy rain/thunderstorm/hail/lightning, and wildfire are the most significant hazards in the Planning Area. These hazards have also been categorized as priority hazards by the HMPC.

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5 Mitigation Strategy

44 U.S. CFR Requirement §201.6(c)(3): [The plan shall include] a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.

This section describes the process to develop the mitigation strategy and mitigation action plan for the City of Petaluma Local Hazard Mitigation Plan (LHMP) update. It describes how the City met the requirements for the Federal Emergency Management Agency (FEMA) 10-step planning process. This chapter specifically discusses:

- Planning Step 6: Set Goals
- Planning Step 7: Review Possible Activities
- Planning Step 8: Draft an Action Plan

The results of the planning process, the risk assessment, the goal setting, the identification of mitigation actions, and the participation of the Hazard Mitigation Planning Committee (HMPC) led to the action plan documented in Section 5.3 Mitigation Action Plan. Taking all the above into consideration, the HMPC developed the following overall mitigation strategy:

- **Communicate** the hazard information collected and analyzed through this planning process so that the community better understands what can happen where and what they can do to be better prepared.
- **Implement** the action plan recommendations of this plan.
- **Use** existing rules, regulations, policies, and procedures already in existence.
    - Given the flood hazards in the Planning Area, an emphasis should be placed on continued compliance with the National Flood Insurance Program (NFIP) and participation in the Community Rating System (CRS).
- **Monitor** multi-objective management actions so that funding opportunities may be shared, projects may be packaged, and broader constituent support may be garnered among neighboring communities.

5.1 Goals and Objectives

Requirement §201.6(c)(3)(i): The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

Up to this point in the planning process, the HMPC has organized resources, assessed hazards and risks, and documented mitigation capabilities. The resulting goals and mitigation actions were developed based on these tasks. The HMPC held a series of meetings and exercises designed to achieve a collaborative mitigation strategy as described further throughout this section.

During the initial goal-setting meeting, the HMPC reviewed the results of the hazard identification, vulnerability assessment, and capability assessment. This analysis of the risk assessment identified areas where improvements could be made and provided the framework for the HMPC to formulate planning goals and objectives and the ultimate mitigation strategy for the City of Petaluma Planning Area.

5.1.1 Goals Development Process

Goals were defined for the purpose of this mitigation plan as broad-based public policy statements that:

- Represent basic desires of the community;
- Encompass all aspects of community, public and private;
- Are nonspecific, in that they refer to the quality (not the quantity) of the outcome;
- Are future-oriented, in that they are achievable in the future; and
- Are time-independent, in that they are not scheduled events.

Goals are stated without regard to implementation cost, schedule, and means. Goals are defined before considering how to accomplish them so that they are not dependent on the means or cost of achievement. The goal statements form the basis for objectives and actions that will be used as means to achieve the goals. Objectives define strategies to attain the goals and are more specific and measurable.

During the planning process, HMPC members were given a list of sample goals to consider from the California 2018 State Hazard Mitigation Plan (SHMP), the 2010 City of Petaluma LHMP Annex to the Association of Bay Area Government's (ABAG) *Taming Natural Disasters* regional multi-jurisdictional LHMP for the Bay Area, the City of Petaluma General Plan Health and Safety Element, the City Council's 2019-2020 Strategic Plan, and the 2016 Sonoma County Operational Area HMP. They were also provided a list of goal statements from neighboring city and county hazard mitigation plans (e.g. City of Santa Rosa LHMP). They were told that they could use, combine, or revise the statements provided or develop new ones, keeping the risk assessment in mind. Each member was each given three 3 by 5 inch sticky notes and asked to write a goal statement on each sticky note. Goal statements were collected and grouped into similar themes and pasted onto the wall of the meeting room. The goal statements from the HMPC were discussed until the team came to consensus. Some of the statements were determined to be better suited as objectives or actual mitigation actions and were set aside for later use.

5.1.2 Objectives Development Process

Next, the HMPC was asked whether they wanted to develop objectives that summarized strategies to achieve each goal. The HMPC agreed they would consider the development of objective statements as part of the goal development process and refine the objectives at the next meeting. The HMPC also reviewed the City Council's 2019-2020 Strategic Plan to look for opportunities to align the Strategic Plan with the LHMP goals and objectives. The HMPC revisited the goal statements prepared and categorized during the next HMPC meeting (HMPC Meeting #3). During this meeting, the Wood team explained that Wood staff and the City Project Manager reviewed each goal, re-arranged them by theme and removed duplicate goal statements. The remaining draft goals focused on loss of life and property prevention, resilience of the natural and built environment, emergency response coordination, public education, and plan implementation.

Based on the risk assessment review and goal setting process, the HMPC identified the following five goals, which provide direction for reducing future hazard-related losses within the City of Petaluma Planning Area. Statements that were more specific and measurable, but not as detailed as mitigation actions were categorized as objectives.

Goal 1: Minimize loss of life, property, and economic damage and protect people and property from hazards.

- **Objective 1.1:** Ensure public infrastructure and critical facilities are earthquake and flood safe and can withstand natural hazards through the implementation of mitigation projects for the built environment.
- **Objective 1.2:** Review land use regulations, development standards, and growth management programs to ensure future development exposure to natural and human-caused hazards is minimized.

Goal 2: Preserve and protect Petaluma's natural environment as an efficient resource to build community resilience against natural hazards.

- **Objective 2.1:** Enhance the City's natural environment capacity through mitigation projects designed to withstand hazards.
- **Objective 2.2:** Restore Petaluma river to improve water quality, expand economic opportunities, increase recreation accessibility, and enhance flood protection.

Goal 3: Educate and build community awareness on natural hazard risks and the importance of resiliency and emergency preparedness.

- **Objective 3.1:** Improve emergency preparedness awareness with an emphasis on outreach in vulnerable and socially disadvantaged populations by increasing coordination with these communities to ensure hazard risks, preparedness, and evacuation information is available and well understood.
- **Objective 3.2:** Develop outreach programs for the general public to increase awareness of hazards and to share ideas on hazard mitigation.
- **Objective 3.3:** Create partnerships with Sonoma Water to build awareness on water supply, drought, and conservation measures.

Goal 4: Enhance City staff coordination, training, and response during disasters and ensure City facilities and infrastructure are operational and provide safe places for the community to shelter during hazard events.

- **Objective 4.1:** Coordinate and share resources and information technology with neighboring jurisdictions and other agencies during disaster response and recovery training exercises.
- **Objective 4.2:** Develop contingency plans for critical facilities and infrastructure to maintain adequate water and wastewater services during hazard events.
- **Objective 4.3:** Upgrade and improve redundancy at critical facilities to ensure there are safe places and designated shelters during disasters.

Goal 5: Implement and regularly update the LHMP as an integrated planning mechanism to prepare the City for natural, human-caused, and climate change-related hazards.

- **Objective 5.1:** Schedule annual reviews of mitigation actions and regular 5-year updates of the LHMP to optimize funding opportunities and to efficiently track implementation progress.
- **Objective 5.2:** Continue to assess the effects of climate change on natural hazards, specifically sea level rise through annual review of scientific data and modelling.

5.1.3 Incorporation into Existing Planning Mechanisms

The information contained within this plan, including results from the vulnerability assessment, and the mitigation strategy will be used by the City to help inform updates and the development of local plans, programs and policies. The City Public Works and Utilities Department may utilize the hazard information when implementing the City's Infrastructure Master Plans and the Planning, Building, Housing, Fire, and Police Departments may utilize the hazard information when reviewing a site plan or other types of residential and commercial development applications. The City may incorporate information in this LHMP into future updates to the City's General Plan 2025 Health and Safety Element, 2015 Floodplain Management Plan (FMP), and River Access and Enhancement Plan. Information may include hazard profile information on climate change impacts and the incorporation of climate change adaptation strategies into other local and regional plans and outreach programs. The City will also incorporate this LHMP into the Health and Safety Element of the General Plan 2025, in accordance with California's Assembly Bill (AB) 2140.

Lastly, the HMPC representatives report on efforts to integrate the LHMP into local plans, programs and policies and will report on these efforts at the annual HMPC plan review meeting.

5.2 Identification and Analysis of Mitigation Actions

Requirement §201.6(c)(3)(ii): The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

In order to identify and select mitigation actions to support the mitigation goals, each hazard identified in Section 4.1 Identifying Hazards: Natural Hazards was evaluated, as well as human-caused hazards identified in Section 4.4 Human-caused Hazards. Only those hazards that were determined to be a priority hazard were considered further in the development of hazard-specific mitigation actions.

The priority natural hazards are:

- Dam Incidents
- Drought
- Earthquake
- Flood: 100/200/500-Year, Localized Flooding
- Sea Level Rise
- Severe Weather: Extreme Heat
- Severe Weather: Heavy Rains/Thunderstorms/Hail/Lightning/Dense Fog
- Severe Weather: High Winds
- Wildfire

Hazardous materials incidents (releases from a fixed facility or transportation accidents) and cyber threats were also identified by the HMPC as priority hazards, as noted in Section 4.4 Human-caused Hazards. Climate change impacts are qualitatively discussed in each hazard profile section. Public Safety Power Shutoffs (PSPS), commonly associated with high wind and wildfire events, are addressed by the Severe Weather: High Wind actions.

Once it was determined which hazards warranted the development of specific mitigation actions, the HMPC analyzed viable mitigation options that supported the identified goals and objectives. The HMPC was provided with the following list of categories of mitigation actions, which originate from the CRS:

- **Prevention**: Administrative or regulatory actions or processes that influence the way land and buildings are developed and built to reduce hazard losses. This includes planning and zoning, floodplain regulations, capital improvement programs, open space preservation, and stormwater management regulations.
- **Property Protection**: Actions that involve the modification of existing buildings or structures to protect them from a hazard or remove them from the hazard area. This includes acquisition, elevation, relocation, structural retrofits, storm shutters, and shatter-resistant glass.
- **Structural**: Actions that involve the construction of structures to reduce the impact of a hazard.
- **Natural Resource Protection**: Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural systems. This includes dams, levees, floodwalls, retaining walls, and safe rooms.
- **Emergency Services**: Actions that protect people and property during and immediately after a disaster or hazard event. This includes warning systems, emergency response services, and the protection of essential facilities.
- **Public Information/Education and Awareness**: Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigate them. This includes outreach, real estate disclosure, hazard information kiosks, and education programs.

At the mitigation strategy meeting the HMPC was provided with a matrix showing examples of potential mitigation action alternatives for each of the above categories, for each of the identified hazards. The HMPC was also provided a handout that explains the categories and provided further examples. Another reference document titled "Mitigation Ideas" developed by FEMA was distributed to the HMPC during the mitigation strategy meeting. This document lists the common alternatives for mitigation by hazard. The HMPC was instructed to consider both future and existing buildings in considering possible mitigation actions. The HMPC was also asked to consider possible climate adaptation strategies in order comply with California Government Code Section 65302 subsection (g)(4). This code section addresses Senate Bill 379 requirements related to the probable consequences of climate change and assessing how climate change may affect critical facilities, infrastructure, and land uses. The HMPC was provided the California Adaptation Planning Guide (APG), which is a set of four complementary documents that provide guidance to support communities in addressing the consequences of climate change. Specific climate adaptation strategies were discussed as they relate to the priority natural hazards. The HMPC also discussed which mitigation actions and strategies should be pursued first to address immediate community needs.

A facilitated discussion took place to examine and analyze the options. Appendix C provides the matrix of alternatives considered. Each proposed action was written on a large sticky note and posted on flip charts underneath the hazard it addressed.

5.2.1 Prioritization Process

Once the mitigation actions were identified, the HMPC was provided with several decision-making tools, including FEMA's recommended prioritization criteria, STAPLEE, to assist in deciding why one recommended action might be more important, more effective, or more likely to be implemented than another. STAPLEE stands for the following:

- **Social:** Does the measure treat people fairly? (e.g., social equity, different groups, different generations)
- **Technical:** Is the action technically feasible? Does it solve the problem?
- **Administrative:** Are there adequate staffing, funding, and other capabilities to implement the project?
- **Political:** Who are the stakeholders? Will there be political and public support for the project?
- **Legal:** Does the jurisdiction have the legal authority to implement the action? Is it legal?
- **Economic:** Is the action cost-beneficial? Is there funding available? Will the action contribute to the local economy?
- **Environmental:** Does the action comply with environmental regulations? Will there be negative environmental consequences from the action?

The HMPC also discussed prioritizing actions that focus on climate adaptation, social equity, and community resiliency. They reviewed planning materials and tools designed to assist local communities in the development of climate adaptation and social equity goals and strategies.

In accordance with the Disaster Mitigation Act requirements (44 CFR , Section 201.6(c)(3)), an emphasis was placed on the importance of a benefit-cost analysis in determining action priority. As part of this evaluation, the benefits of proposed actions were weighed against estimated costs as part of the prioritization process. Other criteria used to assist in evaluating the benefit-cost of a mitigation action included:

- Does the action address priority hazards or areas with the highest risk?
- Does the action protect lives?
- Does the action protect infrastructure, community assets or critical facilities?
- Does the action meet multiple objectives (Multiple Objective Management)?
- What will the action cost?
- What is the timing of available funding?

The mitigation categories, multi-hazard actions, and criteria are included in Appendix C: Mitigation Categories, Alternatives, and Selection Criteria.

At the mitigation strategy meeting the HMPC used STAPLEE to determine which of the identified actions were most likely to be implemented and effective. With these criteria in mind, team members were given a set of five green sticky-dot stickers. The team was asked to use the dots to prioritize projects with the above criteria in mind, essentially voting on the projects. The projects with the most dots became the higher priority projects. This process provided both consensus and priority for the recommendations.

The process of identification and analysis of mitigation alternatives allowed the HMPC to come to consensus and to collectively prioritize recommended mitigation actions. During the voting process, emphasis was placed on the importance of a benefit-cost review in determining project priority; however, this was not a quantitative analysis. Benefit-cost was considered in greater detail in the development of the Mitigation Action Plan detailed below in Section 5.3. For example, parameters were established for assigning subjective ratings (high, medium, low) to the benefits and costs of each mitigation action. Specifically, each action developed for this plan contains a description of the problem and proposed project, the entity with primary responsibility for implementation, any other alternatives considered, a cost estimate, expected project benefits, potential funding sources, and a schedule for implementation.

Development of these project details for each action led to the determination of an overall high, medium, or low priority for each action.

Recognizing the limitations in prioritizing actions from multiple departments and the regulatory requirement to prioritize by benefit-cost to ensure cost-effectiveness, the HMPC decided to pursue mitigation action strategy development and implementation according to the nature and extent of damages, the level of protection and benefits each action provides, political support, project cost, available funding, and jurisdiction and department priority. This process guided the development of a prioritized action plan for the City of Petaluma. Cost-effectiveness will be considered in greater detail through a formal benefit-cost analysis when seeking FEMA mitigation grant eligibility and funding (e.g. Hazard Mitigation Grant Program, Pre-Disaster Mitigation grant program) for eligible actions associated with this plan.

5.3 Mitigation Action Plan

Requirement §201.6(c)(3)(iii): The mitigation strategy section shall include] an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

This action plan was developed to present the recommendations developed by the HMPC for how the City of Petaluma can reduce the vulnerability of people, property, infrastructure, and natural and cultural resources to future disaster losses. Over time, the implementation of these projects will be tracked as a measure of demonstrated progress on meeting the plan's goals.

5.3.1 Progress on 2010 City of Petaluma LHMP Annex Mitigation Actions

The City of Petaluma has been implementing actions identified in the City of Petaluma LHMP Annex developed and last updated by the ABAG in 2010, and working steadily towards meeting the 2010 plan goals based on funding and staff availability. During the 2019 LHMP update process the City reported on the status of the 2010 actions. The City provided input on whether the action had been completed, was deferred (not yet implemented, but still relevant for the updated plan), was in progress, or should be deleted.

Given the City has historically been impacted primarily by flood hazards, all goals and objectives from the 2010 FMP were carried forward into the 2010 LHMP Annex, plus five new mitigation strategies. For this 2019 LHMP update, new flood hazard mitigation actions were developed, but only four of the five mitigation strategies from the 2010 LHMP Annex were carried forward into the 2019 LHMP. This includes Strategy #GOVT-b-14, Strategy #GOVT-b-15, Strategy #GOVT a-7, and Strategy #GOVT a-9. Strategy #GOVT-b-22 was completed. Other strategies listed in the 2010 LHMP Annex were not funded and are no longer relevant for the City of Petaluma. These four strategies were consolidated into three mitigation actions in the 2019 LHMP mitigation strategy.

Strategy #GOVT-b-14 included the installation of a warning system with outdoor sirens, and coordinating installation with neighboring jurisdictions. This mitigation strategy was deferred and carried forward into the 2019 LHMP. In the 2019 LHMP, this strategy is included as MH-1: Evacuation Alert and Warning System and Periodic Testing.

Strategy #GOVT-b-15 involved conducting periodic tests of the outdoor sirens once per month. This mitigation strategy was deferred and carried forward into the 2019 LHMP. In the 2019 LHMP, this strategy is also included as MH-1: Evacuation Alert and Warning System and Periodic Testing.

Strategy #GOVT a-7 included periodically assessing the need for new or relocated fire or police stations and other emergency facilities; changes in staffing levels; and additional or updated supplies, equipment, technologies, and in-service training classes. This mitigation strategy was not funded in the 2010 LHMP Annex, and therefore carried forward into the 2019 LHMP. In the 2019 LHMP, this strategy is included as MH-2: Periodically assess the need for new or relocated fire or police stations and other emergency facilities; changes in staffing levels; and need for supplies, equipment, technologies, and in-service training classes.

Strategy #GOVT-a-9 involved developing and maintaining a system of interoperable communications for first responders from cities, counties, special districts, state and federal agencies. This mitigation strategy was not funded in the 2010 LHMP Annex, and therefore carried forward into the 2019 LHMP. In the 2019 LHMP, this strategy is included as MH-3: Develop and maintain a system of interoperable communications for first responders from local, state, and federal agencies.

The fifth mitigation strategy in the 2010 LHMP Annex, Strategy #GOVT-b-22, involved investigating the use of phone-based warning systems for selective geographic areas. Strategy #GOVT-b-22 was funded, implemented, and completed at the County level. Sonoma County has a system in effect that has been used to broadcast messages across the County during recent flood and wildfire emergencies. The system is coordinated throughout the Sonoma County Operation Area and at the County Emergency Operations Center (ABAG 2010).

The majority of the flood hazard goals, objectives, and actions listed in the 2010 LHMP Annex are in progress and integrated into the 2019 LHMP update. Details are highlighted in the new flood action descriptions. Details on the progress of these actions since the 2010 LHMP Annex planning process can be found in subsection 5.3.3 and Table 5-1 below.

5.3.2 Continued Compliance with National Flood Insurance Program

Recognizing the importance of the NFIP in mitigating flood losses, an emphasis will be placed on continued compliance with the NFIP by the City of Petaluma. As a NFIP participant, Petaluma will continue to make every effort to remain in good standing with NFIP. This includes continuing to comply with the NFIP's standards for updating and adopting floodplain maps and maintaining and updating the floodplain regulations. Other details related to NFIP participation are discussed in the flood vulnerability discussion in Chapter 4 and in the capability assessment in Chapter 2. Additional actions are related to participation with the CRS program. The City's participation in the CRS is further evidence of continued NFIP compliance.

5.3.3 Mitigation Action Plan

This action plan presents the recommendations developed by the HMPC outlining how the City of Petaluma can reduce the risk and vulnerability of people, property, infrastructure, and natural and cultural resources to future disaster losses. The mitigation actions developed by the HMPC are summarized in Table 5.1 and listed in detail in the mitigation action worksheets that follow. Table 5.1 is a summary table for quick reference. It identifies the mitigation action title, lead agency/department, hazards mitigated, priority and if the action mitigates losses to existing or future development. The 'Related Goal' column notes which of the five goals in Section 5.2 that the action helps achieve. The action worksheets that follow provide more background information, ideas for implementation, lead agency, partners, potential funding sources, cost estimates, benefits, and timeline for each identified action.

The City of Petaluma has other existing, detailed action descriptions in planning documents, such as General Plan 2025 Health and Safety Element, 2015 FMP, Infrastructure Master Plans, Capital Improvement Program and Budgets, and other planning mechanisms. These actions are considered to be part of this plan, and the details, to avoid duplication, should be referenced in their original source document. The HMPC also realizes that new needs, priorities, and adaptation strategies may arise as a result of a disaster or other circumstances and reserves the right to support new actions and strategies, as necessary, as long as they conform to the overall goals of this plan.

The actions included in this mitigation strategy are subject to further review and refinement; alternatives analyses; and reprioritization due to funding availability and/or other criteria. The City is not obligated by this document to implement any or all of these projects. Rather this mitigation strategy represents the desires of the City and the community to mitigate the risks and vulnerabilities from identified hazards.

Many of the action items included in this plan are also a collaborative effort among City of Petaluma departments, Sonoma County, Sonoma Water, City of Sebastopol, Climate Action Commission, and other state, regional, and local agencies and stakeholders in the City of Petaluma Planning Area and greater Sonoma Valley.

Table 5- 1: Mitigation Action Summary Table

Action ID	Action Title	New Action/2010 Action	Hazard(s) Mitigated	Responsible Office / Agency	Address Existing or Future Development	Priority	Related Goal
Dam Incidents							
DI-1	Assess downstream impacts associated with dam incidents	New	Dam Incidents, Flood Hazards	Public Works and Utilities Department	Both	Low	1, 3, 4
Drought							
DR-1	Groundwater supply augmentation for drought resiliency	New	Drought	Public Works and Utilities Department	Both	Medium	1, 2, 3, 4
DR-2	Sustainable Groundwater Management Planning	New	Drought	Public Works and Utilities Department	Both	Low	1, 3, 4, 5
Cyber Threats							
CT-1	Develop a Water Infrastructure Vulnerability Risk and Resilience Plan and Emergency Response Plan that addresses cyber sufficiency	New	Cyber Threats, Drought	Public Works and Utilities Department	Both	Low	1, 2, 3, 4, 5
Earthquake							
E-1	Implement Seismic Retrofits at Petaluma Historic Library and Museum	New	Earthquake Hazards	Building Department, Public Works and Utilities Department	Existing	Medium	1, 2, 3, 4
E-2	Seismic Retrofit Analysis of City buildings	New	Earthquake Hazards	Building Department, Public Works and Utilities Department	Existing	High	1, 2, 3, 4
Flooding							
F-1	Enhance structural flood mitigation projects to reduce near annual floods on north end of City	New	Flood Hazards	Public Works and Utilities Department	Both	High	1, 2, 3, 4, 5
F-2	Floodplain property protection, acquisition, and relocation	New	Flood Hazards, Sea Level Rise	Public Works and Utilities Department	Existing	Low	1, 3, 4

Action ID	Action Title	New Action/2010 Action	Hazard(s) Mitigated	Responsible Office / Agency	Address Existing or Future Development	Priority	Related Goal
F-3	Continue annual stream and creek channel maintenance	New	Flood Hazards	Public Works and Utilities Department	Both	Low	1, 2, 3, 4
F-4	Higher Regulatory Standards for Flood Protection	New	Flood Hazards	Building Department, City Engineer	Both	Medium	1, 3, 4
F-5	Improve National Flood Insurance Program Community Rating System rating	New	Flood Hazards	Public Works and Utilities Department	Both	Medium	1, 3, 4
Hazardous Material Releases							
HM-1	Evacuation Planning	New	Hazardous Material Releases, Multiple Hazards	Fire Department, Industrial Company	Both	Low	1, 3, 4, 5
Sea Level Rise							
SLR-1	Explore natural protection with wetland enhancement, marshland protection, and restoration project implementation in the Petaluma River and San Pablo Bay transition zone	New	Sea Level Rise, Flood Hazards	Public Works and Utilities Department	Both	Low	1, 2, 3, 4
SLR-2	Continue Petaluma River Dredging Program to enhance flood resilience	New	Sea Level Rise, Flood Hazards	Public Works and Utilities Department	Both	Medium	1, 2, 3, 4
SLR-3	Open space preservation in areas prone to sea level rise along the Petaluma River	New	Sea Level Rise, Flood Hazards	Parks and Recreation Department, City Engineer, Public Works and Utilities Department, Building Department	Existing	Medium	1, 2, 3, 4, 5

Action ID	Action Title	New Action/2010 Action	Hazard(s) Mitigated	Responsible Office / Agency	Address Existing or Future Development	Priority	Related Goal
SLR-4	Map and assess vulnerability to sea level rise and integrate the information with the City GIS mapping capabilities to educate the community and help them gain awareness of the potential impacts and actions the City is taking to plan and adapt	New	Sea Level Rise, Flood Hazards	Public Works and Utilities Department	Both	Medium	1, 3, 4
SLR-5	Assess sea level rise modelling for use in the LHMP and how those projections can be routinely re-evaluated in subsequent climate adaptation planning efforts	New	Sea Level Rise, Flood Hazards	Public Works and Utilities Department	Both	Low	1, 3, 4, 5
SLR-6	Update City Implementing Zoning Ordinance (IZO) to manage development in high risk areas	New	Sea Level Rise, Flood Hazards	Planning Department, City Engineer	Both	Low	1, 3, 4, 5
Severe Weather: Heavy Rains/Thunderstorms/Hail/Lightning/Dense Fog							
SW-1	Replace aging generator and plan for severe weather by obtaining backup generators at City critical facilities, including the Communications Center	New	Severe Weather: Heavy Rains/Thunderstorms/ Hail/Lightning/Dense Fog; Earthquake; Extreme Heat; Wildfire; PSPS	Public Works and Utilities Department	Existing	Medium	1, 3, 4, 5
Severe Weather: Extreme Heat							
SW-2	Establish a resiliency hub at City Community Center to be used during severe weather	New	Severe Weather: Extreme Heat	Parks and Recreation Department, Public Works and Utilities Department	Both	Medium	1, 4, 5

Action ID	Action Title	New Action/2010 Action	Hazard(s) Mitigated	Responsible Office / Agency	Address Existing or Future Development	Priority	Related Goal
	events involving heat waves and wildfires						
Severe Weather: High Wind							
SW-3	Enhance local building code to incorporate wind-resistant design features that address high wind hazards	New	Severe Weather: High Wind; PSPS	Building Department	Both	Low	1, 3, 4, 5
SW-4	Develop a PSPS toolkit for local businesses	New	Severe Weather: High Wind; PSPS	Public Works and Utilities Department, Economic Development Department	Both	Low	1, 3, 4, 5
Wildfire							
W-1	Defensible space funding program	New	Wildfire	Fire Department	Both	Medium	1, 3, 4, 5
W-2	Develop a City-wide Fire Suppression Master Plan	New	Wildfire	Fire Department, Fire Prevention Bureau, Public Works and Utilities Department	Both	Medium	1, 3, 4, 5
W-3	Evaluate the WUI Zone in the City Limits	New	Wildfire	Fire Department, Fire Prevention Bureau	Both	Medium	1, 3, 4, 5
W-4	Install Fire Protection System in all City facilities	New	Wildfire	Public Works and Utilities Department, Fire Prevention Bureau, Building Department	Existing	Medium	1, 3, 4, 5

Action ID	Action Title	New Action/2010 Action	Hazard(s) Mitigated	Responsible Office / Agency	Address Existing or Future Development	Priority	Related Goal
W-5	Wildland Urban Interface Pre-Fire Plan	New	Wildfire	Fire Department	Both	High	1, 3, 4, 5
			Multi-Hazard Actions				
MH-1	Evacuation Alert and Warning System and Periodic Testing	2010 Action	Multi-Hazard, Dam Incidents, Earthquake, Floods, Hazardous Material Releases	Fire Department, Police Department	Both	Low	1, 3, 4, 5
MH-2	Periodically assess the need for new or relocated fire or police stations and other emergency facilities, changes in staffing levels, and need for supplies, equipment, technologies, and in-service training classes	2010 Action	Multi-Hazard, Dam Incidents, Floods, Earthquake, Severe Weather, Wildfire	Police Department, Fire Department, Public Works and Utilities Department	Existing	Medium	1, 3, 4, 5
MH-3	Develop and maintain a system of interoperable communications for first responders from local, state, and federal agencies	2010 Action	Multi-Hazard, Dam Incidents, Floods, Earthquake, Severe Weather, Wildfire	Fire Department, Police Department	Both	High	1, 3, 4, 5
MH-4	Update the City Emergency Operations Plan	New	Multi-Hazard, Dam Incidents, Floods, Earthquake, Severe Weather, Wildfire	Fire Department	Both	High	1, 3, 4, 5
MH-5	Emergency Operations Center replacement and upgrades	New	Multi-Hazard, Dam Incidents, Floods, Earthquake, Severe Weather, Wildfire	Public Works and Utilities Department	Both	High	1, 3, 4, 5
MH-6	Expand Community Emergency Pre Program	New	Multi-Hazard, Dam Incidents, Floods,	Fire Department	Both	Low	1, 3, 4, 5

Action ID	Action Title	New Action/2010 Action	Hazard(s) Mitigated	Responsible Office / Agency	Address Existing or Future Development	Priority	Related Goal
			Earthquake, Severe Weather, Wildfire				
MH-7	Community Emergency Preparedness Webpage	New	Multi-Hazard, Dam Incidents, Floods, Earthquake, Severe Weather, Wildfire	City Manager’s Office	Both	Low	1, 3, 4, 5

The following mitigation actions provide project specific information and implementation details on each mitigation activity identified. They are grouped by the type of hazard(s) they address.

DI-1 Assess downstream impacts associated with dam incidents

Mitigation Project Title	Assess downstream impacts associated with upstream dam incidents
Hazard(s) Mitigated	Dam Incidents, Flood Hazards
Project Description, Issue/Background	The City of Petaluma will assess downstream impacts anticipated from the breach or failure of existing dams located upstream of the City of Petaluma. There is currently one dam, La Crema Winery dam, located east of the City of Petaluma. While the likelihood of dam failure or breach for this dam is low, there may be impacts to downstream properties and critical facilities. This dam lacks available Geographic Information System (GIS)-based inundation mapping and an Emergency Action Plan (EAP). By analyzing the risks in detail, the City, in collaboration with the dam owners and operators, can determine whether there is risk. If there is a risk for a dam incident the City can prioritize planning, warning, and evacuation procedures to raise awareness of the hazard in targeted areas. If necessary, evacuation procedures can be integrated into Mitigation Action MH-1: Evacuation Alert and Warning System and Periodic Testing.
Related planning mechanisms	General Plan 2025, Evacuation Planning, 2007 Emergency Operations Plan
Other Alternatives	Partner with other agencies, such as Sonoma County for infrastructure improvements assessments on dams and levees and public awareness of potential dam and levee failure impacts. Work with existing inundation mapping data based on water storage facility information.
Responsible Office/ Agency	Public Works and Utilities Department
Partners	Dam Owners (e.g. La Crema Winery), Reclamation Districts, Sonoma County, California Department of Water Resources (DWR)
Priority (High, Medium, Low)	Low
Cost Estimate	Varies, if dam inundation modelling is not available, modeling and inundation mapping costs depend on the size of the dam; $25,000 - $50,000 given existing upstream water storage facilities are small.
Benefits (Avoided Losses)	The risk to the City is low due to the distance between the downstream properties and dam locations. However, the downstream impacts should be further evaluated to confirm no City-owned critical facilities would be impacted. Also, if needed, educating home buyers of the upstream dams and flood protections should be considered in order to avoid loss of life and injuries if an event where to occur. Understanding the risk that could occur can improve warning and evacuation procedures. Currently, there is mainly open space and rural agricultural land located downstream of the La Crema Winery dam.

Potential Funding	Homeowners should be encouraged to purchase flood insurance in areas near the dams. FEMA High Hazard Potential Dam Grants, Dam Owners could partially fund studies
Schedule	2020-2024

DR-1 Groundwater supply augmentation for drought resiliency

Mitigation Project Title	Groundwater supply augmentation for drought resiliency
Hazard(s) Mitigated	Drought
Project Description, Issue/Background	According to the City's 2015 Urban Water Management Plan (UWMP), the City does not rely on groundwater as a significant portion of supply due to yield and water quality limitations. Groundwater is only used for peak water demand needs or to minimize short-term supply cost impacts and only half of the City's existing wells are used due to low yields, poor water quality, and deteriorating well conditions. Instead, the City obtains the majority of its water supply from Russian River surface water deliveries from Sonoma Water. While the City currently relies on various groundwater management tools and studies are underway to better understand the groundwater basin, the City anticipates using more groundwater to meet demand during emergencies, when back-up supplies are necessary during drought conditions. As a result, the City of Petaluma has a 20 percent maximum daily demand (MDD) peak water usage goal. The City intends to achieve this 20 percent goal by relying on City groundwater supply through the rehabilitation and installation of additional groundwater wells and by expanding the existing recycled water system. Over the years, the increased reliance on City groundwater has been the result of rehabilitated well sites and studies to determine the actual production capabilities in the event of emergency use. The City is in the process of expanding the groundwater well system. The City recently expanded the recycled water distribution system in the urban area. Another phase is planned with the Maria Drive reconstruction within the next year. Future phases may be constructed through 2040.
Related planning mechanisms	City's Municipal Code, 2015 UWMP, City's Water Shortage Contingency Plan (WSCP) (Chapter 8 of UWMP), Water Shortage Contingency Resolution
Other Alternatives	Ongoing water conservation efforts to mitigate the impacts to water supply; water conservation education and outreach
Responsible Office/ Agency	Public Works and Utilities Department
Partners	Sonoma Water, California DWR, North Bay Water Reuse Program (NBWRP)
Priority (High, Medium, Low)	Medium
Cost Estimate	$25,000 - $200,000 annually depending on well rehabilitation and installation costs and civil engineering associated with water recycling facility expansion.

Benefits (Avoided Losses)	The City of Petaluma has cycle periods of wet and drought years. The last drought in California was longer and more devastating than prior droughts, due to both increased temperatures, and higher demand on public services. Well rehabilitation, new well installation, and recycled water use are long-term solutions for mitigating the impacts of drought years. Long-term City investment in an expanded recycled water and distribution system will provide a sustainable water solution to the City that promotes drought resiliency.
Potential Funding	General Fund, California Proposition 1 Grants, California DWR Sustainable Groundwater Planning Grants Program, State's Water Recycling Funding Program (WRFP), Integrated Regional Water Management (IRWM) Grant Programs, and funding from other agencies (i.e., Sonoma Water)
Schedule	2020-2022; Ongoing

DR-2 Sustainable Groundwater Management Planning

Mitigation Project Title	Sustainable Groundwater Management Planning
Hazard(s) Mitigated	Drought
Project Description, Issue/Background	The 46,000-acre Petaluma Valley Groundwater Basin is located within the larger 93,440-acre Petaluma Valley watershed. The City of Petaluma relies on local groundwater to supplement imported Russian River surface water supplies from Sonoma Water. While studies are underway to evaluate groundwater conditions in Petaluma Valley Groundwater Basin, current conditions suggest that groundwater elevations are relatively stable in southern and central Petaluma Valley, but areas in the northwest have exhibited long-term declines. The Basin has historical occurrences of serious nitrate contamination in the western portion of the Basin and evidence of saltwater intrusion from the tidally influenced portion of the Petaluma River. Other degradation of water quality impacts and loss of storage capacity continue to be evaluated through the installation of new groundwater monitoring wells and technical guidance from the California DWR. The Sustainable Groundwater Management Act (SGMA) provides for the establishment of local Groundwater Sustainability Agencies (GSAs) to manage groundwater sustainability within groundwater subbasins. The City of Petaluma is a local agency (as defined by §10723 of the Water Code) which overlays the Petaluma Valley Groundwater Basin, and as such the City has become part of the local GSA. The Petaluma Valley GSA was required to develop and implement, no later than January 31, 2022, a Groundwater Sustainability Plan (GSP) to ensure a sustainable yield of groundwater, without causing undesirable results. The GSP is a 20-year plan to ensure that groundwater will be used sustainably in the groundwater basin. The Petaluma Valley GSA is a multi-agency GSP consisting of Sonoma Resource Conservation District, Sonoma Water, Sonoma County, North Bay Water District, and the City of Petaluma formed to develop the GSP and sustainably manage groundwater in Petaluma Valley. As of 2017, the City of Petaluma participates in the groundwater management planning process. The development of the Petaluma Valley GSA and the implementation of a GSP will allow the City to maintain sustainable groundwater supplies, coordinate with other water agencies and districts, while providing insurance and resilience against periods of long-term drought.
Related planning mechanisms	GSP, City's Municipal Code, 2015 UWMP, City's WSCP (Chapter 8 of UWMP),
Other Alternatives	None, compliance required by law, failure to meet requirements will result in State intervention and oversight.

Responsible Office/ Agency	Public Works and Utilities Department
Partners	Sonoma Water, Sonoma County, Sonoma Resource Conservation District, North Bay Water District
Priority (High, Medium, Low)	Low
Cost Estimate	Varies by GSA for preparation of the required GSP. Further expenses are anticipated to be accrued for the planning and construction of groundwater recharge or monitoring projects.
Benefits (Avoided Losses)	Preparation and implementation of the GSP will result in the management of groundwater in a manner that is sustainable and avoids undesirable results as defined by the California DWR.
Potential Funding	Property owner assessments along with grant funding opportunities from the State.
Schedule	GSAs must complete and submit the required GSP to DWR by January 31, 2022, which is to be fully implemented and result in sustainability of the groundwater basin, with no undesirable effects, by the year 2042.

CT-1 Develop a Water Infrastructure Vulnerability Risk and Resilience Plan and Emergency Response Plan that addresses cyber sufficiency

Mitigation Project Title	Develop a Water Infrastructure Vulnerability Risk and Resilience Plan and Emergency Response Plan that addresses cyber sufficiency
Hazard(s) Mitigated	Cyber Threats, Drought
Project Description, Issue/Background	Section 2013 of America's Water Infrastructure Act of 2018 (AWIA) requires community water systems serving more than 3,300 people to develop or update risk and resilience assessments and emergency response plans (ERPs). The risk and resilience assessments must be conducted and certification submitted to the U.S. EPA by March 31, 2020 if the utility serves more than 100,000 people; December 31, 2020 if the utility serves 50,000 to 99,999 people; and June 30, 2021 if the utility services 3,301 to 49,999 people. The City must also develop or update ERPs and complete certification submittals to the U.S. EPA no later than six months after the risk and resilience assessments are certified. These risk and resilience assessments evaluate vulnerabilities, threats, and consequences from potential natural hazards and malevolent acts. They also assess the resilience of water facility infrastructure (pipe, water sources of collection, treatment, storage, distribution and electronic and computer systems), monitoring practices, chemical storage and handling, and operation and maintenance activities. ERPs include strategies and resources to improve resilience, including physical security and cybersecurity. ERPs also cover plans and procedures for responding to natural hazards or malevolent acts that threaten safe drinking water. Implementation of this action would ensure that City water supply wells and pump status are secure and appropriate site and cyber security is in place, thereby also minimizing impacts related to drought hazards.
Related planning mechanisms	2007 Emergency Operations Plan, Draft Water Infrastructure Vulnerability Risk and Resilience Assessment, Facility Assessment
Other Alternatives	Existing Facility Vulnerability Assessments, LHMP Vulnerability Assessment (public water drinking water supply infrastructure assessment was included, but facilities were not mapped due to sensitivity of information)
Responsible Office/ Agency	Public Works and Utilities Department
Partners	Sonoma Water
Priority (High, Medium, Low)	Low
Cost Estimate	$50,000 - $100,000

Benefits (Avoided Losses)	The implementation of a detailed vulnerability risk and resilience assessment of the City's drinking water supply infrastructure would better prepare the City for natural and human-caused hazards. The assessment would also allow the City to prepare hazard-specific contingency plans and identify additional hazard mitigation actions.
Potential Funding	U.S. EPA grant funding
Schedule	June 30, 2020 based on federal AWIA legislation and population served by City water and wastewater services

E-1 Implement seismic retrofits at Petaluma Historic Library and Museum

Mitigation Project Title	Implement seismic retrofits at Petaluma Historic Library and Museum
Hazard(s) Mitigated	Earthquake
Project Description, Issue/Background	In 1992 the City adopted a resolution establishing a list of unreinforced masonry buildings in the City for the purpose of setting a timeframe for strengthening the Unreinforced Masonry (URM) Building Ordinance. The resolution classified the buildings into four groups, with the first groups being potentially the highest risk and need for prioritized retrofitting. Higher occupancy buildings were also identified as higher risk structures that needed to be retrofitted, as well as other factors, such as the physical height of the building and the proximity to pedestrian activity. The classification included 98 buildings within the City that needed to be retrofitted within the next 20 years. As of early 2020, all of the classified buildings have been retrofitted with the exception of the Petaluma Historic Library and Museum located at 20 4th Street. This action involves seismically retrofitting the historic library and museum for earthquake, fire, and public safety hazards. Seismic modifications to the library and museum must also take into consideration the architectural integrity of the building to avoid compromising the building's historical features.
Related planning mechanisms	2016 California Building Code, URM Building Ordinance, 1992 URM Building Resolution
Other Alternatives	None
Responsible Office/ Agency	Building Department, Public Works and Utilities Department
Partners	Petaluma Museum Association
Priority (High, Medium, Low)	Medium
Cost Estimate	$1,000,000 - $5,000,000
Benefits (Avoided Losses)	Seismic retrofits of Petaluma's historic library and museum would better preserve the historic and architectural integrity of the building, while also addressing seismic, fire, and public safety hazards.
Potential Funding	General funds, grant fund opportunities
Schedule	2022-2025

E-2 Seismic Retrofit Analysis of City buildings

Mitigation Project Title	Seismic Retrofit Analysis of City buildings
Hazard(s) Mitigated	Earthquake
Project Description, Issue/Background	The City of Petaluma adopted the 2016 California Building Code (CBC), which governs the design, construction, and maintenance of buildings. In California, most cities adopt model building codes maintained by the International Building Code (IBC) and every few years the International Code Council (ICC) publishes new editions of the codes. The CBC requires specific tests for masonry to ensure that structures can adequately resist seismic forces during earthquakes. The City of Petaluma has already identified unreinforced masonry properties in their jurisdiction that are vulnerable to seismic risk and have removed or retrofitted most of the City-owned buildings and facilities, with the exception of the City's historic museum and library. While most City-owned facilities have been seismically retrofitted, there are key critical facilities in the City where seismic retrofit analyses need to be conducted to better understand detailed vulnerabilities during major earthquakes. These buildings include the City police and fire stations, City Emergency Operations Center (EOC), and City's Emergency Communication Center. This can include bracing of non-structural items to reduce damage potential to building contents and reduce risk of injury, ensuring continuity of operations during an incident. An earthquake retrofit analysis would include a structural and non-structural assessment of City buildings, as well as infrastructure, such as water tanks, sewer lines, bridges, and roads. Initial retrofitting analysis may involve a survey of the structural condition at critical facilities and prioritized surveys at buildings closer to major fault or liquefaction zones. Replacement and retrofits can then occur as funding becomes available. Various resources provided by FEMA and the American Society of Civil Engineers (ASCE) provide seismic retrofitting guidelines and techniques to strengthen the structural elements of buildings, and better protect non-structural components.
Related planning mechanisms	Survey, evaluate, and prioritize existing structures and prioritize worst-case buildings and properties and repair these as funding becomes available.
Other Alternatives	Completion of Unreinforced Masonry Retrofit Program (historic museum and library is only remaining City-owned facility that needs retrofitting) Update City's building code to exceed current state seismic and safety standards in order to minimize earthquake damage for new buildings and structures. Voluntary seismic retrofitting and encouraging property owners to exceed state seismic standards.

Responsible Office/ Agency	Building Department, Public Works and Utilities Department
Partners	None
Priority (High, Medium, Low)	High
Cost Estimate	$200,000 - $1,000,000 (varies depending on whether buildings have already been assessed and need retrofits)
Benefits (Avoided Losses)	Protection of life and property during an earthquake by removing the threat of loss, injury, and damage to people and property from building hazards.
Potential Funding	City General Fund, State funding
Schedule	Ongoing; 2020-2024

F-1 Enhance structural flood mitigation projects to reduce near annual floods on north end of City

Mitigation Project Title	Enhance structural flood mitigation projects to reduce near annual floods on the north end of the City
Hazard(s) Mitigated	Flooding
Project Description, Issue/Background	For over the past 15 years, the City of Petaluma has been proactive to mitigate flood hazards within the Petaluma watershed. The City has worked on the Petaluma River Flood Control Project, as part of the joint effort with the U.S. Army Corps of Engineers, and has received state funding to implement four phases of the Petaluma River–Denman Reach flood mitigation project near the north end of the City along Industrial Avenue. Both projects help the City implement the 1996 Petaluma River Access and Enhancement Plan, General Plan 2025, and the 2015 FMP. These past and current structural projects increase the capacity of the historic floodplain and alleviate flood impacts to neighboring residences and businesses. The Petaluma River Flood Control Project included channel widening, floodwalls along Washington Creek and the Petaluma River, a concrete transition weir, two new pump stations, replacement of the Payran Street Bridge and the Lakeville Street Bridge, and the creation of a U-shaped channel along one reach of the river. This project was completed in late 2015. The first three phases of the Petaluma River–Denman Reach project were completed from 2005 to 2018 with California DWR grant funds. The first phases involved acquiring vacant parcels, developing a permanent trail easement, opening the river channel and extending a flood terrace along the top of the bank, widening the eastern bank of the River within the lower portion of Denman Reach (between Petaluma Boulevard North and Corona Road), and creating wetlands and riparian habitat. The final phase is currently under construction and funded by a California DWR grant award through coordination with Sonoma Water. Phase 4 is expected to be completed in early 2020. The completed project will lower the flood elevation for the 100-year storm up to one foot in areas around Industrial Avenue and Corona Road. The City will continue to pursue and implement future structural flood control projects under this mitigation action, as they relate to new projects developed in the FMP update.
Related planning mechanisms	1996 River Access and Enhancement Plan, General Plan 2025, 2015 FMP
Other Alternatives	Other Flood Mitigation Projects, Non-Structural Projects
Responsible Office/ Agency	Public Works and Utilities Department

Partners	U.S. Army Corps of Engineers, Sonoma Water, Conservation Corps of the North Bay
Priority (High, Medium, Low)	High
Cost Estimate	$1,000,000 - $2,000,000 for implementation of all phases of each project
Benefits (Avoided Losses)	Structural flood control projects will ensure the City continues to provide adequate flood protection, which will minimize flood related losses associated with property damage.
Potential Funding	DWR grant funding (Urban Streams Restoration grant funds, Proposition 1E funds)
Schedule	Ongoing; Construction anticipated to be complete for Denman Reach Phase 4 in 2020

F-2 Floodplain property protection, acquisition, and relocation

Mitigation Project Title	Floodplain property protection, acquisition, and relocation
Hazard(s) Mitigated	Flooding, Sea Level Rise
Project Description, Issue/Background	Consistent with the General Plan 2025 and the 2015 FMP goals and property protection activities, the City of Petaluma has successfully undertaken efforts to acquire and relocate 13 properties in the floodplain. The City will continue to explore opportunities for property protection, acquisition, and relocation consistent with the General Plan 2025 Policy 8-P-37 and the 2015 FMP property protection activities. The City would seek acquisition and relocation funding using pre-disaster mitigation and flood mitigation assistance (FMA) program funding, with a focus on acquiring properties in the repetitive loss areas of the floodplain. These property acquisitions would increase floodplain capacity and reduce flood hazards. This action supports the preservation of open space and natural areas according to General Plan 2025 Policies 4-P-1 through 4-P-4 and the establishment of a 200-foot setback on both sides of the Petaluma River based on General Plan 2025 Policy 8-9-30. The action also involves exploring property protection projects and acquisitions in other portions of the floodplain, and is further supports Mitigation Action SLR-2 focused on open space preservation.
Related planning mechanisms	General Plan 2025, 2015 FMP
Other Alternatives	Floodplain Regulation Enforcement, Enhancing Building Codes and Development Standards, Building Elevation Certification, CRS Program Participation
Responsible Office/ Agency	Public Works and Utilities Department
Partners	FEMA, Cal OES, California DWR
Priority (High, Medium, Low)	Low
Cost Estimate	Varies, depending on property relocation and acquisition effort
Benefits (Avoided Losses)	Relocation of buildings or structures in the floodplain or the acquisition of such properties would reduce repetitive losses related to flooding.
Potential Funding	Pre-Disaster Mitigation Grant Funds, FMA Funding
Schedule	Ongoing

F-3 Continue annual stream and creek channel maintenance

Mitigation Project Title	Continue annual stream and creek channel maintenance
Hazard(s) Mitigated	Flooding
Project Description, Issue/Background	The City has worked with Sonoma County and Sonoma Water since the December 11, 2014 flood event to clear channels and creeks of debris, sediment, and overgrown vegetation within the parameters of existing environmental permits. This action would support floodplain management goals to continue annual stream and creek channel maintenance in accordance with established City, County, and Sonoma Water requirements. Permitted creek and stream channel maintenance activities would occur throughout the City and include structural channel modification projects referenced in the 2015 FMP.
Related planning mechanisms	General Plan 2025 Surface Water Management Element, 2015 FMP, City's 5-year Capital Improvement Program (CIP), City-wide Expanded Channel and Creek Maintenance Program and Permit
Other Alternatives	Stormwater Management Program, Phase II Stormwater Management Plan, Storm Water Ordinance Petaluma River Watershed Drainage Master Plan
Responsible Office/ Agency	Public Works and Utilities Department
Partners	Sonoma County, Sonoma Water
Priority (High, Medium, Low)	Low
Cost Estimate	$250,000 - $500,000
Benefits (Avoided Losses)	Routine stream and creek channel maintenance activities, such as debris clearing and vegetation management would provide adequate flood conveyance capacity, improve stream and habitat restoration, and provide improved flood protection for the residents and business in the City of Petaluma. The maintenance activities are also creditable under the CRS.
Potential Funding	Sonoma Water funding, Urban Streams Restoration Program Grant (USRP), Proposition 1 Funding
Schedule	2020-2025

F-4 Higher regulatory standards for flood protection

Mitigation Project Title	Higher regulatory standards for flood protection
Hazard(s) Mitigated	Flooding
Project Description, Issue/Background	Since the implementation of the 2010 LHMP Annex prepared by ABAG, the City of Petaluma has prioritized floodplain management activities in the General Plan 2025 and 2015 FMP. The City joined the NFIP in 1983 and adopted its first FMP in 1995, which was last updated in 2015. The City participates in the CRS program as one of its efforts to reduce potential losses due to flooding, and the NFIP has conducted annual audits of the City's floodplain management efforts for over two decades and awarded the City a Class Rating 6. As part of this action, the City of Petaluma will continue to implement preventative activities summarized in the 2015 FMP that involve enforcing standards that provide more flood protection than the NFIP's minimum requirements. These activities include: • Implement flood protection policies in the General Plan 2025; • Require two feet of freeboard for first floor elevations above the base flood elevation (General Plan 2025 Policy 8-P-37F); • Require foundation protection; • Require digital post-construction elevation certificates for new structures, additions and substantial improvements to structures in the floodplain to be organized into a GIS database; • Require zero net fill on all new developments in the floodplain; • Adhere to federal and state-mandated regulatory standards; and • Maintain adequate staffing in the City's Building Department to continue to enforce building codes for new construction and improvements in the floodplain through the City.
Related planning mechanisms	General Plan 2025, 2015 FMP, CRS Program participation
Other Alternatives	Site-Specific Development Review (case-by-case project site plan review); Building Code Enforcement
Responsible Office/ Agency	Building Department, City Engineer
Partners	None
Priority (High, Medium, Low)	Medium
Cost Estimate	$100,000 annually (staffing costs for enforcement and site plan review)
Benefits (Avoided Losses)	The enforcement of higher regulatory standards will ensure the City continues to provide adequate flood protection, which will minimize flood related losses associated with property damage. This action is integral in maintaining a CRS Class 6 rating, which helps flood insurance be more affordable for City residents. The requirement for organizing digital post-construction elevation certificates in GIS would increase staff

	production time versus referencing paper copies, and ensure accurate flood prediction and mapping data is easily accessible and tracked electronically.
Potential Funding	General Fund
Schedule	Ongoing

F-5 Improve National Flood Insurance Program Community Rating System rating

Mitigation Project Title	Improve National Flood Insurance Program Community Rating System rating
Hazard(s) Mitigated	Flooding
Project Description, Issue/Background	This action involves improving the NFIP CRS Rating for City. Subsequent steps will involve tracking credit opportunities associated with the LHMP and completing the Activity Floodplain Coordinator Manual 510 steps and worksheets. This plan update is already aligned with the CRS planning process to maximize CRS points. Other opportunities to improve credits according to the latest CRS Coordinator's manual will be evaluated.
Related planning mechanisms	General Plan 2025; 2015 FMP, NFIP Participation, CRS Participation
Other Alternatives	2015 FMP Implementation
Responsible Office/ Agency	Public Works and Utilities Department
Partners	None
Priority (High, Medium, Low)	Medium
Cost Estimate	$15,000 - $25,000 for consultant assistance with ISO Verification Process
Benefits (Avoided Losses)	Maximizing participation in the CRS program will reduce property losses and damage. If the City achieves a higher CRS rating, flood insurance policy holders will receive reduced premiums on their policies.
Potential Funding	General Fund
Schedule	Ongoing

HM-1 Evacuation Planning

Mitigation Project Title	Evacuation Planning
Hazard(s) Mitigated	Hazardous Material Releases, Multi-Hazard
Project Description, Issue/Background	The City currently has several industrial sites that during an accident or disaster could release hazardous material that would negatively impact the health of persons in the community. It is important for those potentially affected to know, understand, and practice the best course of action, whether that be to shelter-in-place or evacuation procedures. Once initial action is taken, the community needs to understand the next steps and plan appropriately. This action can be implemented on a neighborhood-by-neighborhood level, and it would take into consideration socially vulnerable and disadvantaged populations in the City. For instance, additional and tailored outreach may be conducted to ensure socially vulnerable and disadvantaged populations in the City understand what actions need to occur during hazard events that may require shelter-in-place or evacuation procedures.
Related planning mechanisms	2007 Emergency Operations Plan
Other Alternatives	During an event, the City could continue a reactionary approach, which will not be as effective and require more effort from public safety officials to complete.
Responsible Office/ Agency	Fire Department, Industrial Company
Partners	Industrial Company
Priority (High, Medium, Low)	Low
Cost Estimate	$20,000-$70,000
Benefits (Avoided Losses)	A plan with an informed community will lead to less confusion and more timely reaction to any accident that requires a response from the community.
Potential Funding	General Fund
Schedule	2020-2024; City anticipates this may be a longer-term action

SLR-1 Explore natural protection with wetland enhancement, marshland protection, and restoration project implementation in the Petaluma River and San Pablo Bay transition zone

Mitigation Project Title	Explore natural protection with wetland enhancement, marshland protection, and restoration project implementation in the Petaluma River and San Pablo Bay transition zone
Hazard(s) Mitigated	Flooding, Sea Level Rise
Project Description, Issue/Background	The Petaluma River stretches for approximately 6.5 miles through the City from the upstream freshwater reaches to the downstream tidally-influenced portion of the river near San Pablo Bay, known as the “transition zone.” Natural protection of wetlands and marsh in the southern portion of the City's Planning Area near the confluence of Petaluma River and San Pablo Bay can help the City adapt to rising sea levels and tidal fluctuations in the Bay. Wetland protection would preserve undeveloped shorelines within San Pablo Bay and support ecosystem adaptation in areas where sea level rise may cause migration of species and habitat changes. Protecting the undeveloped shorelines along the Petaluma and San Pablo Bay transition zone would also maintain ecological values, provide increased flood protection, and support habitat resiliency.
Related planning mechanisms	General Plan 2025, 2015 FMP, 1995 River Access and Enhancement Plan
Other Alternatives	Setback policies, Living Shoreline concept, Conservation programs, Improved Building Codes, Ecosystem preservation and restoration
Responsible Office/ Agency	Public Works and Utilities Department
Partners	General Fund, Army Corps of Engineers Funding, California DWR Grant Funding, Habitat Conservation Fund Grant, California Department of Fish and Wildlife (CDFW) Grants, National Fish and Wildlife Foundation Grants, In-Lieu Mitigation Fees, Local Non-Profits (Petaluma Water Ways, Petaluma River Access Partnerships – P-RAP)
Priority (High, Medium, Low)	Low
Cost Estimate	Varies by wetland restoration project planning, implementation and construction costs.
Benefits (Avoided Losses)	Reduced potential for repetitive flooding; preservation of marshland and habitat
Potential Funding	Local, regional, and state funding opportunities are available.
Schedule	2020-2030

SLR-2 Continue Petaluma River Dredging Program to enhance flood resilience

Mitigation Project Title	Continue Petaluma River Dredging Program to enhance flood resilience
Hazard(s) Mitigated	Flooding, Sea Level Rise
Project Description, Issue/Background	Watershed runoff deposits silt within the waterway. Regular dredging is required to restore the original riverway capacity of Petaluma River to enhance floodwater carrying capacity and maintain adequate depth for boating.
Related planning mechanisms	2015 FMP, 1995 River Access and Enhancement Plan
Other Alternatives	Additional excavation of the Petaluma riverbed may mitigate sea level rise volume. Dredge materials may be used to create earth berms to hold additional sea level volume.
Responsible Office/ Agency	Public Works and Utilities Department
Partners	U.S. Army Corps of Engineers Funding, California DWR Grant Funds
Priority (High, Medium, Low)	Medium
Cost Estimate	Varies phasing of dredging project, but costs could range from $500,000 - $1,000,000.
Benefits (Avoided Losses)	Reduced repetitive flooding; continued navigable access on Petaluma River between the City and San Pablo Bay.
Potential Funding	Local, regional, and state funding opportunities are available.
Schedule	Ongoing

SLR-3 Open space preservation in areas prone to sea level rise along the Petaluma River

Mitigation Project Title	Open space preservation in areas prone to sea level rise along the Petaluma River
Hazard(s) Mitigated	Flooding, Sea Level Rise
Project Description, Issue/Background	The City of Petaluma anticipates planning for and adapting to risk from increased flooding due to sea level rise and coastal storm events along the Petaluma River. A portion of the properties located to south of downtown Petaluma and near the tidally-influenced portions of the Petaluma River consist of open space and park lands that make up the City's greenbelt. Given the open space land use designation, development is not permitted within these low-elevation properties where tidal flooding is common. Although building codes are enforced on adjacent developed commercial properties and flood insurance is required, these developed properties are at risk to future flooding that could be exacerbated by sea level rise. Traditional land management controls, like land use zoning and open space preservation could be used to limit development. The City could also improve interagency cooperation related to ecological conservation efforts within the lands susceptible to flooding and sea level rise by focusing on property acquisition, protecting natural areas. and improving habitat resiliency. Interagency coordination would enhance the overall connectivity of different open space preservation and habitat restoration projects within the San Pablo Bay transition zone. The City plans to continue efforts to keep vacant and floodplain land designated as open space. The City also plans to pursue additional open space acquisition opportunities pursuant to General Plan 2025 goals and policies and the 2015 FMP open space preservation preventative activities. Given the recreational amenities present within these open space areas, this action may also involve ensuring trailheads, trails, and signage are maintained and upgraded to withstand future flooding and erosion that may be associated with sea level rise.
Related planning mechanisms	General Plan 2025, 2015 FMP, 1995 River Access and Enhancement Plan
Other Alternatives	In high hazard areas, building a sea wall at top of bank to protect existing structures. In high hazard areas, require raising first floor level elevation above predicted sea level rise.
Responsible Office/ Agency	Parks and Recreation Department, City Engineer, Public Works and Utilities Department, Building Department
Partners	California Coastal Conservancy, Sonoma County Agricultural Preservation and Open Space, U.S. Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers, San Francisco Bay Regional Water Quality Control Board (RWQCB), San Francisco Bay Conservation and Development Commission

	(San Francisco BCDC), Sonoma Land Trust, State and federal conservancy agencies, Community-Based Organizations
Priority (High, Medium, Low)	Medium
Cost Estimate	Varies by planning efforts and property acquisitions
Benefits (Avoided Losses)	Land use zones, such as open space designation can be successfully used as a tool to limit development, and special flood hazard zones are now often added to comprehensive and general plan land use designations. These overlay designations, or "adaptation action areas" can be defined as areas below, at, or near the mean high water mark, or areas where there is a hydrological connection to coastal waters, such as Petaluma River. These open space overlay areas establish additional and stricter development standards or criteria for development. While an open space designation may limit development on properties prone to future flooding due to sea level rise, the City needs to carefully monitor the scientific data regarding sea level rise and understand the risk levels associated with projected inundation.
Potential Funding	General Fund, Sonoma County Ag and Open Space Matching Grant Program 2020, Habitat Conservation Fund Grant, CDFW Grants, DWR Grant Funding,
Schedule	2020-2024; Ongoing

SLR-4 *Map and assess vulnerability to sea level rise and integrate the information with the City GIS mapping capabilities to educate the community and help them gain awareness of the potential impacts and actions the City is taking to plan and adapt*

Mitigation Project Title	Map and assess vulnerability to sea level rise and integrate the information with the City GIS mapping capabilities to educate the community and help raise awareness of the potential impacts and actions the City is taking to plan and adapt
Hazard(s) Mitigated	Sea level rise, flooding
Project Description, Issue/Background	GIS is an effective tool that can identify where climate-change related effects are likely to occur now and in the future. Mapping and overlaying climate information, such as projected sea level rise projections with critical facilities, parcel, infrastructure, and building footprints can help communities understand the expected extent of sea level rise, and also where flooding, wildfires, and other natural hazards are more likely to occur based on climate change. As of early 2020 the City of Petaluma has not engaged the community on the topic of sea level rise, nor have possible sea level rise scenarios have not been widely distributed to the community. The 2019 LHMP included a preliminary sea level rise vulnerability assessment that analyzed three sea level rise scenarios: 25 centimeters (cm), 75 cm, and 200 cm sea level rise inundation datasets based on best available science from the CoSMos Version 2.1 Model applicable to the City of Petaluma (see Section 4.3.6 Sea Level Rise in Chapter 4). This dataset provided detailed projections of tidal inundation, also referred to the predicted average annual tidal inundation conditions. It also included detailed projections of coastal flood hazards, also referred to the 100-year coastal flood event that accounts for coastal wave and storm surge intervals,. The preliminary vulnerability assessment is consistent with the full spectrum of sea level rise (0 to 2 meters, 5 meters) and storms (daily to 100-year return) used on the outer Sonoma coast and storm events used inside the Bay were derived from the Global Climate Model (GCM). Given sea level rise projections linked to planning horizons can change with new scientific data, the preliminary sea level rise scenarios selected by the City are based on sea level rise elevation. The probabilistic projections based on the high emissions scenario (business as usual) for 2050 and 2070 translates to 1.1 foot by 2050 and 1.9 feet by 2070, both which have a 66 percent probability of occurrence. The conservative approach for 2050 and 2070 have a 0.5 percent probability of occurrence and translate to 1.9 feet by 2050 and 4.0 feet by 2070. The City HMPC also considered one conservative scenario to assess potential future

	impacts to critical infrastructure. These projection recommendations roughly convert to the 25 cm (1 foot or 0.25 meters), 75 cm (2.7 feet or 0.75 meters), and 200 cm (6.6 feet or 2 meters) sea level rise datasets. These three elevations could apply to a range of sea level rise projections and associated planning years. This action considers the findings from the preliminary sea level rise vulnerability assessment included in the 2019 LHMP and determines whether a more detailed vulnerability assessment and Climate Adaptation Plan (CAP) is warranted. As part of this action, the City would select a most likely sea level rise scenario to present to the Climate Action Commission and the community (or a range of scenarios), as part of climate change initiatives. While the City may choose to select all three scenarios considered in the 2019 LHMP vulnerability assessment, the City could also select one scenario with the highest probability of occurrence within the current planning period (by 2030) and proceed with beginning outreach with the community regarding sea level rise science, scenarios, and adaptation planning. Outreach may including GIS mapping and the production of easily understandable maps to distribute within the community, as well as initiating discussions with the community on how to plan for and adapt to sea level rise.
Related planning mechanisms	Select an independent resource to share with community members interested in understanding sea level rise information. Implement base elevation modifications for development based on sea level rise. Maps could be created showing past flooding events and further enhanced with estimated sea level rise projections to identify City-owned buildings and infrastructure would be impacted in future flooding events.
Other Alternatives	Reliance on vulnerability assessment in 2019 LHMP, CAP, Adaptive Management Plan
Responsible Office/ Agency	Public Works and Utilities Department
Partners	Sonoma County
Priority (High, Medium, Low)	Medium
Cost Estimate	$50,000 - $75,000
Benefits (Avoided Losses)	Reduces repetitive flooding, preservation of the built environment, and helps the City develop long-term climate resilience
Potential Funding	General fund, Caltrans SB-1 Climate Adaptation Planning Grant, Sonoma County Transportation Authority (SCTA) Funding, ABAG Funding, California Ocean Protection Council Funding (from Prop 1 funds), California Resilience Challenge Grant Competition
Schedule	2020-2024, or within five years

SLR-5 Assess sea level rise modelling and how current and best available projections can be routinely re-evaluated in subsequent climate adaptation planning efforts

Mitigation Project Title	Assess sea level rise modelling used in the LHMP and how those projections can be routinely re-evaluated in subsequent climate adaptation planning efforts
Hazard(s) Mitigated	Sea level rise, flooding
Project Description, Issue/Background	Sea level rise science continues to evolve and the best available science on sea level rise projections will change. Given the uncertainty in the magnitude and timing of future sea level rise, the City should use scenario-based analysis to examine a range of possible shoreline changes and sea level risks. A similar approach to reviewing climate change scenarios as they relate to other natural hazards, such as extreme heat, flooding, and wildfire risk could also be part of the routine assessment Selection of sea level rise scenario modelling (current best available data for the City of Petaluma Planning Area includes 25 cm, 75 cm, 200 or 300 cm scenarios with and without 100-year coastal flood event) or scenarios based on planning horizons will help guide the City in sea level rise planning efforts. This action could also use sea level rise projections during routine review of applications for new development to ensure new development proposals incorporate adequate protection (e.g. setbacks, armoring) in site plans.
Related planning mechanisms	General Plan 2025, 2015 FMP, Climate Action 2020 and Beyond: Regional Sonoma County CAP (not adopted)
Other Alternatives	City selects sea level rise scenario elevations and produces maps of impacted areas to share with the community.
Responsible Office/ Agency	Public Works and Utilities Department
Partners	Sonoma County, SCTA
Priority (High, Medium, Low)	Low
Cost Estimate	$100,000
Benefits (Avoided Losses)	Avoiding damage and replacement needs of city buildings and infrastructure, as well as private property.
Potential Funding	General fund, Caltrans SB-1 Climate Adaptation Planning Grant
Schedule	2020-2024

SLR-6 Update City Implementing Zoning Ordinance (IZO) to manage development in high risk areas

Mitigation Project Title	Update City Implementing Zoning Ordinance (IZO) to manage development in high risk areas
Hazard(s) Mitigated	Sea level rise, flooding
Project Description, Issue/Background	The City of Petaluma sits mainly in the flattest portion of the watershed basin. The Petaluma River bisects the town and is the main waterway collecting all the runoff from the various streams in the watershed. The area around the river and larger streams are more prone to disaster from flooding. Sea level rise may increase the intensity and frequency of disaster from flooding. Updating zoning tools in these areas can minimize flooding related disasters. The City of Petaluma would also consider updating the IZO and Municipal Code for consistency with the LHMP and General Plan Health and Safety Element.
Related planning mechanisms	Update zoning tools, including the City of Petaluma IZO regardless of sea level rise impacts; General Plan 2025
Other Alternatives	Existing IZO Ordinance
Responsible Office/ Agency	Planning Department, City Engineer
Partners	None
Priority (High, Medium, Low)	Low
Cost Estimate	$100,000
Benefits (Avoided Losses)	Reduce Repetitive flooding in flood hazard zones that may be exacerbated by sea level rise.
Potential Funding	General Fund
Schedule	2020-2024

SW-1 *Replace aging generator and plan for severe weather by obtaining backup generators at City critical facilities, including the Emergency Communications Center*

Mitigation Project Title	Replace aging generator and plan for severe weather by obtaining backup generators at City critical facilities, including the Emergency Communications Center
Hazard(s) Mitigated	Severe Weather: Heavy Rains/Thunderstorms/Hail/Lightning/Dense Fog; Severe Weather: High Wind; Severe Weather: Extreme Heat; Earthquake; Severe Weather: Extreme Heat; Wildfire
Project Description, Issue/Background	Generator replacement can minimize the effects of power outages during earthquake, extreme heat, severe storms, wildfire, and high wind hazard events in the City, as they will supply back-up power during a power outage. City facilities will also need backup power during "planned" PSPS. The City will need reliable emergency backup power when Pacific Gas & Electric (PG&E) power lines are affected by natural hazard events. This action would ensure the City obtains diesel powered generators in select locations at City critical facilities to ensure electrical power is provided for essential services, as well as the City's primary evacuation shelter, the Petaluma Community Center. It would also ensure the City replaces aging generators at key locations, such as the City Police Department and Emergency Communications Center.
Related planning mechanisms	Coordination with EOC staff, 2007 Emergency Operations Plan
Other Alternatives	None
Responsible Office/ Agency	Public Works and Utilities Department
Partners	Police Department, Parks and Recreation Department, Fire Department, City Manager
Priority (High, Medium, Low)	Medium
Cost Estimate	$20,000-$50,000 per generator depending on power needs
Benefits (Avoided Losses)	Reliable and emergency backup power will reduce the risk of property damage and increased life safety.
Potential Funding	General Fund
Schedule	2022-2025

SW-2 Establish resiliency hub at City Community Center to be used during severe weather events involving heat waves and wildfires

Mitigation Project Title	Establish resiliency hub at City Community Center to be used during severe weather events involving heat waves and wildfires. Resiliency hubs or cooling centers should also accommodate sensitive receptors that may be susceptible to poor air quality.
Hazard(s) Mitigated	Severe Weather: Extreme Heat
Project Description, Issue/Background	Climate change is expected to result in longer droughts and longer days of extreme heat. Extreme heat can also disproportionately affect the health of vulnerable populations in the City of Petaluma. This action involves establishing the City Community Center and Petaluma Senior Center located at Lucchesi Park to function as a cooling center, or "resiliency hub" or "safe place" during severe weather events, involving heat waves, poor air quality, and wildfires. A resiliency hub would accommodate sensitive receptors that may be susceptible to poor air quality and respiratory illness. A central and well-used existing community-serving facility location for a cooling center or resiliency hub, such as the City Community Center and Petaluma Senior Center would ensure residents in the community can easily access the facility by public transit and alternative modes of transportation. The resiliency hub would also have other essential resources, such as food, water, ice, refrigeration, medical supplies, charging stations, and back-up power. Currently, neither of these facilities have back-up power and could not function as cooling centers during power outages; PSPS or actual power outages. This action would therefore also entail obtaining sufficient back-up power at each facility. This action involves associated outreach to ensure the vulnerable segments of the local population (e.g. people with disabilities, elderly, low-income) and the local homeless population are aware of the resiliency hub and are able to access it during extreme heat events. Outreach would specifically focus on making sure the public knows where to go to find relief from extreme heat events, poor air quality days, and wildfire events using social media, traditional media, and printed materials/handouts. This includes ensuring there is accessible transportation during extreme heat events, and an appropriate number of resiliency hubs in the City. The action would also involve coordination with local homeless services to ensure that the homeless population is aware of the City's resiliency hub services. The City could work with Sonoma County Department of Health Services Public Health Division and Petaluma Valley Hospital to build outreach capacity to better engage vulnerable and disadvantaged segments of the

	City's population that may need to rely on resiliency hubs or cooling centers and other facilities during extreme heat events.
Related planning mechanisms	General Plan 2025
Other Alternatives	Expand availability of cooling centers to include space for pets
Responsible Office/ Agency	Parks and Recreation Department, Public Works and Utilities Department
Partners	Sonoma County Department of Health Services Public Health Division, Sonoma County Homeless Services, Petaluma Valley Hospital
Priority (High, Medium, Low)	Medium
Cost Estimate	$50,000
Benefits (Avoided Losses)	Protecting life, particularly sensitive receptors and vulnerable populations, such as elderly and residents with respiratory illness in the City of Petaluma during heat events
Potential Funding	City, County, state, and federal funds, Transformative Climate Communities Grant, Emergency Solutions Grants (ESG) Program (funds homeless and improves quality of emergency shelters for homeless), possible PG&E grant funds
Schedule	Ongoing, 2020-2024

SW-3 Enhance local building code to incorporate wind-resistant design features that address wind hazards

Mitigation Project Title	Enhance local building code to incorporate wind-resistant design features that address wind hazards
Hazard(s) Mitigated	Severe Weather: High Wind; Public Safety Power Shutdown PSPS
Project Description, Issue/Background	Enhance local building codes and ordinances to ensure that new structures and remodels or improvements to buildings and structures incorporate wind-resistant design features to withstand high winds and tornadoes. This action would prevent wind damage through revisions to the existing building code and adopting standards for residential construction in high-wind regions. Construction techniques may include requiring structural bracing, straps and clips, anchor bolts, and impact-resistant glass, reinforced garage doors, window shutters, and interlocking roof shingles. Requiring tie-downs with anchors and ground anchors for manufactured homes may also be appropriate. There are also various site and building design standards that could be considered to minimize wind damage in new residential developments.
Related planning mechanisms	City Building Code, Municipal Code
Other Alternatives	None
Responsible Office/ Agency	Building Department
Partners	PG&E
Priority (High, Medium, Low)	Low
Cost Estimate	$50,000
Benefits (Avoided Losses)	Protecting life and property in the City of Petaluma
Potential Funding	City, County, state, and federal funds
Schedule	Ongoing, 2020-2024

SW-4 Develop a Public Safety Power Shutdown (PSPS) Toolkit for local businesses

Mitigation Project Title	Develop a Public Safety Power Shutdown (PSPS) toolkit for local businesses
Hazard(s) Mitigated	Severe Weather: High Wind; PSPS
Project Description, Issue/Background	PG&E is expected to conduct PSPS during high winds and dry conditions and generally a heightened fire risk forecast. The outages could last several days, and PG&E has suggested customers be prepared for outages that could last longer than 48 hours. A majority of Sonoma County could be affected by the power outages including almost the entirety of the City of Petaluma. The City of Petaluma has been proactive with sharing information on the City PSPS website providing tips for citizens to prepare and make plans for their families. The City has opened community shelters, and coordinated with the school districts on school closures and which areas of the City are impacted. This action will expand the existing public information to provide resources and tips for local businesses to be able to continue business operations during PSPS events.
Related planning mechanisms	Traditional outreach materials, including printed informational handouts and brochures that are available at the City offices.
Other Alternatives	Use City website
Responsible Office/ Agency	Public Works and Utilities Department, Economic Development
Partners	Chamber of Commerce, Petaluma Downtown Business Association
Priority (High, Medium, Low)	Low
Cost Estimate	$10,000
Benefits (Avoided Losses)	Avoid economic losses
Potential Funding	General Fund
Schedule	2020-2022

W-1 Establish a Defensible Space Funding Program

Mitigation Project Title	Establish a Defensible Space Funding Program
Hazard(s) Mitigated	Wildfire
Project Description, Issue/Background	California has a long history of wildfire, and the destruction and effects are growing more intense, frequent, and developing into a year-round problem. California law requires landowners in areas with flammable groundcover to maintain defensible space around buildings that can help slow or prevent the spread of wildfire. Petaluma has an area within the City limits that is a designated wildfire urban interface (WUI) and high fire hazard severity zone (FHSZ). The City is also surrounded on the west side by moderate FHSZ and hilly topography, which currently consists of rural residential development and open space. The State of California has implemented specific requirements for new buildings within these zones that mandates fire safe building practices, landscaping, and design. Some jurisdictions throughout the State are implementing stricter codes and requirements specific to their jurisdiction. The City of Petaluma has minimally expanded those requirements. There may be a benefit to expanding those requirements further. Additionally, the limited staff and resources currently deployed in the Fire Prevention Bureau do not have the capacity for education, enforcement or assistance for the community to improve their defensible space. This action will establish a funding program for the City and the community to implement defensible space in the WUI. The program will include the identification of defensible space funding and grant opportunities, incentives for private landowners to conduct brush clearing and home hardening, project implementation tools (e.g. vegetation clearing), and a long-term management program for WUI areas around the City. The program will prioritize defensible space projects that may include brush removal and prescribed burns, while also working with the community to reduce fuel loads on private property. The City would also work with local fire protection agencies to promote structure hardening and retrofitting , and other mitigation techniques summarized in Cal FIRE's Wildfire Mitigation Program.
Related planning mechanisms	2007 Emergency Operations Plan, Community Wildfire Protection Plan
Other Alternatives	Remain status quo in minimal education, engineering and enforcement policies/programs for the WUI area.
Responsible Office/ Agency	Fire Department
Partners	Sonoma County, Cal FIRE
Priority (High, Medium, Low)	Medium

Cost Estimate	Depends on program
Benefits (Avoided Losses)	Limited/lesser wildfire damage, community engagement.
Potential Funding	General Fund, Cal FIRE Fuel Reduction Project Grants, Cal FIRE Forest Health Grants, FEMA HMPG, Wildfire Mitigation Financial Assistance Program (Fire Hardened Homes Revolving Loan Fund)
Schedule	2020-2024; Implementation depends on prioritization and resources

W-2 Develop a City-wide Fire Suppression Master Plan

Mitigation Project Title	Develop a City-wide Fire Suppression Master Plan
Hazard(s) Mitigated	Wildfire
Project Description, Issue/Background	The City's fire suppression water system is an integral part of the Fire Department operations and Fire Prevention planning. There are several areas within the City's water system with low fire-flow. Currently, there is not a system, map, or other record retention system where the Fire Prevention Bureau or Fire Department staff can access fire flow data from each fire hydrant in the City. This action would involve the development of a comprehensive City-wide fire suppression water system Master Plan to assess fire flow water capacity and how to upgrade the water system to accommodate projected changes in water availability and provide adaptability. While the five-year updates to the UWMP address future conditions and community water demand, a City-wide Fire Suppression Master Plan would address water supply needs for fire suppression, assess water supply capacity for fire response within the City's Planning Area, and use the plan recommendations to upgrade the system to improve the City's water system's adaptability to urban fire and wildfire hazards. Appropriate retrofits to the City's water system, specific to fire suppression infrastructure can help the City and community be better prepared and ensure there is adequate water supply, suppression capabilities, and fewer disruptions to water services.
Related planning mechanisms	2007 Emergency Operations Plan
Other Alternatives	2015 UWMP
Responsible Office/ Agency	Fire Department, Fire Prevention Bureau, Public Works and Utilities Department
Partners	Mutual Aid Providers, Sonoma County, California Department of Forestry and Fire (Cal FIRE)
Priority (High, Medium, Low)	Medium
Cost Estimate	$150,000
Benefits (Avoided Losses)	A system where each fire hydrant fire flow and pressure is identified would provide valuable information for pre-planning for emergency incidents. This would also increase the City's ISO rating.
Potential Funding	General Fund, Capital Improvement Funds, Water and Wastewater Infrastructure Improvement Grants, State Water Resources Control Board: Clean Water State Revolving Fund, Water Enterprise
Schedule	2020-2024

W-3 Evaluate Wildland Urban Interface Zone in the City Limits

Mitigation Project Title	Evaluate the WUI Zone in the City Limits
Hazard(s) Mitigated	Wildfire
Project Description, Issue/Background	California has a long history of wildfire, and the destruction and effects are growing more intense, frequent, and developing into a year-round problem. Within the Petaluma city limits there is a designated WUI and high FHSZ. The City is also surrounded on the west side by a moderate FHSZ and hilly topography that consists of rural residential development, undeveloped hillsides, and open space (see Figure 4-19 and 4-20 in Chapter 4). Wildland fires west of the City could be exacerbated by prevailing winds. California has implemented specific requirements for new buildings within the WUI and FHSZs and some jurisdictions throughout the State are implementing stricter codes and requirements specific to their jurisdiction. The City of Petaluma has minimally expanded those requirements, but there may be a benefit to substantially expanding those requirements further. Government Code Sections 65302 subdivision (g)(3) and 65302.5 subdivision (b) require the General Plan Safety Element to address the risk of fire for land classified as SRAs and land classified as very high FHSZ. Additionally, the limited staff and resources currently deployed in the Fire Prevention Bureau do not have the capacity for education, enforcement or assistance for the community to improve their defensible space. The Petaluma Fire Department wildland apparatus is limited to a Type VI pick-up mounted pumper. It may be beneficial to have more wildland specific equipment to avoid wildfire hazards within the WUI. As wildland fire characteristics continue to change, the capabilities, resources, policies and programs need to be re-evaluated to assure the community has the most appropriate protection. This action involves an evaluation of the WUI zone and high and very high FHSZs in the City limits and surrounding areas to develop a comprehensive plan to protect City buildings and infrastructure (building codes, Type 3 Fire engine, water supply, access roads). The evaluation of the extent of the WUI within the City limits and the surrounding unincorporated areas will allow the City to develop a comprehensive plan to protect people, property, and infrastructure. The evaluation would identify the potential for fires to occur within and surrounding new and existing development. The evaluation would address wildfire probability using metrics, such as fire history, fire threat, response time, proximity to the WUI, fuel reduction projects, and mutual aid coordination. The evaluation would also address building codes, the need for a Type 3 fire engine, water supplies, and road accessibility. This action acknowledges the pending Cal FIRE mapping of the SRA and land use distribution within very high FHSZs within the City limits. The

	action would also involve review of construction methods for new facilities in SRAs and very high FHSZs (if applicable), safe access for emergency response (street signs, water supply, and fire suppression), and identification of a minimum of two evacuation routes for neighborhoods in the City of Petaluma. Upon adoption of the LHMP, the City shall align the General Plan Health and Safety Element (Chapter 10 of General Plan) with the LHMP and Government Code Sections 65302 subdivisions (g)(3) and Section 65302.5 that address state legislation, such as SB 2911, SB 1241, and pending Cal FIRE FHSZ map updates. This state legislation requires additional fire safe building practices and fire safe design, and pending changes to the Cal FIRE FHSZ maps may impose additional requirements in areas prone to wildfire. The City Fire Department and Fire Prevention Bureau should review the updated maps and policies to ensure they align with the new legislation.
Related planning mechanisms	2007 Emergency Operations Plan, Community Wildfire Protection Plan
Other Alternatives	None
Responsible Office/ Agency	Fire Department, Fire Prevention Bureau
Partners	Mutual Aid Providers, Sonoma County, Cal FIRE
Priority (High, Medium, Low)	Medium
Cost Estimate	$25,000
Benefits (Avoided Losses)	Less wildfire damage, improved understanding of revised Cal FIRE mapping should enable the City to better prepare for wildland fires, and increase capabilities to respond to wildfire events. .
Potential Funding	FEMA Hazard Mitigation Grant Program
Schedule	2020-2024

W-4 Install Fire Protection System in all City facilities

Mitigation Project Title	Install Fire Protection System in all City facilities
Hazard(s) Mitigated	Urban Fires, Wildfire
Project Description, Issue/Background	The City needs to install an updated fire protection system in accordance with current fire code within all City facilities. This action would provide funding for the installation of the required systems in all City-owned facilities. Fire system upgrades would first occur in designated critical facilities.
Related planning mechanisms	2007 Emergency Operations Plan
Other Alternatives	Build new facilities compliant with current fire code.
Responsible Office/ Agency	Public Works and Utilities Department, Fire Prevention Bureau, Building Department
Partners	None
Priority (High, Medium, Low)	Medium
Cost Estimate	Will depend on building being retrofitted
Benefits (Avoided Losses)	Prevention of injury or loss of life, prevention of facility and file destruction, and the prevention of delay in employee work status due to facility destruction.
Potential Funding	Homeland Security Grants
Schedule	Depends on facility replacement.

W-5 Wildland Urban Interface Pre-Fire Plan

Mitigation Project Title	Wildland Urban Interface Pre-Fire Plan
Hazard(s) Mitigated	Wildfire
Project Description, Issue/Background	As wildland fires spread more rapidly with a drier climate, increased heat days, drought and strong north winds, pre-planning hazard areas, access points, and locations to fight fire are important to ensure a more efficient response and deployment of resources. Cal FIRE has created "pre-fire plans" for other areas of Sonoma County which were used during 2017 and 2019 to better plan and organize responses and tactics. The development of a WUI Pre-Fire Plan will help the City better prepare for future wildfires.
Related planning mechanisms	2007 Emergency Operations Plan, Existing Pre-Fire Plans used in 2017 and 2019 during wildfires, Community Wildfire Protection Plan
Other Alternatives	Continue to use standard mapping and be more reactionary to wildland threats once the fire has started.
Responsible Office/ Agency	Fire Department
Partners	Cal FIRE
Priority (High, Medium, Low)	High
Cost Estimate	General Fund, Staff time for Coordination time with Cal FIRE
Benefits (Avoided Losses)	This will increase effectiveness and coordination of response to wildland urban interface fires in or around the community.
Potential Funding	Cal FIRE funding, Proposition 84 Wildfire Resiliency and Recovery Planning Grants (administered through California's Strategic Growth Council, Office of Planning and Research, and Department of Conservation)
Schedule	By 2020, specifically next fire season

MH-1 Evacuation Alert and Warning System and Annual Testing

Mitigation Project Title	Evacuation Alert and Warning System and Annual Testing *(Strategy #GOVT-b-14 and Strategy #GOVT-b-15 from 2010 LHMP Annex)*
Hazard(s) Mitigated	Multi-Hazard, Earthquake, Flood, Hazardous Materials, Wildfire
Project Description, Issue/Background	The City currently has few routes leading out of downtown Petaluma. During an accident or disaster impacts on these transportation routes could negatively impact the health of persons in our community. It is important to be able to notify the public when they need to take action to protect themselves, whether sheltering-in-place, or evacuating. Emergency notification systems are a critical type of communication that let people know of potential and impending disaster events. The installation of an alert warning system with outdoor sirens and coordinating their use with neighboring jurisdictions was a mitigation action included in the 2005 and 2010 LHMP Annex. Previous studies showed that the City's warning systems are not an effective tool in Petaluma due to the nature of the natural disasters anticipated in the area. Sirens are a common warning device for coastal areas that have some, but little warning of a natural disaster, specifically with tsunamis. In Petaluma, the greatest major natural disaster threat: an earthquake has zero warning signs. Flood hazards usually have several days of warning notice. The City, however, has several other hazards that could result in regional disasters, as well as several industrial sites that during an accident or disaster could release hazardous material that would negatively impact the health of persons in the community and where an alert warning system would be beneficial. While the City currently notifies the public about how to best prepare for natural disasters before they occur through the radio, television, phone-based warning systems (i.e. Strategy #GOVT-b-22 in 2010 LHMP Annex), and other media outlets, it is important to be able to notify the public when they need to take action to protect themselves, whether sheltering-in-place or following evacuation procedures, and how they can make recovery easier. This action would consist of the installation of an evacuation alert and warning system that includes coordination with neighboring jurisdictions and effectively educating the community about the evacuation alert system. The evacuation and alert system would be designed and implemented so that it reaches the needs of segments of the community with functions needs, such as vision or hearing-related disabilities by ensuring there are alternative means for these people to receive information. Once installed, the alert and warning system would also involve conducting annual tests of the outdoor sirens (e.g. once per month). This periodic testing of the outdoor sirens was also part of a mitigation action included in the 2005 and 2010 LHMP Annex (Strategy #GOVT-b-15).

Related planning mechanisms	2007 Emergency Operations Plan
Other Alternatives	Continued use of emergency alert phone calls, text messages, and social media to notify the community. Other alternatives include adding high-lo sirens to emergency vehicles.
Responsible Office/ Agency	Police Department, Fire Department
Partners	Sonoma County, Neighboring Jurisdictions, Community-Based Organizations
Priority (High, Medium, Low)	Low
Cost Estimate	$25,000 Annually
Benefits (Avoided Losses)	A sure-fire way to notify the public when they need to immediately take action will lead to many more persons notified, a more rapid reaction, and decrease the number of people exposed to potential hazard events.
Potential Funding	General Fund
Schedule	2020-2022

MH-2 Periodically assess the need for new or relocated fire or police stations and other emergency facilities, changes in staffing levels, and need for supplies, equipment, technologies, and in-service training classes

Mitigation Project Title	Periodically assess the need for new or relocated fire or police stations and other emergency facilities, changes in staffing levels, and need for supplies, equipment, technologies, and in-service training classes *(Strategy #GOVT-a-7 from 2010 LHMP Annex)*
Hazard(s) Mitigated	Multi-Hazard, Flood, Earthquake, Wildfire, Sea Level Rise
Project Description, Issue/Background	As one of the high priority mitigation strategies from the 2010 LHMP Annex, this action ensures the City periodically assess the need for new or relocated fire and police stations, as well as other emergency facilities. Any upgrades associated with this action, as they relate to the EOC are detailed in MH-4.
Related planning mechanisms	2007 Emergency Operations Plan
Other Alternatives	Continued use of existing fire and police stations. Also assumed continued use of the existing EOC.
Responsible Office/ Agency	Police Department, Fire Department, Public Works and Utilities Department
Partners	Sonoma County
Priority (High, Medium, Low)	Medium
Cost Estimate	Based on need for new fire or police station, which can vary according to property values and construction costs.
Benefits (Avoided Losses)	New or relocated fire and police stations can ensure quick response times, which would reduce the loss of life and property associated with natural and human-caused hazards.
Potential Funding	General Fund
Schedule	2020-2024

MH-3 Develop and maintain a system of interoperable communications for first responders from local, state, and federal agencies

Mitigation Project Title	Develop and maintain a system of interoperable communications for first responders from local, state, and federal agencies *(Strategy GOVT-a-9 in 2010 LHMP Annex)*
Hazard(s) Mitigated	Multi-Hazard, Flood, Earthquake, Wildfire
Project Description, Issue/Background	As one of the high priority mitigation strategies from the 2010 LHMP Annex, this action involves developing and maintaining a system of interoperable communication for first responders to use to support disaster response and recovery efforts during disaster events. The communications system would be used by the EOC during disaster events and would be managed by the City's Fire Department.
Related planning mechanisms	2007 Emergency Operations Plan
Other Alternatives	Mutual Aid Agreements
Responsible Office/ Agency	Fire Department, Police Department
Partners	Sonoma County, Neighboring Jurisdictions
Priority (High, Medium, Low)	High
Cost Estimate	$15,000
Benefits (Avoided Losses)	An effective and interoperable communication system would improve the execution of emergency procedures coordinated among federal, state, local agency and volunteer first responder staff.
Potential Funding	General Fund, staff time
Schedule	2020-2024

MH-4 Update the City Emergency Operations Plan

Mitigation Project Title	Update the City Emergency Operations Plan
Hazard(s) Mitigated	Multi-Hazard; Dam Incidents; Earthquake; Severe Weather: Extreme Heat; Severe Weather: Heavy Rains/Thunderstorms/Hail/Lightning/Dense Fog; Severe Weather: High Winds; Wildfire; Hazardous Material Releases; Cyber Threat
Project Description, Issue/Background	The City's EOP was last updated in 2007. It includes a basic plan that addresses the City of Petaluma's responsibilities in emergencies associated with natural disaster, human-caused emergencies, and technological incidents. It provides a framework for coordination of response and recovery efforts within the City and in coordination with local, state, and federal agencies. The plan establishes emergency organization staff to direct and control operations during a period of emergency by assigning responsibilities to specific personnel. The scope of the plan addresses earthquakes, hazardous materials emergencies, flooding, and wildfires. The plan is now dated and does not address all potential hazards in today's world. A comprehensive update of the EOP would ensure it addresses all hazards covered in the General Plan 2025 Health and Safety Element and the 2019 LHMP and provides a more user-friendly plan document for the City.
Related planning mechanisms	General Plan 2025 Health and Safety Element, 2007 Emergency Operations Plan
Other Alternatives	2007 Emergency Operations Plan
Responsible Office/ Agency	Fire Department
Partners	Sonoma County Neighboring Jurisdictions, Mutual Aid Providers
Priority (High, Medium, Low)	High
Cost Estimate	$80,000
Benefits (Avoided Losses)	An updated plan that consists of training all EOC staff on the plan would help us better identify, prepare, and respond to incidents in a more efficient and productive manner. An updated EOP would also reduce the negative impacts on our community and more rapidly returning City services to normal.
Potential Funding	General Fund
Schedule	2020-2022

MH-5 Emergency Operations Center Replacement and Upgrades

Mitigation Project Title	Emergency Operations Center Replacement and Upgrades
Hazard(s) Mitigated	Multi-Hazard; Dam Incidents; Earthquake, Extreme Heat, Flood; Severe Weather: Heavy Rains/Thunderstorms/Hail/Lightning/Dense Fog; Severe Weather: High Winds; Wildfire; Hazardous Material Releases; Cyber Threat
Project Description, Issue/Background	The City's EOC currently utilizes the police briefing room and surrounding normally occupied offices. Technology, including phones and computers need to be set-up, tables moved, supplies moved from a small towable trailer in the parking lot to inside, and normal police operations changed in order to utilize the EOC. The EOC needs to be in a more functional work-space that also has permanent phones, computers, and other technology.
Related planning mechanisms	2007 Emergency Operations Plan
Other Alternatives	Continued use of the current space in the police briefing room and operations as usual.
Responsible Office/ Agency	Public Works and Utilities Department
Partners	Sonoma County Neighboring Jurisdictions, Mutual Aid Providers
Priority (High, Medium, Low)	High
Cost Estimate	$150,000
Benefits (Avoided Losses)	A more functional and permanent workplace would drastically speed up the time needed to make the EOC operational and would increase work efficiencies once in place. A new or upgraded EOC would also reduce the impacts on the police department personnel and operations.
Potential Funding	General Fund
Schedule	2020-2022

MH-6 Expand Community Emergency Prep Program

Mitigation Project Title	Expand Community Emergency Prep Program
Hazard(s) Mitigated	Multi-Hazard; Dam Incidents; Earthquake, Extreme Heat, Flood; Severe Weather: Heavy Rains/Thunderstorms/Hail/Lightning/Dense Fog; Severe Weather: High Winds; Wildfire; Hazardous Material Releases; Cyber Threat
Project Description, Issue/Background	The City began expanding its community disaster preparation outreach following the 2017 fires to include four quarterly educational sessions per year. The program Citizens Organized to Prepare for Emergencies (COPE) is to encourage residents, families, and neighborhoods to become and remain better prepared to respond to and recover from emergency situations. It is a current program at the City and includes developing individual response plans, maintaining individual emergency supply kits, and ensuring neighbors get to know and plan with other neighbors in their community. The community would like more educational sessions and has expressed interest in a Community Emergency Response Team (CERT) type program. The City has held discussions with other emergency coordinators and Sonoma County about a county-wide program. The initial theory is to train persons that could later be used as volunteers, coordinated through the county volunteer center, to assist in non-operational responses during disaster such as shelter set-up/staffing.
Related planning mechanisms	Existing public outreach and awareness programs
Other Alternatives	Existing COPE Program; CERT program; Continue provide quarterly awareness trainings
Responsible Office/ Agency	Fire Department
Partners	Sonoma County Neighboring Jurisdictions, Mutual Aid Providers
Priority (High, Medium, Low)	Low
Cost Estimate	$25,000
Benefits (Avoided Losses)	An educated and prepared community will be less dependent on services when demand is high during disaster. By training and coordinating volunteers, staffing to provide essential services can be surged to meet the demand and improve support to community members.
Potential Funding	General Fund
Schedule	2020-2024

MH-7 Community Emergency Preparedness Webpage

Mitigation Project Title	Community Emergency Preparedness Webpage
Hazard(s) Mitigated	Multi-Hazard; Dam Incidents; Earthquake, Extreme Heat, Flood; Severe Weather: Heavy Rains/Thunderstorms/Hail/Lightning/Dense Fog; Severe Weather: High Winds; Wildfire; Hazardous Material Releases; Cyber Threat
Project Description, Issue/Background	Members of Petaluma rely on the City for information related to how they can be better prepared for disaster. The City has substantial information currently on its website. The content should be better consolidated and streamlined to make it easier to read and understand. Not all people or businesses that need this information have access to the internet, including segments of the population that are considered social disadvantaged (e.g. low income, language barriers, etc.). The City should convey emergency preparedness information to a wide audience, including the business community, which means developing communication tools in many different formats and languages, if needed. Printed and digital material regarding all types of emergencies and disaster placed at important targeted sites in the City would help educate the community. The City would develop emergency preparedness outreach materials that address differences in adaptive capacity, as some community members in Petaluma may need financial assistance, or help accessing both printed and digital information. This action would involve developing an advisory group of community members who can address social equity issues and provide regular outreach within the community. It would also involve collaboration with regional partners that support resiliency through preparedness education and training.
Related planning mechanisms	Traditional outreach materials, including printed informational handouts and brochures that are available at the City offices.
Other Alternatives	Continued referral to the City website
Responsible Office/ Agency	City Manager's Office
Partners	Sonoma County, Neighboring Jurisdictions, Mutual Aid Providers, Community-Based Organizations, Community Foundation Sonoma County
Priority (High, Medium, Low)	Low
Cost Estimate	$25,000
Benefits (Avoided Losses)	An educated and prepared community will be less dependent on services when demand is high during disaster. By training and coordinating volunteers, staffing to provide essential services can be coordinated to meet the demand and improve support to community members, particularly socially disadvantaged populations.
Potential Funding	General Fund
Schedule	2020-2024

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6 Plan Adoption

44 U.S. CFR Requirement §201.6 Local Mitigation Plans (c)(5): The local hazard mitigation plan shall include] documentation that the plan has been formally approved by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, county commissioner, Tribal Council).

The purpose of formally adopting this plan is to confirm support from the City of Petaluma, raise awareness of the plan, and formalize the plan's implementation. The adoption of this plan completes Planning Step 9 of the 10-step planning process: Adopt the Plan, in accordance with the requirements of DMA 2000. This adoption also establishes compliance with California Government Code Section 65302.6 (Assembly Bill 2140) requiring adoption by reference or incorporation into the safety element of the general plan. The Petaluma City Council has adopted this local hazard mitigation plan by passing a resolution. A copy of the generic resolution is included in Appendix D: Adoption Resolution. Once the plan is adopted, Appendix D will include the executed copies.

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7 Plan Implementation and Maintenance

44 U.S. CFR Requirement §201.6 Local Mitigation Plans (c)(4): The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

Implementation and maintenance of the plan is critical to the overall success of hazard mitigation planning. This is Planning Step 10 of the 10-step planning process. This chapter provides an overview of the overall strategy for plan implementation and maintenance, and outlines the method and schedule for monitoring, updating, and evaluating the plan. The chapter also discusses incorporating the plan into existing planning mechanisms and how to address continued public involvement.

7.1 Implementation

Once adopted, the plan faces the test of its worth: implementation. While this plan contains many worthwhile actions, the City of Petaluma will need to decide which action(s) to undertake first. Two factors will help with making that decision: the priority assigned to each action and funding availability. Low or no-cost actions more readily demonstrate progress toward successful plan implementation. Mitigation is most successful when it is incorporated into the day-to-day functions and priorities of government and development.

Implementation will be accomplished by adhering to the schedules identified for each action (see Chapter 5 Mitigation Actions) and through constant and energetic efforts to update and highlight the multi-objective, win-win benefits of each project to the City of Petaluma community and its stakeholders. These efforts include the routine actions of monitoring agendas, attending meetings, and promoting a safe, sustainable, and resilient community. The four main components of implementation are:

- **Implement** the actions recommended by this plan;
- **Utilize** and enforce existing rules, regulations, policies and procedures;
- **Communicate** the hazard information collected and analyzed through this planning process so that the community better understands what and where hazards can occur, and what they can do themselves to be better prepared; and
- **Publicize** the “success stories” that are achieved through the Hazard Mitigation Planning Committee’s (HMPC) ongoing efforts.

An important implementation mechanism that is highly effective and low-cost is incorporation of the hazard mitigation plan recommendations and their underlying principles into other plans, such as the City of Petaluma General Plan 2025 and the Floodplain Management Plan (FMP). The City of Petaluma already implements policies and programs to reduce losses to life and property from hazards. This plan builds upon the momentum developed through previous and related planning efforts and mitigation programs, such as the FMP, and recommends implementing actions, where possible, through these other program mechanisms.

Simultaneously with these efforts, it is important to constantly monitor funding opportunities that can be leveraged to implement the more expensive recommended actions (for example, structural flood control projects). This will include creating and maintaining a bank of ideas on how to meet local match or participation requirements. When funding does become available, the City of Petaluma will be in a position to capitalize on the opportunity. Funding opportunities to be monitored include special pre- and post-disaster funds, special district budgeted funds, state and federal earmarked funds, and other grant programs, including those that can serve or support multi-objective applications.

7.1.1 Role of Hazard Mitigation Planning Committee in Implementation and Maintenance

With adoption of this plan, the City of Petaluma will be tasked with plan implementation and maintenance. The City of Petaluma agrees to:

- Provide a forum for hazard mitigation issues;
- Disseminate hazard mitigation ideas and activities to all participants;
- Pursue the implementation of high-priority, low/no-cost recommended actions;
- Keep the concept of mitigation in the forefront of community decision making by identifying plan recommendations when other community goals, plans, and activities overlap, influence, or directly affect increased community vulnerability to disasters;
- Monitor multi-objective cost-share opportunities to help the community implement the plan's recommended actions for which no current funding exists;
- Assist in implementation and update of this plan;
- Report on plan progress and recommended changes to Petaluma City Council; and
- Inform and solicit input from the public.

The primary duty of the City of Petaluma is to see the plan successfully carried out and to report to the City Council and the public on the status of plan implementation and mitigation opportunities. Other duties include reviewing and promoting mitigation proposals, considering stakeholder concerns about hazard mitigation, passing concerns on to appropriate entities, and posting relevant information on the City of Petaluma LHMP webpage (and others as appropriate). These activities can be achieved through reconvening the HMPC on an annual basis.

7.2 Maintenance

Plan maintenance is defined as the ongoing effort to monitor and evaluate plan implementation, and to update the plan as progress, roadblocks, or changing circumstances are recognized.

The Petaluma City Council, will designate a Lead Hazard Mitigation Manager who will coordinate plan reviews in consultation with the City's Public Works and Utilities Department and other participating jurisdictions and stakeholders.

7.2.1 Maintenance Schedule

In order to monitor progress and update the mitigation strategies identified in the action plan, the Lead Hazard Mitigation Manager and the HMPC will revisit this plan annually and within 45 days after a hazard event. The annual review will be conducted by the HMPC each year. The HMPC will review progress on the LHMP and complete an annual update to the Petaluma City Council.

This plan will be also updated, approved and adopted within a five-year cycle as per Requirement §201.6(c)(4)(i) of the Disaster Mitigation Act of 2000 unless disaster or other circumstances (e.g., changing regulations) require a change to this schedule. With the initial approval of this plan occurring in late 2020, the plan will need to be updated, reviewed and approved by Cal OES and by FEMA Region IX, and re-adopted by the City of Petaluma by no later than December of 2024 (or within 5 years of the initial approval, which ever date occurs first).

The City will monitor planning grant opportunities from Cal OES and FEMA for funds to assist with the update.

7.2.2 Maintenance Evaluation Process

The HMPC will continually monitor the incorporation process, evaluation and update methodology, continued public participation, and completion of the actions/projects to assure that the plan is being implemented. By monitoring these processes, the HMPC will be able to regularly evaluate the effectiveness of the plan and facilitate necessary changes as needed.

Evaluation of progress can be achieved by monitoring changes in vulnerabilities identified in the plan. Changes in vulnerability may include:

- Decreased vulnerability as a result of implementing recommended actions,
- Increased vulnerability as a result of failed or ineffective mitigation actions,
- Increased vulnerability as a result of new development (and/or annexation) and/or,
- Increased vulnerability as a result of new hazards or circumstances.

The HMPC will use the following process to evaluate progress of any changes in vulnerability as a result of plan implementation.

- A representative from the department identified in each mitigation action will be responsible for tracking project status and reporting to the HMPC on an annual basis to provide feedback on whether the mitigation action as implemented meets the defined objectives and is likely to be successful in reducing vulnerabilities.
    - If the project does not meet identified objectives, or if the mitigation action is new, the HMPC will determine what alternate mitigation actions (or projects) may be implemented, and an assigned individual will be responsible for facilitating and overseeing the scope of action definition. The assigned individual will make any required modification recommendations of the plan to the HMPC, implement the action, monitor the results of the action, and report the findings to the HMPC.
- Projects that were not ranked high priority but were identified as potential mitigation strategies will be reviewed for feasibility and continued appropriateness during the annual monitoring period and the 5-year updating of this plan.
- Changes will be made to the plan to accommodate for mitigation action projects that have failed or are not considered feasible after a review for their consistency with established criteria, the time frame, priorities, and/or funding resources.

Updating of the plan will be by written changes and submissions, as the City of Petaluma deems appropriate and necessary, and as approved by the Petaluma City Council. Updates to this plan will:

- Consider changes in vulnerability due to action implementation;
- Document success stories where mitigation efforts have proven effective;
- Document areas where mitigation actions were not effective;

- Document any new hazards that may arise or were previously overlooked;
- Document hazard events and impacts that occurred within the five-year period;
- Incorporate new data or studies on hazards and risks, specifically on climate change and its effects on flooding, sea level rise, and wildfires;
- Incorporate new capabilities or changes in capabilities;
- Incorporate documentation of continued public involvement;
- Incorporate documentation to update the planning process that may include new or additional stakeholder involvement;
- Incorporate growth and development-related changes to building inventories;
- Incorporate new project recommendations or changes in project prioritization;
- Include a public involvement process to receive public comment on the updated plan prior to submitting the updated plan to Cal OES and FEMA Region IX; and
- Include adoption by Petaluma City Council following Cal OES/FEMA approval.

Annual Review

As part of an annual review process, the City's HMPC will provide opportunities for public input on the LHMP. The City and HMPC will schedule formal LHMP updates at regularly scheduled public meetings to ensure routine maintenance and plan evaluation. The LHMP is designed to be a living document that can be annually updated. Review will involve the following planning processes to encourage public participation, evaluate the effectiveness of the plan, and track mitigation action progress:

- Circulate a press release announcement on the annual review meeting. The press release will advertise the date, time, and location of the public meeting and provide contact information of the Lead Hazard Mitigation Manager.
- Electronic mailings regarding the annual review meeting will be emailed to federal, state, and local agencies, the HMPC, and other representatives.
- Prior to the annual review meeting, the HMPC and City departments will provide an update on their mitigation actions.
- The Lead Hazard Mitigation Manager will announce the meeting using other forms of traditional and digital media platforms, such as newspaper notices, radio announcements, and social media posts.
- A summary of the annual review meeting will be posted on the City's LHMP Webpage and include an annual report on the status of the implementation of the mitigation actions.

The review process should also include information on changing conditions in the City. Specifically, the update should note growth and development changes, the number of retrofitted buildings, or improved buildings with new base elevation certificates, natural hazard events and damage information, and major capital improvement projects to utility infrastructure (e.g. water, sewer, storm water conveyance, roads, levees, gas and electric lines, etc.). The review process should also address changing legislation and new federal and state policies, so these policy updates can be incorporated into the LHMP.

7.2.3 Incorporation into Existing Planning Mechanisms

Planning mechanisms are governance tools used to manage local land use development and community decision-making, such as general plans, floodplain management plans, building codes, emergency operation plans, capital improvement plans, or other long-range plans. Another important implementation mechanism that is highly effective and low-cost is incorporation of the LHMP recommendations and their underlying principles into existing City plans and mechanisms. Federal regulations require that LHMPs describe a process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms, such as a general plan or capital improvement plan. An example of incorporating mitigation actions into other planning mechanisms would be to identify the goals and strategies of the LHMP and document how they have been used to further mitigation efforts in other planning documents.

As previously stated in Section 7.1 of this plan, mitigation is most successful when it is incorporated into the day-to-day functions and priorities of government and development. As described in this plan's capability assessment, the City of Petaluma already implements policies and programs to reduce losses to life and property from hazards. This plan therefore builds upon previous related planning efforts and mitigation programs and recommends implementing actions, where possible, through these other program mechanisms.

These existing mechanisms include (but are not limited to) the following:

- City General Plan 2025 (Health and Safety Element)
- 2015-2023 Housing Element (2017) (part of General Plan 2025)
- 2015 FMP
- 2007 Emergency Operations Plan
- Infrastructure Master Plans
- 2008 Sewer System Management Plan (General Waste Discharge Requirement Order No. 2006-003)
- 2008 Bicycle and Pedestrian Plan
- 1996 River Access and Enhancement Plan
- 2003 Central Petaluma Specific Plan
- 2013 Petaluma SMART Rail Station Areas: TOD Master Plan
- City of Petaluma Municipal Code
- Implementing Zoning Ordinance (IZO)
- Smart Code (Ordinance No. 2470 N.C.S)
- Central Petaluma Specific Plan
- National Flood Insurance Program participation
- Community Rating System participation
- Petaluma Valley Groundwater Sustainability Agency
    - Draft Groundwater Sustainability Plan
- Weed Abatement Program
- Hazardous Materials Business Plan
- Stormwater Master Plan
- 2015 Urban Water Management Plan
- Water Conservation Regional Partnerships
    - Sonoma-Marin Saving Water Partnership
    - Sonoma County Water Agency
    - State Water Resources Board
- Drought Management and Response Plans
- Sustainability Plans and Climate Action Plans
- Capital Improvement Plans and Budgets

- Other plans and policies outlined in the capability assessment
- Other plans, regulations, and practices with a mitigation focus

HMPC members involved in the updates to the planning mechanisms listed above will be responsible for integrating the findings and recommendations of this LHMP with these other plans, programs, and mechanisms as appropriate. As an action step to ensure integration with other planning mechanisms, the Lead Hazard Mitigation Manager will discuss this topic at the annual meeting (refer to Section 7.2.1, Maintenance Schedule) with the HMPC. The HMPC will discuss if there are opportunities to incorporate the plan into other planning mechanisms and who will be responsible for leveraging those opportunities. HMPC members representing local jurisdictions will work with their jurisdictional planning teams to integrate their identified mitigation actions into their own local plans, programs, and mechanisms. Efforts to integrate the hazard mitigation plan into local plans, programs, and policies will be reported during the annual HMPC plan review meeting. Successful integration efforts will be recorded during the meeting.

Specific examples of incorporation of the LHMP into existing planning mechanisms include:

- City adoption (by reference or incorporation) of this LHMP into the Safety Element of the City General Plan per the State of California Assembly Bill 2140 and California Government Code Section 65302.10.
- Integration of wildfire actions identified in this mitigation strategy with the actions and implementation priorities established in the Fire Safe Sonoma plan, the countywide Community Wildfire Protection Plan (CWPP). Key people responsible for development of Fire Safe Sonoma CWPP should participate in the future HMPC, as they can identify key projects in the CWPP and integrate them into the mitigation strategy of the City of Petaluma. Likewise, actual implementation of these wildfire projects will likely occur through the Cal Fire Units and Battalions, Sonoma County Fire and Emergency Services, Sonoma County Fire Chief's Association, and the California Fire Safe Council. The implementation process will be successful through the coordination and effort of individuals from these various organizations.
- Using the risk assessment information in this plan to update the hazard analysis in the current 2007 Emergency Operations Plan.
- Integration of this LHMP into the 2015 FMP. The 2015 FMP included and cross-referenced flood mitigation actions from the 2010 LHMP Annex prepared by the Association of Bay Area Governments.
- Integration of this LHMP into City Infrastructure Master Plans and the Capital Improvement Program. Information on 100-year flood hazards, stormwater flood hazards, and localized flooding can be integrated into the various City facility and infrastructure master plans.

Efforts should continuously be made to monitor the progress of mitigation actions implemented through these other planning mechanisms and, where appropriate, the priority actions should be incorporated into updates of this hazard mitigation plan.

7.2.4 Continued Public Involvement

Continued public involvement is imperative to the overall success of the plan's implementation and goal(s). Efforts will be made to involve the public in the plan maintenance, evaluation, and review process. This includes maintaining a digital version of the plan on the City of Petaluma LHMP webpage for public review. In addition, information on whom to contact within the City will be posted with the plan. The designated Lead Hazard Mitigation Manager at the City of Petaluma will maintain a file of comments received for reference during the next five-year update.

Annual LHMP Review

Any revisions to the plan that may occur as a result of a disaster will also be made public and posted on the City's LHMP Webpage, social media sites, and local media platforms. The City's Lead Hazard Mitigation Manager will place an advertisement in the local newspaper, and also circulate electronic press releases that specify the date and time for review and public input. The City will also invite federal, state, and local agencies to participate, with the HMPC.

Five-Year LHMP Update

The five-year update process provides an opportunity to solicit participation from new and existing stakeholders, to publicize success stories from plan implementation, and seek additional public comment. A public hearing(s) or survey to receive public comment on the plan will be held during the plan update period. When the HMPC reconvenes for the update, the planning process will involve all stakeholders participating in the planning process, including those who joined the HMPC after the initial effort, to update and revise the plan. Public participation will be encouraged and invited through, LHMP Webpage postings and press releases, in addition to email and social media announcements.

Continued public outreach and education is a mitigation strategy in Chapter 5 of this plan, emphasizing a multi-hazard public education and awareness program to be conducted on an annual basis. Activities related to public involvement during the 2019-2020 update are documented in Chapter 3 and Appendix A and C.

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