Local Hazard Mitigation Plan – PUBLIC REVIEW DRAFT

2016-2021

Prepared by City of Benicia Fire Department and Community Development Department

Public Review Draft, June 2016

THE CITY OF BENICIA CALIFORNIA

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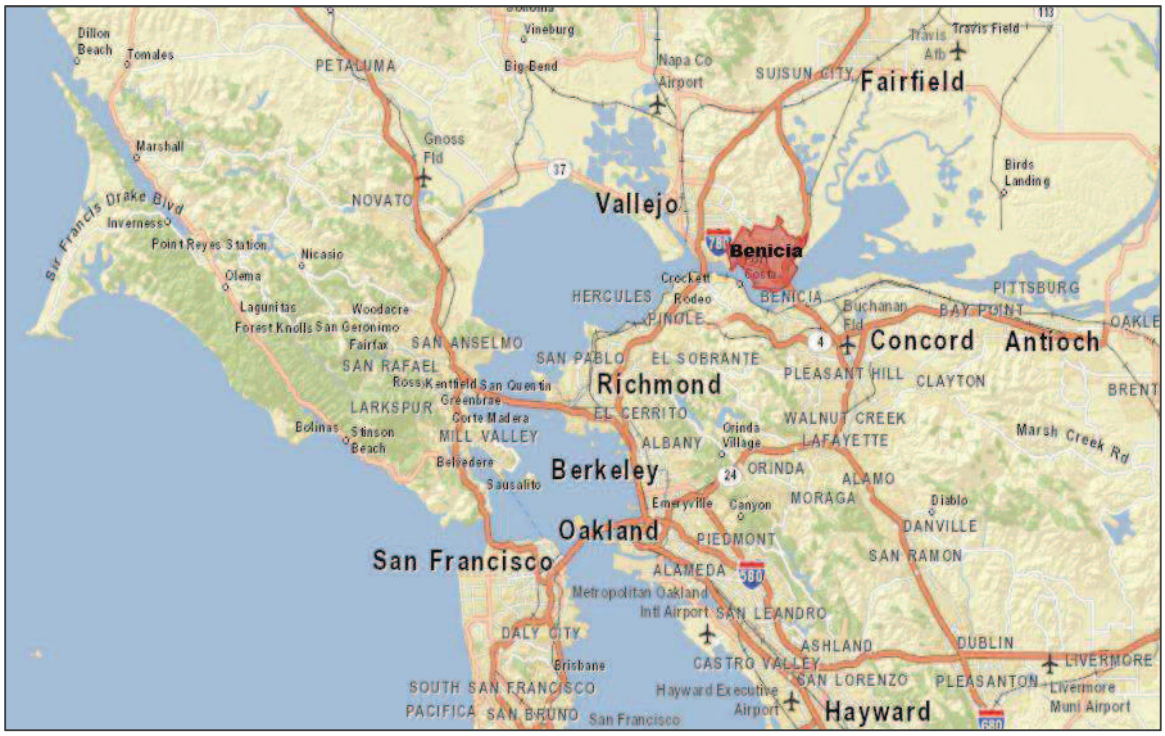
1. Introduction

The City of Benicia is a jurisdiction of 14 square miles located in southwest Solano County, bordered by the Carquinez Strait to the south, Suisun Bay to the east, Benicia State Park to the west, and Lake Herman Road to the north. Two major highways – Interstate 780 and Interstate 680, traverse the southern and eastern sides of the city and connect at the Benicia-Martinez Bridge. Benicia has moderate Mediterranean weather with dry warm summers and moderate winters. According to the U.S. Census 2010-2014 American Community Survey, Benicia's total population is 27,515[1].

Figure 1.1: Location Map



Benicia was incorporated on April 24, 1851. The City is a general law city administered by a council-manager form of government. The City of Benicia provides a wide range of municipal services to its citizens including public safety (fire and police), library, parks and recreation, public works, planning and zoning, water and wastewater utilities, economic development, and general administrative services. The Benicia City Council consists of a mayor and four council members elected to staggered four year terms through a general election process. The City Manager carries out the policies and

[1] United States Census Bureau, American Community Survey 2010-2014. http://factfinder.census.gov.

ordinances of the City Council, oversees the day-to-day operations of the City, and appoints directors of various City departments.

1.1 Background

In Benicia, the most significant natural hazards are related to earthquakes, landslides, floods and fires. Additional hazards are associated with hazardous sites, hazardous materials, air contamination, and utilities. Chapter 4.B. of the Benicia General Plan (1999) describes hazards to the community and establishes goals, policies, and programs to address them. In recent years, the City has also initiated a review of its risk related to sea level rise and climate changed and is developing strategies to adapt to these risks in the future.

The City maintains an Emergency Operations Plan (EOP), which was updated by the Benicia City Council on December 19, 2006 per Resolution No. 06-193. The EOP includes a detailed description of when the plan is to be used, as well as the duties and responsibilities of each city department during an emergency.

1.2 Disaster Mitigation Act of 2000

The federal Disaster Mitigation Act of 2000 (DMA 2000) called for all communities to prepare mitigation plans. The City adopted a plan that met the requirements of DMA 2000 in November, 2011. This Local Hazard Mitigation Plan (LHMP) is the 2016 update to the 2011 LHMP.

Local Mitigation Plans must be updated at least once every five years in order to continue to be eligible for Federal Emergency Management Agency (FEMA) hazard mitigation project grant funding as provided in 44 CFR §201.6(d)(3):

> *A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within five (5) years in order to continue to be eligible for mitigation project grant funding.*

1.3 Purpose

Benicia is committed to diligent preparation, response and recovery from disasters. The ongoing function of city services is essential to ensure local resiliency. While local residents, business and property owners are responsible for emergency preparation, city government provides necessary life safety and supportive services in the event of a disaster and in the immediate aftermath of a devastating event.

The purpose of hazard mitigation is to reduce potential losses from future disasters. Mitigation plans identify the natural hazards that impact communities, identify actions to

reduce losses from those hazards, and establish a coordinated process to implement the plan. (44 CFR §201.1(b)). FEMA defines Hazard Mitigation as follows:

> *Hazard Mitigation is any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards (44 CFR 201.2). Hazard mitigation activities may be implemented prior to, during, or after an event. However, it has been demonstrated that hazard mitigation is most effective when based on an inclusive, comprehensive, long-term plan that is developed before a disaster occurs.*[2]

1.4 Scope

This LHMP complements the adopted General Plan and EOP and identifies the local hazard mitigation strategies that the City will pursue over the next five years to reduce or eliminate long-term risks to people and property from hazards and their effects. This plan is primarily focused on natural hazards, with priority strategies to address preparation, outreach, and improved responsiveness to hazard events.

1.5 Authority

The City of Benicia is responsible for planning, preparation and adoption of this LHMP in accordance with the requirements of the DMA 2000. The State of California designates responsibility to the Association of Bay Area Governments (ABAG) for the initial review and coordination of the plan between Bay Area local government and FEMA. FEMA is responsible for the final review and approval of all Local Mitigation Plans. Once a Local Mitigation Plan is submitted by the State, FEMA is responsible for the overall coordination of plan review, revisions, tracking and approval.

FEMA supports, coordinates and reviews local plans as a means to:

- Foster federal, state, and local partnerships for hazard mitigation;
- Promote more resilient and sustainable communities; and
- Reduce the costs associated with disaster response and recovery by promoting hazard mitigation activities.

[2] Federal Emergency Management Agency. Local Mitigation Plan Review Guide (2011). Web: http://www.fema.gov/media-library/assets/documents/23194

2. Planning Process

2.1 Overview of Hazard Mitigation Planning

Hazard mitigation planning is the effort to reduce loss of life and property by lessening the impact of disasters. State, tribal, and local governments engage in hazard mitigation planning to identify the risk of natural hazards, identify strategies to reduce the effects of those hazards, and establish an approach to implement the plan, in coordination with multiple discipline and taking advantage of available resources.

The LHMP enables the City of Benicia to:

- Increase awareness of threats, hazards, and vulnerabilities;
- Build partnerships for risk reduction with local community organizations, businesses and the public;
- Prioritize long-term strategies to reduce risk, focusing on the greatest areas of vulnerability;
- Identify cost effective risk reduction strategies; and
- Integrate the identified mitigations with existing policies, plans and practices to support funding for implementation.

Hazard mitigation planning takes place *before* a disaster occurs so that the impact to life and property can be reduced. The goal of the Local Hazard Mitigation Plan is to maintain and enhance a disaster-resistant region by reducing the potential for loss of life, property damage, and environmental degradation from natural disasters, while accelerating economic recovery from those disasters. This goal is unchanged from the 2005 plan and continues to be the goal of the City of Benicia in designing its mitigation program. Among the goals of the city, as expressed in its General Plan – Community Health and Safety Element (1999) are to:

1. Minimize harm from geologic hazards
2. Accommodate runoff from existing and future development
3. Prevent property damage caused by flooding
4. Reduce fire hazards

2.2 Preparing the 2015 Update

Under the leadership of the Fire Department, the Plan was developed using an iterative, interdisciplinary process. The City formed a planning team made up of representatives from all City departments. The team identified project goals, hazards of concern, and priority mitigation actions. The extent and impact of current and future hazards were identified using information from the 2011 LHMP, 1999 General Plan, Solano County GIS data, FEMA flood maps, ABAG Resilience Program maps, and the City's Vulnerability Assessment.

While this LHMP is an update of the 2011 plan, it takes on a different format and narrows the selected mitigations into a more focused set of priorities. In order to develop the update, the City used the hazard mitigation planning process that was developed by FEMA which includes the four following steps:

i. **Organize Resources** by assembling the appropriate expertise and stakeholders to guide the plan. Neighboring communities (Solano County) and local and regional agencies involved in hazard mitigation activities (see below), including those agencies that have the authority to regulate development (Bay Conservation and Development Commission (BCDC)) were invited to participate in the Stakeholder meeting. Stakeholders from the Association of Bay Area Governments (ABAG), California Coastal Conservancy, Pacific Gas and Electric Company (PG&E) and City staff, who were also engaged in the development of the Draft Climate Change Vulnerability Assessment and Adaptation Plan, provided comments on the draft mitigation strategies, summarized in Appendix B.
ii. **Assess Risks** to understand the characteristics, likelihood, and potential consequences of a disaster. Inventory the geographic areas of the community that are vulnerable to hazards and develop an understanding of vulnerable populations, infrastructure or assets.
iii. **Develop a Mitigation Plan** that identifies priorities for long-term avoidance or reduction of hazard risks.
iv. **Implement Plan and Monitor Progress** by developing strategies that will bring the plan to fruition. The plan must be implemented on an ongoing basis to remain relevant and should be evaluated periodically to assess progress.

2.3 Community Engagement Process

In addition to meetings held with stakeholders and the internal LHMP planning team, a comprehensive public engagement and outreach process was developed. This provided community members an opportunity to learn about the planning process and hazards in their city, and contribute local knowledge and experience for incorporation into the plan. A complete list of the public outreach efforts completed can be found in Table 2.1.

Table 2.1: Outreach Methods

Outreach Method	Target Group(s)	Goal(s)	Timing
Public Meetings 1. Stakeholder Group 2. Community Meeting (held in Community Center) 3. Updates at City Boards & Commission Meetings	Business and community-based organizations, general public, City Boards and Commissions	• Review overall goal of plan, hazards, assets, and preliminary draft strategies.	April-June 2016
Online Hazards Survey	General Public	• Provide general overview of project, and receive feedback on natural hazards. • Reach citizens not currently engaged in civic processes in a quick, user-friendly format.	April–June 2016
Share Project Information on Social Media (Facebook, Twitter, and NextDoor)	General Public	• Provide general overview of project, and receive feedback on natural hazards. • Reach citizens not previously engaged in civic processes in a quick, user-friendly format. • Provide ongoing project updates.	April–June 2016
Public Notification 1. Project webpage 2. City Manager Report 3. Channel 27 4. Benicia Herald 5. Farmers Market	Stakeholders and General Public	• Provide ongoing project updates. • Notify public of public review draft availability. • Ask the public to identify areas where they have experienced hazards (large map was created and dots used to identify locations).	April–June 2016
Special Notification 1. Rancho Benicia 2. Casa de Vilarrasa	Vulnerable populations, senior citizens, and individuals/groups without online access	• Engage the Benicia Emergency Response Team (BERT) to reach out to vulnerable populations and solicit feedback through surveys.	May–June 2016

Online Hazards Survey

As noted above, the City created an online survey for community members. The purpose of the survey was to gauge understanding and concerns surrounding hazards in Benicia, as well as get a sense of community preparedness in the event of a disaster. The survey included questions about potential hazards facing Benicia and what steps community members have taken or are interested in taking to reduce the threat from

these hazards. The survey was advertised through multiple posts on the City and Fire Department's respective Facebook and Twitter accounts. Emails were sent to the entire roster of City staff, as well as to employees of the Benicia Unified School District. The City Manager's newsletter also included a link to the survey and project website.

In total, 272 individuals completed the survey online. Additionally, a representative from the Benicia Emergency Response Team (BERT), brought hard copies to Casa de Vilarrasa and Rancho Benicia to engage especially vulnerable residents (low income and elderly). A total of 15 surveys were collected from Rancho Benicia Mobile Home Park and Casa Vilarrasa Senior Apartments. Of the nearly 300 total survey responses, the following key outcomes were found:

- Drought, earthquake, and wildfire were the three largest hazards of concern.
- 27% of respondents had been impacted by a disaster in their current residence or place of work. Drought and earthquakes have impacted residents the most.
- Nearly half (48.77%) of respondents had participated in local or national emergency preparedness programs, such as Citizens Organized to Prepare for Emergencies, Benicia Emergency Response Team, or the American Red Cross.
- When asked how the City of Benicia could better help prepare the community for a disaster, most respondents said it could provide effective emergency notifications and communication and ongoing community outreach regarding emergency preparedness.
- Respondents get most of their information from the City through social media and the City of Benicia website. Common "other" responses included radio, neighbors, and television news stations.
- Over half (57.35%) of respondents stated that their employer had a plan for disaster recovery in place.

A complete copy of the survey and detailed findings are included in Appendix A.

Pop-up Events and Community Workshop

In addition to the online survey, the City of Benicia engaged community members and stakeholders at pop-up events as well as a stand-alone community workshop. On both April 28 and May 5, 2016, staff from the Fire Department and Community Development Department hosted a booth at the Benicia Farmers Market. Visitors were invited to place a dot where they had experienced specific hazards in the city. Visitors were also given a half-page handout encouraging them to visit the City's hazard mitigation planning website (www.ci.benicia.ca.us/mitigation) and take the online survey. This information is summarized in Appendix A.

The community workshop was hosted on June 1, 2016, at the Benicia Community Center. The event was advertised on the City's Mitigation website, Facebook pages, Twitter accounts, on NextDoor, the City Manager's newsletter, and on local cable Channel 27. All community members were invited to attend. The planning team presented information about the planning process, major hazards, and what Benicia residents and businesses could do to prepare for these potential events. Participants were then invited to review the hazard maps and comment on the draft mitigation strategies. Under each mitigation strategy, attendees were asked, "Does this strategy protect Benicia from this hazard?" and "Should this strategy be a high priority for the City of Benicia?" Participants were given colored dots to place on a particular spot on the yes/no scale for each question. Participants were also given an opportunity to write down ideas they thought could help protect the community from the potential hazards. This information is summarized in Appendix A.

2.4 Public Review Draft

On June 20, 2016 the City of Benicia's Public Review Draft Local Hazard Mitigation Plan update was released to the general public for review and comment. Electronic versions of the update were posted on the City's website (www.ci.benicia.ca.us/mitigation) with links posted on all of the City's social media accounts. Hard copies of the document were placed at the public counter in the Community Development Department and at the Fire Department. The public review period was open for three weeks. The chart below indicates the comments received and how they were integrated in the final draft of the LHMP.

Table 2.2: Response to Comments (to be completed following public review)

Comment Received	Integrated into LHMP?

2.5 Adoption

After finalizing the LHMP update and submitting it to California Office of Emergency Services (CalOES) and FEMA for review and approval, the planning team prepared the final plan and staff report for the DATE, 2016 Benicia City Council meeting. The City Council adopted the 2016 City of Benicia Local Hazard Mitigation Plan on DATE by Resolution No. 16-INSERT.

3. Capability Assessment

3.1 Relevant Plans and Programs

This plan is part of an ongoing process to build Benicia's disaster resilience. The Benicia community has invested considerable resources in risk reduction activities, including planning for and implementing mitigation activities.

General Plan

The City's long-standing commitment and approach to community safety and disaster resilience is demonstrated in the General Plan. The General Plan, adopted in 1999, serves as a comprehensive guide for making decisions about land use, economic development, road improvements, and protecting natural resources and public health and safety. It provides direction that is the foundation of this Plan. Sustainability is at the heart of the goals developed in Benicia's General Plan.

Benicia put significant effort into developing the City's Community Health and Safety Element of the General Plan, and disaster issues are also addressed in other elements, including the Land Use and Growth Management, Economic Development, Circulation, Community Services, and Community Identity Elements. The objectives in this mitigation plan are guided by the major goals of the General Plan and the objectives of the Community Health and Safety Element.

Many of the actions in this plan are taken from the Community Health and Safety Element and others are supportive of the Element but are more specific to hazards of concern and take into account stakeholder and community input gathered during this planning process.

Table 2.3: Supportive General Plan Goals

General Plan	2016 LHMP Mitigation Strategy
Goal 2.36: Ensure an adequate water supply for current and future residents and businesses	• Urban Water Management Plan • Water Reuse Project • Public Education – Water Conservation
Goal 3.21: Permanently protect and enhance wetlands so that there is no net loss of wetlands within the Benicia Planning Area.	• Urban Waterfront Enhancement Master Plan
Goal 4.1: Make community health and safety a high priority for Benicia	• Evaluate Public Safety Communications Infrastructure including Radio Communications • Critical Facilities, Vulnerable Building Types and Infrastructure Mapping • Plan, Training and Evaluation of Community Vulnerability to Active Shooter or Terrorism • Operational Guidelines for Cooling Centers • Urban Interface Ordinance
Goal 4.11: Minimize harm from geologic hazards	• Vulnerability Assessment of City's Police

	Station to Ground Shaking • Post-Emergency Inspection and Plan Check Protocols • Natural Gas Shut-Off Valve Ordinance • Evaluation of Ordinance and Programs for Earthquake Retrofit of Unreinforced Masonry Structures
Goal 4.1.2: Accommodate runoff from existing and future development	• Stormwater Management and Flood Mitigation Plan
Goal 4.1.3: Prevent property damage caused by flooding.	• Stormwater Management and Flood Mitigation Plan • Storm Ready Community • Flood Fighting Training
Goal 4.1.5: Reduce fire hazards	• Urban Interface Ordinance • Defensible Space Program
Goal 4.22: Update and maintain the City's Emergency Response Plan	• Evaluate Public Safety Communications Infrastructure including Radio Communications • Increase Community Preparedness

Climate Action Plan

The Benicia Climate Action Plan was written through a community-wide process and was adopted by City Council on September 15, 2009. The Plan outlines a vision, goals and policies to reduce community-wide greenhouse gas emissions to 2005 levels by 2010 and reduce GHG emissions to 10 percent below 2000 levels by 2020. Because climate change impacts can cause or exacerbate many of Benicia's hazards of concern, the mitigation strategy has also been directly guided by the Climate Action Plan.

Table 2.4: Supportive Climate Action Plan Policies

Climate Action Plan Policy	2016 LHMP Mitigation Strategy
Objective WW1 Reduce the Amount of Water Consumed 20% by 2020	• Public Education – Water Conservation • Urban Water Management Plan
Objective P1 Reduce the Water Consumed for the Irrigation of Park Space by 40% by 2020	• Turf Analysis (Parks, Trails and Open Space Master Plan Update)
Objective IC4 Encourage the Valero Refinery to Continue to Reduce Emissions	• Water Reuse Project

3.2 Technical, Fiscal, Administrative & Political Capability to Implement Strategies

The City of Benicia has several key resources to support the implementation of mitigation actions. This includes a variety of technical, fiscal, administrative, and political resources, as summarized below.

Table 2.5: Key Resources for Implementation

Resource Type	Resource Name	Ability to Support Mitigation
Technical	Benicia Municipal Code	The Benicia Municipal Code (BMC) contains the city's local laws. Floodplains and building safety are addressed in Title 15, Buildings and Construction. Fire prevention and life safety is addressed in Title 8, Health and Safety. Title 13, Public Services, addresses water and wastewater including regulations to address drought. Land Use is addressed in Title 16, Subdivision, and Title 17, Zoning. The BMC is an important regulatory tool for implementation of mitigations aimed at standards for public health and safety.
Technical	Climate Action Plan	The Climate Action Plan was adopted in 2009 (Resolution No. 9-97) and serves as the "blueprint" for Benicia's actions toward a sustainable future. The Plan touches on a wide range of subject areas, including transportation, land use, water, wastewater, buildings, parks and open space. The objectives of the CAP are generally complementary to, or supportive of, the LHMP strategies.
Technical	Climate Adaptation Plan	The Climate Adaptation Plan, currently in draft review, will be a useful reference document to understand Benicia's vulnerability to climate change (sea level rise and extreme heat), as well as potential strategies for mitigation.
Technical	General Plan	The General Plan, adopted in 1999, is a comprehensive guide for decisions about land use, economic development, transportation, and natural resources and public health and safety. It provides direction that is the foundation of the LHMP. As detailed in Table 2.23, many of the actions in this plan are taken from the General Plan, particularly the Community Health and Safety Element.
Fiscal	General Fund	Benicia adopts a biennial budget which encompasses the General Fund and several special purpose funds. The General Fund is the primary operating fund of the City. While the City has made long-term sustainability of General Fund revenues a priority, new projects that entail dedication of General Fund revenues must be evaluated by the City Council and in light of other needs.
Fiscal	Capital Improvement Program	Eligible implementation measures identified by the City as a high priority will be incorporated into the City's Capital Improvement Program (CIP) planning process. Availability of CIP funds (and consequent LHMP implementation) will be dependent on securing funding for projects and programs, as the City faces ongoing financial challenges. The City's CIP routinely includes public improvements which address public health and safety. The prioritization and mitigation strategies identified in this plan will be used to guide updates to the CIP.
Fiscal	Water Fund	The Water Treatment System treats and distributes drinking water to homes and businesses in Benicia. The Water Funds account for the operating revenues, expenses, debt service, and capital improvement costs related to the utility. Operating activity includes

		costs for water supply contracts, storage, and the negotiation and management of untreated water supply to Valero Refining Company, and costs related to Federal and State water quality and environmental mandates. Some LHMP strategies may be funded or partially funded through the Water Fund, if they align with the purposes and scope of that fund.
Fiscal	Grants	Several mitigations identified in this plan may be supported in whole or in part by grants. For example, the Parks and Community Services Department has been successful in obtaining grants for a number of initiatives and expects to utilize some combination of grant and local funds for implementation of the Urban Waterfront Master Plan. Likewise, the city expects to seek grant funding for a structural vulnerability assessment of the Police Station and improvements to its public safety radio communications capabilities.
Administrative	City Departments	City staff will be the backbone to support implementation of this plan. Staff and leaders of all city departments have been engaged in the identification of hazards and development of mitigations.
Administrative	BERT	The Benicia Emergency Response Team (BERT) is a volunteer group established to help the citizens of Benicia to become more self-sufficient following a major disaster by developing multifunctional teams that are cross trained in basic survival skills. BERT volunteers were essential in the public outreach strategy for development of this plan and will be partners moving forward in implementation of outreach and preparedness strategies.
Political	Boards and Commissioners	Several local boards and commissions will provide guidance at the project level for implementation of the plan, providing expertise, feedback or oversight of mitigation initiatives. These include the Community Sustainability Commission, Parks Commission and Planning Commission. The Benicia City Council has ultimate oversight of all Boards and Commissions and is the final decision-making body. In addition to adoption of this LHMP, mitigations relating to policy, regulations, and certain budget expenditures will require approval by the City Council.

3.3 Previously Implemented Mitigation Measures

The 2011 Local Hazard Mitigation Plan was adopted as an annex to the regional LHMP for the Bay Area. It went through public hearings before the Planning Commission and City Council. There was limited public comment and participation. Subsequently, some mitigation measures have been implemented or carried forward as ongoing activities. See Appendix B for a full list of Mitigation Measures from the 2011 MJHMP that have previously been implemented by the City. A number of regional strategies were not applicable to Benicia and aren't evaluated for inclusion in this LHMP.

3.4 Relation to Other Plans

In addition to the Local Hazard Mitigation Plan, natural and man-made hazards are addressed in the Benicia General Plan (1999) and Climate Change Adaptation Plan (in progress, 2016). The LHMP is written for compliance with the requirements of FEMA

related to hazard mitigation planning and is not intended to duplicate either the General Plan or Climate Adaptation Plan; however, it is complementary these documents and will also advance the established goals and policies of the city. Both the General Plan and Climate Action Plan address hazards on a short- and long-term basis. However, because the LHMP is updated on a five year cycle, the strategies established in this document will be those that can foreseeably be accomplished in the near to mid-term.

Table 2.6: Relation to Other Plans

	Local Hazard Mitigation Plan (2016)	**General Plan Community Health and Safety (1999)**	**Climate Adaptation Plan (*in draft, 2016)***
Earthquake	X	X	
Liquefaction	X	X	
Landslides	X	X	
Floods	X	X	
Sea Level Rise	X	X	X
Fire Hazard	X	X	
Extreme Heat	X		X
Hazardous Waste		X	
Utility Hazards		X	
Air Quality		X	

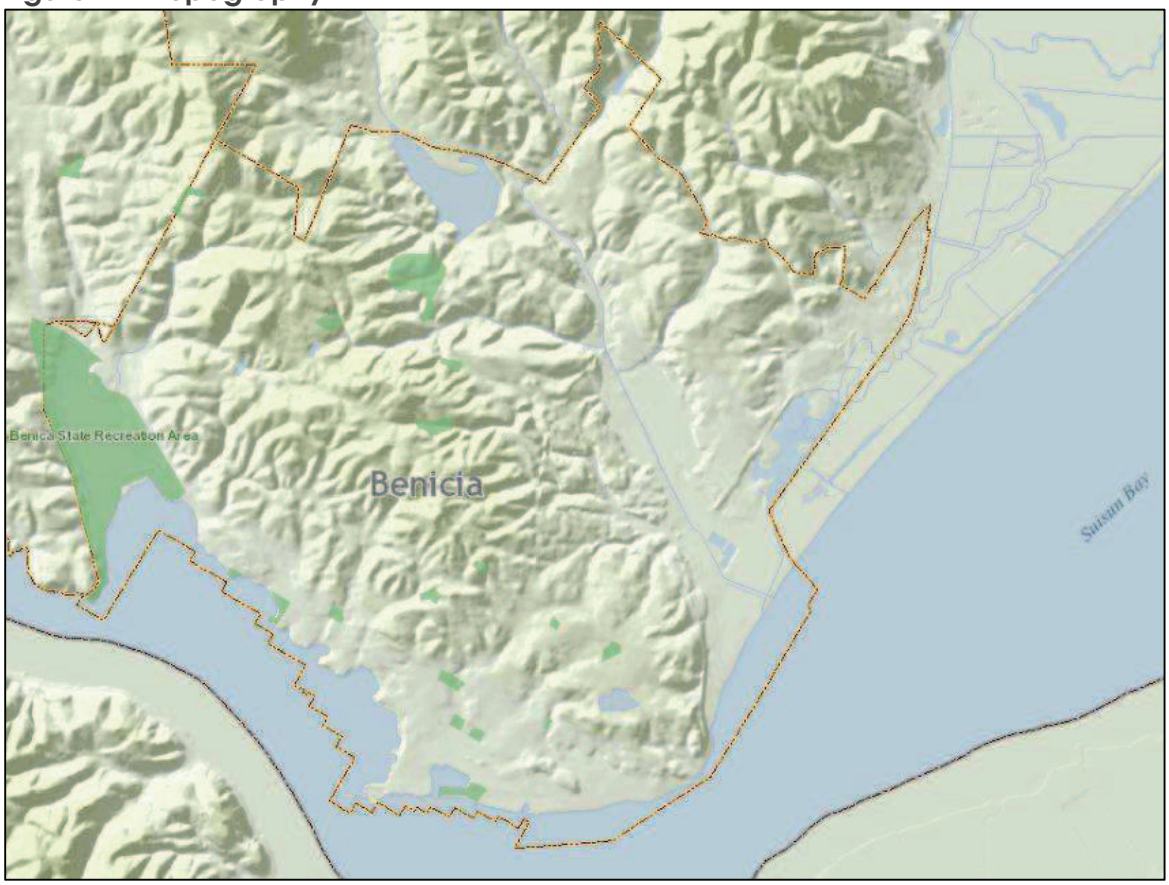
4. Community Profile

4.1 Area at a Glance

Benicia's strategic setting on the north bank of the Carquinez Strait has made it an attractive location as both a place to live and a place for industrial activity. While largely built out, families continue to be attracted to Benicia's quite tree-lined neighborhoods, good schools, low crime rate and historic charm.

Benicia's climate is temperate and Mediterranean, resulting in dry, warm summers and moderate winters. Rainfall averages 19 inches and falls mostly from December through April. The mean annual temperature is 63 degrees with prevailing winds from the west to the southeast.

Figure 4.1: Topography



Benicia's natural features have influenced its development over time. The Carquinez Strait and Suisun Bay provide an extensive, accessible shoreline that is bracketed on both east and west by marsh preserves. The shoreline is divided between residential, recreational, and industrial uses. Within the historic downtown and residential areas at

the southernmost end of the city, land slopes gently down to the Carquinez Strait. The eastern city limits are bordered by the marshlands of Suisun Bay. Relatively flat areas adjacent to the marshes provide sites for industry. At the southwestern boundary of the city, another flat, marshy area has been preserved as the Benicia State Recreation Area. Areas near the water have historically served as centers for trading, industry, and residence. The hills that rise above Benicia have primarily developed for residential use over the past fifty years, and a significant portion of this area is dedicated to permanent open space.

In addition to Benicia's unique history as one of California's first capitols (1853-1854) and a Civil War military post (Benicia Arsenal), it has a long history as a center for manufacturing and trade. Today, the Benicia Industrial Park and Port of Benicia drive the economic strength of the City. The Benicia Industrial Park (BIP) has more than 8 million square feet, 450 businesses and 6,500 employees. The BIP provides a strong tax base for the City, generating over 45% of the local tax revenue collected (property, sales, and utility users). There is a mix of industrial and related uses including petro-chemical, manufacturing, wholesale trade, transportation, supplies to major anchor businesses and emerging new technology businesses.

4.2 Transportation

The original settlement of Benicia was surveyed by Jasper O'Farrell. A five-mile stretch of shoreline was selected and a grid system of streets was superimposed with little relation to topography. All north-south streets in the original settlement have 80-foot wide rights-of-way, while the east-west streets have alternating 60- and 80-foot wide rights-of-way. North-south streets were extended beyond the shoreline and into the water. Streets names are alphabetical in the east-west direction and numbered in the north-south direction. In the mid-1960's, an east-west freeway (I-780) was constructed generally between "O" and "S" Streets. New development north of the freeway subsequently abandoned the grid system to minimize grading and street slope.

Vehicle Transport

Interstates 780 (east-west) and 680 (north-south) provide major routes for trucking, commerce and commuters.

I-680 links the city to the four nearby airports:

- Buchanan Field General Aviation Airport
- Oakland International Airport
- Sacramento International Airport
- San Francisco International Airport

Interstate 80 is also accessible from Benicia by traveling five miles west on I-780. The Benicia–Martinez Bridge is part of I-680 and crosses the Carquinez Strait, connecting

Benicia and the City of Martinez. The bridge system consists of three parallel bridges: two traffic bridges that carry a total of nine lanes, and a lower Union Pacific Railroad drawbridge that is used by freight trains and Amtrak passenger trains. The vehicle bridges are owned by Caltrans and maintained by Caltrans and the Bay Area Toll Authority (BATA).

The majority of Benicia commuters drive to their places of employment or to the Pleasant Hill or Concord/Martinez BART stations. The City of Benicia is responsible for maintaining the local road network.

Rail

Benicia once served as a stop on the transcontinental railroad and provided service for a rail ferry across the Carquinez Strait at the terminus of First Street.

The Union Pacific Railroad (UP) operates the rail line along the eastern boundary of the Benicia Industrial Park along the Suisun Bay, which is an important asset for numerous businesses within the park. UP operates two rail lines that serve the Benicia Industrial Park and provides transcontinental "piggyback" services (i.e., transporting loaded truck trailers on flat cars). Rail service is provided through siding and tie-ins at company facilities in the Industrial Park, affording direct service to rail cars. Union Pacific, AMPORTS, Valero, and the BIP are looking to bring additional rail traffic into the area.

Port of Benicia

The Port of Benicia is privately owned and operated by AMPORTS; however, the underlying land is owned by the City of Benicia. AMPORTS lease on the land will sunset in 2032. The Port, which is located at the southernmost point of Benicia, spans 645 acres within the 4,000-acre Benicia Industrial Park, with 140,000 square feet of vehicle processing buildings and a 38-foot deep channel. The 2,400-foot long deepwater pier has the capacity to berth 3 ships, while on-terminal rail access from Union Pacific can potentially utilize 170 railcars. Inland access to and from the port is from I-680, I-780, I-80, and SR-4.

The Port of Benicia is a trading hub with Japan, South Korea, and Australia, and handles neo-bulk and dry bulk cargos. The port is the Northern California hub for domestic distribution of Ford and Chrysler, and Toyota delivers to Northern California solely through the port of Benicia. The Port also imports oil from to Valero Benicia Refinery.

Transit

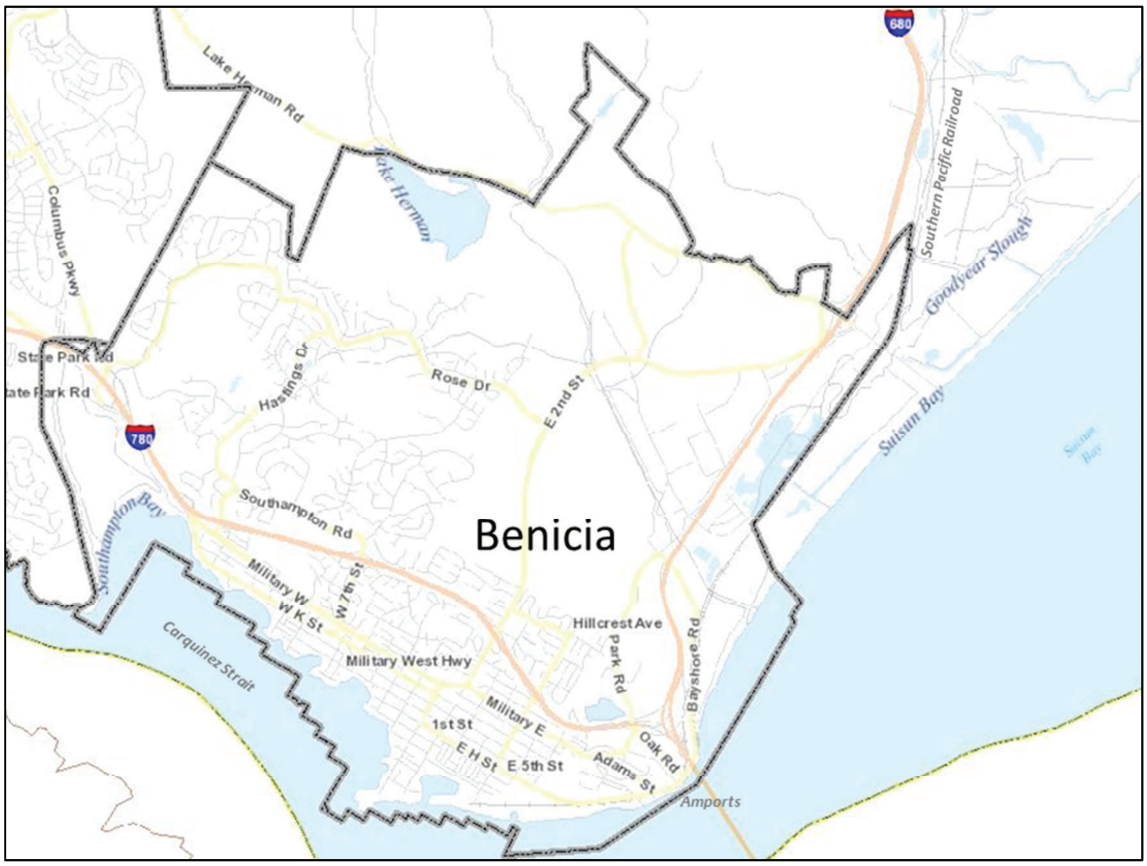
Solano County Transit (SolTrans) provides public bus transportation services for the City of Benicia and the City of Vallejo. Additionally, SolTrans provides a direct link to several major transit hubs, including: the Vallejo Transit Center, Walnut Creek, the El

Cerrito del Norte BART Stations, and the AMTRAK Passenger Rail Service in Martinez, five miles south via I-680.

Recreational Trails

The San Francisco Bay Trail runs through Benicia. The Bay Trail is a planned recreational corridor that, when complete, will encircle San Francisco and San Pablo Bays with a continuous 500-mile network of bicycling and hiking trails. It provides valuable access to recreational opportunities as well as providing a commute alternative for cyclists and connecting numerous public transportation facilities.

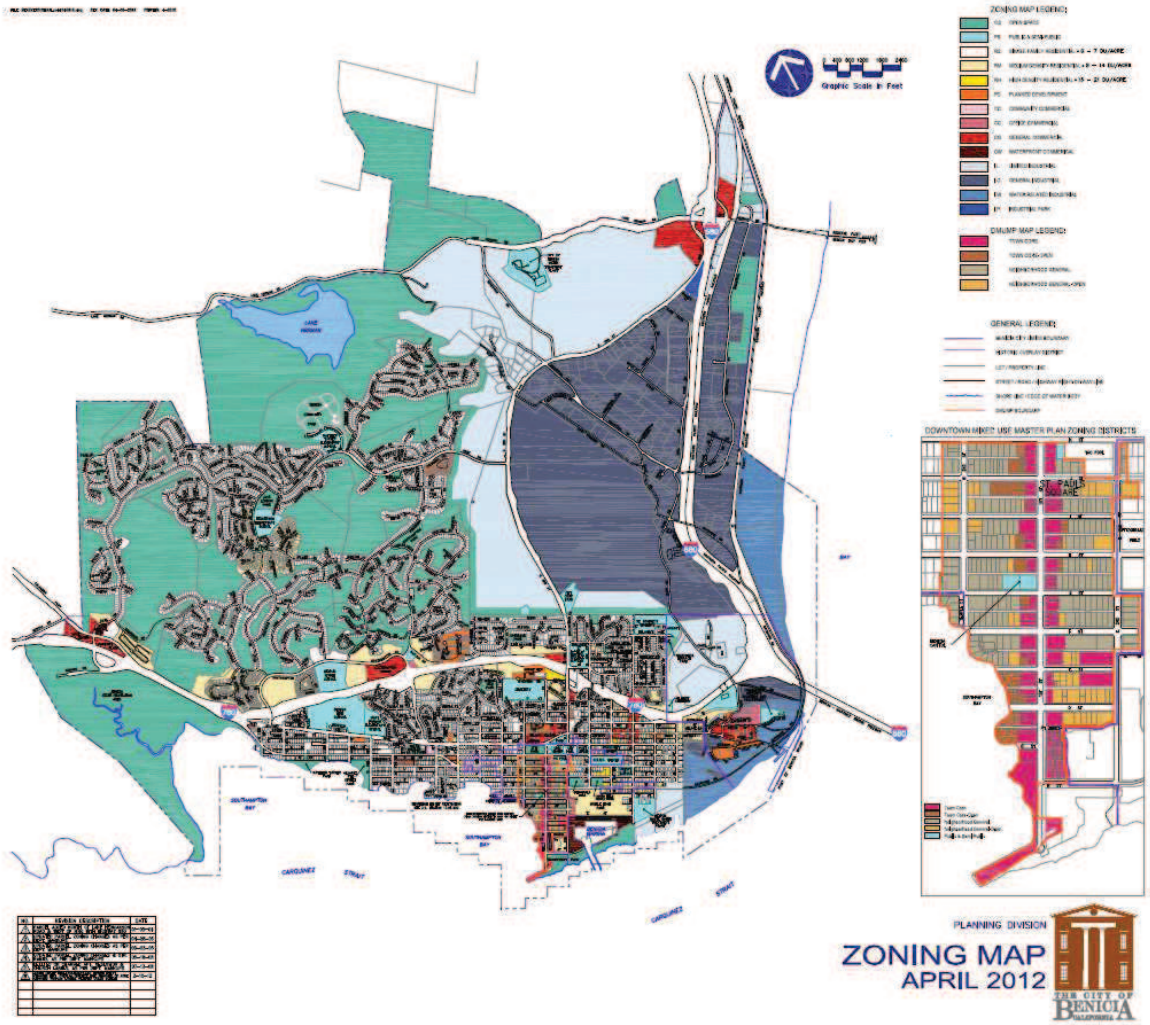
Figure 4.2: Transportation



4.3 Land Use

The Benicia General Plan, adopted in 1999, guides land use decisions within the City. Between 1999 and 2005, several small changes to the zoning were adopted by Resolution and incorporated into the most recent Zoning Map.

Figure 4.3: Zoning Map



Several additional plans govern land use in the city, including the Downtown Historic Conservation Plan, Arsenal Historic Conservation Plan, and Downtown Mixed Use Master Plan. The City has two historic districts – the Downtown Historic District and the Arsenal Historic District – which contain landmarks identified on the local, state and national registers.

Figure 4.4: Downtown Historic District

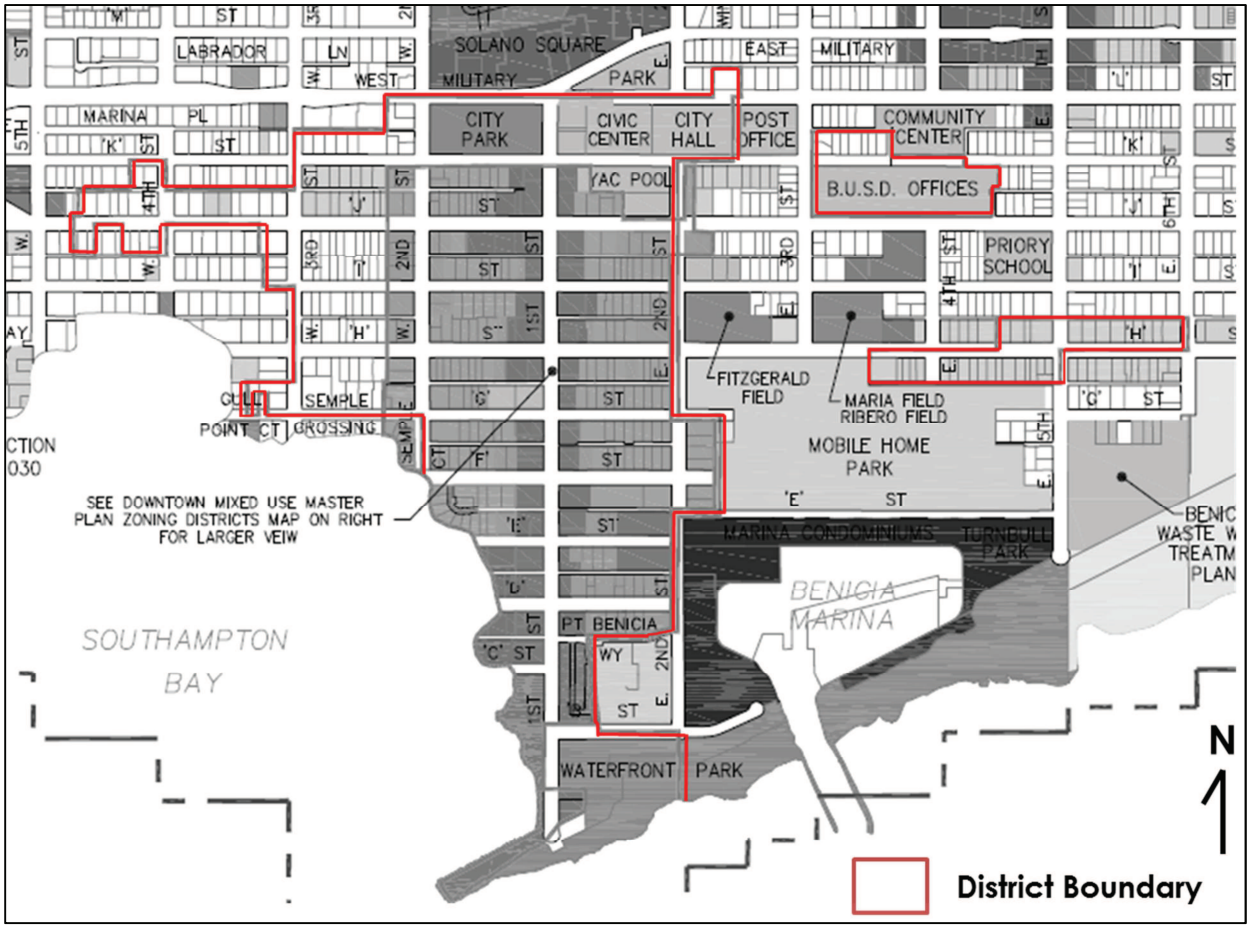
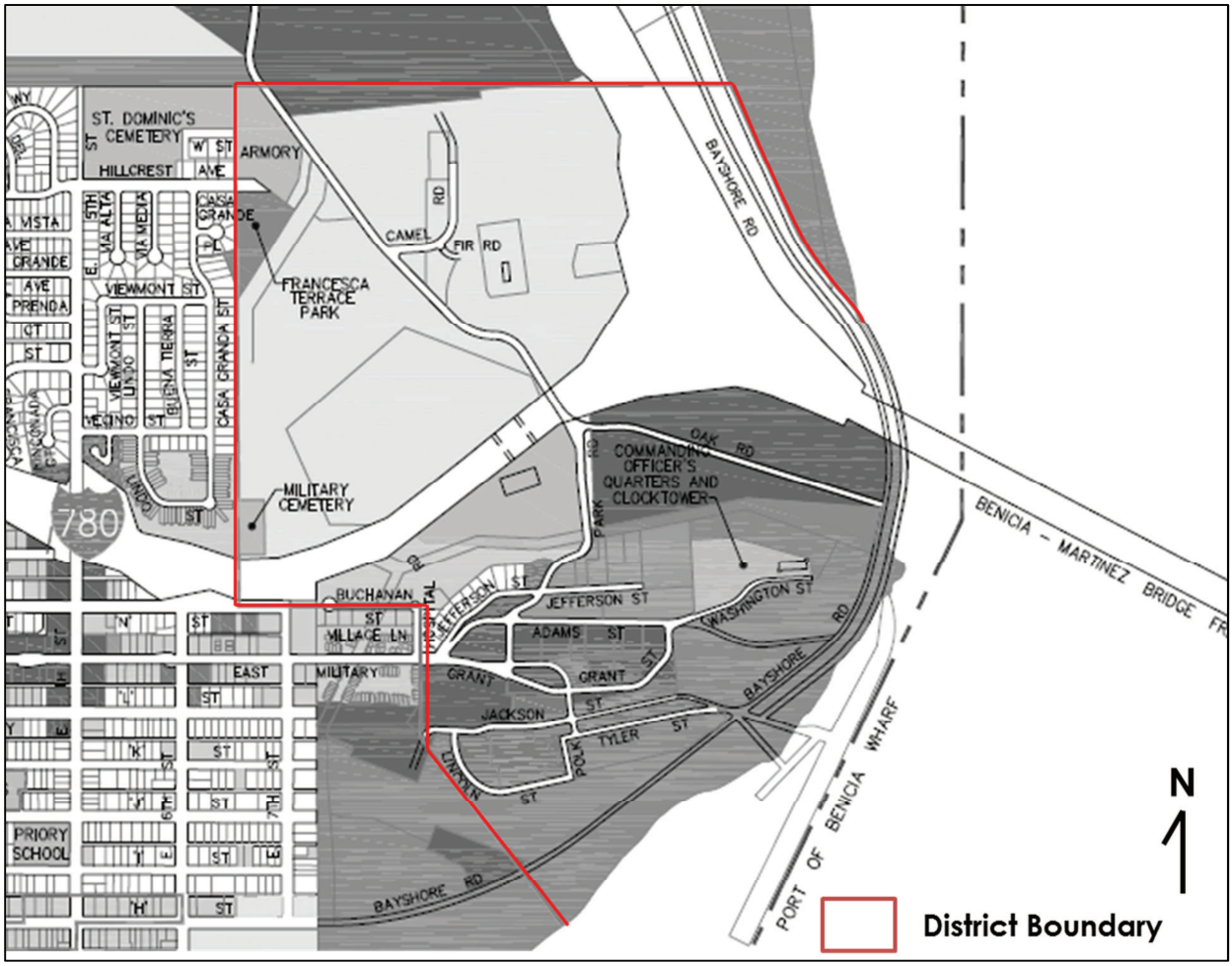


Figure 4.5: Arsenal Historic District



Residential

The city's residential areas include approximately 11,432 housing units[3]. The majority of Benicia's housing stock is single-family units; however, there are a mix of condos, a mobile home park, apartments, and some mixed use-space along the waterfront and downtown areas.

The existing housing stock matches the Benicia zoning regulations with the vast majority of the stock consisting of low density development (0-7 Dwelling Units per Acre). Exceptions to this low density residential pattern include the downtown area and the Benicia Industrial Park.

Natural hazard impacts to housing could require temporary emergency response services and long-term rebuilding assistance.

[3] United States Census Bureau, 2010-2014 American Community Survey. www.census.gov

Commercial/Industrial

The Benicia 2014 Comprehensive Annual Financial Report documents the top city employers. The Benicia Industrial Park (BIP) is the largest industrial park in Solano County, comprised of 600 businesses, and employs over 7,000 individuals. Additionally, it generates over 45% of local tax revenue collected (property tax, sales tax and utility fees). The range of business types include manufacturing, construction, petroleum refining, biotech, and steel fabrication. In particular, the Valero Benicia Refinery is the city's top employer and tax payer. The Valero Benicia Refinery produces 10% of the gasoline used in California and 25% of the gasoline used in the San Francisco Bay Area. Approximately 70% of the refinery's product is gasoline; other products include diesel, jet fuel, fuel oil, propane and asphalt. Natural hazard impacts on any of these employers would impact Benicia's economy.

Table 4.1: City of Benicia Major Employers (2015)

Employer	No. of Employees	% of Total City Employment
Valero	470	1.8%
Benicia Unified School District	375	1.4%
Cytosport	319	1.2%
City of Benicia	232	0.9%
Dunlop	229	0.9%

Source: City of Benicia 2015 Comprehensive Annual Financial Report

The Benicia Arsenal was originally built as part of a large military reservation and was the primary US Army Ordnance facility on the West Coast. The base was closed by the Army in the early 1960's and given to the City of Benicia which then sold portions to various private parties. The base is now home to a thriving arts, health, food, and entertainment community as well as many industrial businesses. The Arsenal is on the National Register of Historic Places and designated as a local historic district.

Public Facilities

Critical facilities are the structures and institutions that are necessary for the community's response to and recovery from emergencies. Critical public facilities within the City of Benicia are listed in Table 4.2.

Table 4.2: Critical Public Facilities

Facility Name	Location	Facility Type	Structure Type
Water Treatment Plant	100 Water Way	Utilities	Reinforced Masonry
Wastewater Treatment Plant	614 E. 5th Street	Utilities	Reinforced Masonry
Pump Station 1	2400 E. 2nd Street	Utilities	Reinforced Masonry
Pump Station 2	E. 2nd and Tennys	Utilities	Reinforced Masonry
Pump Station 3	E. 2nd & Rose Drive	Utilities	Reinforced Masonry
Fire Station #11	150 Military West	Public Safety	Wood Frame
Fire Station #12	601 Hastings Dr.	Public Safety	Wood Frame

Police Station	200 E. L Street	Public Safety	Wood frame brick veneer
City Hall	250 E. L Street	Administration	Reinforced Masonry
Liberty High School	350 E. K Street	Administration	Reinforced Masonry
Corporation Yard	2400 E. 2nd Street	Administration	Light Metal Frame

Natural hazard impacts to any of these facilities would limit the city's ability to respond and assist the public following a natural hazard.

4.4 Demographics

The city encompasses 15.7 square miles, 12.9 of which are land miles and 2.8 of which are water miles. This results in an average population density of 1,748 residents per square mile; however, portions of Benicia, such as downtown, are significantly denser. According to the U.S. Census 2010-2014 American Community Survey (ACS) 5-year estimates, Benicia's total population is 27,450[4]. Table 4.3 provides selected population and demographic characteristics for Benicia.

Table 4.3: Demographic Characteristics

	Estimate	%
Total Population	27,450	
Median Age	43	
Population < 18 years of age	6,514	24%
Population 19-64 years of age	17,153	62%
Population > 65 years of age	3,783	14%
Workers 16 years and over	13,046	48%
Mean travel time to work	30 min.	
Median household income ($)	$89,094	
Below poverty level	1,510	5%

Source: U.S. Census 2010-2014 ACS

According to ABAG's 2013 population projections, Benicia's population will increase at an average rate of 140 people every year between 2015 and 2023, reaching a total population of 28,720 people in 2023.

Table 4.4 details selected household characteristics based upon the 2010-2014 ACS. While a majority of households are occupied by families, a significant portion (25%) of households are occupied by a single individual. Most residents have access to a vehicle and telephone; however, Census estimates indicate that hundreds of households in the community lack access to a vehicle and/or telephone, leaving these individuals potentially at risk in the event of a disaster.

[4] United States Census Bureau, Census American Community Survey (2010-2014). http://factfinder.census.gov.

Table 4.4: Household Characteristics

	Estimate	%
Households	**10,788**	
Average Household Size	2.40	
Family Households	7,379	68%
Non-family Households	3,409	32%
Householder living alone	2,718	25%
Households with children under 18	3,711	34%
No vehicle available	345	3%
No telephone service available	218	2%

Source: U.S. Census 2010-2014 ACS

The vast majority of housing units in Benicia (92%) were built prior to 2000. Benicia's residential growth began in the historic downtown and waterfront areas and primarily expanded over the course of several decades through build-out of the Southampton neighborhood north of I-780. Table 4.5 provides selected Census information about Benicia's housing stock.

Table 4.5: Housing Characteristics

	Estimate	%
Housing Units	**11,432**	
Owner-Occupied	7,355	64%
Median Value	*$424,000*	
Owner-occupied with a mortgage	*5,878*	*80%*
Owner-occupied without a mortgage	*1,477*	*20%*
Renter-Occupied	3,433	30%
Vacant	644	6%
Structure built 2000 or later	880	8%
Structure built 1970-2000	8,242	72%
Structure built 1940-1970	1,588	14%
Structure built 1939 or earlier	722	6%

Source: U.S. Census 2010-2014 ACS

Today, there are few vacant residential parcels remaining within the City limits; therefore, future housing development will be in the form of infill on vacant or underutilized lots or redevelopment of existing sites, including the addition of new accessory dwellings on single-family lots. As of the most recent analysis (2015), there are 48 legal accessory dwellings in the city.

4.5 Assets (Services & Facilities)

An important step in developing the LHMP is identification of community assets, particularly those that are vulnerable due to their physical characteristics or socioeconomic uses. FEMA defines assets as "the people, structures, facilities and

systems that have value to the community."[5] The following asset categories are defined/described by FEMA:

- *People:* areas of increased population density, or groups of individuals who may not be able to comfortably or safely access standard resources offered in emergencies (e.g., children, the elderly, people with disabilities, non-English speakers, those who are medically or chemically dependent). This asset category includes facilities that provide support services for these populations (e.g., hospitals, dependent care facilities, oxygen delivery, accessible transportation).

- *Economy:* these assets may be described in terms of direct losses (such as damage to a building) or indirect losses (such as loss of employment). This asset category may include primary economic sectors (e.g., manufacturing) as well as major employers and commercial centers that support the community.

- *Built Environment:* is inclusive of existing buildings, infrastructure, critical facilities, and cultural resources. Buildings may be vulnerable assets due to location, age, construction type, conditions or use. Infrastructure is inclusive of transportation, utilities, and communication systems. Critical facilities are those structures and institutions necessary for the community's response to and recovery from emergencies. Cultural resources are those historic or cultural assets that are unique or irreplaceable.

- *Natural Environment:* refers to natural and environmental resources that are essential to the community identity and local economy, as well as critical habitat areas and those areas that provide "ecosystem services" (for example, wetlands help to absorb flood waters).

The following assets were identified through development of the draft Vulnerability Assessment + Adaptation Plan (2016) and further refined through community consultation in development of LHMP.

Table 4.6: Vulnerable Assets

Category	Assets	Natural Hazard Risk
People	Rancho Benicia Mobile Home Park	Ground Shaking, Liquefaction, Flood
	Portside Village Townhomes	Ground Shaking, Liquefaction, Flood
	Benicia Marina live-aboards	Ground Shaking, Flood
	Casa de Vilarrasa I Senior Housing (383 East I St.)	Ground Shaking
	Casa de Vilarrasa II Senior Housing (921 E. 4th St.)	Ground Shaking
	Senior Center (1201 E. 2nd Street)	Ground Shaking

[5] United States Department of Homeland Security, Federal Emergency Management Agency. Local Mitigation Planning Handbook, 2013. http://www.fema.gov/media-library-data/20130726-1910-25045-9160/fema_local_mitigation_handbook.pdf

	Youth Center (150 E. K Street)	Ground Shaking
	SolTrans Dial-A Ride	Indirect service risk
Economy	Downtown Commercial Areas	Ground Shaking, Flood (lower First Street)
	Benicia Industrial Park	Ground Shaking, Liquefaction, Flood, Wildland-Urban Interface
	Port of Benicia	Ground Shaking, Liquefaction, Tsunami, Flood, Wildland-Urban Interface
	Southern Pacific Railroad	Ground Shaking, Liquefaction, Flood,
Built Environment	*Buildings*	
	Benicia Community Center (370 E. L St.)	Ground Shaking
	Unreinforced Masonry Buildings, Soft Story Buildings, Tilt-Up Buildings	Ground Shaking
	Buildings in FEMA Flood Hazard Zones	Flood
	Infrastructure	
	Industrial Way	Ground Shaking, Liquefaction, Flood
	Bayshore Road adjacent to AMPORTS	Ground Shaking, Liquefaction, Flood, Wildland-Urban Interface
	East 2nd Street / East B Street	Ground Shaking, Liquefaction, Flood
	East 5th Street	Ground Shaking
	Stormwater outfalls at East 2nd Street and East 5th Street	Ground Shaking, Liquefaction
	PG&E Infrastructure*	*Not assessed for single site*
	Critical Facilities	
	Water Treatment Plant	Ground Shaking, Wildland-Urban Interface
	Wastewater Treatment Plant	Ground Shaking, Liquefaction, Flood
	Fire Stations	Ground Shaking, Wildland-Urban Interface
	Police Station	Ground Shaking
	City Hall	Ground Shaking
	Liberty High School/School District Offices	Ground Shaking
	Public Safety Radio System (200 East L Street) and repeaters throughout community	Ground Shaking
	Corporation Yard	Ground Shaking, Wildland-Urban Interface
	Pump Station 1 (2400 E. 2nd Street)	Ground Shaking, Wildland-Urban Interface
	Pump Station 2 (E. 2nd and Tennys)	Ground Shaking, Wildland-Urban Interface
	Pump Station 3 (E. 2nd & Rose Drive)	Ground Shaking, Wildland-Urban Interface
	Cultural Resources	
	Benicia Public Library (150 E. L Street)	Ground Shaking
	Downtown Historic District	Ground Shaking
	Arsenal Historic District	Ground Shaking, Liquefaction,

		Flood, Wildland-Urban Interface
	Benicia State Capitol – Historic	Ground Shaking
	Southern Pacific Depot (90 First Street) – Historic	Ground Shaking, Liquefaction
	Camel Barn Museum (2060 Camel Road) – Historic	Ground Shaking, Wildland-Urban Interface
	Clocktower – Historic	Ground Shaking, Wildland-Urban Interface
	Commandant's House – Historic	Ground Shaking, Wildland-Urban Interface
	Crooks Mansion (285 W. G Street) – Historic	Ground Shaking, Wildland-Urban Interface
	Fischer-Hanlon House (135 W. G Street) – Historic	Ground Shaking
	Masonic Hall (106 W. J Street) – Historic	Ground Shaking
	Von Pfister General Store (waterfront b/t C and D Streets) – Historic	Ground Shaking, Flood
	Point Benicia Pier	Ground Shaking, Liquefaction, Flood
	Benicia Community Park	Ground Shaking, Wildland-Urban Interface
	Matthew Turner Park (12th Street)	Ground Shaking, Wildland-Urban Interface
	Fitzgerald Field	Ground Shaking, Liquefaction
Natural Environment	Benicia State Recreation Area	Ground Shaking, Liquefaction, Tsunami, Flood
	Shoreline marsh areas along Benicia Industrial Park and Benicia Marina	Ground Shaking, Liquefaction, Flood
	Waterfront Trail and street end parks (W. 2nd to First)	Ground Shaking, Liquefaction, Flood
	Marina Green and Bay Trail / Ridge Trail	Ground Shaking, Liquefaction, Flood
	First Street Green (Waterfront Park)	Ground Shaking, Liquefaction, Flood
	Bay Trail near Sulphur Springs	Ground Shaking, Flood, Wildland-Urban Interface
	Sulphur Springs Creek	Ground Shaking, Liquefaction, Flood
	Rollye Wiskerson Trail and Bay Area Ridge Trail	Ground Shaking, Wildland-Urban Interface
	Lake Herman & Lake Herman Regional Park	Ground Shaking, Wildland-Urban Interface

*** PG&E representatives are aware that climate change poses risks to their infrastructure and are internally conducting vulnerability assessments.**

4.6 Past Disasters

Understanding the history of previous hazard events helps to estimate the likelihood and potential impact of future events. The information gathered here is based upon available documentation.

Between 1950 and 2015, the Bay Area was affected by disasters including floods, earthquakes, energy shortages, and disease[6]. In this timeframe Solano County was affected by 25 state or federally-declared disasters. Similar to the State and Federal Governments, the City of Benicia may declare a state of emergency. Since 2000, the City of Benicia has declared 1 local emergency (repairs to City Hall resulting from storms in 2002-2003). In 2006, the Emergency Operations Center was operated due to localized flooding in the low-lying areas near downtown, though a local emergency was not declared. In 2014, the City's Cordelia Water Transmission Pipeline was damaged during the West Napa Earthquake and repaired at a cost of $105,000.

The history of state and federally-declared emergencies is summarized below.

Table 4.7: Past Disasters

Event	Description	Year	Extent
Drought	Statewide drought, beginning in 2013, that remains ongoing at the time of this plan. The Governor's office established mandatory water reductions. Estimate of total damages unavailable.	2014	Statewide
West Napa Earthquake	Magnitude 6.0 earthquake, south of Napa on the West Napa Fault. Total damage is estimated at over $300 million. 1 person killed; 200 injured.	2014	Napa and Solano Counties
Swine Flu	Global outbreak of H1N1 influenza virus resulting in closure of Bay Area schools.	2009	Statewide
Drought	Three-year drought resulting in over $300 million in ag. Revenue loss; up to $3 billion in accumulated economic loss.	2009	Statewide
Oil Spill	53,500 gallons of heavy oil spilled into San Francisco Bay after container ship struck Oakland Bay Bridge	2007	Bay Area incl. Solano County
Storms	Roadway damage resulted from storms.	2006	Northern California, incl. Solano County
Winter Storms	Severe storms, flooding, mudslides, landslides resulting in appx. $100 million damage, two deaths from falling trees, damage to businesses and homes.	2005-2006	Bay Area incl. Solano County
West Napa Earthquake	Earthquake in Napa resulting in 41 injuries and appx. $15-70 million in damages.	2000	Napa, Solano, Sonoma, Contra Costa Counties
El Nino	Severe flooding, landslides, flash floods. More than 11,000 evacuated, 17 deaths	1998	Most areas of the state, incl. Solano County
Floods	Over 300 square miles of flooding and 120,000 people evacuated, 2,000 businesses damaged or destroyed. 8 casualties and $1.8 billion damages.	1996-1997	Central & Northern California including Solano County
Winter Storms	Severe storms, flooding, landslides, mud flows. Small stream flooding. Total damages of $741.4 million, 11 deaths.	1995	Most areas of the state, incl. Solano County
Freeze	Cold conditions resulted in freeze throughout the state affecting public buildings, utilities, agriculture. Joblessness and hunger among farm workers. 5,400 homes affected.	1990	Most areas of the state, incl. Solano County

[6] 2010 Multi-Jurisdictional Local Hazard Mitigation Plan, Appendix D; FEMA website

	Total damages $856,329,675		
Loma Prieta Earthquake	Magnitude 7.1 earthquake. 23,408 homes and 3,530 businesses damaged; 1,018 homes and 366 businesses destroyed. Severe damage to infrastructure. 63 fatalities, 3,757 injuries, total damage of $5.9 billion.	1989	Bay Area incl. Solano County
Fires – 49er, Miller, Fern	No casualties, total damage of $31,247,534; 234 homes destroyed, 41 homes damaged, 29 businesses destroyed	1988	Shasta, Solano, Yuba, Nevada counties
Winter Storms	Rains, winds, flooding and mud slides. 13 deaths, 67 injuries, total damage of $407,538,904 (public and private) including 1,382 homes and 185 businesses destroyed.	1986	Northern California, incl. Solano County
Winter Storms	Heavy rains, high winds, flooding, levee breaks. Total damage of $523,617,032 inclusive of public, private and agricultural improvements.	1982-1983	Most areas of the state, incl. Solano County
Winter Storms	Heavy winds, rain, flooding, mud slides. Damage to public and private facilities including 256 homes and 41 businesses destroyed. Total damage appx. $273,850. 33 deaths, 481 injuries.	1982	Northern and Central California coastal counties, incl. Solano County
Storms	Rain, winds, mud slides, flooding. Total damage to public, private and agricultural improvements total $316,640,817.	1980	Stanislaus, Monterey, Solano, Santa Cruz counties
Gasoline Shortage	OAPEC embargo on U.S. resulting in gasoline shortage.	1979	Statewide
Drought	1976 and 1977 were two of driest years in CA history, particularly in northern two-thirds of the state. Total damage $2,664,000,000.	1976-1977	Northern and Central California, incl. Solano County
Gasoline Shortage	OAPEC embargo on U.S. resulting in gasoline shortage.	1974	Most urbanized areas of the state, incl. Solano County
Winter Storms	Winter storms resulted in total damages of $300 million, 47 deaths and 161 injuries	1969	Most areas of the state, incl. Solano County
Fires	Widespread fires over 113,766 acres resulted in destruction of 41 buildings. Damage cost estimate not available.	1965	Marin, Napa, Placer, Solano, Sonoma Counties
Floods	Statewide floods in December resulted in 74 deaths and approximately $200 million in damages.	1950	Statewide
Floods	Statewide floods in November resulted in 9 deaths and total damages of $32,183,000.	1950	Statewide

Sources: Bay Area Multi-Jurisdictional Local Hazard Mitigation Plan 2010 Update, Appendix D; FEMA Disaster Declarations http://www.fema.gov/disasters

4.7 New and Planned Development

The City of Benicia is a built-out community with very little opportunity for new development. Following the Great Recession of 2007-2009, there has been very little new or infill development. Table 4.8 summarizes approved development proposals over the past 5 years, from 2011-2016.

Table 4.8: New and Planned Development

Year	Project	Description
2014	Northgate Church Expansion	Construction of major addition to Northgate Church north of Lake Herman Road, area prone to fire hazard.
2014	1035 West K Street Subdivision	Subdivision of land for four infill single-family lots
2015	10th and L Subdivision	Subdivision of land for five infill single-family lots
2016	6100 Goodyear Road	Tentative Parcel Map for vacant land in Industrial Park

The Northgate Church expansion did take place in an area prone to fire hazard; however, through environmental review of the church campus several mitigations were applied to address fire hazard, emergency response, and water supply. No modifications to this plan were required in order to address the Northgate site.

Presently, there is an application under consideration for transport of crude oil by rail to the Valero refinery, located east of East Second Street in the Industrial Park. The refinery is in an area subject to earthquake hazards. Valero maintains its own hazard planning and on-site fire department; additionally, this project has been evaluated with respect to the natural environment. No additional mitigations were developed for the Local Hazard Mitigation Plan with respect to the Valero Refinery's operations or deliveries.

A conceptual application has been received and preliminary public comments have been provided for development of a 527-acre site at the north end of the city (southwest corner of Lake Herman Road and East Second Street) with a mix of residential, commercial and industrial uses. Development of the site as proposed in concept would require an amendment to Benicia's General Plan and Zoning Map. Due to its proximity to open space north of Lake Herman Road, the area is subject to fire hazard. Like all of Benicia, it is also subject to ground shaking in the event of a strong earthquake, particularly along the Concord-Green Valley Fault. The applicant has not provided adequate detail at this time to determine the specific nature of hazards; however, the project will be evaluated pursuant to CEQA and development of a Specific Plan, and site-appropriate mitigations will be developed at that time. No additional mitigations were developed for the Local Hazard Mitigation Plan with respect to this conceptual application for site development.

5. Hazard Identification, Analysis, Assessment

ABAG has prepared an analysis of the significant natural hazards that impact the people, built environment, economy and society of the San Francisco Bay Area in its 2015 Report, *Bay Area Risk Landscape*. Following an introduction to the regional hazard risks, Benicia's local risk is further described in this section.

From *Risk Landscape:*

> *In the Bay Area, earthquakes are the hazards that have the highest combined likelihood to cause extensive, multi-jurisdictional damage. All of the Bay Area is exposed to earthquake hazard, and impacts can cause region-wide disruptions. Disruptive earthquakes also have high likelihood of occurring at any given time. With the combined likelihood and extent of earthquakes, much of the focus of this chapter is on earthquake hazards.*
>
> *Flooding, while less extensive in its impacts, is another major hazard that the Bay Area is exposed to, both along the bay and ocean shorelines and inland from rivers and streams. Localized flooding due to severe storms is fairly common, occurring, on average, once every other year. Temporary flooding and permanent inundation are also highly likely to become more extensive and severe in the future due to climate change. Flooding can cause significant impacts not just to the building stock but to sensitive infrastructure assets, so even localized flooding can affect the entire region.*
>
> *Other hazards may be less widespread or less frequent in the Bay Area, but can still cause significant local impacts and have cascading effects on the region. The most notable is wildfire, as the Oakland Hills Firestorm in 1991 still lives in the region's memory. Other hazards the Bay Area faces include landslides, drought, extreme heat, and dam and levee failure.*

An understanding of existing hazards and their potential impacts is critical to the development of this LHMP. Benicia is exposed to a number of natural hazards with the potential for varying intensity and impacts. This mitigation plan addresses the following natural hazards which were identified by ABAG as priority hazards; many are also addressed in the Benicia General Plan (1999):

- Earthquakes
- Tsunamis
- Landslides
- Floods
- Fire
- Drought

- Extreme Heat

The hazard identification, analysis and assessment includes a description of the type, location and extent of the natural hazards that can affect Benicia. This assessment includes the following:

- **Location:** the geographic areas that are expected to be affected by the hazard (shown on maps for each hazard type). In some cases, all of Benicia is susceptible to a particular hazard type, such as drought.
- **Extent:** the strength or magnitude of the hazard. This describes the characteristics of the hazard and can be described in a narrative manner, through standard measurements or depicted on a map.
- **Previous occurrences:** understanding the history of previous hazards helps to estimate the likelihood of future events and predict potential impacts. Where available, a description of previous occurrences will include the extent and impacts of such events, such as fatalities and injuries, building and infrastructure damages, and loss of services.
- **Probability of future events:** the likelihood of the hazard occurring in the future. Probability can be described using historical frequencies, general descriptions or seasonal characteristics.

The best available technical methods were used to assess hazard risk and potential impacts to the city. Benicia does not maintain a GIS database, therefore specific information about parcel and building characteristics was not available for the analysis. Information available from ABAG, including the Bay Area *Risk Landscape* (2015) and online mapping information from state agencies, was heavily referenced for development of this LHMP.

5.1 Hazard Characterization & Risk Assessment

5.1.1 Earthquake

Earthquakes happen when tectonic plates beneath the Earth's surface slip past each other along a fault[7]. Faults are the connection point where two tectonic plates align. The movement of tectonic plates is a regular and ongoing event; however, the friction caused by jagged edges of tectonic plates slipping against one another causes earthquakes, the sudden and rapid shaking of the ground[8]. The location on the earth's surface directly above plate movement is referred to as the "epicenter." The energy

[7] U.S. Geological Service "The Science of Earthquakes" http://earthquake.usgs.gov/learn/kids/eqscience.php
[8] Ibid

released by an earthquake travels in seismic waves from the epicenter. The waves shake buildings, structures and the earth and can be measured using a seismograph.[9]

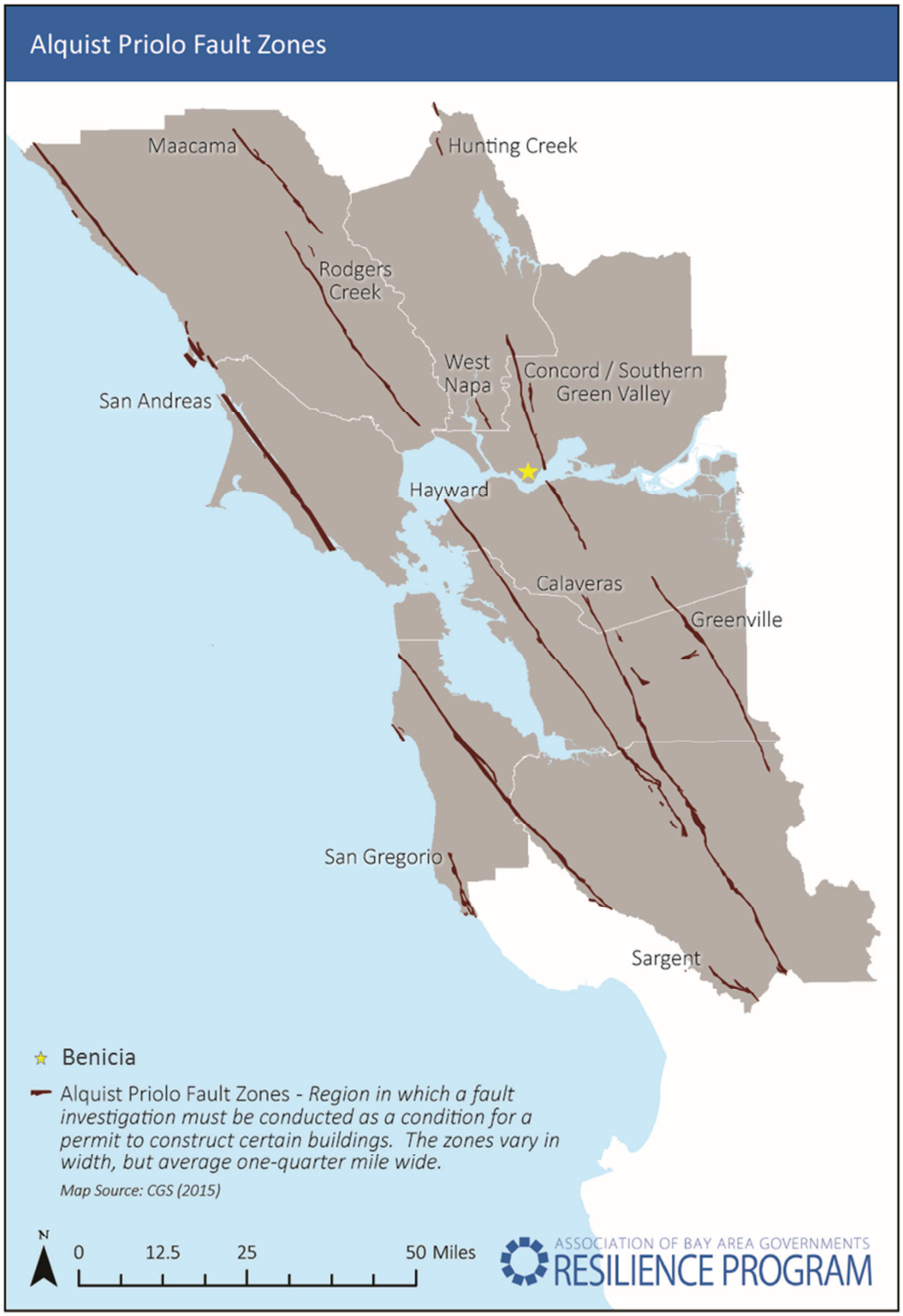
The magnitude of an earthquake can vary from one to the next depending on factors such as the length of the fault and the ease with which the tectonic plates slip past one another. Magnitude is measured using a seismograph and is typically expressed using the Richter Scale or the moment magnitude scale. The scale reflects the amplitude of seismic waves and increases logarithmically by factors of 10 along the scale. In other words, an earthquake with a magnitude of 5.0 has shaking amplitude approximately 10 times greater than one that measures 4.0. Major earthquakes can be preceded by foreshocks, smaller earthquakes that result from tectonic plate slippage along the fault line, and similarly are often followed by aftershocks, which can continue for months to years after a major earthquake.[10]

Earthquake intensity is measured as the strength of shaking produced by the earthquake at a certain location. Intensity is determined from effects on people, human structures, and the natural environment.

Major faults cross through all nine Bay Area counties. Every point within the Bay Area is within 30 miles of an active fault, and 97 of the 101 cities in the Bay Area are within ten miles of an active fault.[11] Figure 5.1 shows the location of active faults in the Bay Area that are mapped by the State of California under the Alquist-Priolo Act. In the Bay Area, scientists are most concerned about the San Andreas and Hayward faults, which are the most likely to produce large, regionally damaging earthquakes. Benicia is located closest to the West Napa and Concord/Southern Green Valley faults.

[9] Ibid
[10] U.S. Geological Service "The Science of Earthquakes" http://earthquake.usgs.gov/learn/kids/eqscience.php
[11] ABAG *Risk Landscape*, 2015

Figure 5.1: Alquist Priolo Fault Zones



The Benicia General Plan identifies the most significant geologic hazards as those associated with landslides, debris flows and ground shaking during earthquakes. The principal faults in Benicia's vicinity are capable of generating large earthquakes that could produce strong to violent ground shaking in Benicia. In the event of an earthquake, seismic risk to a structure will depend on the characteristics of the earthquake, the distance to the earthquake epicenter, the subsurface conditions underlying the structure and its immediate vicinity, and the characteristics of the structure.

Historic Occurrences

Bay Area Risk Landscape provides the following synopsis of historic earthquake occurrences in the Bay Area:

> *The Bay Area has experienced significant, well-documented earthquakes. In 1868, a significant earthquake occurred on the Hayward fault with an estimated magnitude of 6.8-7.0. The fault ruptured the surface of the earth for more than 20 miles and significant damage was experienced in Hayward and throughout Alameda County, and as far away as San Francisco, Santa Rosa, and Santa Cruz. The M7.8 1906 earthquake on the San Andreas Fault, centered just off the coast of San Francisco, devastated San Francisco and caused extensive damage in Oakland, San Jose, and Santa Rosa. More recently, the M6.9 1989 Loma Prieta earthquake caused severe damage in Santa Cruz and the surrounding mountains, where it was centered, as well as fatal damage 50 miles away in Oakland and San Francisco. Moderate earthquakes are much more common in the Bay Area; twenty-two have occurred in the last 178 years, averaging every eight years.*

In 2000 and 2014, earthquakes along the West Napa Fault were felt in Napa, Solano and Contra Costa Counties with damage estimated at $15-70 million in 2000 and $300 million to $1 billion in 2014. The 2014 Napa Earthquake had a magnitude of 6.0 and resulted in 1 death and approximately 200 injuries in the affected region. In Benicia, one building was damaged as well as various infrastructure including the 24" Cordelia Transmission Main which provides raw water supply to Benicia. The total cost of the transmission main repair was approximately $105,000.

Table 5.1: Past Earthquake Events in Benicia

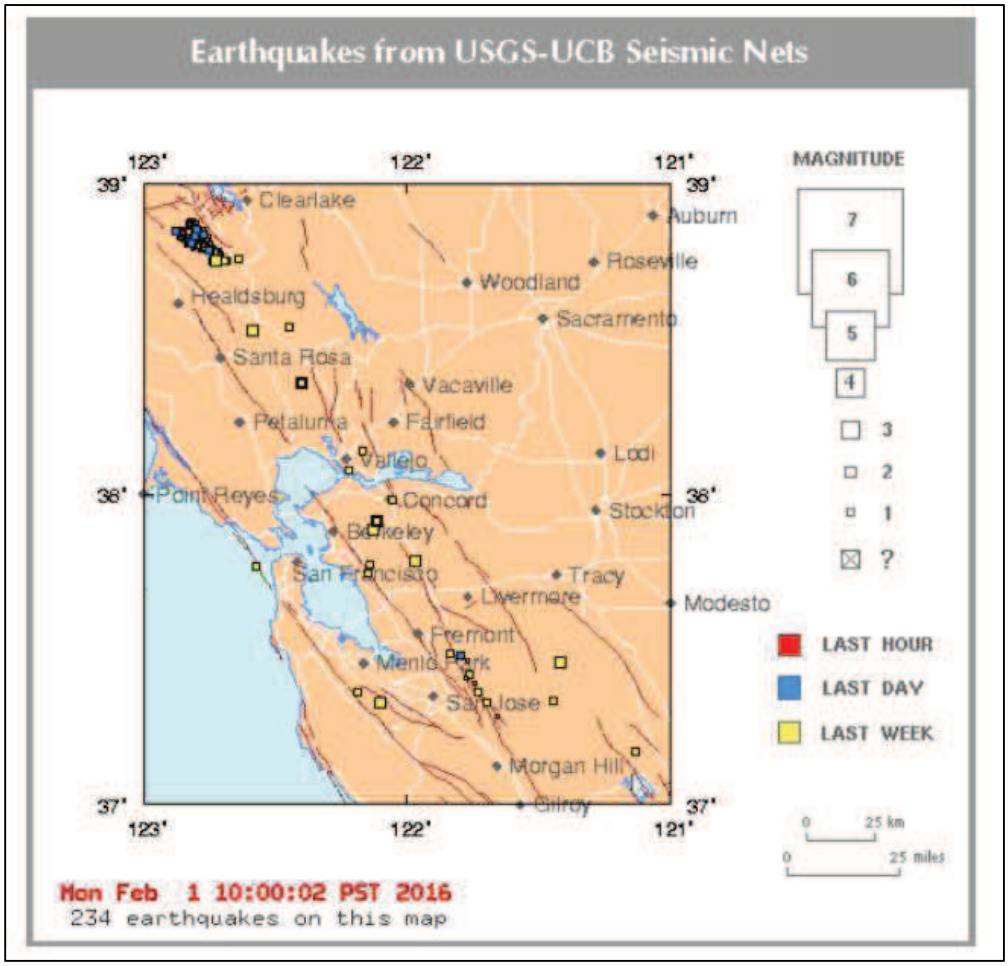
Event	Description	Year	Extent
Napa Earthquake	Magnitude 6.0 earthquake, south of Napa on the West Napa Fault. Total damage is estimated at $300 million to $1 billion. 1 person killed; 200 injured.	2014	Napa and Solano Counties
Napa Earthquake	Earthquake in Napa resulting in 41 injuries and appx. $15-70 million in damages.	2000	Napa, Solano, Sonoma, Contra Costa Counties
Loma Prieta Earthquake	Magnitude 7.1 earthquake. 23,408 homes and 3,530 businesses damaged; 1,018 homes and 366 businesses destroyed. Severe damage to infrastructure. 63 fatalities, 3,757 injuries, total damage of $5.9 billion.	1989	Bay Area incl. Solano County

Sources: Bay Area Multi-Jurisdictional Local Hazard Mitigation Plan 2010 Update, Appendix D; FEMA Disaster Declarations *http://www.fema.gov/disasters*

Probability of Future Earthquakes

Earthquakes are regular events in the Bay Area, and future earthquakes are certain to occur. Figure 5.2 below, produced by the Southern California Earthquake Data Center at the California Institute of Technology, shows earthquake activity for the week preceding February 1, 2016. Of the 234 events recorded, most were “micro earthquakes” below magnitude 2.0. Ten events exceeded magnitude 2.0, and none exceeded magnitude 3.0. These low intensity earthquakes are typically not perceptible to people and are unlikely to cause damage to life or property.

Figure 5.2: Greater Bay Area Earthquake Activity 1/25 to 2/1/2016



Source: Southern California Earthquake Data Center at the California Institute of Technology

While powerful earthquakes such as the 1906 earthquake or 1989 Loma Prieta earthquake are rare, the United States Geological Survey (USGS) estimates that there is a 72% chance of one or more earthquakes of at least 6.7 magnitude in the next 30 years in the Bay Area.[12]

In March 2015, the USGS released the Third Uniform California Earthquake Rupture Forecast, which estimates the future probability of large earthquakes[13]. The report includes an assessment of the likelihood of each fault segment producing M6.7, M7.0 and M8.0 and greater earthquakes. Table 5.2 summarizes the probabilities of future earthquakes in California.

[12] Field, E.H., and 2014 Working Group on California Earthquake Probabilities (2015). UCERF3: A new earthquake forecast for California's complex fault system: U.S. Geological Survey 2015–3009.
[13] Ibid

Table 5.2: Likelihood of earthquake ≥ M6.7 over the next 30 years

Earthquake Fault	Probability[1]
San Andreas (Mendocino Coast to San Benito County)	33%
Hayward	28%
Calaveras	24%
Hunting Creek, Berryessa, Green Valley, Concord	24%
Maacama	23%
Rodgers Creek	15%
San Gregorio	5%
Greenville	6%
Mt. Diablo	3%
West Napa	2%

Source: Third Uniform California Earthquake Rupture Forecast, 2015

The probabilities in Table 5.2 above suggest that current Benicia residents are likely to experience a severe earthquake during their lifetime. To provide a historical context, the 1994 Northridge earthquake, which occurred in the north-central San Fernando Valley region of Los Angeles and resulted in an economic loss of more than $20 billion, was a magnitude 6.7 earthquake.[14] This strength of earthquake in the Bay Area would produce strong shaking and ground failure throughout the region, causing significant damage in nearly every Bay Area city and county.

Ground Shaking

The most significant physical characteristic of a major earthquake is ground shaking, which is caused by the vibrations or waves generated by tectonic plates as they slide past one another. During an earthquake, the ground can shake for a few seconds or up to a minute or more.

The strength and duration of ground shaking is affected by many factors, including the types of soils underlying a city, and the distance, size, depth, and direction of the fault rupture that caused the quake. The strongest shaking is typically close to the fault where the earthquake occurs.[15]

Weak soils, such as bay mud and fill along the waterfront, may experience strong shaking in earthquakes, even from distant quakes. According to the USGS, as seismic waves pass from rock to soil, they slow down but get bigger. Hence a soft, loose soil

[14] Pacific Earthquake Engineering Research Center: Northridge Earthquake http://nisee.berkeley.edu/northridge/

[15] United States Geological Survey (2007).Putting Down Roots in Earthquake Country: Your Handbook for the San Francisco Bay Region. General Information Product 15. http://pubs.usgs.gov/gip/2005/15/gip-15.pdf

may shake more intensely than hard rock at the same distance from the same earthquake.

Bay Area Risk Landscape provides the following description:

> *Larger magnitude earthquakes generally cause a larger area of ground to shake, and to shake more intensely. As a result, one principal factor in determining anticipated levels of shaking hazard in any given location is the magnitude of expected earthquakes. The intensity of ground shaking felt in one area versus another, however, is based on the magnitude and other factors including distance to the fault; direction of rupture; and, the type of geologic materials at the site. For example, softer soils tend to amplify ground shaking, while more dense materials limit ground shaking impacts at the site surface.*
>
> *Ground shaking is commonly characterized using the Modified Mercalli Intensity (MMI) scale, which illustrates the intensity of ground shaking at a particular location by considering the effects on people, objects, and buildings. The MMI scale describes shaking intensity on a scale of 1-12. MMI values less than 5 don't typically cause significant damage; MMI values greater than 10 have not been recorded.*
>
> *As described, there are a number of different faults that contribute to the seismic hazard in the Bay Area. ABAG and the USGS worked collaboratively to characterize which fault contributes most to an areas seismic hazard.*

Table 5.3 MMI Intensity Table

Intensity	Building Contents	Masonry Buildings	Multi Family Wood-Frame Buildings	1&2 Story Wood-Frame Buildings
MMI 6	Some things thrown from shelves, pictures shifted, water thrown from pools.	Some walls and parapets of poorly constructed buildings crack.	Some drywall cracks.	Some chimneys are damaged, some drywall cracks. Some slab foundations, patios, and garage floors slightly crack.
MMI 7	Many things thrown from walls and shelves. Furniture is shifted.	Poorly constructed buildings are damaged and some well-constructed buildings crack. Cornices and unbraced parapets fall.	Plaster cracks, particularly at inside corners of buildings. Some soft-story buildings strain at the first floor level. Some partitions deform.	Many chimneys are broken and some collapse, damaging roofs, interiors, and porches. Weak foundations can be damaged.
MMI 8	Nearly everything thrown down from shelves, cabinets, and walls. Furniture overturned.	Poorly constructed buildings suffer partial or full collapse. Some well-constructed buildings are damaged. Unreinforced walls fall.	Soft-story buildings are displaced out of plumb and partially collapse. Loose partition walls are damaged and may fail. Some pipes break.	Houses shift if they are not bolted to the foundation, or are displaced and partially collapse if cripple walls are not braced. Structural elements such as beams, joists, and foundations are damaged. Some pipes break.
MMI 9	Only very well anchored contents remain in place.	Poorly constructed buildings collapse. Well-constructed buildings are heavily damaged. Retrofitted buildings damaged.	Soft-story buildings partially or completely collapse. Some well-constructed buildings are damaged.	Poorly constructed buildings are heavily damaged, some partially collapse. Some well-constructed buildings are damaged.
MMI 10	Only very well anchored contents remain in place.	Retrofitted buildings are heavily damaged, and some partially collapse.	Many well-constructed buildings are damaged	Well-constructed buildings are damaged.

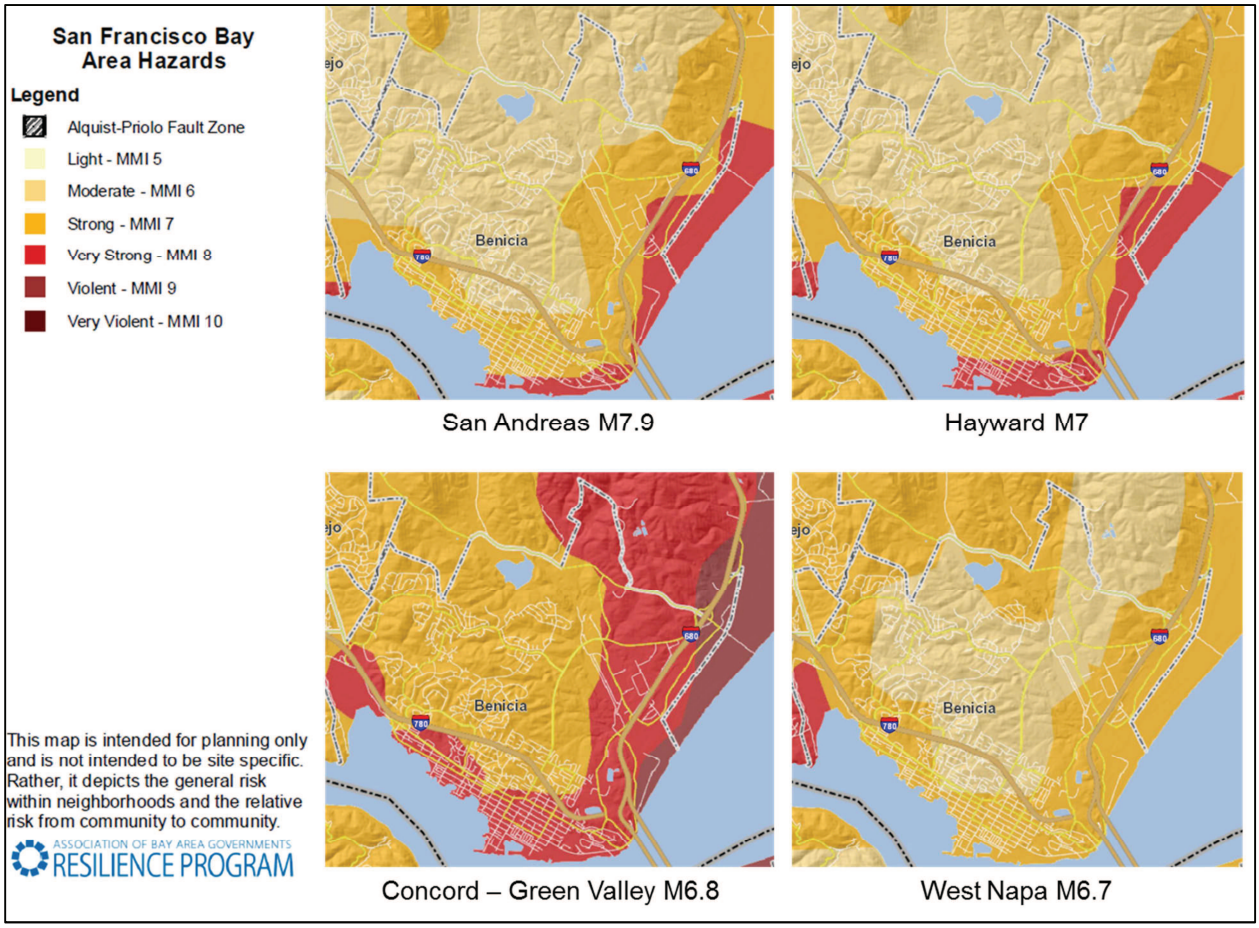
Source: ABAG, 2013 Modified Mercalli Intensity Scale; ABAG *Risk Landscape*, 2015

ABAG has prepared scenario maps to depict shaking intensity in the Bay Area for various faults, based upon plausible earthquake scenarios with a given magnitude on each individual fault. The maps depict possible levels of ground shaking based upon the earthquake magnitude, rupture location and direction, and soil conditions. Shaking scenarios for earthquakes along the San Andreas and Hayward faults (two faults with greatest damage and rupture potential within the Bay Area) as well as the Concord-Green Valley and West Napa faults (two faults located closes to Benicia) are shown in Table 5.4 and Figure 5.3 below.

Table 5.4: Shaking Scenarios in Benicia

Fault / Magnitude	Strong Shaking (MMI 7)	Very Strong/Violent Shaking (MMI 8-10)
San Andreas 7.9	Most areas south of I-780; Industrial Park; Benicia State Park.	Downtown south of E Street; downtown condominiums (Harbor Walk, Benicia Marina, Portside Village, Marina Condos); Wastewater Treatment Plan, Benicia Arsenal and Port, Industrial Park along Industrial Way and vicinity of Stone Road/Park Road; shoreline open space
Hayward 7.0	Benicia Arsenal north of I-680; Industrial Park west of I-780; residential and schools south of I-780; Robert Semple School and residential east of East Second Street.	Downtown south of F Street; Rancho Benicia and downtown condominiums (Harbor Walk, Benicia Marina, Portside Village, Marina Condos); portions of residential east of East 3rd Street and extending north to Military East; Wastewater Treatment Plan, Benicia Arsenal and Port, Industrial Park along Industrial Way and vicinity of Stone Road/Park Road; shoreline open space
Concord-Green Valley 6.8	All areas of Benicia not subject to very strong/violent shaking (Southampton and northernmost open space areas).	Downtown; most areas south of Military East and West; Solano Square commercial; residential and schools north of Military West and residential west of West 5th up to I-780 (portions of West Manor, Carquinez Square, Hamann Hills and Bayview subdivisions); residential east of E. Second Street extending north toward I-680 (portions of Francesca Terrace and Casa Hills subdivisions); Benicia Arsenal and Port; Industrial Park; shoreline open space.
West Napa 6.7	Downtown; all areas south of Military East and West; residential west of West 7th Street extending northward into portions of Southampton; residential north of I-780 and east of East 5th Street; Benicia Arsenal and Port; Industrial Park; shoreline open space.	Benicia State Park

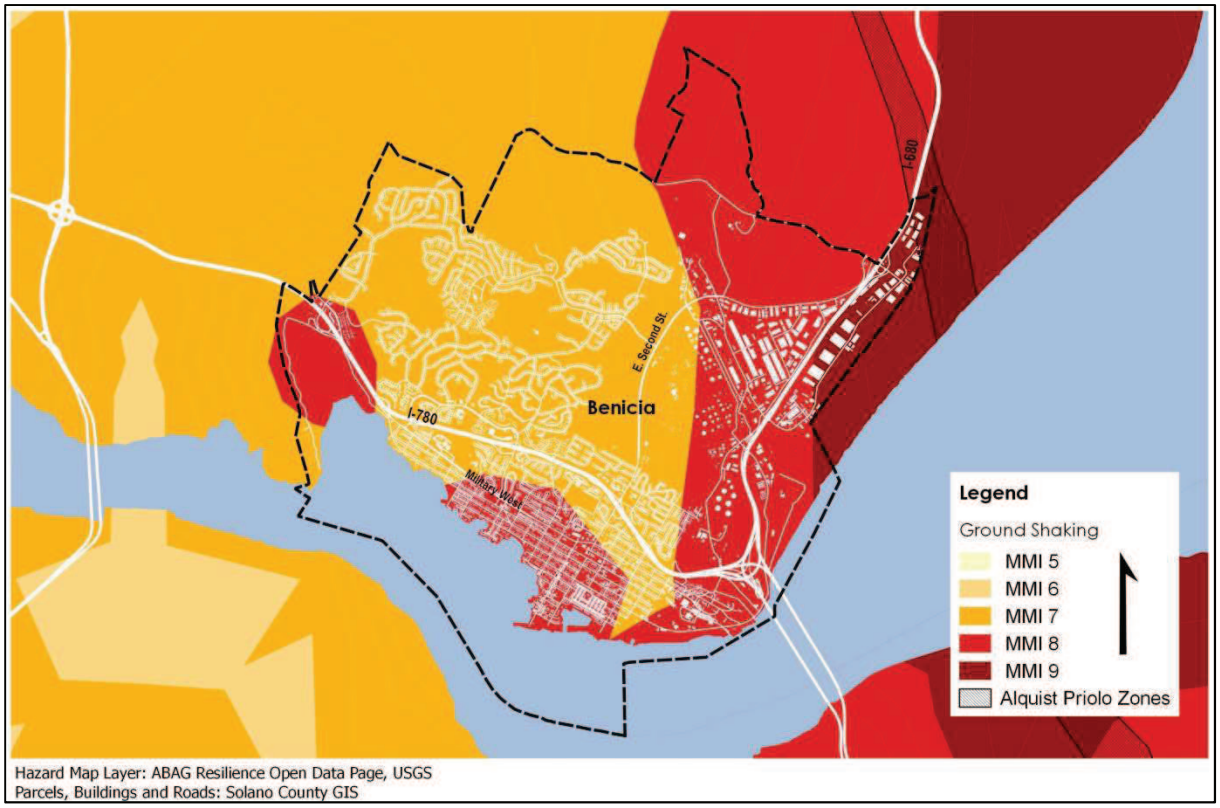
Figure 5.3: Shaking Scenarios



As the ABAG analysis shows, Benicia's greatest community-wide risk for strong to violent shaking would be associated with a large earthquake along the Concord-Green Valley fault. The likelihood of this type of event in the next 30 years is approximately 24% based upon USGS data. A magnitude 6.8 earthquake on the Concord-Green Valley Fault would subject about 1/3 of the community (3,491 parcels) to very strong or violent shaking (MMI 8-9) and 2/3 of the community (7,829 parcels) to strong shaking (MMI 7). Generally, the areas at risk for very strong or violent shaking are those with the oldest structural age and historic value, highest residential density, and greatest economic impact (Downtown commercial and residential areas, Arsenal, most areas of the Benicia Industrial Park).

Areas of Benicia that are most susceptible to amplification during ground shaking are underlain by soft sediments such as bay mud. In several areas along the Benicia waterfront, fill and buildings have been placed over bay mud. These areas are likely to experience substantially stronger ground shaking than areas underlain by bedrock.

Figure 5.4: Benicia Shaking in Concord-Green Valley Earthquake M6.8



Although the magnitude 6.0 West Napa earthquake in 2014 resulted in property damage in the downtown areas of Benicia (one compromised downtown commercial structure) and damage to a critical water transmission line, the intensity of shaking was milder than would be expected of comparable events along the San Andreas, Hayward, or Concord-Green Valley faults.

The State of California is required by the Alquist-Priolo Act of 1972 and the Seismic Hazards Mapping Act of 1990 to establish and map Seismic Hazard Planning Zones, depicting areas within the state with the potential to experience ground failure resulting from liquefaction, surface rupture, or landslide.[16] Maps of surface rupture or earthquake-related hazards are not available for Benicia from the California Geological Survey. The Benicia General Plan (1999) notes:

> *The Green Valley fault is the only active fault known in the Planning Area. Fault rupture is likely to occur along the Green Valley fault as a result of an earthquake there. The risk of fault rupture elsewhere in the Planning Area is very low,*

[16] California Geological Survey Regulatory Maps
http://www.quake.ca.gov/gmaps/WH/regulatorymaps.htm

Liquefaction hazard is assessed based upon up-to-date available information from ABAG and USGS. Landslides associated with rainfall events are discussed further in the LHMP.

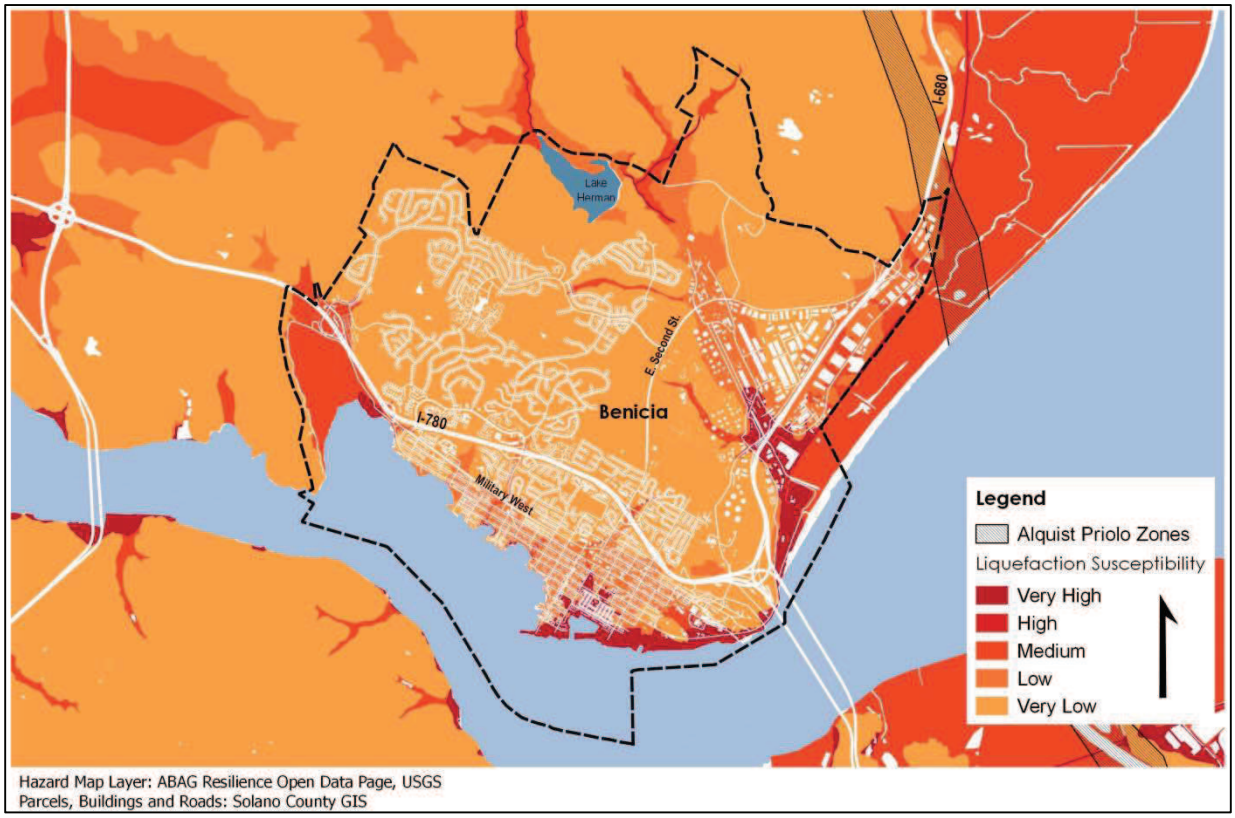
Liquefaction

Liquefaction is a type of ground failure that occurs when soil at or near the ground surface loses its strength in response to ground shaking. Liquefaction is often followed by sudden local settling or slope failure. While liquefaction often causes severe damage to structures, structural collapse is uncommon. *Bay Area Risk Landscape* provides the following description:

> *Soil that is loose, sandy, silty, or saturated with water can result in soil liquefaction if it is shaken intensely for an extended period. When ground liquefies in an earthquake, it behaves like a liquid and may sink, spread, or erupt in sand boils. This can cause pipes to break, roads and airport runways to buckle, and building foundations to be damaged. Liquefaction can only occur under certain circumstances:*
>
> - ***Loose Soils*** *The soils must be loose, such as uncompacted or unconsolidated sand and silt without much clay. This happens most often in the Bay Area along the Bay shoreline, near creeks or other waterways, on dry creek beds, and in areas of man-made fill, such as the Marina District in San Francisco or parts of Alameda.*
> - ***Soggy Soils*** *The sand and silt must be soggy and saturated with water due to a high water table.*
> - ***Ground Shaking*** *The ground must be shaken long and hard enough by the earthquake to trigger liquefaction.*
>
> *Liquefaction may not necessarily occur even if all three conditions are present. Additionally, if liquefaction does occur, the ground may not move enough to have significant impact on the built environment. As with ground shaking, several types of maps depict liquefaction potential.*

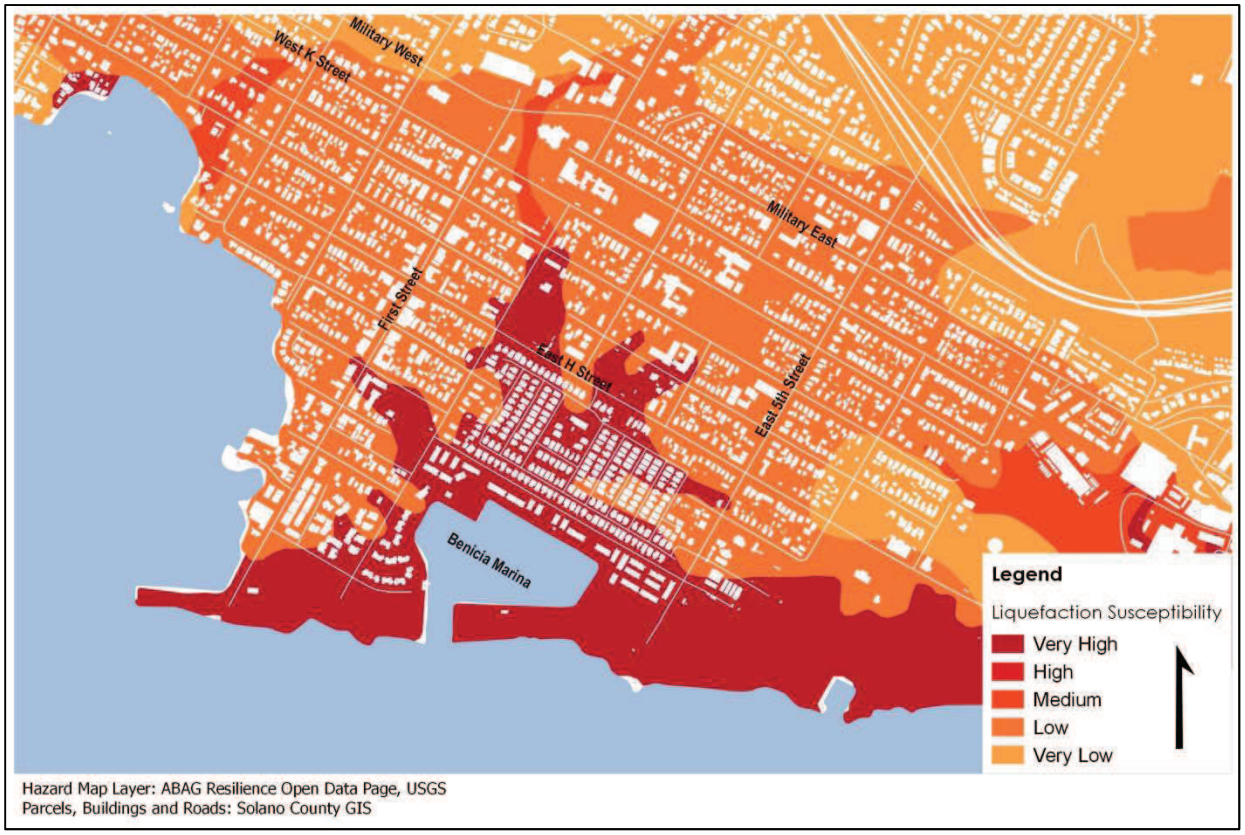
The risk of liquefaction can be determined based upon soil types that are prone to intense shaking. The Benicia General Plan identifies the potential for liquefaction to be greatest in areas underlain by bay mud or alluvium. Figure 5.5 depicts ABAG's assessment of liquefaction potential in Benicia based upon soil maps and USGS earthquake-scenario maps.

Figure 5.5: Liquefaction Susceptibility



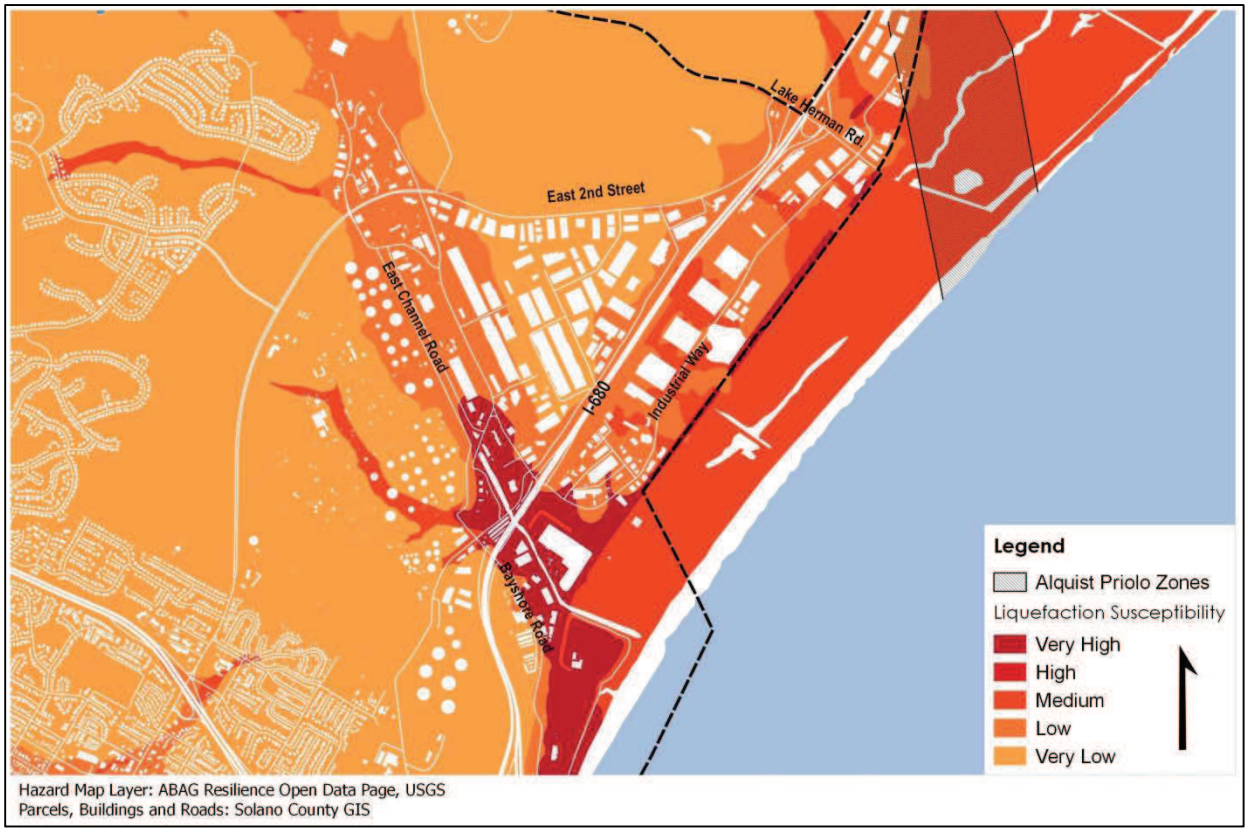
Figures 5.6 and 5.7 below show the two areas of Benicia most susceptible to high or very high liquefaction. In the downtown area, liquefaction potential is greatest along the shoreline areas east of First Street, including residential condominium communities, Rancho Benicia mobile home park and the Wastewater Treatment Plant.

Figure 5.6: Liquefaction Susceptibility in Downtown



In the Industrial Park, liquefaction susceptibility is greatest along the Suisun Bay and in the vicinity of Bayshore Road, as well as areas along East Channel Road which correspond to the Sulphur Springs Creek floodplain.

Figure 5.7: Liquefaction Susceptibility in Industrial Park



The Benicia General Plan states that while liquefaction often causes severe damage to structures, structural collapse is uncommon. It identifies the risk to public safety as relatively low and notes that structures can be protected from liquefaction through the use of special foundations.

Building Types Susceptible to Earthquake Damage

The building types in Benicia that are most susceptible to earthquake damage are older structures (built before 1950), unreinforced masonry buildings (URM's) and soft-story buildings.

Older wood-frame structures may experience structural damage as a result of poorly designed foundations or a lack of structural bonding between the foundation and the building. Additionally, some wood structures in Benicia lack a building foundation altogether.

URM's are those buildings constructed of brick, cinder block, or stone without steel reinforcement and were common in California in the early 20th century. URM's are prone to collapse during large earthquakes but can be reinforced for seismic safety by the addition of structural reinforcements.

Soft-story buildings are multi-story buildings with one or more floors that have openings (windows, wide doors, etc) where a shear wall would normally be required for stability. A typical example of a soft-story building is a building with open parking or commercial space on the first floor and housing or offices on upper floors. In an earthquake, ground shaking can cause these structures to sway and sometimes collapse.

"Tilt-up" buildings are typically commercial or industrial buildings. These structures are constructed of pre-manufactured concrete walls that are delivered to a site, tilted into vertical positions, and connected to each other and to the roof. Weak connections between the walls and roofs can result in building collapse during ground shaking if the walls pull away from the roof. Tilt-up buildings built before the mid 1970's are of particular concern.

An inventory of URM's was completed in the early 1990's and Chapter 15.60 of the Benicia Municipal Code establishes a Seismic Hazards Identification Program. The City does not presently maintain a parcel-based inventory of unreinforced wood-frame structures, URM's, soft-story buildings or tilt-up buildings.

5.1.2 Tsunami & Seiches

The National Oceanic and Atmospheric Administration (NOAA) defines tsunamis as follows[17]:

> ***A tsunami is a series of ocean waves*** *generated by sudden displacements in the sea floor, landslides, or volcanic activity. In the deep ocean, the tsunami wave may only be a few inches high. The tsunami wave may come gently ashore or may increase in height to become a fast moving wall of turbulent water several meters high.*

ABAG's *Risk Landscape* describes tsunami risk:

> *Tsunamis can result from off-shore earthquakes within the Bay Area or from distant events. It is most common for tsunamis to be generated by offshore subduction faults such as those in Washington, Alaska, Japan, and South America. Tsunami waves generated at those far-off sites can travel across the ocean and can reach the California coast with several hours of warning time. Local tsunamis can also be generated from offshore strike-slip faults. Because of their close proximity, we would have little warning time. However, the Bay Area faults that pass through portions of the Pacific coastline or under portions of the Bay are not likely to produce significant tsunamis because they move side to side, rather than up and down, which is the displacement needed to create significant tsunamis. They may have slight vertical displacements, or could cause small underwater landslides, but overall there is a*

[17] National Oceanic and Atmospheric Administration: Tsunami http://www.tsunami.noaa.gov/

minimal risk of any significant tsunami occurring in the Bay Area from a local fault. The greatest risk to the Bay Area is from tsunamis generated by earthquakes elsewhere in the Pacific.

Seiches are similar to tsunamis, except that they occur within an enclosed body of water such as a lake or harbor. NOAA defines a seiche as a standing wave oscillating in a body of water and describes it as follows[18]:

Seiches are typically caused when strong winds and rapid changes in atmospheric pressure push water from one end of a body of water to the other. When the wind stops, the water rebounds to the other side of the enclosed area. The water then continues to oscillate back and forth for hours or even days. In a similar fashion, earthquakes, tsunamis, or severe storm fronts may also cause seiches along ocean shelves and ocean harbors.

Historic Occurrences

No state or federal emergencies have been declared in Solano County due to tsunamis or seiches, though high waves have been reported in Half Moon Bay, San Francisco, Marin County, Sonoma County, Santa Cruz and Crescent City following earthquakes off the coast of Chile, Japan and Alaska.

In 2011 a tsunami off the coast of Japan, which resulted from a M9.0 earthquake, was alleged to cause minor damage in Benicia. The Benicia Marina reported that docks were damaged as a result of wave action.

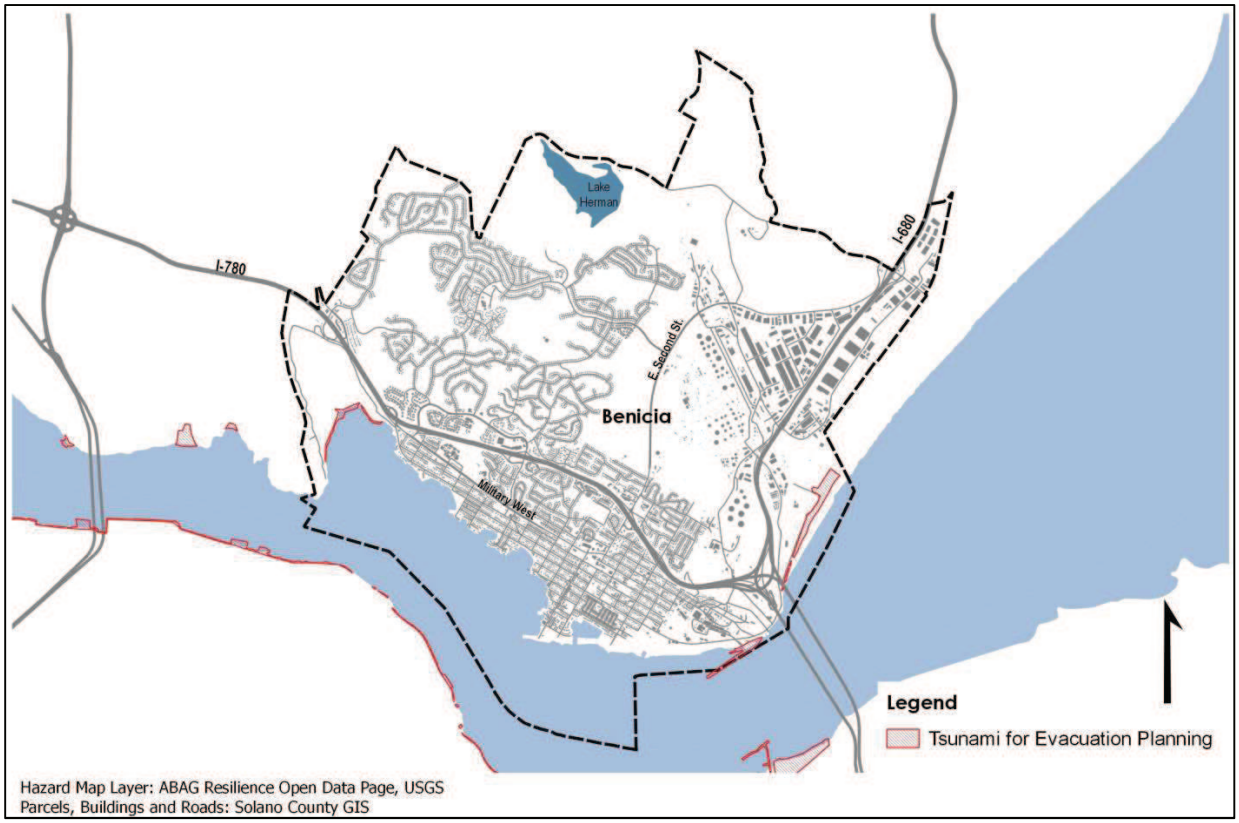
Probability of Future Tsunami's and Seiches

Based upon analysis by the USGS and U.S. Department of the Interior in 2013, Benicia has a low risk of inundation due to tsunami following a M9.1 earthquake off the Alaskan coast, a scenario that is likely to occur once in a 100-year period[19]. Areas most likely to experience inundation (projected at 2 to 7 feet) are those low-lying shoreline areas in the Benicia State Park, the eastern shoreline adjoining Suisun Bay, and the Port of Benicia.

[18] National Oceanic and Atmospheric Administration: What is a Seiche? http://oceanservice.noaa.gov/facts/seiche.html

[19] ABAG *Risk Landscape*, 2015

Figure 5.8: Scenario Tsunami from M9.1 Alaska Earthquake



Because tsunami's and seiches are a hazard of low to minimal risk, they are not a priority for mitigation strategies in this plan.

5.1.3 Landslides

Landslides can cause damage to buildings, roadways or other facilities located in the landslide area. The Benicia General Plan characterizes landslides as significant geologic hazards in the city. Landslides are relatively rare in the developed areas of Benicia, but have occurred in the hilly, undeveloped areas.

ABAG's *Risk Landscape* describes landslide risk:

> *In the Bay Area landslides typically occur as a result of either earthquakes (earthquake-induced landslides), or during heavy and sustained rainfall events. A given area can be at risk for both earthquake-induced landslides as well as landslides caused by rain-saturated soils but the variables that contribute to each landslide risk are different. Typically an earthquake-induced landslide occurs when seismic energy at the top of a slope gets concentrated and breaks off shallow portions of rock. In rainfall-induced landslides, the slide can begin much deeper in the slope, in very-saturated layers of soil.*

For both types of landslides, there are not currently methods available to estimate the probabilities of future landslides at a local, or jurisdictional, scale. Steep slopes and varied types of underlying soils can influence the likelihood of landslides. Additionally, surface and subsurface drainage patterns also affect landslide hazard, and vegetation removal can increase landslide likelihood. Future landslides are most likely to occur within and around the places where they have previously occurred.[20]

Debris flows are fast-moving, highly fluid landslides that originate where hillside swales filled with unstable colluvium on steep slopes become saturated during a period of very heavy rainfall. Once the colluvium slides a short distance, the soil loses its structure, liquefies, and moves rapidly down the swale or ravine, coming to rest in the valley bottom.[21] Areas of debris flow are located primarily in the hilly region northeast of Lake Herman.

ABAG *Risk Landscape* identifies the following conditions that are associated with landslides.

Winter rain storms can impact hillsides by triggering fast-moving debris flows, or mudslides, and other slower-moving landslides. In general, landslides are most likely during periods of higher than average rainfall or El Nino winter storms. In addition, the ground must be saturated prior to the onset of a major storm for significant landsliding to occur. But there is currently no method to estimate the scale of individual landslides in terms of size or extent based on these maps, or to assign specific probabilities to these areas in terms of the likelihood of future landslides. The USGS developed a region-wide rainfall-induced landslide hazard map…that shows areas where rainfall-induced landslides have occurred in the past, as landslides are most likely to occur in and around areas where they have previously occurred.[22]

In the 1999 Benicia General Plan, the entire city was evaluated for potential landslide. As noted previously, maps of earthquake-induced landslide risk from the California Geological Survey are not presently available for Benicia; therefore, only rainfall-induced landslides are evaluated in this plan. The hazard information presented in this LHMP utilizes the best available information available from ABAG's Resilience Program.

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[20] United States Geological Survey (1999) Land Subsidence in the United States. Circular 1182 U.S. Department of the Interior, U.S. Geological Survey http://pubs.usgs.gov/circ/circ1182/pdf/05SantaClaraValley.pdf

[21] Benicia General Plan (1999)

[22] San Francisco Bay Landslide Mapping Team (1997) San Francisco Bay Region, California, Landslide Folio, California, U.S. Department of the Interior, U.S. Geological Survey, Open-File Report 97-745, http://pubs.usgs.gov/of/1997/of97-745/

Historic Occurrences

ABAG's *Risk Landscape* notes the following historic occurrences of landslides:

> *Flooding and landslides associated with severe storms have been among the most common disasters in the Bay Area during the period from 1950 to 2009. Extensive landslides have occurred in 24 times since 1950, approximately once every three years.*[23]
>
> *Losses from landslides are typically lower than those from associated flooding. However, in the El Nino storms of early 1998, USGS documented approximately $150 million in losses due to approximately 300 landslides of varying sizes that occurred in the Bay Area and Santa Cruz County.*[24] *The greatest number of landslides in the region since 1950 occurred in 1982, when a large storm event preceded by a wet winter triggered over 18,000 landslides in the region, which resulted in 33 deaths and 481 injuries.*[25]

Table 5.5: Declared Disasters for Past Landslide Events in Solano County

Event	Description	Year	Extent
Winter Storms	Severe storms, flooding, mudslides, landslides resulting in appx. $100 million damage, two deaths from falling trees, damage to businesses and homes.	2005-2006	Bay Area incl. Solano County
El Nino	Severe flooding, landslides, flash floods. More than 11,000 evacuated, 17 deaths	1998	Most areas of the state, incl. Solano County
Winter Storms	Severe storms, flooding, landslides, mud flows. Small stream flooding. Total damages of $741.4 million, 11 deaths.	1995	Most areas of the state, incl. Solano County
Winter Storms	Rains, winds, flooding and mud slides. 13 deaths, 67 injuries, total damage of $407,538,904 (public and private) including 1,382 homes and 185 businesses destroyed.	1986	Northern California, incl. Solano County
Storms	Rain, winds, mud slides, flooding. Total damage to public, private and agricultural improvements total $316,640,817.	1980	Stanislaus, Monterey, Solano, Santa Cruz counties

Sources: Bay Area Multi-Jurisdictional Local Hazard Mitigation Plan 2010 Update, Appendix D; FEMA Disaster Declarations *http://www.fema.gov/disasters*

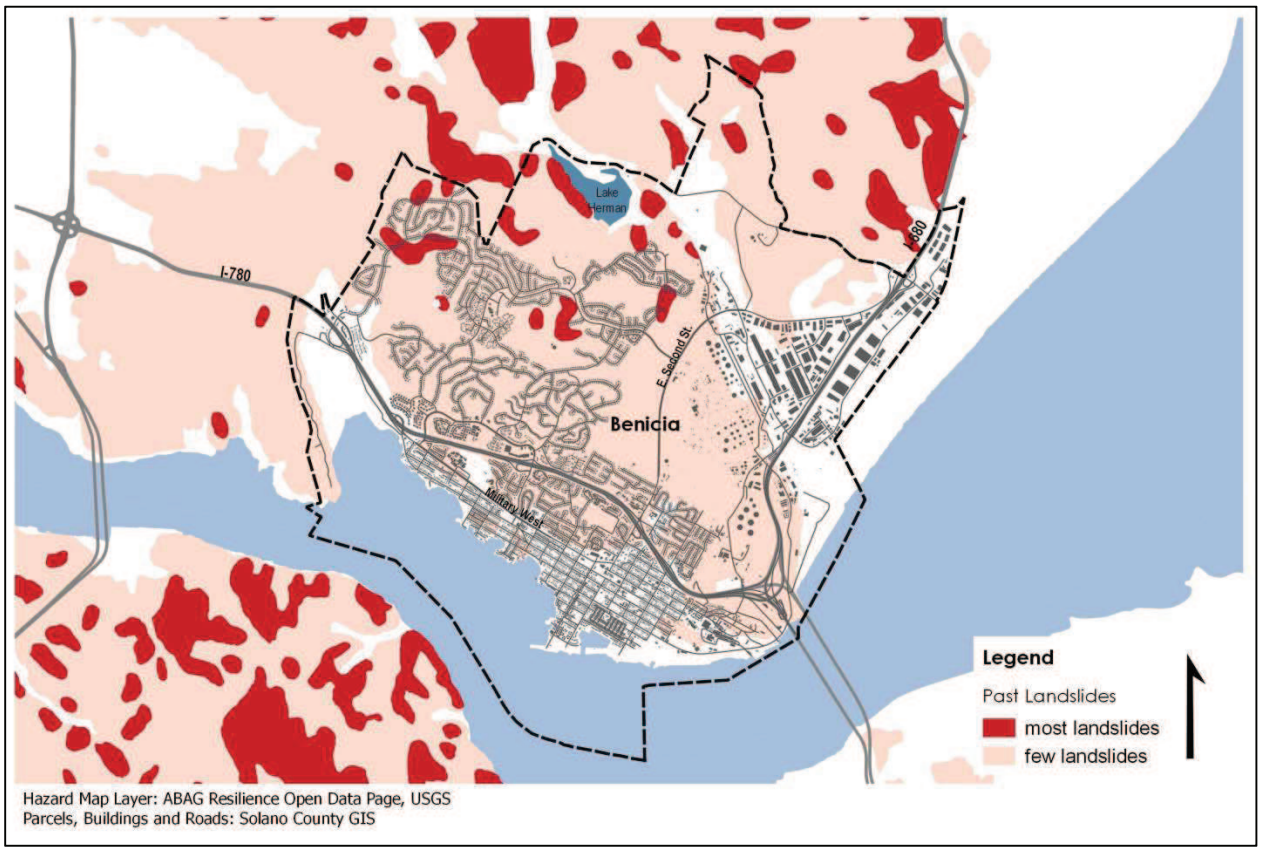
[23] State of California Multi-Hazard Mitigation Plan, California Governor's Office of Emergency Services, http://hazardmitigation.calema.ca.gov/docs/SHMP_Final_2013.pdf

[24] Godt, J.W., ed., (1999) Maps showing locations of damaging landslides caused by El Niño rainstorms, winter season 1997-98, San Francisco Bay region, California, Pamphlet to accompany Miscellaneous Field Studies Maps MF-2325-A-J, http://pubs.usgs.gov/mf/1999/mf-2325/

[25] Ellen, S.D., and Wieczorek, G.F., eds., (1998). Landslides, Floods, and Marine Effects of the Storm of January 3-5, 1982, in the San Francisco Bay Region, California, U.S. Geological Survey Professional Paper 1434 Version 1.0, http://pubs.usgs.gov/pp/1988/1434/

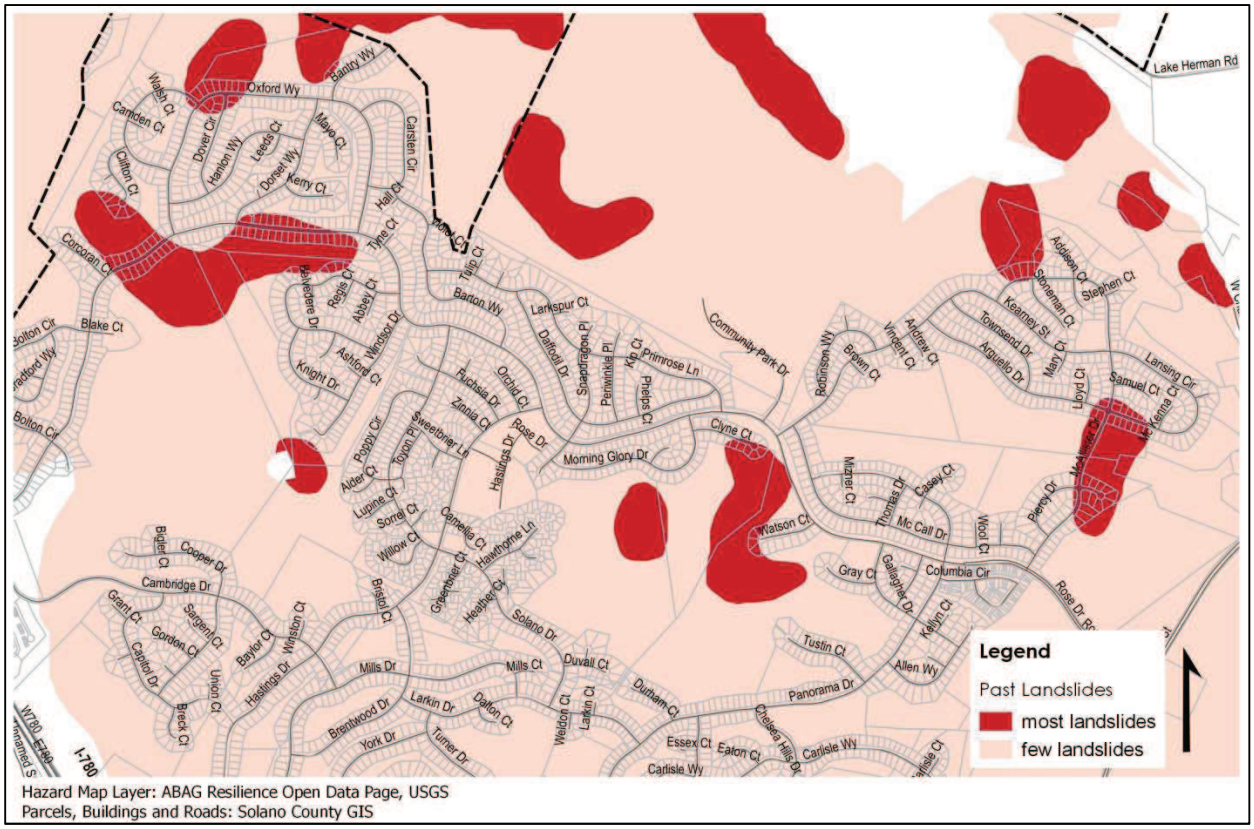
Based upon available information, landslides have not resulted in deaths or injuries in the City of Benicia. No estimates are available to indicate whether there have been any disaster-related losses from landslides in Benicia. Figure 5.9 shows areas of Benicia where landslides have occurred in the past based upon information compiled by USGS. The designation “most landslides” refers to mapped landslides and an envelope around the previous slide area; “few landslides” refers to areas with, at most, scattered small landslides. This map does not depict evidence of recent movement nor does it identify landslides that are currently active. Despite that, it remains the best available predictor of where movement of slides and earth flows might occur in the future.

Figure 5.9: Rainfall-Induced Landslides



While certain hillside areas in the Southampton neighborhood and open space near Lake Herman show evidence of past landslide activity, Benicia for the most part remains an area with a history of few landslides. Figure 5.10 below shows the areas of highest past landslide activity greater detail.

Figure 5.10: Southampton Area Rainfall-Induced Landslides



Probability of Future Occurrences

Landslides can result from earthquakes or rainfall events. While climate change is not expected to impact seismic risk, it can affect weather patterns including the duration, intensity or severity of seasonal storms. According to ABAG's *Risk Landscape*, higher intensity rainfall events or extreme wet weather seasons can increase the chance of rainfall-induced landslides. Additionally, landslide risk can increase when fire or vegetation removal destabilize hillsides by reducing attenuation of surface water flow and increasing erosion. Proper vegetation management is essential to reduce wildfire risk and maintain slope stability in the upland areas of Benicia.

The General Plan notes that risk associated with debris flows can be reduced by avoiding placement of structures and facilities in debris flow paths or stabilizing debris flow source areas through retaining walls, regrading, sub-drainage, debris basins, or diversion of debris away from structures.

5.1.4 Floods

Flooding is the most common natural disaster in the United States. Flooding that causes damage to land and property in Benicia typically occurs following severe rainstorms coincident with near-saturated soil conditions or high tides, or both. ABAG *Risk Landscape* describes flooding as follows:

Flooding is a temporary condition that causes the partial or complete inundation of land that is normally dry. Flooding occurs when streams, rivers, lakes, reservoirs, or coastal water bodies are abnormally high and overflow into adjacent low-lying areas, areas at risk of recurring floods known as floodplains.

Coastal flooding is generally associated with Pacific Ocean storms from November through February when high tides coincide with strong winds both on the outer coast and within the Bay.

Riverine flooding, also known as overbank flooding, can occur if there is excessive rainfall especially in conjunction with high tides and strong winds. Riverine floodplains range from narrow, confined channels in the steep valleys of mountainous and hilly regions to wide, flat areas in plains and coastal regions. The potential for flooding of a floodplain is a function of the size and topography of the contributing watershed, the regional and local climate, and land use characteristics. Flooding in steep, mountainous areas is usually confined, occurs with less warning time, and has a short duration. Larger rivers typically have longer, more predictable flooding sequences and broad floodplains. The lower portion of coastal rivers are more likely to flood during high tides with backwater conditions that lead to overbank flooding.

Localized, or nuisance, flooding can occur in areas that typically do not flood during locally heavy precipitation events, especially if ground water levels are high during extremely wet seasons or if stormwater storage or conveyance facilities are inadequate. Localized flooding tends to occur in flat, urbanized areas that are highly impermeable and can result in inundation of basements, low lying roads, and parking lots from street drainage.

The vast majority of the Project Area consists of low-lying land without any appreciable grade. This constrains the natural drainage systems, some of which have been interrupted by development or eliminated due to Bay fill, and leads to inland back-up of rainfall runoff.

FEMA maintains flood maps, known as the Flood Insurance Rate Map (FIRM) that identifies the areas most at risk for flooding. Special Flood Hazard Areas (SFHAs) are geographic areas that the FEMA has defined according to varying levels of flood risk. The SFHAs, also referred to as flood zones, are depicted on a community's FIRM. Each zone reflects the risk of flooding:

Moderate- to low-risk areas are identified on the FIRMs as:

Shaded Zone X. These properties are in moderate- to low-risk areas. The risk is reduced in these areas but not eliminated.

Zone X. These properties are in an area of overall lower risk.

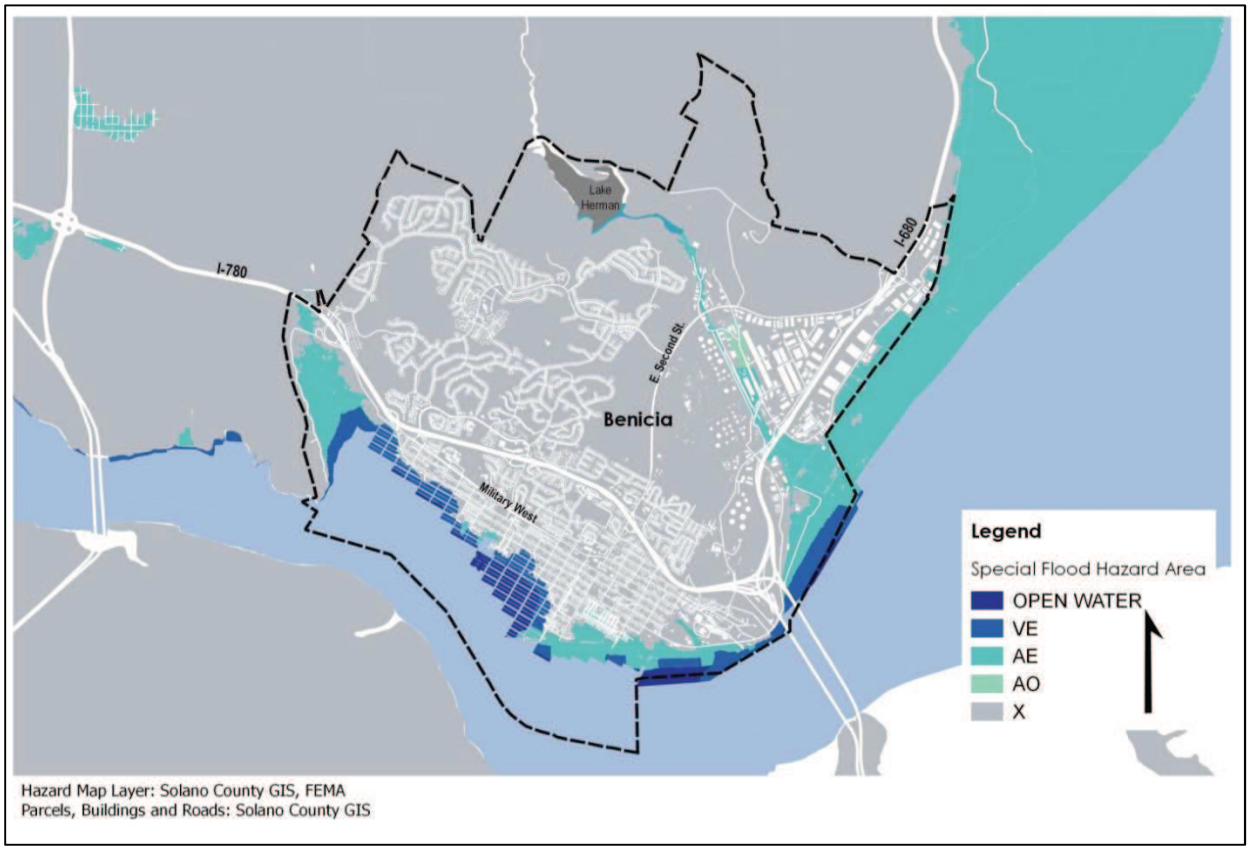
High-risk areas are identified on the FIRMs as:

Zones AE, A, AH, AR, A99, or AO. These properties have at least a 26 percent chance of flooding over the life of a 30-year mortgage.

Zones VE or V. These properties also have at least a 26 percent chance of flooding over the life of a 30-year mortgage. In addition, these properties face hazards associated with coastal storm waves and storm surge.

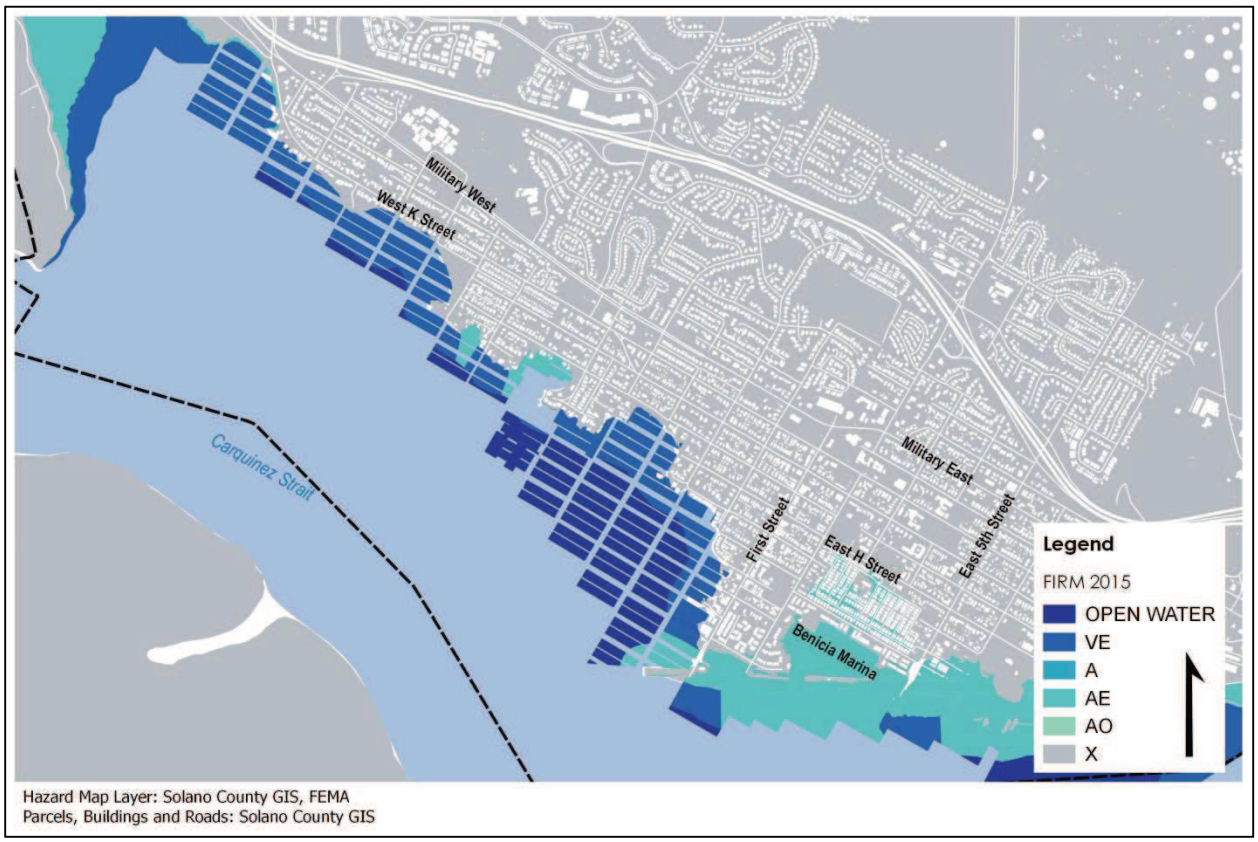
The Federal Emergency Management Agency (FEMA) is currently in the process of completing the San Francisco Bay Area Coastal Study, which is the most comprehensive coastal hazard analysis of San Francisco Bay coastal communities to date. Benicia is a coastal community due to its location adjacent to the Carquinez Strait. The updated maps, which were presented for public comment in 2015, will become effective in summer, 2016. While the maps provide improved accuracy about flood risks based upon past data and modeling for the 1% annual chance of flood (also referred to as the 100-year flood), they do not project or account for future impacts associated with climate change and sea level rise. Figure 5.11 depicts flood hazard areas in Benicia as shown in the 2015 FIRM (will become effective in August, 2016).

Figure 5.11: Benicia Special Flood Hazard Areas



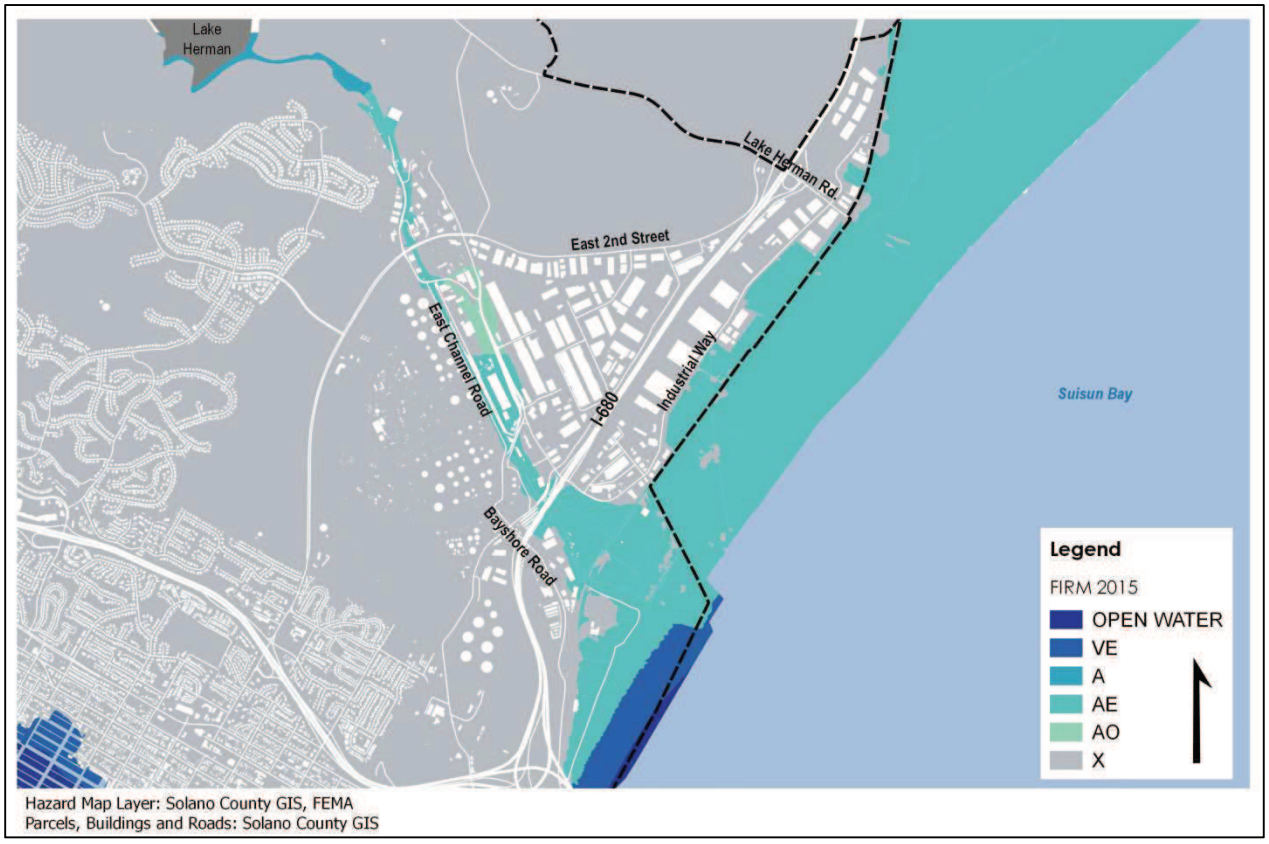
Excluding submerged parcels in the Carquinez Strait designated Open Water, a total of 463 properties citywide fall partially or entirely within a flood zone. Of these, 175 parcels are residential; 159 parcels are industrial; 64 parcels are public/semi-public and 20 parcels are commercial. The residential and commercial parcels lie primarily along the shoreline and downtown, with areas west of First Street designated in SFHA's that present risk associated with coastal storm waves, storm surge risk and inundation (V and VE) and areas east of First Street designated in SFHA's that are at risk for inundation.

Figure 5.12: Downtown Special Flood Hazard Areas



Public and semi-public properties include parcels owned for parks and open space along the shoreline, including the Benicia State Park. Areas within the Benicia Arsenal, Port of Benicia and Benicia Industrial Park are also designated in SFHA's. Flood hazard areas in the Benicia Industrial Park follow the historic floodplain of Sulphur Springs Creek inland toward Lake Herman.

Figure 5.13: Industrial Park Special Flood Hazard Areas



The factors that contribute to flooding either alone in combination can the affect frequency and severity of flood events[26]:

Coastal Flooding (bay)

- Astronomical tides
- Storm surge
- Wind waves
- El Nino events
- Sea level rise

Riverine Flooding (streams & creeks)

- Rainfall intensity & duration
- Antecedent moisture conditions
- Watershed conditions (steepness of terrain, soil types, vegetation, development density)
- Attenuating features in the watershed (wetlands, lakes, dams, etc.)
- Flood control features (levees & flood control channels)
- Velocity of water flow
- Availability of sediment for transport, erosion of streambed & banks

National Flood Insurance Program

FEMA maintains the FIRMs and administers the National Flood Insurance Program (NFIP) in partnership with private insurance companies to offer flood insurance to

[26] ABAG *Risk Landscape*, 2015

homeowners, renters, and business owners. As a participating agency in the National Flood Insurance Program, the City of Benicia is responsible for the distribution of public information and administration of the local Floodplain Ordinance, contained in Chapters 15.40 through 15.48 of the Benicia Municipal Code. Property owners within a SFHA who hold a mortgage from a federally regulated or insured lender, must carry flood insurance. According to FEMA, everyone is at risk for flooding; therefore, all property owners are encouraged to carry flood insurance, even if not required.

Stormwater Management

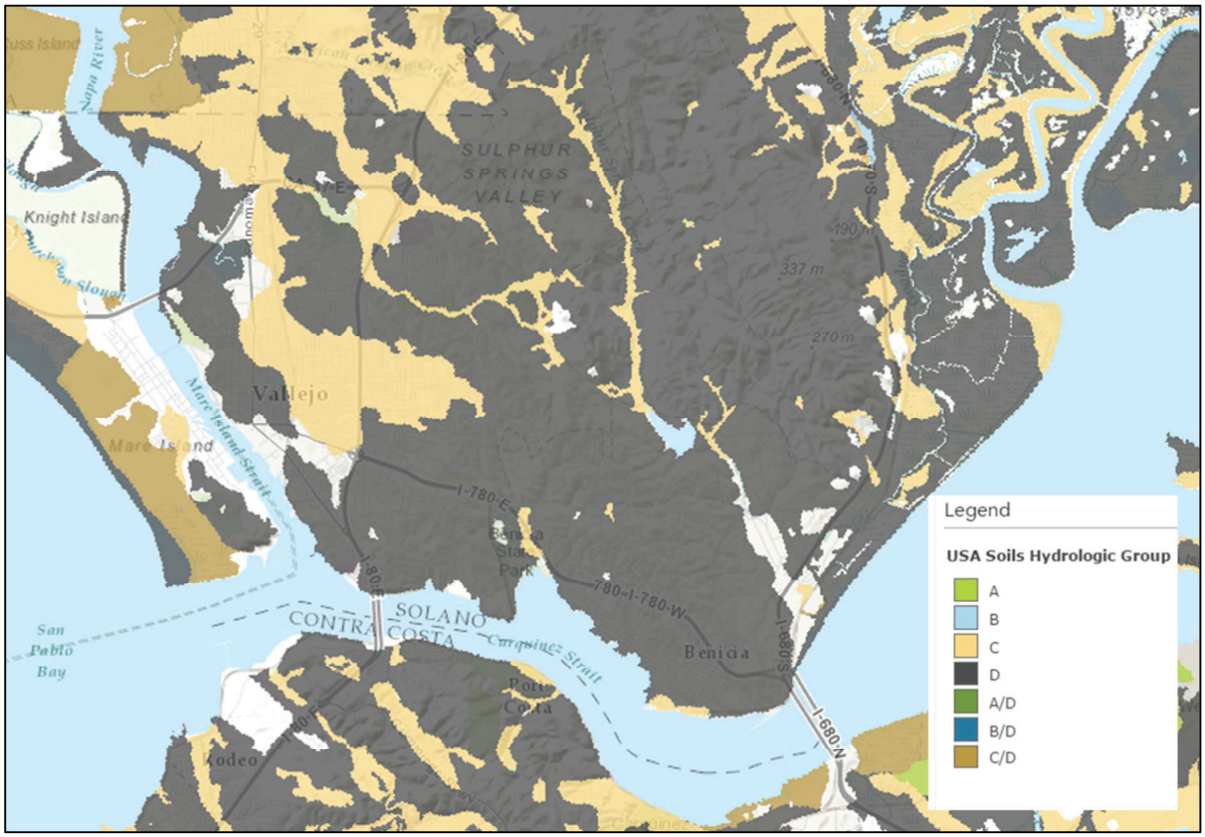
Stormwater management is an important practice to address water pollution and reduce flood hazards. Water pollution is caused by water that runs untreated off of streets, parking lots, sidewalks, rooftops, and construction sites. Pollutants, such as sediment, oils, chemicals, trash, and other materials, are carried by the rain into the storm sewer system or directly into waterways. Stormwater is untreated, that is, it does not go to a wastewater treatment plant.

While water quality is an important consideration for stormwater management, stormwater management is also essential for flood prevention. Water naturally flows to streams through runoff from rainfall or snow melt flowing over land or below the ground surface. Flooding occurs when large volumes of runoff flow quickly into streams and rivers. The quick flow of runoff can occur as a result of the intensity and duration of rainfall, topography, geology, soil and vegetation conditions, and hydrologic conditions from prior storm events.[27] Urban development practices, such as removing vegetation and soil, grading the land, and constructing drainage networks, can also increase runoff to streams following rainfall. While vegetated surfaces can attenuate and capture water as it runs downstream, hard impermeable surfaces do not provide this capacity to capture stormwater run-off. Water flows faster and in greater quantities over impermeable surfaces, resulting in higher peak flows and increased velocity for streams. Proper stormwater management practices can help to mitigate flood hazards by slowing the flow of runoff, capturing some water on-site for infiltration into the soil, and attenuating water as it flows toward streams.

Soil permeability is a predictor of stormwater runoff. Figure 5.14 below illustrates hydrologic soils in Benicia. Classifications range from Group A (more infiltrative) to Group D (less infiltrative). Hydrologic soil conditions can be used to inform both hydromodification management and complimentary low-impact development (LID) best management practices (BMPs) as an aide to guide optimum development decisions and BMP selection.

[27] Konrad, C.P. United States Geological Survey. Effects of Urban Development on Floods. Fact Sheet 076-03 http://pubs.usgs.gov/fs/fs07603/

Figure 5.14: Hydrologic Soils Groups



Source: ESRI ArcMap, Bureau of Land Management

The Federal Clean Water Act and the California State Porter-Cologne Water Quality Act have requirements to protect and enhance water quality in watercourses. On February 5, 2013, the State Water Resources Control Board (SWRCB) adopted the Phase II Small Municipal Separate Stormwater Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) Permit, Water Quality Order No. 2013-0001-DWQ, General Permit No. CA S000004 (Phase II Stormwater Permit). The Phase II Stormwater Permit regulates discharges from small MS4s and requires permittees to implement a stormwater management program. The City of Benicia is named as a Small MS4 permittee in the Phase II Stormwater Permit. On May 5, 2015 the City of Benicia adopted a Stormwater Ordinance that includes the following requirements:

- Expand storm water control measures, includes significant updates to Best Management Practices (BMPs) for ground disturbing activities, and creates a new clause for Best Management Practices for new development, and redevelopment, as follows:

- The development and implementation of Erosion and Sediment Control Plans are required for all projects requiring a grading permit.
- New development and redevelopment projects must implement post-construction Best Management Practices to control the volume, rate, and potential pollutant load of storm water runoff.

- New development and redevelopment projects, which create or replace 2,500 square feet of impervious area, must submit and implement a Storm water Control Plan, which is separate from an Erosion and Sediment Control Plan that identifies the post-construction BMPs planned to control the volume, rate, and potential pollutant load of storm water runoff.
- Require the use of appropriate BMPs to reduce pollutants in storm water discharges to the maximum extent practicable;
- Require operators of construction sites to develop erosion and sediment control plans and install, implement, and maintain appropriate BMPs; and
- Require applicants for land development and redevelopment to develop stormwater control plans to reduce storm water pollutant discharges through the construction, operation and maintenance of source control measures, low impact development design, site design measures, storm water treatment measures and hydromodification management measures, and require agreements to ensure the future operation and maintenance of the practices.

Historic Occurrences

According to ABAG's *Risk Landscape:*

> *Flooding associated with severe storms has been among the most common disaster in the Bay Area during the period from 1950 to 2015, occurring on average 1.3 times a year over the past 60 years. Often heavy rainfall brings many areas of localized flooding, especially in low lying areas of the region. Many other locally significant floods have occurred during this time period.*

Table 5.6: Declared Disasters for Past Flood Events in Solano County

Event	Description	Year	Extent
Winter Storms	Severe storms, flooding, mudslides, landslides resulting in appx. $100 million damage, two deaths from falling trees, damage to businesses and homes.	2005-2006	Bay Area incl. Solano County
El Nino	Severe flooding, landslides, flash floods. More than 11,000 evacuated, 17 deaths	1998	Most areas of the state, incl. Solano County
Floods	Over 300 square miles of flooding and 120,000 people evacuated, 2,000 businesses damaged or destroyed. 8 casualties and $1.8 billion damages.	1996-1997	Central & Northern California including Solano County

Winter Storms	Severe storms, flooding, landslides, mud flows. Small stream flooding. Total damages of $741.4 million, 11 deaths.	1995	Most areas of the state, incl. Solano County
Winter Storms	Rains, winds, flooding and mud slides. 13 deaths, 67 injuries, total damage of $407,538,904 (public and private) including 1,382 homes and 185 businesses destroyed.	1986	Northern California, incl. Solano County
Winter Storms	Heavy rains, high winds, flooding, levee breaks. Total damage of $523,617,032 inclusive of public, private and agricultural improvements.	1982-1983	Most areas of the state, incl. Solano County
Winter Storms	Heavy winds, rain, flooding, mud slides. Damage to public and private facilities including 256 homes and 41 businesses destroyed. Total damage appx. $273,850. 33 deaths, 481 injuries.	1982	Northern and Central California coastal counties, incl. Solano County
Storms	Rain, winds, mud slides, flooding. Total damage to public, private and agricultural improvements total $316,640,817.	1980	Stanislaus, Monterey, Solano, Santa Cruz counties
Winter Storms	Winter storms resulted in total damages of $300 million, 47 deaths and 161 injuries	1969	Most areas of the state, incl. Solano County
Floods	Statewide floods in December resulted in 74 deaths and approximately $200 million in damages.	1950	Statewide
Floods	Statewide floods in November resulted in 9 deaths and total damages of $32,183,000.	1950	Statewide

Sources: Bay Area Multi-Jurisdictional Local Hazard Mitigation Plan 2010 Update, Appendix D; FEMA Disaster Declarations *http://www.fema.gov/disasters*

Pursuant to funding from the California Coastal Conservancy, the City of Benicia, in partnership with ICF International and Placeworks, Inc., examined the climate change related vulnerabilities and risks in Benicia (i.e. changing sea levels and temperature changes). Past flood occurrences, detailed in the Climate Change Vulnerability Report Summary (2014) are summarized below[28]:

Residential: In 2005, Benicia experienced a 40-year storm event that coupled extreme high tides with heavy rain. This event led to coastal water overtopping local flood protection structures, flooding downtown, neighboring residential areas, and other portions of the City. According to the national weather service, Benicia received 2.11 inches of rainfall in just one day, and a cumulative 3 inches over the next several days.

Regular flooding of residential areas occurs during high tide and storm events, particularly along East B Street and in the vicinity of East Second and East Fifth Streets. Residential areas that have historically been impacted by flooding include Portside Village, properties surrounding the Benicia Marina, the Rancho Benicia mobile home park, and some homes along the 300 block of East I Street.

[28] City of Benicia (2014). Climate Change Vulnerability Report Summary.

Some residents recall flooding events at Rancho Benicia during extreme tide events that were severe enough to require evacuation via boat. This issue has somewhat been mitigated by changes to the City drainage system. During storm events, the City now diverts water away from Rancho Benicia and over to the Fitzgerald baseball field. This practice minimizes flooding in streets and residential areas along E 2nd Street and H Street.

Residential areas east of the downtown provide housing for lower income and elderly residents who require additional assistance during extreme weather events. The community center and other shelters remain open during extreme weather events in order to shelter and care for these residents. There is a low lying family health center at the end of Military West that susceptible to extreme weather events; however, according to local emergency personnel, there are no major evacuation facilities (e.g., shelters), police, fire stations, or safety facilities that currently experience flooding.

Arsenal: The shoreward portion of the Benicia Arsenal is also subject to inundation during extreme weather events.

Industrial: Portions of the Industrial Park along the Suisun Bay shoreline and Sulphur Springs Creek are flood prone. During extreme high tide events, water back-up has been reported onto the I-680 on and off ramps just inland of the industrial area. Flooding along Sulfur Springs Creek pours over and affects several transportation assets, including access to Park Road, Bayshore Road and the Bay Trail.

The Union Pacific rail lines that parallel Suisun Bay act to both reduce and exacerbate flooding issues in Benicia. The lines provide a defense against coastal flooding since the tracks are elevated; however, they occasionally overtop. When there is inland flooding due to precipitation that collects in Sulfur Springs Creek, the UP tracks and vegetation growth within their right of way limits drainage. This causes longer duration flood events.

Repetitive Loss Properties

Through the LHMP, Benicia is required to document “repetitive loss properties” and address these structures. A repetitive loss property is a NFIP insured structure that has had at least two paid flood losses of more than $1,000 each in any 10-year period since 1978. At the time of this LHMP, there are no repetitive loss structures within the City of Benicia, as defined by FEMA. However, certain properties in Benicia have been known to flood due to other factors. These include Waterstone Apartments (522 1/2 W K St.), 472 East N Street and homes at 224, 228, 230 and 232 St. Augustine Court.

Though these properties are not designated within a Special Flood Hazard Area, they are eligible for flood insurance through the NFIP and, as participants in the NFIP they may also qualify for flood mitigation grants administered by FEMA.

Probability of Future Flooding

Future flood events are expected to occur. The FIRM maps show flood risk by location based upon past data and can be used to predict the likelihood (% chance) of future flooding. Sea level rise will increase likelihood of major flood events due to higher water levels.[29] While the City can and does take action now to prepare for anticipated flood events, climate change will alter future weather patterns, including rainfall intensity and duration, in ways that scientists are working to predict.

Sea Level Rise

The Climate Change Vulnerability Assessment Report Summary (2014) details expected sea level rise in Benicia by the end of the century. The findings of this report are excerpted below[30]:

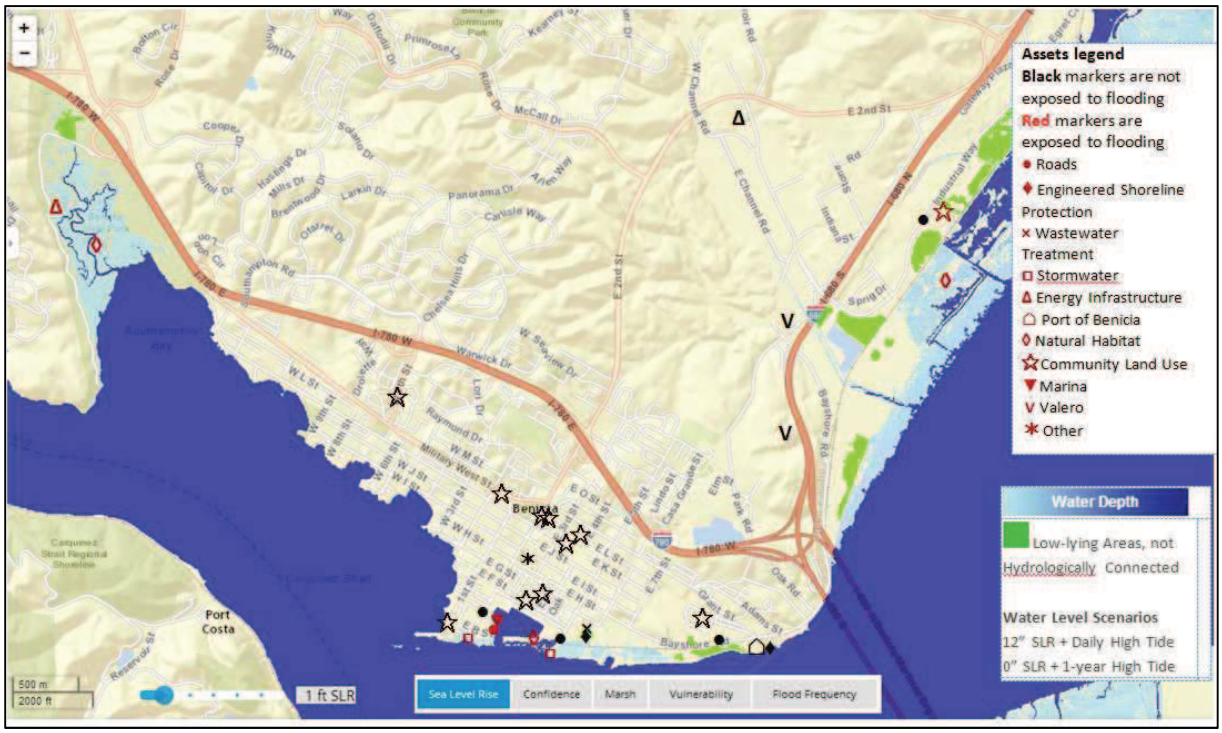
> *Sea levels have risen in the past and are projected to rise at an accelerated rate due to climate change. For Benicia and other coastal communities, without intervention, this will lead to flooding of critical structures, infrastructure, and natural habitats.*
>
> *For this project, the ICF Team used the California Ocean Protection Council (OPC) 2013 sea level rise planning guidance projections. Benicia utilized publicly available sea level rise mapping tools (the National Oceanic and Atmospheric Administration (NOAA) Digital Coast Sea Level Rise Viewer[31] and Climate Central's Surging Seas Tool2[32]) to visualize the following three sea level rise scenarios:*
>
> - *12 inches (low, mid-century projection)*
> - *24 inches (high, mid-century projection and the low end-of-century projection)*
> - *60 inches (high end-of-century projection)*
>
> *To visualize impacts on natural habitats (e.g., marshes), the ICF Team used the Blue Point Conservation Science's Future San Francisco Bay Tidal Marshes: A Climate-Smart Planning Tool.[33]*
>
> *To determine the effect of storms on coastal flooding, a FEMA study of average water level depths during storm events of various return intervals (e.g., 1-, 2-, 5-, 10-*

[29] ABAG *Risk Landscape*, 2015
[30] City of Benicia (2014). Climate Change Vulnerability Report Summary.
[31] National Oceanic and Atmospheric Administration Office for Coastal Management. Digital Coast Sea Level Rise Viewer. http://coast.noaa.gov/digitalcoast/tools/slr
[32] Climate Central. Surging Seas Sea Level Rise Analysis. http://sealevel.climatecentral.org/
[33] United States Fish and Wildlife Service, Point Blue Conservation Science. Future San Francisco Bay Tidal Marshes, a Climate – Smart Planning Tool. http://data.prbo.org/apps/sfbslr

, 25-, 100-year) within the San Francisco Bay was used to identify current flood levels[34]. To combine the sea level rise mapping data and the storm depth data, the ICF Team used an approach called "total water levels". Total water levels allows for the simultaneous consideration of changes in short-term, storm-related flooding as well as long-term permanent inundation due to sea level rise.

It should be noted that the elevation data used in the mapping may omit fine features affecting flooding connectivity (e.g. seawalls, ditches), meaning that the sea level rise maps may overstate the extent of flooding in certain locations. For example, the Benicia Wastewater Treatment Plant is protected by a flood wall that is not represented in the sea level rise model.

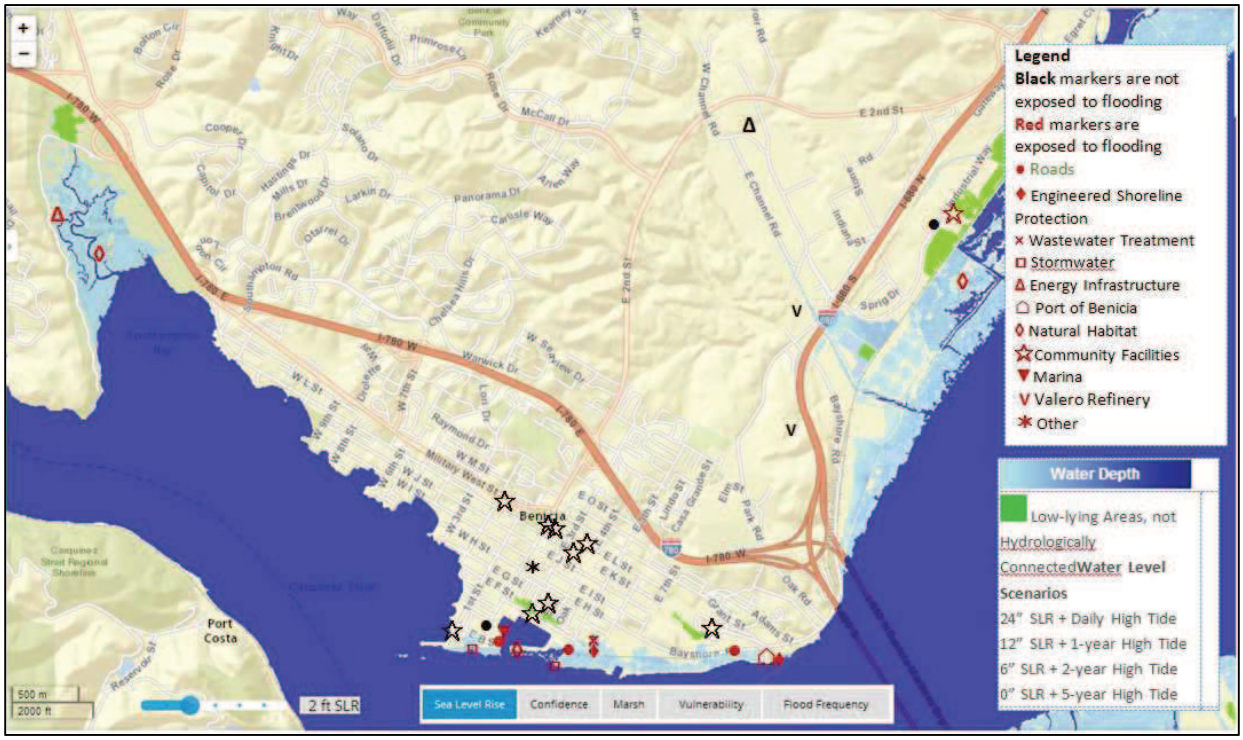
Figure 5.15: 12 Inches (1 foot) Sea Level Rise



Source: City of Benicia Climate Change Vulnerability Report Summary, 2014

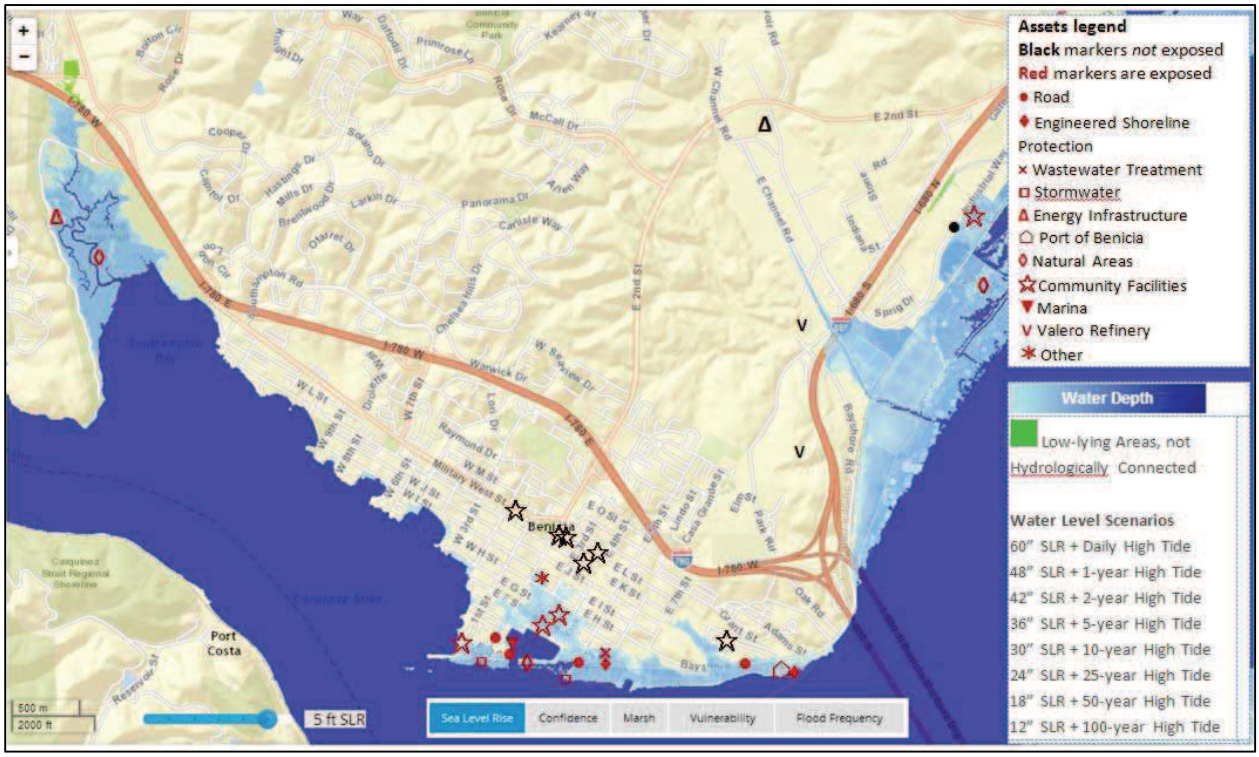
[34] Federal Emergency Management Agency Region IX National Flood Insurance Program. CCAMP San Francisco Bay Area Coastal Study, http://www.r9map.org/Pages/San-Francisco-Coastal-Bay-Study.aspx

Figure 5.16: 24 Inches (2 Feet) Sea Level Rise



Source: City of Benicia Climate Change Vulnerability Report Summary, 2014

Figure 5.17: 60 Inches (5 feet) Sea Level Rise



Source: City of Benicia Climate Change Vulnerability Report Summary, 2014

Although individual residences and businesses are not listed as exposed to sea level rise, Table 5.7 summarizes the potential population and economic impacts of sea level rise and storm surge flooding.

This analysis assumes static land use patterns and 2012 dollar values; most of the data is drawn from the 2010 Census data (for more information, please see the Climate Central Surging Seas Tool[35]).

Table 5.7: Projected Exposure to Sea Level Rise

	12" Total Water Level (daily inundation at mid-century)	24" Total Water Level (daily inundation at late mid-century to early end-of-century)	60" Total Water Level (daily inundation at end-of-century)
Population	75	115	836
Property Value (millions)	$31	$64	$213
Homes	41	62	515
Land (acres, excluding saltwater marsh)	50	118	402

[35] Climate Central. Surging Seas Sea Level Rise Analysis. Risk Finder: California http://sealevel.climatecentral.org/http://sealevel.climatecentral.org/ssrf/california

Source: City of Benicia Climate Change Vulnerability Report Summary, 2014

Table 5.8 provides an overview of the total water levels at which select transportation assets will be exposed to flooding.

Table 5.8: Projected Exposure to Sea Level Rise

Asset	Currently Floods due to Inadequate Drainage	12" Total Water Level (daily inundation at mid-century)	24" Total Water Level (daily inundation at late mid-century to early end-of-century)	60" Total Water Level (daily inundation at end-of-century)
E. 2nd St. / E. B St.	X		X	X
E. 5th St.	X		X	X
Bayshore Road			X	X
Bay Trail	X	X	X	X
Union Pacific	Unknown		X	X

Source: City of Benicia Climate Change Vulnerability Report Summary, 2014

5.1.5 Fire

Fire is an important natural ecosystem function that promotes vegetation and wildlife diversity, releases nutrients into the soil, and eliminates heavy accumulation of underbrush that can fuel catastrophic fires[36]. However, fire can also be a hazard that results in loss of life, and damage to the built environment as well as natural resources. ABAG's *Risk Landscape* provides the following overview of fire:

Fires are typically characterized into three categories: urban fires, wildland-urban interface fires, and wildland fires.

- *Urban fires occur within a developed area and pose a direct risk to development.*
- *Wildland-urban interface (WUI) fires occur where the built environment and natural areas are intermixed (the fringe of urban areas).*
- *Wildland fires exist in wilderness land.*

Fires in the urban environment and in the wildland-urban interface result in direct damage to the built environment and can injure or kill residents. Wildland fires can cause damage to linear infrastructure systems that serve the Bay Area, causing outages downstream of the failure; can impact the air quality in cities during the duration of the fire; and can impact water quality in watersheds impacted by a wildland fire. Wildland and wildland-urban interface fires can also damage natural

[36] California Energy Commission Cal-Adapt. Wildfire: Risk Map http://cal-adapt.org/fire/

environments, such as recreational areas, and can cause lasting impacts to slopes and soils.

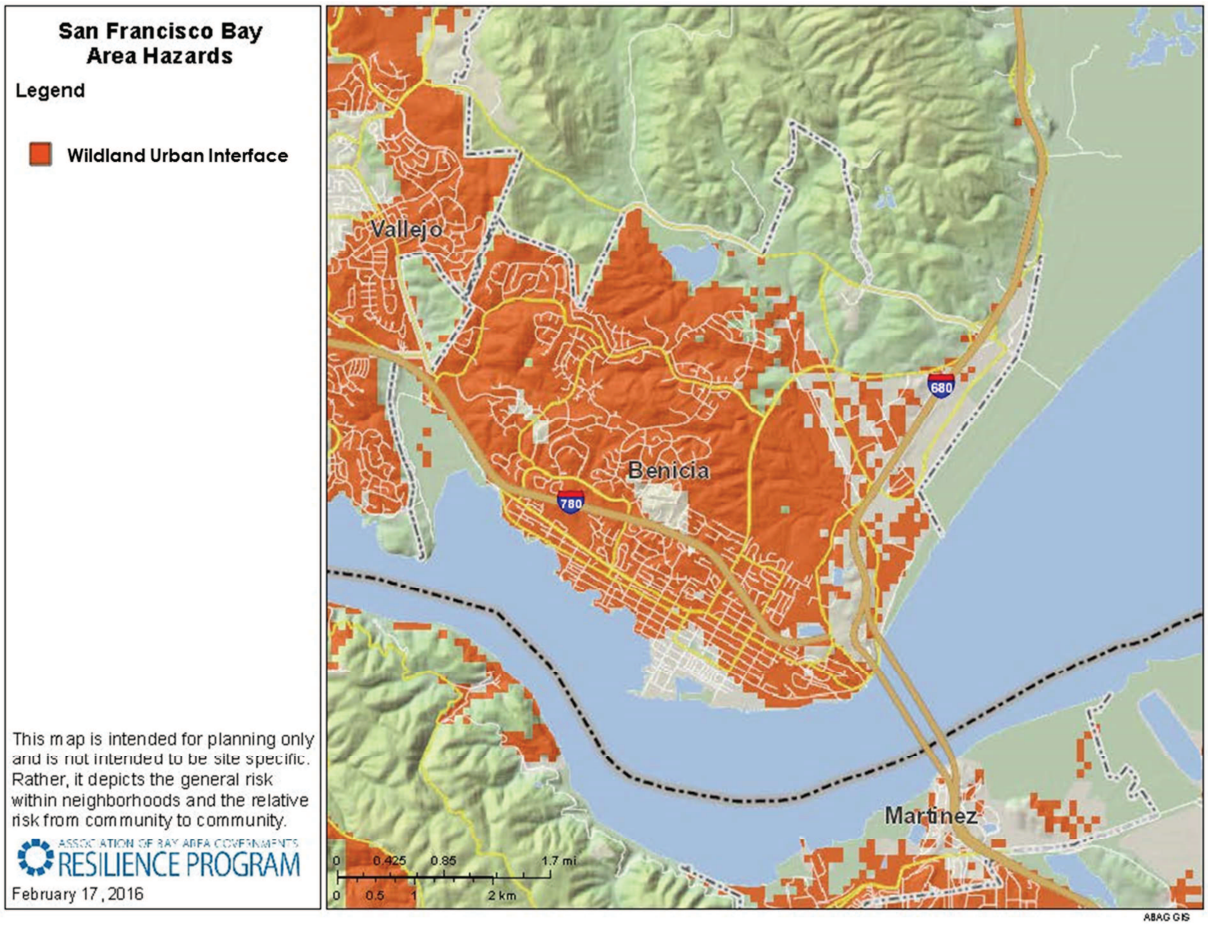
In the Bay Area, fire areas generally fall into two categories – State Responsibility Areas, where CALFIRE is responsible for fire protection, and Local Responsibilities, where local fire departments and fire protection districts have responsibility.

The Benicia General Plan notes that the City's jurisdiction includes large grassland open space areas. Interspersed among these areas are residential and industrial uses, which occupy the wildland-urban interface and may be impacted by fire. Fires within the wildland-urban interface are likely to cause damage to the natural and built environment and present a danger of injury or death for people and animals.

Fires within the wildland-urban interface are spread by the interaction of wind speed and direction, fuel and topography. Hot, dry, windy weather can create conditions that are conducive to fire. Vegetation that is dry or dense, including some residential landscaping, can provide fuel for fire. Similarly, wood roofs and siding increase vulnerability. The heat associated with a fire can deteriorate infrastructure, such as concrete and asphalt roadways, curbs, sidewalks and drainage structures. Communications infrastructure, such as telephone and cable lines, street lights, and traffic signals, can also be damaged. Injuries and death may be caused by burns and smoke inhalation; the associate air pollution from fire debris can exacerbate respiratory illness, asthma, allergies, chronic obstructive pulmonary disease and other health conditions. Proper management of the wildland-urban interface, both on public and private lands, is necessary to control fire risk.

While large areas of Benicia are located within the wildland-urban interface, there is not a history of significant fires within this area. Figure X depicts Benicia's wildland-urban interface, based upon information compiled by Cal Fire, which highlights areas with burnable vegetation and residential density greater than one unit per 20 acres. The wildland-urban interface represents areas of potential fire and high exposure of people and property.

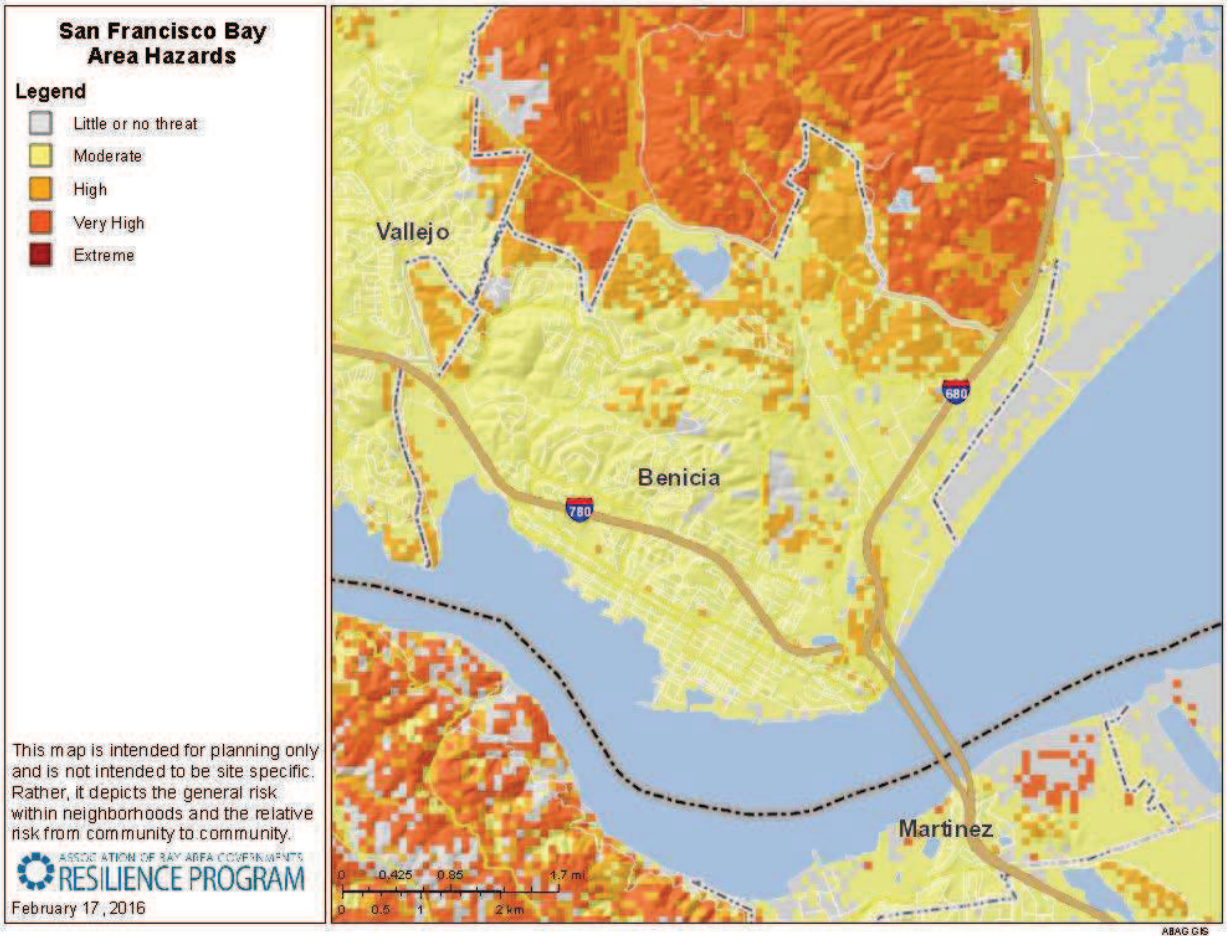
Figure 5.18: Wildland Urban Interface



Benicia's risk of wildfire is moderate-to-high as shown on the ABAG Hazard Map below. Areas with high risk are those located within the open space surrounding Lake Herman and along the northern border along Lake Herman Road. The Sky Valley Open Space, which is a State Responsibility Area (SRA) is designated as very high wildfire risk.

The effects of the fire can have long-term impacts on urbanized and natural areas. In addition property loss, fire can result in the partial or total loss of vegetation that stabilize hillsides, resulting in increased susceptibility to erosion. The remaining soil surface is less permeable and therefore has a reduced ability to absorb water; during rain events, this can lead to increased runoff, erosion, and landslide risk.

Figure 5.19: Wildfire Risk



Historic Occurrences

Risk Landscape describes historic occurrences of fire in the Bay Area:

> *Wildfires were common disasters in the Bay Area during the period from 1950 to 2014. Large wildfires occurred in 1961, 1962, 1964, 1965, 1970, 1981, 1985, 1988, 1991, and 2008. The 1991 fire in the Oakland-Berkeley Hills was the largest urban-wildland fire in the Bay Area, and resulted in $1.7 billion in losses. In that fire, 3,354 single-family dwellings and 456 apartments were destroyed, while 25 people were killed and 150 people were injured.[37] Despite the drought conditions locally over the past four years the Bay Area has had very few fires, and few large fires.*

The City of Benicia maintains a Vegetation Management Program. The goal of Vegetation Management is to control plant material to prevent the spread of wildfire by

[37] State of California Multi-Hazard Mitigation Plan, California Governor's Office of Emergency Services, http://hazardmitigation.calema.ca.gov/docs/SHMP_Final_2013.pdf

changing the characteristics of the vegetation surrounding homes and other structures. The focus of vegetation management is not to remove all vegetation within this area, but rather to create both horizontal and vertical separation between the various vegetation in the area and adjacent structures. The separation serves to slow the spread of a wildfire, thereby improving fire containment efforts. The efforts to carry out this task are not a one-time event. The City of Benicia utilizes multiple approaches in its Vegetation Management Program, including disking, spraying, and goats.

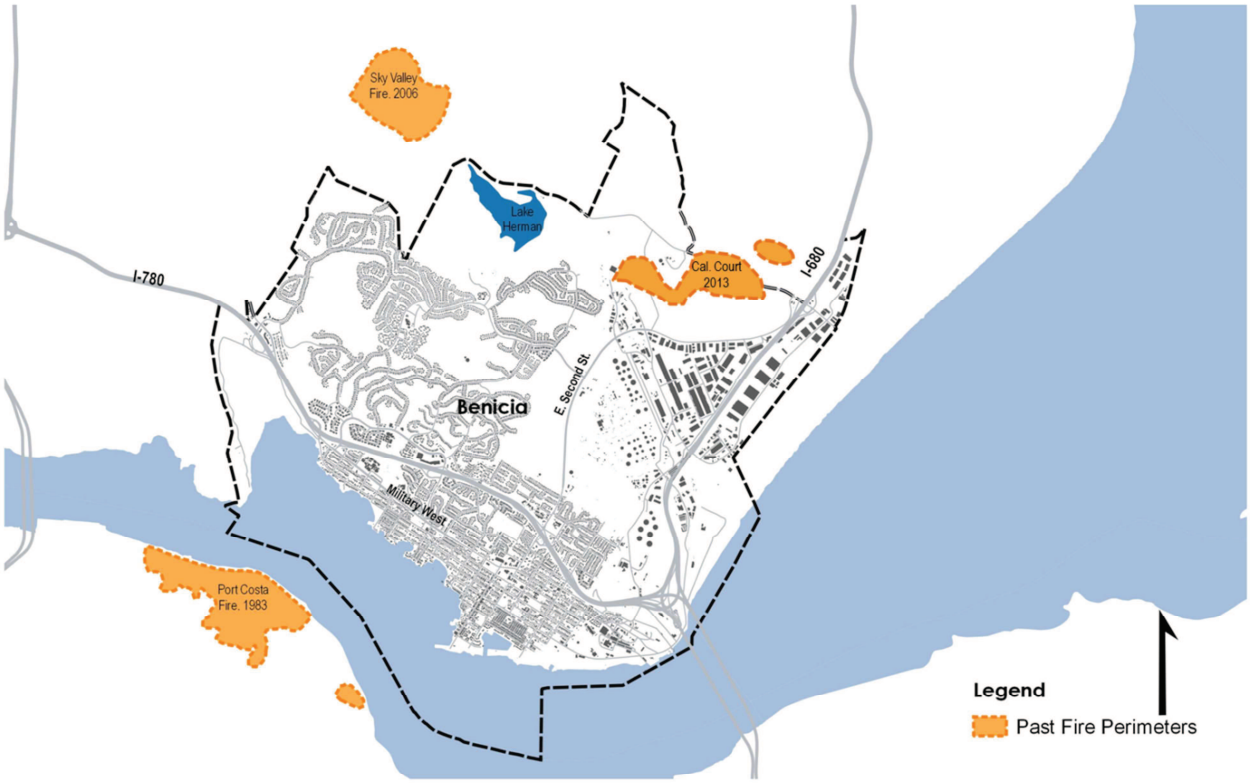
Table 5.9: Declared Disasters for Past Fire Events in Solano County

Event	Description	Year	Extent
Fires – 49er, Miller, Fern	No casualties, total damage of $31,247,534; 234 homes destroyed, 41 homes damaged, 29 businesses destroyed	1988	Shasta, Solano, Yuba, Nevada counties
Fires	Widespread fires over 113,766 acres resulted in destruction of 41 buildings. Damage cost estimate not available.	1965	Marin, Napa, Placer, Solano, Sonoma Counties

Sources: Bay Area Multi-Jurisdictional Local Hazard Mitigation Plan 2010 Update, Appendix D; FEMA Disaster Declarations http://www.fema.gov/disasters

While structure fires occur from time to time, the only recent fires in the wildland-urban interface near Benicia (1950-2015) were the Sky Valley Fire in 2006 and the California Court Fire in 2013 as shown on Figure 5.20 below. The data for Figure 5.20 was compiled through the Fire and Resource Assessment Program as part of the California Fire Plan and generally includes brush fires of at least 50 acres, grass fires at least 300 acres in size, or wildland fires that destroy three or more structures or cause $300,000 or more in damage.

Figure 5.20: Large Fire Perimeters (1950-2015)



Hazard Map Layer: ABAG Resilience Open Data Page
Parcels, Buildings and Roads: Solano County GIS

Probability of Future Fire

As depicted on Figure 5.19 and 5.20, the City of Benicia is currently at risk for fire in the wildland-urban interface and adjacent open space areas. Climate change is expected to exacerbate the risk of fire in some areas due to increased temperatures and changes in precipitation patterns. ABAG's *Risk Landscape* provides the following analysis:

> *Wildfire risk increases due to climate change because of higher temperatures and longer dry periods over a longer fire seasons. Additionally, wildfire risk will also be influenced by potential changes in vegetation.*[38]
>
> *Research out of UC Merced has projected the future fire risk, impacted by climate change, compared to existing fire risk. In the Bay Area the results are mixed. The research projects some locations in the East Bay and South Bay to exhibit decreased fire risk, while areas on the Peninsula and North Bay exhibit a 150 percent increase in fire risk by 2085. Generally, across the Bay Area there is fairly*

[38] California Climate Change Center, (2012). Our Changing Climate 2012: Vulnerability & Adaptation to the Increasing Risks from Climate Change in California. A Summary Report on the Third Assessment from the California Climate Change Center, http://www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdf

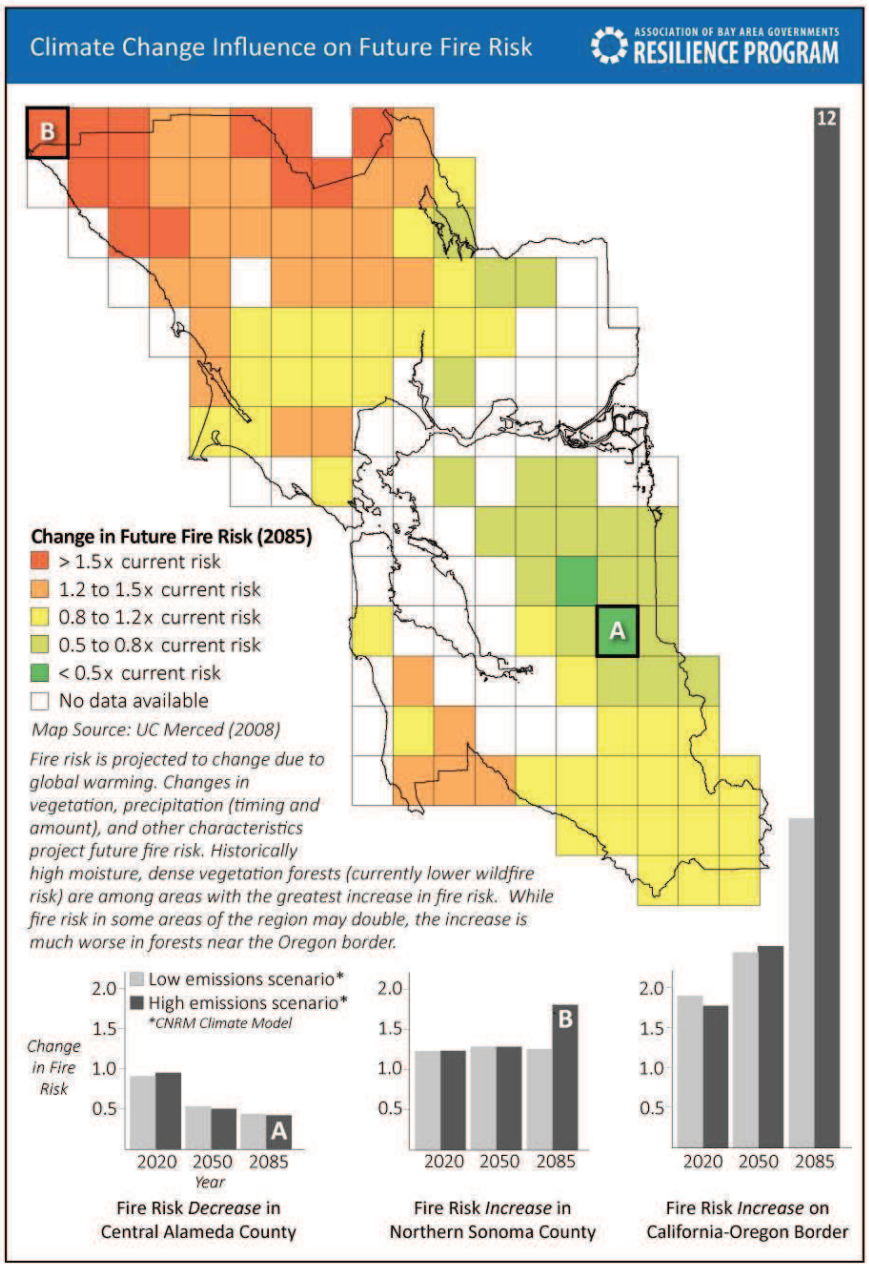
limited change in fire risk in the year 2050, with the greatest change in occurring between 2050 and 2085, especially in the high emission scenario. The Cal Adapt data suggests that some jurisdictions might have to adapt more aggressively compared to others.

The future fire risk model analyzes two primary variables: fuel availability and flammability of fuel. In California the change in fire risk is a result of either a densely forested ecosystem becoming drier, or a dry climate experiencing large vegetation growth after a year of above average precipitation. In the first scenario the suite of climate impacts (higher temperatures, less snow pack, earlier springs) result in previously wet dense fuel ecosystems becoming dry – increasing the fire risk. In the second ecosystem, dominated by grass and low density shrubs, the risk is often unchanged or decreased because the availability of fuel is the governing variable for fire risk, which remains unchanged or decreases as a result of projected precipitation.[39] These modeling characteristics are reflected in the Bay Area's future fire risk map.

The Bay Area, compared with other portions of California, especially those near the Oregon border, have a much lower projected increase in fire risk due to climate change. Near the Oregon border, many areas are expecting a 500 percent increase in fire risk by 2085, with some areas projected to see their fire risk increase more than 10 times.[40]

[39] Westerling, A.L., Bryant, B.P. (2008). Climate Change and Wildfire in California. Climatic Change Vol. 87. Suppl. 1 s231-s247. http://ulmo.ucmerced.edu/pdffiles/08CC_WesterlingBryant.pdf
[40] Ibid

Figure 5.21: Climate Change Influence on Future Fire Risk



Cal-Adapt was established by the California Energy Commission to provide access to climate change scenarios and research in a manner that will aid local decision-makers. The website, www.cal-adapt.org, provides a view of how climate change will impact communities at the local level. Cal-Adapt provides scenario information for increased temperature and wildfire risk; however, a model has not yet been developed for Benicia. In general, the areas of Solano County that have been evaluated by Cal-Adapt (portions

of Fairfield and Vacaville) predict a small increase in the potential area burned during wildfire.[41]

5.1.6 Drought

A drought is a period of below-average rainfall that results in prolonged shortages in water supply. The effects of drought in California can be felt regionally or statewide. ABAG's *Risk Landscape* provides additional information about drought.

> *A drought is a gradual phenomenon that occurs over several dry years, depleting reservoirs and groundwater basins without the expected annual recharge from winter precipitation. While drought does not have any primary impacts in the Bay Area, prolonged periods of drought can cause secondary impacts that can affect the region, including:*
>
> - *Reduced water supply for crops and livestock feed, impacting the economy centered around the agriculture industry*
> - *Increased wildfire hazard, including more fire starts and more prolonged conflagrations fueled by excessively dry vegetation and reduced water supply for firefighting purposes*
> - *Subsidence due to a lowering water table*
> - *May be correlated to high heat conditions.*
>
> *Drought is not localized, but occurs simultaneously across the region, and may extend statewide or across a larger expanse of western states. This has been the case in California since 2013. While the drought exists in every county, the impacts of the drought are locally unique, based on local water supply systems, soil conditions, and the typical climate and vegetation land covering. The effects of drought are managed in the Bay Area through the importation of water and the storage of water in reservoirs.*
>
> *The United States Drought Monitor is produced by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture. The Monitor releases weekly maps of current drought conditions. NOAA also publishes one year outlook maps for temperature and precipitation.[42] The maps project temperature and precipitation twelve months out – describing the conditions as likely below, above, or average.*
>
> *Drought Hazards in the Bay Area:*

[41] California Energy Commission Cal-Adapt. Wildfire: Risk Map http://cal-adapt.org/fire/
[42] National Oceanic and Atmospheric Administration, National Weather Service. Climate Prediction Center http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.php

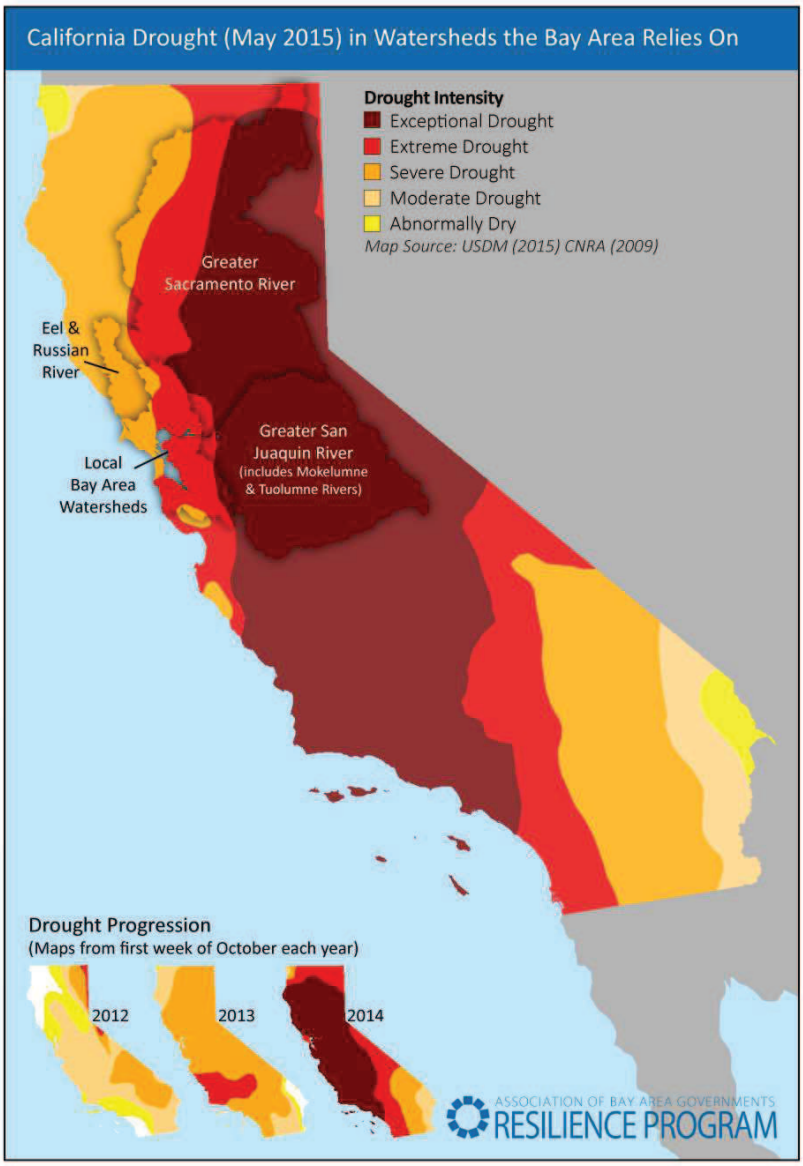
Water Supply

Drought can impact the entire Bay Area, not just one particular county or a few cities. In addition, shortages in precipitation in the Sierra Nevada can have a more pronounced impact on water supply in the region than a drought in the Bay Area itself because of the reliance of the region on water from the Tuolumne, Mokelumne, Sacramento, and San Joaquin watersheds. Thus, drought is not a hazard that can be depicted by a Bay Area map; rather a map of Northern California is necessary to understand the impact of drought on Bay Area water supply.

Increased Fire Hazard

Fire hazard increases where drought conditions are high. There are multiple drought related factors that contribute to increased fire hazard: longer fire season, drier vegetation, and hot days. Additionally, drought reduces the water supplies available to fight wildfires, leading to larger and more extended fires.

Figure 5.22: Drought in Watersheds Serving Bay Area (2015)



Drought affects the local water supply for Benicia. The City of Benicia has a population of approximately 28,000 people, 8,500 residential water meter service connections, and 1,000 commercial, industrial and institutional connections.

The City purchases approximately 10,000 acre-feet or 3.3 billion gallons of water per year, and approximately half of this water is used at the Valero Benicia Refinery. The State Water Project (SWP) supplies 75% to 85% of the City's water from the Sacramento - San Joaquin Delta and the Solano Project (SP) supplies 15% to 25% of the City's water from Lake Berryessa. Lake Herman has historically been used as an emergency water supply and temporary storage reservoir.

Figure 5.23: Bay Area Water Source Portfolio and Annual Normal Supply

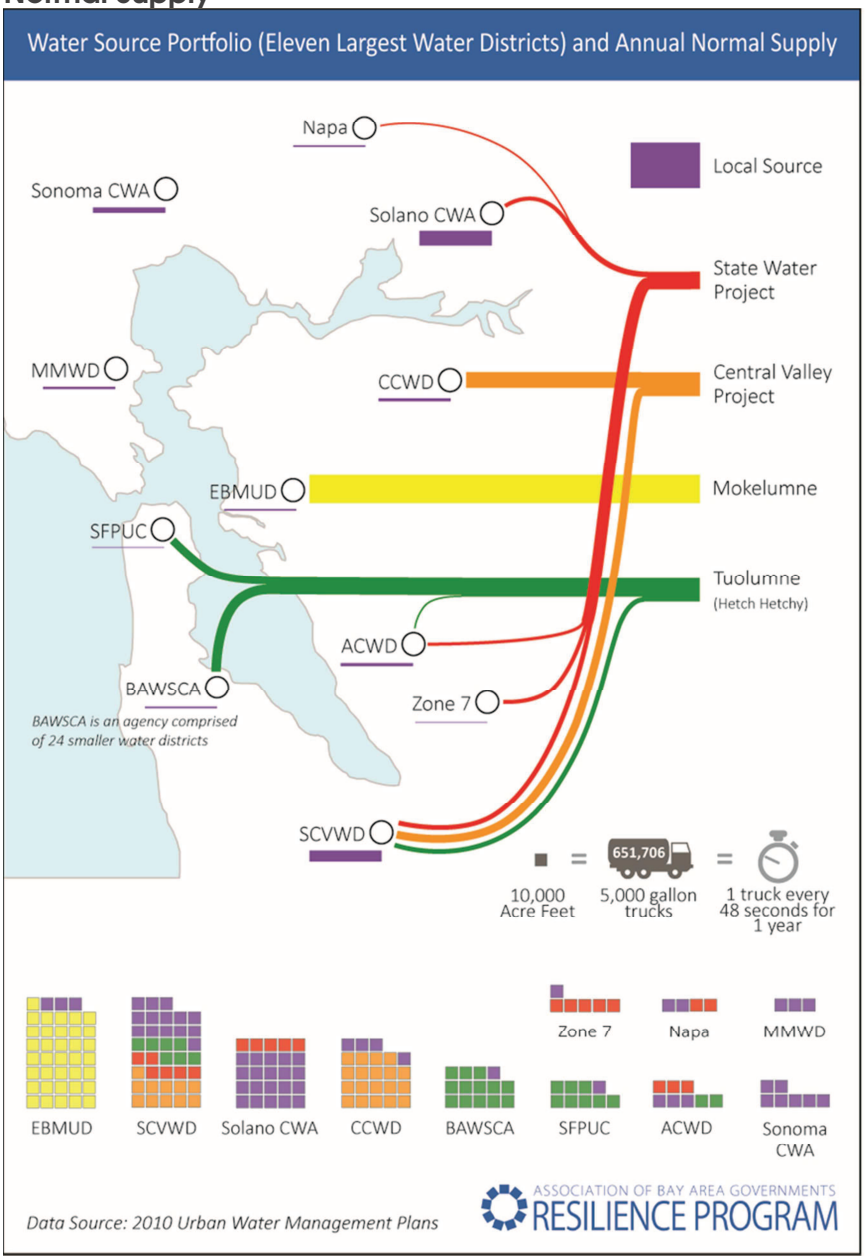


Table 5.10 details the usage of Benicia's water supplies in 2014 and 2015. SWP and SP water stored in Lake Herman is shown as negative. When water stored in Lake Herman is used to meet water demand, it is shown as positive. Rainfall runoff into Lake Herman is captured in "Lake Herman Supply".

Table 5.10: 2014 and 2015 Source Water Usage (acre-feet)

	Total Raw Water Demand	State Water Project Supply	Solano Project Supply	Lake Herman Supply	Lake Herman Stored Water
2014 Total	**9,954**	**6,785**	**2,138**	**745**	**0**
2015					
January	**800**	147	0	653	
February	**679**	541	112	26	
March	**813**	27	750	36	
April	**787**	0	742	45	
May	**923**	483	453		(13)
June	**920**	1,134	0		(214)
July	**958**	1,062	0		(104)
August	**922**	882	0		40
September	**891**	835	0		56
October	**828**	851	0		23
November	**735**	566	0		169
December	**731**	10	712		9
2015 Total	**9,987**	**6,538**	**2,769**	**760**	**(34)**

Table 5.11 summarizes Benicia's water supply portfolio. The State Water Project water that the City is guaranteed comes from "Table A" contract water, the Carryover from previous years, and water obtained from a Settlement Agreement or exchanged for Vallejo's Permit Water. Vallejo's Permit Water originates from the same source as the North Bay Aqueduct, and can be described as a "use it or lose it" water each calendar year. This exchange with Vallejo can only occur while Vallejo has access to its Permit Water.

Table 5.11: Benicia Water Portfolio for 2014 – 2016 (acre-feet)

Water Source	**2014**	**2015**	**2016**
State Water Project	7,898	10,844	9,145
Solano Project	11,963	13,042	13,850
Lake Herman – Projected Supply	745	750	750
Grand Total	**20,606**	**24,636**	**23,745**

On January 17, 2014, the Governor declared a statewide drought. Benicia is under a state-mandated water conservation target of 20%. Benicia has consistently been ahead of state-mandated targets due to the community's water conservation efforts. Benicia reduced its water use by 36% in 2015 compared to the 2013 baseline. In December 2015, Benicia's water use was reduced by 46% compared to December 2013 with residents using a record low 43 gallons per person per day.

To promote water conservation, the City of Benicia has engaged in the following activities:

- *Public Outreach and Direct Mail:* The City engaged the community through public meetings in 2015 to inform the public and listen to citizens' concerns and suggestions. An open house public meeting was held on December 10, 2015. Direct mail information has been provided to water customers to provide information about the status of the drought, outdoor watering restrictions, a drought surcharge, water conservation techniques, and individualized water conservation data. Water conservation is also encouraged through signage, informational handouts, and table tents at restaurants to encourage customer conservation of drinking water.
- *Participation in Solano Turf Replacement Program:* The Solano County Water Agency (SCWA) has administered a turf-replacement program since 2010 using state Proposition 84 grant funding that provides rebates to residents who replace their water thirsty lawn with drought-tolerant landscaping. This program has reimbursed a property owner $1.00 per square foot, up to $1,000 per project.
- *Water Conservation Rebates:* The City offered rebates to Benicia residents in partnership with the Solano County Water Agency, including high efficiency washers and toilets, turf replacement rebates, and commercial / industrial / institutional high efficiency toilet rebates.
- *Water Leak Detection:* The City's leak detection contractor, Utility Services Association, conducted their work between April 29, 2015 and August 28, 2015. The firm searched for water leaks on 125 miles of pipeline throughout the City. The leak detection contractor found a total of 49 water leaks, six of which were significant leaks estimated at over five gallons of water loss per minute. Of the 49 water leaks, 8 were on the customer side of the water meter and those customers were notified. Of the 41 leaks that the City is responsible for all repairs completed as of February, 2016.

Additional upcoming tasks related to water conservation include water meter replacement and advanced metering infrastructure (AMI), an update to the Urban Water Management Plan, and evaluation of water reuse potential in Benicia.

Historic Occurrences

California has a climate with drought cycles every 10 to 20 years. The last two severe droughts were in the mid-1970's and late-1980's to early 1990's.

ABAG's *Risk Landscape* provides a summary of historic droughts affecting California and the Bay Area:

> *Major droughts occurred in California that affected the Bay Area in 1973, 1976-77, 1987-1991, and 2007-09. Drought conditions in 1973 led to a state-declared disaster in Glenn, San Benito, and Santa Clara counties, resulting in $8 million in agricultural loss. Between 1976 and 1977, California experienced one of its most*

severe droughts. 1977 was the state's driest year on record. In the Bay Area, Contra Costa, Napa, San Mateo, and Marin counties were four of the several counties where a state disaster was declared. Statewide, $2.67 billion in damages occurred in the two-year period. Marin, Solano, and Sonoma counties were also affected in the 1987-1991 drought, which caused $1.7 billion in crop losses nationwide. The 2007-2009 drought did not directly affect Bay Area counties, but caused $300 million in crop loss statewide.[43]

In January 2014, the Governor declared a State of Emergency in California in response to current drought conditions, which began in 2012. Thus far, 2015 has surpassed 1977 as the driest year on record in California. As of June 2015, statewide reservoirs are at 18-67 percent of average and Sonoma County has declared a local Emergency Proclamation.[44]

Table 5.12: Declared Disasters for Past Drought Events in Solano County

Event	Description	Year	Extent
Drought	Statewide drought, beginning in 2013, that remains ongoing at the time of this plan. The Governor's office established mandatory water reductions. Estimate of total damages unavailable.	2014	Statewide
Drought	Three-year drought resulting in over $300 million in ag. Revenue loss; up to $3 billion in accumulated economic loss.	2009	Statewide
Drought	1976 and 1977 were two of driest years in CA history, particularly in northern two-thirds of the state. Total damage $2,664,000,000.	1976-1977	Northern and Central California, incl. Solano County

Sources: Bay Area Multi-Jurisdictional Local Hazard Mitigation Plan 2010 Update, Appendix D; FEMA Disaster Declarations *http://www.fema.gov/disasters*

Probability of Future Drought

As noted previously, droughts regularly occur in California and are likely to continue into the future. ABAG's *Risk Landscape* provides analysis of future drought risk in light of climate change.

Climate change is likely to increase the number and severity of future droughts. The cumulative impact of climate change impacts will result in drier conditions, and will alter the timing and efficiency of the Bay Area water supply. An increase in temperature and a reduction in snow pack are the two most direct effects of climate change that will result in a drier state with fewer natural water resources than historically have been available.

[43] State of California Multi-Hazard Mitigation Plan, California Governor's Office of Emergency Services, http://hazardmitigation.calema.ca.gov/docs/SHMP_Final_2013.pdf
[44] California Governor's Office of Emergency Services (2015), Drought Update, Tuesday, June 2, 2015, http://ca.gov/drought/pdf/archive/WeeklyDroughtUpdate(06-02-15).pdf

In the Bay Area temperatures are projected to increase between 3 degrees (low emission scenario) and 6 degrees Fahrenheit (high emission scenario).[45] In the eastern regions of the state the increase is 4 to 9 degrees.

The reduction in snowpack does not have direct impacts in the Bay Area as the region does not accumulate meaningful levels of snow. The Bay Area is adversely impacted by the severe reduction in snow pack in the Sierras, the source of two-thirds of the region's water. By the end of the century the spring snow pack in the Sierra could be reduced by as much as 70 to 90 percent [of] the historic average.[46]

5.1.7 Extreme Heat

"Extreme heat" refers to unusually hot weather conditions with the potential to harm human health.[47] Cal-Adapt defines an extreme heat day as "a day in April through October where the maximum temperature (Tmax) exceeds the 98th historical percentile of maximum temperatures based on daily temperature data between 1961-1990.[48]" A heat wave is an extended period of extreme heat. Often, heat waves are accompanied by high humidity.[49]

Extreme heat and heat waves can be dangerous or life threatening for people and animals. The Centers for Disease Control and Prevention (CDC) has determined that exposure to extreme heat can cause discomfort, fatigue and heat cramps, and increase emergency room visits and hospitalizations.[50] Over the 10-year period from 1999 through 2009, extreme heat exposure caused or contributed to more than 7,800 deaths in the United States.[51]

Older adults, young children, and people who are sick or overweight are susceptible to the effects of extreme heat.[52] Additionally, those who live in poverty or social isolation,

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[45] Cayan, D., et al. (2009). Climate Change Scenarios and Sea Level Rise Estimates for California - 2008 Climate Change Scenarios Assessment - Final Report. Scripps Institution of Oceanography - California Nevada Applications Program. http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-014-F

[46] Scripps Institute of Oceanography (2012) Projected Snow Water Equivalent. Scripps Institute of Oceanography - California Nevada Applications Program. http://cal-adapt.org/snowpack/decadal/

[47] Department of Health and Human Services, Centers for Disease Control and Prevention. Climate Change and Extreme Heat Events. http://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf

[48] California Energy Commission Cal-Adapt. www.cal-adapt.org

[49] Department of Homeland Security Federal Emergency Management Agency. Ready: Prepare. Plan.Stay Informed: Extreme Heat. www.ready.gov/heat

[50] Department of Health and Human Services, Centers for Disease Control and Prevention. Climate Change and Extreme Heat Events. http://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf

[51] Ibid

[52] Department of Homeland Security Federal Emergency Management Agency. Ready: Prepare. Plan.Stay Informed: Extreme Heat. www.ready.gov/heat

or homeless individuals have an elevated risk of heat-related health problems.[53] Extreme heat conditions can be exacerbated by poor air quality, stagnant atmospheric conditions, and urbanized areas with expanses of asphalt and concrete which create an "urban heat island" that stores heat longer and releases it more gradually.[54]

ABAG *Risk Landscape* provides the following overview of extreme heat in the Bay Area:

> *The Bay Area has historically experienced 4 extreme heat days a year.[55] Depending on low and high emission scenarios, and the location within the region, in the future a city may experience an average of anywhere from 20 to 80 extreme heat days in a year. Cal-Adapt, California's database of climate data and visualization tools provides five different ways to define the extreme heat hazard: (1) number of extreme heat days by year, (2) number of warm nights by year, (3) number of heat waves by year (heat wave is defined as 5 consecutive extreme heat days), (4) timing of extreme heat days by year (i.e. which months do extreme heat hazards occur), (5) the maximum duration of heat wave by year. These metrics are projecting both the intensity and the temporal nature of extreme heat.*
>
> *<u>Intensity</u>*
> *The intensity of extreme heat is defined differently for each location in the region. In San Francisco County an extreme heat day is defined as a day above 78°, while for inland portions of Solano County extreme heat is defined as a day above 100°. The threshold is the 98th percentile historic maximum temperature. The threshold is set locally to recognize services and buildings in cooler climates may not be designed to handle moderate heat, while those areas where high heat has always been an occurrence, already have measures to address their historic temperatures.*
>
> *In addition to the number of extreme heat days expected to rise in the Bay Area, the temperature is expected to increase well above thresholds over the next century. In San Francisco County by the end of the century there could be multiple days a year where temperatures reach 95°, while in Solano County there may be multiple days above 115° each year.*

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[53] Department of Health and Human Services, Centers for Disease Control and Prevention. Climate Change and Extreme Heat Events. http://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf

[54] Department of Homeland Security Federal Emergency Management Agency. Ready: Prepare. Plan.Stay Informed: Extreme Heat. www.ready.gov/heat

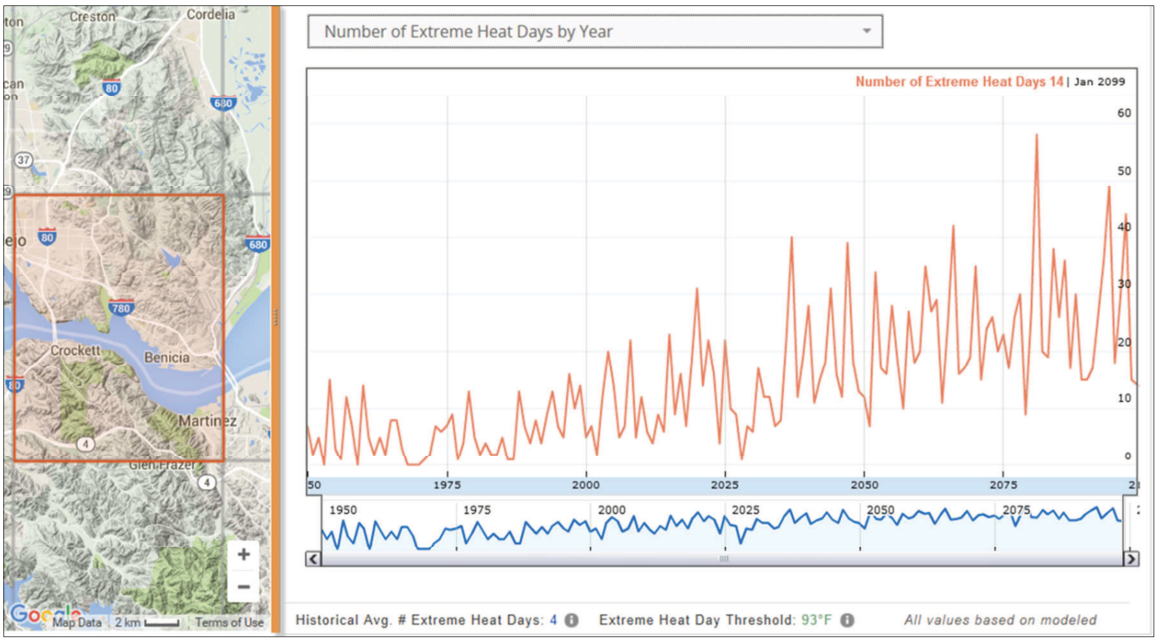
[55] Cayan, D., et al. (2009). Climate Change Scenarios and Sea Level Rise Estimates for California - 2008 Climate Change Scenarios Assessment - Final Report. Scripps Institution of Oceanography - California Nevada Application Program. http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-014-F

<u>Temporal</u>

Extreme heat is made worse when it is experienced over a longer stretch of time. The number of heat waves (five or more consecutive days of extreme heat) will increase as will the length of heat waves.[56] By the end of the century most of the region will average six heat waves a year, with the average longest heat wave lasting ten days. In addition to the more frequent occurrence and duration of heat waves, they are expected to occur in months the region historically hasn't experienced extreme heat. Historically, extreme heat occurs between July and August, but in the future extreme heat will be an issue the region faces in both the Spring and Fall.[57]

Cal-Adapt has prepared maps that depict historic and projected extreme heat and heat wave events. Figure 5.24 displays a count of the number of days that Benicia is projected to exceed a calculated "extreme heat threshold" of 93° for each year 1950-2099. In 2015, Benicia experienced 23 extreme heat days. The historical average (1961-1990) is four extreme heat days per year.[58]

Figure 5.24: Extreme Heat Days by Year 1950 - 2009



Source: Cal-Adapt, www.cal-adapt.org/temperature/heat

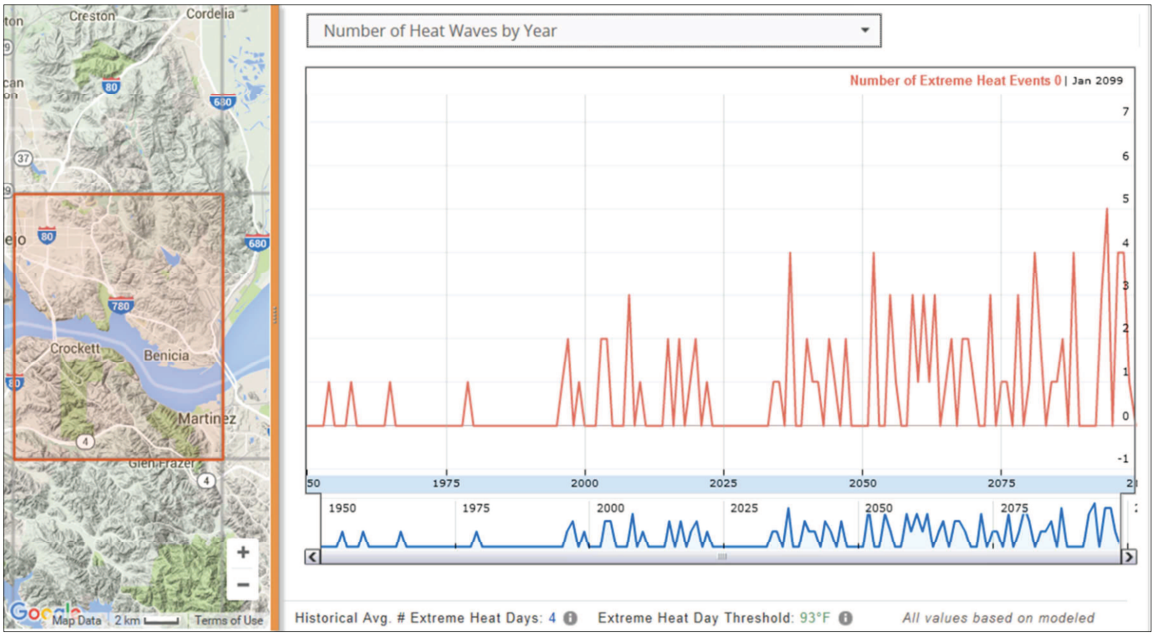
[56] Ibid.

[57] California Climate Change Center (2006). Our Changing Climate: Assessing the Risks to California. A Summary Report from the California Climate Change Center http://meteora.ucsd.edu/cap/pdffiles/CA_climate_Scenarios.pdf

[58] California Energy Commission Cal-Adapt. Temperature: Extreme Heat Tool www.cal-adapt.org

Figure 5.25 depicts the number of 5-day heat waves that Benicia is has historically seen and is projected to experience for each year 1950-2099. Each 5 day-period exceeding the extreme heat threshold is counted as one heat wave; therefore, a 20 day heat wave would result in 4 counted periods.[59]

Figure 5.25: Extreme Heat Days by Year 1950 - 2009



Source: Cal-Adapt, www.cal-adapt.org/temperature/heat

Historic Occurrences

ABAG *Risk Landscape* provides a summary of historic extreme heat occurrences in the Bay Area:

> *No heat emergencies in California have been declared a disaster at the state or federal level between 1960 and 2008.[60] The Spatial Hazard Events and Loss Data for the United States estimates approximately 47 heat events in California during this time. In 2006 a notable heat wave spread throughout most of the United States and Canada, causing 140 fatalities in California.[61]*

[59] Ibid
[60] State of California Multi-Hazard Mitigation Plan, California Governor's Office of Emergency Services, http://hazardmitigation.calema.ca.gov/docs/SHMP_Final_2013.pdf
[61] Ibid

Probability of Future Extreme Heat

The Climate Change Vulnerability Assessment Report Summary (2014) details projected temperature changes for Benicia by the end of the century. The findings of this report are excerpted below:[62]

> *Over the next 30 or so years, temperatures in Benicia are projected to climb. While the average temperature will only increase by a few degrees, Benicia may experience up to two months (54-66 days) of temperatures over 92 °F. Historically, temperatures have only reached this threshold on the hottest five percent of days (18 days) per year. Looking out to the end-of-century time frame, these temperatures may occur even more frequently—62 to 101 days per year.*
>
> *Table 1 displays annual temperature statistics. In order to avoid idiosyncrasies in the weather of any given year, the results display the average of a 49 year time frame. Temperature projections are derived from the World Climate Research Programme's Fifth Coupled Model Intercomparison Project (CMIP5). CMIP5 averages the projections of many climate models under different future greenhouse gas emissions scenarios. ICF used the CMIP Climate Data Processing Tool, soon to be available on the US Department of Transportation (DOT) website, to process the model outputs into variables that are more useful for planning and engineering.*

Table 5.13: Range of Projected Changes in Temperature

Variable	Baseline (1950-1999) *Observed Value*	Mid-century (2046-2065) *Modeled Value*	End-of-century (2080-2099) *Modeled Value*
Average Annual Mean Temperature	59 °F	62 - 63 °F	63 – 67 °F
Hottest Temperature of the Year	102 °F	107 – 108 °F	108 – 112 °F
Average Days per Year > 92.4 °F *	18 days	54 – 66 °F	62 – 101 days
Maximum Number of Consecutive Days per Year above 92.4 °F	5 days	12 – 15 days	13 – 32 days
Average Summer Temperatures	84 °F	88 – 89 °F	89 – 93 °F
Highest 4-Day Average Summer Temperature	98 °F	102 – 104 °F	103 – 107 °F
*95% of days in Benicia have historically fallen below 92.4 °F			

Source: City of Benicia Climate Change Vulnerability Report Summary, 2014

5.1.8 Terrorism

Terrorism is the use or threat of force against persons and/or property to intimidate the population and government in order to achieve a particular political or social objective.

[62] City of Benicia (2014). Climate Change Vulnerability Report Summary.

In the U.S., acts of terror are frequently perceived as being conducted by foreign individuals and groups, but terrorist attacks are also carried out by American citizens. This plan is primarily concerned with natural disasters and this section does not include an in-depth analysis of terrorism. Therefore, the City chose not to include mitigation actions for terrorism.

It is extremely difficult to estimate when and where a terrorist attack will occur. Given the variety of potential targets and the objectives of the terrorists, there is no location that is completely safe from terrorism. Terrorist attacks can be conducted against prominent buildings such as government offices or corporate headquarters, but can also be carried out against lower-profile facilities such as private homes and places of worship. In addition, soft targets, such as schools and day cares, are also potential targets. The California Multi-Hazard Mitigation Plan identifies a number of key statewide pieces of infrastructure that are considered vulnerable to terrorism:

- Water storage and transportation facilities, including dams, canals, and levees
- Transportation infrastructure (roads, airports, railways, bridges, etc.)
- Agricultural operations
- Oil and natural gas facilities, including refineries, shipping terminals, and pipelines
- Electricity generation and transmission/distribution infrastructure
- Seaports
- Chemical manufacturing and storage locations

A number of these facility types are located in Benicia, including the port, refinery, and industrial park.

Historic Occurrences

No acts of terror have occurred in recent decades in the region surrounding Benicia, however, there are indicators of terrorist activities in California. Nonetheless, law enforcement agencies in the Bay Area work to prevent and prepare for terrorist attacks. This is consistent with other cities and regions throughout the U.S. who understand the potential impacts due to recent high-profile, international attacks, such as those in Paris and Brussels in 2015 and 2016.

Probability of Future Terrorism Events

Unlike many of the natural hazards profiled in this plan, it is not possible to estimate the risk of a terrorist attack occurring. Further analysis would be beneficial. Prioritization of terrorism readiness efforts through the identification of critical sites and emergency response protocols helps identify and remedy vulnerabilities to such attacks.

6. Mitigation & Adaptation Strategy

6.1 Introduction & Mission Statement

Benicia strives to be a disaster-resilient community. It is our mission to prepare for, survive, recover from, and thrive after a disaster while maintaining the quality of life our residents enjoy. We envision a community in which the people, buildings, and infrastructure, in and serving Benicia, are resilient to disasters; City government provides critical services in the immediate aftermath of a devastating event of any kind; and basic government and commercial functions resume as quickly as possible after a damaging earthquake or other significant event.

Disaster mitigation reduces or eliminates long-term risks to people and property from hazards and their effects, and/or provides passive protection at the time of disaster impact. Disaster mitigation is a foundational element of disaster resilience.

6.2 Analysis of Mitigation Measures

The Mitigation Action Plan was developed through an analysis of Benicia's hazard risks, participation from local stakeholders, and the extent to which mitigations can be achieved in a five-year time horizon. Most selected mitigations align with established policies and programs (ex: implementation of the Urban Waterfront Master Plan), while others represent new policies or initiatives. While cost is a consideration in terms of overall feasibility, it was not the determinative factor in the selection or prioritization of mitigation tasks. The Local Hazard Mitigation is to serve as a point of reference in identifying budget priorities, developing a capital improvement plan, and seeking grant funding for eligible activities in the future five years.

6.3 Mitigation Goals

The goal of the Local Hazard Mitigation Plan is to maintain and enhance a disaster-resistant region by reducing the potential for loss of life, property damage, and environmental degradation from natural disasters, while accelerating economic recovery from those disasters. This goal is unchanged from the 2005 plan and continues to be the goal of the City of Benicia in designing its mitigation program. Among the goals of the city, as expressed in its General Plan – Community Health and Safety Element (1999) are to:

1. Minimize harm from geologic hazards
2. Accommodate runoff from existing and future development
3. Prevent property damage caused by flooding
4. Reduce fire hazards

6.4 Mitigation Action Plan

This plan advocates 20 mitigation actions. Table 5.13 summarizes all of the actions, identifies the hazard(s) and mitigation objective(s) each action addresses, and indicates the assigned priority level of the action.

Table 5.13: Mitigation Action Plan

High Priority Strategies			
1. Urban Water Management Plan The Department of Water Resources requires water utilities to prepare an Urban Water Management Plan update every five years. Urban Water Management Plans (UWMPs) are prepared by California's urban water suppliers to support their long-term resource planning, and ensure adequate water supplies are available to meet existing and future water demands.			
Hazard Drought	*Funding Source* Internal Water Fund	*Estimated Timeline* 2016 (Due to DWR on 7/1/2016; Required to update every 5 years)	*Responsible Party* Public Works Department
2. Evaluate Public Safety Communications Infrastructure including Radio Communications Hire a consultant to conduct an assessment			
Hazard Multiple	*Funding Source* Internal and/or grant	*Estimated Timeline* 2016-2017	*Responsible Party* Police Department & Fire Department
3. Vulnerability Assessment of the City's Police Station to Groundshaking Police Department is identified as Critical Facility. Assessment will be outsourced to qualified structural engineer.			
Hazard Earthquake	*Funding Source* $50,000 - $100,000 grant possibly from Cal EMA	*Estimated Timeline* 2017-18; start looking for grant opportunities	*Responsible Party* Police Department
4. Urban Waterfront Enhancement Master Plan The Master Plan was adopted by City Council in November 2014. Funding is sought for detailed design and engineering and permitting, with phased construction to follow.			
Hazard Flooding	*Funding Source* California Coastal Conservancy, Active Transportation program, Prop 1 Grants, Measure AA	*Estimated Timeline* Detailed design, engineering and permitting will begin when funding is available, expected to take appx. 12 months. Construction will be completed in phases over appx. 10 years.	*Responsible Party* Parks & Community Services

5. Post Emergency Inspection and Plan Check Protocols

Develop protocols for building official and inspectors to conduct post-emergency inspections of damaged structures. Criteria for documentation of building condition, "tagging", and occupancy will be outlined. Methods to ensure timely repair will be established. Develop a process for expedited plan check and permitting for emergency repairs involving Planning, Building, Public Works and Fire.

Consider development of a repair and reconstruction ordinance to ensure that damaged buildings are repaired in an appropriate and timely manner and retrofitted concurrently.

Hazard	*Funding Source*	*Estimated Timeline*	*Responsible Party*
Multiple Hazards	Internal	2017-2018	Community Development Department

6. Critical Facilities, Vulnerable Building Types & Infrastructure Mapping for Hazard Identification

Add updated hazards information to the City's GIS infrastructure, presently GIS Online. Conduct parcel-based mapping of critical facilities, field assessment of vulnerable building types (soft story, tilt up concrete, unreinforced masonry, etc.). Map and survey critical and vulnerable infrastructure assets

Hazard	*Funding Source*	*Estimated Timeline*	*Responsible Party*
Multiple	FEMA Hazard Mitigation Grant; General Fund	2018-2020	Community Development Department and Public Works Dept.

Medium Priority Strategies

7. Natural Gas Shut-Off Valve Ordinance

Draft an ordinance to require natural gas shut-off valves for new construction and major remodels/additions.

Hazard	*Funding Source*	*Estimated Timeline*	*Responsible Party*
Earthquake	Internal	2017-18	Community Development Department

8. Stormwater Management and Flood Mitigation Plan

Evaluate flooding and strategies for stormwater management / flood mitigation in the Sulphur Springs Creek area (Industrial Park) and in the vicinity of East 2nd Street and East B Street (Downtown).

Hazard	*Funding Source*	*Estimated Timeline*	*Responsible Party*
Flooding	Measure C	2017-2018	Public Works Department - Engineering

9. Creation of a complete plan and subsequent training and evaluation of the vulnerability of the community to an active shooter or terrorist event creating mass casualties.

Create working team to draft implementation plan.

Hazard	*Funding Source*	*Estimated Timeline*	*Responsible Party*
Terrorism	Internal	2017-2018	Police Department

10. Evaluation of Jurisdictional Ordinances and Programs for Earthquake Retrofit of Unreinforced Masonry Structures

Evaluate programs and regulations of Bay Area and statewide jurisdictions related to compulsory retrofit of unreinforced masonry structures, including issues related to expected compliance and enforcement. Evaluate the local impact and need for such an ordinance in Benicia.

Hazard	*Funding Source*	*Estimated Timeline*	*Responsible Party*
Earthquake	Internal	2018-2020	Community

			Development
11. Defensible Space Program - Site Specific Assessment			
Hazard Wildfire	*Funding Source* Internal	*Estimated Timeline* 2017-18	*Responsible Party* Fire Department
12. Water Reuse Project Prepare a feasibility study and environmental documents for the project that would further treat Wastewater Treatment Plant effluent to tertiary recycled water standards and provide recycled water to Valero Benicia Refinery for use in cooling towers. If constructed, this project could reduce the City's need for imported water by more than 20%, allowing the banking of water during wet years for use in future droughts.			
Hazard Drought	*Funding Source* Hasn't been determined; internal and external funding sources	*Estimated Timeline* 2019 - Complete Construction (pending 2016 feasibility study results and funding identification)	*Responsible Party* Public Works Department
Low Priority Strategies			
13. Turf Analysis (Parks, Trails, and Open Space Master Plan Update) Funding being sought to update the City's 1997 Parks, Trails & Open Space Master Plan. That plan process will include a comprehensive assessment of water-intensive turf throughout the City's parks system. Where usage does not justify continued turf maintenance, a variety of low water retrofits will be considered to retain high service levels with a lower water footprint.			
Hazard Drought	*Funding Source* City General Fund, Solano County Water Authority Prop 1 programs	*Estimated Timeline* 2016-2017	*Responsible Party* Parks & Community Services
14. Storm Ready Community - National Weather Service			
Hazard Flood	*Funding Source* Internal Funding	*Estimated Timeline* 2016-2017	*Responsible Party* Fire Department; CDD and PW will be involved
15. Flood Fighting Training – Department of Water Resources			
Hazard Flood	*Funding Source* Grant funding through DWR	*Estimated Timeline* 2016-2017 and continue on	*Responsible Party* Fire Department; Public Works, Parks, and Police Dept.
16. Develop Operational Guidelines for Cooling Centers			
Hazard Extreme Heat	*Funding Source* Internal	*Estimated Timeline* 2017-2018	*Responsible Party* Fire Department
17. Urban Interface Ordinance			
Hazard Wildfire	*Funding Source* Internal	*Estimated Timeline* 2018-19	*Responsible Party* Fire Department

18. Increase Community Preparedness Conduct outreach and provide information to residential areas in the downtown and east of downtown regarding emergency preparation, building safety, and evacuation procedures. This includes outreach to hazard prone areas.			
Hazard	*Funding Source*	*Estimated Timeline*	*Responsible Party*
Multiple Hazards	Internal/Grant funding	2019	Fire, Community Development, others
19. Expand Training Program for City Staff of Emergency Operations Center			
Hazard	*Funding Source*	*Estimated Timeline*	*Responsible Party*
Multiple Hazards	Internal	On-going	Fire Department
20. Public Education – Water Conservation			
Hazard	*Funding Source*	*Estimated Timeline*	*Responsible Party*
Drought	Water Fund and Solano County Water Agency	Ongoing	Public Works Department

7. Plan Maintenance Procedures

7.1 Implementation, Updating and Enhancement

On June 2, 2015, the City Council adopted the FY 2016 and FY 2017 Biennial Budget, which included the Budget Implementation Plan and Priority Projects. Many actions outlined in this Mitigation Strategy have already been integrated into the Budget Implementation Plan and Priority Projects.

For upcoming budget cycles, the Fire Department will work with Department leaders to further incorporate funded actions from this Mitigation Strategy into the Budget Implementation Plan and Priority Projects. City staff indicated under “Lead Organizations/Departments and Staff Leads” will be responsible for further developing the project plans, schedules and budgets outlined for actions in the Mitigation Strategy.

Additionally, each year, the City assesses potential capital improvement projects and available funding as it implements its Capital Improvement Plan. Capital Improvement actions in this Plan will be assessed as part of this annual process. Implementation of many of these actions will be dependent on outside funding sources.

Per Federal regulations, this Plan must be updated once every five years. To ensure future compliance with these regulations, the 2020 mitigation strategy meeting will commence the comprehensive process to create the 2021 Plan update. This process will be similar to the annual mitigation strategy update process defined above, but will be expanded to address all sections of the Plan:

1. City staff may consult, if deemed necessary, with scientists and hazard experts to conduct a thorough evaluation and update of this Plan’s hazard analysis. The

update will include any new scientific research about Benicia's hazards, the city's exposure and vulnerabilities, as well as a thorough review of all loss estimates.
2. City staff will measure and report progress on actions.
3. Items 1 and 2 together will inform the assessment of the updated mitigation strategy.
4. City staff will assess incomplete actions to determine if they should be removed, retained or rewritten
5. City staff will propose new actions for the updated Plan.
6. City staff will perform another community review process, including input opportunities for institutional community partners and individual members of the public.
7. City staff will incorporate appropriate public feedback and will conduct an outreach and adoption process, involving City commissions and City Council.

7.2 Monitoring

The Fire Department will coordinate monitoring, evaluation and updates to the mitigation plan on an annual basis within the five-year cycle. The City currently utilizes a process for monitoring and evaluating General Plan Implementation, requiring lead departments to update the status of their programs. At the beginning of each calendar year, the same process will be used for the LHMP, requiring lead staff to address the City's overall progress on this Mitigation Strategy, including to:

- Provide qualitative and quantitative performance data related to actions
- Identify any necessary changes to existing Plan actions
- Identify new Plan actions to be incorporated into the Strategy

7.3 Plan Amendments

Per Federal regulations, this Plan must be updated once every five years. To ensure future compliance with these regulations, the 2018 mitigation strategy meeting will commence the comprehensive process to create the 2019 Plan update. This process will be similar to the annual mitigation strategy update process defined above, but will be expanded to address all sections of the Plan:

1. City staff may consult, if deemed necessary, with scientists and hazard experts to conduct a thorough evaluation and update of this Plan's hazard analysis. The update will include any new scientific research about Benicia's hazards, the city's exposure and vulnerabilities, as well as a thorough review of all loss estimates.
2. City staff will measure and report progress on actions since the Plan's inception.
3. Items 1 and 2 together will inform the assessment of the updated mitigation strategy.

4. City staff will assess incomplete actions to determine if they should be removed, retained or rewritten
5. City staff will propose new actions for the updated Plan.
6. City staff will perform another community review process, including input opportunities for institutional community partners and individual members of the public.
7. City staff will incorporate appropriate public feedback and will conduct an outreach and adoption process, involving City commissions and City Council.

7.4 Continued Public Involvement

The City has created and will maintain the City of Benicia Mitigation webpage (*www.ci.benicia.ca.us/Mitigation*) and email address *Mitigation@Benicia.org.* Community members will be able to submit feedback during the implementation of this plan through this website and email address.

Additionally, community members are able to write and mail or hand-deliver feedback to the City Manager's Office or Fire Department at any time. The City will also its website and social media (Facebook & Twitter) as a means of reporting implementation progress to the community.