RESOLUTION NO. 69,236-N.S.

ADOPT THE LOCAL HAZARD MITIGATION PLAN (LHMP)

WHEREAS, the Council adopted the Disaster Mitigation Plan on June 22, 2004; and

WHEREAS, the Plan was updated in 2014; and

WHEREAS, the 2014 Plan has expired; and

WHEREAS, the adoption of a current LHMP as an appendix to the Disaster Preparedness and Safety Element of the City's General Plan will maintain the City's compliance with 44 CFR Part 201, Section 201.6, and Government Code 65302.6 requirements, and associated eligibility for mitigation grant funding; and

WHEREAS, City staff has collaborated with numerous partner representatives, scientists and hazard experts to develop a First Draft Plan; and

WHEREAS, from December 18, 2018 through February 28, 2019, the community and all City commissions and boards were invited to provide feedback on the First Draft Plan, and these comments were reviewed and incorporated into the Final Draft 2019 LHMP; and

WHEREAS, at its meeting on June 11, 2019, the State of California Board of Forestry and Fire Protection reviewed the Final Draft LHMP and the Disaster Preparedness and Safety Element of the General Plan and determined that they met requirements of Government Code 65302.5; and

WHEREAS, on September 20, 2019, the Federal Emergency Management Agency determined the Final Draft Plan to be eligible for final approval pending its adoption by the Berkeley City Council; and

WHEREAS, on October 23, 2019, the Disaster and Fire Safety Commission reviewed the Final Draft 2019 LHMP and voted unanimously to recommend adoption of the LHMP; and

WHEREAS, on November 6, 2019, the Planning Commission held a duly noticed Public Hearing to consider public input and comment on the Final Draft LHMP and to consider changes to the Disaster Preparedness and Safety Element of the General Plan to update the LHMP reference in the General Plan; and

WHEREAS the Planning Commission voted to recommend adoption of the LHMP;

NOW THEREFORE, BE IT RESOLVED by the Council of the City of Berkeley that the Local Hazard Mitigation Plan is hereby adopted, as shown in Exhibit A.

The foregoing Resolution was adopted by the Berkeley City Council on December 10, 2019 by the following vote:

Ayes: Bartlett, Droste, Hahn, Kesarwani, Robinson, Wengraf, and Arreguin.

Noes: None.

Absent: Davila and Harrison.

Jesse Arreguin, Mayor

Attest:

Mark Numainville, City Clerk

City of Berkeley

2019 Local Hazard Mitigation Plan

Final Draft

September 19, 2019

Acknowledgements

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Executive Summary

Berkeley is a vibrant and unique community. But every aspect of the city – its economic prosperity, social and cultural diversity, and historical character – could be dramatically altered by a disaster. While we cannot predict or protect ourselves against every possible hazard that may strike the community, we can anticipate many impacts and take steps to reduce the harm they will cause. We can make sure that tomorrow's Berkeley continues to reflect our current values.

City government and community members have been working together for years to address certain aspects of the risk – such as strengthening structures, distributing disaster supply caches, and enforcing vegetation management measures to reduce fire risk. The 2004 Disaster Mitigation Plan formalized this process, ensuring that these activities continued to be explored and improved over time. The 2014 Local Hazard Mitigation Plan continued this ongoing process to evaluate the risks that different hazards pose to Berkeley, and to engage the community in dialogue to identify the most important steps that the City and its partners should pursue to reduce these risks. Over many years, this constant focus on disasters has made Berkeley, its residents and businesses, much safer.

The federal Disaster Mitigation Act of 2000 (DMA 2000) calls for all communities to prepare mitigation plans. The City adopted a plan that met the requirements of DMA 2000 on June 22, 2004, and an update on December 16, 2014. This is the 2019 update to that plan, called the 2019 Local Hazard Mitigation Plan (2019 LHMP).

Plan Purpose

The 2019 LHMP serves three functions:

1. The 2019 LHMP documents our current understanding of the hazards present in Berkeley, along with our vulnerabilities to each hazard – the ways that the hazard could impact our buildings, infrastructure, community, and environment.
2. The document presents Berkeley City government's Mitigation Strategy for the coming five years. The Mitigation Strategy reflects a wide variety of both funded and unfunded actions, each of which could reduce the Berkeley's hazard vulnerabilities.
3. By fulfilling requirements of the DMA 2000, the 2019 LHMP ensures that Berkeley will remain eligible to apply for mitigation grants before disasters, and to receive federal mitigation funding and additional State recovery funding after disasters.

Plan Organization

Unlike prior versions of the plan, the 2019 LHMP has been structured to specifically address DMA 2000 requirements. The 2019 LHMP is organized as follows:

Element A: Planning Process

This section of the 2019 LHMP describes the process used to develop the document, including how partners, stakeholders, and the community were engaged. It also addresses the City's approach to maintaining the 2019 LHMP over the five-year planning cycle.

Element B: Hazard Analysis
This section of the 2019 LHMP outlines the different hazards present in Berkeley. Analysis of each hazard includes the areas of Berkeley with exposure to the hazard, the potential impacts of each hazard, and Berkeley's vulnerabilities to each hazard.

Element C: Mitigation Strategy
The Mitigation Strategy section first documents the authorities, policies, programs, and resources that the City brings to bear in implementing mitigation actions. Second, this section outlines a comprehensive range of specific mitigation actions and projects designed to reduce Berkeley's hazard vulnerabilities. This section also describes how the 2019 LHMP is integrated with other City plans.

Element D: Plan Review, Evaluation, and Implementation
This section describes how changes in development have influenced updates to the 2019 LHMP. It also provides a detailed description of Berkeley's progress on the Mitigation Strategy proposed in 2014.

Element E: Plan Adoption
This section will be used to document formal adoption of the Final Draft 2019 LHMP by the Berkeley City Council.

In the pages that follow, this Executive Summary describes highlights from Element B: *Hazard Analysis* and Element C: *Mitigation Strategy*, as well as any key updates that were made to the section since the 2014 version.

Element B: Hazard Analysis

To become disaster resilient, a community must first understand the existing hazards and their potential impacts. Berkeley is exposed to a number of natural and human-caused hazards that vary in their intensity and impacts on the city. This mitigation plan addresses six natural hazards: earthquake, wildland-urban interface (WUI) fire, flood, landslide, and tsunami. Each of these hazards can occur independently or in combination, and can also trigger secondary hazards.

Although this plan is focused on natural hazards, four human-caused hazards of concern are also discussed: hazardous materials release, climate change,[1] extreme heat events, and terrorism. They are included because of their likelihood of occurrence and the magnitude of their potential consequences, as outlined in the table below.

Table 1. Summary of Hazard Analysis

Hazard	Likelihood	Severity of Impact
Earthquake	Likely	Catastrophic
Wildland-Urban Interface Fire	Likely	Catastrophic
Rainfall-Triggered Landslide	Likely	Moderate
Floods	Likely	Minor
Tsunami	Possible	Moderate
Climate Change	Likely	Moderate to Catastrophic*
Extreme Heat	Likely	Moderate to Catastrophic*

**Consequence levels for climate change and extreme heat depend highly on the success of global climate mitigation over the coming decades. If greenhouse gas emissions are significantly reduced, and carbon sequestration is increased, impacts may be moderate. If emissions remain steady at present levels or even increase, consequences may increase to catastrophic, although effects will differ widely over the globe.*[23]

Hazardous materials release is described only as a cascading impact of a natural hazard. Because this plan focuses on natural hazards as emphasized in DMA 2000, likelihood and consequence levels for hazardous materials release and terrorism are not defined.

Hazards of Greatest Concern

Earthquake

We do not know when the next major earthquake will strike Berkeley. The United States Geological Survey states that there is a 72% probability of one or more M 6.7 or greater earthquakes from 2014 to 2043 in the San Francisco Bay Region.[4] There is a 33% chance that a 6.7 or greater will occur on the Hayward fault system between 2014 and 2043.[5] This means that many Berkeley residents are likely to experience a severe earthquake in their lifetime.

A catastrophic earthquake on the Hayward Fault would cause severe and violent shaking and three types of ground failure in Berkeley. Surface fault rupture could occur in the Berkeley hills along the fault, damaging utilities and gas lines that cross the fault. Landslides are expected in the Berkeley hills during the next earthquake, particularly if the earthquake occurs during the rainy winter months. Landslide movement could range from a few inches to tens of feet. Ground surface displacements as small as a few inches are enough to break typical foundations. Liquefaction is very likely in the westernmost parts of the city and could occur in much of the Berkeley flats. Liquefaction can destroy pavements and dislodge foundations.

Shaking and ground failure is likely to create impacts that ignite post-earthquake fires. Firefighting will be simultaneously challenged due to broken water mains and damage to electrical, transportation, and communication infrastructure.

In a 6.9 magnitude earthquake on the Hayward Fault, the City estimates that over 600 buildings in Berkeley will be completely destroyed and over 20,000 more will be damaged. One thousand to 4,000 families may need temporary shelter. Depending on the disaster scenario, one hundred people could be killed in Berkeley alone, and many more would be injured. Commercial buildings, utilities, and public roads will be disabled or destroyed. This plan estimates that building damage in Berkeley alone could exceed $2 billion, out of a multi-billion dollar regional loss, with losses to business activities and infrastructure adding to this figure.

Low-income housing units are expected to be damaged at a higher rate than other residences. Other types of housing, such as condominiums, may replace them when land owners rebuild. This could lead to profound demographic shifts in Berkeley.

Wildland-Urban Interface Fire

Berkeley is vulnerable to a wind-driven fire starting along the city's eastern border. The fire risk facing the people and properties in the eastern hills is compounded by the area's mountainous topography, limited water supply, minimal access and egress routes, and location, overlaid upon the Hayward Fault. Berkeley's flatlands are also exposed to a fire that spreads west from the hills. The flatlands are densely-covered with old wooden buildings housing low-income and vulnerable populations, including isolated seniors, people with disabilities, and students.

The high risk of wildland-urban interface (WUI) fire in Berkeley was clearly demonstrated in the 1991 Tunnel Fire, which destroyed 62 homes in Berkeley and more than 3,000 in Oakland. Accounts of major wildfires in Berkeley date back to at least 1905 when a fire burned through

Strawberry Canyon and threatened the University campus and the small Panoramic Hill subdivision. Other major fires occurred in the 1970s and 1980s.

In 1923, an even more devastating fire burned through Berkeley. It began in the open lands of Wildcat Canyon to the northeast and, swept by a hot September wind, penetrated residential north Berkeley and destroyed nearly 600 structures, including homes, apartments, fraternities and sororities, a church, a fire station and a library. The fire burned downhill all the way to Shattuck Avenue in central Berkeley.[6]

If a fire occurred today that burned the same area, the loss to structures would be in the billions of dollars.[7] Destruction of contents in all of the homes and businesses burned would add hundreds of millions of dollars[8] to fire losses. Efforts to stabilize hillsides after the fire to prevent massive landslides would also add costs. Depending on the speed of the fire spread, lives of Berkeley residents could also be lost. Many established small businesses, homes, and multi-family apartment buildings, particularly student housing, would be completely destroyed, changing the character of Berkeley forever.

Natural Hazards of Concern

This plan identified three additional natural hazards of concern: rainfall-triggered landslide, floods, and tsunami. These hazards could cause significant damage and losses in Berkeley. However, unlike earthquake and WUI fire, their impacts are likely to be smaller, and confined to specific areas.

Rainfall-Triggered Landslide

Berkeley has a number of deep-seated landslides that continuously move, with the rate of movement affected by rainfall and groundwater conditions. Significant localized areas of the Berkeley hills face risk from landslide, and a major slide could endanger lives and impact scores of properties, utilities and infrastructure.

Floods

Floods also could damage property and cause significant losses in Berkeley. Flooding can occur when stormwater exceeds the capacity of a creek channel, or the capacity of the storm drain system. Creek flooding in Berkeley has the potential to affect about 675 structures, mainly in the western, industrial area of the city. It is unlikely that floodwaters will reach higher than three feet, but damages to homes, businesses, and their contents could total over $160 million. Storm drain overflow creates localized flooding in many known intersections in Berkeley. With few properties covered by flood insurance, these costs would be borne primarily by Berkeley residents and businesses.

Tsunami

Tsunamis, though rare inside the San Francisco Bay, can occur from large offshore subduction style earthquakes around the Pacific Rim. Small, local tsunamis can also result from offshore strike-slip Faults such as parts of the San Andreas Fault of the Peninsula and the Hayward Fault through San Pablo Bay. The March 2011 Japan earthquake generated a devastating tsunami, which reached the Bay Area and caused minor damage to docks and floats in the Berkeley Marina. A larger tsunami could impact much more of Berkeley's western shores. Buildings, infrastructure, and roadways could be damaged, and debris and hazardous materials could cause post-tsunami fires. Deaths are possible if individuals choose not to evacuate hazardous areas, do not understand tsunami warnings, or are unable to evacuate.

Manmade Hazards of Concern

While the focus of the 2019 LHMP is on natural hazards as emphasized in the Disaster Mitigation Act of 2000 (DMA 2000),[9] the plan provides analysis of four manmade hazards of concern. Climate change is described because its impacts are likely to exacerbate the natural hazards of concern identified in the plan. The 2019 LHMP specifically addresses the hazard of extreme heat events because they are projected to increase exponentially in the next century as climate change continues. Hazardous materials release is addressed in this mitigation plan as a potential impact from a natural hazard. Terrorism is identified as a hazard of concern but is not analyzed in-depth.

Climate Change

Like regions across the globe, the San Francisco Bay Area is already experiencing negative impacts of climate change. These impacts will continue to grow in intensity and will disproportionately affect communities such as the elderly, children, people with disabilities, and people with low incomes.

The severity of these impacts will depend on the amount of greenhouse gas emissions produced worldwide over the coming decades. Mitigation of further emissions will reduce Berkeley's exposure to climate change. Berkeley's Climate Action Plan[10] identifies the City's plan for emissions reductions, known as climate change mitigation. Simultaneously, we are already experiencing climate change impacts that will intensify over time—including sea level rise, prolonged poor air quality from wildfires, drought, severe storms, and extreme heat – so it is also critical that Berkeley adapt to current and projected impacts in order to protect Berkeley's community, infrastructure, buildings, and economy, known as climate change adaption.

Climate change will have direct impacts and will also exacerbate the natural hazards of concern outlined in this plan. Rising sea levels have the potential to impact infrastructure and community members in west Berkeley and the Berkeley waterfront. This will increase Berkeley's exposure to tsunami inundation and to flooding of critical infrastructure in these areas, which includes sanitary sewers, state highways, and railroad lines. Increased temperatures, when coupled with prolonged drought events, can increase the intensity of wildfires that may occur, and pose significant health and safety risks to people. By 2100, most of the Bay Area will average six heat waves per year, each an average length of ten day.[11] Shorter, more intense wet seasons will make flooding more frequent, and may increase the landslide risk in the Berkeley hills. California may experience greater water and food insecurity, and drought will become a more persistent issue as the effects of climate change deepen.

Extreme Heat Events

Multiple factors contribute to the extreme heat hazard, including very high temperatures, nights that do not cool down, consecutive days of extreme heat, and extreme heat during unexpected times of the year. Extreme heat events impact public health, increase fire risk, damage critical facilities and infrastructure, and worsen air quality.

Social factors play a key role in vulnerability to extreme heat events, meaning that people with disabilities, chronic diseases, the elderly, and children under five are the most at risk to heat-related illnesses.[12] Across California, the highest risk of heat-related illness occurs in the typically cooler regions found in coastal areas like Berkeley.

Projections indicate that the number of extreme heat days, warm nights, and heat waves will increase exponentially: by 2099, the City of Berkeley is expected to average 18 days per year with temperatures over 88.3 degrees F.

Hazardous Materials Release

Over the last 25 years, Berkeley has seen a more than 90 percent reduction in the number of facilities with extremely hazardous materials. The City carefully tracks hazardous materials within its borders, and works closely with companies using large amounts of potentially dangerous materials. The City has identified fifteen facilities in Berkeley with sufficiently large quantities of toxic chemicals to pose a high risk to the community. Hazardous materials also travel through Berkeley by truck and rail. Natural hazards identified in the plan could trigger the release of hazardous materials.

Terrorism

It is not possible to estimate the probability of a terrorist attack. Experts prioritize terrorism readiness efforts by identifying critical sites and assessing these sites' vulnerability to terrorist City officials are currently working with State and regional groups to prevent and prepare for terrorist attacks.

Access and Functional Needs

This plan recognizes that there are many individuals that are still disproportionately vulnerable during disasters. People with access and functional needs are defined as community members who may have additional needs before, during and after an incident in functional areas, including but not limited to: maintaining independence, communication, transportation, supervision, and medical care. Individuals in need of additional response assistance may include those who have disabilities, live in institutionalized settings, are elderly, are children, are from diverse cultures, have limited English proficiency, or are non-English speaking, or are transportation disadvantaged. An individual with a disability is defined by the ADA as a person who had a physical or mental impairment that substantially limits one or more major life activities, a person who has a history or record of such an impairment, or a person who is perceived by others as having such an impairment. The ADA does not specifically name all of the impairments that are covered.

Summary of Changes to the Hazard Analysis

The 2019 LHMP contains numerous updates to facts, figures, and descriptions. The City has incorporated the newest-available hazard data, including impact maps for particular scenarios. The City and its partners have provided additional descriptions, details and definitions to explain the science of these hazards and their potential impacts. Advances in GIS mapping technology have enabled the City to present maps that help to visualize information.

Institutional community partners have updated information regarding their vulnerabilities to the described hazards, as well as significant mitigation activities that they have completed, are in progress, or planned for the coming five years.

Within the historical section for each hazard, the City has added information about any instances of the hazard affecting Berkeley since 2014. Throughout the plan, the City has updated financial loss estimates for inflation.

Hazards Described in the 2014 Plan

For the first time, the plan identifies extreme heat events as a hazard of concern. Significant changes and updates to the analysis of each hazard are described below:

Earthquake (Section B.5)

- The 2019 LHMP integrates the 2018 HayWired scenario developed by the USGS to help illustrate the potential impacts of a catastrophic earthquake near Berkeley. The plan now includes five maps with data from the scenario.
- Berkeley's liquefaction hazard is now mapped using both overall levels of susceptibility and probability of liquefaction in the 7.0M HayWired scenario.
- The seismic stability of City-owned and leased buildings has been updated to reflect significant retrofit and rebuilding efforts since 2014.
- The City has updated the plan to describe Berkeley's progress on mitigating earthquake vulnerabilities in privately-owned buildings. Detailed analysis along with three new maps have been provided to describe and illustrate the locations of potentially seismically vulnerable buildings, including unreinforced masonry buildings, soft story buildings, non-ductile concrete buildings, and tilt-up or other rigid-wall flexible diaphragm buildings.
- The Earthquake section includes updated descriptions from Key Institutional Partners about mitigation efforts completed or planned. Updated partner profiles include UC Berkeley, Berkeley Lab, Berkeley Unified School District, East Bay Municipal Utility District, AT&T, and Alta Bates Summit Medical Center.
- Earthquake risk and loss estimates have been updated to integrate regional estimates from the 2018 HayWired earthquake scenario.

Wildland-Urban Interface Fire (Section B.6)

The 2019 LHMP integrates hazardous fire zones as defined by the City of Berkeley and the California Department of Forestry onto one map.

The 2019 LHMP presents a new map overviewing the locations of pedestrian pathways in Berkeley. These pathways are key resources for pedestrian evacuation from wildland-urban interface fire.

Rainfall-Triggered Landslide (Section B.7)
This section has been updated to describe hazard occurrences in Berkeley since 2014.

Floods (Section B.8)
The Floods section has been updated to include newly-revised flood exposure maps for Berkeley from the FEMA National Flood Insurance Program.

Tsunami (Section B.9)
The Tsunami section now includes a map of Tsunami Evacuation Playbook zones. These zones, developed by the California Geological Survey, California Governor's Office of Emergency Services, and the National Ocean and Atmospheric Administration (NOAA), reflect more refined and detailed planning, in which forecasted tsunami amplitudes, storm surge, and tidal information can help guide what areas might be inundated.

The Tsunami section also includes new information about infrastructure vulnerabilities of the Berkeley Marina, based on recent tsunami inundation modeling by the California Geological Survey, University of Southern California, California State Lands Commission, and California Governor's Office of Emergency Services.

Climate Change (Section B.10)
The Climate Change section has been updated to use the latest available science and policy guidance on the direct and secondary impacts of climate change. It describes recent events that demonstrate climate change impacts that we are already experiencing.

The section provides new analysis of amounts of sea-level rise anticipated under different projected carbon emissions scenarios, as well as new maps of expected levels of inundation from 2-ft, 4-ft, and 5.5-ft sea level rise scenarios using the Adapting to Rising Tides Bay Shoreline Flood Explorer.

Extreme Heat Events (Section B.11)
Extreme heat events are a newly-introduced hazard of concern for the 2019 LHMP. The extreme heat events section describes factors that contribute to the extreme heat hazard, and describe how the Urban Heat Island Effect can further exacerbate impacts of extreme heat events. The section outlines the secondary hazards created by extreme heat, including public health impacts, fire, damage to critical facilities and infrastructure, and worsened air quality.

The section also describes the predicted average number of extreme heat days in Berkeley through the end of the century.

Hazardous Materials Release (Section B.12)
The Hazardous Materials Release section contains updated figures on the number of sites with hazardous materials in Berkeley. Additionally, the section has been updated since 2014 to reflect Berkeley industrial sites with large quantities of extremely hazardous materials. These sites have been mapped for reference.

Element C: Mitigation Strategy

Authorities, Policies, Programs and Resources

Through many years of diligent effort by City government and the community, Berkeley has developed many innovative initiatives to increase our disaster resilience. The authorities, policies, programs and resources that Berkeley will use to support execution of the 2019 LHMP Mitigation strategy include:

- The City has strengthened its ability to serve the community during and after disasters by seismically upgrading or replacing buildings that house critical City functions. In 2017, work was completed on the James Kenney Recreation Center and the Center Street Garage. Since 2004 the City has strengthened or rebuilt all seven of the City's fire stations, the historic Ratcliff Building (which houses the Public Works Department Operations Center), the Civic Center (which houses many key government functions), the Public Safety Building, a new animal shelter, and all libraries.
- The Berkeley Unified School District, supported by voter-approved bonds, has strengthened all public schools.
- The City of Berkeley has worked diligently to enhance public safety and reduce physical threats from earthquakes by requiring owners of soft story and unreinforced masonry buildings to retrofit their structures.
    - Berkeley was the first city in the nation to inventory the community's soft-story buildings. In 2014 Berkeley mandated retrofit of soft story buildings with five or more dwelling units. Since then, 61 percent of these identified buildings have had retrofits completed.
    - Over 99% of Berkeley's 700 unreinforced masonry buildings have been retrofitted or demolished since a City mandate began in 1991.
- The City offers a comprehensive suite of programs to encourage the community to strengthen buildings to be more hazard-resistant.
    - In early 2017, the Building and Safety Division developed a new Retrofit Grants program with funding from a Hazard Mitigation Grant from the Federal Emergency Management Agency (FEMA) and the California Governor's Office of Emergency Services (Cal OES).
    - Since July 2002, the City has distributed over $12 million to homeowners through the Transfer Tax Rebate Program, which reduces the real estate transfer tax to building owners who perform seismic safety work.
    - The City participates in the Earthquake Brace + Bolt (EBB) program, a grant program administered by the California Earthquake Authority, providing grants of up to $3,000 for seismic retrofits of owner-occupied residential buildings with 1-4 dwelling units.
- The City, working together with key partners, is using a comprehensive strategy to aggressively mitigate Berkeley's wildland-urban interface (WUI) fire hazard. These approaches include:

  - Prevention through development regulations with strict building and fire code provisions, as well as more restrictive local amendments for new and renovated construction;
  - Enforcement programs including annual inspections of over 1,200 high-risk properties annually;
  - Natural resource protection through four different vegetation management programs;
  - Improvement of access and egress routes;
  - Infrastructure maintenance and improvements to support first responders' efforts to reduce fire spread.
- The Disaster Cache Program incentivizes community-building for disaster readiness. To date, the City has awarded caches of disaster response equipment to neighborhoods, congregations, and UC Berkeley Panhellenic groups that have undertaken disaster readiness activities.
- Berkeley's 2009 Climate Action Plan has served as a model for jurisdictions across the nation. The Climate Action Plan also guides the City's new climate adaptation strategy.

These programs, and many others, place Berkeley as a leader in disaster management. Long-term maintenance and improvements to these programs will support execution of the 2019 LHMP Mitigation strategy, and will help to protect the Berkeley community in our next disaster.

Disaster Mitigation Goals and Objectives

Berkeley will focus on three goals to reduce and avoid long-term vulnerabilities to the hazards identified in Element B: *Hazard Analysis*:

1. The City will evaluate and strengthen all City-owned properties and infrastructure, particularly those needed for critical services, to ensure that the community can be served adequately after a disaster.
2. The City will establish and maintain incentive programs and standards to encourage local residents and businesses to upgrade the hazard resistance of their own properties.
3. The City will actively engage other local and regional groups to collaboratively work towards mitigation actions that help maintain Berkeley's way of life and its ability to be fully functional after a disaster event.

Five objectives guide the mitigation strategy:

A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts.

B. Increase City government's ability to serve the community during and after hazardous events by mitigating risk to key City functions.

C. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.

D. Preserve Berkeley's unique character and values from being compromised by hazardous events.

E. Protect Berkeley's historically underserved populations from the impacts of hazardous events by applying an equity focus, including equal access, to mitigation efforts.

Overview of Actions

This plan identifies and analyzes 27 mitigation actions to reduce the impacts from hazards described in Element B: *Hazard Analysis.* This suite of actions addresses every natural hazard posing a threat to Berkeley, with an emphasis on new and existing buildings and infrastructure.

Tables 1, 2, and 3 below summarize all of the actions. The tables group actions by their priority level (see Element C.5.a for details on prioritization of actions), and identify the hazard(s) and each action addresses.

Table 2. High-Priority Actions in mitigation strategy

Name	Action	Hazards
Building Assessment	Continue appropriate seismic and fire safety analysis based on current and future use for all City-owned facilities and structures.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat
Strengthen and Replace City Buildings	Strengthen or replace City buildings in the identified prioritized order as funding is available.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat

Name	Action	Hazards
Buildings	Reduce hazard vulnerabilities for non-City-owned buildings throughout Berkeley.	Earthquake Wildland-Urban Interface Fire Landslide Floods Climate Change Extreme Heat
Retrofit Grants	Implementation of the Retrofit Grants Program which helps Berkeley building owners increase safety and mitigate the risk of damage caused by earthquakes	Earthquake
Soft Story	Continued Implementation of the Soft Story Retrofit Program, which mandates seismic retrofit of soft story buildings with 5+ residential units.	Earthquake
Unreinforced Masonry (URM)	Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings.	Earthquake
Concrete Retrofit Ordinance Research	Monitor passage and implementation of mandatory seismic retrofit ordinances for concrete buildings in other jurisdictions to assess best practices.	Earthquake
Gas Safety	Improve the disaster-resistance of the natural gas delivery system to increase public safety and to minimize damage and service disruption following a disaster.	Earthquake Wildland-Urban Interface Fire Landslide Tsunami
Fire Code	Reduce fire risk in existing development through fire code updates and enforcement.	Wildland-Urban Interface Fire
Vegetation Management	Reduce fire risk in existing development through vegetation management.	Wildland-Urban Interface Fire Climate Change
Hills Pedestrian Evacuation	Manage and promote pedestrian evacuation routes in Fire Zones 2 and 3.	Earthquake Wildland-Urban Interface Fire

Name	Action	Hazards
Hills Roadways and Parking	Improve responder access and community evacuation in Fire Zones 2 and 3 through roadway maintenance and appropriate parking restrictions.	Earthquake Wildland-Urban Interface Fire
Undergrounding	Coordinate with PG&E for the construction of undergrounding in the Berkeley Hills within approved Underground Utility Districts (UUDs).	Earthquake Wildland-Urban Interface Fire
EBMUD	Work with EBMUD to ensure an adequate water supply during emergencies and disaster recovery.	Earthquake Wildland-Urban Interface Fire
Extreme Heat	Reduce Berkeley's vulnerability to extreme heat events and associated hazards.	Climate Change Extreme Heat
Hazardous Materials	Mitigate hazardous materials release in Berkeley through inspection and enforcement programs.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change
Air Quality	Define clean air standards for buildings during poor air quality events and use those standards to assess facilities for the Berkeley community.	Wildland-Urban Interface Fire Climate Change Extreme Heat
National Flood Insurance Program (NFIP)	Maintain City participation in the National Flood Insurance Program.	Floods
Hazard Information	Collect, analyze and share information with the Berkeley community about Berkeley hazards and associated risk reduction techniques.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat

Name	Action	Hazards
Partnerships	Coordinate with and encourage mitigation actions of key City partners.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat

Table 3. Medium-Priority Actions in mitigation strategy

Name	Action	Hazards
Severe Storms	Reduce Berkeley's vulnerability to severe storms and associated hazards through proactive research and planning, zoning regulations, and improvements to stormwater drainage facilities.	Landslide Floods Climate Change
Energy Assurance	Implement energy assurance strategies at critical City facilities.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat
Climate Change Integration	Mitigate climate change impacts by integrating climate change research and adaptation planning into City operations and services.	Earthquake Wildland-Urban Interface Fire Landslide Tsunami Climate Change Extreme Heat
Sea Level Rise	Mitigate the impacts of sea level rise in Berkeley.	Climate Change
Water Security	Collaborate with partners to increase the security of Berkeley's water supply from climate change impacts.	Climate Change

Table 4. Low-Priority Actions in mitigation strategy

Name	Action	Hazards
Tsunami	Mitigate Berkeley's tsunami hazard.	Tsunami
Streamline Rebuild	Streamline the zoning permitting process to rebuild residential and commercial structures following disasters.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami

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[1] Human action directly influences the probability that climate change will occur. Climate change is referenced as a natural hazard here because of its potential to exacerbate natural hazards described in this plan.

[2] Ackerly, David. 2018. California's Fourth Climate Change Assessment, San Francisco Bay Area Region Report. http://www.climateassessment.ca.gov/regions/docs/20190116-SanFranciscoBayArea.pdf

[3] https://cal-adapt.org/tools/extreme-heat/

[4] Detweiler, Shane and Wein, A., 2018, The HayWired Earthquake Scenario – Earthquake Hazards: U.S. Geological Survey Scientific Investigations Report 2017-5013-A-H, p.3.

[5] Detweiler, Shane and Wein, A., 2018, The HayWired Earthquake Scenario – Earthquake Hazards: U.S. Geological Survey Scientific Investigations Report 2017-5013-A-H, p.4.

[6] City of Berkeley. *Fire Hazard Mitigation Plan.* February 25, 1992.

[7] Total square footage of buildings in burn area is 9,386,281 square feet.

[8] In 2004, estimate was $500 million.

[9] Public Law 106-390

[10] Berkeley Climate Action Plan (City of Berkeley, 2009) www.cityofberkeley.info/climate/

[11] San Francisco Bay Area 2017 Risk Profile (ABAG, 2017, p58-59) http://resilience.abag.ca.gov/wp-content/documents/mitigation_adaptation/RiskProfile_4_26_2017_optimized.pdf

[12] San Francisco Bay Area 2017 Risk Profile (ABAG, 2017) http://resilience.abag.ca.gov/wp-content/documents/mitigation_adaptation/RiskProfile_4_26_2017_optimized.pdf

Element A: Planning Process

Note: Meeting minutes, sign-in sheets, and other supporting documents to described activities are provided for State and federal reviewers in Attachment 1: *Documentation.*

A.1 *Plan Development Process*

Planning Process Overview

The City of Berkeley's Local Hazard Mitigation Plan was originally adopted by the City Council on June 22, 2004, following a process that built on years of disaster mitigation activities. An update to the Plan was adopted on December 16, 2014. To create the 2019 LHMP update, Berkeley followed the same multi-phased, broadly-inclusive process used to update the Plan in 2014.

LHMP Kickoff Meeting

On August 24, 2017, the City of Berkeley hosted a special USGS Earthquake Hazard Briefing about the HayWired earthquake scenario, and used this gathering to kick off the 2019 Local Hazard Mitigation Plan process. Earthquake is one of Berkeley's hazards of greatest concern; presenters included the United States Geological Survey (USGS). At this meeting, City staff and key partners learned together about the latest earthquake science, anticipated impacts, and experts' proposed mitigation actions to consider for the 2019 LHMP.

Development of First Draft Plan

Throughout 2018, the Project Manager collaborated with numerous City staff, partner representatives and hazard experts to update the plan's hazard analysis, progress on 2014 actions, and to develop the 2019 mitigation strategy. During this time City leaders provided guidance to the Project Manager through participation in the Core Project Team. As the Project Team created the First Draft 2019 LHMP, members engaged institutional key partners to include detailed information about partners' hazard and risk assessments and mitigation initiatives in the hazard analysis section of the Plan. The Project Team worked with partner representatives to identify opportunities for collaboration on Actions in the 2019 mitigation strategy.

Institutional Community Partner Meeting

In December 2018, the Core Team hosted an Institutional Community Partner Meeting to provide the 2019 LHMP Draft Mitigation Strategy for feedback by partner agencies. This event was the culmination of a yearlong collaboration to develop the First Draft 2019 LHMP. Meeting participants were provided the 2019 mitigation strategy's pre-draft objectives and actions. Attendees helped the City to ensure that the 2019 mitigation strategy aligned with their agencies' strategic program goals. Partner representatives and City staff discussed mitigation approaches proposed in the pre-draft mitigation actions, identifying actions that were most supportive of their agencies' missions, as well as opportunities for partnership to implement mitigation initiatives. The City incorporated feedback from those partner agencies.

Public Review of First Draft Plan

From December 18, 2018 through February 28, 2019 the City posted the First Draft Plan on the City website and at City libraries for review and comment by the Berkeley community. All of the City's 30+ commissions were invited to provide feedback on the Plan, as well as all community members.

This public review process is considered a key step in the City Council's adoption of the 2019 Local Hazard Mitigation Plan. See Element E: *Plan Adoption* for details on the public review process.

Note: Meeting minutes, sign-in sheets, and other supporting documents to described activities are provided for State and federal reviewers in Attachment 1: *Documentation.*

A.2 *Stakeholder Engagement*

The Project Team relied heavily on input from neighboring communities, fellow government agencies, and institutional key partners throughout the 2019 plan development process.

The City of Berkeley's planning process termed neighboring communities, local, and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development, as well as other interested parties as "Institutional Key Partners." The Project Manager collaborated with these agencies to include detailed information about partners' hazard and risk assessments and mitigation initiatives in the hazard analysis section of the Plan. Additionally, Institutional Key Partners were invited to review and provide comment on proposed actions as part of the process to develop the First Draft 2019 LHMP. Institutional Key Partners were invited to participate in person in the planning process at the Institutional Community Partner Meeting on December 3, 2018.

Institutional Key Partners were also invited to provide feedback on the First Draft Plan as part of the public process. See A1: *Public Review of First Draft Plan.*

Stakeholders were contacted through email, phone, and in-person meetings. Participation was multi-phased and included opportunities to contribute to and provide feedback:

- At the 2019 LHMP Kickoff Meeting, before plan development began
- Through the Disaster Questionnaire (see A3 for details)
- Throughout drafting of the First Draft 2019 LHMP, through
    - Contribution of narratives to the Hazard Analysis
    - Opportunities to provide feedback on the internal draft Mitigation Strategy both online and in-person at the Institutional Community Partner Meeting
- During the Public Review of the First Draft Plan (see A1 for details)

Note: Meeting minutes, sign-in sheets, and other supporting documents to described activities are provided for State and federal reviewers in Attachment 1: *Documentation.*

A.3 *Public Engagement during Drafting Stage*

In order to involve the public early in the mitigation planning process, the City of Berkeley's Office of Emergency Services designed and distributed a questionnaire. It included seven open-ended questions about hazard concerns, preparedness, perceptions about the role of government, and suggestions for what the City could do better. There were also seven demographic questions to capture who answered the survey and how responses may differ, depending on personal identities and or where one lives or visits in Berkeley.

The questionnaire was available on Berkeley Considers, an online forum the City uses for community discussion and commentary, from June until September 2018. The questionnaire was announced on the City website and forwarded to partners for distribution. Over 500 people responded to the questionnaire. The responses were aggregated and categorized into themes. The Core Project Team used and referenced these results when developing the hazard analysis and mitigation strategy.

Note: Questionnaire documentation is provided for State and federal reviewers in Attachment 1: *Documentation.*

A.4 *Update of Technical Information*

The Project Manager worked with City staff to update information in the 2014 hazard analysis, accounting for new scientific research on hazards that could affect Berkeley, their areas of exposure and their potential impacts.

To update hazard analysis references to key infrastructure and programs not operated by the City, the Project Manager also worked with Institutional Key Partners outside of City government: both those identified in the 2014 Plan, as well as new partners identified for the 2019 Plan.

The Endnotes Section of the Element B: *Hazard Analysis* provides a detailed listing of technical information incorporated into the plan.

A.5 *Ongoing Public Participation and Plan Maintenance*

The City's Disaster and Fire Safety Commission will serve as the advisory body for implementation of this Plan. This group was created by ordinance to advise the City Council on disaster-related issues. All meetings of this Commission are held in public. Staff will present progress on mitigation strategy implementation to this group on an annual basis.

The City will maintain the www.CityofBerkeley.info/Mitigation website and the Mitigation@CityofBerkeley.info email address. 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 at any time. The City will also use the website as one means of reporting implementation progress to the community.

A.6 *Plan Monitoring and Updates*

The City of Berkeley will monitor, evaluate, and update the 2019 LHMP's Hazard Analysis and Mitigation Strategy throughout the five-year plan cycle. The City will incorporate these efforts into a comprehensive plan evaluation and update for the 2024 LHMP. More specifics are discussed below.

Hazard Analysis

The City's Office of Emergency Services (OES) monitors newly-emerging information that will inform updates to the Hazard Analysis of the LHMP, including:

- Type, location, and extent of all natural hazards covered in the 2014 LHMP, as well as newly-emerging hazards;
- Occurrences of hazards (inside and outside Berkeley) and estimated probabilities of future hazard events; and
- Hazard impacts and community vulnerabilities.

OES staff will continue to monitor relevant hazard occurrences and new scientific discoveries that may impact the 2019 LHMP's Hazard Analysis. OES will provide this information to City staff, partners, and the public through the Digital LHMP (https://arcg.is/reqbG) and through Berkeley Ready outreach programs.

Actions in 2019 LHMP's Mitigation Strategy

Each action in the Mitigation Strategy identifies a Staff Lead. As part of their day-to-day work, Staff Leads will monitor, evaluate and report on the progress of their assigned LHMP actions at necessary meetings with other staff, institutional community partners, the Disaster Council, relevant City commissions, and the Berkeley City Council.

At the beginning of each calendar year the Office of Emergency Services will coordinate a monitoring, evaluation, and reporting effort for the entire LHMP. OES will collect an updated progress report from each identified Staff Lead for each action. The progress report will:

- Provide qualitative and quantitative evaluation of City progress on activities
- Identify any necessary changes to the action in order to more effectively achieve stated purpose and goals
- Identify new Plan actions to be incorporated into the Strategy

In this way the individual actions in the plan will be monitored, evaluated, and updated during the five-year cycle. The Office of Emergency Services will maintain this information in order to facilitate the process each year, as well as the comprehensive update of all elements of the 2019 LHMP (see below).

Comprehensive Plan Evaluation and Update

Comprehensive plan evaluation update will occur if a disaster occurs, or no later than the 4-year mark of the 2019 plan (late 2023). In either case, OES will reconvene the Core Planning team to perform a thorough evaluation of the plan, including the ongoing efforts to keep hazard analysis and mitigation action information up-to-date as described above.

Evaluation will include examination of:

- Significant development in or affecting Berkeley, in order to update the Hazard Analysis and Mitigation Strategy;
- Current data, scientific discoveries, and recent hazard events since plan adoption, in order to update hazard profiles and vulnerability assessments in the Hazard Analysis;
- New policy, priority, and planning changes affecting Berkeley, in order to update the Mitigation Strategy;
- Progress on actions in the 2019 Plan's mitigation strategy, in order to update plan goals, objectives, and mitigation actions for 2024.

The Core Project Team, coordinated by the Office of Emergency Services, will use these assessments to create the updated Internal First Draft 2024 LHMP. The Core Project Team will first share this internal document with Institutional Community Partners for review and feedback. Following their review and relevant changes, the Core Project Team will provide the First Draft 2024 LHMP to the Berkeley community for review. Public feedback, including that of Berkeley Commissions and individual community members, will inform development of the Final Draft 2024 LHMP, which will be provided for review to the California Board of Forestry, the California Governor's Office of Emergency Services, and then to the Federal Emergency Management Agency (FEMA).

Following receipt of feedback from the California Board of Forestry and approval pending adoption from FEMA, the 2024 LHMP will go to the City's Planning Commission and Disaster and Fire Safety Commission for recommendations to the City Council for adoption. The Berkeley City Council is the governing body that adopts the updates to the City of Berkeley Local Hazard Mitigation Plan.

The table on the following page summarizes the City's approach to monitoring, evaluating, and updating the 2019 LHMP.

	Hazard Analysis	2019 Mitigation Strategy: Actions	Comprehensive Plan Evaluation and Update
WHO	Office of Emergency Services	Staff Leads, with Office of Emergency Services as Coordinator	Core Project Team, with Office of Emergency Services as Lead
WHEN	Ongoing	Ongoing/Annually	Every 5 years Update process to start at least one year prior to plan expiration After a disaster event
HOW	Monitors hazard information Reports information to stakeholders and public through Digital LHMP and Berkeley Ready outreach programs	Staff Leads will monitor, evaluate and report on the progress of their assigned LHMP actions through day-to-day work OES collects progress reports on annual basis	Review/revise Plan accounting for: • Development affecting Berkeley • Hazard/vulnerability data and recent hazard events • Policy, priority, and planning changes • Progress on actions in 2019 Mitigation Strategy

Element B Contents

Tables in Section B: Hazard Analysis

Maps in Section B: Hazard Analysis

B. Hazard Analysis

To become disaster resilient, a community must first understand the existing hazards and their potential impacts. Berkeley is exposed to a number of natural and human-caused hazards that vary in their intensity and impacts on the city. This mitigation plan addresses six natural hazards: earthquake, wildland-urban interface (WUI) fire, flood, landslide, tsunami, and extreme heat. Each of these hazards can occur independently or in combination, and can also trigger secondary hazards.

Although this plan is focused on natural hazards, three human-caused hazards of concern are also discussed: hazardous materials release, climate change,[1] and terrorism. They are included because of their likelihood of occurrence and the magnitude of their potential consequences.

The analysis of hazards in this plan has the following components:

- Historical Events. Within recent history the city has experienced the effects of all hazards addressed in this plan. Descriptions of the impacts of these disasters help illustrate some of the types of damage they can cause.

- Hazard. Describes the ways that each hazard can damage the community, and maps the locations in Berkeley that are particularly prone to specific hazards, such as the "one-percent annual chance" floodplain. Areas that could experience secondary hazards, such as liquefaction following earthquakes, are also discussed.

- Exposure and Vulnerability. This plan identifies the people, buildings and infrastructure that exist in hazard zones. Vulnerability refers to the susceptibility to physical injury, harm, damage, or economic loss of the exposed people, buildings and infrastructure. City elements exposed to each hazard are listed and mapped, and their vulnerability is discussed. This section includes discussion of cascading hazards and impacts created by the primary hazard, for example utility disruption caused by damage from earthquake shaking.

- Risk and Loss Estimates. The expected damage to be caused by future hazard events is estimated quantitatively, when possible. For most hazards, specific figures are estimated for the damage and losses that could occur. Consequences of damage on city residents and visitors are explored.

The best available technical methods were used to estimate possible losses caused by various hazards. The City's detailed GIS databases, which include carefully gathered information about building types, natural features, and important property uses, were extensively used to characterize the city's hazards.

B.1 *Hazard Analysis Summary*

First, this section summarizes the relative likelihood and severity of impact of each of the hazards identified in Sections B.5 – B.13. Next, Berkeley's key vulnerabilities to each hazard are summarized.

B.1.a Hazards Description

Sections B.5 – B.13 present hazards in Berkeley, describing their likelihood and detailing their potential consequences. Using a structure outlined by Saunders, Beban and Kilvington (2013 draft), the table below summarizes these hazards, their relative likelihoods, and the relative severities of their potential consequences.

Relative degrees of likelihood are described as:

- *Likely*: The event may occur several times in your lifetime, up to once every 50 years
- *Possible*: The event might occur once in your life time, Once every 51 – 100 years
- *Unlikely*: The event does occur somewhere from time to time, once every 101 – 1,000 years
- *Rare*: Possible but not expected to occur except in exceptional circumstances, once every 1,001 to 2,500 years
- *Very rare*: Conceivable but highly unlikely to occur, once every 2,500+ years

Relative severity of hazard impacts is described using the following terms, which are defined by matrix of factors, including Social/Cultural, Buildings, Critical Buildings, Lifelines, Economic and Health and Safety:

- *Catastrophic*
- *Major*
- *Moderate*
- *Minor*
- *Insignificant*

Table 1. Summary of Hazard Analysis

Hazard	Likelihood	Severity of Impact
Earthquake	Likely	Catastrophic
Wildland-Urban Interface Fire	Likely	Catastrophic
Rainfall-Triggered Landslide	Likely	Moderate
Floods	Likely	Minor
Tsunami	Possible	Moderate
Climate Change	Likely	Moderate to Catastrophic*
Extreme Heat	Likely	Moderate to Catastrophic*

**Consequence levels for climate change and extreme heat depend highly on the success of global climate mitigation over the coming decades. If greenhouse gas emissions are significantly reduced, and carbon sequestration is increased, impacts may be moderate. If emissions remain steady at present levels or even increase, consequences may increase to catastrophic, although effects will differ widely over the globe.*[23]

Hazardous materials release is described only as a cascading impact of a natural hazard. Because this plan focuses on natural hazards as emphasized in DMA 2000, likelihood and consequence levels for hazardous materials release and terrorism are not defined.

B.1.b Identification of Hazards

B.1.b.i *Natural Hazards*

The natural hazards included in this plan were first identified through a community-based process during the revision of the Disaster Preparedness and Safety Element of the City's General Plan, adopted in 2002. The General Plan is the result of four drafts, approximately 100 hours of public workshops, meetings, and hearings, almost 1,000 pages of policy suggestions submitted by Berkeley citizens, and the hard work and dedication of the Berkeley community and Berkeley Planning Commission[4]. Specialists from the California Geological Survey, US Geological Survey, UC Berkeley, the Earthquake Engineering Research Institute (EERI), the Association of Bay Area Governments (ABAG) and many others worked with the city on programs and research that were incorporated in the Disaster Preparedness and Safety Element.

In 2019, extreme heat was added as a specific hazard to the mitigation plan.

B.1.b.ii *Manmade Hazards*

The focus of this mitigation plan is on natural hazards as emphasized in the Disaster Mitigation Act of 2000 (DMA 2000).[5] However, the plan addresses four manmade hazards—climate change, extreme heat events, hazardous materials release, and terrorism.

Climate change was specifically identified as a hazard of concern in the City's 2009 Climate Action Plan, and in 2014, climate change was added to the mitigation plan. Newly-available maps and information now allow us to identify potential climate change impacts, and to consider related mitigation actions. The 2019 LHMP specifies extreme heat events as an additional hazard of concern.

Hazardous materials release is addressed in this mitigation plan as a potential impact from a natural hazard. Terrorism is identified as a hazard of concern but is not analyzed in depth. Other manmade hazards that could occur in Berkeley, such as ground water contamination, are not included in this plan, but may be addressed by other City programs in ongoing regulatory processes, such as activities of the Toxics Management Division.

The worst potential disaster that Berkeley could face involves multiple hazards happening at the same time. A major earthquake could trigger significant landslides, spark fires and release toxic chemicals. If an earthquake occurred during the rainy winter season, landslides would be worsened and flooding could occur, exacerbated by damaged creek culverts and storm drains. In addition, the severity and frequency of extreme heat events, flooding, and wildfires are worsening over time due to climate change. City staff conducts planning and training to respond to challenging, multi-hazard events such as these. In addition to looking at each hazard individually, this plan explores how the hazards interact, and how mitigation activities for each hazard impact the overall disaster risk in Berkeley.

B.1.b.iii *Public Health Impacts of Identified Hazards*

The City's Public Health and Environmental Health Divisions have provided guidance on the public health impacts associated with hazards included in this plan. For example, drinking water quality is likely to be impaired after a major earthquake or flood, and air quality can be affected by a fire. Impure water and poor air quality have public health impacts, and providing accurate and timely information along with disease prevention measures are core public health functions. Power outages can threaten the lives of people with disabilities and people with access and functional needs that rely on electrical equipment.

In 2014, the Public Health Division participated in the Bay Area Regional Risk-Based Assessment of public health impacts of a variety of hazards. The assessment for Berkeley focused on the health impacts of a severe or moderate earthquake, a wildland/urban interface fire, and a moderate influenza pandemic. In addition to evaluating these categories of risk, the assessment focused on three sub-populations considered most vulnerable in a disaster: 1) seniors and homebound individuals with disabilities, 2) individuals with mental/behavioral health illness, and 3) UC Berkeley students in multi-unit residential housing. The assessment helps to inform our public health emergency preparedness and mitigation efforts. It also helped to engage our partners with recommendations for improving their own preparedness plans as they serve these most vulnerable populations.

B.1.b.iv *Acccess and Functional Needs*

While the assessment mentioned above focused on those three sub-populations specifically, this plan also recognizes that there are many individuals that are still disproportionately vulnerable during disasters. People with access and functional needs are defined as community members who may have additional needs before, during and after an incident in functional areas, including but not limited to: maintaining independence, communication, transportation, supervision, and medical care. Individuals in need of additional response assistance may include those who have disabilities, live in institutionalized settings, are elderly, are children, are from diverse cultures, have limited English proficiency, or are non-English speaking, or are transportation disadvantaged. An individual with a disability is defined by the ADA as a person who had a physical or mental impairment that substantially limits one or more major life activities, a person who has a history or record of such an impairment, or a person who is perceived by others as having such an impairment. The ADA does not specifically name all of the impairments that are covered.

B.1.b.v *Hazards Not Considered in the Plan*

Other natural hazards that are extremely rare in Berkeley are not included in this plan; these include prolonged low temperatures, heavy rainfall and hail; high winds; and small tornados and waterspouts. This plan does not focus on these hazards because they are not as likely to occur or to create damage that is as serious as the hazards addressed in detail. California is not generally exposed to the large tornado events experienced in the Midwest. Berkeley's geographic location and moderate climate typically shelters it from prolonged storms and extremes of cold and heat. Ocean temperatures moderate the power of tropical storms, lessening the effects of low barometric pressure and storm surge. However, these hazards may become more prevalent in Berkeley with the changing climate.

Naturally-occurring communicable disease outbreaks (e.g. a flu pandemic; measles; norovirus) do pose a significant risk to the Berkeley community, but are not addressed in this plan. Mitigation activities for communicable disease include, for example, measures to provide and promote a high baseline level of immunization in the community, both for routine childhood immunizations and for annual seasonal flu vaccination. The City's Public Health Division leads Berkeley's communicable disease and public health emergency preparedness planning, in conjunction with State and Bay Area local health jurisdictions.

B.1.c Hazard Location

Sections B.5 – B.13 detail the locations of all hazards addressed in this hazard analysis.

B.1.d Hazard Extent

Sections B.5 – B.13 detail the extent of all hazards addressed in this hazard analysis.

B.2 *Previous Occurrences and Future Probabilities*

Sections B.5 – B.13 detail the previous occurrences in Berkeley of each hazard in this hazard analysis and examine the propbability of future hazard events in Berkeley. Probabilities are summarized in Table 1 above.

B.3 *Vulnerabilities*

For each hazard presented in Sections B.5 – B.13, the following list summarizes Berkeley's key vulnerabilities to the structures, systems, populations, and other community assets that are susceptible to damage and loss from hazard events. For each hazard, the following information is identified:

Numbers (1, 2, 3, etc.) define the category of the vulnerability being described. If the City of Berkeley does not own or control the category, the responsible entity is included. Below each number, letters (a, b, c, etc.) highlight vulnerabilities identified in this plan.

This list identifies both primary and cascading vulnerabilities. Primary vulnerabilities are directly related to the primary natural hazard, such as building vulnerabilities to earthquake shaking. Cascading vulnerabilities result from primary vulnerabilities, and are included in the list below. For example, structures that are not seismically sound have increased vulnerability to fire following earthquake. This format demonstrates how mitigating primary vulnerabilities can also mitigate cascading impacts.

This list highlights key vulnerabilities identified through this planning process; but it is not all-inclusive.

List of Vulnerabilities:

B.3.a.i *Earthquake (Including shaking, surface fault rupture, liquefaction, seismically- triggered landslides, and fire following earthquake)*

1. Structures
    a. City buildings vulnerable to collapse from exposure to earthquake shaking:
        i. Old City Hall
        ii. Veterans Memorial Building
        iii. Un-assessed City buildings may be vulnerable to earthquake shaking and ground failure
    b. Privately-owned buildings
        i. Soft-story buildings: 70 unretrofitted soft-story buildings vulnerable to damage/collapse from exposure to earthquake shaking
        ii. 6 unretrofitted unreinforced masonry (URM) buildings vulnerable to collapse from exposure to earthquake shaking. 274 retrofitted URM buildings vulnerable to moderate or greater damage from exposure to earthquake shaking
        iii. Non-ductile concrete buildings are vulnerable to collapse and perform poorly during earthquakes.
        iv. Ridid wall flexible diaphragm buildings including tilt up buildings may also be highly sustceptible to adverse affects from earthquakes, such as collapse during ground shaking.

v. If buildings are damaged/collapse from exposure to earthquake shaking or ground failure:
    1. Buildings are more vulnerable to gas line rupture at service connections
    2. Buildings are more vulnerable to fire following earthquake
    3. People more vulnerable to injury/death from exposure to building damage/collapse
    4. People with disabilities and people with access and functional needs, students, and low income individuals may live in older housing units that are more vulnerable to collapse or damage from earthquakes.
    5. People are more vulnerable to illness from exposure to asbestos or encapsulated asbestos, which may dislodge in an earthquake

c. Healthcare Facilities (Alta Bates Summit)
    i. Five Alta Bates Campus buildings are vulnerable to damage from exposure to earthquake shaking
    ii. Four buildings on the Herrick campus are vulnerable to major damage from earthquake shaking
    iii. People in and around four buildings on the Herrick campus are vulnerable to injury or death from exposure to seismic building damage
d. School Facilities (Berkeley Unified School District)
    i. Unreinforced Masonry Building at BUSD Corporation Yard vulnerable to damage from earthquake shaking
    ii. People in and around Unreinforced Masonry Building at BUSD Corporation Yard are vulnerable to injury/death from exposure to seismic building damage
e. BART
    i. BART tracks in Berkeley vulnerable to damage from earthquake shaking
f. Railroad (Union Pacific)
    i. Railroad infrastructure vulnerable to damage from exposure to earthquake shaking and liquefaction (specific vulnerability unknown)
    ii. If railroad infrastructure is damaged due to earthquake shaking and/or liquefaction:
        1. Trains more vulnerable to accidents
        2. People more vulnerable to illness/injury from exposure to hazardous materials, if trains carrying hazardous materials
g. Highways and Interstate (Caltrans)
    i. Interstate 80 vulnerable to damage from exposure to liquefaction
    ii. Parts of Highways 13 and 24 vulnerable to damage from exposure to liquefaction
    iii. Overpasses at Ashby and University Avenues vulnerable to damage from exposure to earthquake shaking (but are not expected to collapse).
    iv. If roads are damaged from earthquake shaking and/or liquefaction:
        1. People in vehicles more vulnerable to injury/death in accidents
        2. People vulnerable to injury/death from exposure to hazardous materials, if transportation accidents occur involving vehicles carrying hazardous materials
h. Streets/Curbs/Solano Tunnel

        i. Solano Tunnel vulnerable to isolation if fault rupture or earthquake- induced landslide in surrounding areas cause road blocks
        ii. Streets and curbs vulnerable to damage from exposure to liquefaction, fault rupture and earthquake-induced landslides
        iii. Significant damage to streets and curbs may prevent people with disabilities and people with access and functional needs from navigating to their destinations
        iv. If significant street damage impedes access by emergency responders to fight fires, perform rescues, access utilities or perform other emergency response actions:
            1. People vulnerable to additional injuries/death
            2. Structures and infrastructure vulnerable to additional damage
    i. Hazardous Materials
        i. If earthquake shaking causes lab spills, storage tank failures and/or industrial equipment problems, people in Berkeley vulnerable to injury/death from exposure to hazardous materials release

2. Systems
    a. Water system (EBMUD)
        i. Water pipes vulnerable to rupture from exposure to liquefaction, landslide-induced earthquake and fault rupture
        ii. If water pipes rupture due to earthquake shaking or ground failure, structures more vulnerable to damage/destruction from fire following earthquake.
        iii. Depending on the severity of earth movement, water and sewer lines may break, and the safety of the drinking water supply may be compromised.
    b. Sanitary Sewer System
        i. Sanitary sewer system vulnerable to blockage/pipe rupture/damage from exposure to liquefaction, landslide-induced earthquake and fault rupture
        ii. If sanitary sewer system is blocked/ruptured/damage from seismic ground failure, roads and buildings more vulnerable to sinkhole
    c. Storm Drain System
        i. Storm drain system vulnerable to blockage/rupture/other damage from exposure to liquefaction, landslide-induced earthquake and fault rupture/
    d. Creek Culverts
        i. In an earthquake, there is a strong possibility that some of these culverts may be damaged and, in some cases, collapse.
    e. Electricity System (PG&E)
        i. Utility poles vulnerable to toppling from exposure to earthquake shaking and from exposure to liquefaction, landslide-induced earthquake and fault rupture
        ii. Aboveground utility lines vulnerable from exposure to falling trees and structure collapse from earthquake shaking and from exposure to liquefaction, landslide-induced earthquake and fault rupture
        iii. PG&E Electrical substations vulnerable to damage from exposure to earthquake shaking and from exposure to liquefaction, landslide- induced earthquake and fault rupture
        iv. Underground cables vulnerable to rupture from exposure to liquefaction,

landslide-induced earthquake and fault rupture

v. If power is lost, there will be many impacts to vulnerable City and private infrastructure
vi. Interruptions in electrical power may jeopardize people with disabilities and people with access and functional needs that rely on electrical equipment for survival

f. Natural Gas System (PG&E)
   i. Gas transmission pipeline, distribution lines and service lines and valves in west Berkeley vulnerable rupture from exposure to liquefaction
   ii. Gas distribution lines, service lines and valves vulnerable to rupture from exposure to earthquake-induced landslides and fault rupture
   iii. If gas system ruptures occur, fire following earthquake is more likely, and:
      1. Infrastructure/buildings are more vulnerable to damage/destruction
      2. People are more vulnerable to injury/death
g. Aviation Fuel System (Kinder Morgan)
   i. Exposed to liquefaction (specific vulnerability unknown)
h. Communication Systems
   i. Land line telephone distribution system and cable system use utility poles, which are vulnerable to toppling from exposure to earthquake shaking and ground failure
   ii. Underground communication lines vulnerable to rupture from exposure to earthquake-induced landslides, fault rupture and liquefaction
   iii. Mobile phone system antennae vulnerable to:
   iv. Damage from earthquake shaking
   v. Power outage from damage to electrical infrastructure (vulnerability increased if generators not onsite)
      1. Interruptions in electrical power jeopardize people with access and functional needs that rely on electrical equipment for survival
   vi. If communication systems are damaged due to earthquake shaking and ground failure:
      1. Cellular voice communication may be unusable due to earthquake impacts, combined with high demand. Voice communication is more vulnerable than SMS text messaging systems.
      2. Cable customers may experience a total loss of video service, and total loss or severe network congestion of voice and data services.
      3. People with disabilities and people with access and functional needs that require assistance from others may not be able to reach them

3. Populations
   a. People in Berkeley are exposed to ground shaking, landslides, liquefaction, in addition to fire following earthquake
   b. People with disabilities and people with access and functional needs may be separated from their caregivers and may need assistance
   c. A number of the cascading impacts of earthquake on people are mentioned above in the relevant section

B.3.a.ii ***Wildland-Urban Interface Fire***

1. Structures
    a. 8,300 properties in Fire Zones 2 and 3 vulnerable to damage/destruction from exposure to WUI fire
    b. 215 dwelling units in Fire Zone 3 - Panoramic Hill area (280 including Oakland units) especially vulnerable to damage/destruction from exposure to WUI fire, due to undersized water main and limited access routes for firefighters
    c. Wooden buildings with narrow side yards and dense vegetation in Fire Zone 1 vulnerable to damage/destruction from exposure to a WUI fire beginning in Fire Zone 2 or 3
    d. People with access and functional needs, students, and low income individuals may live in older housing units that do not have the most up to date safety features.
    e.
2. Populations
    a. Residents and firefighters in Fire Zone 2 vulnerable to injury/death from exposure to WUI fire
    b. 520 residents in Panoramic Hill area (620 including Oakland residents) especially vulnerable to injury and death from exposure to WUI fire, due to limited access/egress routes
    c. People with disabilities and people with access and functional needs may be separated from their caregivers and may need assistance
    d. People with disabilities and people with access and functional needs may not have immediate transportation options to evacuate quickly
    e. People with disabilities and people with access and functional needs face physical and socioeconomic barriers that may prevent them from participating certain mitigation activities, such as vegetation management.
    f. Berkeley residents and visitors vulnerable to eye and respiratory illnesses from exposure to air pollution caused by large WUI fires
3. Electricity system (PG&E)
    a. Cascading Vulnerabilities
        i. If exposed to extreme heat from WUI fire:
            1. Utility poles vulnerable to toppling
            2. Aboveground utility lines vulnerable to burning
            3. Underground cables vulnerable to melting
        ii. Interruptions in electrical power jeopardize people with disabilities and people with access and functional needs that rely on electrical equipment for survival
4. Natural Gas System (PG&E)
    a. Gas service connections vulnerable to rupture in buildings exposed to WUI fire
    b. Structures, Infrastructure and People/Natural Gas System (PG&E)
    c. People, structures and infrastructure in areas exposed to gas line rupture vulnerable to additional fire exposure
5. Communication Infrastructure (AT&T)
    a. Land line telephone distribution system uses utility poles, which are vulnerable to toppling if exposed to heat from WUI fire.
    b. People with disabilities and people with access and functional needs that require assistance from others may not be able to reach them
6. Streets and curbs

   a. Streets and curbs in Fire Zones 2 and 3 vulnerable to damage/destruction from exposure to WUI fire
   b. Significant damage to streets and curbs may prevent people with disabilities and people with access and functional needs from navigating to their destinations
7. Storm drain system
   a. Drainage structures in Fire Zones 2 and 3 vulnerable to damage/destruction from exposure to WUI fire
8. Structures and Infrastructure
   a. Structures and infrastructure in fire-burned areas in Fire Zones 2 and 3 vulnerable to damage/destruction from exposure to landslide and flooding

B.3.a.iii *Rainfall-triggered landslides*

1. Structures
   a. Approximately 6,000 structures vulnerable to damage or destruction from exposure to landslide
2. Systems
   a. Water system (EBMUD)
      i. Water pipes vulnerable to rupture from exposure to landslide
   b. Sanitary Sewer System
      i. Sanitary sewer system pipes vulnerable to rupture from exposure to landslide
   c. Storm Drain System
      i. Storm drain system vulnerable to blockage/rupture/other damage from exposure to landslide
   d. Electricity System (PG&E)
      i. Utility poles and aboveground utility lines vulnerable to toppling from exposure to landslide
      ii. Underground cables vulnerable to rupture from exposure to landslide
      iii. Interruptions in electrical power jeopardize people with disabilities and people with access and functional needs that rely on electrical equipment for survival
   e. Natural Gas System (PG&E)
      i. Gas distribution and service lines and valves in Berkeley hills vulnerable to rupture from exposure to landslide

B.3.a.iv *Floods*

1. Structures
   a. 475 structures vulnerable to damage to first floor and basement finishes, contents and appliances from exposure to up to 1 foot of flooding. 200 additional structures, also primarily in the City's west, are vulnerable to damage from exposure from up to two feet of flooding.
   b. Streets, structures and infrastructure in the Potter Watershed are vulnerable to damage from exposure to localized flooding in the following locations:
      i. San Pablo Avenue between Ward and Murray
      ii. California Street between Woolsey and Harmon
      iii. Woolsey Street between California and Adeline
      iv. Woolsey Street at Dana
      v. Ashby Avenue between California and King

vi. Martin Luther King, Jr. Way between Russell and Woolsey
vii. Parker Street between Seventh and Fourth
viii. Fulton Street at Derby
ix. Ellsworth Street between Blake and Parker
x. Telegraph Avenue between Ashby and Woolsey
xi. Telegraph Avenue at Stuart
xii. College Avenue at Dwight

c. Streets, structures and infrastructure in the Cordonices Watershed are vulnerable to damage from exposure to localized flooding in the following locations:
   i. Second Street, Creek corridor to Gilman
   ii. Railroad tracks, Creek corridor to Gilman and to Albany
   iii. Gilman Street between Sixth and Second
   iv. Codornices Creek at Sixth, at most street crossings east of San Pablo, at Glen
   v. Ninth Street between Harrison and Creek Corridor
   vi. Monterey Ave between Posen and Hopkins
   vii. Hopkins Street at Carlotta
   viii. The Alameda between Napa and Yolo
   ix. Sonoma Ave between Fresno and Hopkins
   x. Spruce Street, Eunice to Creek corridor
   xi. Euclid Ave, Cragmont to Codornices Park
   xii. Cragmont, Euclid to Regal
   xiii. Various locations on La Loma, Glendale, Campus Drive, Queens, Shasta Road

B.3.a.v ***Tsunami***

1. Structures
   a. City buildings exposed to tsunami inundation (the extent of each building's vulnerability is unknown)
      i. Dona Spring Animal Shelter
      ii. Marina Boat Docks
      iii. Berkeley Yacht Club
      iv. Shorebird Nature Center
      v. Marina Corporation Yard
      vi. Marina Administration Building
   b. Privately-owned structures in the Marina and on the western edge of Berkeley exposed to tsunami inundation. The extent of each building's vulnerability is unknown.
2. Populations
   a. Estimated 23 traditional households and over 200 individual Marina boat residents are exposed to tsunami inundation. Specific vulnerability is unknown.
   b. Estimated that staff/customers at 77 businesses are exposed to tsunami inundation. Staff and guests at the DoubleTree hotel alone may account for 600+ people.
   c. Estimated that 1,664 employees at four government offices are exposed to tsunami inundation. Specific vulnerability unknown.
   d. People with disabilities and people with access and functional needs may not have

immediate transportation options to evacuate quickly.

3. Systems
    a. Gas Dock, Docks B-K, and Dock O have moderate vulernability to some tsunami events
    b. Key roads exposed to tsunami inundation:
        i. Ramps to University Avenue Bridge
        ii. Frontage road north to Gilman Street
        iii. Frontage road south to Ashby Avenue/CA-13
        iv. Interstate 80
        v. Ramps to I-80 Bicycle/Pedestrian overcrossing: Specific vulnerability is unknown.
4. Other community assets
    a. 1,000 boats in Marina slips exposed to tsunami inundation. Specific vulnerability unknown.

B.3.a.vi *Climate Change*

1. Structures
    a. Structures in low-lying areas around Berkeley Aquatic Park, as well as land around the Berkeley Marina and infrastructure east of the highway along 2nd Street, are exposed to sea level rise. Specific vulnerability is unknown.
    b. Sea level rise will cause the groundwater table and stream water levels to rise, increasing the structures exposed to liquefaction in an earthquake. Specific increase in vulnerability unknown.
    c. Rising sea levels will increase the structures exposed to tsunami inundation. Specific increase in vulnerability unknown.
    d. Increases in the intensity and frequency of winter storms due to climate change will increase exposure to landslides for structures in the Berkeley hills. Specific increase in vulnerability unknown.
    e. More structures will become vulnerable to damage from exposure to flooding
2. Systems
    a. Flooding resulting from sea level rise in combination with severe storms may threaten natural gas pipelines regionally. This can lead to disrupted service and the leakage of methane gas from the system. Methane is both a health and safety hazard as well as a highly potent greenhouse gas, further contributing to climate change.
    b. Drought affects local water supply for urban, agricultural, and environmental uses, and can also increase wildfire hazard, and may be correlated with high heat conditions. Climate change is likely to exacerbate the occurance of prolonged droughts.
3. Populations
    a. People vulnerable to increased incidences of West Nile virus, human hanta virus, and Lyme disease from increased exposure to disease vectors, caused by increases in air temperature and changes in precipitation.
    b. Climate change is likely to exacerbate the natural hazards of concern identified in the plan, making more people vulnerable to their impacts.

B.3.a.vii *Extreme Heat*

1. Structures
    a. High temperatures can damage critical transportation infrastructure, such as roads.
2. Populations
    a. People with disabilities, people with access and functional needs, people with chronic diseases, the elderly, and children under five are the most at risk to heat-related illnesses.
    b. Communities of color, people with low incomes, people with disabilities, and people with access and functional needs suffer during extreme because of lack of access to common heat adaptation strategies, such as air conditioning.
3. Systems
    a. Extreme heat often leads to power outages because of the extra demand on the power grid.
    b. Interruptions in electrical power jeopardize people with disabilities and people with access and functional needs that rely on electrical equipment for survival
4. Other community assets
    a. Extreme heat can cause stagnant air conditions and ground-level ozone.
    b. Extreme heat dries out vegetation.
        i. Cascading Vulnerability
            1. Dry vegetation can act as fire fuel, promoting spread of WUI fires.

B.4 *NFIP-Insured Structures*

The City of Berkeley does not have NFIP-insured structures that have been repetitively damaged by floods.

SECTION I: HAZARDS OF GREATEST CONCERN

Earthquakes and wildland-urban interface (WUI) fires are the hazards of greatest concern to Berkeley. Both of these hazards have a relatively high likelihood of occurrence and the potential for widespread damage within the city and the greater east bay region. Berkeley is committed to reducing the impact of these hazards on the city, and therefore they are the primary focus of the mitigation actions identified in Element C: *Mitigation Strategy* of this plan.

B.5 *Earthquake*

B.5.a Historical Earthquakes

Destructive earthquakes struck the Bay Area in 1838, 1868, 1898, 1906, 1911, 1989, and 2014. Impacts of the earlier earthquakes in Berkeley are not well documented, but the damage of the 2014 Magnitude (M) 6.0 South Napa Earthquake is fresh in the memory of many Berkeley residents. It took the lives of two people, injured 300 others, and caused moderate to severe damage to more than 2,000 structures.[6] Electricity and water services sustained disruptions and there was minor damage to roads, water and natural gas lines and wastewater treatment facilities.

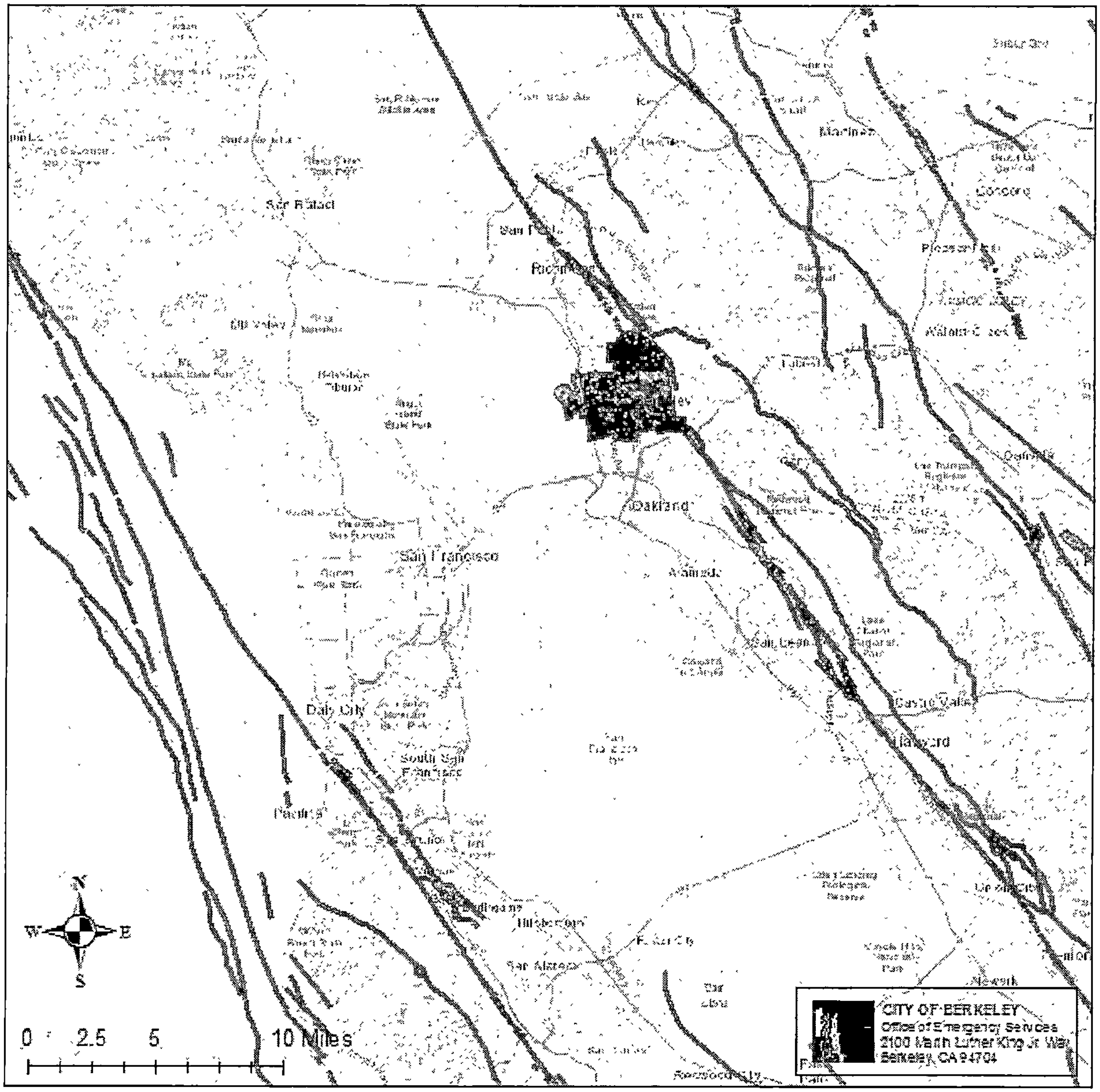
The 1989 Loma Prieta earthquake also informs the Bay Area's understanding of earthquakes. Sixty-two people died in the Bay Area as a direct result of this earthquake. Most of the fatalities, 42, were caused by the collapse of a two-level elevated highway in Oakland only a few miles from the Berkeley city limits. Damage in the City of Berkeley was minor in comparison to many of its neighbors. Many residential structures experienced collapse of unreinforced masonry chimneys, and new cracks were found in the Martin Luther King, Jr. Civic Center Building. The earthquake epicenter was far from Berkeley, but region-wide impacts and disruption increased the Berkeley community's awareness of the high risk Berkeley faces from much closer earthquakes.

The 1906 San Francisco Earthquake caused structural damage in Berkeley, including chimney cracking and collapse, and considerable damage to some public buildings including Berkeley High School structures.[7] Other "small" earthquakes in Berkeley over the years have caused slight damage to some buildings.

B.5.b Earthquake Hazard

Map 1 shows the City of Berkeley and its proximity to known active geologic faults in the San Francisco Bay Region. This map shows most the San Francisco Bay Area, with the City of Berkeley shaded in dark gray. Many red lines move across the map. One line moves from south to east from the Pacific coast down the Peninsula, and another set of lines moves west to south-east down the East Bay. One line, the Hayward fault, of particular concern, stretches from the middle of San Pablo Bay, crosses directly through the eastern section of Berkeley, and terminates in Hayward. A large earthquake on any of the illustrated faults could impact Berkeley. For example, the 1989 M 6.9 Loma Prieta earthquake was a rupture of the San Andreas fault, and the 2014 M 6.0 South Napa earthquakes occurred along the West Napa fault.

Map 1. ***Regional faults and their location with respect to Berkeley***



Source: In 2012, USGS mapped multiple faults in the region that can produce damaging shaking in the region. (Shapefiles and description from ABAG website)
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, ©

Fault

City of Berkeley

USGS states that there is a 72% probability of one or more M 6.7 or greater earthquakes from 2014 to 2043 in the San Francisco Bay Region.[8] There is a 33% chance that a 6.7 or greater will occur on the Hayward fault system between 2014 and 2043.[9] This means that many Berkeley residents will experience a severe earthquake in their lifetime.

To provide a historical context, the 1994 Northridge earthquake, which caused an economic loss of $40 billion dollars,[10] was a M 6.7 earthquake. 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.

Earthquake Scenarios

Scenarios are used to help us understand and prepare for disasters, by painting a detailed, vivid, realistic picture of what it would be like if such an event occurred under current social and economic conditions. Scenarios are not predictions, and should be treated as a tool to drive and support the hazard mitigation planning process.

HAZUS, an earthquake loss estimation program developed by FEMA, was used to estimate damage to buildings, economic losses, deaths and injuries, and shelter requirements after an earthquake. This plan includes information from both a 2004 earthquake scenario and the 2018 HayWired scenario developed by the USGS to help illustrate the potential impacts of a catastrophic earthquake near Berkeley.

B.5.b.i *Ground Shaking*

The most significant physical characteristic of a major earthquake is ground shaking. 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. Horizontal shaking in particular causes most earthquake damage, because structures often have inadequate resistance to this type of motion.

Weak soils, such as bay mud and fill at the city's waterfront, also 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 may shake more intensely than hard rock at the same distance from the same earthquake. An extreme example for this type of amplification was in the Marina district of San Francisco during the 1989 Loma Prieta earthquake. That earthquake was 100 kilometers (60 miles) from San Francisco, and most of the Bay Area escaped serious damage. However, some sites on landfill or soft soils, like San Francisco's Marina district, experienced significant shaking.

Magnitude and Intensity[11]
Two commonly-used scales represent different earthquake characteristics: magnitude and intensity.

Magnitude
An earthquake has a single magnitude, which indicates the overall size and energy released by the earthquake. Magnitude is measured using moment magnitude (M).

Intensity
In the same earthquake, different locations will experience different amounts of shaking. The shaking experienced at different locations varies based on:

- The earthquake's overall magnitude
- The distance from the fault that ruptured in the earthquake
- The ground type: thick valley deposits shake longer and harder than rock.

Intensity measures the strength of earthquake shaking at a particular location. Intensity is measured using the Modified Mercalli Intensity (MMI) scale. Intensity is based on observed effects. The MMI value assigned to a specific site after an earthquake provides a more meaningful measure of the earthquake's severity at that location than the magnitude, which applies one value to the entire earthquake.

As shown in Table 2, the MMI scale is composed of twelve increasing levels of intensity that range from imperceptible shaking to catastrophic destruction. Lower numbers on the intensity scale generally deal with the manner in which the earthquake is felt by people. Higher numbers on the scale are based on observed structural damage.

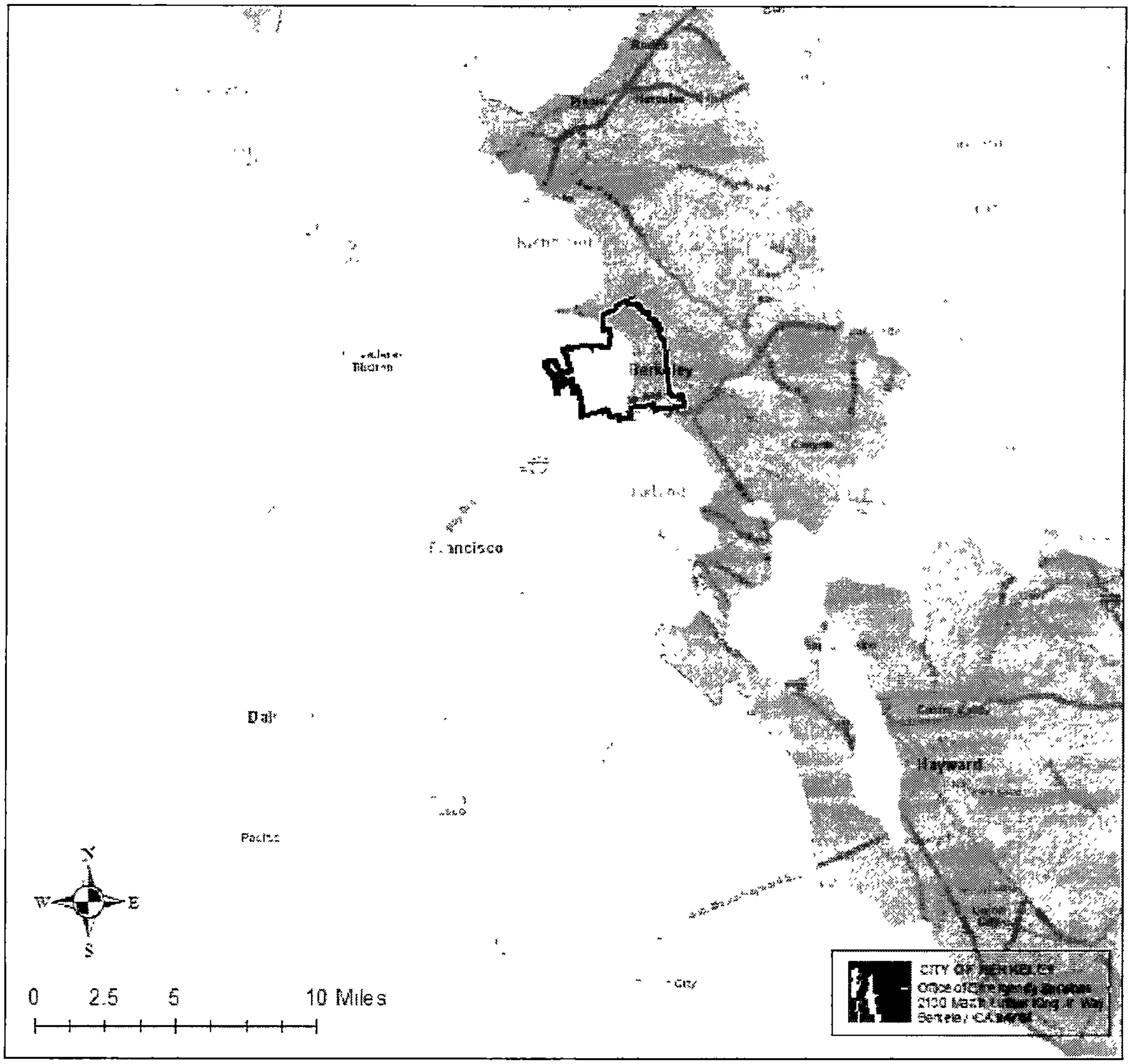
Table 2. MMI descriptions[12]

MMI	Shaking	Description and damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly build or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shift off foundations.
X+	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Map 2 shows most of the San Francisco Bay Area and the different levels of shaking intensity anticipated in the HayWired Scenario. Shaded in colors of yellow, orange, and red, the map shows that very strong, severe, and violent shaking will be felt all along the East Bay, stretching from Pinole to south of Hayward.

Berkeley is outlined with a thick black line and is shaded in colors of orange and red, indicating that in this scenario, Berkeley will experience severe and violent shaking, associated with MMI Levels VIII and IX.

Map 2. ***Modified Mercalli Intensity for HayWired Earthquake Scenario***



Source: USGS, HayWired Scenario, August 2017.
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Berkeley

I (Not Felt)
II - III (weak shaking)
IV (light shaking)
V (moderate shaking)
VI (strong shaking)
VII (very strong shaking)
VIII (severe shaking)
IX (violent shaking)
X+ (extreme shaking)

B.5.b.ii *Ground Failure*

Earthquakes can cause the ground to fail in several ways: through surface fault rupture, liquefaction, and seismically-triggered landslides.

Ground Failure Maps

This section presents maps to explore Berkeley's exposure to different types of ground failure. When a map is presented, the title indicates whether it is a:

- General Susceptibility Map
- Seismic Hazard Planning Zone Map
- Scenario Map

These maps present different information from different sources and cannot always be compared side-by-side. Each of these map types is describe below; readers are encouraged to refer back to these definitions when reviewing maps in this section.

General Susceptibility Maps

General susceptibility maps show areas that are exposed to a particular hazard. They show areas that are more prone to experiencing the hazard over time. These maps do not refer to any specific event circumstances, like a particular earthquake with a specific epicenter, Magnitude, and depth.

Seismic Hazard Planning Zone Maps[13]

Seismic Hazard Planning Zone Maps are a type of General Susceptibility map that deals with ground failure. These State regulatory maps do not consider a particular earthquake event, and instead are used:

- To support land use decisions by identifying areas where future earthquake-induced ground failure is more likely to occur, and
- To determine whether approval of more in-depth site-specific hazard investigation and mitigation may be required for certain projects during the construction permitting process.[14]

HayWired Scenario Maps

HayWired maps show the three types of ground failure in a specific earthquake scenario. This type of map helps planners to consider the general impacts of a catastrophic earthquake on the Hayward fault. However, these maps should be used carefully and not be considered an accurate predictor of the future. The data used to make these maps is not granular enough to predict an earthquake's impact at a specific address or location. Further, the specific location and magnitude of Berkeley's next big earthquake is unlikely to match this scenario exactly.

B.5.b.iii *Surface Fault Rupture*

Fault slip describes movement of the earth at fault lines. The movement can be very slow (fault creep) or very sudden (coseismic slip, which is part of all earthquakes).

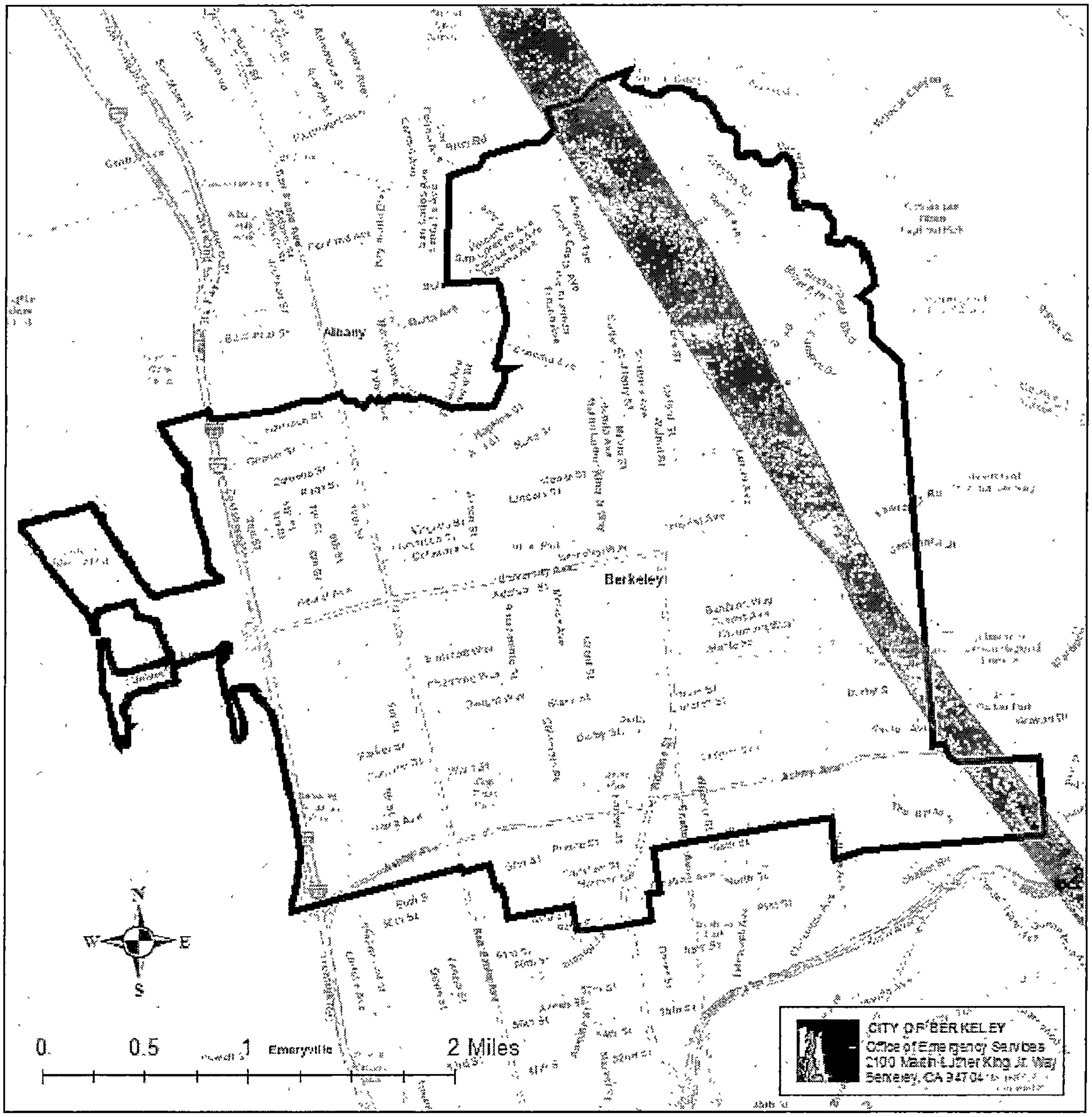
Generally this movement occurs miles below the surface. When the fault slips all the way to the surface, this is called surface fault rupture. In surface fault rupture, one side of a fault can shift by several feet vertically and horizontally from its previous location. This can severely damage structures that cross the fault, including buildings, roads, pipelines, and train tracks.

The Earthquake Fault Planning Zone in Berkeley is indicated in a thick red line on Map 3. The map is zoomed in on the City of Berkeley, which is outlined in a thick black line. The Zone depicted includes an area approximately ¼-mile wide along the Hayward fault, which runs in the northwest-southeast direction along the base of the hills in the eastern portion of the city. This Zone indicates the area of Berkeley that is exposed to surface fault rupture.

Fault rupture may not occur in every earthquake, but when it does, it is likely to be concentrated in a narrow zone, with small parallel surface ruptures occurring over a wider area. If fault rupture occurs, potential impacts include damage to:

- Underground and aboveground utilities (electricity, water, sewer) and communications conduits that cross the fault
- Gas lines that cross the fault, causing fire ignitions
- Important east-west streets, making travel between the hills and flatland areas difficult where displacements are large
- The Solano Tunnel, which is an important transportation connection in the north-south direction
- Buildings, due to ground displacement.

Map 3. ***California Geological Survey Earthquake Fault Planning Zone***



Source: California Geological Survey, Earthqauke Fault Planning Zone.
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Earthquake Fault Zone

City of Berkeley

B.5.b.iv *Seismically-Triggered Landslides*

Rainfall-triggered landslides are described in detail in Section B7.

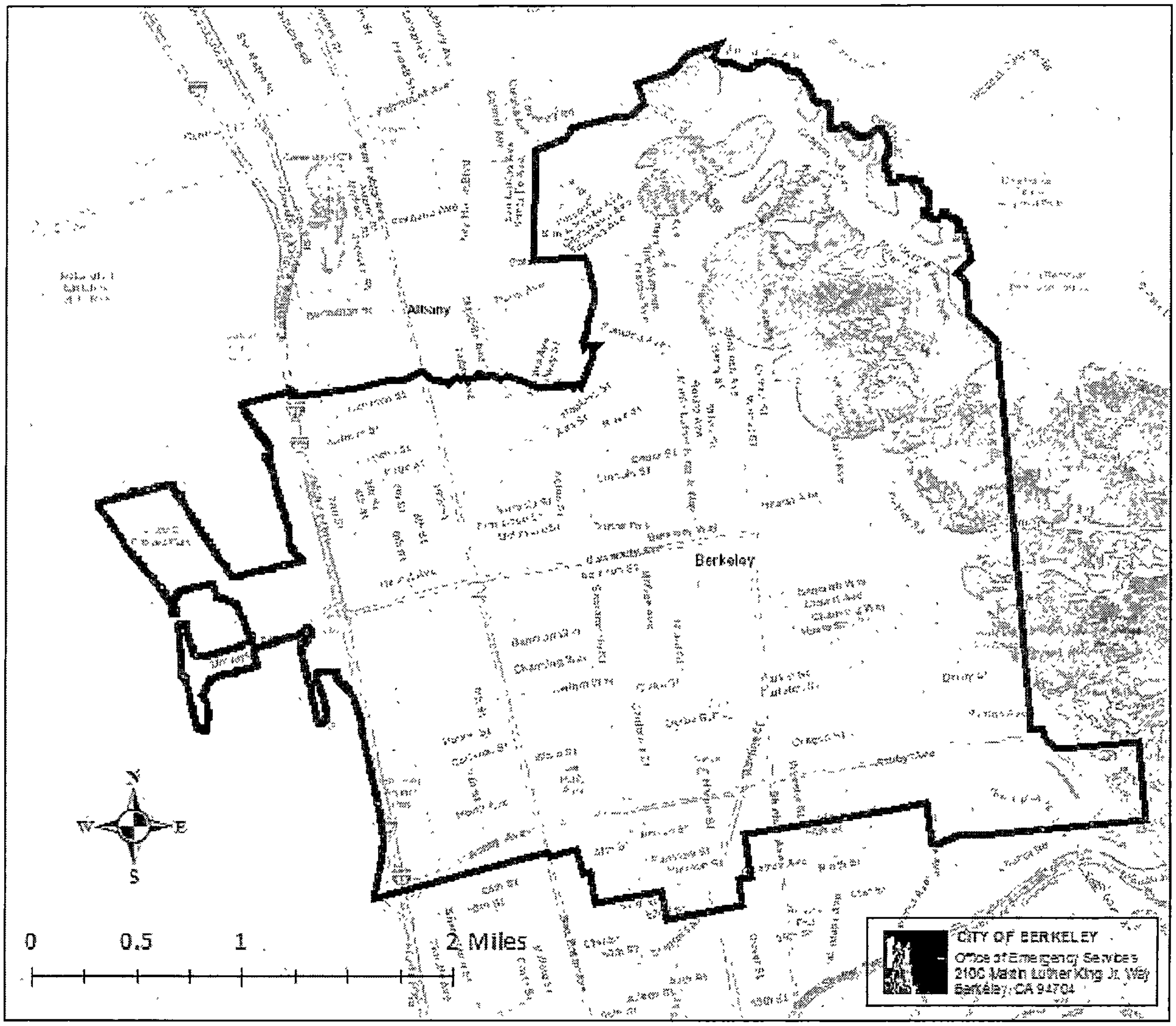
Seismically-triggered landslides can result in significant property damage, injury and loss of life. Berkeley expects to experience landslides during the next earthquake, particularly if the earthquake occurs during the rainy winter months. While rainy weather or earthquakes could cause small landslide events that would impact a few homes, strong earthquake shaking coincident with wet, saturated hills presents a worst-case scenario.

Movement could range from a few inches to tens of feet, but ground surface displacements as small as a few inches are enough to break typical foundations. Even small aftershocks could continue to cause slides for weeks and months after a quake, blocking roads and damaging homes. Even small landslide displacements caused by earthquake shaking can open surface cracks, which allow subsequent rainfall to infiltrate the slide mass and cause instability long after the earthquake.

In Berkeley, the potential for landslide from seismic activity is high in the hill areas and along creek banks. Areas of Berkeley that are exposed to seismically-triggered landslides are displayed in increasing levels of detail on the three maps described below.

The California Geological Survey has identified the areas of Berkeley with potential to experience earthquake-induced landslide. These areas are shown in light brown on Map 4 throughout the Berkeley hills. These areas are identified by combining information on rock or soil strength, slope gradient (steepness), and anticipated future shaking levels. All areas underlain by known active or dormant landslides are included in the zone. Map 4 indicates that significant portions of the Berkeley hills have the potential to experience earthquake-induced landslide.

Map 4. ***California Geological Survey Earthquake-Induced Landslide Planning Zone***



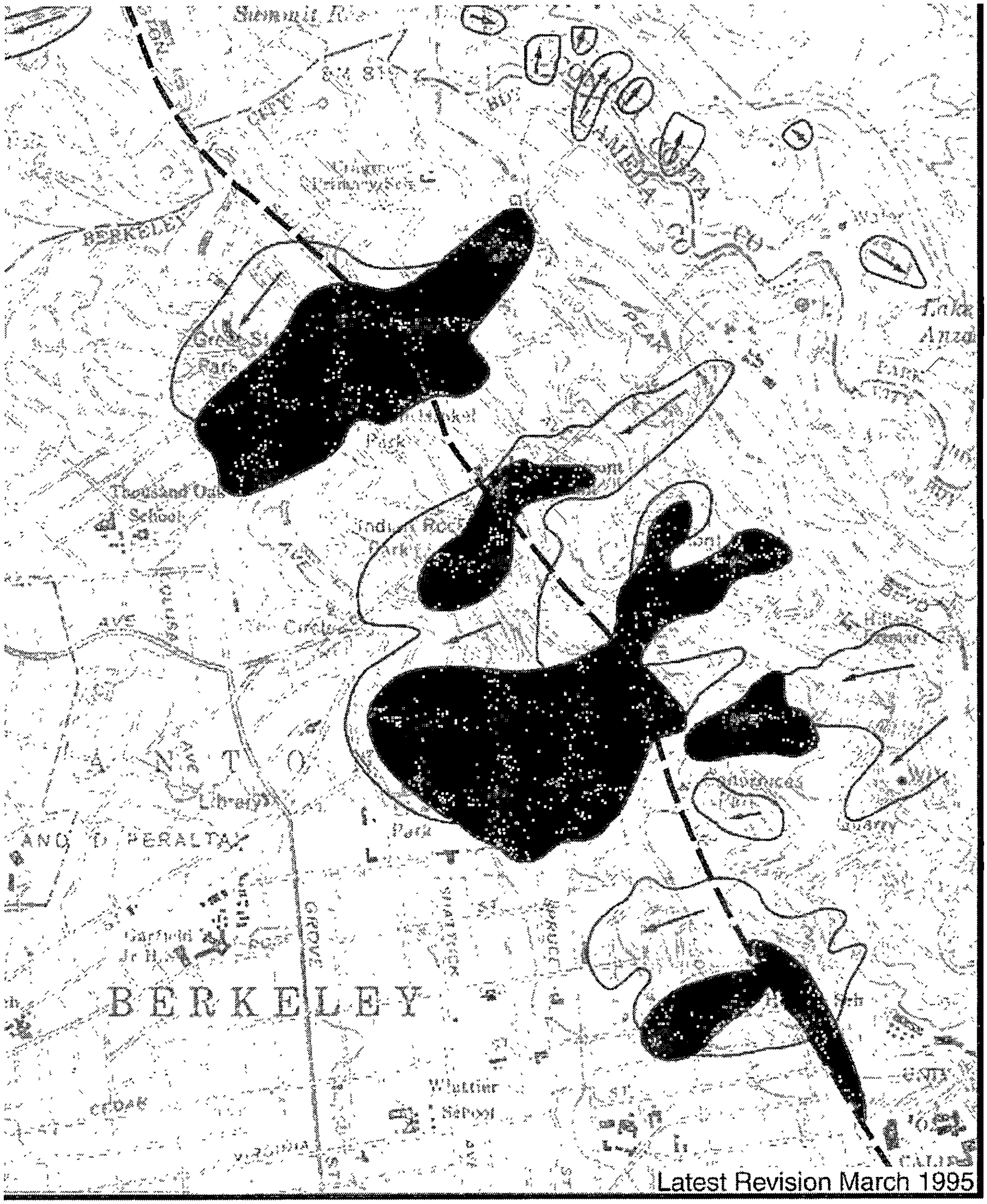
Source: California Geological Society, Earthquake-Induced Landslide Planning Zone.
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Berkeley

Earthquake-Induced Landslide Planning Zone

Map 5, created by Alan Kropp and Associates, focuses on a specific area in the northern part of the Berkeley hills. This map illustrates this area in particular because the area has active landslides, indicated in red on the map. Potentially-active slides are indicated in yellow. In a Hayward fault earthquake, significant movement is likely in active landslide areas. Earthquake shaking and active slides together could activate other potentially-active slides.

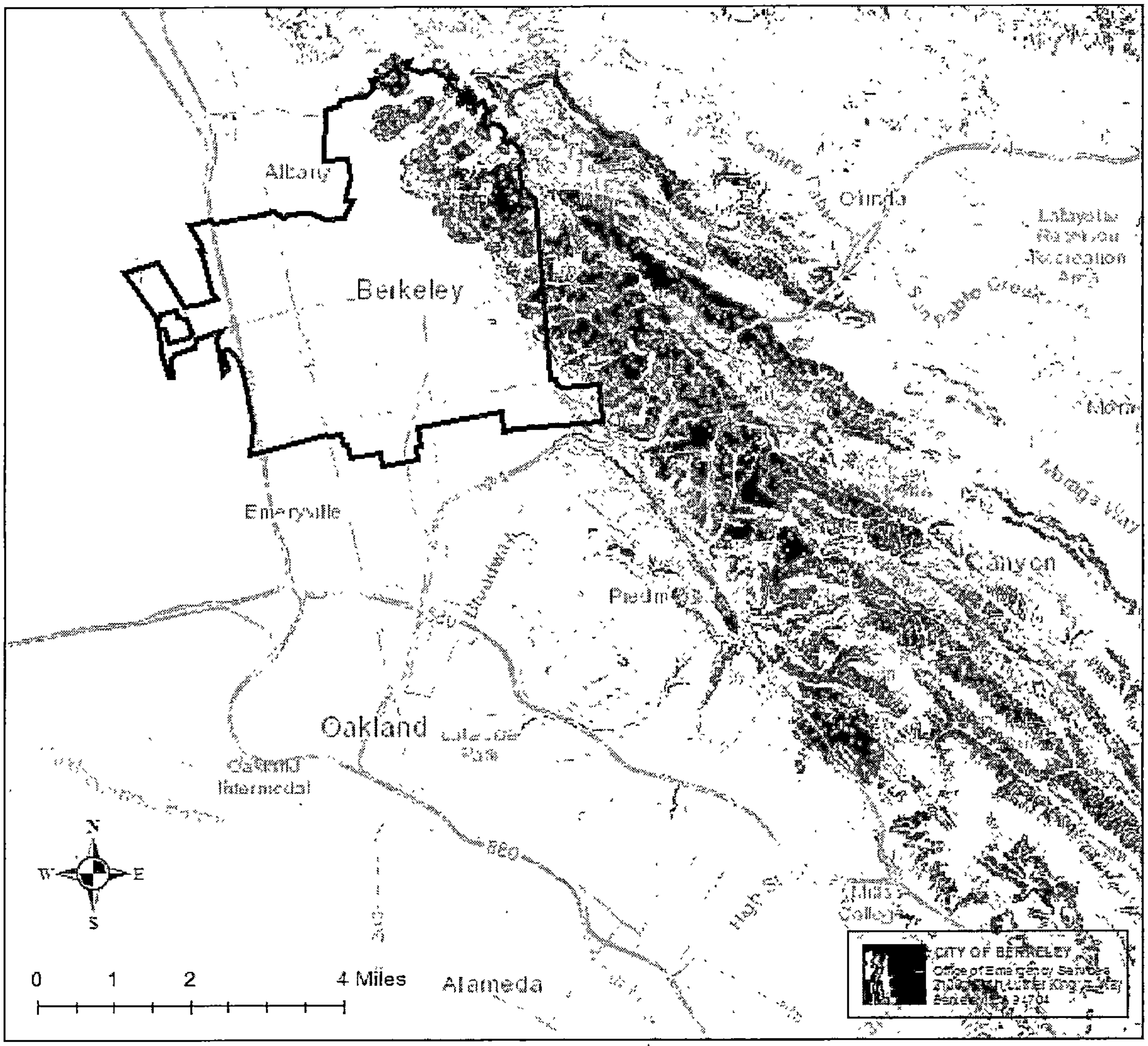
Map 5. ***Active and potentially-active landslides in Berkeley hills (developed by Alan Kropp Associates and used with permission)***



Map 6 shows where landslides are most likely to occur during the mainshock of the HayWired scenario earthquake. To make this prediction, scientists at USGS considered ground shaking intensity, the geology of the study area, and elevation. Probability of landslide is presented as medium (lavender areas), high (magenta areas), and very high (dark purple areas). The maps shows that in Berkeley, the chance of landslide exists primarily in the hills (or in the eastern part of the city), with probabilities ranging from 2% to greater than 32% in some places.

Map 6 is not zoomed in on Berkeley to ensure accuracy of the data. Presenting data at a parcel level could produce inaccurate results. The map shows parts of Oakland, Alameda, Orinda, and Albany.

Map 6. ***Probability of Landslide in HayWired Earthquake Scenario***



Source: USGS, HayWired Scenario, August 2017.
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors,

City of Berkeley
Medium (2-15%)
High (15-32%)
Very High (>32%)

There are few generally-accepted methods to estimate damage from landslides caused by earthquakes.

Earthquake-induced slides may occur at the time of a major earthquake, or in subsequent aftershocks or rainstorms. Residents may have some warning that slides are imminent, helping to reduce damage and casualties. Landslide consequences would be seen primarily in the hills areas of Berkeley, and would likely include:

- Damage to structures, primarily residences. Damage homes could vary considerably, depending on their location and the quality of their foundations, and if there are any retaining walls. Some houses could be entirely destroyed or moved down the hill, while others could see minimal, repairable damage.

- Gas line rupture, igniting multiple fires

- Water line rupture, reducing water supply to fight fires

- Rupture of other underground and aboveground utility and communication systems

- Distortion of major and minor roads. This would make access difficult or impossible for firefighters and other emergency responders. It would also make egress difficult for residents of impacted areas.

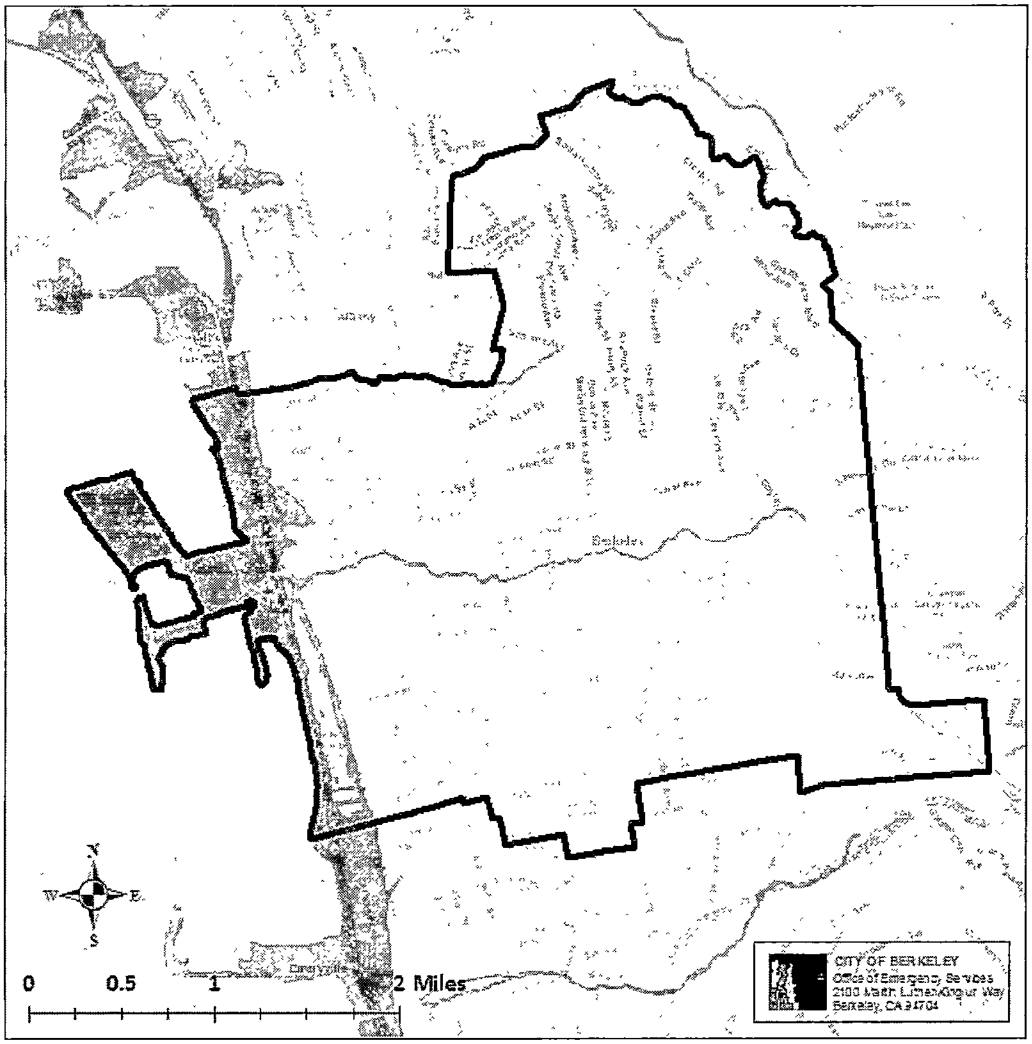
B.5.b.v ***Liquefaction***

Liquefaction is a phenomenon that occurs in wet, sandy or silty soils. When shaken, the soil grains consolidate, pushing water towards the surface and causing a loss of strength in the soil. The ground surface may sink or spread laterally. Structures located on liquefiable soils can sink, tip unevenly, or even collapse. Pipelines and paving can tear apart.

Three ingredients are necessary for liquefaction to occur:
1. Liquefiable sediments
2. Ground shaking
3. Groundwater within three meters of the surface

In an earthquake, liquefiable soils need to be shaken hard and long enough to trigger liquefaction. The USGS classified sediments in the Bay Area based on their susceptibility to liquefaction. Map 7 depicts in various shades of green the areas in Berkeley where soil types and groundwater conditions are more or less susceptible to liquefaction. West Berkeley, along the Bay, is the most susceptible to liquefaction, shaded in very dark green. Moving east into the city, the susceptibility decreases. The Berkeley flats, or the center part of the city, have moderate to low susceptibility to liquefaction, shaded in light shades of green. East Berkeley and the hills have very low susceptibility to liquefaction, with no shading.

Map 7. ***Level of Susceptibility to Liquefaction in Berkeley***



Source. USGS, 2006.
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Berkeley
Very low
Low
Moderate
High
Very high

Map 8 shows the liquefaction predicted to occur in Berkeley in a magnitude 7.0 earthquake on the Hayward fault, as explored in the HayWired scenario. The maps indicates the City of Berkeley with a thick black line and is zoomed out to also show parts of Oakland and Alameda.

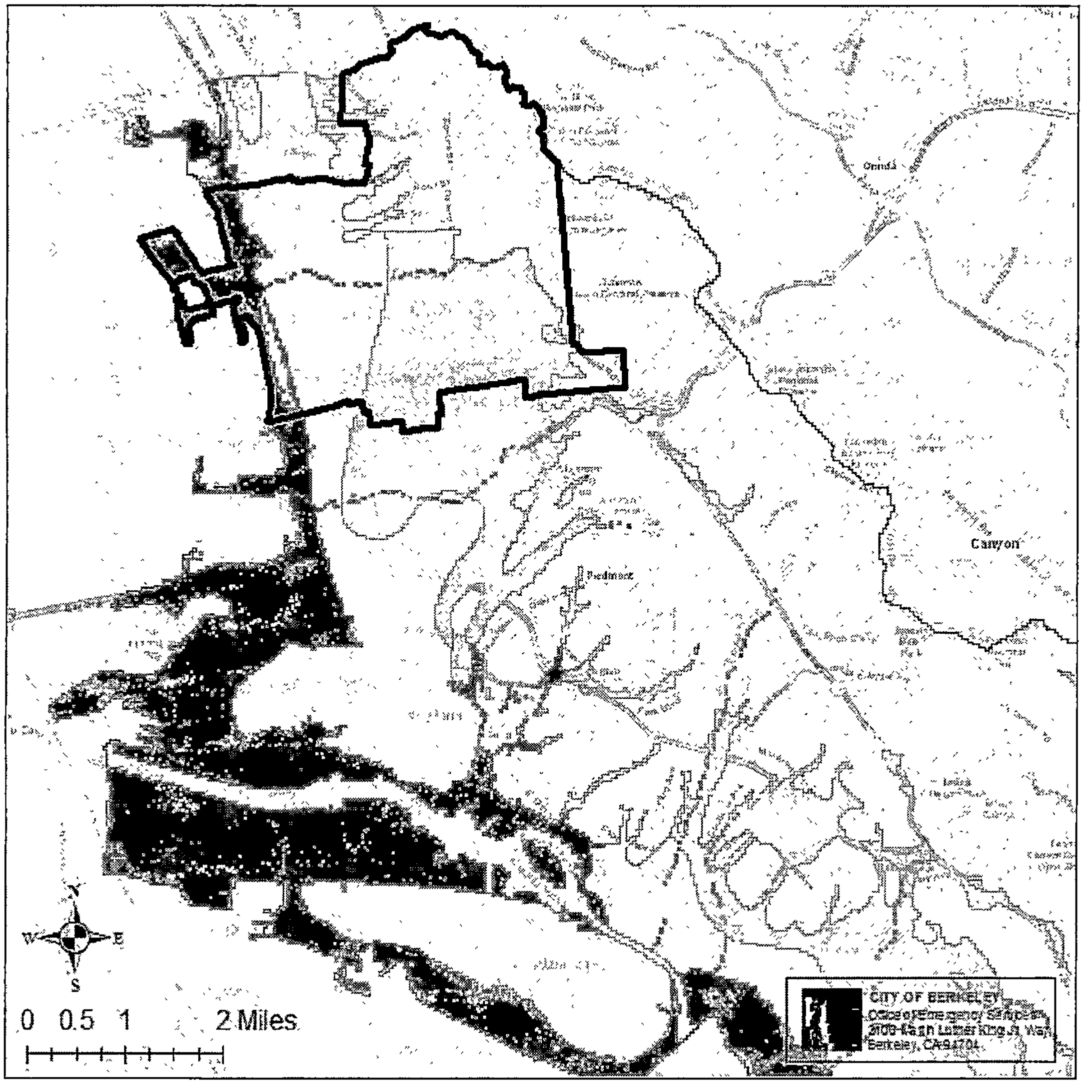
To make this prediction the USGS considered areas' general susceptibility to liquefaction (as shown above in Map 7) and expected levels of ground shaking in the HayWired scenario earthquake. The resulting map divides Berkeley and surrounding areas by their likelihood of experiencing liquefaction.

The probability of liquefaction is highest in west Berkeley along the Bay at 40% or greater, shaded in dark green. This area includes Interstate 80, Aquatic Park, and the Berkeley Marina. The probability decreases to 10% or less in the central and southern parts of Berkeley, shaded in light greens.

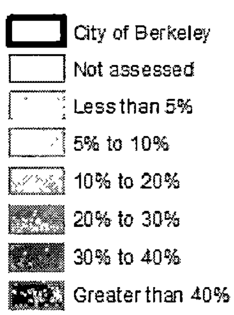
Percentages in this map can also be interpreted as the likelihood that any particular location within an area will experience liquefaction in the HayWired scenario.

Sea-level rise resulting from climate change may raise the water table in Berkeley and increase the areas of Berkeley that are susceptible to liquefaction.[15]

Map 8. ***Probabiliy of Liquefaction in Berkeley in HayWired Earthquake Scenario***



Source: USGS, HayWired Scenario, August 2017.
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community



B.5.b.vi *Fire Following Earthquake*

Significant portions of the following section were originally developed for the City of San Francisco through the Community Action Plan for San Francisco (CAPSS)[16]. While the report was developed for San Francisco, many of the findings are relevant to Berkeley. Both cities have potential for high earthquake shaking, which increases the risk of post-earthquake fire ignitions. Both cities also have dense multi-family housing, which facilitates fire spread.

Additionally, Fire Following Earthqake was analyzed in the HayWired earthquake scenario. Expected impacts are described later in the Earthquake Risk and Loss section.

Fires break out following all major earthquakes. Fire following earthquake presents a significant problem in dense urban environments, where many simultaneous ignitions lead to a firestorm. In these cases, fire damage is even more severe than damage from earthquake shaking. There are many examples from around the world of fire following earthquake:

Earthquake	**Impacts of Earthquake-Caused Fire**
2014 South Napa Earthquake[17]	Nine fires erupted post-earthquake. Immediately after the earthquake, the City of Napa continued pushing water through the damaged system to maintain firefighting and other critical functionality. Although this resulted in an estimated total loss of 100-acre feet of water (about 7% of monthly water usage), it also ensured that water was available for firefighting at all but one of the nine post-earthquake fires.
1995 Kobe Earthquake	More than 100 fires broke out following the 1995 Kobe earthquake, during which broken water mains left the fire department helpless, and fires destroyed more than 7,000 buildings. Fire was also a major contributor to the death toll.
1994 Northridge Earthquake	More than 100 fires broke out following the 1994 Northridge earthquake, severely impacting area fire departments, even though it largely affected only the edge of greater Los Angeles.
1989 Loma Prieta Earthquake	Thirty-six fires broke out in San Francisco. Natural gas line rupture was responsible for some of the fire ignitions. Failure of the city's electrical systems may have actually reduced the number of fire ignitions. Fires in the Marina District claimed four structures in the area, but lack of wind that night assisted in preventing the fires from spreading. Overall, the shaking experienced in the Loma Prieta earthquake was moderate, as the epicenter was 70 miles away.
1906 San Francisco Earthquake	The earthquake was followed by a firestorm that lasted for three days, and in that time swept over an area of over 3.5 square miles.[18] It is estimated that 80 percent of San Francisco's property value was lost in the fire.

B.5.b.vi.1 Fire following earthquake hazard

Earthquake shaking can start fires in numerous ways, such as:

- Tipping over appliances with pilot lights
- Damaging electrical equipment leading to sparks
- Exposing materials to open flames from stoves, candles, fireplaces and grills

> In the 1994 Northridge earthquake in Los Angeles, over half of the ignitions were due to electrical systems, and about a quarter were fueled by gas.

Ground failure due to liquefaction, surface fault rupture and landslide can rupture gas lines (both underground and at the private gas meter). These ruptures can start and fuel fires.

Earthquakes can also damage the systems we have in place to stop fires. Earthquake shaking can damage a building's active fire protection systems (e.g., fire alarms and sprinkler systems), as well as its passive fire protection systems (construction features designed to slow/stop fire, e.g. fire walls, fire-rated floor-ceiling assemblies, fire doors).

Post-earthquake fires can also spread quickly due to spilled flammable chemicals.

Fires also spread more quickly after major earthquakes because earthquakes damage the infrastructure needed to fight fires. Earthquake shaking and ground failure due to liquefaction, surface fault rupture and landslide can simultaneously:

- Break water mains, causing a drop in water pressure
- Damage electrical systems necessary to provide energy to pump water
- Damage communication infrastructure
- Impede transportation routes with debris or landslides
- Jam firehouse doors, preventing apparatus from responding.

Fires can occur in the days or months following an earthquake due to the aforementioned possible damage to electrical systems, fire protection systems, and gas lines.

B.5.b.vi.2 Exposure and vulnerability

Soft-story and unreinforced masonry buildings are more prone to earthquake damage (see Section B.5.c.iii), and thus are also likely to be a key source of earthquake-caused fires when gas or electricity lines break or rupture. Additionally, Berkeley has many older multi-unit apartment buildings without fire sprinkler systems. These buildings could both cause and feed fires following an earthquake. Even buildings that survive earthquake shaking can succumb to fire, including those buildings that have been seismically retrofitted.

Densely-populated neighborhoods with wooden homes, such as most of the residential areas in Berkeley, are at high risk of fire spread following a major earthquake. Earthquakes in places with this type of construction have caused the two largest peacetime urban fires in history: in 1923 in Tokyo; and in 1906 in San Francisco, where 80% of the 28,000 destroyed buildings were lost due to fire.

The Berkeley Fire Department today is a well-prepared, professional organization that trains for earthquake-caused fires. However, after the next large earthquake, there are likely to be more fires than Berkeley's firefighters can respond to at one time.

Compounding this challenge, fire personnel will not only be fighting fires, but will also be responding to needs for search and rescue and emergency medical services.

Firefighters in nearby cities will be struggling to address response needs in their own jurisdictions, and State and federal resources may not be able to help the City for many hours. The 1991 East Bay Hills Fire destroyed 3,354 structures in only a few hours and overwhelmed the capacity of local fire departments, even though neighboring departments were available to assist.

Fires in Berkeley could burn out of control, and may threaten entire neighborhoods. Fire damage will add to the city's overall earthquake damage, making recovery more difficult and lengthy by increasing the number and severity of damaged buildings, lengthening the time required to repair and replace damaged buildings, displacing residents, and weakening neighborhoods.

B.5.c Exposure and Vulnerability

This section describes Berkeley's earthquake vulnerabilities. It contains four parts:

- Buildings
- Infrastructure (systems for utilities, transportation and communications)
- Critical response facilities
- People

In some instances, a system's earthquake vulnerability could potentially create a secondary hazard (e.g., if earthquake shaking were to result in a hazardous materials spill.)

Much of Berkeley's built environment is owned and operated by other public and private entities and is not under the City's direct authority. The City works with other public agencies and companies on disaster planning, and this section includes information about some of the activities that the City's key community partners are undertaking to mitigate the hazards that may impact or originate on their own property.

B.5.c.i *Buildings*

Ground shaking produces most building losses in typical earthquakes. Buildings are also vulnerable to ground displacements associated with primary fault rupture, liquefaction and landslides.

This section first addresses the earthquake exposure and vulnerability for City-controlled buildings. Secondly, it describes earthquake exposure and vulnerability for buildings *not* controlled by the City, including private residences and commercial buildings.

Retrofitting vs. New Construction

Building codes are continually improved, incorporating new knowledge about building methods that effectively resist seismic forces.

Buildings built using older techniques can be especially vulnerable to earthquake damage. Buildings are usually retrofitted with the goal of reducing loss of life, but damage can still be expected in many retrofitted buildings. Building retrofit is often preferable to building replacement, as retrofitting an existing building can be more cost-effective and environmentally-friendly, while preserving historic architecture.

New building construction is expected to perform better than retrofitted buildings in an earthquake. However, the goal of the building code is to reduce loss of life in an earthquake, not to ensure the continued use of the building. This means that a large earthquake will damage even new buildings, which may remain unusable for long periods of time.

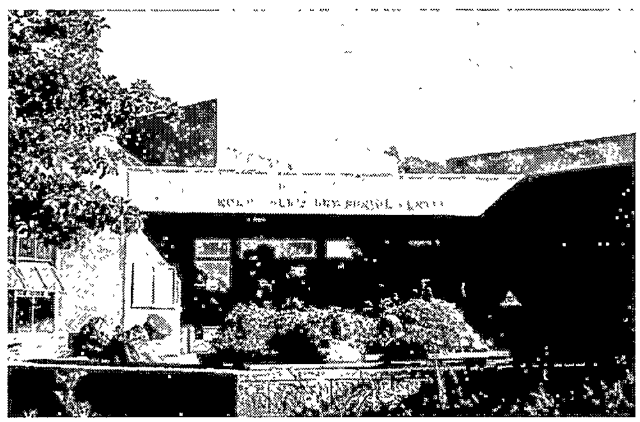
B.5.c.ii *City-Owned Buildings*

The City of Berkeley owns or leases approximately 221 buildings and structures. These facilities have multiple uses, including running City government, providing emergency services, low-income housing, and recreation. In recent years, the City has been seriously examining the risk to its buildings from disasters, particularly earthquakes. Many important City buildings have been assessed for seismic safety and, when possible, strengthened or replaced.

However, additional of City buildings need to be assessed to determine their level of vulnerability to seismic events. Some may pose some risks to life and emergency operations. Four of these vulnerable buildings are explored further below.

North Berkeley Senior Center, 1901 Hearst Street

The North Berkeley Senior Center is a dynamic community gathering place offering a wide array of services and social events, including classes, a senior lunch program, and field trips. The Center also serves as a gathering place for community and commission meetings, and as an affordable rental for other organizations looking to host a gathering in a large community hall. During emergencies the Center has also been identified as one of the City's mass care and shelter sites.



In February 2016, FEMA awarded the City a Pre-Disaster Mitigation Grant of $1.875 million to mitigate the Center's seismic vulnerabilities, including possible collapse. With the passage of Bond Measure T1 in the fall of 2016, the City has secured funding for the retrofit of the North Berkeley Senior Center.

Mandatory safety upgrades will be performed during this retrofit, including structural seismic upgrades so that the building can be immediately occupied after a major earthquake; upgrades for compliance with current building codes, including ADA and Fire codes; and deferred maintenance including exterior, roof replacement, and first floor restroom upgrades. The Center will also have a hookup for a generator, increasing the facility's ability to provide services in the event the grid is down.

Live Oak Community Center, 1301 Shattuck Avenue

The Live Oak Community Center currently houses youth and family recreation programs and public events during evenings and on weekends. The building is also used as a shelter in the event of emergencies.

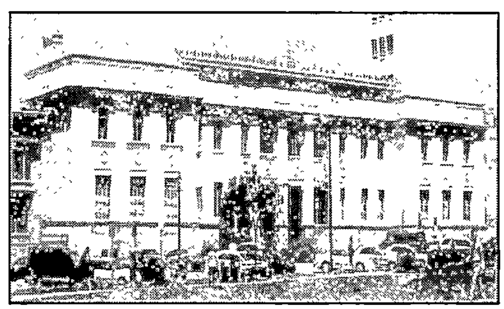
The Live Oak Community Center Seismic Retrofit project will include seismic upgrades, needed repairs to building systems, including plumbing, mechanical, electrical, accessibility, and architectural features, and energy and water efficiency upgrades to meet current building codes.

Project work will improve the building's expected post-earthquake damage state performance level from collapse prevention to either life safety or immediate occupancy. This change will allowing the facility to be used as mass care site in the event of an earthquake.

Old City Hall, 2134 Martin Luther King, Jr. Way

Old City Hall is a City of Berkeley Landmark that is part of the Civic Center Historic District and listed on the National Register of Historic Places. This building potential collapse hazard that needs to be retrofitted. There is no identified funding source to retrofit this building. As of December 2018, plans are underway to use the site as Berkeley's Emergency Storm Shelter, which will operate when it's raining or under 40 degrees.

Veterans' Memorial Building, 1931 Center Street



Veterans' Memorial Building is also a City of Berkeley Landmark, part of the Civic Center Historic District, and listed on the National Register of Historic Places. It is used for public assembly, as a homeless shelter, and for daytime homeless services, is a potential collapse hazard that needs to be retrofitted. A homeless shelter currently operates in the building. During the day, the Dorothy Day House, Berkeley Food and Housing Project, Options Recovery, Building Opportunities for Self Sufficiency (BOSS), and Berkeley History Center use the building for their homeless service programs. There is no identified funding source to retrofit this building.

Notable Mitigation Activities

The City has strengthened many important buildings for emergency response and recovery. Since 2014, the City has continued its program to strengthen or replace key at-risk structures, including the Center Street Garage and James Kenney Recreation Center. In 2019, the City is developing its Civic Center Vision and Implementation Plan for Old City Hall and Veterans Memorial Building.

Center Street Garage, 2025 Center Street

The replacement of the Center Street Garage has been one of the City's high priority downtown projects. The preexisting 5-story structure did not meet current seismic standards and retrofit was determined to be infeasible. The new 8-story facility opened in October 2019 and meets current seismic standards. It has 720 parking spaces, solar panels, electric vehicle charging stations, a water storage system, secure bicycle parking, office space for parking management, and commercial and art display space on the first floor. Construction was funded through 2016 Parking Revenue Bond Fund ($28.3 million) and the Off Street Parking Fund (Fund 835) ($8.2 million).

James Kenney Recreation Center, 1720 Eighth Street

The James Kenney Community Center currently houses daycare, afterschool children's programs, day camps, various teen recreation programs, open gym, and public events during evenings and on weekends. The site is the City's best equipped mass care and shelter site in the event of a disaster.

In 2017, a retrofit of the facility was completed at a total cost of $3.05 million. The James Kenney Community Center Seismic Retrofit project involved seismic strengthening of the Recreation and Gym Building, as well as fire protection sprinklers throughout the building, and necessary ADA upgrades.

This work was made possible by a Pre-Disaster Mitigation Program grant for $727,499, provided by the State Office of Emergency Services and the Federal Emergency Management Agency, as well as a Department of Housing and Community Development Grant for over $1 million.

Civic Center Vision and Implementation Plan

The City is embarking on a community process to develop a shared vision and plan for Old City Hall, the Veterans Memorial Building and Civic Center Park – critical, underutilized civic resources that would support current and future community needs while celebrating their architectural significance, central location, and history as the center of City government.

The project team, which would start in fall 2019, would aim to build civic trust, establish shared and realistic expectations of the capacities of three elements, and, ultimately, deliver preliminary design concepts of the space to City Council for review a year later in Fall 2020.

B.5.c.iii *Privately-Owned and Other Structures*

Berkeley has about 43,636 housing units[19], serving the city's population of 112,580[20]. Most were built before 1980, meaning that few of Berkeley's homes were constructed to modern building code standards, which require earthquake-resistant structural measures, fire-resistant materials, and landslide-resistant siting and landscaping.

Older houses constructed with a crawl space or aboveground basement below the first floor can have several weaknesses, because older building codes were inadequate to resist seismic forces, or because codes were not followed properly. The bottom of the wood frame exterior walls may not be adequately bolted to the foundation, meaning the house can slide off the foundation during strong shaking. The foundation itself may be constructed of weak or deteriorated materials, like brick or very old concrete. Also, the wall that encloses the crawl space, known as a cripple wall, may be weak and vulnerable to collapse due to inadequate bracing and deterioration of wood members from termite attack and dry rot. Hillside houses can suffer from any of these weaknesses, but have increased risks of failure to cripple walls and poorly braced extra-tall walls along the sloping sides.

Notable Mitigation Activities

A number of City incentive programs and educational efforts promote seismic strengthening activities.

Plan Set A
The City's adoption of Standard Plan Set A[21] educates homeowners and contractors about measures to improve seismic resistance of their homes. Contractors' adherence to this Standard simplifies the City's plan review and inspection process.

Mandatory Retrofit Ordinances

The City of Berkeley has worked diligently to enhance public safety and reduce physical threats from earthquakes by requiring owners of soft story and unreinforced masonry buildings to retrofit their structures. Berkeley Municipal Code (BMC) Chapter 19.39, effective January 4, 2014, mandated owners of soft story (also known as soft, weak or open front / "SWOF") buildings with five or more dwelling units to apply for a building permit for a seismic retrofit by December 31, 2016. Owners were given two years to complete the work upon submission of the permit application. Previously, the City approved an ordinance in 1991 (BMC 19.38) requiring owners of unreinforced masonry (URM) buildings to evaluate their buildings, obtain retrofit permits and complete seismic retrofits according to a schedule based on each building's risk categorization but in all cases no later than 2001.

Through these hazard mitigation measures, the City of Berkeley hopes to increase the safety and resilience of the city's building stock to prevent injury and loss of life and reduce post-disaster recovery time.

Soft Story Ordinance for Buildings with Five or More Dwelling Units

Soft story buildings are characterized as multi-story wood-frame buildings with extensive ground story openings such as windows, storefronts, garage openings, or open-air spaces such as parking. These buildings may have few perimeter or interior walls at the ground level, leading to a relatively soft or weak lateral load resisting system in this lower story. Since the collapse of soft story buildings in the 1989 Loma Prieta and the 1994 Northridge earthquakes, there has been considerable concern in California about tenant safety and the seismic deficiencies in these buildings. In 2005, Berkeley was the first city in the country to pass an ordinance to address this potentially unsafe condition.

Berkeley's original 2005 ordinance added Chapter 19.39 to the Berkeley Municipal Code, requiring owners of soft story buildings with five or more dwelling units to submit a seismic engineering evaluation report analyzing the ability of the building to resist earthquake forces and describing possible work to remedy weaknesses. The ordinance also required owners to notify tenants of the building's soft, weak or open front (SWOF) condition and post an earthquake warning notice at the building entrance. The initial wood-frame SWOF inventory included 321 buildings. The inventory has since increased to 332 buildings, containing 3,665 units.

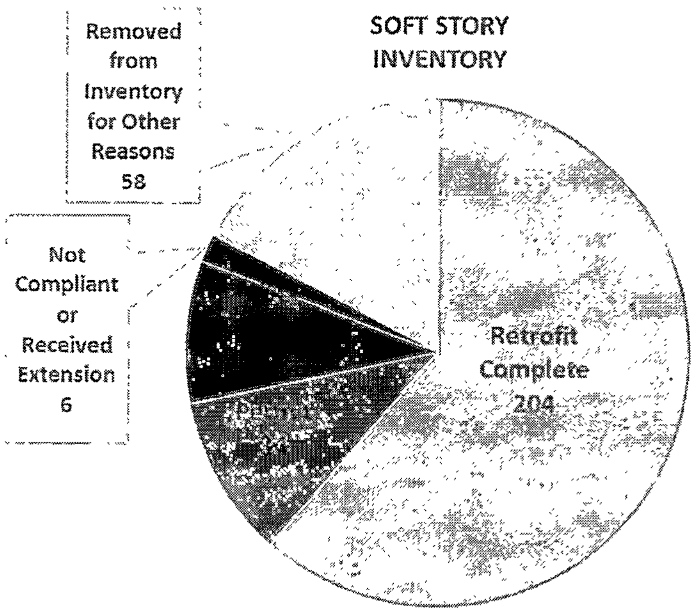
On December 3, 2013, Council adopted amendments to Berkeley Municipal Code Section 19.39.110 establishing mandatory seismic retrofit requirements for soft story buildings with five or more dwelling units. The ordinance established December 31, 2016 as the deadline for property owners to apply for a building permit. Owners must complete retrofits within two years of submitting the permit application. Table 3 describes the status of the 332 soft story buildings subject to mandatory retrofit as of December 2018.

Table 3. Berkeley Soft-Story Building Status as of December 2018

Number of buildings	Percent*	Status
204	61	Retrofit Complete
34	10	Permit
30	9	Applied for Permit
6	2	Not Compliant or Received Extension
58	17	Removed from Inventory for Other Reasons
332	*100%*	*Total buildings identified as soft-story*

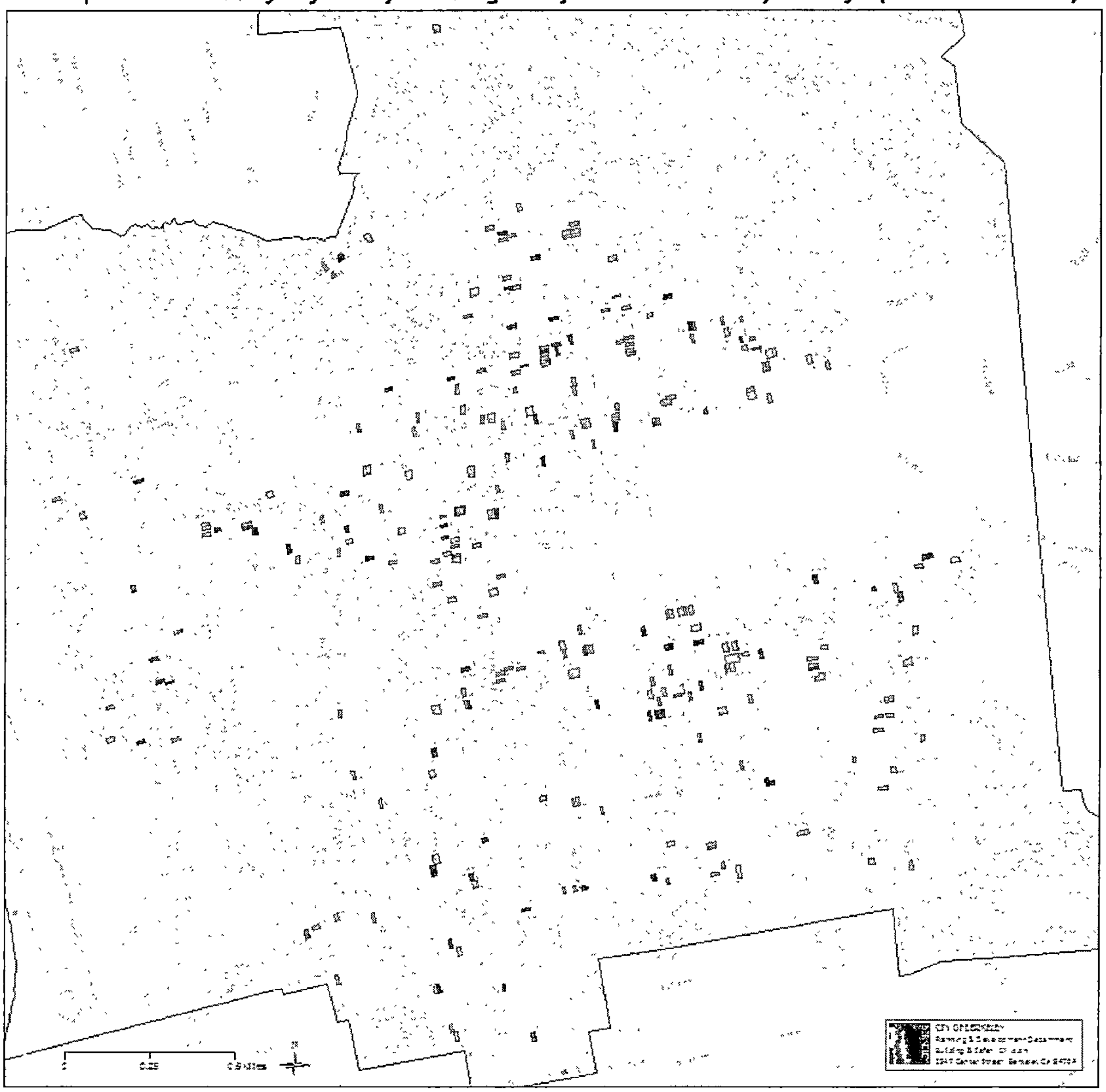
*Due to rounding, percentages do not add up to 100 percent.

Table 4. Chart of Berkeley Soft-Story Building Status as of December 2018



Map 9 shows the retrofit status of soft story buildings subject to mandatory retrofit, as of December 2018. Green symbols depict parcels with retrofit buildings, blue indicates parcels containing one or more buildings with permits issued or currently under review, and red shows parcels with extensions filed or buildings out of compliance.

Map 9. ***Status of Soft Story Buildings Subject to Mandatory Retrofit (December 2018)***



RETROFIT COMPLETED
PERMIT ISSUED OR IN REVIEW
NOT COMPLIANT OR RECEIVED EXTENSIONS

Unreinforced Masonry (URM) Ordinance

Unreinforced masonry (URM) buildings are generally constructed of brick, block, tile, stone, or other types of masonry, and were built prior to modern earthquake-resistant design. During an earthquake, unreinforced masonry walls that were originally built with inadequate reinforcement (embedded steel bars) are susceptible to collapse. In addition, URM buildings often include unreinforced masonry parapets, chimneys, and high brick veneers that tend to disconnect from the building and fall outward, creating a hazard for people below and in some instances causing the building to collapse. Weak or nonexistent connections between the masonry walls and the floors and roofs place occupants, pedestrians, and adjacent buildings in harm's way.

Although unreinforced masonry buildings are no longer constructed today, existing URM buildings can be retrofitted to reduce risks caused by earthquake activity. If these buildings are not retrofitted and suffer major damage in an earthquake, the costs of repair after the earthquake could be prohibitively high and may result in demolition or loss of use.

In response to State law, the City of Berkeley compiled an inventory of unreinforced masonry buildings in 1989, identifying approximately 700 residential and commercial URM buildings that were built prior to 1956. In 1991, the City adopted the Unreinforced Masonry Ordinance 6088-N.S. Subsequent amendments to the ordinance required owners of unreinforced masonry buildings to evaluate their buildings, obtain necessary permits and complete seismic retrofits by 2001.

Of the approximately 700 buildings originally included in the City's unreinforced masonry (URM) inventory, hundreds were removed from the list after owners provided evidence the buildings adequately met building standards or that the buildings were not unreinforced masonry structures. Of the original list, roughly 99% have been seismically retrofitted, demolished or demonstrated to have adequate reinforcement. As of August 2018, six buildings are still required to retrofit in order to avoid further penalties. Five of the six building owners have applied for retrofit permits.

Map 10 shows the unreinforced masonry (URM) inventory as of June 2018. Parcels in yellow contain buildings that are compliant with the Unreinforced Masonry Ordinance 6088-N.S. Red triangular symbols denote unreinforced masonry buildings still subject to mandatory retrofit, including those currently in the permitting process.

Map 10. ***Berkeley Parcels with Unreinforced Masonry Building Types (June 2018)***

COMPLIANT WITH URM ORDINANCE

▲ NOT COMPLIANT WITH URM ORDINANCE (INCLUDING THOSE IN PERMIT REVIEW PROCESS)

Financial Incentives

Retrofit Grants
In early 2017, the Building and Safety Division developed a new Retrofit Grants program with funding from a Hazard Mitigation Grant from the Federal Emergency Management Agency (FEMA) and the California Governor's Office of Emergency Services (Cal OES). In the first round of the Retrofit Grants program, the City offered grants of up to $25,000 to owners of soft story buildings with five or more units, and unreinforced masonry buildings. During the first round of the grant program, owners of 48 buildings containing over 400 housing units applied for grants, amounting to over $1 million in federal funding.

The Building and Safety Division launched the second round of grant funding in May 2018, offering design and construction grants to owners of other seismically vulnerable buildings: rigid wall - flexible diaphragm buildings (RWFD) with walls made of concrete or masonry and wood or steel roofs, non-ductile concrete buildings (NDC), and soft story buildings with 3-4 residential units and non-residential uses, which are not covered under the mandatory soft story retrofit program. In the second round of the grant program, as of August 2018, owners of 66 buildings applied for an additional $1.3 million in FEMA funding. These buildings contain almost 300 housing units in addition to a variety of retail, commercial, and educational occupancies.

In the spring of 2018, City staff conducted outreach to promote the second round of grant funding and assist owners with the application process. Information packets, including applications, fact sheets about relevant building types and grant program details were mailed to property owners of nearly 1,000 potentially vulnerable buildings. The application deadline for the second phase of the Retrofits Grants Program was June 25, 2018.

Although single-family homes and duplexes were not eligible for this program, other programs are available for property owners and are detailed below.

Transfer Tax Rebate Program
By ordinance, the City created a program to rebate up to one- third of the transfer tax amount to be applied to earthquake upgrades on homes. The process begins once the homeowner makes seismic safety improvements. When the owner wishes to sell the house and the sale amount has been determined, the buyer and seller place a portion of the real estate transfer tax amount in an escrow account to be drawn down after improvements are complete. Since July 2002, the City has distributed over $12 million to homeowners through this program as outlined in Table 5 below.

Table 5. Transfer Tax Rebate Program

Fiscal Year	Property Transfer Rebates	Total Funds Issued
2003	382	$1,133,047
2004	467	$ 1,539,738
2005	385	$ 1,459,510
2006	262	$ 1,168,654
2007	144	$ 611,433
2008	152	$ 681,002
2009	138	$ 533,061
2010	150	$ 592,539
2011	157	$ 593,974
2012	166	$ 623,502
2013	159	$ 766746
2014	164	$ 798,370
2015	138	$ 773,697
2016	147	$ 859,831
2017	55	$ 423,586
2018[1]	31	$ 165,010
Total (FY 2003-2018)	3,097	$12,723,700

Earthquake Brace + Bolt

The City participates in the Earthquake Brace + Bolt (EBB) program, a grant program administered by the California Earthquake Authority, providing grants of up to $3,000 for seismic retrofits of owner-occupied residential buildings with 1-4 dwelling units.

The EBB program provides incentives to homes most vulnerable to severe damage in an

[1] As of September 2018. Taxpayers may still claim seismic-related refunds for properties purchased in FY 2018.

earthquake, typically those built before 1979 with raised foundations and unbraced "cripple walls," the wood-framed walls which surround the crawl space. Bracing the cripple walls with plywood and using anchor bolts to improve the connection between a home's wood framing and its foundation are seismic improvements that can help reduce potential damage to a home during an earthquake.

The program supplements other programs to subsidize or finance seismic improvements in Berkeley homes; these programs can be used in combination or separately.

Property Assessed Clean Energy (PACE)
Additionally, the PACE program provides financing for seismic improvements, and allows owners to pay back costs over time on their property tax bills with no upfront costs.

Expanded Inventory of Seismically Vulnerable Buildings
With the launch of the Retrofit Grants Program, staff conducted extensive research to update and refine the City's inventory of seismically vulnerable buildings. In addition to soft story buildings not currently subject to mandatory retrofit such as those with 3-4 residential units or commercial uses, Berkeley has numerous non-ductile concrete and tilt-up or other rigid wall-flexible diaphragm (RWFD) buildings. These additional building types may also be highly susceptible to adverse effects from earthquakes.

Although no ordinance currently requires property owners of these building types to retrofit, the City of Berkeley has encouraged owners to apply for grant money under the City's Retrofit Grants Program.

Non-Ductile Concrete Buildings
Non-ductile concrete buildings built prior to the mid-1970's and modern seismic code standards have performed very poorly in recent earthquakes, and have resulted in catastrophic collapses. In older concrete buildings, the detailing and construction of the reinforcing steel may be inadequate to safely resist large seismic forces caused by ground motions on these heavy structures. The most vulnerable buildings contain elements like columns, wall piers, and joints of beams and slabs that can fail in an earthquake. These buildings are considered "non-ductile" (i.e. brittle) concrete buildings and pose a high risk during a major earthquake. Retrofits of these buildings can vary widely in terms of scope and level of difficulty, and are often expensive to retrofit or rebuild.

Rigid Wall-Flexible Diaphragm (RWFD) Buildings Including Tilt-Up Buildings
Tilt-up or other rigid wall-flexible diaphragm building types are typically one or two story commercial buildings with reinforced concrete or reinforced masonry (brick or concrete block) walls. A "tilt-up" building is a specific type of building with precast concrete walls and is distinguished by its method of construction. RWFD have "flexible" roof diaphragms that consist of wood or steel beams, trusses, or rafters with wood sheathing or metal decking above. They may also have flexible diaphragms at intermediate floor levels. These buildings commonly include warehouses, manufacturing facilities, large retail stores, and other similar structures. The most common deficiency is an inadequate connection between the rigid walls and the roof (and floors) leading walls to pull away and collapse during ground shaking. Buildings designed under

codes that predated the 1998 California Building Code are of primary concern.

Soft Story Buildings Not Subject to Mandatory Retrofit
Similar to Soft Story buildings subject Berkeley Municipal Code Section 19.39.110, those with only 3-4 unit or commercial uses are also vulnerable to collapse in the event of an earthquake due to weak lateral load resisting systems. Since the initial phase of the project, the grant program has expanded to include Soft Story buildings with 3-4 residential units, and some mixed-use or nonresidential Soft Story buildings that are not mandated to retrofit.

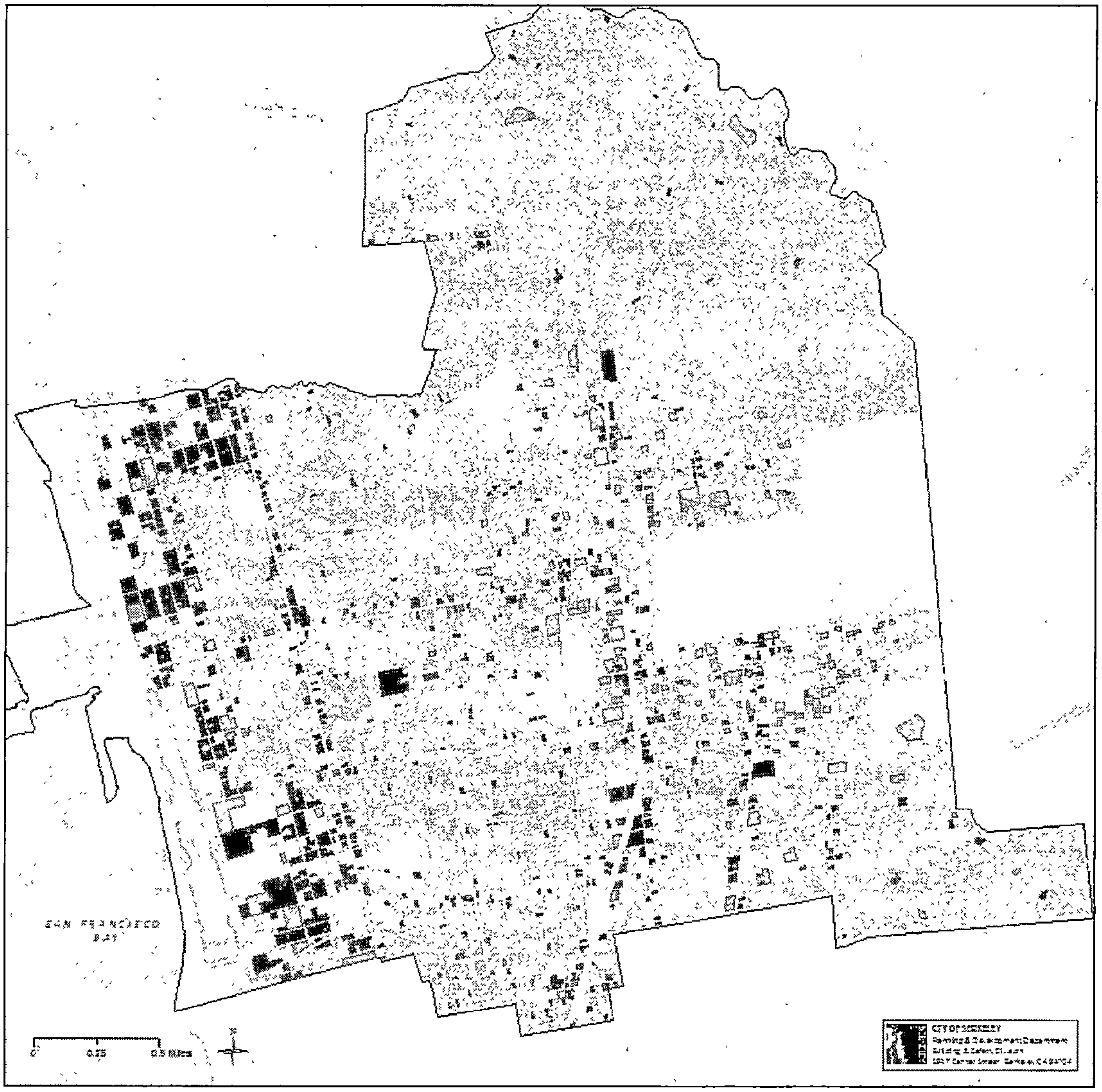
Process for Updating the Inventory of Seismically Vulnerable Buildings
The City has worked diligently to update and broaden its inventory of seismically vulnerable buildings to include non-ductile concrete buildings, rigid wall-flexible diaphragm buildings, and soft story buildings with 3-4 residential units or commercial uses. This effort began with extensive staff research to identify vulnerable buildings using City and other data sources.[22] It was followed by a field study with the Earthquake Engineering Research Institute (EERI) to assess a portion of the newly identified non-ductile concrete and rigid-wall flexible-diaphragm buildings[23], and a "virtual survey" to identify potential soft story buildings.[24]

<u>Updated Inventory of Seismically Vulnerable Buildings (2018)</u>
As of June 2018, the City identified 1,047 potentially seismically vulnerable buildings that did not already appear on the soft story or URM inventories. The updated inventory includes 230 potentially non-ductile buildings and nearly 550 buildings that may be rigid wall-flexible diaphragm, including tilt-ups. The City has also added to the inventory approximately 240 soft story buildings not subject to mandatory retrofit under Chapter 19.39 of the Berkeley Municipal Code.

Map 11 shows Berkeley's updated Inventory of Seismically Vulnerable buildings, as of June 2018. Soft story buildings are somewhat evenly spread throughout the City. Potentially non-ductile concrete buildings and rigid wall-flexible diaphragm buildings are more heavily concentrated along commercial corridors and west of San Pablo Avenue. Non-ductile concrete buildings are also clustered in central Berkeley, and near the UC Berkeley Campus. Soft story buildings are depicted in blue, non-ductile concrete buildings in orange, rigid wall-flexible diaphragm buildings in purple, and unreinforced masonry buildings in red.

This map reflects properties that are eligible for the Cal OES/FEMA Grant Program.

Map 11. ***Updated Inventory of Potentially Seismically Vulnerable Buildings (June 2018)***



POTENTIALLY NON-DUCTILE CONCRETE

POTENTIALLY TILT-UP OR OTHER RIGID WALL-FLEXIBLE DIAPHRAGM

POTENTIALLY SOFT STORY AND WOOD FRAMED BUILDINGS

UNREINFORCED MASONRY

B.5.c.iv ***Infrastructure***

This section examines the earthquake exposure and vulnerability of Berkeley's infrastructure. It is organized into three components: utilities, transportation and communications.

Infrastructure described in this section provides the foundation for day-to-day life in Berkeley. These systems are also vital to many of the City's disaster response activities, and restoration of these systems will be critically important to Berkeley's recovery from a major earthquake.

Many of these systems are also significant because their failure in an earthquake could create secondary hazards, compounding the challenge to Berkeley's disaster response and recovery activities.

Much of the City-owned infrastructure was built before World War II when the city was growing and modernizing. After over 90 years in service, much of the infrastructure requires extensive maintenance, repair or enhancements.

Electrical, natural gas, petroleum, telecommunications, and potable water supply infrastructures are not under the City's control, but rather are owned and managed by other quasi-governmental, private or special district entities.

The following three sections (Utilities, Transportation and Communications) describe these key infrastructure systems and their vulnerabilities, demonstrated by the earthquake hazard exposure depicted on Maps 3, 4, and 7. These sections also outline how these vulnerabilities may create secondary hazards following an earthquake. Included in each section are the City's key partners and their mitigation activities.

The Department of Public Works has an up-to-date database describing elements, characteristics and conditions of all roads, storm drains, and sewer pipelines. The database includes specific information on these systems and their conditions for maintenance and management purposes. This type of information will also facilitate Public Assistance applications after a disaster, as federal repair guidelines attempt to apportion damage due to the hazard event and damage from normal wear and tear.

Disputes over existing element conditions can lead to additional expense and delays in making needed repairs.

Utility Systems: Earthquake Exposure and Vulnerability

The table below shows owners of key utility system infrastructure in Berkeley.

Table 6. Key Berkeley Utility Systems

Owner/Manager	Infrastructure
City of Berkeley	• Storm drains • Retaining walls in right-of-way • Sanitary sewer collection system that links to the EBMUD system • Creeks, open channels and creek culverts in right-of-way and on City property • Street Lights and traffic lights on poles or utility poles and above- and below-ground conduits supplied from the PG&E system • Transfer Center, city waste disposal and recycling, located at Second and Gilman streets
EBMUD	• Potable and fire suppression water supply system consisting of pipelines, pumping plants, flow/pressure control facilities, and storage tanks and reservoirs owned by the East Bay Municipal Utility District • Sanitary sewer transmission pipeline (EBMUD wastewater interceptor) and pumping station
PG&E	• Electric distribution system, including substations, mains, laterals and meters, owned by the Pacific Gas and Electric Company • Natural gas distribution system, including main pipelines, lateral pipelines and meters
AT&T, Comcast and others	• Telecommunications aerial and underground conduits
Kinder Morgan Corporation	• Aviation fuel and multi-product pipelines buried under the right-of-way of the Union Pacific railroad tracks
Various	• 513 sites in the city storing more than 55 gallons, 200 cu ft or 500 lbs accumulated hazardous materials and hazardous waste

Liquefaction is a significant contributor to utility failure after an earthquake. When soil liquefies, the effective stress of a soil is reduced to essentially zero, which corresponds to a complete loss of shear strength or shear resistance. Sloping ground and ground next to creeks and the Bay may slide on a liquefied soil layer, opening large cracks or fissures in the ground. This can cause significant damage to infrastructure lines such as water, natural gas, sewage, storm, electrical and telecommunications systems installed in the affected ground. Buried tanks, pipelines, conduits, and manholes may float in the liquefied soil due to their buoyancy.

Landslides, liquefaction, or subsidence caused by earthquakes may subject pipelines to significant displacement, causing the pipelines to develop leaks or breaks.

The following systems are described in further detail:

- Water System
- Sanitary Sewer System
- Storm Drain System
- Natural Gas and Electricity Systems
- Aviation Fuel Pipeline
- Hazardous Materials Management

Water System: Earthquake Exposure and Vulnerability

Key Partner: East Bay Municipal Utility District (EBMUD)[25]

The East Bay Municipal Utility District (EBMUD) provides drinking water to approximately 1.4 million people and sewer services to 640,000 in the East Bay. After an earthquake, EBMUD is responsible for maintaining and providing water and sewer services to its customers, including water for post-earthquake fire suppression. Much of the water for the East Bay comes through the Claremont Tunnel. This water is stored in a network of reservoirs throughout the Berkeley Hills and is distributed to customers through underground pipelines. EBMUD was created in 1923, and the age and extent of its system makes it particularly vulnerable to damage in earthquakes. EBMUD has studied the impacts of earthquake shaking, liquefaction, landslides and fault rupture on most of its infrastructure.

Following a major seismic event:

- Earthquake-induced landslides in the Berkeley hills could impact water lines, reducing water available for firefighting
- If fault rupture occurs, water lines within the fault rupture planning zone could be broken
- Liquefaction in the western part of the city could impact water service

In the HayWired earthquake scenario, EBMUD's 4,162 miles of pipe suffer about 1,800 breaks and 3,900 leaks during the earthquake sequence. EBMUD crews will likely begin working to repair the system immediately after an event. The average EBMUD customer would be without water for 6 weeks, some for as many as 6 months.[26]

Depending on the severity of earth movement, water and sewer lines may break, and the safety of the drinking water supply may be compromised. In addition, without power, sewer lift pumps will fail, leading to major sewage overflows. For this reason, the City's Environmental Health and Public Health Divisions may issue precautionary drinking water advisories, either in collaboration with water utilities or independently. These advisories may be in place until the drinking water system is confirmed safe.[27]

Sanitary Sewer System: Earthquake Exposure and Vulnerability

The City's sanitary sewer system is made up of pipelines with large diameter (six inches to 120 inches). Some of the large diameter pipes provide temporary storage when the EBMUD wastewater interceptor[28] system cannot accept flows. The amount of storage time provided by these large diameter pipes depends on the inflow rate and the ability of downstream segments to accommodate flow. Failure of the EBMUD interceptor system or the City's sanitary sewer system could cause sewage to back up beyond the Berkeley sanitary sewer system's storage capacity. When the volume of effluent is larger than the sanitary sewer system's storage capacity, it will overflow through manhole covers onto city streets and into the storm drain system and creeks that flow to the Bay.

The table below outlines the total length of Berkeley's sanitary sewer system, as well as the length and percentage of the system that lies within the hazard areas depicted on Maps 3,4, and 7.

Table 7. Sanitary Sewer System

Infrastructure Element	Total Length	Length in Hazard Areas		
		Earthquake-Induced Landslide Planning Zone	Fault Rupture Planning Zone	Very High, High, and Moderate Liquefaction Susceptibility Zone
Sanitary sewer	260 miles	50 miles (19%)	29 miles (11%)	101 miles (39%)

The Berkeley hills have a high landslide risk, which could particularly impact the sanitary sewer system.

If fault rupture occurs, it could critically damage portions of the sanitary sewer system that are within the Fault Rupture Planning Zone.

The liquefaction hazard is more acute on the west side of the city. Liquefaction-caused earth movements will affect underground infrastructure, including a high proportion of the sanitary sewer system. Liquefied areas may move laterally, breaking Berkeley's underground sanitary sewer pipelines. Liquefied areas could also compromise EBMUD's wastewater interceptor line, adjacent to Interstate 80. Damage to either system would interrupt the systems' ability to convey sewage.

Storm Drain System: Earthquake Exposure and Vulnerability

Areas of the city's storm drainage system are known to be extremely weak and at risk of collapse. An earthquake would cause significant damage to this system. If the next earthquake occurs during or shortly before a rainstorm, the city could experience significant flooding in areas that have not seen floodwaters previously. The weaknesses of this system are described in more detail in Section B.8, which addresses floods.

The table below outlines the total length of Berkeley's storm drain system, as well as the length and percentage of the system that lies within the hazard areas depicted on Maps 3,4, and 7.

Table 8. Storm Drain System

Infrastructure Element	Total Length	Length in Hazard Areas		
		Earthquake-Induced Landslide Planning Zone	Fault Rupture Planning Zone	Very High, High, and Moderate Liquefaction Susceptibility Zone
Storm Drains	94 miles	13 miles (14%)	8 miles (9%)	45 miles (48%)

Earthquake-caused ground failure could change the horizontal alignment of pipes so that storm drains would not function.

The Berkeley hills have a high landslide risk, which could block or damage storm drains.

If it occurs, fault rupture could damage portions of the storm drainage system within the Fault Rupture Planning Zone.

The liquefaction hazard is more acute on the west side of the city. Liquefied areas may move laterally, breaking underground storm pipelines and affecting other underground infrastructure and creeks.

Electricity and Natural Gas Systems: Earthquake Exposure and Vulnerability

Electricity

Berkeley's electricity system is almost entirely aboveground. Earthquakes can topple or break utility poles, and falling trees or collapsing structures can damage utility lines.

Electrical switches and transformers in the distribution system can be damaged, as can equipment at substations and transmission lines, possibly leading to system wide loss of these utilities. Grid-tied photovoltaic (solar) panels are reliant on the electric grid being functional unless they are designed with smart inverters and battery back-up storage so that they can island from the grid.

Because electrical system infrastructure exists throughout Berkeley, earthquake shaking, liquefaction, fault rupture and earthquake-induced landslides can all damage this infrastructure both above and below the ground. This means that a major earthquake will cause significant power loss to Berkeley. Loss of power can lead to many cascading and significant consequences such as impacts to vulnerable infrastructure, inability to operate fuel and water systems that require electricity, communication and service disruption, loss of heating or cooling, and loss of critical function for populations that rely on power for survival.

Natural Gas

Underground systems are particularly prone to damage from ground failure in earthquakes and landslides. Natural gas line rupture is one of the chief causes of post-earthquake fires, as discussed in Section B.5.b.vi Fire Following Earthquake.

Additionally, rupture compromises this lifeline unless redundant connections unaffected by the earthquake are available. Underground damage is harder to detect and repair, and the length of service losses may be greater than for aboveground systems.

This plan is focused on natural hazards and their impacts. This plan addresses gas pipeline rupture as a secondary hazard to earthquake liquefaction, earthquake-induced landslides and surface fault rupture.

The term "gas pipeline" includes:

- Transmission pipelines, which carry natural gas across long distances, usually to and from compressors or to a distribution center or storage facility. Transmission lines are large steel pipes (10" to 42" in diameter) that are federally-regulated. They carry unodorized gas at a pressure of approximately 60-900 psi.

- Distribution pipelines ("gas mains"), which are the middle step between high-pressure transmission lines and low-pressure service lines. Distribution pipelines are small- to medium-sized pipes (.25" to 24" in diameter) that are federally-regulated and carry odorized gas at intermediate pressure levels, from 2 to 60 psi.

- Service pipelines, which connect to meters to deliver natural gas to individual customers. These narrow pipes are usually less than 2" in diameter, and carry odorized gas at low pressures, such as 6 psi.

Like electricity infrastructure, service and distribution pipelines exist throughout Berkeley. In the HayWired Scenario, service and distribution pipelines will be exposed to severe and violent shaking, as well as to liquefaction concentrated in the western part of Berkeley, earthquake-induced landslides and fault rupture in the Berkeley hills. Rupture of service and distribution lines can ignite and fuel fires. Additionally, natural gas leaks within buildings can cause carbon monoxide poisoning. Finally, any loss of service could lead to loss of heating and cooling, which may jepordize the health and safety of many people.

Not only do ruptures have the potential to cause fires, but they also have climate implications. The main component of natural gas is methane, which is a potent greenhouse gas that is 25 times more harmful to the atmosphere over a 100-year period than carbon dioxide.[29]

In addition to service and distribution lines, transmission pipelines are also vulnerable to ground failure in a major earthquake. Map 12 uses thick blue lines to identify PG&E's natural gas transmission lines. Significant portions of PG&E natural gas transmission lines lie in areas of Berkeley that are more susceptible to liquefaction (Map 7). In an earthquake, these soils need to be shaken hard and long enough in order to trigger liquefaction. If liquefaction does occur, pipelines located in liquefiable soils can tear apart.

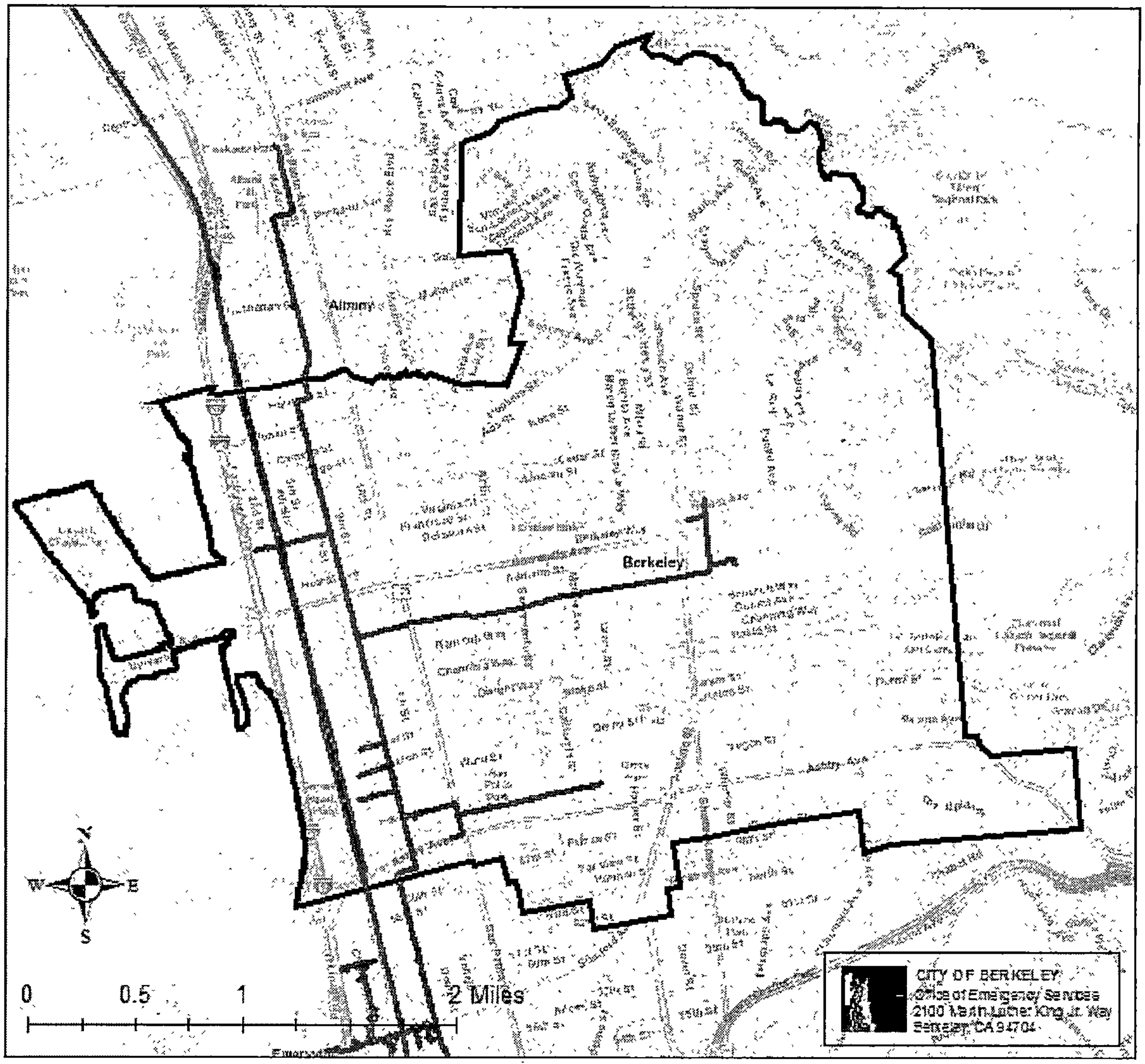
The natural gas transmission line runs the length of Berkeley (north-south direction) under Seventh Street.

- The Seventh Street transmission line branches out to the West in four locations: Grayson, Carleton, Parker and Virginia Streets. The Virginia street branch runs almost all the way to the Eastshore Freeway.

- The Seventh Street transmission line branches out to the east in two locations. The first is at Heinz Avenue, continuing onto Russell Street after passing San Pablo Avenue. The transmission line ends where Russell Street crosses McGee Avenue. The second is at Allston Way. The transmission line extends the entire length of Allston Way, to the edge of UC Berkeley campus at Oxford Street, where it splits. One short transmission line continues into the campus and the other follows Oxford Street north just past Hearst Avenue, where it ends.

Map 12 also shows in a thick red line the location of pipelines carrying aviation fuel. These pipelines run along the Union Pacific railroad right-of-way in the western part of the city.

Map 12. ***Gas Transmission Pipelines and Jet Fuel Line***



Sources: PG&E and Kinder-Morgan

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Berkeley
Jet Fuel Line
Gas Transmission Lines

Notable Mitigation Activities

One potential solution to mitigate some of the negative impacts of the use of natural gas is to encourage buildings to switch from natural gas to electricity for water heating and space heating or cooling in buildings. The electrification of buildings helps reduce greenhouse gas emissions, especially if the electricity is powered by solar or by carbon-free energy provided by East Bay Clean Energy. The Office of Energy & Sustainable Development is currently exploring options for all-electric buildings, which would potentially no longer need to be connected to the natural gas power grid. This would significantly reduce risk for the fire, health, and climate impacts associated with widespread existing leakages in the system as well as damage to the pipelines from a natural disaster. The electrification of buildings, when coupled with on-site solar and back-up storage batteries, could also provide clean energy back-up power to buildings in the event of a power outage. OESD is currently working to address financial, regulatory, and technical barriers to this clean energy solution, while also exploring the energy assurance aspects of potential solutions.

Key Partner: Pacific Gas and Electric Company (PG&E)[30]

Pacific Gas and Electric (PG&E) provides electricity and natural gas to 15 million people in northern and central California. They have a staff of 20,000 prepared to respond to restore electrical service after disasters and storms. They also have a well-established priority system for restoring power to emergency services before other community needs. PG&E recognizes that large earthquakes may damage key facilities and that electric power might be lost for limited periods of time. The potential for a loss of power means that emergency and critical uses should have dedicated emergency power sources.

Natural gas is subject to damage and disruption in areas with soil failure, for example landslide and liquefaction. Broken lines can create fires if ignited until the fuel supply is exhausted. The repair of damaged underground lines will take time. Following the Loma Prieta earthquake it took about 30 days to repair damaged lines in the San Francisco Marina.

Key Partner's Notable Mitigation Activities

PG&E has assessed the seismic vulnerability of many elements of its system and has taken steps to improve its functionality after an earthquake, such as replacing bushings on high voltage lines, anchoring substation equipment and replacing old gas lines with more flexible alternatives.

As a consequence of the San Bruno rupture, the National Transportation Safety Board (NTSB) has issued a number of recommendations to State and federal administrations and institutions to improve the safety of pipeline networks as well as to upgrade the integrity management program and emergency response system[31].

As a result, PG&E has proposed $2.2 billion in pipeline upgrades through 2014 and outlined a Pipeline Safety Enhancement Plan to modernize its gas transmissions operations over the next several years. As part of this plan and in direct response to the recommendations issued by the

NTSB, PG&E has begun improving its network by automating shutoff valves, with more automatic shutoff valves planned for Berkeley; updating its emergency response plan to reflect industry best practices; and implementing data management systems intended to ensure its pipeline records are traceable, verifiable and complete.

Additionally, PG&E has created a First Responders Safety website, which provides secure access to maps and information about natural gas transmission lines, natural gas storage facilities, and shut-off valves. The City's Information Technology department has incorporated this information into its GIS maps. Berkeley first responders have attended PG&E's First Responder Workshops to learn more about components of natural gas and electric utility infrastructure, as well as how to respond to natural gas hazards and avoid dangers presented by migrating natural gas and secondary ignition sources.

Aviation Fuel Pipeline

Map 12 shows in red lines the location of pipelines carrying aviation fuel. These pipelines run along the Union Pacific railroad right-of-way in the western part of the city. Per Map 7, soils in this area are potentially susceptible to liquefaction. Like with the PG&E natural gas transmission lines, rupture of these aviation fuel lines during an earthquake could spark and feed a dangerous fire.

Key Partner: Kinder Morgan, Inc.[32]
Two aviation and multipurpose pipelines run along the railroad tracks from Richmond to the Oakland Airport, through western Berkeley. The pipes are made of high-pressure welded steel, installed primarily in the 1960s, although a few segments were installed in the 1950s. The company has not conducted a study of the impacts of an earthquake on the Hayward fault. This type of pipeline, however, is known to have performed well, due to its ductile nature, in earthquakes elsewhere in the world. Kinder Morgan, Inc. has focused on developing procedures to respond immediately after a disaster to shut down the pipeline. Each pipeline has automatic, remote control and other manual valves along its length and the flow can be shut down within minutes. Kinder Morgan, Inc. reported that after the 1989 Loma Prieta earthquake, these pipelines were shut down and monitored for leaks, breaks and changes in pressure. No damage was found.

Hazardous Materials Management

The shaking and ground failure that can accompany earthquakes could cause hazardous materials release. The City carefully tracks and regulates hazardous materials in both public and private structures through its Toxics Management Division. There are 513 facilities in the city that store more than 55 gallons, 200 cu ft or 500 lbs accumulated hazardous materials and hazardous waste.[33] The majority of these sites are automobile-related facilities (e.g., facilities with motor oil), and medical facilities. To minimize the risk of release during an earthquake, the City requires engineering studies for facilities having extremely hazardous substances. These studies are discussed in more detail in Section B.12 *Hazardous Materials Release*.

Transportation System Earthquake Vulnerabilities

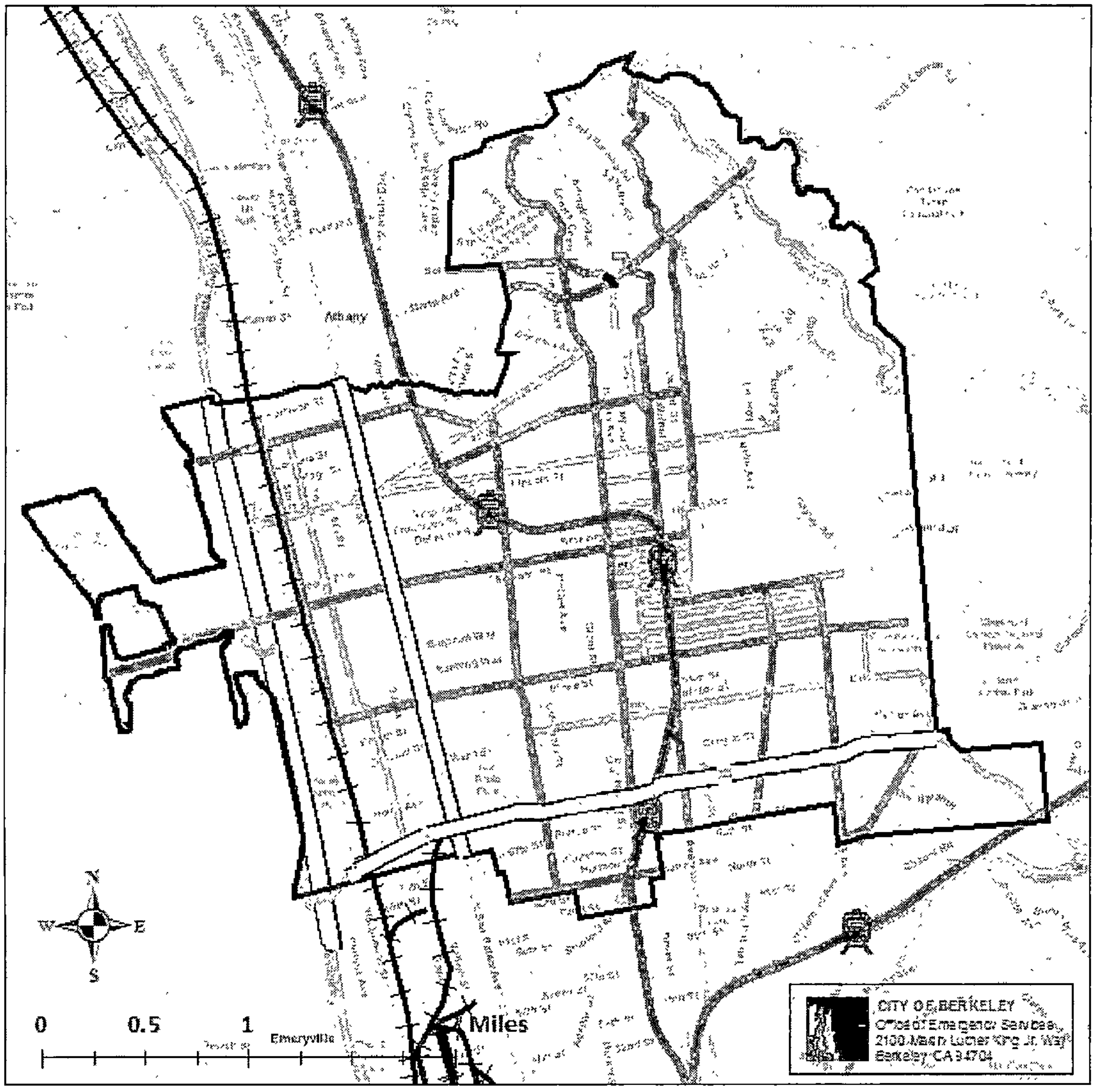
The table below shows key transportation system infrastructure in Berkeley, along with the agencies responsible for the systems.

Table 9. Key Berkeley Transportation Systems

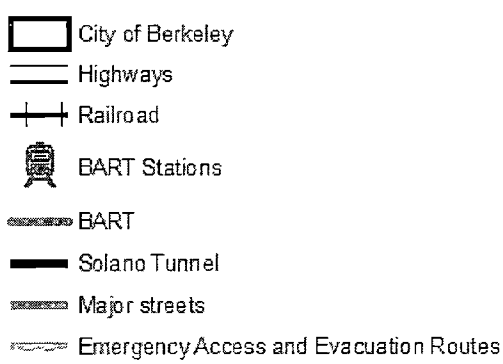
Owner/Manager	Infrastructure
City of Berkeley	• Roads, curbs, paths and sidewalks • Traffic lights on poles, and above and below ground conduits supplied from the PG&E system • Traffic circles and islands • Sutter Street Solano Avenue tunnel • I-80 Pedestrian Bridge • University Avenue interchange approach structure and railroad crossing
Caltrans	• US Interstates 80 and 580 and freeway access structures at Ashby, University and Gilman streets in Berkeley, and at Powell and Buchanan streets in Emeryville and Albany owned by the State Department of Transportation • Tunnel Road/Ashby (State Route 13), and San Pablo Avenue (State Route 123)
Bay Area Rapid Transit District	• BART system, consisting of four miles of underground rails and three stations, at Adeline/Ashby, Center Street, and North Berkeley
Union Pacific	• Train tracks
Amtrak	• University Avenue passenger stop

Map 13 below shows the location of major transportation infrastructure. Designated Emergency Access and Evacuation Routes [34] are indicated with purple lines. The Union Pacific railroad is indicated with a black hatched line along Berkeley's western shoreline. Interstate 80 and California State Highways 13 and 123 are indicated in light blue, running along Berkeley's western shoreline, southern end, and north to south in Berkeley's west, respectively. The Bay Area Rapid Transit (BART) tracks are indicated with thick blue lines, with station icons for the system's three Berkeley stations and the El Cerrito Plaza station in the City of El Cerrito provided for context. The Solano Tunnel, which provides a key north-south connection to vehicles in the eastern portion of the City, is indicated with a thick black line.

Map 13. ***Transportation Infrastructure in Berkeley***



Sources: Berkeley Planning Department, BART, and ESRI, Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community



The table below calculates the exposure of City-owned transportation infrastructure to earthquake these hazards.

Table 10. Curbs, Streets and the Solano Tunnel

Infrastructure Element	Total Length	Length in Hazard Areas		
		Earthquake-Induced Landslide Planning Zone	Fault Rupture Planning Zone	Very High, High, and Moderate Liquefaction Susceptibility Zone
Curbs	354 miles	56 miles (16%)	42 miles (12%)	177 miles (50%)
Streets	258 miles	43 miles (17%)	26 miles (10%)	117 miles (45%)
Solano Tunnel	0.09 miles	0 miles (0%)	0 miles (0%)	0 miles (0%)

Map 13 and Table 10 together identify key areas of exposure within Berkeley's transportation infrastructure.

Nearly half of all City streets are have a moderate or greater exposure to liquefaction, meaning that vehicle movement throughout the city is likely to be impacted by liquefaction-caused earth movements in a major earthquake. This movement will also affect aboveground infrastructure (streets, curbs and sidewalks.) Transportation infrastructure west of Interstate 80 is especially vulnerable to liquefaction. Per Map 8, in the HayWired scenario earthquake, over 40 percent of this area is expected to liquefy.

Transportation infrastructure in the area could be severely damaged. Additionally, emergency services vehicles may not be able to access the area, at least until the University Avenue overpass is inspected for damage.

Half of all City streets are have a moderate or greater exposure to liquefaction. Curbs serve as water barriers to property when it rains, curbs function as part of the drainage system. If curbs are impacted by ground failure from an earthquake, they lose their ability to function in this way.

To the city's east, 17 percent of City streets are situated in the earthquake-induced landslide planning zone. Landslides in this area could distort major and minor roads. This would make access difficult or impossible for firefighters and other emergency responders. It would also complicate evacuation for residents in the Berkeley hills.

Fault rupture, if it occurs, could damage important east-west streets along the fault, making travel between the hills and flatland areas difficult where displacements are large.

The Solano Tunnel is an important connection in the north-south direction. It is not located in a seismic hazard zone. However, it is situated in the direct proximity of the Fault Rupture Planning Zone, as well as the Earthquake-Induced Landslide Planning Zone. Should one of these hazards occur, access to Solano Tunnel could be limited or even impossible.

Key Transportation Partners

Partner-run transportation systems have varying levels of exposure to seismic hazards.

Per Map 13, Interstate 80 is susceptible to earthquake-induced liquefaction. Additionally, the HayWired Scenario Liquefaction Map (Map 8) shows that in a 7.0 magnitude earthquake on the Hayward fault, 40% or more of the ground underneath Berkeley portions of Interstate 80 is predicted to liquefy. This is a major thoroughfare for Berkeley and the Bay Area overall.

Caltrans[35]
Caltrans is responsible for constructing and maintaining the statewide highway system. The 1989 Loma Prieta earthquake caused significant damage to Caltrans structures, such as bridges, overpasses and on-ramps. As a result, Caltrans launched a comprehensive review of earthquake safety on highways throughout the state. A program to retrofit all vulnerable structures was started and the two overpass structures in Berkeley, at Ashby and University Avenues, have already been strengthened. These retrofits were designed to prevent collapse in a major earthquake, but will not guarantee that these structures can be used after an earthquake. Depending on damage levels, demolition may be required. Caltrans also strengthened the City-owned approach ramps to the overpass on University Avenue to the same standards. Caltrans emergency response teams are trained to inspect their facilities and manage some elements of traffic flow after a major earthquake.

The City owns a portion of a structure at University Avenue that provides access to the state-owned interchange structure connecting to Interstate 80. The City portion of this structure extends over the railroad tracks and west to ground level. Caltrans owns the eastern portion. Caltrans retrofitted both the state-owned and City-owned structures in recent years to high standards of safety.

Bay Area Rapid Transit District (BART)[36]
The Bay Area Rapid Transit District (BART) provides an important public transportation link between Berkeley, San Francisco, and other Bay Area locations to 360,000 riders daily. In the 1960s, Berkeley taxpayers issued a separate tax to have the BART facilities in Berkeley (three stations and over four miles of tunnel) put underground, and these tunnels are generally considered low risk by BART engineers.

According to Map 13, within Berkeley, the BART system is not exposed to ground failure from earthquakes. However, Map 2 shows that BART infrastructure in Berkeley will be subject to severe shaking in a 7.0 magnitude Hayward fault earthquake.

Key Partner's Notable Mitigation Activities

In 2002 BART completed a study of the earthquake vulnerability of the entire system, analyzing multiple earthquakes, predicting damage, and assessing cost-effectiveness of retrofits. Upgrades to the system are being funded by $980 million in General Obligation Bonds, authorized by voters in Alameda, Contra Costa, and San Francisco counties, supplemented with an additional $240 million from other sources. Since 2008, retrofit has been completed on many elevated tracks, stations, parking structures, and rail yards. Work to upgrade the Transbay Tube seismic joints was completed in 2010. BART is continuing to secure the Transbay Tube to a higher level of strength against future large earthquakes. The current effort is expected to be completed in 2014. Evaluations of several other areas of the Tube are ongoing and further retrofits may be constructed in the future. At this time, those retrofits are expected to be completed in approximately 2018.

As part of the vulnerability study, BART determined that the Berkeley Hills Tunnel which crosses the Hayward fault may be damaged in an earthquake on that fault, cutting a key commuting link. Initial evaluations determined that retrofit or replacement of this tunnel were not viable options. BART continues to study the feasibility of adequately strengthening the tunnel but as yet there is not a retrofit solution that can appropriately achieve this goal. Therefore there are no current plans to perform retrofit construction on the tunnel. BART will however be prepared with materials and crews to respond quickly to any damage that may occur in an earthquake.

BART's investment in earthquake retrofit is strengthened by its earthquake early warning system, which can help prevent train derailments in the system by slowing or stopping trains upon notification of an earthquake. Currently, BART has a system in place, which is activated when an earthquake larger than magnitude 4 or 5 is experienced within the BART system. BART is working with UC Berkeley and others to implement a statewide earthquake early warning system. This system would issue notification to operators such as BART upon detection of P-waves.[37] Upon notification, BART would automatically slow or stop trains within the system. The length of advance warning depends on how far away the earthquake originates.

Communications System Earthquake Vulnerabilities

The table below shows key communications system infrastructure in Berkeley, along with the companies responsible for the systems.

Table 11. Key Berkeley Communications Systems

Owner/Manager	Infrastructure
AT&T	• Land line telephone distribution system that shares poles with PG&E in some locations and is located underground in other locations
Comcast and other companies	• Cable systems that share poles with PG&E in some locations and are located underground in other locations
Verizon, Sprint PCS, Nextel and other companies	• Cellular telephone antennae distributed throughout the city

Communications infrastructure is spread throughout Berkeley, and thus is exposed to all earthquake ground failure hazards.

Telephone and cable communications systems are almost entirely aboveground in Berkeley. Earthquake shaking can topple or break utility poles, and falling trees or collapsing structures can damage utility lines.

Additionally, Berkeley's underground utilities include communications conduits. Underground systems are particularly vulnerable to damage from ground failure in earthquakes. Displacement on the Hayward fault could rupture these systems, compromising these lifelines unless redundant connections unaffected by the earthquake are available. Ground movement due to liquefaction in the west and landslides in the east will also severely impact these systems. Liquefied areas may move laterally, breaking underground cables and damaging communication lines. Landslides can damage underground and aboveground communications infrastructure during earthquakes, or in separate slides that can occur for weeks or months following an event.

Underground damage is harder to detect and repair and the length of service losses may be greater than for aboveground systems.

Key Communications Partners

AT&T[38]

AT&T provides and maintains telephone service to Berkeley residents, along with internet access, Uverse Television Service, mobile telephone service, and other business services. The telephone wires, conduits, coaxial cables and fiber optic lines have been tested and designed to be highly resistant to earthquake shaking, and easy to reroute should problems occur. For example, slack is provided in underground cables to permit earth movement without damage. All

AT&T facilities have batteries that can run for four hours without electrical service, and many diesel generators are available to supplement the batteries if needed. Minimal water is required to keep the electrical equipment from overheating.

AT&T expects some telephone outages, including mobile phone service, after a major earthquake, and service restoration would take hours to days, depending on location and the situation. A major earthquake could impact service in a 50 square mile radius. The central office in Berkeley, with major equipment, has been seismically strengthened, but it is possible that neighboring buildings that have structural deficiencies could collapse into this building and cause damage. If the central office building was completely destroyed, portable equipment and trailers could quickly reestablish service. AT&T is prepared to set up additional phone lines open to the public at a central location if major service losses occur.

The AT&T Network Disaster Recovery (NDR) team has managers, engineers, and technicians who receive special training in physical recovery of AT&T's network. Members participate in several recovery exercises each year to test, refine, and strengthen AT&T's business continuity and disaster response services in order to minimize network downtime.

AT&T's Network Disaster Recovery organization is responsible for the rapid recovery of service at AT&T sites following a catastrophic event.

In the case of an event or disaster the NDR has three primary goals:

1. Route noninvolved telecommunications traffic around an affected area

2. Give the affected area communications access to the rest of the world

3. Recover communications service to a normal condition as quickly as possible through restoration and repair

AT&T won Frost & Sullivan's 2010 Product Leader Leadership of the Year Award for Business Continuity and Disaster Recovery Services in North America.

Verizon Wireless[39]

Verizon Wireless serves its individual, government and business customers with voice and/or data services via Verizon's wireless cellular network.

Verizon has designed and built its network with day-to-day reliability and disaster resilience in mind. Since inception, all Verizon Wireless facilities in California have been built to the most stringent California building codes. Verizon also follows an internal Network Equipment Building System standard. Since 2004, Verizon has hardened its network by moving two of its Bay Area switching facilities to newly-constructed facilities. These facilities meet or surpass all then-current earthquake standards; they also provide additional redundancy with respect to capacity for battery back-up, generators, fuel and HVAC. The facilities also have increased security through design and alarming capabilities. All major transport facilities (i.e., the links between switching facilities, network hubs, the internet, etc.) are fully redundant either through

SONET Ring architecture or diverse path routing.

Verizon Wireless has worked with the City to place all 13 of its Berkeley cell site facilities. In the Verizon Wireless Northern California network, about two-thirds of all sites have permanent generators. This represents an approximately 250 percent since increase since 2004. In Berkeley in particular, cell site facilities have relatively few generators, with only 2 of the 13 sites so equipped.

In a disaster, Verizon's basic service mission does not change. However, it is understood that the network may be damaged from the impacts of a disaster, such as an earthquake, and that the demand on the network will simultaneously rise. In this case, the mission of Verizon Wireless will be to:

1. Restore and/or enhance the network as quickly as possible, to the greatest extent possible.

2. Assist with local communities' wireless communications needs to the greatest extent possible to enhance public safety and relief or rescue efforts.

Verizon's local network group trains and drills for disaster events, and local personnel have aided recovery efforts for other disasters outside the area, such as Hurricanes Katrina and Sandy. In the event of a disaster, Verizon makes the resources of the entire company available locally.

Comcast[40]
Comcast provides the following services to the Berkeley community:

- Voice (wireline telephone service)
- Video (television)
- Data (high-speed Internet, Wi-Fi hotspots, cellular backhaul services)
- Home security/home automation

Comcast's distribution telephony network depends on other communications providers. If supporting providers' networks are operational, Comcast will maintain connectivity to all its customers. If an individual network fails, Comcast will lose its connection to the customers using that particular network.

To protect its infrastructure in earthquakes and other disasters, Comcast has hardened all its sites. Additionally, all sites are connected via redundant fiber networks to maintain service to greater service areas. Major metro fiber routes are backed up by redundant routes and failover technologies.

After a catastrophic earthquake, due to facility redundancy of backbone/regional networks, Comcast expects that transport of major traffic should continue. However, local serving areas are more likely to experience gaps in service due to lessened redundancy between headend facilities[41] and customer homes.

In the event of a power outage, Comcast will use battery backup to maintain service for up to eight hours. Comcast monitors its power supplies, and in the event of the backup batteries being depleted, generators are in place to maintain service.

Comcast's ability to recover from facility damage after an earthquake will be determined by its ability to access headend locations, as well as to refuel generators if commercial power is lost. Customers may experience a total loss of video service, and total loss or severe network congestion of voice and data services. Comcast also provides cellular backhaul services[42] for Verizon Wireless. Impacts to Comcast's infrastructure could potentially impact Verizon's service to its customers.

B.5.c.v *Critical Response Facilities*

In addition to the infrastructure mentioned above, a key network of facilities supports disaster response activities. This network includes facilities owned by the City, as well as others owned by the City's key partners. Map 14 shows the locations of all of these facilities. Because these facilities serve the whole Berkeley community on a day-to-day basis, they are positioned throughout the City.

Recognizing that these facilities will need to be as usable as possible following a catastrophic earthquake, the City has put major effort into ensuring seismic stability of these buildings:

- The Public Safety Building was built in 2000 to essential services standards. This facility houses the Police Department Headquarters and 9-1-1 Communication Center, the Fire Department Headquarters, and the City's primary Emergency Operations Center.

- The City's seven fire stations (on Map 14 with red circles and a "F") have all been retrofitted or built to essential services standards.

- City libraries serve as community gathering points both prior to and following disasters. The City's Main Library, which underwent a complete retrofit in 2002, is planned for use as a disaster volunteer reception center. In 2009, the Branch Library Improvement program began work to renovate the City's four branch libraries for seismic safety. Over the next five years Claremont and North branches were remodeled and expanded while South/Tool Lending Library and West branches were demolished and rebuilt. The program was completed in December 2013.

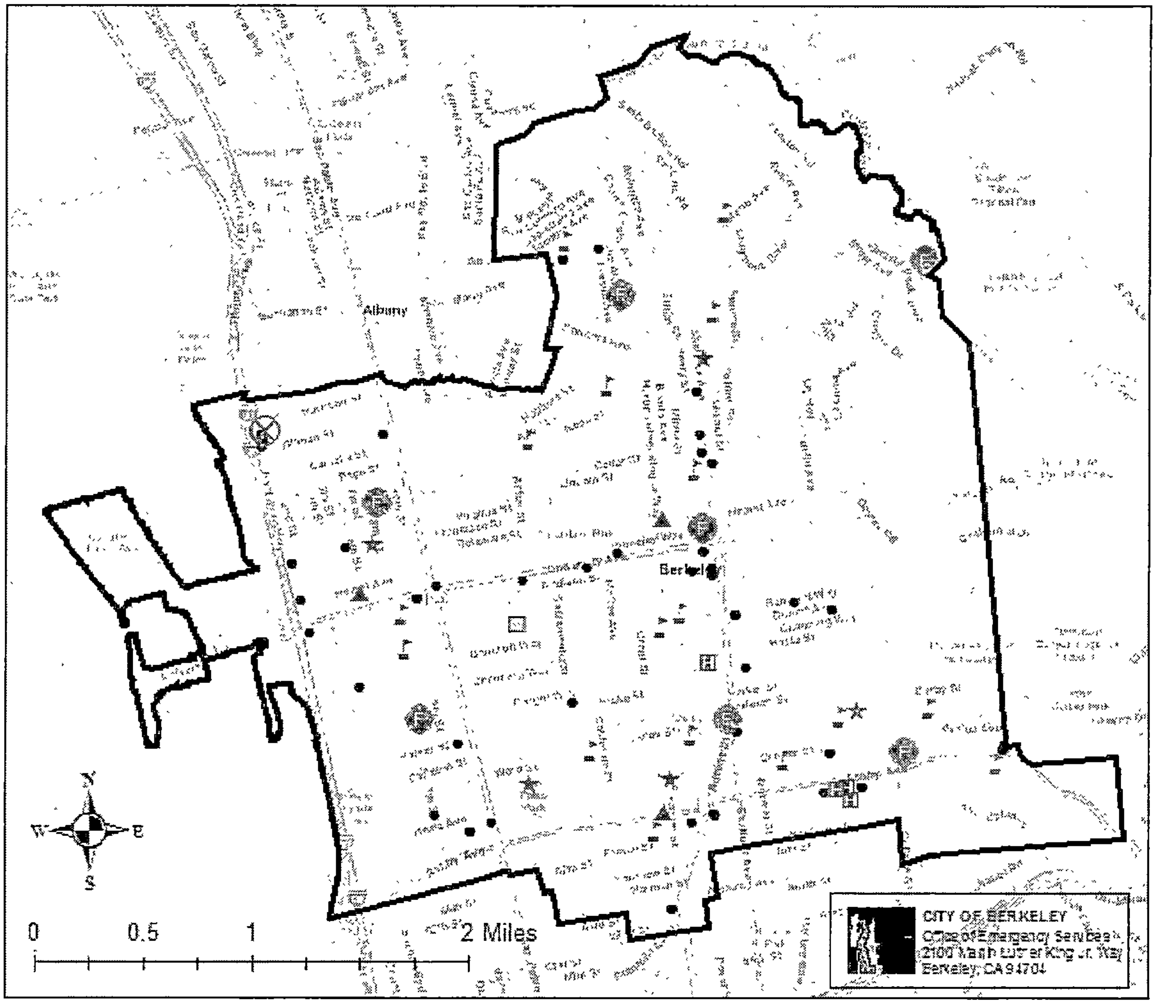
- The Civic Center Building's isolation system and retrofit elements were designed to provide life safety and limited repairable damage in a Design Basis Earthquake (DBE), and life safety and repairable damage in the Maximum Considered Earthquake (MCE). Although the building's base isolation system would meet the essential services standard of the 2010 California Administrative Code, the building was not built to essential services standards. The nonstructural systems and equipment in the Civic Center Building would need to be evaluated to ensure that their support and bracing systems also meet essential services requirements. Nonstructural elements along the access path to the essential services area should also be evaluated to ensure unobstructed access to these areas in the aftermath of an earthquake.

- City recreation centers (on the map with blue stars) and senior centers (one the map with purple triangles) are considered potential disaster shelter sites. The James Kenney Recreation Center was retrofitted in 2017. Funding (including FEMA mitigation grant funding) has been secured for a retrofit of the North Berkeley Senior Center.

Also on Map 14, are:

- Berkeley Unified Schools (green flags spread throughout)
- Corp Yard (pink rectangle located in Central Berkeley)
- Tansfer Station (X in a circle in Northwest Bekeley near the highway)
- Hospitals (blue H with two spots in South and South Central Berkeley)
- Telecom Antennas (black dots spread throughout)

Map 14. ***City of Berkeley Critical Facilities***



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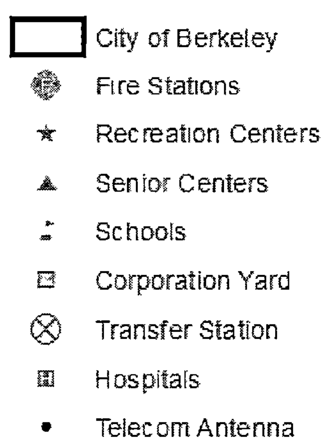


Key Critical Response Facility Partner: Hospitals

Hospitals are not operated or owned by City government, but they are critical to disaster response: Following an earthquake, hospitals must be able to care for not only their existing patients, but also a surge of new patients who are injured in the earthquake.

In 1973 as a direct result of the devastation caused by the 1971 San Fernando earthquake (65 deaths and a hospital collapse), the State Legislature passed the Alfred E. Alquist Seismic Safety Act. The Act requires every hospital in California with acute care patient facilities to be built to higher standards than other buildings so they can be reoccupied after major earthquakes. Eleven years later, following the 1994 Northridge earthquake, Senate Bill 1953 expanded the scope of the 1973 Act, requiring:

- By 2002, all critical non-structural components in surgery and emergency medical rooms be retrofitted;
- By 2013, all hospital buildings built before 1973 be replaced or retrofitted so they can reliably survive earthquakes without collapsing or posing threats of significant loss of life;
- By 2030, all existing hospitals (including those built after 1973) be seismically evaluated and retrofitted, if needed, so they are reasonably capable of providing services to the public after disasters.

The Office of Statewide Health Planning and Development develops and regulates seismic performance standards for hospitals.

Alta Bates Summit Medical Center[43]
There is one acute care hospital in Berkeley, Alta Bates Summit Medical Center, owned and operated by the Sutter East Bay Hospitals. The hospital has two campuses in Berkeley: Alta Bates and Herrick.

The Alta Bates campus is a full service acute care hospital, while the Herrick campus provides acute care limited to mental health and cancer care services. Alta Bates is comprised of eight buildings used to provide acute patient care, five of which were built to pre-1973 seismic standards. These buildings are not considered a threat to life safety, but may not be functional or repairable after an earthquake.[44] The Hospital Seismic Safety Act requires these buildings to be retrofitted or replaced by 2030 to meet standards to be repairable or functional following an earthquake. Three additional buildings at Alta Bates and three at Herrick have already met this standard.[45] Four buildings at the Herrick Campus are considered to be a significant risk to life safety.[46] Acute care functions formerly housed in these buildings have been relocated into seismically compliant portion of the Herrick campus and/or to the Summit Campus as of 2013.

UC Berkeley University Health Services

University Health Services (UHS), located at the Tang Center, is a fully-accredited ambulatory health facility serving the students, faculty and staff of the University of California, Berkeley.

UHS provides medical care, including urgent care, primary care, occupational health and specialty services, supported by a pharmacy, laboratory, physical therapy, immunization/travel services, a medical records department, radiology services and advice nurse access. UHS also offers counseling, social services and psychiatric care to support students' academic success.

UHS' disaster response role depends on the needs at the time of the event. In a localized emergency, UHS may provide for members of the campus by addressing mental health needs, distributing vaccinations, assisting with relocation, or by providing other support services. In a catastrophic earthquake, UHS will use available resources to triage and care for campus persons, but will require additional resources to care for large numbers of people who may present. By providing care on campus, UHS will help to reduce demand on local emergency rooms from people who do not need tertiary care.

UHS coordinates its disaster readiness activities with both the City of Berkeley's Public Health Division and the Alameda County Public Health Department. Relationships between these entities have been built over many years, establishing the understandings and relationships that will support effective disaster response.

In 1993, the Tang Center was constructed to an essential facilities standard, due to both its health-related mission and its then-designation as a backup Emergency Operations Center for the campus.

To secure access to electronic health records, UHS moved its clinical management system to a secure hardened facility with redundant power and network connectivity. Backups of all data reside both locally in the Data Center and at the San Diego Super Computing Center (SDSCC).

UHS has located shipping containers in close proximity to the building to store medical supplies to support basic triage immediately following a major earthquake.

In coordination with the Office of Emergency Management, and local entities, UHS participates in planning and drills for various emergency scenarios, including loss of water and power.

Key Critical Response Facility Partner: Public Schools

Public schools are not operated or owned by City government, but they are critical to disaster response: they may be used for temporary sheltering of people displaced from their homes following an earthquake. Schools also support disaster recovery, providing a welcome return to normal routines for children, and childcare so that parents can rejoin the workforce.

Unlike laws and regulations for privately-owned buildings, there is a statewide approach to retrofitting and upgrade of existing schools, which must meet special earthquake design standards. The Division of the State Architect is the review agency for the design and construction of public K-12 school facilities in California. The Field Act, originally passed in 1933, regulates the design, construction and renovation of public school buildings, and the inspection of existing school buildings. Many subsequently adopted State laws, amendments to the Field Act, and supplementary laws, call for additional safety measures for all public K-12 schools in the state. California has the most stringent safety codes for school buildings in the U.S.

Up until June 30, 2006, community colleges had to comply with the Field Act. In 2006, Assembly Bill 127 was passed, giving community colleges the option of choosing to design and construct under local building codes or under the Field Act.[47]

Only some charter school buildings are subject to Field Act provisions. Many school and building officials are unclear about the rules that apply when the Field Act does not.[48]

Berkeley Unified School District[49]
The Berkeley Unified School District, a special local government district, manages primary and secondary education and educational facilities, including all public schools in the city. City government provides police and fire services to the District, but has limited authority over these structures.

In 1989, shortly after the Loma Prieta earthquake, the District hired engineers to evaluate the structural safety of the buildings. Engineers found significant problems at many schools. The District's Board took swift action. Within a year, the District closed a number of schools, took precautionary measures at ones that remained open, and developed a plan of action to correct safety problems within the District as a whole.

Local voters have approved several bond measures to renovate and modernize city schools. In June 1992, local voters approved a bond measure to raise taxes to provide $158 million to renovate and modernize the city's schools. In November 2000, voters approved another supplemental bond measure for the safety program totaling an additional $116.5 million. In the years since voters approved the original tax measure, all of the schools identified by the engineers have been seismically strengthened or demolished and replaced.

Notable Mitigation Activities
As of 2013, all District pre-K, K-12, and adult educational facilities, requiring retrofit under the Field Act and subsequently adopted State safety laws have been retrofitted. Additionally, with the exception of plant operations, all administrative spaces have been retrofitted and the transportation facility was built in strict accordance with the seismic building code.

In November 2010, Berkeley voters approved Measure I, funding improvements to school safety and facilities. Seismic work funded by the measure includes:

- Demolition of the Old Gymnasium at Berkeley High School.
- Replacement of the unreinforced masonry building at the BUSD corporation yard that functions as its maintenance facility. Due to cost estimates proving to be much higher than the original projections, this project remains on the unfunded list and has been delayed.

In 2012, the District moved its administrative offices out of the seismically-unsafe Old City Hall and into a newly-renovated building on Bonar and University.

In addition, as the building code becomes more stringent, Berkeley continues to improve the seismic safety of its schools. For example, Berkeley plans to do a voluntary upgrade of the Berkeley Community Theater located at Berkeley High School as well as the Multi-Purpose Room building at Rosa Parks Elementary School over the next two years.

Berkeley City College[50]
Berkeley City College is a community college serving about 6,297 students in downtown Berkeley. The college, funded by two local measures, is a state-of-the-art facility meeting the latest seismic and fire safety codes. The building's primary Emergency Operations Center (EOC) is located in the Auditorium, Room 021. Its secondary EOC is located in Room 431. The EOC will be connected to the Alameda County Sheriff and the Peralta Community College district headquarters through short-wave radio.

UC Berkeley Campus
UC Berkeley is a major institution separate from the City but located at its core. 42,000 students, 2,200 faculty and over 11,000 staff work or study on campus. The Hayward fault runs through the eastern half of the UC Berkeley campus, and beginning in the early 1970's, the University began earthquake vulnerability studies and retrofit projects, championed by senior University officials. In the early part of 1997, the campus reassessed the condition of its buildings and began an effort to comprehensively address its seismic risk. The SAFER Program (Seismic Action Plan for Facilities Enhancement and Renewal) was launched through Chancellor Robert Berdahl and Vice Provost Nicholas Jewell. A 1997 structural survey of existing campus buildings revealed that about 27 percent of the building space could perform poorly in a major local or regional earthquake.[51] These findings led to SAFER effectively becoming a physical renewal plan for UC Berkeley's built environment. Since 1997, $500 million worth of seismic improvements have been made to campus buildings and, as of early 2006, work has been completed or started on 72 percent of the square footage identified as needing seismic improvement.[52] The seismic improvement work completed at UC Berkeley has reduced by half the life safety risks for students, faculty, and staff and has cut the risks of potential earthquake-caused economic losses by 25 percent.[53] Planners and executive staff also devoted attention to a wide range of disaster preparedness efforts, ranging from emergency preparedness to facilities and lifeline planning, along with a robust financing strategy.[54]

The City and the University have independent disaster planning programs. However, their risks are inextricably intertwined. A significant portion of UC Berkeley students, faculty and staff live in the city and rely on Berkeley's private industries, housing, and infrastructure. The city's condition after a disaster directly impacts the ability of the University students, faculty and staff to continue their work. Likewise, the city depends on the jobs, commerce, and income created by the University. This means that the viability of University labs, research and other facilities after a disaster has a large influence on the current way of life. The University depends on the City's fire, search and rescue, and hazardous materials emergency services for the campus. Therefore, the risk of fire and catastrophic building collapses on campus directly impacts the capacity of the City's emergency responders. It is in the mutual interest of both the City and the University to coordinate disaster readiness efforts.

Berkeley Lab[55]
Berkeley Lab is a member of the national laboratory system supported by the U.S. Department of Energy through its Office of Science. It is managed by the University of California (UC) and is charged with conducting unclassified research across a wide range of scientific disciplines such as genomics, physical biosciences, life sciences, fundamental physics, accelerator physics and engineering, energy conservation technology, and materials science. The Laboratory's research is conducted in close collaboration with many UC campuses, especially UC Berkeley, UC San Francisco, and UC Davis.

Berkeley Lab employees 5,200 scientists, engineers, support staff and hosts 20,000 guests and users from around the world each year.

Berkeley Lab is located northeast of the City of Berkeley and UC Berkeley campus, on the hill slopes in the East Bay in the Tilden Regional Park area. Parts of the Lab are located on the Hayward fault line, which can result in and significant building damage and earthquake-induced landslides.

The Lab's emergency management function is administered through the Berkeley Lab Emergency Management Program. The mission of the Lab's Emergency Management Program is to build a safe and secure foundation for scientific discovery by preparing for, mitigating, responding to, and recovering from potential hazards caused by natural, technological, and human-caused emergencies.

Berkeley Lab continuously reviews and updates buildings with regard to seismic requirements in accordance with the California Building Code. Several buildings have been retrofitted over the last two decades, with new buildings meeting or exceeding existing code requirements.

Berkeley Businesses

Businesses are vital to the economy of the city and provide jobs to city residents. Ensuring that businesses and employers can return to normal function quickly will in turn ensure that the city recovers quickly from a disaster.

Table 12. Top 25 Berkeley Employers, by Number of Employees[56]

Employers	
Alta Bates Medical Center	Lawrence Berkeley Laboratory
Ansys, Inc.	Lifelong Medical Care
Bayer Healthcare LLC	Meyer Sound
Backroads Active Travel	MSCI Inc.
Berkeley Bowl Produce	OC Jones & Sons
Berkeley Clement Inc.	Recreational Equipment Inc.
Berkeley City College	Siemens Corporation
Berkeley Marina Doubletree	Target
Berkeley Repertory Theatre	University of California, Berkeley
Berkeley Unified School District	US Postal Service
City of Berkeley	Whole Foods Market California Inc.
Genji Pacific	YMCA of the Central Bay Area
Kaiser Permanente	

B.5.c.vi *People*

People with disabilities and people with access and functional needs, students, and low income individuals may live in older housing units that are more vulnerable to collapse or damage from earthquakes. These groups may also have less socioeconomic means to prepare for and recover from an earthquake that damages their home. Interruptions in electrical power jeopardize people with disabilities and people with access and functional needs that rely on electrical equipment for survival. Significant damage to streets, curbs, and transportation systems may prevent people with disabilities and people with access and functional needs and people without cars from navigating to their destinations. Damage to and reduced functionality of communication systems may make it difficult for people to meet up with family, friends, and caregivers.

B.5.d Earthquake Risk and Loss Estimates

No one knows what the characteristics of the next damaging quake to strike Berkeley will be. A quake could occur on any of the regional faults, be deep or shallow under the ground, and shake for a few seconds or up to nearly a minute. The degree of shaking and resulting damages will vary greatly depending on these characteristics.

However, FEMA developed the Hazards US (HAZUS) software to help estimate the consequences of different earthquake scenarios. HAZUS runs a computer model of a hypothetical earthquake, defining the earthquake's magnitude, epicenter location, rupture mechanism and time of day. Using this information, HAZUS estimates losses for that particular earthquake. **These theoretical losses will not exactly predict the actual damage of the scenario earthquake.** Instead, they provide reasonable data to help guide earthquake readiness activities.

Scenario Predictions

This section references three different HAZUS analyses:

- For the 2004 version of this plan, a magnitude 6.9 scenario earthquake on the Hayward fault underneath Berkeley was simulated using HAZUS.[57] In 2014, these loss estimates were combined with impact descriptions from newer HAZUS scenarios for a larger earthquake.[58] Because Berkeley's increased population and density since 2004, it is likely that these predictions underestimate the impacts and associated costs of such an event.
- For the HayWired Earthquake Scènario, a magnitude 7.0 scenarios earthquake on the Hayward fault epicentered in Oakland was simulated using HAZUS. Predictions from this scenario consider all losses across the Bay Area, not just those in Berkeley specifically.

Together, these scenario descriptions create a broad picture of the impact to Berkeley and the Bay Area overall from a catastrophic earthquake.

These HAZUS analyses predict:

Deaths and injuries:

- One hundred people in Berkeley could be killed by this earthquake. Fifty more will be in critical condition requiring urgent medical care. Three hundred additional people will need hospitalization and 1,000 people will require first aid.
- HayWired suggests that across the Bay Area, 800 deaths and 16,000 nonfatal injuries could occur from shaking alone.[59]

Fire following earthquake:

- In the first day following the earthquake[60], fires could ignite in six to twelve[61] different locations around the city. Outside fire departments may not be able to provide mutual aid. Emergency personnel will be stretched thin fighting these fires and may need to use a temporary, aboveground water supply system to pump water from the Bay. Fire could burn for hours or days in a worst-case scenario. Post-earthquake fires could add $32 to $64 million[62] of damage to structures in Berkeley.

- In counties nearest the fault rupture, the HayWired mainshock could cause about 450 large fires, burning building floor area equivalent to that of more than 52,000 single-family dwellings. Such fires would kill hundreds of people and cause property (building and content) losses approaching $30 billion.[63]

- For the HayWired scenario, an estimated 500,000 to 1 million people will need shelter as a result of fire following earthquake.

- Other potential economic impacts from fire following earthquake in the HayWired scenario include the loss of perhaps $1 billion in local tax revenues.

Debris:

- Following the earthquake, the city will need to remove and dispose of up to 570 tons of debris, consisting of building materials, personal property, and sediment will be generated by the earthquake. "Traditional" household waste volumes will also increase due to large amounts of spoiled food resulting from power outages and other debris from residential cleaning. Equipment beyond the current capacity of the region's private waste management companies will be needed to clear debris. Transportation routes will need to be cleared and restored to move debris out of damaged areas. Before heading to landfill or recycling areas, debris must be sorted at separate facilities. A key challenge will be the disposal of large amounts of contaminated, electronic, and hazardous materials waste. Landfill space is scattered throughout the region.

Buildings:

- Over $2 billion[64] of building damage could occur in Berkeley. Commercial corridors will see damage to URM buildings. Damage to tilt-up buildings will impact businesses in the western area of the city. Soft-story buildings, which are situated throughout Berkeley, will be damaged. 620 buildings will be completely destroyed. 21,000 more will have slight to moderate damage, primarily residential structures.

- Regionally, HayWired suggests that building damage could total $43.3 billion in 2016 dollars, with an additional $17.0 billion in 2016 dollars from damage to contents and commercial inventories.

Displacement:

- From 3,000 to 12,000 households will be displaced from their homes after the quake. About 200 more families will be forced to leave their homes due to fire damage. This represents up to a quarter of households in the city. One thousand to 4,000 of those households will seek temporary shelter provided by the City and the Red Cross. The remainder may stay with friends, relatives or in hotels.
- Haywired estimates that in Alameda County, 51,975 households would be displaced and 38,430 people will seek short-term shelter.

- Low-income and student populations disproportionately live in soft-story multi-unit apartment buildings, older buildings with weak foundations, and other vulnerable types of structures. Much of the damage to residential structures will occur in housing for these populations.

Infrastructure

Sanitary Sewer System
Interceptors (sewer pipes) will suffer major damage following an earthquake. Loss of electrical power will render pumping plants unusable, causing sewage backups and spills through the street access holes, posing potential public health concerns. Open trenches may be necessary to carry sewage for short distances. Sewer pipeline breaks may cause "sinkholes" that undermine roads and buildings.

Water System
EBMUD serves Alameda County and has strengthened its water treatment plants and major aqueducts. Of particular concern, however, are underground pipes, which distribute water from larger aqueducts to customers.

In the HayWired scenario, EBMUD's 4,162 miles of pipe suffer about 1,800 breaks and 3,900 leaks during the earthquake sequence. The average EBMUD customer would be without water for 6 weeks, some for as many as 6 months.[65]

These impacts can be reduced if current efforts to replace old, brittle pipe are completed before the next large bay-region earthquake occurs, because such pipe is more susceptible to earthquake damage.

Additionally, EBMUD's Claremont Tunnel has been seismically retrofitted and is not likely to be vulnerable to landslide. It may incur fault offset of up to 7.5 feet immediately but this effect has been incorporated into the mitigation design.[66]

Electricity
Immediately following the earthquake, 29,000 homes, more than 60% of Berkeley households, will be without electricity. Power will be down for days to a week. For the HayWired scenario, Pacific Gas and Electric Company (PG&E) was unable to offer a public estimate of the time required to restore power throughout the San Francisco Bay area after the HayWired scenario mainshock.

The majority of electrical power in the region is transmitted by Pacific Gas & Electric Company (PG&E). Most of PG&E's electrical substations in the Bay Area were built in the 1900s and 1920s. Although mitigation efforts have been made, significant damage to these buildings is expected. Underground cables that cross liquefiable and weak soils are vulnerable. Immediately after the earthquake, PG&E is likely to initiate power shedding to balance the grid, followed by a progressive blackout of the Bay Area to prevent cascading power failure.

Damaged sections in the transmission and distribution system will need to be repaired or bypassed. Before electrical circuits are energized, inspections for gas leaks in impacted areas will be necessary. Under the normal circumstances, it takes 2 to 3 days to restore a transmission system. Impeded accessibility as well as workforce shortages will, at the minimum, double restoration times.

Natural Gas

PG&E is the provider of natural gas in the Bay Area. Across the Bay Area, ground failure is expected to damage the network of pipes beneath city streets. Hundreds of breaks in mains, valves, and service connections will occur. Broken gas mains could fuel street fires. Structural fires will occur as a result of broken service connections.

HayWired provides estimates for restoration of natural gas in the City of Oakland, to Berkeley's south. HayWired estimates that fifty percent of Oakland buildings will have service restored within 10 days of the quake, and 90 percent will have service restored after 36 days.

Restoration of service across the Bay Area could take as long as two months for customers because individual connections will need to be inspected and appliances re-lighted. Most gas shutoffs are expected to be initiated by cautious customers.

Hazardous Materials Management

Building structural failures, dislodging of asbestos or encapsulated asbestos, laboratory spills, transportation accidents, pipeline breaks, storage tank failures, and industrial equipment problems will be the major sources of hazardous materials accidents following an earthquake.

Transportation

Highways

In Oakland, Highways 580, 880, 980, and 24, where they form the MacArthur Maze, a complex of elevated interchange structures, are built on liquefiable soils. Closure of sections of the Maze due to inspection or damage will restrict access into and throughout areas of need in the East Bay.

The Caldecott Tunnel provides the central link between Contra Costa and Alameda, carries Highway 24, as well as main electrical and gas, transmission lines beneath the roadway. Adjacent, separate tunnels are used for BART and water pipelines. The Claremont Tunnel (EBMUD) has been retrofitted. The BART tunnel is vulnerable to closure due to landslide. If the utilities or mass transit below the roads are damaged, Highway 24 will be closed for months for reconstruction.

BART

BART could be damaged in neighboring cities on all sides, shutting off a major mode of public transit to San Francisco, Oakland and other destinations. Additional ferries and bus lines could be established within a week to provide substitutes for BART.

The BART Berkeley Hills Tunnel which crosses the Hayward fault would be damaged in a major earthquake on that fault, cutting a key commuting link. As yet, retrofit or replacement of this tunnel is not a viable option and BART has instead developed plans to quickly return this section to service. Depending on the amount of damage sustained, the line could return to partial service within weeks of an earthquake with full replacement potentially taking several years to complete. This will cause inconvenience to many Berkeley residents and may change employment patterns. Temporary transport options, such as buses and increased use of individual cars, are likely to be more polluting than BART. In general, the traffic on all Berkeley roads and highways will probably increase for at least two years following the earthquake. Since 2008, retrofits have been completed on many elevated tracks, stations, parking structures and rail yards. At this time, all retrofits are expected to be completed by approximately 2018.

Communications

In the HayWired Scenario, communications systems, particularly telephone networks, will sustain damage that reduces capacity. Power outages will reduce functionality in situations when the outages last longer than the performance of battery backup and maybe even generator refueling. Congestion will also reduce functionality to a great degree, for several hours or more.[67]

An overload of post-earthquake calls in the region will make phoning difficult. Carriers will block the calls coming into the region to relieve circuit overloading. Outbound calls, as well as text messaging, are likely to be available.[68] The region's telecommunications companies will prioritize calls to allow emergency responders to communicate by phone.

Customers located in areas subject to severe ground shaking and high probability of ground failure may lose land-based connections to the telephone system. Access for repairs in those areas will be a major problem.

The cellular phone system relies on the integrity of antennas that are mostly located on building tops. Cell phone calls typically connect to the same landline systems that will be hampered by the expected overload of calls.

UC Berkeley

Enrollment at UC Berkeley may slow for a few years, depending on the level of damage experienced on campus. In the unlikely but possible event of a catastrophic incident, such as significant loss of life in a residence hall or classroom building, declines in enrollment will be significant. Remaining students, currently about 30 percent of the city's population, may struggle to find affordable housing. Businesses may rebuild or may move to new, cheaper locations. Many local, independent businesses will need to make the tough decision to rebuild or close shop. Retail businesses will be affected by dèmographic changes after an earthquake. Businesses located in neighborhoods with significant damage will suffer as customer demand changes, even if the businesses themselves are undamaged by the earthquake.

Businesses

Additional losses to income will likely occur due to Berkeley business closures, estimated at $288 million.[69]

Regionally, HayWired predicts $12.3 billion (in 2016 dollars) in building damage-related income losses (for example, relocation costs and lost rent), and total direct economic loss as $82.6 billion in 2016 dollars.

Rebuilding

Based on experiences in large urban areas being rebuilt following disaster, planners expect that rebuilding activities will begin quickly, but will prove expensive as construction professionals around the Bay Area are overloaded with work. Owners of damaged multi-unit rental housing may not be able to rebuild affordable housing, and may choose to build condominiums or other higher-profit housing to replace the damaged structures. Many residents will discover they are underinsured for earthquake and fire damage, making it difficult or impossible for them to rebuild. Rebuilt homes, meeting modern codes and style considerations, will change the look of the city.

Although much harder to predict, demographic shifts may also follow an up-ended housing market. Older homeowners may be unable or unwilling to rebuild, for example, and young families may need to relocate, at least temporarily, to ensure the continuity of their children's education. The likely loss of older, more affordable housing stock will also change Berkeley's economic profile.

An event similar to this scenario is likely to occur in the next few decades. Earthquakes causing significantly more or less damage are also possible.

B.6 *Wildland-Urban Interface Fire*

There are two primary types of wildfires: "wildland" fire and "wildland-urban interface" (WUI) fire. WUI fires occur where the natural landscape and urban-built environment meet or intermix. There may be a distinct boundary between the built and natural areas, or development or infrastructure may be intermixed in the natural area. WUI fires primarily cause damage to the natural and built environment, as well as injury and death of people and animals.

B.6.a Historical Wildland-Urban Interface Fires

Catastrophic fires, including the 2018 Camp Fire in Butte County and the October 2017 North Bay Fires demonstrate the wildland-urban interface fire hazard that is present and growing in California. Berkeley itself has significant WUI fire history, most recently in the October 20, 1991 Tunnel Fire. This fire in the Oakland/Berkeley hills started the day before as a vegetation fire in the drought-dried hills east of Oakland. It was reignited and whipped into firestorm proportions by 20-30 mph winds, gusting to 60 mph, and spread within minutes to residential structures. While the fire burned a greater area in Oakland, it raged across city boundaries between Oakland and Berkeley, destroying entire neighborhoods in both cities and remaining out of control for more than 48 hours. Sixty-two single-family homes[70] were destroyed in Berkeley. Ten thousand people were evacuated from the hills areas. Most of the 25 people killed in the blaze were trying to evacuate when they were killed. FEMA estimated the damage at $1.5 billion in 1991 (approximately $2.8 billion in 2018 dollars[71]).

The 1991 firestorm also caused $3 million of damage to Berkeley's public infrastructure[72]. The 2,000-degree fire affected utility systems, including power, gas, telephone and water. Ten key water tanks were drained at the peak of the fire as a result of unprecedented demand from firefighting units, fire prevention measures by homeowners (e.g. wetting roofs with garden hoses), and broken water service connections in burned homes. Early in the fire, burning power lines and melting underground services resulted in a loss of power, which affected water system pumping plants. A total of eight pumping plants, which refilled the water tanks being used by fire fighters, lost power by the first afternoon. Although these were restored by evening, the capacity of the water system pumps was far less than the amount of water used by firefighters and spilled by broken connections.

Total damages in the city of Berkeley, including loss of private structures, loss and damage of public infrastructure, and the cost of City services, are estimated at $61 million.[73]

The day of the 1991 fire, the Bay Area experienced high temperatures of 80-90 degrees, and unusually hot, dry winds blowing from the east, rather than the normal, moisture- laden western winds from the ocean. This type of wind, referred to as Foehn or Diablo winds, occurred 21 days in 2018. These winds, combined with the high temperature, low humidity, and built-up dry fuel load create Red Flag conditions. The number of Red Flag Warnings issued for the East Bay Hills by the National Weather Service has increased from three in 2012 to nine in 2018. These conditions were present for the 1991 Tunnel Fire. The firefighters were helped when on the second day, the winds shifted to the west and cooler temperatures and fog rolled in.

Historically, major fires have occurred in the wildland-urban interface under virtually the same critical fire conditions. The table below identifies significant WUI fires in Berkeley history.

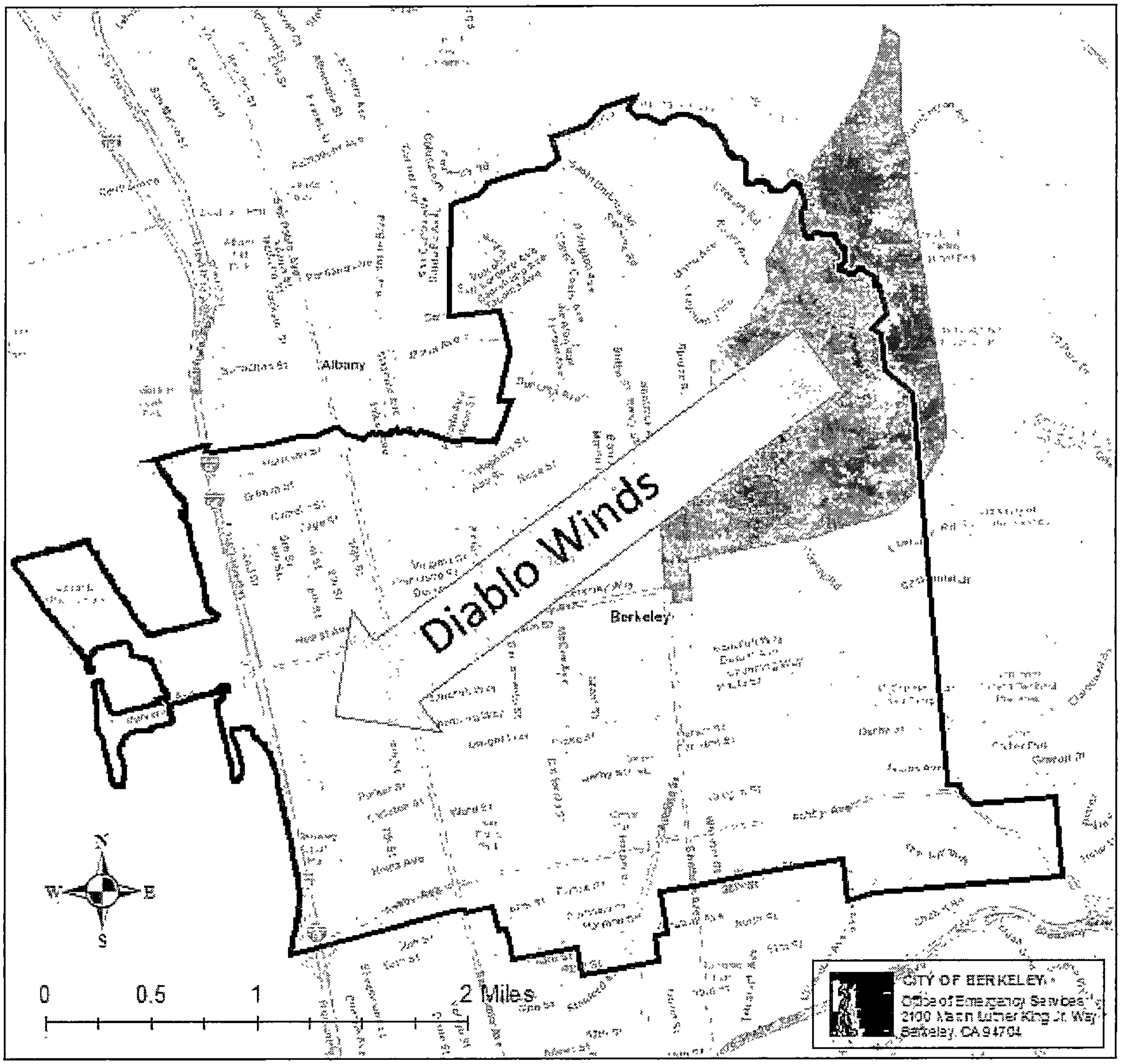
Table 13. History of Major Wildland-Urban Interface Fires in the Oakland/Berkeley Area[74]

September 17, 1923	Berkeley Fire	568 structures
September 22, 1970	Fish Canyon Fire (Oakland)	39 structures
December 14, 1980	Wildcat Canyon Fire (Berkeley)	5 structures
October 20, 1991	Tunnel Fire (Oakland/ Berkeley)	3,354 dwellings; 25 lives lost

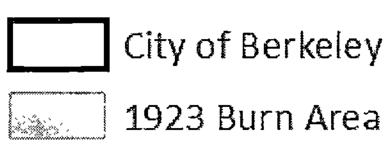
The Berkeley Fire of 1923 began in the open lands of Wildcat Canyon to the northeast and, swept by a hot September Diablo wind, penetrated residential north Berkeley and destroyed nearly 600 structures, including homes, apartments, fraternities and sororities, a church, a fire station and a library. Wood shake roofs are cited as a large contributing factor in the spread of this fire. The fire burned downhill all the way to Shattuck Avenue in central Berkeley. A total of 130 built-up acres were burned, and about 4,000 people were made homeless. Historical analysis of newspaper reports after the fire indicates that significant acreage was burned in both Strawberry and Claremont Canyons. Because there were few, if any structures in these areas, the full scope of the fire has been underreported in subsequent years. After this devastating fire, officials stated that the only reason that the fire stopped spreading was because the northeast wind stopped and the damp western wind took over. Fire officials at the time were certain that if the northeast wind had not stopped, the buildings would have burned all the way to the bay in Berkeley, and the fire would have devastated Emeryville and moved south and west into Oakland[75].

Map 15 depicts in red the area burned by the 1923 fire, which stretches from East Bay Regional Parks to Shattuck Avenue. It also overlays the Diablo wind pattern (indicated by a big blue arrow) to demonstrate how the fire could have spread into the Berkeley flatlands, had it not been for the change in wind direction.

Map 15. ***Area burned by 1923 Berkeley Fire***



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community



B.6.b Wildland-Urban Interface Fire Hazard

The City of Berkeley faces an ongoing threat from a very likely wildland fire along its hillsides, where wildland and residential areas intermix. Wildland-urban interface (WUI) fires can be sparked by both human activity and natural causes. Once ignited, these fires can be difficult to contain when they occur during extreme fire weather conditions. A WUI fire can move with breathtaking speed. In the recent North Bay Fires, it is said that the fire burned the equivalent of a football field every second.[76]

Hot, dry, windy weather often coincides with WUI fires. WUI fire spread is affected by wind speed and direction, fuel and topography. Dry, dense vegetation feeds fires, including some residential landscaping. Wooden homes also serve as fuel for fire. Tall trees, present throughout Berkeley, can harbor canopy fires at the treetops that contribute to fire spread and are particularly difficult to fight. Fire spreads uphill quickly.

Fires burn buildings and threaten infrastructure. The intense heat associated with a firestorm can deteriorate concrete and asphalt pavement, curbs, sidewalks, and drainage structures. Other infrastructure that burns includes aboveground wiring for electricity, telephone and cable, and poles for lights and street signals.

In addition to impacts on the natural and built environment, fire has impacts to public health. Fires can result injuries and death from burns and smoke inhalation.

Secondary Hazards

Worsened air quality

Air pollution from fires both in Berkeley and throughout the region can cause eye and respiratory illnesses, and can exacerbate asthma, allergies, chronic obstructive pulmonary disease, and other cardiovascular diseases. The City of Berkeley Occupational Health, Public Health, and Environmental Health Divisions coordinate air quality messages for staff and community through the Public Information Officer in the City Manager's Office.

Landslide

WUI fires can increase an area's risk of landslide and flooding. When all supporting vegetation is burned away, hillsides become destabilized and prone to erosion. The charred surface of the earth is hard and absorbs less water. When winter rains come, this leads to increased runoff, erosion and landslides in hilly areas.

Flooding

Erosion and land slippage subsequent to fires can lead to temporary or permanent displacement and property damage or loss,[77] [78] making it a secondary hazard that must be mitigated immediately after a fire.

Power outages

Fire can lead to power outages in two ways, either by manual shutoff by the utility in order to reduce the risk of wildfires or wildfire spread or a result of a wildfire. Loss of power can lead to many cascading and significant consequences, such as impacts to vulnerable infrastructure, inability to operate fuel and water systems that require electricity, communication, and service disruption, loss of heating or cooling, and loss of critical functions for people that rely on power for survival.

B.6.c Exposure and Vulnerability

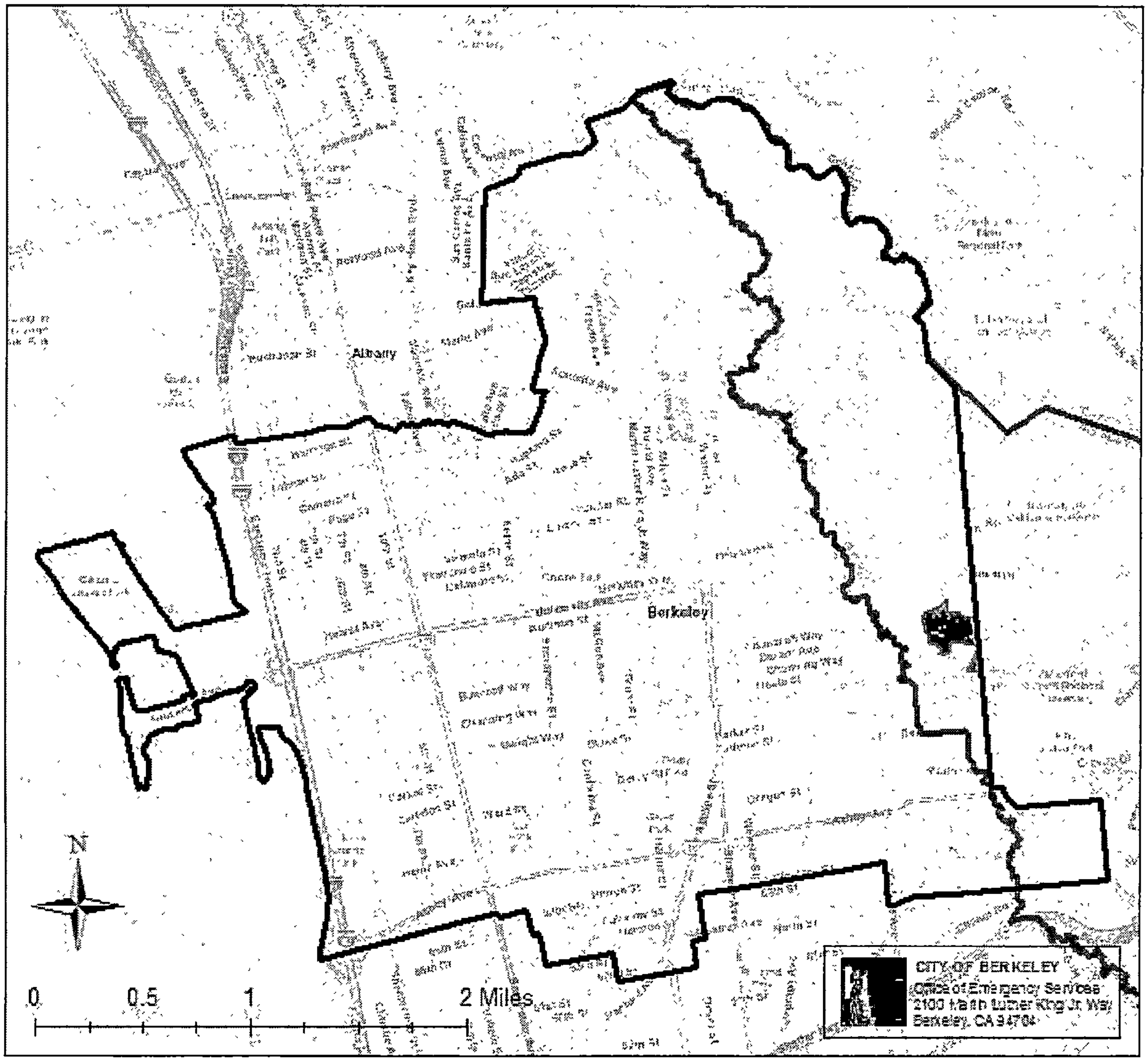
Berkeley is most vulnerable to a wind-driven fire incident originating in an area adjacent to the City's eastern border, in land owned by UC Berkeley, Berkeley Lab, the East Bay Regional Park District, the City of Oakland or Contra Costa County. The WUI fire risk facing Berkeley's wildland-urban interface area is compounded by the area's mountainous topography, its limited water supply, its minimal access and egress routes, and its location, overlaid upon the Hayward Fault. These factors have all contributed to the area's significant WUI fire history. Given the right wind conditions, a fire in one of these areas could quickly enter and encroach itself in Berkeley.

Since before the 1920s, the City of Berkeley has established and adjusted fire zones in Berkeley. While the zones were initially established to address urban fire issues, they have evolved to designate the City's WUI fire hazard. Currently, the Berkeley Fire Department currently has divided the city into Fire Zones 1, 2, and 3, designated in order of ascending fire risk. These zones are shown in Map 16.

Fire Zone 3 is the Panoramic Hill area specifically and is colored in red on Map 16; Fire Zone 2, colored in yellow-orange, covers the remainder of the city's eastern hills; Fire Zone 1, with no coloring, covers the rest of the City west of the hills. Fire Zones 2 and 3 currently include about 8,300 properties. These zones have the strictest fire prevention standards in the City for issues such as building materials for new structures. The City also enforces vegetation management measures in these areas.

The California Department of Forestry has designated a Very High Fire Severity Zone that covers a portion of the Berkeley hills but not all of Fire Zone 2. It is indicated on Map 6 by a thick red, line.

Map 16. ***California Department of Forestry and City of Berkeley Hazardous Fire Zones***



Sources: Fire Zones 1, 2, and 3 as of 01/2013 Berkeley Ordinance NO. 7,157-N.S., and California Department of Forestry. Service Layer Credits: Sources. Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Berkeley

CA Dept of Forestry, Very High Fire Severity Zone

Berkeley Fire Zones

Hazardous Fire Zone 1

Hazardous Fire Zone 2

Hazardous Fire Zone 3

While much of the concern for fire is placed on the hills, Berkeley's flatlands are at risk as well. The flatlands are densely covered with old wooden buildings that have narrow side yards and dense vegetation. Most of these houses are old and not built with modern, fire-resistant materials. They have a high risk of damage in an earthquake, which could spark multiple ignitions, for example, by damaging gas or electric lines.

Panoramic Hill Area
The Panoramic Hill area (labeled as the "Hazadous Fire Zone 3" Fire Zone on Map 16) has the greatest WUI fire vulnerability.

It is a wildland-urban interface area located on a hill above Memorial Stadium, between Strawberry Canyon to the north and Claremont Canyon Nature Preserve to the south. The ample vegetation in both canyons adds to the neighborhood's WUI fire risk. Many of the homes in this area have wood shake and shingle roofs and are surrounded by brush-type vegetation. Panoramic Hill also includes one of Berkeley's most architecturally-significant residential districts, which is listed in the National Register of Historic Places because of its association with the Arts and Crafts movement.

The neighborhood lies in both Berkeley and Oakland. There are about 280 dwelling units on Panoramic Hill, including 215 dwelling units in the Berkeley part of the neighborhood. There are approximately 520 residents in the area, including close to 100 in Oakland. The area is surrounded by the Berkeley Lab, the University of California, Berkeley (Clark Kerr campus) and the East Bay Regional Park District.

The Hill's limited water supply, access/egress routes, and its exposure to fault rupture further exacerbate the area's WUI fire risk above that of Fire Zone 2.

Water Supply Limitations

Water supply to the Panoramic area is limited to one undersized water main. As of December 2018, work is in progress to improve water supply. If the existing main is damaged by an earthquake or landslide, any area beyond the point of the break will be without water service. This is different from other areas in the hills and flatlands, where the "gridded" structure of the water system allows for more redundancy in the event of a water main break. In Panoramic Hill, an earthquake could spark a fire, which could be fueled by damaged gas lines. Damage to the area's one water main from an earthquake or resulting landslide could limit residents' and professionals' ability to suppress the fire.

This sequence of events could devastate the neighborhood and grow into a firestorm, threatening other parts of the city and neighboring jurisdictions.

Access and Egress

Panoramic Way is the only paved road into and out of this neighborhood. It forms a single loop, 12-18' wide, that begins and ends just south of Memorial Stadium. The street's narrow width and hairpin turns make it barely accessible to fire apparatus, which are required to perform three-point-turns to ascend the Hill.

Panoramic Way's narrow width also means that at many points the road is not wide enough to allow vehicles to pass one another. Under normal conditions, vehicles responding to medical emergencies have been impeded by commercial vehicles, trash collection trucks, and illegally-parked personal vehicles.

History demonstrates that endangered residents in the path of a major fire will attempt to leave the area via private vehicles crammed with personal belongings. When there is another major hill area fire or an earthquake, emergency access and egress on the substandard road will be highly constrained. People trying to leave a dangerous condition will conflict with emergency personnel trying to address it or trying to reach others who need help to leave. Further, an earthquake-induced landslide impacting Panoramic Way could also block any vehicles from entering or leaving the area.

Exposure to Fault Rupture

Further intensifying the neighborhood's vulnerability, the Hayward Fault runs under Panoramic Way, just before it crosses the parking lot and bisects the Memorial Stadium. In a Hayward Fault earthquake, the Panoramic Hill area will likely be isolated from the City's emergency services, all of which lie on the other side of the fault to the West (with the exception of Fire Station 7, which lies north of the UC Berkeley campus).

Notable Mitigation Activities

The City, working together with key partners, is using a comprehensive strategy to aggressively mitigate Berkeley's WUI fire hazard. These approaches include prevention through development regulations; natural resource protection through vegetation management; improvement of access and egress routes; and infrastructure maintenance and improvements to support first responders' efforts to reduce fire spread.

<u>Prevention</u>

The City enforces several programs to reduce Berkeley's fire hazard, especially the WUI fire hazard in the hills. These include strict building and fire code provisions, as well as more restrictive local amendments[79] for new and renovated construction, and vegetation control inspections in high-risk properties.

PG&E's Community Wildfire Safety Program has precautionary measures in place to help reduce the risk of wildfires. Its goal is to help customers prepare for and stay safe during extreme weather events, including sending notifications when and where power may be turned off for safety. The City works closely with PG&E and is mindful of the impacts that power outages may have on people with disabilities and people with access and functional needs.

Panoramic Hill Area Development Regulations

Following the 1970 Fish Canyon Fire, the Planning Department established the Berkeley portion of the area as an ES-R (Environmental Safety-Residential) zone. This action limited the use of land and the size and occupancy of residential structures in the area.

The ES-R regulations are the most stringent residential standards in the Berkeley Zoning code.

The City has continued to adopt strict standards that curtail development on Panoramic Hill, so that as few additional people as possible are placed at risk until the area's underlying infrastructure issues are addressed. In 2008, City Council adopted a moratorium on development on the hill. In May 2010, the Council repealed the moratorium, passing an ordinance that blocks establishment of any residential units on the Hill. The restriction remains in effect until Council adopts a Specific Plan for the area's land use. The Specific Plan must include:

- Proposals for water, wastewater and storm water systems
- Proposals for a circulation system adequate to accommodate projected traffic, and to provide for emergency access to the area
- An action plan and finance measures necessary to carry out the Specific Plan.

Because the neighborhood resides in both Berkeley and Oakland, in 2006, the Alameda County Local Agency Formation Commission (LAFCo) expanded Berkeley's Sphere of Influence to include the Oakland part of Panoramic Hill. LAFCo acted to do so despite opposition letters from the City Manager of the City of Berkeley and City Administrator from City of Oakland. LAFCo's action means that the City of Berkeley is now officially charged with planning for all of Panoramic Hill, including those areas currently in Oakland. While Berkeley must consider the entire Hill in its planning documents, it only gains zoning authority if those portions of the Hill in Oakland are annexed to the City of Berkeley – a long and complicated process requiring agreement of both Cities.

Since it is highly unlikely that there will be City funds available to undertake the planning and then the design and construction necessary to address the area's infrastructure deficiencies in the foreseeable future, existing land and homeowners in Berkeley and Oakland will likely need to collaborate to provide the necessary funding for a Specific Plan. Grant funding may also be available to undertake some of the necessary planning, design, and construction.

<u>Natural Resource Protection</u>
The Hazardous Fire Area Inspection Program is in place for a subset of properties within Fire Zones 2 and 3. Each year, Fire Department personnel inspect over 1,400 parcels in Fire Zones 2 and 3. Additionally, personnel conduct complaint-driven inspections in all three of the City's Fire Zones.

The City also runs a number of vegetation management programs to reduce fuel loads, including:

- The Fire Fuel Chipper Program, a popular yard waste collection service. The

Program serves properties in the hills from June through September each year. Since 2014, over 100 tons of vegetation was collected and recycled, on average, each year.[80]

- A fire fuel abatement program on public land. This Program was maintained in order to reduce fire fuel on public property. From May to mid-August each year, an average of 125 tons of debris are removed from approximately 98 public sites, including parks, pathways and landscaped medians.[81]
- The Fire Fuel Debris Bin Program is coordinated by the Department of Public Works' Zero Waste Division, which delivers and removes 30 yard roll-off boxes from requesting neighborhoods. This effort yields an average of 132 tons of plant debris per year.[82]
- Additionally, 30,000 tons of residential and commercial plant debris and commercial food waste[83] is collected each year through weekly curbside collection and converted to compost.
- The City of Berkeley's Zero Waste Division has expanded staffing to include a full-time Recycling Program Manager, and is working to hire additional field representatives to help educate the community about its vegetation management programs. Additionally, the Division is performing a Feasibility Study to reimagine the City's Solid Waste and Recycling Transfer Station to achieve its goal of Zero Waste. This reenvisoned facility will help to support outreach staff in their efforts to promote vegetation management programs.

<u>Safe Passages Program</u>

Safe Passages is a project to support the City's emergency evacuation plan by helping to ensure clear ingress for emergency vehicles and egress routes for evacuation. Project implementation will include evaluation of streets requiring parking restrictions, enforcement mechanisms, vegetation clearing and management, and a robust public education campaign to reduce risks and maximize benefits.

<u>Access and Egress</u>

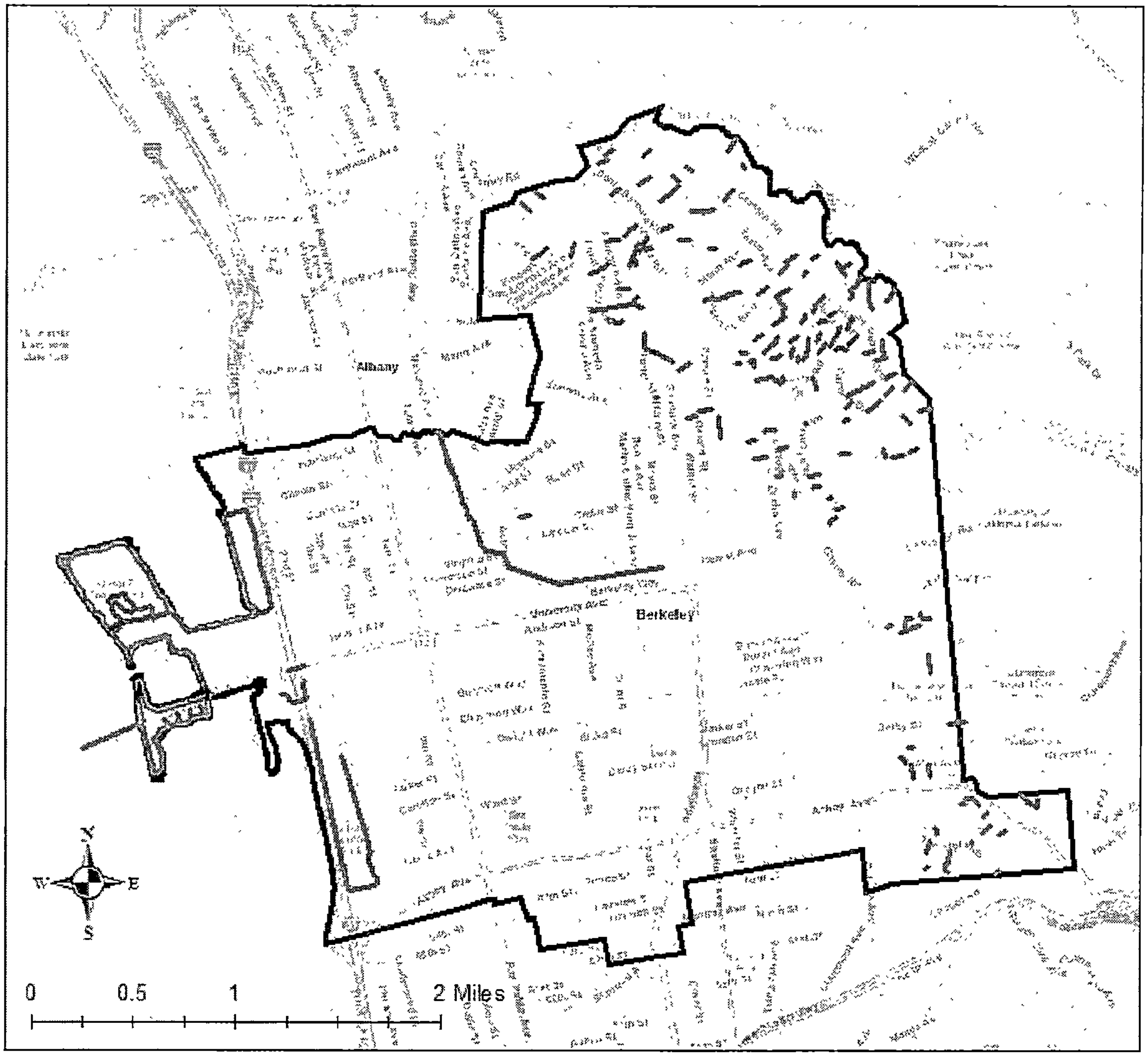
Key Partner: Berkeley Path Wanderers Association

Berkeley Path Wanderers Association (BPWA) is an all-volunteer nonprofit organization concerned with Berkeley paths. In the city's many steep neighborhoods with winding roads, these paths take the shortest, most direct routes, mimicking city block grids that do not exist. In addition to producing a community recreation asset, these pathways can assist evacuation and firefighting efforts in the hills. In preparedness outreach, the City instructs community members to always be ready to evacuate without a car and to be aware of the locations of developed paths that may reduce evacuation distance. However, because developed pathway conditions vary widely from those with concrete steps and railings to those with wooden steps, these paths may not be good options for evacuees with mobility issues or low vision. For these evacuees, the City recommends City streets for pedestrian evacuation.

Since 1997, BPWA has built and maintained rustic paths using wood ties secured to the ground with rebar, replaced wooden ties and rebar when necessary, cleared overgrown vegetation, and conducted monthly weeding. The group also cleans and clears historic cement paths. BPWA has also contributed funds for installation of handrails. The City's Department of Public Works performs more heavy maintenance, such as cement work and hand rail installation and replacement.

Map 17 shows pedestrian paths in the City of Berkeley using blue lines. As indicated on the map, there are many small paths in the Berkeley hills that can help with fire evacuation and firefighting efforts.

Map 17. ***Pedestrian Pathways in Berkeley***



Source: Berkeley Path Wanderers Map, 8th Edition.
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Berkeley
Berkeley Paths

BPWA has improved 34 paths in the hills north of the UC Berkeley campus. Most of the paths offer more expeditious evacuation routes than the surrounding city streets. The table below shows some of the BPWA paths that significantly reduce pedestrian evacuation distances.

Table 14. Noteworthy BPWA Paths

Path Name	Distance	Distance without Path
Acacia Walk	0.1 miles	0.4 miles
Atlas Path	<0.07 miles	0.2 miles
Bret Harte Path	< 0.1 miles	0.2 miles
Glendale Path	0.2 miles	0.6 miles
John Muir Path	< 0.1 miles	0.3 miles
Northgate Path	< 0.1 miles	0.4 miles
Upper Covert Path	< 0.1 miles	0.5 miles
Wilson Walk	< 0.03 miles	0.4 miles
Yosemite Steps	0.1 miles	0.4 miles
Dwight Way Path	Links Dwight Way and Clark Kerr Fire Trail	

In July of 2018, BPWA conducted a survey of all the paths, noting the condition and needed repairs of each path. BPWA plans to continue conducting full path surveys every five years. City staff met with BPWA about the survey and are working on reviewing their comments, concerns and stated priorities. With new funding for pathway improvements, the Department of Public Works is preparing cost estimates to confirm how to best use this initial funding. It will likely include signage and possibly other work as funds are available.

In addition to maintaining paths, the group raises awareness of the paths for use as both escape routes for residents and as access routes for emergency personnel. BPWA performs outreach through a published map, their newsletter, free public meetings, and free guided walks.

In fall of 2018, the BPWA hosted walks with three Berkeley neighborhoods to practice using evacuation routes out of the Berkeley hills. These routes included key paths, and served to better familiarize community members with evacuation routes they may need to use in a disaster that blocks roadways.

Notable Mitigation Activities

In the spring of 2015 the City performed repair work on Bret Harte Path. Work included the removal and replacement of damaged concrete stairs, removal and replacement of damaged concrete walkway, and the installation of handrails.

In the spring and summer of 2016 the City developed the previously undeveloped John Muir Path.

The BPWA does not maintain paths on UC Berkeley land, but is exploring ways to work with UC Berkeley to improve pedestrian transitions between UC and adjacent neighborhoods. For example, in the winter of 2017 the Berkeley Path Wanderer's Association (BPWA) installed approximately thirty 4'-wide wooden stairs at the bottom steep section of Dwight Way Path. This path is located at the top of Dwight Way (a City street) and merges onto the Clark Kerr Fire Trail on UC Berkeley property.

The City-BPWA partnership will continue into the future:

- The City is currently working on the future development of the currently undeveloped Devon Lane.
- The City has entered into an agreement with EBMUD to realign and upgrade Arden Path. The current upper portion of the path is on EBMUD property rather than City property and will be realigned onto City property. The path will also receive a new staircase over a step section of the path. EBMUD is scheduled complete this work in late 2019.
- City forces are currently working to install a handrail along the lower portion of Park Path. Work is scheduled to be complete in 2019.

Improving Firefighting Readiness

Early suppression efforts prevent many WUI fires from growing out of control. Since the 1991 fire, the City has continued to build firefighting infrastructure to enable firefighters to reduce fire spread.

In 2006, the City constructed a new fire station on Shasta Road, just north of the UC Berkeley campus in the hills. This station, in addition to being in the wildland-urban interface, is the only City fire station east of the Hayward fault.

In 2010, the City put into operation an aboveground, portable water system that can pump water from any source, including the San Francisco Bay, in the event of drained tanks or damaged pipelines. This system is designed to carry up to 20,000 gallons of water per minute for a distance of one mile and elevation gain of 100 feet; it will also carry smaller flows to higher elevations. This capacity was based on calculations of water volumes required to fight the fire front presented in the 1991 blaze, assuming that some capacity will be available from EBMUD sources, in light of system upgrades.

Since the 1991 fire, the Berkeley Fire Department has been also working to strengthen its wildland firefighting skills and to prevent conflagrations. Firefighters remain in a constant state of readiness to respond to a wind-driven WUI fire in the hills, which could transition into a fast-moving urban firestorm in the flatlands. Additionally, the City has built cooperative relationships with neighboring fire departments to put out vegetation fires before they grow into multi-jurisdictional problems. Mutual response agreements among the City and its neighboring jurisdictions have increased the fire resources that respond to the reporting jurisdiction.

This cooperation has been assisted through formal efforts, such as the inter-jurisdictional Hills Emergency Forum (HEF), started after the 1991 fire. HEF exists to coordinate the collection, assessment and sharing of information on East Bay Hills fire hazards, and to provide a forum for building interagency consensus on the development of fire safety standards and codes, incident response and management protocols, public education programs, multi-jurisdictional training, and fuel reduction strategies.

Key Partner: UC Berkeley

UC Berkeley campus lands include approximately 800 acres of wildland in the East Bay hills that border on residential neighborhoods in Berkeley and Oakland. The combination of an accumulation of dense nonnative vegetation and increased urbanization has created a wildland-urban interface (WUI) condition posing an extreme threat to lives and property. From 1923 to 1991, 14 major fires have occurred in this area, including the 1991 Tunnel Fire that destroyed more than 3,354 dwellings and claimed 25 lives.

UC Berkeley depends on the City for fire services, but does not fall under City fire preparedness ordinances. The University has an established Campus Fire Mitigation Committee to develop and oversee a program to manage the WUI fire hazard. The goal is to manage vegetation to ensure that the vulnerable areas are WUI fire-defensible by improving accessibility for fire crews, creating and maintaining escape routes, and lessening the rate of fire spread and/or reducing the potential for embers to ignite adjacent neighborhood. The University has made repeated efforts since 1974-75 to eliminate the vast groves of eucalyptus trees on its property. Earlier efforts were unsuccessful, as the felled trees regrew from their cut stumps. UC efforts since 2001 have emphasized the use of herbicides to kill the eucalyptus trees after felling, along with an integrated management approach to prevent the millions of viable eucalyptus seeds from germinating. The University's goal is to convert its eucalyptus- and pine-forested areas to oak/bay woodland, scrubland, grassland or other floral communities historically found in the East Bay hills. In 2006, UC Berkeley opened the Center for Fire Research and Outreach to encourage and facilitate collaboration on fire-related research questions and provide a central point for wildfire information.[84]

Key Partner: Berkeley Lab[85]

With regard to wildland fire and wildland-urban interface (WUI), the Berkeley lab is in a vulnerable position. The lab borders a potential wildland fire area in the Tilden Regional Park area and borders a highly populated urban area in the City of Berkeley. This can cause challenges with timely evacuations, thus the laboratory has developed an invacuation process for shelter-in-place during wildland fires if necessary. The goal will be to evacuate the laboratory, however, this may not be the safest thing for employees after an earthquake or prior to a wildland fire. The lab has a trained and qualified Emergency Response Organization (ERO) to make critical decisions regarding protective actions and the safety of lab employees.

B.6.d Wildland-Urban Interface Fire Risk and Loss Estimates

The 1923 fire was the worst WUI fire to impact Berkeley in recent history. This plan calculates losses that would occur if that fire were to recur today. A repeat of this fire would cause significantly more damage in Berkeley than the recent 1991 Tunnel fire.

The 1923 Berkeley Fire started in Wildcat Canyon to the northeast of the city and burned south and west down to Shattuck Avenue, stopping at the edge of UC Berkeley. Map 15 shows the area burned by this fire. The California Railroad Commission documented the burned area in 1923, three months after the fire. By superimposing this historical map onto the current day structures of Berkeley using the City's Geographic Information System, we find that, today, over 3,000 structures are located in the footprint of the 1923 fire. These structures include single-family homes, multi-family residences (many of which house UC Berkeley students), and stores, restaurants, and offices central to downtown Berkeley.

If a fire occurred today that burned the same area, the loss to structures would be in the billions of dollars.[86] Destruction of contents in all of the homes and businesses burned would add hundreds of millions of dollars[87] to fire losses. Efforts to stabilize hillsides after the fire to prevent massive landslides would also add costs.

While the financial losses from this scenario are staggering, the social impacts of such a fire could be devastating. Thousands of families could be homeless following such an event, losing all of their possessions. Many more could need short-term shelter while the fire was burning. Residents and firefighters could be killed, especially in difficult-to-access areas. Local, independent businesses might disappear forever. A large portion of the city would need to be entirely rebuilt. In short, the entire face of northeast Berkeley could be completely changed.

SECTION II: HAZARDS OF CONCERN

Rain-induced landslides, flooding, tsunami and climate change are hazards of concern for Berkeley, because of their potential to severely impact specific areas of the city. Section C of this plan identifies mitigation actions to reduce the impact of each of these hazards.

Climate change is addressed in further detail in Berkeley's Climate Action Plan.

B.7 *Rainfall-Triggered Landslide*

Seismically-triggered landslides are discussed in detail in B.5.b.iv.

B.7.a Historical Rainfall-Triggered Landslides

The most recent landslide in Berkeley occurred in January 2017. In January 2017, the overall rainfall in California was on pace to be the wettest season in over 100 years on record. Rain created saturated soil conditions in parts of Berkeley and throughout the State. The slide occurred on an undeveloped lot in the North Berkeley hills and threatened to close the street lying in the path of the slide. Repairs to the hillside were completed in late 2018. No one was hurt.

Berkeley's most significant recent landslide occurred in North Berkeley during the winter of 1997-98, when soil became oversaturated from heavy rains brought by the El Nino weather system. One home was significantly damaged and had to be demolished. Two additional homes were yellow-tagged, meaning they were of questionable safety, but residents were able to reoccupy these homes after the hillside was stabilized. No one was hurt.

At other times during the 20th century landslides of rainfall-saturated ground in the Berkeley Hills damaged and sometimes destroyed homes and public infrastructure, including streets, sewers, and other utilities. Most of the areas damaged were later rebuilt or built over.[88]

Other recent landslide experiences are limited to minor slides blocking roads, such as the collapse of the Euclid Avenue retaining wall in 1996.

B.7.b Rainfall-Triggered Landslide Hazard

Landslides are natural geologic phenomena that range from slow moving, deep-seated slumps to rapid, shallow debris flows. Landslide risk can be exacerbated by development. Grading for roads, home construction and landscaping can decrease hillside stability by adding weight to the top of a slope, destabilizing the bottom of a slope, and/or increasing water content of the underlying materials.

Landslides are most frequently triggered in periods of high rainfall, and are likely to continue occurring in Berkeley. The hazard is greater in steeply-sloped areas, although slides may occur on slopes of 15 percent or less if the conditions are right. Slope steepness and underlying soils are the most important factors affecting the landslide hazard. However, surface and subsurface drainage patterns also affect the landslide hazard, and vegetation removal can increase the likelihood of a landslide.

The most dangerous landslides in terms of life safety are fast-moving, generally shallow debris flows. These are triggered when intense rainfall follows storms that have already saturated hillsides. Debris flows initiate in concave slope areas where subsurface water is concentrated, elevating pore pressure above the natural strength of the soil. Once initiated, debris flows can travel great distances at relatively high velocities, flowing down drainages and onto alluvial fans and damaging any structures lying in their paths. Preexisting and recently-active, larger landslides (such as those shown in Map 5) are more often triggered by exceptionally long periods of seasonal rainfall, and sometimes do not start moving until long after the rain has stopped. These types of slides may not move as rapidly as debris flows, but can damage large areas and many structures, resulting in extensive landslide losses.

B.7.c Exposure and Vulnerability

Berkeley faces a moderate landslide hazard. There are a number of deep-seated landslides that continuously move, with the rate of movement affected by rainfall and groundwater conditions. These active landslides are shown in red on Map 5. Landslide movement could range from a few inches to tens of feet in any given year, but ground surface displacements as small as a few inches are enough to break typical foundations. In addition, there are many more deep-seated landslides that are not currently moving, but have moved in historic time or in recent geologic time. The more significant of these are shown in yellow on Map 5. These "dormant" landslides could be reactivated by changing surface or subsurface conditions.

Areas of the community situated on historic or recent deep-seated landslides are most vulnerable to landslide hazards. Vulnerabilities in these areas include hundreds of homes, roads, sidewalks, underground utilities (water, sewer lines, storm drains, natural gas lines, and conduits) and aboveground utilities (electricity, telecommunications, cable). People may be hurt or killed during the landslide. Damage to roads and sidewalks may prevent, especially people with disabilities and people with access and functional needs from navigating the area or evacuating quickly. Damage to underground utilities may pose serious health and environmental risks. Interruptions in electrical power jeopardize people with disabilities and people with access and functional needs that rely on electrical equipment for survival.

For debris flows, hazard areas are typically at the base of steep hillsides, near the mouths of steep hillside drainages, and in or around the mouths of canyons that drain steep terrain[89]. In Berkeley, several collector streets that are critical for emergency access and evacuation are located in areas susceptible to landslides.

Key Mitigation Activities

Regardless of triggering mechanism, landslide hazard mitigation techniques are the same. Landslide hazard can be reduced through grading, soil strengthening, geotechnical engineering components, drainage, control of runoff, and landscape methods. In new development, the City regulates the issuance of permits and inspects new development activities. However, most

Berkeley hillside development predates current best practices and codes and therefore remains vulnerable to the threat of landslides. The City maintains major retaining structures in the right-of-way that help to control landslide risk in key areas.

B.7.d Rainfall-Triggered Landslide Risk and Loss Estimates

There are few generally-accepted methods to estimate damage from landslides caused by rain. However, many of Berkeley's hillside homes are located in areas that could slide under the right circumstances. According to a USGS report[90], approximately 6,000 structures are located in areas at moderate to high risk of landslides.

B.8 *Floods*

B.8.a Historical Floods

Berkeley's most recent widespread flooding occurred in 2004 throughout the City during a 25-year rainfall event. Flooding also occurred during the 1997 - 1998 El Niño season.

In the early 1960s, the Strawberry and Codornices Creeks overflowed, causing flooding of streets and intersections. The flooding was of short duration and shallow depth and occurred in small areas. A few buildings flooded, including some on the University of California, Berkeley campus.

B.8.b Flood Hazard

Berkeley faces a minor flood hazard, primarily from local creek flooding and storm drain overflow.

Creek Flooding

Like in many urban areas, creeks in Berkeley have been affected by urban development. Stretches of creeks in Berkeley are completely contained by culverts[91], and open channel segments of the creeks are often segmented by shorter culverts that enable streets and development.

Creeks in west Berkeley flow year-round. The upper reaches of creeks only flow for a short time after rainfall. When the level of runoff exceeds the capacity of a creek, the flood waters overtops the banks and floods into properties and streets.

Creek flooding in Berkeley generally originates on private property.

Storm Drain Overflow

The City's storm drainage infrastructure collects urban runoff, and carries it either directly to the Bay or to nearby watercourses that discharge to the Bay. Flooding from storm drainage infrastructure can happen independently of creek flooding. Causes for such flooding are generally rainfall events that exceed the capacity of the storm drainage facilities, blockages, or storm drainage damage that reduces the capacity of the storm drainage infrastructure.

<u>Capacity</u>

When storm water runoff exceeds the capacity of the storm drain infrastructure, the excess water flows into city streets. Most of Berkeley's storm drain infrastructure is engineered to accommodate a 10-year design storm[92]. Using this 10-year design storm standard is considered the most cost-effective design practice,[93] and provides guidance for computing flows and for sizing storm drainage infrastructure.

<u>Age</u>

Maintenance helps preserve the flow capacity of the infrastructure, reducing the frequency of flooding, however many components of Berkeley's storm drain infrastructure are over 90 years old and are past their useful life expectancy. Concrete pipes have eroded or separated and metal pipes have corroded over the years. In some locations sink holes have formed as soil enters the storm drain through cracks and other defects. Berkeley's Watershed Management Plan (see *Notable Mitigation Activities)* recommends an inspection program to identify infrastructure that has deteriorated to a condition of being in danger of collapse or deteriorated reducing hydraulic flow capacity.

Creek Culverts

Berkeley is underlain by a patchwork of creek culverts, most privately constructed and many a century or more old. In a catastrophic event such as an earthquake, there is a strong possibility that some of these culverts may be damaged and, in some cases, may collapse. A culvert collapse could be physically and economically catastrophic in an area such as Downtown Berkeley where buildings have deep basements, many underground utilities, and streets are congested with vehicle and pedestrian traffic. Most culverts are located on private property, with some located beneath private improvements. Failure of a private culvert may cause significant damage to private property, and improvements on that property. For culvert breaks beneath public property, the City intends to repair such a break on an as needed basis, as it currently does with a break in its storm drains. However, many private property owners are unaware that improvements on their property may be situated above a culvert.

Flooding Factors

Factors that induce flooding in Berkeley include:

- Winter storms with heavy rainfall: Heavy rainfall increases urban runoff and flows to creeks and the City's storm drainage infrastructure.

- Blockages: Blockages can happen in creeks and in the City's storm drainage infrastructure. The City increases maintenance efforts of its infrastructure ahead of and during significant rainfall events. Residents are responsible for maintaining their creeks and infrastructure within their property.

- Bay tides: Runoff from Berkeley goes directly to the Bay. Higher tide and sea level rise reduce creek and storm drainage flow capacity in the western portions of the City.

- Power outage: An unknown number of property owners rely on electric sump pumps to keep their homes buildings free from water during the rainy season. Any protracted power outage during the rainy season could disable these pumps and lead to water damage in many structures.

- Climate change and its effects: Climate change is linked to increasing the intensity and severity of rainfall events and to sea-level rise. The effects of heavy rainfall and sea-level rise are discussed above. (See Section B10: Climate Change.)

Public Health Impacts[94]
Urban runoff typically contains contaminants that can threaten public health. These include bacteria, toxins, petroleum products, etc. Watersheds in the City are not a source of municipal potable water.[95] Flood waters represent of potential source of contamination to improvements that are at risk of flooding. Local gardens face a similar threat of contamination if they are exposed to urban runoff. Heavy storm water runoff can contaminate the ocean, lakes, and other bodies of water with other bacteria.[96]

B.8.c Exposure and Vulnerability

Flooding exposure in Berkeley generally results from creek flooding and storm drain overflow.

Creek Flooding Exposure - National Flood Insurance Program

Berkeley's creek flooding exposure is assessed through the National Flood Insurance Program (NFIP), which makes federally-backed flood insurance available to homeowners, renters, and business owners in participating communities. Participants in the NFIP must regulate development in floodplain areas in accordance with NFIP criteria.

Berkeley has participated in the NFIP since September 1, 1978 and is currently in good standing with the Program. NFIP compliance is monitored by FEMA regional staff and by the California Department of Water Resources under a contract with FEMA.

As part of Berkeley's effort to comply with the requirements of the NFIP, Berkeley has adopted various floodplain management measures. Thanks to the fact that the City has abided by and enforced federal flood insurance program requirements since the 1970s, flood insurance claims have been extremely low.

Berkeley's Flood Zone Development Ordinance regulates development in areas identified in the Flood Insurance Study and Flood Insurance Rate Maps. To file insurance claims with FEMA for flood damage, owners of parcels in this area must have FEMA flood insurance, and comply with the terms and conditions of the insurance. Few Berkeley homeowners are known to carry flood insurance, presumably because of negligible flood damage in recent decades, so those losses would be borne almost entirely by building owners.

The City last updated Berkeley Municipal Code (BMC) Chapter 17.12: *Flood Zone Development Ordinance* in September 2009 to maintain Berkeley's continued compliance with FEMA National Flood Insurance Program requirements. The Ordinance regulates all publicly- and privately-owned land within the areas of special flood hazard. BMC 17.12 automatically incorporates new FIRM panels. BMC 17.12 establishes the Director of the Public Works Department as the Floodplain Administrator for the City and addresses standards for construction, utilities, subdivisions, manufactured homes and recreational vehicles.

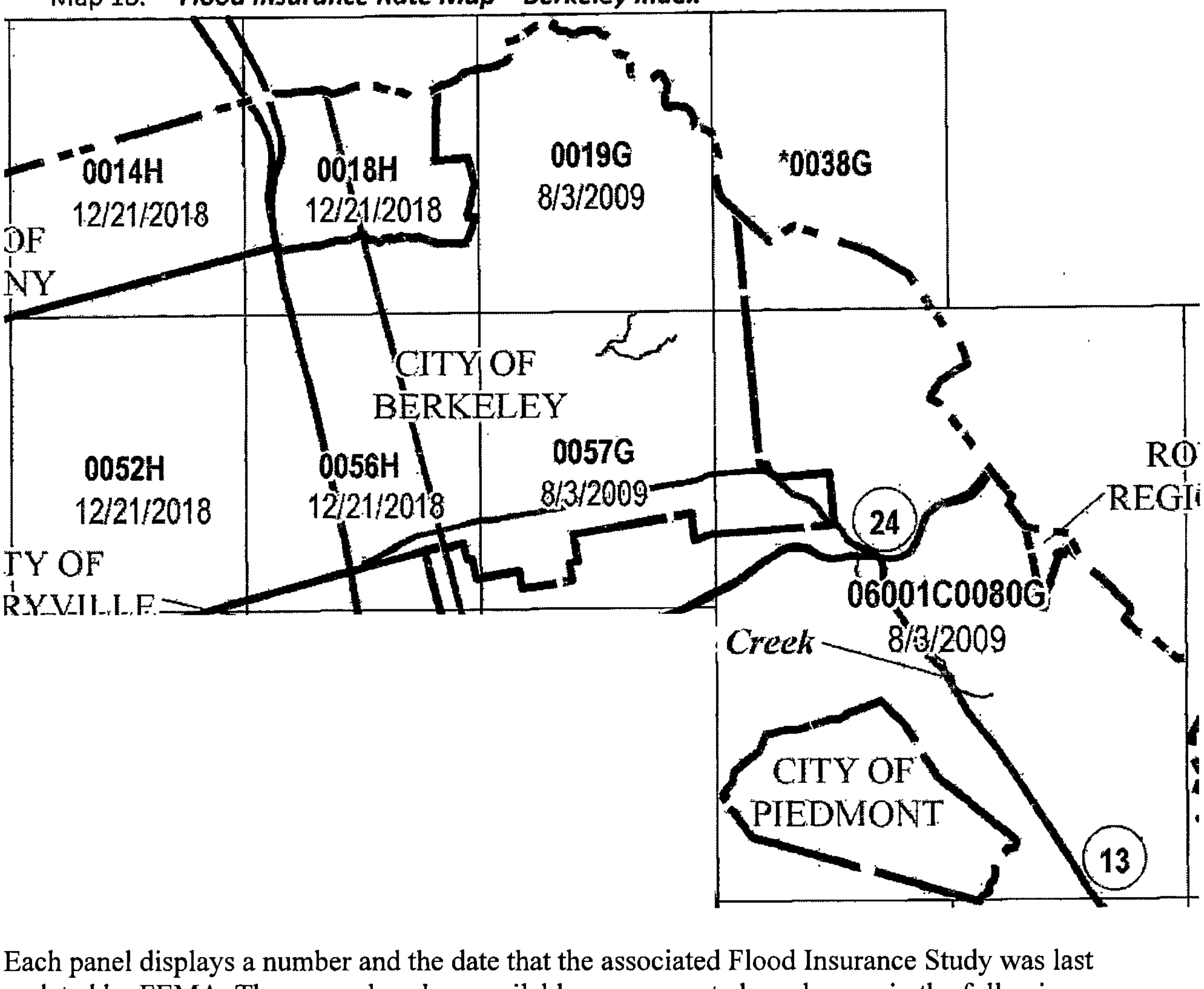
The City of Berkeley will maintain participation in the National Flood Insurance Program under the Public Works Department's Engineering Division and the Planning and Development Department's Land Use Planning and Building and Safety Divisions. The Supervising Civil

Engineer will work with FEMA and other partners to continue to update and revise flood maps for the City, and to continue to incorporate FEMA guidelines and suggested activities into City plans and procedures for managing flood hazards. The Zoning Officer and Building Official are responsible for applying BMC requirements to private property projects.

Analysis: Flood Insurance Rate Maps

Map 18 shows the FEMA Flood Insurance Rate Map panels that apply to the City of Berkeley. The map panels present areas of special flood hazard in Berkeley are identified by the FEMA "Flood Insurance Study, Alameda County, California and Incorporated Areas," dated August 3, 2009 and revisions effective December 21, 2018.[97] The study presents flood zone boundaries and any known flood depths or elevations for the one-percent annual chance flood and the 0.2-percent annual chance flood.

Map 18. ***Flood Insurance Rate Map – Berkeley Index***



Each panel displays a number and the date that the associated Flood Insurance Study was last updated by FEMA. These panels, when available, are presented one by one in the following pages.

The pages that follow present the map panels from the index above ordered left to right, top row to bottom row:

Panel Number	Update Date	Notes
0014H	12/21/2018	
0018H	12/21/2018	
0019G	08/03/2009	
0038G	09/30/2015	Not presented because FEMA did not print panel
0052H	12/21/2018	
0056H	12/21/2018	
0057G	08/03/2009	
0080G	08/03/2009	

Maps highlight areas of flood hazard using the following structure[98]:

- Areas highlighted in blue (2018 maps) or blue polka dots (2009 maps) represent Special Flood Hazard Areas subject to inundation by the 1% annual chance flood, meaning that they have a one percent probability of flooding in a given year.
- Areas highlighted in brown (2018 maps) or black polka dots (2009 maps) represent areas of 0.2% annual chance flood hazards, meaning that they have a 0.2% probability of flooding in a given year.

Maps show that flood depths from creek flow in Berkeley are not great.

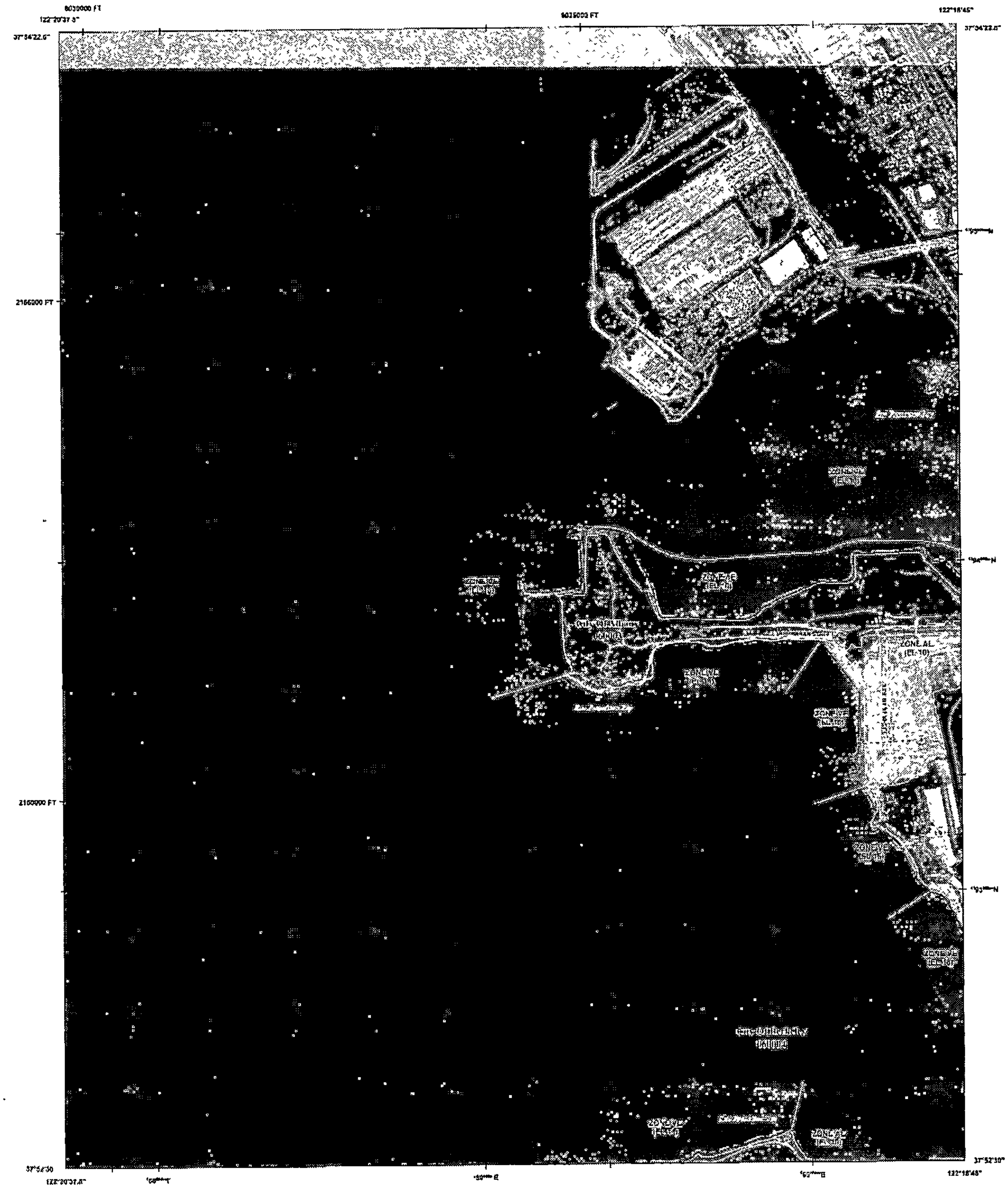
<u>2004 Flood Analysis</u>
A 2004 analysis explored Berkeley's flood exposure and vulnerabilities to a one percent annual chance flood occurred in Berkeley. This analysis predicted that:

- The maximum flood depth would be two feet deep, mostly near creek channels.
- Approximately 675 structures would be impacted to various degrees:
  - The majority would be inundated by one foot or less of water.
  - Approximately 200 structures could flood with up to two feet of water.

A flood depth of one to two feet has the potential to damage structures, first floor and basement finishes, contents and appliances in exposed buildings.

Berkeley's exposure to a one percent annual chance flood has likely increased since 2004 but resources are not available at this time to perform a new analysis.

<u>Repetitive Loss Properties</u>
Berkeley does not have any Repetitive Loss Properties as defined by the National Flood Insurance Program.[99]



FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT HTTP://MSC.FEMA.GOV

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE)
	With BFE or Depth
	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile
	Future Conditions 1% Annual Chance Flood Hazard
	Area with Reduced Flood Risk due to Levee See Notes.
	Area with Flood Risk due to Levee
OTHER AREAS	NO SCREEN Area of Minimal Flood Hazard
	Area of Undetermined Flood Hazard
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer
	Levee, Dike, or Floodwall
	Cross Sections with 1% Annual Chance Water Surface Elevation
	Coastal Transect
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
	Base Flood Elevation Line (BFE)
OTHER FEATURES	Limit of Study
	Jurisdiction Boundary

NOTES TO USERS

[illegible]

SCALE

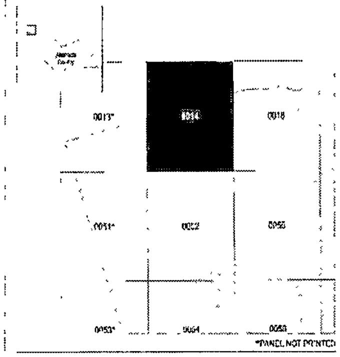
Map Projection

1 inch = 500 feet 1:6,000

0 250 500 750 1,000 2,000 Feet

0 125 250 500 Meters

PANEL LOCATOR



FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

ALAMEDA COUNTY, CALIFORNIA

and Incorporated Areas

PANEL 14 OF 725

COMMUNITY	NUMBER	PANEL	SUFFIX
ALBANY, CITY OF	[illegible]	[illegible]	[illegible]
BERKELEY, CITY OF	[illegible]	[illegible]	[illegible]

VERSION NUMBER
2.3.2.0

MAP NUMBER
06001C0014H

MAP REVISED
DECEMBER 21, 2018

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

HTTP://MSC.FEMA.GOV

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE)
		With BFE or Depth
		Regulatory Floodway
		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile
		Future Conditions 1% Annual Chance Flood Hazard
OTHER AREAS OF FLOOD HAZARD		Area with Reduced Flood Risk due to Levee See Notes.
		Area with Flood Risk due to Levee
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard
		Area of Undetermined Flood Hazard
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
		Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
		Base Flood Elevation Line (BFE)
OTHER FEATURES		Limit of Study
		Jurisdiction Boundary

Final Draft 2019 Local Hazard Mitigation Plan

NOTES TO USERS

SCALE

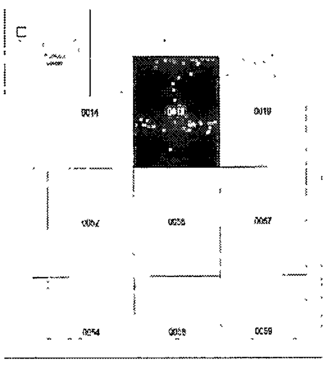
Map Projection

1 inch = 500 feet 1:6,000

0 250 500 750 1,000 2,000 Feet

0 125 250 500 Meters

PANEL LOCATOR



FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

ALAMEDA COUNTY, CALIFORNIA

and Incorporated Areas

PANEL 18 of 725

COMMUNITY	NUMBER	PANEL	SUFFIX

VERSION NUMBER

2.3.7.0

MAP NUMBER

06001C0018H

MAP REVISED

DECEMBER 21 2018

NOTES TO USERS

[illegible]

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or floodways have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. [illegible]

Coastal Base Flood Elevations [illegible]

[illegible]

[illegible]

The projection used in the preparation of this map was Universal Transverse Mercator (UTM) Zone 10. The horizontal datum was NAD 83, GRS80 spheroid. [illegible]

[illegible]

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

[illegible]

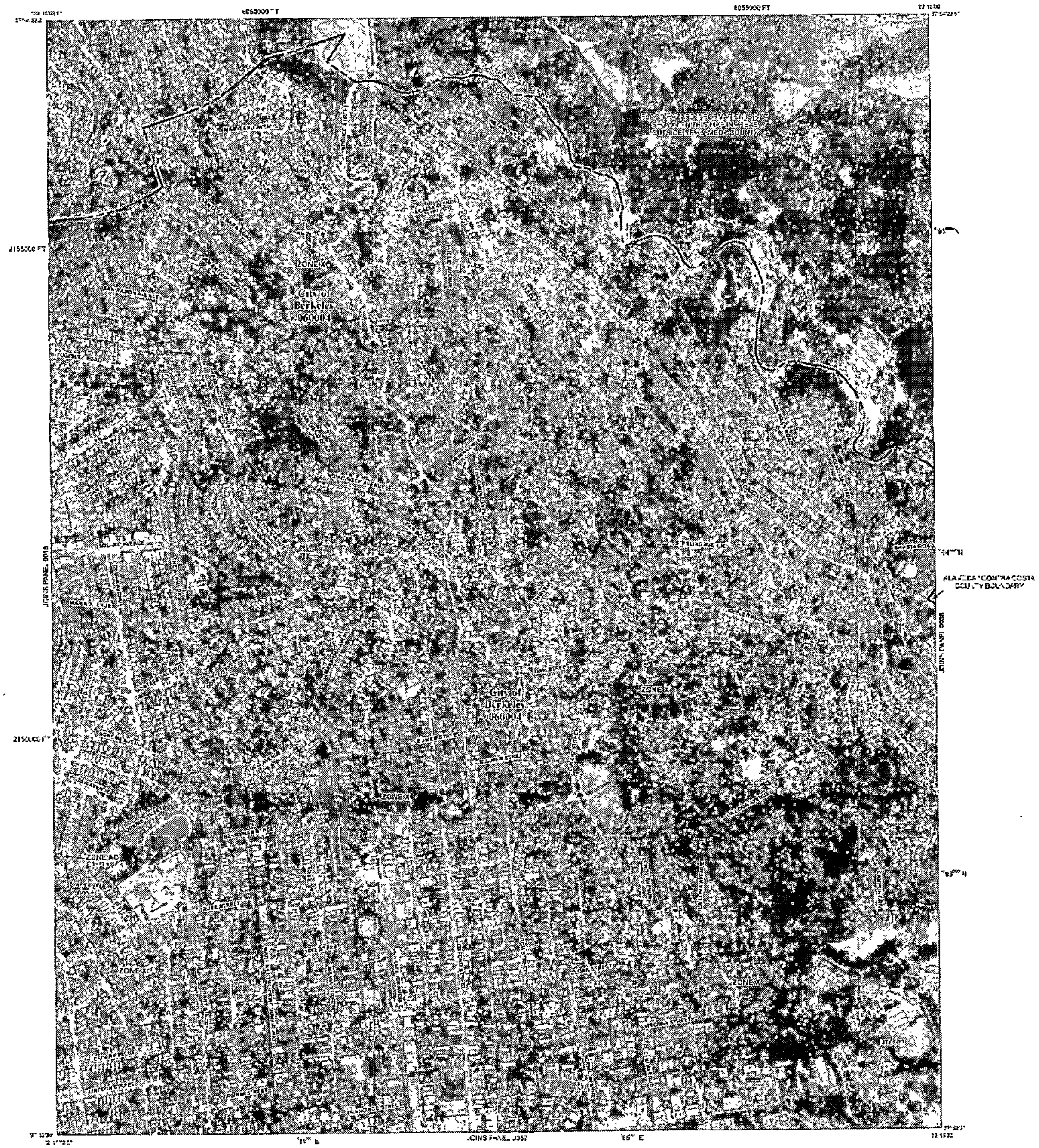
[illegible]

[illegible]

[illegible]

[illegible]

[illegible]



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

[illegible]

FLOODWAY AREAS IN ZONE AE

OTHER FLOOD AREAS

OTHER AREAS

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

[illegible]

MAP SCALE 1" = 500'

NFIP

PANEL 0019G

FIRM
FLOOD INSURANCE RATE MAP

ALAMEDA COUNTY, CALIFORNIA
AND INCORPORATED AREAS

PANEL 19 OF 725
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

[illegible]

MAP NUMBER
06001C0019G

EFFECTIVE DATE
AUGUST 3, 2009

Federal Emergency Management Agency

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT

HTTP://MSC.FEMA.GOV

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE)
- With BFE or Depth
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile
- Future Conditions 1% Annual Chance Flood Hazard
- Area with Reduced Flood Risk due to Levee See Notes.
- Area with Flood Risk due to Levee

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard
- Area of Undetermined Flood Hazard

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

- Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- Base Flood Elevation Line (BFE)

OTHER FEATURES
- Limit of Study
- Jurisdiction Boundary

NOTES TO USERS

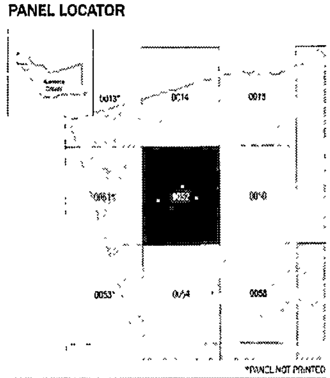
SCALE

1 inch = 500 feet 1:6,000

0 250 500 750 1,000 2,000 Feet

0 125 250 500 Meters

PANEL LOCATOR



*PANEL NOT PRINTED

FEMA National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

ALAMEDA COUNTY, CALIFORNIA
and Incorporated Areas

PANEL 52 OF 725

COMMUNITY	NUMBER	PANEL	SUFFIX
BERKELEY, CITY OF	060004	0052	H
EMERYVILLE, CITY OF	[illegible]	0052	H

VERSION NUMBER
2.3.2.0

MAP NUMBER
06001C0052H

MAP REVISED
DECEMBER 21, 2018

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT HTTP://MSC.FEMA.GOV

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE)
		With BFE or Depth
		Regulatory Floodway
		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile
OTHER AREAS OF FLOOD HAZARD		Future Conditions 1% Annual Chance Flood Hazard
		Area with Reduced Flood Risk due to Levee See Notes.
		Area with Flood Risk due to Levee
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard
		Area of Undetermined Flood Hazard
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
		Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
		Base Flood Elevation Line (BFE)
OTHER FEATURES		Limit of Study
		Jurisdiction Boundary

NOTES TO USERS

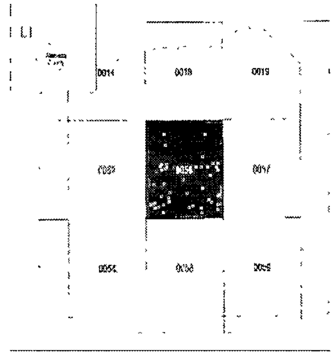
SCALE

1 inch = 500 feet 1:6,000

0 250 500 750 1,000 2,000 Feet

0 125 250 500 Meters

PANEL LOCATOR



FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

ALAMEDA COUNTY, CALIFORNIA

and Incorporated Areas

PANEL 56 OF 725

COMMUNITY	NUMBER	PANEL	SUFFIX
BERKELEY, CITY OF	[illegible]	0056	H
[illegible]	[illegible]	0056	
OAKLAND, CITY OF	[illegible]	0056	

VERSION NUMBER

2.3.2.0

MAP NUMBER

06001C0056H

MAP REVISED

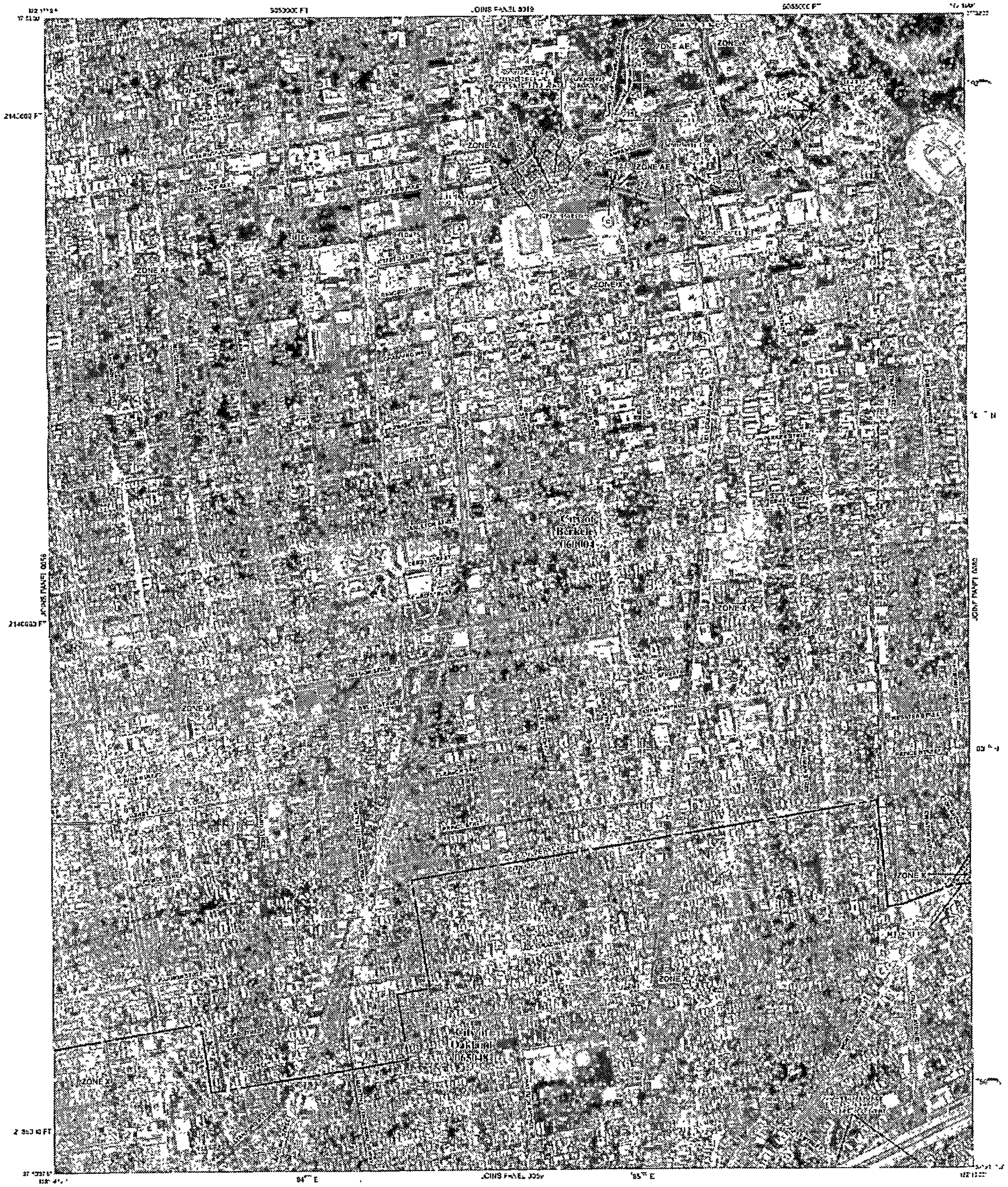
DECEMBER 21, 2018

NOTES TO USERS

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or floodways have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88).

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

FLOODWAY AREAS IN ZONE AE

OTHER FLOOD AREAS

OTHER AREAS

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

MAP SCALE 1" = 500'

PANEL 0057G

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

ALAMEDA COUNTY, CALIFORNIA AND INCORPORATED AREAS

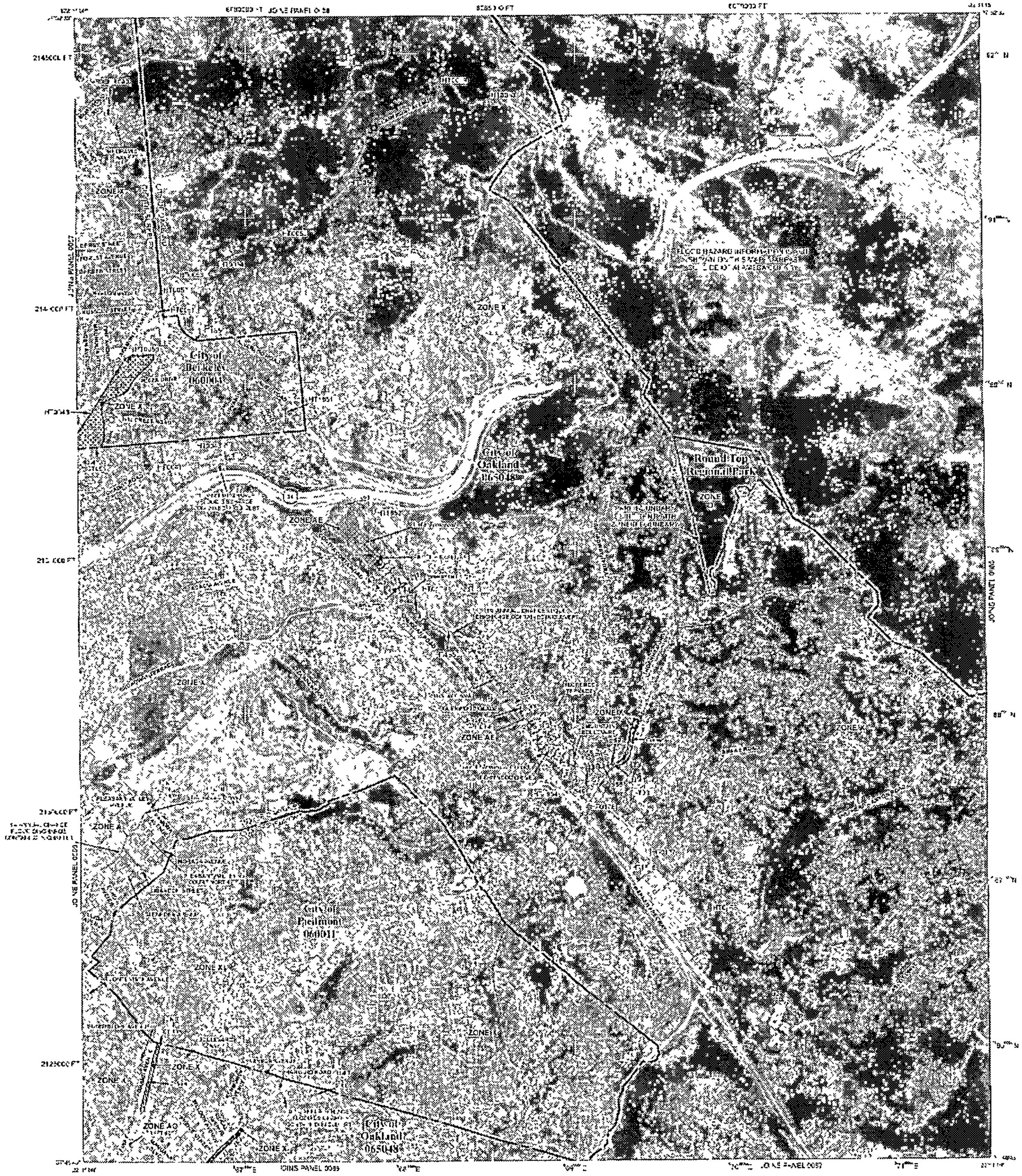
PANEL 57 OF 725
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

MAP NUMBER
06001C0057G

EFFECTIVE DATE
AUGUST 3, 2009

Federal Emergency Management Agency

NOTES TO USERS



LEGEND

MAP SCALE 1" = 1000'

PANEL 0080G

NATIONAL FLOOD INSURANCE PROGRAM

NFIP

FIRM

FLOOD INSURANCE RATE MAP

ALAMEDA COUNTY, CALIFORNIA AND INCORPORATED AREAS

PANEL 80 OF 725

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

MAP NUMBER 06001C0080G

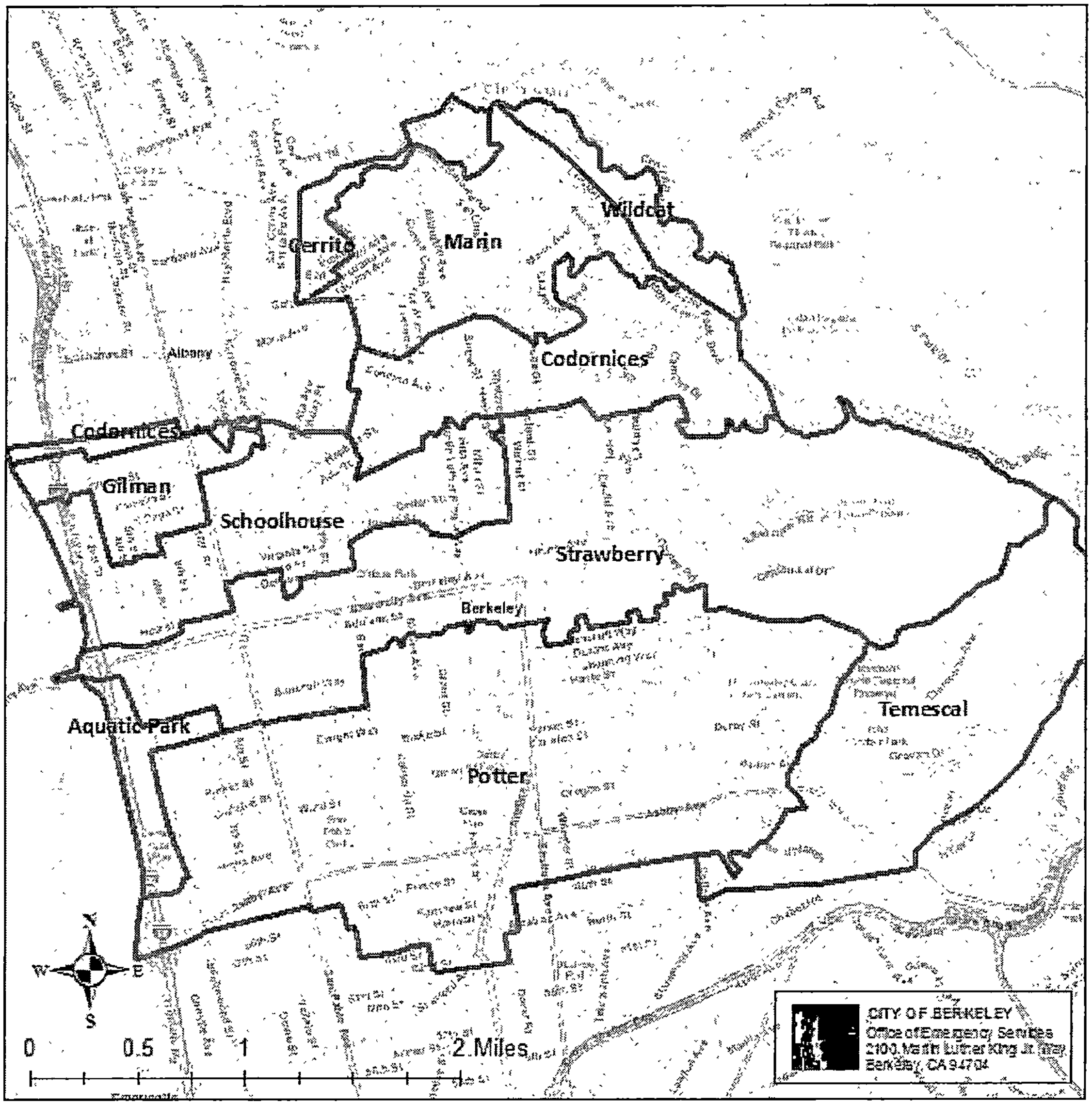
EFFECTIVE DATE AUGUST 3, 2009

Federal Emergency Management Agency

Storm Drain Overflow Exposure

In 2011, the Engineering Division of the City's Public Works Department developed the Watershed Management Plan (WMP). The WMP examined two of the watersheds in the City, represented in Map 27. The Potter and Codornices Watersheds were selected because they represent the full range of the urban drainage spectrum in Berkeley.[100] The modeling identified locations of predicted overflows. See Watershed Resources - City of Berkeley, CA for information on the WMP.

Map 26. ***Berkeley Area Watersheds***



Source: Stormwater Plan (1984) identified 10 major drainage systems in Berkeley. Last updated 2004.
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Potter Watershed

The Potter Watershed is the largest in the City. It experiences localized flooding in many areas, and contributes some runoff to the Aquatic Park Lagoons. Localized flooding can be expected in varying degrees at several locations including:

- San Pablo Avenue between Ward and Murray
- California Street between Woolsey and Harmon
- Woolsey Street between California and Adeline
- Woolsey Street at Dana
- Ashby Avenue between California and King
- Martin Luther King, Jr. Way between Russell and Woolsey
- Parker Street between Seventh and Fourth
- Fulton Street at Derby
- Ellsworth Street between Blake and Parker
- Telegraph Avenue between Ashby and Woolsey
- Telegraph Avenue at Stuart
- College Avenue at Dwight

Many of these locations were confirmed as chronic nuisance flooding sites by Public Works Maintenance staff and correspond well with City experiences during the storms of February 25, 2004 and the El Nino events of the 2005-06 rainy season.

Additionally, tidal effects from the Bay influence flooding issues in the Potter Watershed. This is due to the water surface of the Bay effectively reducing the discharge ability of the storm drain outfall to the Bay.

Codornices Watershed

The Codornices Watershed is regionally significant as Codornices Creek is one of the least culverted creeks in the East Bay; and is one of the few with a salmonid population. Localized flooding can be expected in varying degrees at several locations including:

- Second Street, Creek corridor to Gilman

- Railroad tracks, Creek corridor to Gilman and to Albany
- Gilman Street between Sixth and Second
- Codornices Creek at Sixth, at most street crossings west of San Pablo, at Glen
- Ninth Street between Harrison and Creek Corridor
- Monterey Ave between Posen and Hopkins
- Hopkins Street at Carlotta
- The Alameda between Napa and Yolo
- Sonoma Ave between Fresno and Hopkins
- Spruce Street, Eunice to Creek corridor
- Euclid Ave, Cragmont to Codornices Park
- Various locations on LaLoma, Glendale, Campus Drive, Queens, Shasta Road

The City plans to develop hydraulic models of the remaining eight watersheds within Berkeley.

<u>Watershed Management Plan</u>

In October 2012, Council adopted the Watershed Management Plan (WMP). The mission of the WMP is to promote a healthier balance between the urban environment and the natural ecosystem, including the San Francisco Bay. One of the WMP's four goals is to reduce urban flooding, with associated objectives as follows:

- Maintain and operate appropriately sized storm drain pipe infrastructure.
- Reduce peak runoff volumes and velocities.
- Keep storm water inlets free of obstructions.
- Collect/analyze data to better understand issues and plan accordingly.

To this end, the WMP recommends analysis and rehabilitation of existing storm drain pipes, along with landscape-based retrofits within the public right-of-way or open space areas. Studies have indicated that when these landscape-based retrofits are combined with other traditional approaches, a number of WMP goals can be met for a capital cost similar to merely upsizing storm drain pipes to convey flow.

Until 2018, no funding was identified to implement the Watershed Management Plan. Voting property owners approved the 2018 Clean Stormwater Fee, which Council adopted through

Resolution No. 68,483-N.S. on June 12, 2018. Revenues collected through this fee will provide a stable funding source to move Watershed Management Plan activities forward.

B.8.d Flood Risk and Loss Estimates

A 2004 analysis explored Berkeley's flood exposure and vulnerabilities to a one percent annual chance flood occurred in Berkeley.

The 2004 analysis used FEMA's standard loss curves to determine the percent of replacement value of damage caused by various heights of creek flooding. These curves are based on years of data from flood losses on insured properties around the country. Single-story structures with one foot of floodwater are estimated to have structural damage equal to 14% of their replacement value and damage to 21% of the structures contents. Single-story structures with three feet of water on average experience 27% loss of their replacement value and 40% loss to their contents.

In the 2004 plan, flood losses were estimated using the following calculations:

Table 15. 2004 Flood Loss Analysis

	Three Feet Flood Waters			One Foot Flood Waters			*Totals (2004)*	*Totals (2018)*[101]
	Value	% Damage	Damage	Value	% Damage	Damage		
Structures	$70 mill	27%	$19 mill	$250 mill	14%	$35 mill	$54 mill	$72 mill
Contents[102]	$35 mill	40%	$14 mill	$250 mill	21%	$53 mill	$67 mill	$90 mill
Totals (2004)	$105 mill		$33 mill	$500 mill		$88 mill	**$121 mill**	**$162 mill**

The estimated losses to properties in Berkeley from a one percent annual chance flood total $162 million in 2018 dollars. Approximately $72 million is damage to the building structures, including walls, finishes, etc. $90 million is losses to contents, including damage to furniture in homes and equipment and inventory in commercial and industrial properties.

Berkeley's exposure to a one percent annual chance flood has likely increased since 2004 but resources are not available at this time to perform a new analysis.

Few Berkeley homeowners are known to carry flood insurance, presumably because of negligible flood damage in recent decades, so those losses would be borne almost entirely by building owners. Some of these losses could be avoided if property owners were able to protect properties through sandbagging or other activities, particularly in areas expected to receive one foot or less of flood water. The City offers free sandbags to city occupants. Remediation activities like sandbagging require property owners to have adequate warning time and manpower.

Due to the small watersheds and paved, urban environment, floodwaters in Berkeley are likely to both rise and recede quickly. This means residents and business owners may have only a short warning period for impending floodwaters, but they should be able to begin the cleanup and repair process quickly. Building cleanup will occur within a handful of days; repairing and replacing furniture and equipment will take weeks to months.

It is possible that key underpasses and roads accessing Interstate 80 could be inaccessible during high floodwaters. This could cause significant traffic problems regionally.

B.9 *Tsunami*

B.9.a Historical Tsunamis

The most recent tsunami to impact Berkeley was associated with the March 2011 earthquake off the coast of Japan. As a result of the tsunami, a half-meter-tall surge was observed nearby in Oakland with 4-6 knot current[103]. The tsunami surge entered the Berkeley marina, causing $158,000 of damage to docks and boats.

Tsunamis generally impact the Pacific Coast of California, and reports of tsunamis entering the San Francisco Bay are rare. Tsunamis, or seiches as they are called when they occur within an enclosed body of water, can also be generated within the Bay by the Hayward fault, which passes under San Pablo Bay. The 1868 Earthquake on the Hayward fault is reported to have created a seiche within the Bay. It is unknown whether the seiche impacted the City of Berkeley. The 1964 Alaska earthquake caused extensive tsunami damage that flooded and heavily damaged coastal northern California near Crescent City.

B.9.b Tsunami Hazard

A tsunami occurs in a body of water when a rapid disturbance vertically displaces the water, causing a series of surges. These changes can be caused by an underwater fault rupture (that generates an earthquake) or underwater landslides (typically triggered by earthquakes).

Tsunamis affecting the Bay Area can result from offshore earthquakes within the Bay Area, or from very distant events. While it is most common for tsunamis impacting the Bay Area to be generated by faults in Washington and Alaska, local tsunamis can be generated from local faults running underwater (such as the small tsunami that was triggered by the 1906 earthquake). The San Andreas Fault runs along the coast off the Peninsula and the Hayward fault runs partially through San Pablo Bay.

The 2013 Science Application for Risk Reduction (SAFRR) Tsunami Scenario[104] outlines multiple mechanisms of tsunami damage, which are described below:

- Buildings affected by tsunamis can be damaged by either the inflow or outflow of water, which can affect building finishes, carpets, carpets, electrical wiring, computers and other contents. Tsunamis may deposit soil or other water-borne debris in or around buildings. Tsunamis can erode soil around the building, especially at corners. In more severe cases, the pressure of the moving water can damage a building's structural components, and can even displace the entire building. Additionally, buoyancy can lift and move a building off its foundation.
- Tsunami damage to coastal infrastructure can release complex debris, crude oil, various fuel types and other petroleum products, cargo, and diverse other pollutants into nearby coastal marine environments and onshore in the inundation zone.
- Fires often occur within the inundation zone of a tsunami. Ignitions can occur when spilled liquid fuels mingle with waterborne debris, which can spark when jostled.
- Tsunamis can damage roads though erosion ("scour") of the land beneath the

roadway, especially if the roadway is on a levee or embankment.

- Tsunamis can damage railroad embankments and tracks, which can be submerged, washed out-of-line, or washed out completely. Rolling stock can be overturned or derailed.
- Deaths are possible if individuals choose not to evacuate hazardous areas, do not understand tsunami warnings, or are unable to evacuate for various reasons. Injuries and illness can result from contact with tsunami surges, such as drowning and/or trauma from being struck by debris in the tsunami flow. Post-tsunami, mold can develop in inundated houses, buildings, and debris piles. Secondary infections can result from injuries or from living conditions following the disasters, such as an increase in pneumonia from water aspiration, as well as cellulitis from exposure of breaks in the skin to contaminated water.
- Physical damages, debris, and contamination can have short- and longer-term impacts on the environment and the health of coastal marine and terrestrial ecosystems. Marine habitats in intertidal zones, marshes, sloughs, and lagoons can be damaged by erosion or sedimentation, and can receive an influx of debris, metal and organic contaminants, and sewage-related pathogens. Debris and re- exposed contaminated sediments could pose chronic toxicity threats to ecosystems.

B.9.c Exposure and Vulnerability

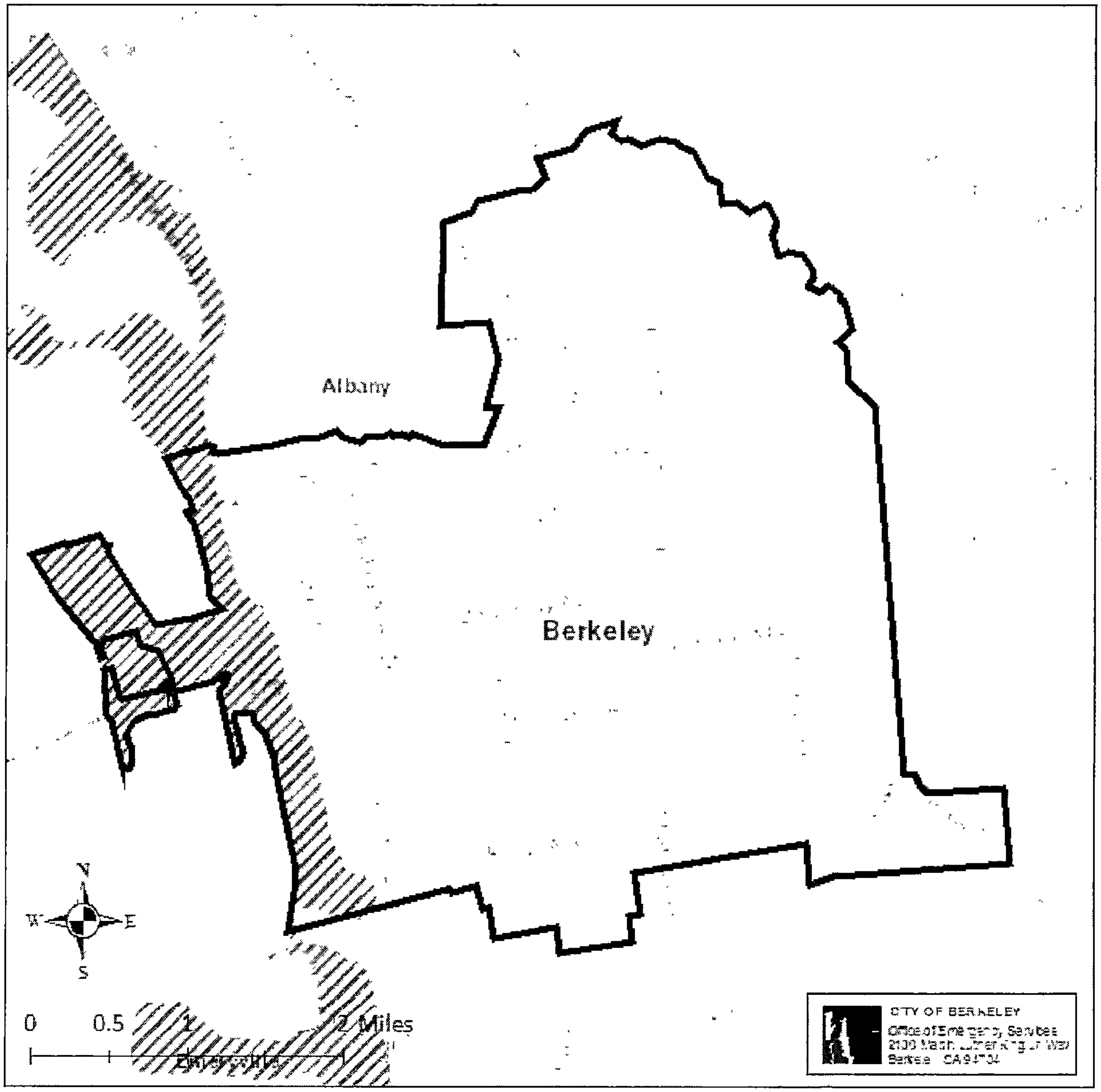
Given the known history of tsunamis within the San Francisco Bay, tsunamis are considered to be possible, but the severity of their impacts on Berkeley cannot be determined at this time.[105] In December 2010, the California Emergency Management Agency released the first ever tsunami inundation map within the San Francisco Bay, shown in Map 27. This map is based on current sea levels and land elevation. This map shows in blue hatched lines the area of potential tsunami inundation in Berkeley. It does not reflect the inundation area from any singular tsunami. Rather, it depicts the worst-case scenario run-up heights from all potential tsunami sources across the Pacific Rim. This map is intended to be used to evacuation planning purposes only.

Given Berkeley's sloping terrain and the Bay's waters at their current levels, tsunami inundation will not extend far inland from the shoreline. According to Map 27 and shaded in blue hatched lines the tsunami inundation zone extends along the entire shoreline of the Bay. Starting at the city's northern border, the zone stretches east from the Bay until it meets the western edge of Interstate 80. At Virginia Street, the edge of the zone crosses Interstate 80 and stretches as far east as Second Street. The edge of the zone runs south along Second Street and the eastern edge of Aquatic Park to Ashby/CA-13. In this area, the edge of the zone extends further east to Fifth Street and Hollis.

According to Map 27, the zone captures Golden Gate Fields, the Tom Bates Regional Sports Complex, Eastshore State Park, the Berkeley Marina, the Dona Spring Animal Shelter, portions of Interstate 80 and the frontage roads beside it, the San Francisco Bay Trail, and Aquatic Park.

Sea-level rise associated with climate change will increase the zone of potential inundation, but the future boundaries of the zone are not yet clear.

Map 27. ***Berkeley Tsunami Inundation***



Source: Initial tsunami modeling was performed by the University of Southern California (USC) Tsunami Research Center funded through the California Emergency Management Agency (Cal EMA) by the National Tsunami Hazard Mitigation Program. Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Berkeley

Tsunami Inundation Area

Tsunami Evacuation Playbooks

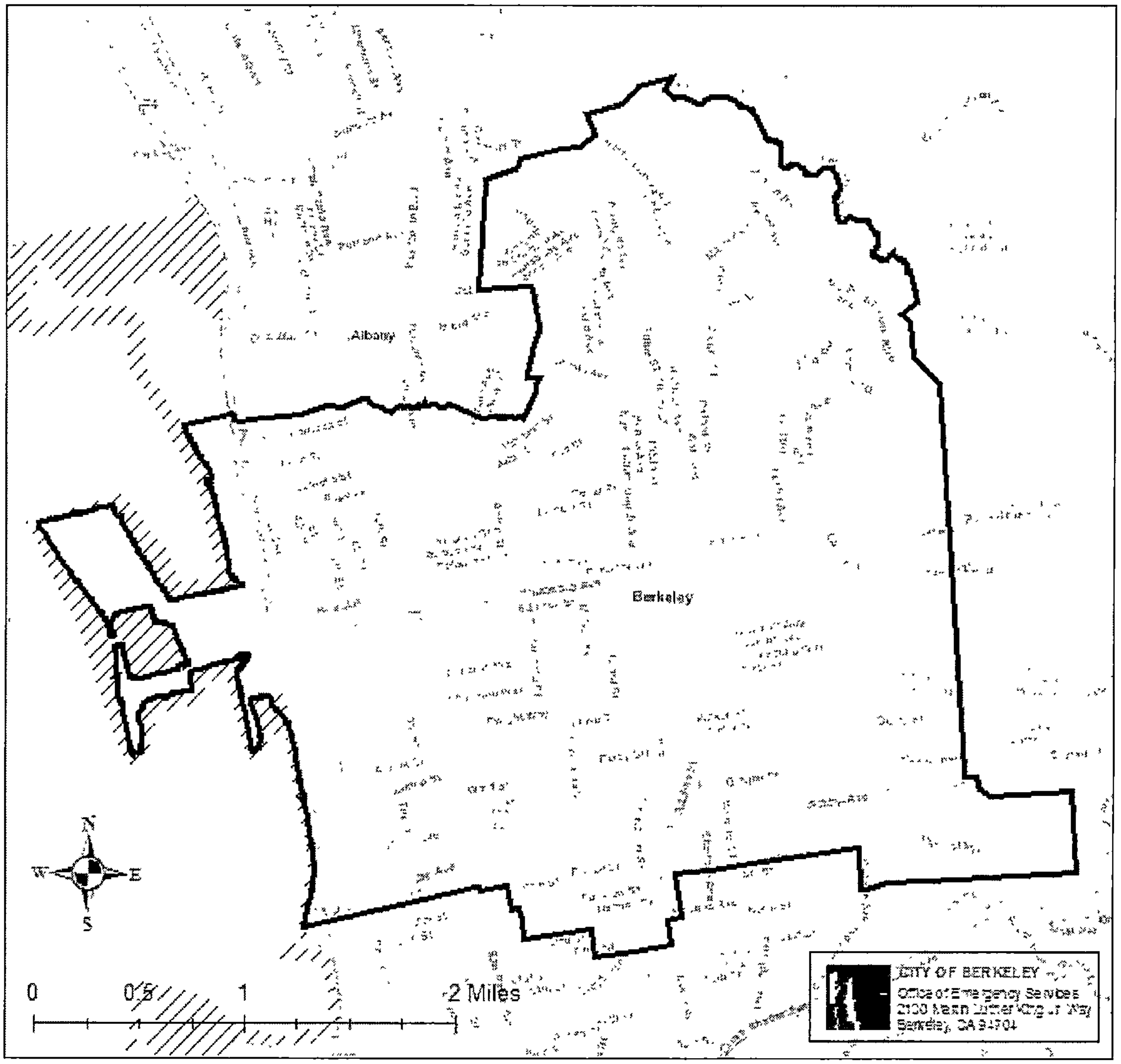
In 2018, the California Geological Survey, the California Governor's Office of Emergency Services, and the National Ocean and Atmospheric Administration (NOAA) released the California Tsunami Evacuation Playbook for the City of Berkeley.

Tsunami Evacuation Playbooks reflect more refined and detailed planning, in which forecasted tsunami amplitudes, storm surge, and tidal information can help guide what areas might be inundated. This information helps NOAA to better predict inundation areas based on the specific tidal and storm conditions when the tsunami is predicted to arrive in Berkeley. Local emergency managers can use this information to better target evacuation areas.

Map 28 presents these Playbook zones, with expanding areas of evacuation:

- Phase 1 is not presented as it includes beaches, harbor docks and boats, and piers.
- Phase 2 is presented in yellow and black hatched lines and adds small areas of land south of University Avenue and west of the West Frontage Road.
- Phase 3 is presented in solid yellow and adds Golden Gate Fields, the Tom Bates Regional Sports Complex, Eastshore State Park, the Berkeley Marina, and portions of the San Francisco Bay Trail.
- The Maximum Evacuation Zone is presented in dark green and is based on areas presented on Map 27. The Maximum Evacuation Zone includes the Dona Spring Animal Shelter, portions of Interstate 80 and the frontage roads beside it, Aquatic Park, and the Police Department Traffic Substation.

Map 28. ***Tsunami Evacuation Zones***



Source: California Geological Survey, California Governor's Office of Emergency Services, and National Oceanic and Atmospheric Administration, California Tsunami Evacuation Playbook No.2018-Alam-02. Service Layer Credits: Sources. Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Berkeley

Phase 2 Tsunami Evacuation Zone

Phase 3 Tsunami Evacuation Zone

Maximum Phase Tsunami Evacuation Zone

USGS Exposure Study[106]

A USGS study of community exposure to tsunami hazards in California found that in Berkeley:

- Approximately 47 residents (23 households) live in the tsunami inundation zone.
  - Eight of the residents are over 65 and one is under five. Elderly and young residents as well as those in group homes may have a particular challenge evacuating from tsunamis.
  - Seven of the households are non-institutionalized group quarters, 20 households are owner-occupied, and 3 are rented.

The study also found that:

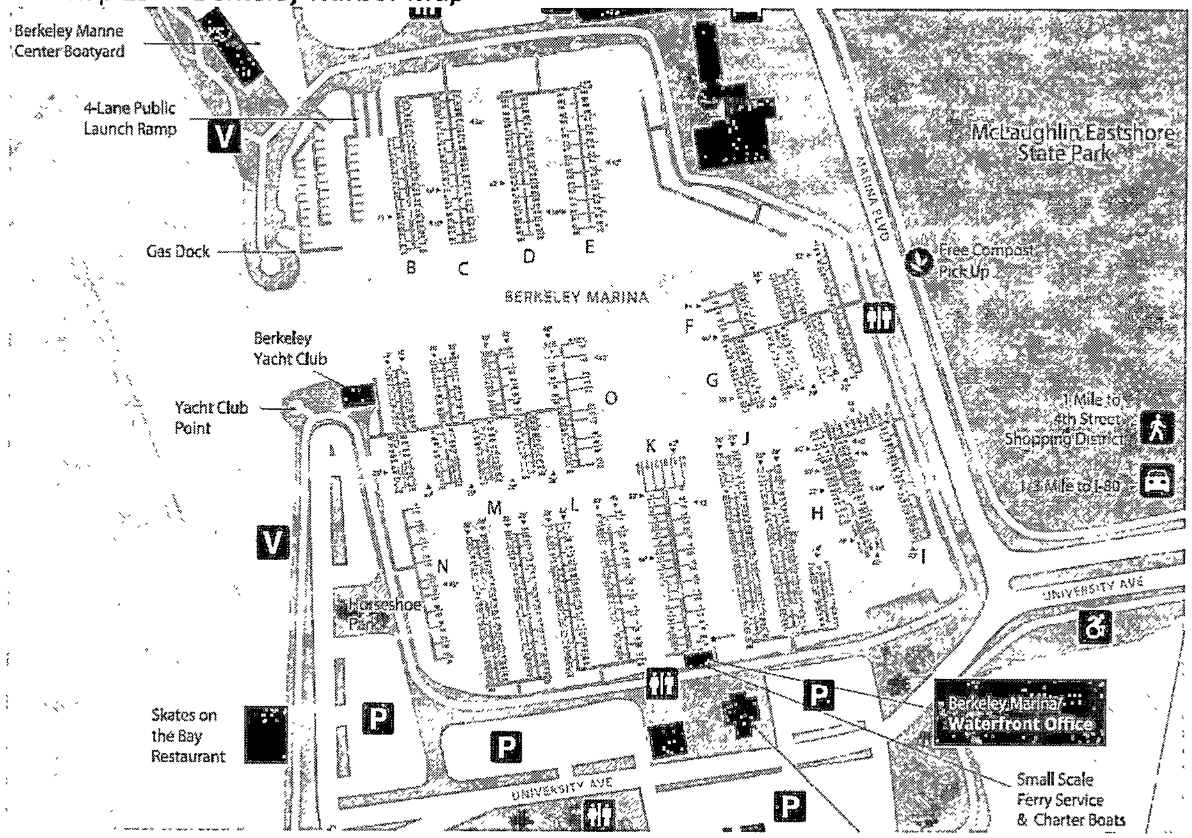
- 77 businesses and 4 government offices with 1,664 employees are located in the tsunami inundation zone.
  - 80% of these businesses are estimated to have high visitor potential, including the DoubleTree hotel. Visitors may not be aware of what to do in case of a tsunami warning.

While this study examined the Berkeley Marina, its information on residents at the Marina and surrounding park area is not as detailed or accurate as City of Berkeley data. For example, figures do not include the 100 live aboard households, as well as 13 houseboats, at the Marina, for a total of 113 households. At least three children under 5 live on boats. In addition, these figures do not account for boaters who stay on board their vessels regularly up to 12 nights per month, but do not "live" aboard.

Berkeley Marina

Of primary concern to the City is the Marina, which is primarily used for recreational purposes, educational and environmental programming, industrial, non-profit, and commercial operations.

Map 29. ***Berkeley Harbor Map***



Infrastructure Vulnerabilities

Existing docks are more than 40 years old and in significantly deteriorated condition. Broken finger docks, utilities, and pilings pose a safety risk to Marina customers and their vessels. This deteriorating infrastructure exacerbates the area's vulnerability to tsunami. D & E docks were damaged badly in the Tsunami of 2011, and many finger docks and piling are still unusable and have not been repaired or replaced. This results in lost revenue to the marina, lost capacity, and a reduction in the recreational resources available to the public.

Recent tsunami inundation models[107] have identified a moderate tsunami vulnerability in the Gas Dock, Docks B-K, and Dock O. Docks D and E as being the area's most vulnerable to modeled tsunami events, with a moderate level of vulnerability to all events. The next most vulnerable area is Docks B and C, which have a moderate vulnerability to particular scenario events.

In this study, moderate vulnerability was defined as damage to 10% - 90% of cleats and pile guides.

Additional Vulnerabilities

The area includes a 378-room hotel, with many ground floor rooms; three restaurants, several offices, commercial boating operations, sailing clubs and businesses, nonprofit offices, two small-scale commuter ferry operations, the Adventure Playground, Shorebird Park Nature Center, Shorebird Park, and an industrial boat yard. Despite the area's low density, the area's populations, roadways, and businesses will be vulnerable to a tsunami:

- Marina residents: The Berkeley Marina has 1,000 boat slips. Approximately 200 residents live onboard boats in these slips. An additional estimated 13 live on board houseboats, and regulations permit all slip holders to spend 12 nights per month on their boats.

- Marina businesses and visitors: A number of Marina restaurants, such as Skates on the Bay, often have large numbers of customers. The DoubleTree Hotel has 378 rooms, and regularly hosts events with 500-600 attendees, potentially making it the City's most densely-populated location with tsunami exposure.

- Roadways: Inundation maps show overtopping of parking areas and inundation of buildings in the Marina. The University Avenue access road is also within the inundation zone. The University Avenue overpass over Interstate 80 is also shown to be within the inundation zone. It is unlikely that the overpass itself would be inundated due to its height and its limited extent beyond Second Street. However, if water extends to Second Street, the access ramps on either end of the overpass would be covered, making the overpass impassable.

Evacuation Challenges
The numbers of people and assets exposed to a tsunami are relatively low as compared with other hazards presented in this Plan. However, evacuation routes for Marina residents and visitors are limited. Interstate 80 runs north-south along the eastern edge of the Marina, bisecting the area from the rest of the city. There are six access/egress routes from the Marina into Berkeley:

1. Via the University Avenue Bridge
2. Via the frontage road north to Gilman Street
3. Via the frontage road south to Ashby Avenue/CA-13
4. Via Interstate 80
5. Via the I-80 Bicycle/Pedestrian overcrossing[108]

In the event of a distant-source tsunami, where the underlying earthquake does not impact Berkeley, warnings can be issued before the tsunami arrives onshore in Berkeley. However, the limited number of egress routes will slow evacuations. Evacuations will also be slowed by the pinch point created on the stretch of University Avenue between Marina Boulevard to the west and West Frontage Road to the east. This stretch of roadway is the only driving option out of the Marina.

An earthquake occurring in the waters close to Berkeley could cause a near-source tsunami, which would allow for little to no time to provide warning to people in the inundation area. A near-source tsunami could severely compound evacuation challenges for individuals in the

Marina: all of the above listed routes lie within the tsunami inundation zone.

These evacuation challenges will disproportionately impact people with disabilities and people with access and functional needs. They may not have immediate transportation options to evacuate quickly. Additionally, in the event of a tsunami, they may be separated from their caregivers and may need assistance to evacuate.

B.9.d Tsunami Risk and Loss Estimates

Estimating losses from tsunami inundation is difficult given that the inundation maps do not represent inundation from a single scenario event. Inundation from any single event will almost certainly be less severe than depicted in Map 27, which is intended to display worst-case scenario run-up heights from all potential tsunami sources across the Pacific Rim.

The 2013 SAFRR tsunami scenario[109] depicts a hypothetical but plausible tsunami, created by an earthquake offshore from the Alaska Peninsula. The study projected impacts on the California coast, which included:

- Pilings in the Berkeley Marina will not be overtopped by tsunami waters, but over one-half of the docks in California coastal marinas will be damaged or destroyed
- One-third of boats in California coastal marinas will be damaged or sunk
- In Alameda County, tsunami inundation will create $20 million in building damage and $164.4 million in damage to building contents
- Wastewater treatment plants in Alameda County will be inundated and could release raw or partially-treated sewage and wastewater-treatment chemicals.

City of Berkeley Assets

The most significant financial losses to the City of Berkeley in the event of a tsunami would be inundation of the following structures:

- City Animal Shelter[110]
- Marina Boat Docks
- Berkeley Yacht Club
- Shorebird Nature Center
- Marina Corporation Yard
- Marina Administration Building

Other City- and privately-owned facilities of significant value sit in the tsunami inundation zone. These facilities host a number of businesses and community recreation assets. Tsunami damage could also lead to a drop in revenue to the City from the buildings it leases to others, as well as a drop in tax revenue from businesses operating in the area.

Further research is needed to fully assess Berkeley's tsunami hazard, including the following:

- Definition of Berkeley's different areas of inundation for different tsunami scenarios;

- Vulnerabilities of each evacuation route to tsunami inundation;
- Structural assessment of buildings and infrastructure in the inundation zone, to determine if they are designed and constructed with the strength and resilience needed to resist the effects of tsunami surges.

The City will leverage ongoing research and coordinate with regional, State and federal partners to help answer these questions.

SECTION III: MANMADE HAZARDS OF CONCERN

The focus of this mitigation plan is on natural hazards as emphasized in the Disaster Mitigation Act of 2000 (DMA 2000).[111] However, a few manmade hazards are included. Climate change, known to be manmade, is included in the plan because its impacts are likely to exacerbate the natural hazards of concern described in Sections I and II. Next, extreme heat events are also included in this section because they are projected to increase exponentially in the next century as climate change continues. Then, hazardous materials release is addressed in this part of the mitigation plan as a potential impact from a natural hazard. Finally, terrorism is identified as a manmade hazard of concern but is not analyzed in-depth.

B.10 *Climate Change*

Human activities have created a large quantities of greenhouse (GHG) emissions that have been and continue to be released into the atmosphere. The majority of the emissions come from burning fossil fuels. Other activities, such as deforestation and solid waste disposal, also play a role. Greenhouse gas (GHG) emissions, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Ozone (O_3) and water vapor, trap heat in the atmosphere and prevent the planet from cooling down at night[112]. This is known as the greenhouse effect. While it is a natural phenomenon, it is accelerated by a dangerous buildup of GHG emissions in the atmosphere resulting in climate change.

Earth's average temperature has increased by over 1° F during the past century, and average temperatures in California increased 1.7°F since 1985.[113] Because global greenhouse gas (GHG) emissions will likely continue to increase, scientists predict that average global surface temperatures will rise 2.5° to 10° F by the end of the century.[114] For the Bay Area, scientists estimate that average temperatures will increase about 3 - 6° F by century's end, compared to the average temperature during the historical period 1961 - 1990.[115]

This section identifies the main climate change impacts that Berkeley is currently experiencing, or is projected to experience in the future. This section also describes how climate change exacerbates natural hazards of concern identified in this plan. Where possible, the information provided here is specific to Berkeley, the Bay Area, and/or the state of California. For each climate impact, the associated historical events, hazard description, exposure and vulnerability analysis, and risk and loss estimates are presented, as available.

A discussion of many of the local climate impacts, and recommendations for mitigating those impacts, are also included in the Berkeley Climate Action Plan (CAP). The CAP was adopted by the Berkeley City Council in 2009, and is designed to guide community-wide efforts to achieve deep and sustained reductions in global warming emissions, and to help the community prepare for the impacts of the changing climate. Additional information on the CAP and its implementation is included at the end of this section. Ongoing updates on the CAP are available at www.CityofBerkeley.info/climate.

B.10.a Direct and Secondary Climate Change Impacts

Climate change is a global issue with local effects. Like regions across the globe, the San Francisco Bay Area is experiencing increasing impacts of the changing climate, including increased temperatures and sea level rise. Extreme heat events and heavy rains are exacerbated by high winds, sparking wildfires and increasing damage from flooding. These impacts affect the natural environment, but they also affect our infrastructure, local and regional economies, food security, and the health and safety of the people in our community, while disproportionately impacting people of color and the poor.[116] The impacts of climate change also exacerbate the natural hazards of concern in this plan, including extreme heat events, flooding[117], wildland-urban interface fire,[118] and landslides.[119]

The next section focuses on the direct and indirect impacts from climate change.

Extreme Heat

Extreme heat events will increase in the Bay Area due to climate change in intensity, length, and frequency. By the end of the century, Bay Area residents may average six heat waves annually, which will average a length of ten days[120]. Extreme heat threatens critical infrastructure, air quality, and public health. The urban heat island effect, where built surfaces absorb and retain heat causing higher nighttime temperatures, can exacerbate those health risks. See Section B11 *Extreme Heat* for further details.

Precipitation and Drought

As GHG emissions continue to increase, more of the precipitation will fall as rain instead of snow in the mountains, and the snow that does fall will melt earlier.[121] This has significant implications for the Sierra Nevada spring snowpack. The water distribution system for the state, including Berkeley and many other parts of the Bay Area, depends on the snowpack for water during the dry spring and summer months. Rising temperatures and the change of precipitation from rain to snow could reduce the snowpack by as much as 70 to 90 percent by century's end.[122] A shrinking snowpack poses significant challenges for water managers and for all communities that depend on this vital water source. The loss of snowpack also poses challenges for hydropower generation, which contributes significantly to California's energy. Hydropower is an emissions-free source of energy, and currently plays a considerable role in the quest to reduce emissions from fossil fuel power generation.

Climate change is also likely to increase the severity and frequency of drought. Temperature increases and reduction in snowpack 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."[123] Drought not only affects local water supply for urban, agricultural, and environmental uses, but can also increase wildfire hazard, and may be correlated with high heat conditions.[124]

California experienced a prolonged drought from 2012-2016. Record-setting temperatures induced by global warming may have amplified the drought.[125] The drought resulted in well-documented agricultural, physical (e.g. groundwater depletion-related subsidence), environmental (tree death) and wildlife impacts (e.g. fish mortality)[126]. To mitigate water supply impacts, surface and groundwater supplies were used, and water use restrictions were implemented at state and local levels.

Atmospheric Rivers

Atmospheric rivers are relatively long, narrow regions in the atmosphere, like rivers in the sky, that transport most of the water vapor outside of the tropics. These columns of vapor move with the weather, carrying an amount of water vapor roughly equivalent to the average flow of water at the mouth of the Mississippi River. When the atmospheric rivers make landfall, they often release this water vapor in the form of rain or snow.[127]

Atmospheric Rivers are characterized as a type of extreme storm (along with tropical storms, severe convection, and winter storms), and are increasing in occurrence and intensity with climate change. Atmospheric rivers have emerged recently as a subject of interest with the scientific community, water managers, emergency managers, media, the public, and policy makers. Atmospheric rivers bring extreme precipitation, flooding, and drought. The American Meteorological Society recently released a scale to characterize the strength and impacts of Atmsophetirc Rivers.[128]

The Bay Area experienced several Atmospheric Rivers in 2018, including heavy rain and wind.[129]

Sea Level Rise

Warmer temperatures associated with climate change are causing global sea levels to rise through two processes:

1. Warmer temperatures are increasing the amount of ice melt from the world's glaciers, ice caps and ice sheets. This melted ice increases the volume of water in the ocean.

2. In a process termed "thermal expansion," warmer temperatures cause ocean water to expand, increasing the ocean's volume.

Sea level rise has multiple cascading impacts. When sea levels rise:

- Beaches and shoreline habitats become permanently inundated. These changes are expected to substantially alter the Bay ecosystem, reducing wetlands, affecting water quality, and adversely affecting wildlife.[130]
- Groundwater table and stream water levels rise, increasing areas subject to flooding.
- Storm surges rise, increasing risks in areas previously not susceptible to flooding.
- Coastal erosion increases, expanding areas susceptible to flooding and inundation[131].
- Levees and storm walls have to endure increasing loads and may be susceptible to overtopping, making these traditional measures to address sea level rise no longer adequate or financially feasible.

Sea level rise is an ongoing challenge for communities surrounding the San Francisco Bay. It is estimated that the San Francisco Bay has already risen approximately eight inches since 1900.[132]

Carbon Emissions Scenarios and Sea Level Rise

Sea level rise in the Bay Area will continuously rise in the next few decades, but most considerably in the latter half of the 21st century. Recent studies have suggested that the

Antarctic ice sheets are melting at rates much faster than previously reported. The Intergovernmental Panel on Climate Change has identified four scenarios, known as Representative Concentration Pathways (RCPs) that reflect different greenhouse gas concentrations of the atmosphere. They range from RCP 2.6, which represents not only stopping all current emissions but also significant carbon sequestration (a negative carbon output), to RCP 8.5, which represents continuing and increasing carbon emissions. Each scenario presents estimates for expected increase in sea level rise as the planet warms and melting rates increase. Below is a table of median probability projections of sea level rise for the state and the Bay Area under different climate scenarios in year 2100.[133]

Table 16. Sea Level Rise Projections in year 2100

Source	**Projected Carbon Emissions Scenarios**		
	Carbon Sequestration & Eliminate Carbon Emissions (RCP 2.6)	Significant Carbon Emissions Reductions (RCP 4 .5)	Carbon Emissions Increase (RCP 8.5)
State Projections (Fourth CA Climate Assessment)[134]	N/A	2.4 ft	4.5 ft
Bay Area Projections (Ocean Protection Council)[135]	1.6 ft	N/A	2.5 ft

Sea Level Rise Exposure and Vulnerability

An interactive, Bay Area-specific map called the Bay Shoreline Flood Explorer (available at https://explorer.adaptingtorisingtides.org/explorer) was produced by Adapting to Rising Tides (ART) purely based on topography.

These maps do not take into account riverline flooding, wave hazards, groundwater, erosion and subsidence, marsh vegetation, and salt ponds and wetlands, which would require further hydrological modeling and mapping analysis to understand how they would affect inundation and flooding areas.[136]

Three maps below depict the permanent inundation that may occur based on sea level rise of 2 feet, 4 feet, and 5.5 feet. These maps indicate that sea level rise is expected to mainly affect the shoreline areas of Berkeley. The Berkeley Marina is the most vulnerable, as sea level rise will permanently inundate commercial and recreational areas.

Map 30 shows that with two feet of sea level rise, which is considered very likely by 2100, the edge of Berkeley shoreline will experience shallow inundation, with small sections of the northern and southern edges of McLaughlin Eastshore State Shoreline experiencing inundation further in. Deeper permanent inundation can be expected along edge of Berkeley Marina.

Map 30. ***Berkeley Shoreline Areas Prone to Permanent Inundation due to 2-ft of Sea Level Rise by year 2100 (Very likely scenario)***

Map 31 shows that with four feet of sea level rise, which is considered likely by 2100, all edges of Berkeley will experience inundation, with further inward expansion in the inundation areas of McLaughlin Eastshore State Shoreline. Additionally, with four feet of sea level rise, portions of Tom Bates Regional Sports complex will experience shallow inundation.

Map 31. ***Berkeley Shoreline Areas Prone to Permanent Inundation due to 4-ft of Sea Level Rise by year 2100 (Likely scenario)***

This map shows that with 5.5 feet of sea level rise, which is considered not as likely by 2100, the shoreline of the entire Berkeley Marina peninsula will experience deep inundation, and the majority of the McLaughlin Eastshore State Seashore will be inundated with varying depths of water, along with similar portion of Tom Bates Regional Sports Complex as with four feet of sea level rise (as presented on the previous map).

Map 32. ***Berkeley Shoreline Areas Prone to Permanent Inundation due to 5.5-ft of Sea Level Rise by year 2100 (Not as likely scenario)***

Sea Level Rise and Severe Storms

It is important to note that the maps above only present permanent inundation from sea level rise alone. Sea level rise causes permanent inundation that increases the areas of temporary flood exposure during severe storms and high tides.

Map 33 below considers a combined scenario of increased carbon emissions (per Table 16) resulting in 5.5 feet of sea level rise, combined with a 25-year design storm. Under these circumstances water could inundate Interstate 80 and potentially as far east as Fifth Street in Berkeley.

Map 33. ***Comparison maps of Berkeley Shoreline with modeled 5.5 feet of sea level rise (left) and its compounded effects from a 25-year storm surge (right).***

5.5 ft SLR *Inundation in majority of McLaughlin Eastshore State Shoreline*	*5.5 ft SLR + 25-yr storm surge* *Inundation of McLaughlin Eastshore State Shoreline, flooding of Aquatic Park, Interstate 80, and parts of Northwest Berkeley reaching Fourth St.*

As sea levels rise, storms could cause key underpasses and roads accessing Highway 80 to flood more often or be permanently inundated, impacting transportation on this major regional artery, including Ashby Avenue (State Highway 13). Other nearby infrastructure that is vulnerable to inundation includes Berkeley's stormwater and sanitary sewer pipes, the Oakland International Airport, and the East Bay Municipal Utility District's wastewater treatment plant, located just east of the Bay Bridge.

Consideration of storm surge and other compounding effects is increasingly important, particularly when designing infrastructure with finite effectiveness, such as sea walls or barriers. Both permanent inundation from sea level rise as well as more frequent and more extensive flooding will need to be considered in long-term planning along the City's coast.

In addition, flooding resulting from sea level rise in combination with severe storms may threaten natural gas pipelines regionally. Prolonged and more frequent inundation from sea level rise can accelerate structural failures and threaten functionality of California's natural gas distribution system[137]. This infrastructure vulnerability can lead to disrupted service and the leakage of methane gas from the system. Methane is both a health and safety hazard as well as a highly potent greenhouse gas, further contributing to climate change.

More comprehensive vulnerability assessments are necessary to clearly define the structures and infrastructures that will be affected with particular levels of sea level rise, and identify ways to address these issues. The Berkeley Marina Area Sea Level Rise Assessment is one such site-specifc analysis currently underway in order to apply with state requirement AB691. The plan will include detailed analysis of potential sea level rise impacts, and will be used to inform future City of Berkeley projects and development at the Marina.

Land subsidence increases the areas that are exposed to sea level rise. Landfilled areas and areas experiencing drought—both common in the Bay Area—are particularly susceptible to land subsidence, which is the gradual settling or sudden sinking of land.[138] In the Bay Area, this includes developed areas that sit on top soft compressible bay mud[139]. Land subsidence can expand areas susceptible to sea level rise as these areas sink while sea levels are rising to meet them[140].

Food-, Water-, and Vector-Borne Diseases[141]

Climate change may also accelerate the incidence and geographic distribution of diseases that are transmitted through food, water, and animals such as deer, birds, mice, and insects. Increases in air temperature and change in precipitation and humidity levels may expand the territory of many species, including pests. In California, three vector-borne diseases of particular concern are: West Nile virus, human hanta virus, and Lyme disease. Salmonella and other bacteria-related food illnesses also grow more rapidly in warm environments, causing gastrointestinal distress and, in severe cases, death. Flood events may also cause contamination from toxic materials stored in flood zones, and can also lead to the growth of harmful molds.[142] These molds can trigger allergies and asthma attacks in physically vulnerable populations, including children under the age of 5, health-impaired adults, and the elderly.[143]

B.10.b Climate Change Impacts to Natural Hazards of Concern

Climate change is expected to exacerbate the natural hazards of concern identified in this plan. The ways that climate change affects Berkeley's natural hazards of concern are described below.

Earthquake (Section B5)

Sea level rise will cause the groundwater table and stream water levels to rise, increasing the areas subject to liquefaction risks in the event of an earthquake.[144]

Wildland-Urban Interface Fires (Section B6)

Climate change will bring higher temperatures and increased risk of drought, which will likely lengthen the fire season in our region.[145] The incidences of large wildfires in California could more than double by the end of the century.[146] Due to Berkeley's biophysical setting, climate, and other jurisdictional characteristics, scientists project little change to fire risk in Berkeley specifically.[147] However, Berkeley is still at risk due to the increased vulnerability of surrounding jurisdictions to wildland fire. A wildland fire that ignites outside of Berkeley's borders could spread into Berkeley.

Further complicating matters, wildfires are a large contributor of greenhouse gases that will lead to further climate change impacts.

Landslides (Sections B7)

Increases in the intensity and frequency of extreme storms will cause more frequent landslides in the Berkeley hills.

Severe Storms and Floods (Section B8)

The effects of climate change will increase the frequency and severity of extreme storm and precipitation events[148]. As climate change impacts continue to intensify, rainfall events for California are expected to exhibit higher amounts of precipitation over shorter time periods coupled with longer dry spells.

Climate change will increase the frequency of flood events, and will expand the areas of Berkeley that are exposed to flooding. A confluence of factors contributes to these changes:

- More precipitation over a shorter period of time each year; [149]
- Frequent and more hazardous storms, combined with sea level rise and high tides, can lead to more frequent and amplified storm surge events;
- Freshwater outfalls in Berkeley go directly to the Bay, and are influenced by tidal effects. As the sea level rises, it will require less rain to cause upstream flooding.
- Under drought conditions, soil moisture decreases and makes natural areas that typically absorb water less permeable; this can contribute to flooding.

These factors will likely cause more frequent and extensive flooding events long before sea level rise leads to permanent inundation of the shoreline.[150] Further analysis is necessary to truly understand Berkeley's flooding exposure and vulnerability under the combined impacts of severe storms, storm surge, and sea level rise. This analysis could also impact flood insurance and development, and infrastructure safeguarding and building for the future.[151]

Tsunami (Section B9)

Rising sea levels will increase Berkeley's exposure to tsunami inundation, making more people and property vulnerable to tsunami impacts.

Notable Climate Change Mitigation and Adaptation Activities

The Berkeley Climate Action Plan (CAP) provides policy and project recommendations to advance community-wide efforts to reduce, or mitigate, global warming emissions and to prepare for and adapt to the climate change impacts identified above. The severity of climate change impacts are entirely dependent on the amount of emissions we continue to emit in the near future. Just as the challenges to adaptation and mitigation are often interrelated, the solutions overlap and provide multiple benefits.

CAP recommendations are implemented through City departments and community stakeholders. Outlined below are examples of specific CAP recommendations related to both mitigating global warming emissions and adapting to climate change impacts, and some explanation of how each of the identified recommendations is being implemented.[152]

Water Efficiency and Recycling

The CAP recommends proactive efforts to mitigate vulnerabilities of the regional water supply to climate change, including the following:

In preparation for the impacts of climate change on the region's water resources, partner with local, regional, and State agencies to encourage water conservation and efficiency and expand and diversify the water supply (see CAP, Adapting to a Changing Climate, Goal 1, Policy B).

Water efficiency and reuse reduces global warming emissions and helps the community prepare for potential future water resource constraints. The City is advancing water efficiency and water recycling efforts in several ways. In 2010 the City developed a voluntary *Guide to Conserving Water through Rainwater Harvesting and Graywater Reuse for Outdoor Use*. The purpose of the guide is to give homeowners the information they need to install effective, safe, and legal rainwater and/or graywater irrigation systems. Rainwater and graywater systems can help residents save water (and money) by reducing demand for potable water. The City coordinates with regional agencies such as StopWaste to provide education and training on new State water requirements: the Water Efficiency Landscape Ordinance (WELO), reinforcing landscape irrigation and water conservation best practices for new and existing landscapes, and SB704, requiring low-flow plumbing fixtures at time of sale. Additionally, the City conducts regular water audits of its buildings and infrastructure. Since the drought began in 2012, several City buildings and parks have received the WaterSmart Certification from East Bay Municipal Utility District.

Mitigating Vulnerabilities to Flooding and Coastal Erosion

The CAP recommends proactive efforts to prepare for potential flooding associated with climate change impacts, including:

In preparation for rising sea levels and more severe storms, partner with local, regional, and State agencies to reduce the property damage associated with flooding and coastal erosion (see CAP, Adapting to a Changing Climate, Goal 1, Policy C).

West Berkeley is particularly low-lying and vulnerable to sea level rise, as well as potentially increased flooding from severe storms. For all City-owned development projects, the City reviews and works to mitigate any risk from coastal flooding. The City needs to develop guidelines, regulations and review development standards to ensure new and existing public and private developments and infrastructure are protected from floods due to sea level rise.

The City's urban forestry program mitigates global warming emissions through a process called carbon sequestration. The program also mitigates the impacts of climate change, such as flooding and extreme heat events. For example, one of the benefits of the City's ongoing urban forestry program is stormwater management. Trees absorb rainwater, reducing runoff and delaying peak flows. Tree roots also draw and hold water in the soil, helping the soil retain moisture and helping keep nearby plants hydrated. Berkeley's urban forest also helps to mitigate the impacts of extreme heat events by shading buildings and paved and dark-colored surfaces, such as roads and parking lots that absorb and store heat. (See Section B11 *Extreme Heat* for more details.)

Another strategy designed to assist with stormwater management is installation of green roofs. A green roof, also known as a "living roof" or "vegetated roof," is a planted rooftop garden that offers an attractive and energy-saving alternative to a conventional rooftop. One of the many benefits of green roofs is that they help filter and retain rainwater onsite and alleviate stormwater management needs throughout the City. As part of the City's education and outreach efforts, the City developed a Permit Guide to Living Roofs, which is designed to assist residents and businesses to understand the benefits and permitting requirements associated with installing a green roof.

As part of an effort to increase green infrastructure in Berkeley, the City has installed bioswales to curb water runoff in several locations around Berkeley. Bioswales use a stepped grade and native plants to redirect water away from flowing directly downhill, into an earthen swale which catches the water, which allows the water to slowly penetrate into the soil over a longer period of time. This helps replenish the groundwater, and provides water for summertime use by trees. By reducing this direct runoff into stormwater drains, bioswales also help reduce flooding from storm drain overflow, as well as the amount of debris washed into storm sewers, keeping organic matter and trash out of the Bay. Along with these great benefits, increasing vegetation in the City helps address issues related to the urban heat island effect and water management as these are impacted by climate change.

<u>Electrification and Energy Efficiency</u>

As a climate mitigation and adaptation strategy, the City is promoting electrification as a method to reach the community's ambitious climate goals. State and local policy is working toward 100% carbon-free electricity, achieved through programs like East Bay Community Energy (EBCE), a community-governed, local power supplier, or through rooftop solar. As electricity reaches this goal, the remainder of our emissions will come from transportation (gasoline and diesel) and natural gas in buildings. Transitioning natural gas uses in buildings to electricity provides many co-benefits that address climate adaptation as well as reducing emissions, such as better health and safety for populations inside and outside buildings (as the natural gas system is susceptible to leaking methane), especially after a disaster which could cause breakage in the natural gas delivery system. Reducing our reliance on natural gas will reduce air quality issues during extreme heat events, our vulnerability to fire following earthquake, and vulnerability to pipeline infrastructure damage from flooding and inundation. This transition is complex and will require strategic investments. City staff is working to address technical and regulatory barriers, educate contractors and the community, and implement strategic investment to ensure clean, equitable, and reliable electricity for the entire Berkeley community.

A transition to clean electricity will require reducing our overall energy demands. This includes encouraging non-polluting modes of transportation, such as walking, biking, and public transit, while transitioning remaining cars to electricity. In buildings, this means continued work on energy efficiency. Beginning in 2015, the Office of Energy & Sustainable Development has been implementing the Building Energy Saving Ordinance (BESO), requiring buildings to complete energy efficiency opportunity assessments. The ordinance offers opportunity to incorporate electrification, battery storage, and building cooling capacity to address the natural hazards that are and will be felt throughout the community as climate change progresses.

In order to ensure accountability and progress on its emissions reduction and climate adaptation efforts, the City regularly reports on the status and outcomes of CAP implementation (see www.CityofBerkeley.info/climate). Effectively monitoring and reporting progress and working to engage the community in advancing CAP-related actions is fundamental to achieving the CAP goals. Actions outlined in this plan are designed to be consistent with CAP goals.

B.11 *Extreme Heat Events*

B.11.a Historical extreme heat events

In August 2017, the Bay Area experienced record-setting high temperatures.[153] A Berkeley weather station on the University of California, Berkeley campus near Hearst and Euclid avenues reported a temperature of 108.5°F.[154] The National Weather Service issued an excessive heat warning that lasted five days for the Bay Area, and during this time there were six heat-related deaths in nearby San Francisco and San Mateo Counties.

Additionally in July 2006, there were five consecutive days with temperatures above 110° F in the Bay Area, and approximately 75 heat-related deaths during this period. The last comparable extreme heat event prior to 2006 was in 1972, which lasted two days.[155]

B.11.b Extreme Heat Hazard

According to Cal-Adapt, California's database of climate information, multiple factors contribute to the extreme heat hazard:

1. Extreme heat days: An extreme heat day is when temperatures reach the 98th percentile of historic maximum temperature. In Berkeley, an extreme heat day is a day above 88.3 degrees F.
2. Warm nights: A warm night in Berkeley is considered to be one that does not cool below 61.7 degrees F. Warm nights can increase health risks significantly, as people do not have the ability to cool down and recover.
3. Heat wave: When there are five or more days of extreme heat.
4. Extreme heat during unexpected times of year: When extreme heat occurs outside of historically hotter months.
5. Duration of heat wave: Longer heat waves have proportionally more negative impacts than shorter heat waves.

Projections indicate that the number of extreme heat days, warm nights, and heat waves will increase exponentially in the next century. In addition to this increased frequency and duration, heat waves are also expected to also occur in months not typically associated with extreme heat.

<u>Urban Heat Island Effect</u>

Extreme heat events can be further exacerbated by the urban heat island (UHI) effect, through which densely-built cities like Berkeley experience higher temperatures in comparison to surrounding more rural areas.

Factors contributing to the UHI effect include:

- A relative lack of vegetation;
- Reduced air flow;
- An abundance of hard, dark surfaces—such as buildings, streets, cars and sidewalks—which absorb heat rather than reflect it. These surfaces also slowly release that absorbed heat throughout the night, contributing to warmer nighttime temperatures as well.

The UHI effect can also worsen air quality (particularly ground-level ozone) in urban environments.[156] The UHI effect increases heat-related illnesses and fatalities, particularly after two to three days of extreme heat.[157]

Vegetation helps mitigate the UHI effect through evaporative cooling, making urban tree cover, parks, and green roofs essential to combatting the UHI effect. Green roofs, cool roofs, and cool pavements (light-colored materials that reflect, rather than absorb, solar energy) reduce the UHI effect, and can also lower cooling loads in buildings. Urban vegetation and increased urban tree cover reduce temperatures, with co-benefits such as improving air quality and providing needed shade (for buildings and people) during heat events.

Secondary Hazards

Public health impacts
Public health impacts associated with extreme heat events include premature death, cardiovascular stress and failure, and heat-related illnesses such as heat stroke, heat exhaustion, and kidney stones.[158]

Fire
While hot temperatures do not necessarily start fires, they can decrease moisture in vegetation, increasing its flammability and the length and severity of the fire season.[159] Warming temperatures combined with increased development in the wildland-urban interface are projected to increase fire risk in most of the Bay Area.

Damage to critical facilities and infrastructure
Extreme heat can lead to power outages. Due to Berkeley's historically mild climate, many buildings are not equipped with efficient cooling systems, and therefore rely on inefficient and sometimes ineffective methods of indoor cooling, such as window air conditioning units. This increases electricity demands that can overwhelm the power grid, causing power outages when people need their cooling devices the most. Power outages can lead to many cascading and significant consequences such as consequences to vulnerable infrastructure, inability to operate fuel and water systems that require electricity, communication, and service disruption, and loss of critical functions for people that rely on power, such as people with disability and people with access and functional needs that use medical devices.

High temperatures also damage critical infrastructure, such as transportation systems. During a fall 2017 extreme heat event, BART and Caltrain operated trains at reduced speeds in order to avoid damage to the tracks.[160] Unreliable public transit during extreme heat could cause more people to drive, adding to the heat and worsening air quality. Extreme heat events also create needs for additional infrastructure maintenance, particularly for roadways where heat can contribute to deformation or premature failure.[161]

As extreme heat becomes more frequent and severe, Berkeley buildings will need to add cooling capacity. This effort will need to be done strategically over the coming decades to find solutions that are clean, efficient, and functional during electrical grid outages. Approaches will include natural ventilation and passive cooling techniques such as shading and orientation, particularly in new building design. For existing buildings and new construction, consideration may also be given to heat pump technology, a highly-efficient electric system (up to 400% efficient[162] in energy efficient buildings) with both heating and cooling capabilities. The California Energy Commission and City staff are working to promote this technology and to optimize usage to take advantage of California's abundant solar energy, even after the sun goes down and even during high-usage events without overwhelming the grid.

Strategic planning is also needed to ensure the readiness of critical City facilities during grid failure. The ability for these facilities to island off of the grid and rely on clean backup energy during a power outage would improve the City's energy assurance during extreme heat events.

Worsened Air Quality

While naturally-occurring ozone that exists higher in the Earth's atmosphere is beneficial to the climate, ground-level ozone can be extremely harmful to human health. Extreme heat can contribute to the formation of ground-level ozone, also known as smog, and other secondary air pollutants, when emissions from industrial facilities, power utilities, cars, trucks and other sources chemically react in the presence of heat and sunlight.

Extreme heat can also cause stagnant air conditions, causing the smog to stay low longer, and increase community exposure.[163] Community reactions to extreme heat – including use of cars for transport and use of cooling systems in buildings – can compound the already heightened creation of ozone. For this reason, the availability of non-polluting modes of transportation and ultra-efficient building systems can mitigate both the direct impacts of the heat on the community and the worsened air quality.

Exposure to increased ozone concentrations is associated with pneumonia, asthma, allergic rhinitis, and other respiratory diseases, as well as premature death, and the elderly, infants, and children are particularly susceptible to experiencing these impacts.[164]

B.11.c Exposure and Vulnerability

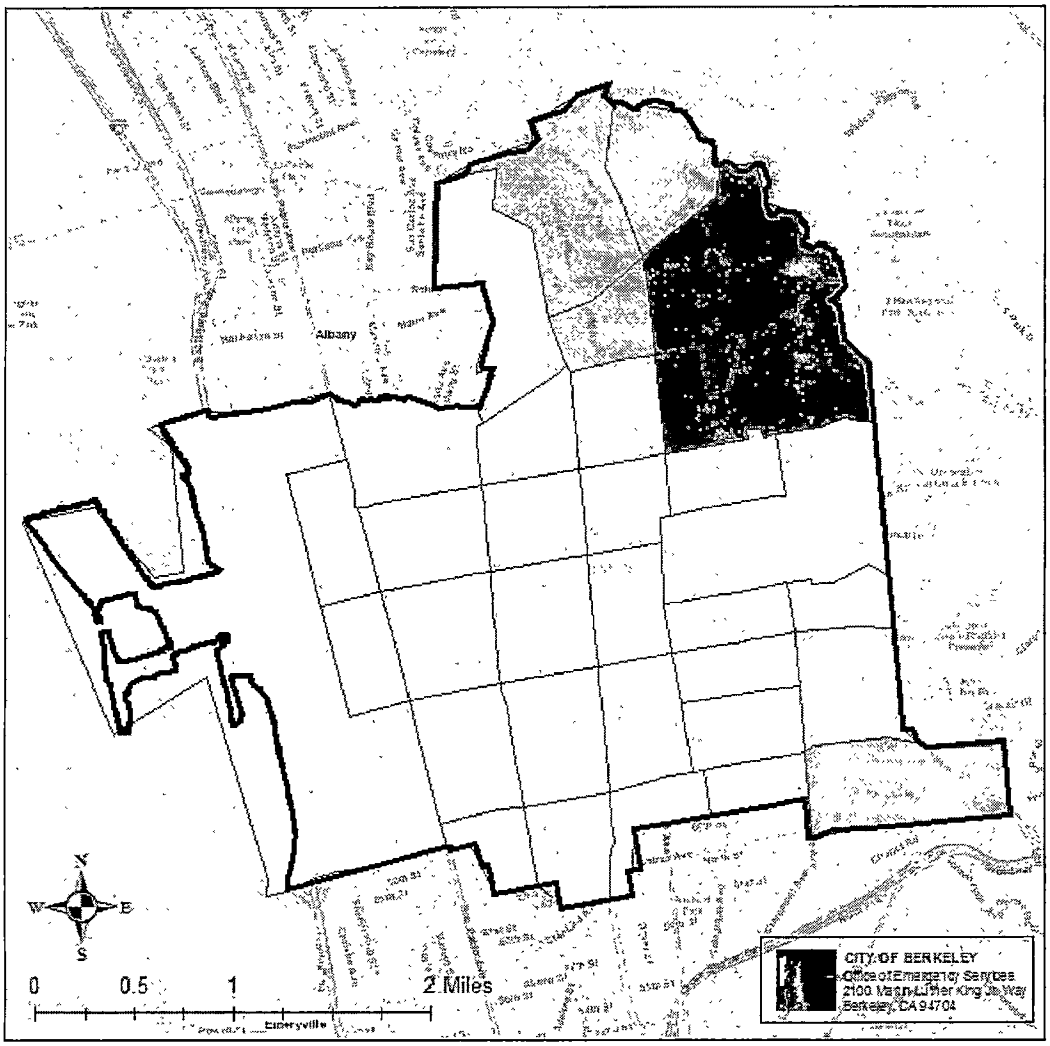
There are social, infrastructure and environmental factors that contribute to the Berkeley community's exposure and vulnerability to heat wave. These factors are explored further below.

Trees

A dense tree canopy can result in fewer heat related emergencies.[165] Urban tree canopy directly reduces surface and air temperatures through shading and absorption, directly combating the urban heat island effect. In addition, shading can reduce cooling loads in buildings and provide shade for individuals as well. Trees also improve air quality that often worsens during extreme heat.

In Berkeley, census tracts have between 4% and 48% tree coverage. As of November 2018, Cal Adapt predicts that this coverage will decrease over time. Map 34 shows the current percentage of tree coverage for each census tract in Berkeley. The areas shaded in darker green, predominately in the hills in east Berkeley, have the greatest percentage of tree canopy, while west and south Berkeley have the smallest percentage of tree canopy, meaning that these buildings and communities will likely not benefit from reduced temperatures provided by urban tree cover.

Map 34. ***Percentage of tree coverage in City of Berkeley***



Source: Cal Adapt https://cal-adapt.org/
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Berkeley

Tree Coverage

41% to 50%

31% to 40%

21% to 30%

11% to 20%

Less than 10%

Notable Mitigation Activity: City Tree Programs[166]

The City of Berkeley's municipal forest is maintained by the Urban Forestry Unit of the Parks Division, which is part of the Parks, Recreation, and Waterfront Department. There are approximately 38,000 street, park, and median trees that comprise the municipal forest in Berkeley.

The City's Urban Forestry Unit plants trees on the public right-of-way, in City parks, and on City-owned property. The public right-of-way includes the planting strip between the curb and the sidewalk, and street medians.

Residents can submit a tree planting application to have the City plant a tree, or to purchase and plant a tree at their own expense. Based on Tree Planting Location Standards, the City will designate the species and location of any tree that is planted on the public right-of-way, regardless of who purchases and/or plants it.

The Urban Forestry Unit is actively engaged in diversifying the urban forest population. Various species have been planted to determine their viability as a street or park tree. Climate change, the potential for temperature increase, and drought are additional considerations that are also changing the tree species selection process.

Social Factors

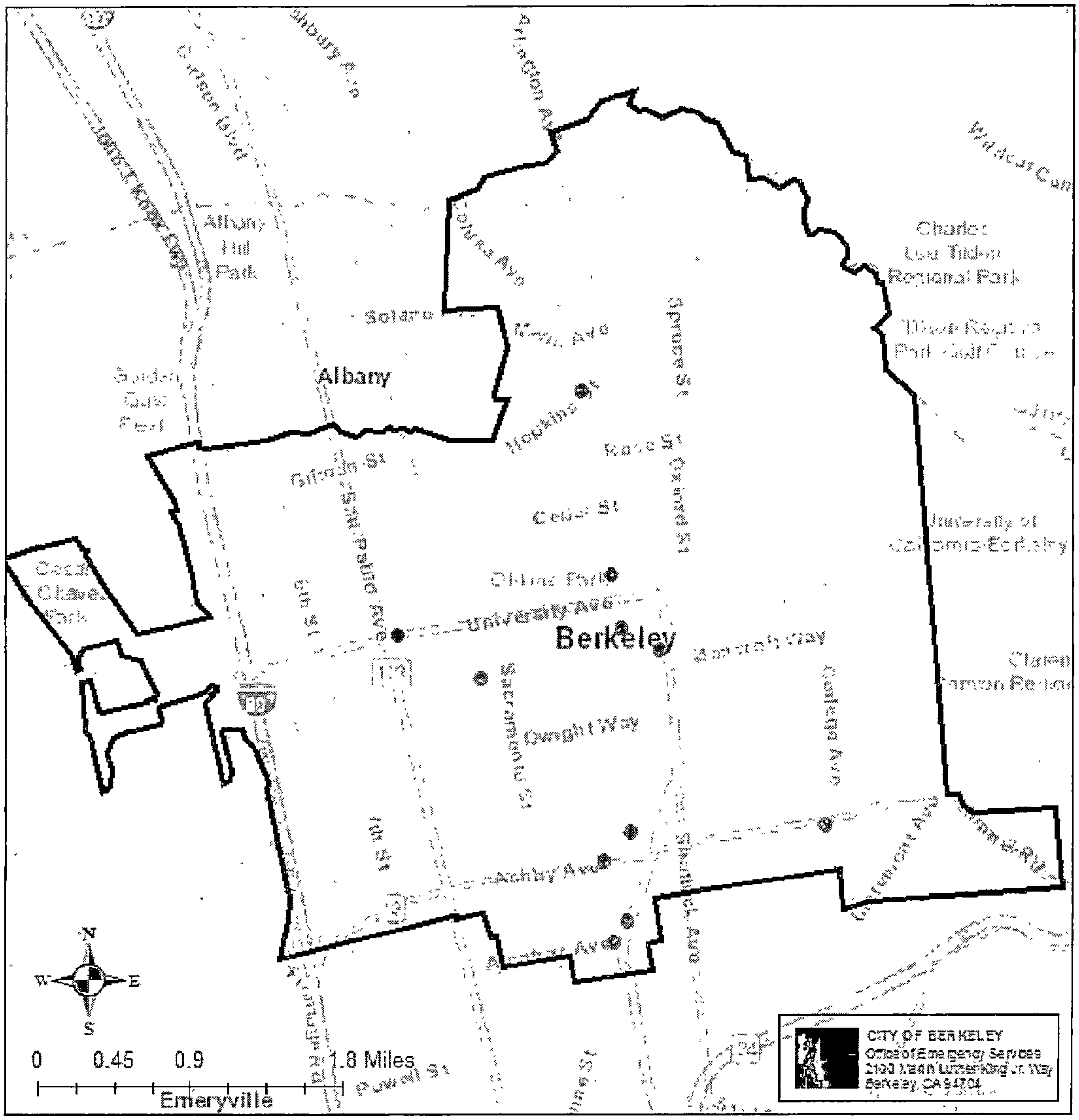
People with disabilities and people with access and functional needs, chronic diseases, the elderly, and children under five are the most at risk to heat-related illnesses.[167] Research also indicates that communities of color, and the poor suffer more during extreme heat events because of lack of access to common heat adaptation strategies, such as tree canopy for shading, air conditioning and insulation in buildings, or car ownership to travel to public cooling centers that allow them to escape the heat.[168] People working outdoors and homeless populations are also vulnerable.

Across California, the highest risk of heat-related illness occurs in the typically cooler regions found in coastal areas like Berkeley. Some of this vulnerability is because these communities are relatively unaccustomed to extreme heat. As a result, they are less acclimatized or potentially less aware of preventative behavior.[169]

Infrastructure

Having access to an air conditioner, or a building with ventilation, can make a huge difference to individuals during periods of extreme heat. Berkeley has public buildings that are equipped to provide relief from extreme heat and can serve as cooling centers during extreme heat events. Map 35 shows the location of these buildings with a blue dot throughout the city, but clustered in the center. There are only a few of them, mostly libraries and community centers, and they are clustered in a few neighborhoods.

Map 35. ***Location of Cooling Centers in City of Berkeley***



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City of Berkeley

Cooling Centers

B.11.d Extreme Heat Event Risk and Loss Estimates

Based on climate models from Cal-Adapt, the average number of extreme heat days in Berkeley is projected to increase by more than 10 days by the end of the century. Table 17 shows how this number will gradually increase between now and 2099.

Table 17. Predicted average number of extreme heat days in Berkeley by year

2011-2030	2021-2040	2031-2050	2041-2060	2051-2070	2061-2080	2071-2090	2081-2099
5	6	7	8	10	12	15	18

Source: https://cal-adapt.org/tools/extreme-heat/
Note In Berkeley, an extreme heat day is when daily maximum temperature is above 88.3 degrees F

Social and Infrastructure Impacts
The specific impacts of future heat waves are difficult to predict, but may include illness, injury, death, and damage to critical infrastructure. According to California Climate Change Center, by mid-century, extreme heat in urban centers could cause two to three times more heat-related deaths than occur today.[170]

B.12 *Hazardous Materials Release*

Because this plan is concerned with natural disasters, hazardous materials release is considered primarily as a secondary impact of the hazards presented in Sections B5 to B11. This section will identify how the natural hazards discussed in the plan can trigger the release of hazardous materials, as well as the potential impacts of those hazardous materials releases.

B.12.a Historical Hazardous Materials Releases

Berkeley has not recently experienced significant hazardous materials releases secondary to a natural disaster. However, the city has experienced industrial accidents from both mobile and fixed sources. Truck accidents involving potentially harmful materials have occurred in the western part of the City, on Interstate 80 and its ramps. Industrial sites have released small amounts of dangerous substances, such as anhydrous ammonia from an ice rink and a sake brewery.[171] In 2011, an uncontrolled release of 1,600 gallons of diesel on the UC Berkeley campus resulted in diesel entering the stormwater system, and discharging into Strawberry Creek.[172] In 2017 a truck accident on Interstate 80 released approximately 200 gallons of diesel fuel on the roadway next to the estuary. The fuel was contained and the fuel did not release into the estuary. After the incident the roadway barriers have been strengthened and improved.

B.12.b Hazardous Materials Release Hazard

Hazardous materials release could harm community members by exposing people to vapors that are toxic, suffocating, cause burns or are irritating. Hazardous materials release can threaten not only life and property, but also the environment, in areas such as creeks, the Aquatic Park lagoons and the San Francisco Bay.

The impacts of a release depend on its chemical characteristics, the amount and rate of substance spilled, the location, and its dispersion. Flammable and combustible materials can cause fires in areas that are largely constructed of wood; they may also cause explosions. Wind speed and direction, as well as topography, can greatly impact the dispersion plume of a release.

The City's Toxics Management Division (TMD), within the Department of Planning and Development, maintains the Hazardous Materials Area Plan, which identifies facilities that, in the event of a regional disaster, may pose the greatest risk to human health or the environment.

The Fire Department is the first responder for hazardous materials incidents within the City, and has access to chemical inventories, locations and emergency planning for all these facilities. The chemical inventories and facility maps are available electronically to the Fire Department.

The Department of Public Works manages the City's hazardous materials emergency response to spills on the right-of-way and also manages the hazardous materials emergency response contractor.

B.12.c Exposure and Vulnerability

Hazardous Materials Sites

There are 513 facilities[173] within Berkeley that are regulated by TMD.[174] TMD has grouped these facilities into Hazard Levels 1, 2 and 3:

- Level 1: Facilities that have substantial quantities of hazardous materials onsite, and/or have hazardous materials that can easily disperse or explode, and are toxic or pose other special hazards to human health and the environment.

- Level 2: Facilities that have medium to large quantities of hazardous materials onsite, and/or materials with known hazards.

- Level 3: Facilities for which Berkeley Fire Department engine companies can handle incidents without additional facility storage information, because the hazards are known or familiar (e.g., gas station without welding cylinders, or a facility with motor oil).

The majority of the 513 facilities in Berkeley are Level 3 automotive- or medically- related facilities with limited quantities of hazardous materials and hazardous waste.

Fifteen Hazard Level 1 facilities hold sufficiently large quantities of toxic chemicals to pose a high risk to the community.[175] TMD works directly with each of these sites to make sure they meet stringent safety requirements. Facilities in Table 18 are at the highest risk level.

Table 18. Berkeley industrial sites with large quantities of extremely hazardous substances

Site	Location
Alta Bates Summit Medical Center	2450 Ashby Avenue
Atlas Welding Supply, Inc.	1224 Sixth Street
Bayer Healthcare LLC	800 Dwight Way
Davlin Coatings	700 Allston Way
DSM Biomedical, Inc.	829 Heinz Avenue
Electro Coatings, Inc.	893 Carleton Street
Enthalpy Analytical LLC	2323 Fifth Street
Henkel Corporation	742 Grayson Street
Howlett Machine Works	746 Folger Avenue
Lawrence Berkeley National Lab	1 Cyclotron Road
Precision Technical Coatings, Inc.	800 Grayson Street
Ravago Chemical Distribution	2424 Fourth Street
The Polymer Technology Group	2810 Seventh Street
TPMG Regional Lab (Kaiser)	1725 Eastshore Highway
UC Berkeley – Main Campus	200 California Hall MC

Hazardous Materials Sources Outside of Berkeley

Airborne toxic plumes, including smoke, can travel into Berkeley from surrounding cities. Petrochemical refineries and other large chemical facilities in Contra Costa County could release hazardous materials that could impact the Berkeley community.

Hazardous Materials Transportation

Hazardous materials also travel through Berkeley by truck and rail. Specific routes known to carry hazardous chemicals are:

- Interstate 80
- San Pablo Avenue and the industrial areas to the west
- State Highway 13/Ashby Avenue
- Gilman Avenue
- University Avenue
- Union Pacific Railroad
- Fuel pipelines in the western edge of the City (see Map 12 *Gas Transmission Lines and Jet Fuel Line*)

Transportation accidents have occurred with trucks carrying dangerous materials. These accidents will undoubtedly occur in the future.[176] A release on the freeway or railway would most immediately impact the western industrial area of the city. Winds typically blow from the west to the east, meaning that a gaseous release could easily spread to the City's eastern residential areas.

The City has completed a Hazardous Materials Commodity Flow Study with a grant from the California Office of Emergency Services and the federal Department of Transportation. This study retrieved or collected data on bulk chemicals being transported on freeways, major city streets, and the railroad and through pipelines.

Links to Berkeley's Hazards of Concern

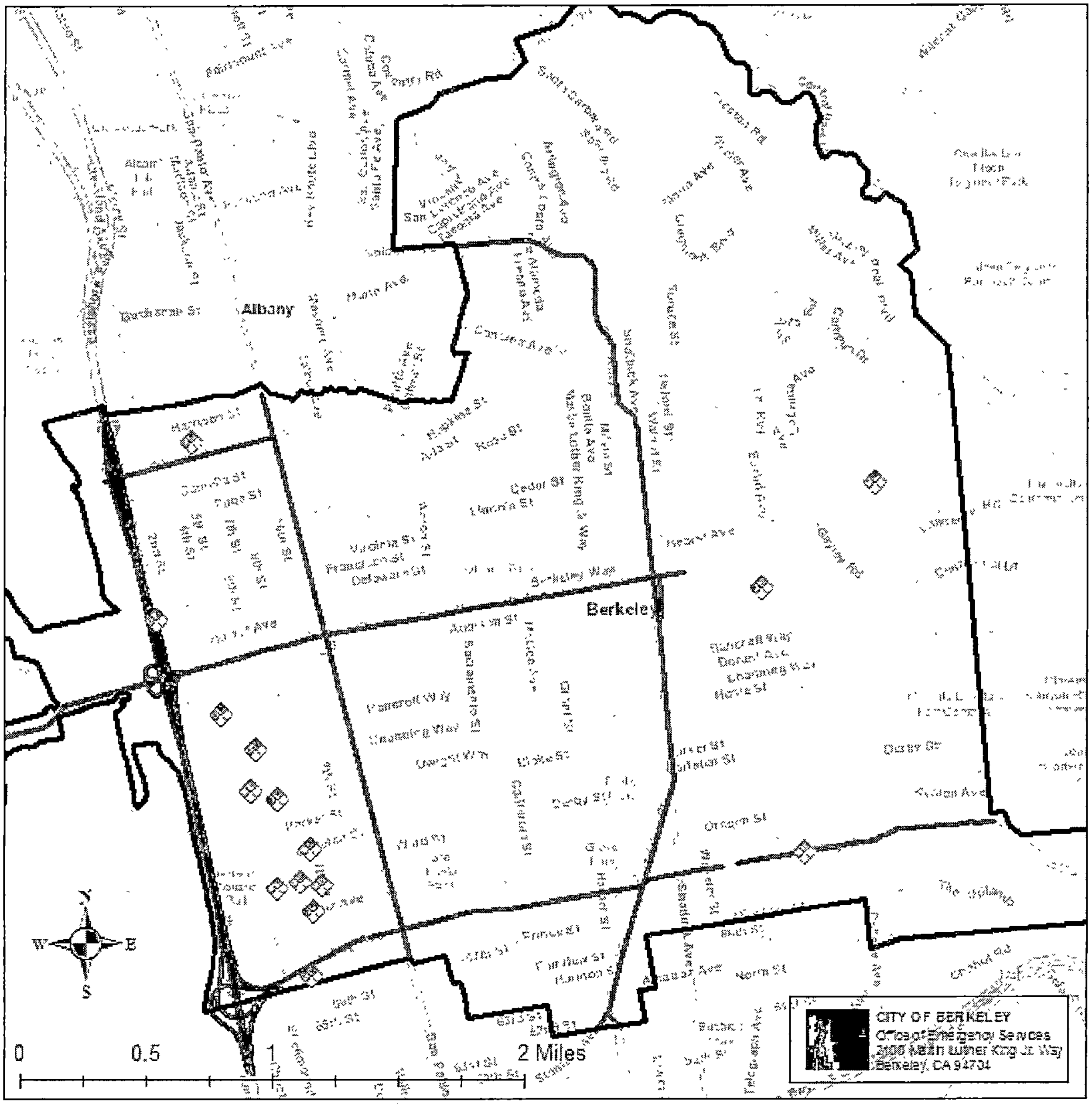
Map 36 identifies the locations of Hazard Level 1 Industrial Sites, along with key hazardous materials transportation routes. Level 1 industrial sites are identified as square red, blue, white, and yellow icons on the map. Hazardous materials transportation routes are identified by thick purple lines, which include Shattuck Avenue, University Avenue, San Pablo Avenue, part of Gilman Street up to when it meets San Pablo Avenue, and Ashby Avenue.

In the wildland-urban interface (WUI) in the Berkeley hills, there are two major sources of dangerous chemicals: UC Berkeley and the Berkeley Lab. Both have significant amounts of flammable and toxic chemicals, including radioactive chemicals. While both sites have active disaster preparedness programs, WUI fires are notoriously difficult to fight and hazardous materials could be released in a major conflagration.

While business owners are required to secure and isolate hazardous chemicals, this may not prevent spills from causing fires or health hazards after an earthquake.

Flooding could cause hazardous materials release. The City requires some hazardous materials to be surrounded by berms to contain any spills. The Berkeley Municipal Code[177] requires development in flood-prone areas to be protected against flood damage at the time of initial construction.

Map 36. ***Level 1 Hazardous Materials Facilities and Transportation Systems***



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City of Berkeley

Level 1 Hazardous Materials Facilities

Hazardous Materials Transportation Route

Notable Mitigation Activities

The State of California requires engineering studies for facilities exceeding threshold quantities of extremely hazardous substances (EHS).[178] EHS regulations may also require mechanical and structural improvements to the respective facilities. Implementing State laws over the past twenty years has resulted in the decline of the number of EHS- regulated facilities in Berkeley by over 90 percent.

The City's Toxics Management Division regulates use and management of non- radioactive[179] hazardous materials at UC Berkeley and Berkeley Lab.[180] Both of these sites provide lists of the substances used in campus research to the TMD, which makes the information available to the Berkeley Fire Department in accordance with California Health and Safety Code. The TMD also makes these chemical types and volumes publicly available as part of its Community Right-to-Know program; however, locations of these chemicals are not disclosed to the public.

<u>Key Hazardous Materials Partners</u>

University of California at Berkeley

Hazardous materials are dispersed throughout many laboratories on the UC Berkeley campus, which has comprehensive programs to secure hazardous materials during and after disasters. The UC Berkeley campus relies on the City for fire and search and rescue services.

Berkeley Lab[181]

There are hazardous materials at the Berkeley Lab, which consist of radiological materials, biological agents and toxins, and chemicals. The Emergency Management Program analyzes these materials to determine those that are a threat to workers and the public to ensure protective actions are predetermined and administrative and engineering controls are identified and implemented.

Although additional planning and response efforts are in place for hazardous material releases, response to earthquakes and WUI fires can be complicated with the presence of hazardous materials.

Bayer Corporation[182]

Bayer's headquarters for biotechnology manufacturing is located in Berkeley and employs over 1,000 workers. Bayer has been proactive in managing its disaster risk, focusing on both reducing risks to buildings and equipment and preparing for a robust emergency response. The entire site has been assessed for earthquake risk; buildings and other structures have been retrofitted on a risk-basis. All production-related buildings have been structurally strengthened to at least 1.5 times code requirements, all other structures meet or exceed earthquake standards, including the ammonia-based refrigeration facility. New buildings have been designed to exceed code requirements.

Bayer also trains its own emergency response team each year with the following capabilities:

- Industrial Firefighting

- Hazardous Materials Response (including 'level A' response)
- Advanced first aid
- Confined space rescue, including non-entry rescue

Bayer has a type-1 fire engine to bolster City's fire suppression capabilities. Bayer conducts at least annual joint training sessions with the Berkeley Fire Department, which allows the two groups to understand the capabilities of each other's organizations. Bayer has created plans and entered into contracts with vendors in order to mitigate the damage associated with earthquakes or other disasters. Internal and community-based communications plans are being updated to assure timely communications in the event of a range of emergencies.

B.12.d Hazardous Materials Release Risk and Loss Estimates

Because of the uncertain nature of industrial accidents, loss estimates are not presented in this plan. City staff uses PEAC software to plan for and respond to chemical emergencies.

B.13 *Terrorism*

The City considers terrorism to be a hazard of concern. However, because this plan is concerned with natural disasters, an in-depth analysis of terrorism is not included, and mitigation actions for terrorism will not be identified.

It is not possible to estimate the probability of a terrorist attack. Experts prioritize terrorism readiness efforts by identifying critical sites and assessing these sites' vulnerability to terrorist attack. Critical sites include those that are essential to the functioning of the City, that contain critical assets, or which would cause significant impacts if attacked (e.g., a chlorine gas release). Vulnerability of these sites is determined subjectively by considering factors such as visibility (e.g., does the public know this facility exists in this location?), accessibility (e.g., is it easy for the public to access this site?) and occupancy (e.g., is there a potential for mass casualties at this site?)

City officials are currently working with State and regional groups to prevent and prepare for terrorist attacks. This effort involves the City's Police, Fire, Public Works, Public Health, and Toxics Management groups. The City also participates in the federal BioWatch program, designed to allow early detection of release of bioterrorism agents in the city.

The City's emergency response teams actively train to detect Pre-Incident indicators for all types of terrorist events including, but not limited to, bomb scenarios, hostage situations, infrastructure damage and a multitude of other terror-associated threats. Since any terrorist event has the potential to significantly impact the city and the region, City emergency response teams regularly conduct training with emergency response teams from neighboring jurisdictions to ensure seamless integration of resources and personnel should such a need arise.

Buildings and other structures constructed to resist earthquakes and fires usually have qualities that also limit damage from blasts and resist fire spread and spread of noxious fumes in the event of a terrorist attack.

Endnotes

[1] Climate-warming trends over the past century are extremely likely to have been caused by human activities (known as anthropogenic climate change). Future anthropogenic emissions will determine the degree of impacts felt by climate change, some of which are already being felt. Climate change may also be referenced as a natural hazard here because of its potential to exacerbate natural hazards described in this plan.

[2] Ackerly, David. 2018. California's Fourth Climate Change Assessment, San Francisco Bay Area Region Report. http://www.climateassessment.ca.gov/regions/docs/20190116-SanFranciscoBayArea.pdf

[3] https://cal-adapt.org/tools/extreme-heat/

[4] Documentation is on file at the Berkeley Planning Department

[5] Public Law 106-390

[6] Johnson, L. and Mahin, S. California Seismic Safety Commission Pacific Earthquake Engineering Research Center (PEER). 2016. The Mw 6.0 South Napa Earthquake of August 24, 2014: A Wake-up Call for Renewed Investment in Seismic Resilience across California. http://peer.berkeley.edu/publications/peer_reports/reports_2016/CSSC1603-PEER201604_FINAL_7.20.16.pdf

[7] Schwartz, Richard. Earthquake Exodus, 1906, 2006.

[8] Detweiler, Shane and Wein, A., 2018, The HayWired Earthquake Scenario – Earthquake Hazards: U.S. Geological Survey Scientific Investigations Report 2017-5013-A-H, p.3.

[9] Detweiler, Shane and Wein, A., 2018, The HayWired Earthquake Scenario – Earthquake Hazards: U.S. Geological Survey Scientific Investigations Report 2017-5013-A-H, p.4.

[10] Southern California Earthquake Center. *A Comparison of the February 28, 2001, Nisqually, Washington, and January 17, 1994, Northridge, California Earthquakes.* http://www.scec.org/news/01news/feature010313.html

[11] Information adapted from the United States Geological Survey: http://earthquake.usgs.gov/learn/topics/mag_vs_int.php

[12] https://wim.usgs.gov/geonarrative/safrr/haywired_vol1/

[13] The State of California is required by two Acts of the State Legislature to establish and map three Seismic Hazard Planning Zones, depicting areas within the state with the potential to experience these types of ground failure.

Seismic Hazard Planning Zones, also known as Zones of Required Investigation, are regulatory maps that depict areas identified as having a high potential for earthquake- triggered ground failure caused by fault rupture, landsliding or soil liquefaction. These maps are used to guide land use planning and construction permitting for projects that fall within the area. Applicants for permits who are in one of the zones are required to have site-specific geotechnical investigations and use engineering measures to mitigate the hazard.

Seismic Hazard Planning Zones do not show effects of a particular earthquake scenario, but rather, consideration of all future earthquakes affecting the area. They are used to support land use decisions by identifying areas where future earthquake- induced ground failure is more likely to occur, and to determine whether approval of more in-depth site-specific hazard investigation and mitigation may be required for certain projects during the construction permitting process.

[14] Charles Real, California Geological Survey

[15] Yasuhara K., Komine H., Murakami S., Chen G., Mitani Y. (2010) Effects of climate change on geo-disasters in coastal zones. Journal of Global Environmental Engineering, JSCE 15, 15–23.

[16] ATC 52-1. 2010. San Francisco Department of Building Inspection, Community Action Plan for Seismic Safety (CAPSS) Project. *Here Today Here Tomorrow: The Road to Earthquake Resilience in San Francisco.* http://www.sfgsa.org/modules/showdocument.aspx?documentid=9753.

[17] Johnson, L. and Mahin, S. California Seismic Safety Commission Pacific Earthquake Engineering Research Center (PEER). 2016. The Mw 6.0 South Napa Earthquake of August 24, 2014: A Wake-up Call for Renewed Investment in Seismic Resilience across California. http://peer.berkeley.edu/publications/peer_reports/reports_2016/CSSC1603-PEER201604_FINAL_7.20.16.pdf

[18] http://www.sfmuseum.org/conflag/underwriters.html

[19] City of Berkeley Budget Book FY2012-2013,Community Profile Data

[20] 2010 American Community Survey.

[21] The City has adopted Standard Plan Set A for wood frame homes of two stories or less that provides typical details and other guidance. This plan set simplifies the design of cripple wall retrofits for many homes in Berkeley.

[22] To create the City's inventory of non-ductile concrete and rigid wall-flexible diaphragm buildings, staff did extensive research, including examining local Sanborn maps, Google Map images, building permit data obtained from Accela, real estate data from RealQuest, housing unit data from the Rent Stabilization Board, and City of Berkeley records such property cards, microfiche data, files from prior field surveys, and zoning data. Sanborn maps, which were originally created for assessing fire insurance liability, provide the approximate size, shape and construction material of each building within the city that existed at the time. The City of Berkeley's Sanborn maps were last updated in the early 1980's, and were therefore useful as a starting point for identifying older buildings constructed of concrete or reinforced masonry that may be vulnerable in a seismic event.

After identifying concrete buildings on the Sanborn maps, staff investigated each building's current status. Buildings confirmed to still be in existence were researched for construction material and year built, as well as for any permit history indicating whether alterations and/or seismic retrofits might have occurred. Information was also gathered for each building's use classification, APN, alternate addresses, square footage, number of stories and residential units, historic registry list data, and property ownership information required for conducting outreach.
[23] During a sidewalk survey in November 2017, contracted EERI engineers visually assessed over 250 buildings to validate the City's inventory of seismically vulnerable buildings and identify common structural deficiencies. Additionally, two teams of experienced structural

engineers were hired to help develop engineering guidelines and establish minimum standards for retrofits of non-ductile concrete and other rigid wall-flexible diaphragm buildings supported by FEMA-funded Retrofit Grants, in an effort to improve their performance during an earthquake.

[24] To help identify soft story buildings with 3-4 residential units or commercial uses, staff utilized a Rental Housing Safety Program database and field survey sheets of nonresidential buildings from the original Soft Story inventory conducted in the 1990s. Staff undertook a "virtual" survey of each building using Google maps aerial and street view imagery to identify potential Soft Story buildings, and then verified the unit count and building configuration for each property by consulting City and county property records.

[25] Information provided by Steven Frew, Elizabeth Bialek, Jose Rios, and Mike Ambrose, EBMUD.

[26] Detweiler, Shane and Wein, A., 2018, The HayWired Earthquake Scenario – Engineering Implications: U.S. Geological Survey Scientific Investigations Report 2017-5013-I-Q, p.6.

[27] Information provided by Manuel Ramirez, City Environmental Health Division Manager, and Dr. Janet Berreman, City Health Officer, as of November 2012

[28] Interceptors are sewer pipes, as large as 10 feet in diameter, which form the backbone of the wastewater transport system.

[29] Methane Emissions (EPA, 2018) https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane

[30] Information provided by Stuart Nishenko, Senior Seismologist, and PG&E

[31] National Transportation Safety Board, 2011. *Pipeline Accident Report: Pacific Gas and Electric Company Natural Gas Transmission Pipeline Rupture and Fire San Bruno, California, September 9, 2010,* Washington D.C.

[32] Information provided by Nicole Stewart, Area Manager Brisbane Terminal & Richmond Station of the Kinder Morgan, Inc., as of December 2018.

[33] Karl Busche, City Toxics Management Division, August 2018.

[34] Evacuation routes are designated in the City's General Plan, Transportation Element policy T-28: Emergency Access.

[35] Information provided by Craig Whitman, Office of Earthquake Engineers, Steve Prey, Energy Conservation Program Coordinator, and Robert Braga (January 2012), Branch Chief Maintenance Services/Emergency Management: Planning & Training, all at Caltrans.

[36] BART information provided by Tracy Johnson, Seismic Engineering Manager, BART, June 2013. BART earthquake early warning system information provided by John McPartland, BART Board of Directors.

[37] P-waves are non-destructive, earthquake-generated waves. They travel faster than secondary waves (S-waves), which create the strong shaking responsible for structural damage in earthquakes.

[38] Information provided by Rochelle Pollard Account Manager for AT&T, in March 2018.

[39] Information provided by Ken Fattlar, Director of Network Operations for Verizon Wireless in

Northern California, in April 2013.

[40] Bryan Byrd, Comcast, Director, Communications, June 2013

[41] A "headend" is a master facility for receiving television signals for processing and distribution over a cable television system.

[42] In a hierarchical telecommunications network, the "backhaul" portion of the network comprises the intermediate links between the core network, or backbone network and the small sub-networks at the "edge" of the entire hierarchical network.

[43] Carl Scheuerman, Director of Regulatory Affairs, Sutter Health Facility Planning & Development, personal communication February 23, 2012

[44] These buildings are categorized as SPC-2 according to the Hospital Seismic Safety Act. Structural Performance Category (SPC) 1 is the most vulnerable ranking for buildings. Many SPC 1 hospitals pose significant collapse risks. SPC 5 hospitals pose the least structural risk. Significant changes impacting life safety were made to the Building Code in 1973, particularly regarding reinforced concrete buildings. These changes built on lessons learned in California earthquakes, including the 1971 San Fernando earthquake. According to state law, SPC-2 buildings must comply with standards intended to keep hospitals open and providing medical care following a severe earthquake by 2030.

[45] These buildings are categorized as SPC-3 and SPC-4. Structural Performance Category (SPC) 1 is the most vulnerable ranking for buildings. Many SPC 1 hospitals pose significant collapse risks. SPC 5 hospitals pose the least structural risk.

[46] These buildings are categorized as SPC-1. Structural Performance Category (SPC) 1 is the most vulnerable ranking for buildings. Many SPC 1 hospitals pose significant collapse risks. SPC 5 hospitals pose the least structural risk.

[47] California Seismic Safety Commission. *The Field Act and Public School Construction: A 2007 Perspective.* February 2007.

[48] California Seismic Safety Commission. *Seismic Safety in California's Schools: Findings and Recommendations on Seismic Safety Policies and Requirements for Public, Private, and Charter Schools.* December 2004.

[49] John Calise, Executive Director of Facilities, Berkeley Unified School District

[50] Shirley Slaughter, Berkeley City College Business Officer and Safety Committee Co-Chair, December 2018.

[51] Camerio, Mary. "The Economic Benefits of a Disaster Resistant University: Earthquake Loss Estimation for UC Berkeley." April 12 2000, Institute of Urban Design and Regional Development.

[52] See http://www.berkeley.edu/administration/facilities/safer/index.html for more information on UC Berkeley's SAFER program.

[53] www.berkeley.edu/administration/facilities/safer/

[54] Office of the Vice Provost and the Disaster Resistant University Steering Committee. Strategic Plan for Loss Reduction and Risk Management: University of California, Berkeley. Working Paper 2000-03. University of California, Berkeley, July 2000.

[55] Information provided by Dr. Tonya Petty, Emergency Manager and Continuity Manager, Lawrence Berkeley National Laboratory, as of October 2018.
[56] City of Berkeley, Office of Economic Development, Economic Dashboard, September 2018.

[57] The 2004 scenario was calculated using HAZUS-MH. The program's default data on buildings (types and economic values) and soils (for liquefaction and landslides) were used. 2004 shelter figures are taken from a previous analysis conducted by the Association of Bay Area Governments. HAZUS estimates of shelter populations were lower. Special thanks to Rich Eisner for help preparing these estimates.

[58] This 2013 LHMP Update includes impacts described in the 2008 FEMA/Cal EMA (Cal OES) Catastrophic Earthquake Incident Scenario. This scenario is based on a HAZUS-MH™ study completed by Charles A. Kircher, Hope A. Seligson, Jawhar Bouabid, and Guy C. Morrow as part of a series of papers presented at the 100th Anniversary Conference on the 1906 San Andreas Fault Earthquake. Descriptions of damage in this scenario is based on impacts expected from a magnitude 7.7 to 7.9 earthquake on the San Andreas fault, but the general level and type of impacts are expected to be similar for a Hayward fault event. The report was based on the most accurate data available at the time and the results were reviewed by peers. Additional analysis and data were prepared by Kircher, et al. for Golden Guardian 2006.

[59] Detweiler, Shane and Wein, A., 2018, The HayWired Earthquake Scenario – Engineering Implications: U.S. Geological Survey Scientific Investigations Report 2017-5013-I-Q, p.1.

[60] About 20% of ignitions typically occur within the first hour after the earthquake, 50% within about 6 hours and almost all ignitions occur within the first day.

Risk, S. P. A. "Enhancements in HAZUS-MH Fire Following Earthquake, Task 3: Updated Ignition Equation pp. 74pp. *SPA Risk LLC, Berkeley CA. Principal Investigator C.Scawthorn. Prepared for PBS&J and the National Institute of Building Sciences, San Francisco* (2009).

[61] Estimation derived from Ch. 10, particularly Eqn. 10-1, of HAZUS Earthquake Tech Manual MR 4: FEMA, 2003. Multi-hazard Loss Estimation Methodology, Earthquake Model, HAZUS-MH MR4 Technical Manual. Developed by: Department of Homeland Security, Federal Emergency Management Agency, Mitigation Division, Under a contract with: National Institute of Building Sciences Washington, D.C., p. 712.

[62] In 2004, estimate was $20 million damage from 5 estimated fires. This plan estimates 6-12 fires. If $4 million/ignition assumed, $24 million - $48 million damage is estimated in 2004 dollars. This figure was then updated for 2018 to $32 million - $64 million using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[63] Detweiler, Shane and Wein, A., 2018, The HayWired Earthquake Scenario – Engineering Implications: U.S. Geological Survey Scientific Investigations Report 2017-5013-I-Q, p.2.

[64] In 2004, estimate was $1.5 billion. Updated for 2018 using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[65] Detweiler, Shane and Wein, A., 2018, The HayWired Earthquake Scenario – Engineering Implications: U.S. Geological Survey Scientific Investigations Report 2017-5013-I-Q, p.6.

[66] Information provided by Bill Cain (ret.), EBMUD

[67] Detweiler, Shane and Wein, A., 2018, The HayWired Earthquake Scenario – Engineering Implications: U.S. Geological Survey Scientific Investigations Report 2017-5013-I-Q, p.390.
[68] Per Rochelle Pollard, Account Manager for AT&T, in March 2018.For Prioritization and Preemption of the Berkeley first responders, the cornerstone of the AT&T Mobile solution is FirstNet.

First Priority™ & Preemption Capability

First Priority™, which means first responders connect first – they don't have to compete with non-emergency users for a connection. Delivery of priority and preemption capabilities, an exclusive public safety core, application ecosystem, deployables and mission critical services – all required by the government contract

Highly reliable and extensive coverage

- A contractual commitment to build a network designed to meet a 99.99% end-to-end service availability objective – a standard unmatched by any other large-scale LTE network in the world today.
- A commitment to grow coverage to rural, tribal and
- U.S. territories specifically for public safety
- Public safety Band 14 deployment to 95% of America's population
- Deployables dedicated exclusively for public safety
  - for planned activities and disaster recovery
- Local control of users and applications and the ability to give others priority access to the network
- A network backbone that supports integration with Next Generation 9-1-1 and Smart Cities public safety applications – ensuring emergency work/call flows are available to public safety.
- Preemption will make sure first responders have the bandwidth they need by detouring others off the network. This works like vehicle traffic being routed off the highway to make room for emergency personnel.

Unprecedented level of network security

- Building a physically separate dedicated core with end-to-end encryption
- Single-sign-on and federated identity, providing ease of use and integration between the network, applications and public safety databases
- A robust and highly secure device ecosystem – with a broad portfolio of devices enabled for multiple bands, including Band 14
- Dedicated security operations center to monitor the network (24/7/365) and mitigate threats

Critical interoperability

- Building a dedicated, interoperable network, and ecosystem
- Building a dedicated public safety application store with certified, public-safety relevant, highly secure and interoperable applications

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[69] In 2004, estimate was $215 million. Updated for 2018 using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[70] City of Berkeley. *Fire Hazard Mitigation Plan.* February 25, 1992.

[71] Updated for 2018 using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[72] City of Berkeley. *Fire Hazard Mitigation Plan.* February 25, 1992.

[73] City of Berkeley. *Fire Hazard Mitigation Plan.* February 25, 1992.

[74] United States Fire Administration. *The East Bay Hills Fire, Oakland-Berkeley, California (October 19-22, 1991): Report 60 of the Major Fires Investigation Project.*

[75] City of Berkeley. *Fire Hazard Mitigation Plan.* February 25, 1992.

[76] Judson Jones. "One of the California Wildfires Grew so Fast It Burned the Equivalent of a Football Field Every Second." CNN. Accessed May 16, 2019. https://www.cnn.com/2018/11/09/us/california-wildfires-superlatives-wcx/index.html.

[77] California Department of Public Health. 2008. Public Health Climate Change Adaptation Strategy for California. http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy.pdf

[78] Pacific Institute. (2010). A Review of Social and Economic Factors that Increase Vulnerability to Climate Change Impacts in California.

[79] 2010 CBC Chapter 7A: Materials and Construction Methods for Exterior Wildfire Exposure, and 2010 CRC Section R327: Materials and Construction Methods for Exterior Wildfire Exposure

[80] Per Dan Gallagher, Senior Forestry Supervisor, City of Berkeley: The Fire Fuel Chipper Program collected green waste vegetation in the following amounts in the following years:

- 2005: 264.35 tons
- 2006: 237.59 tons
- 2007: 189.06 tons
- 2008: 175.16 tons
- 2009: 167.17 tons
- 2010: 161.31 tons
- 2011: 187.24 tons
- 2012: 155.94 tons
- 2013: 141.27 tons
- 2014: 119.72 tons
- 2015: 130.26 tons
- 2016: 430 cubic yards of wood chips and 34.28 tons of loose vegetation

[81] Information provided by Susan Ferrera, Superintendent of Parks, City of Berkeley, as of November 2018

[82] Information provided by Greg Apa, Solid Waste and Recycling Manager of Zero Waste Division, City of Berkeley, as of September 2018

[83] Information provided by Greg Apa, Solid Waste and Recycling Manager of Zero Waste Division, City of Berkeley, as of September 2018

[84] http://firecenter.berkeley.edu/

[85] Information provided by Dr. Tonya Petty, Emergency Manager and Continuity Manager, Lawrence Berkeley National Laboratory, as of October 2018.

[86] Total square footage of buildings in burn area is 9,386,281 square feet.

[87] In 2004, estimate was $500 million.

[88] Finacom, Steven. "Berkeley, A Look Back: Thorsen Home Becomes Frat House." Accessed April 17, 2019. https://www.eastbaytimes.com/2017/07/25/berkeley-a-look-back-thorsen-house-turned-from-private-home-to-fraternity-house/.

[89] Ellen et al. "Map showing principal debris-flow source areas in Alameda County, California." USGS Open-File Report 97-745 E.

[90] Pike et al. "Map and map database of susceptibility to slope failure by sliding and earth flow in the Oakland area, California." USGS MF-2385.

[91] In Berkeley, culverted creeks are below ground and within a pipe or box-shaped conduit in a creek bed.

[92] The City of Berkeley Watershed Management Plan Appendix D, Page 9 lists design storms. The depth of the 10-year, 6 hour duration event varies from 1.81" to 2.27" depending on if the desired location is in the Bay Plains or in the hills.

[93] The City uses a 10-year design storm as representation of a rainfall event that reflects local conditions.

[94] California Adaptation Planning Guide, July 2012.

[95] There are no wastewater treatment facilities located in Berkeley. The East Bay Municipal Utility District (EBMUD) operates multiple potable water reservoirs within the City limits. EBMUD is responsible for protecting their facilities and ensuring their proper function.

[96] California Adaptation Planning Guide, July 2012.

[97] Revisions effective December 21, 2018 present the results of revised coastal hazard analysis and resulting flood elevations and flood depths. These revisions result in reissued Flood Insurance Rate Map, Panel numbers 14, 18, 52, 54, and 56.

[98] The FIRM map was created by the Federal Emergency Management Agency (FEMA) for the National Flood Insurance Program. Data current as of 2009, with revisions effective December 18, 2018.

[99] Repetitive loss properties are those that have submitted claims for flood reimbursement through the National Flood Insurance Program at least twice in the last ten years. The goal of mapping these properties is to identify what locations flood repetitively and seek to mitigate the problem to reduce flood damage.

[100] The Potter Watershed drains approximately one-third of the land area of the City through storm drain pipe infrastructure. The Codornices Watershed drains about one- tenth of the City through open watercourses and creek culverts. Findings from these two watersheds could be extrapolated to the other watersheds, but it is preferable to continue hydraulic modeling of the remaining watersheds.

[101] In 2018, loss estimates quoted in the narrative were updated using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[102] Contents were assumed to be worth 50% of the total structural replacement value for single-family homes and 100% of the total structural replacement value for commercial and industrial properties. The majority of structures in the zone with up to 3 feet of floodwaters are residential, so contents for all structures in this zone were estimated at 50% of structure value. The majority of structures in the zone with up to 1 foot of water are commercial or industrial, and contents value was assumed to equal structure value for these properties.

[103] Wilson, R., Ewing, L., Dengler, L., Boldt, E., Evans,T., Miller, K., Nicolini, T., and Ritchie, A. Effects of the February 27, 2010 Chilean Tsunami on the Harbors, Ports, and the Maritime Community in California With Comparison to Preliminary Evaluation of March 11, 2011 Tsunami. Proceedings from ASCE Coasts, Oceans, Ports, and Rivers Institute Conference, Alaska, June 2011.

[104] The SAFRR Tsunami Modeling Working Group, 2013, Modeling for the SAFRR Tsunami Scenario—Generation, propagation, inundation, and currents in ports and harbors, chap. D in Ross, S.L., and Jones, L.M., eds., The SAFRR (Science Application for Risk Reduction) Tsunami Scenario: U.S. Geological Survey Open-File Report 2013– 1170, 136 p., http://pubs.usgs.gov/of/2013/1170/d/.

[105] A team of scientists from California Geological Survey, US Geological Survey and the California Office of Emergency Services are in the process of developing a methodology for estimating tsunami hazard to the west coast. In 2013 they expect to begin two pilot studies to test the methodology in Crescent City and Huntington Beach. Following validation of the pilot studies, probabilities for the rest of the state will be developed.

[106] Wood, N., Ratliff, J., and Peters, J., 2013, Community exposure to tsunami hazards in California: U.S. Geological Survey Scientific Investigations Report 2012-5222, 49p.

[107] California Geological Survey, University of Southern California, California State Lands Commission, California Governor's Office of Emergency Services: February 2018 DRAFT Harbor Improvement Report (HIR) No. 2018-Alam-01

[108] Overcrossing provides non-automobile access between the residential and business districts on the east side of I-80 and the Berkeley waterfront, Bay Trail and Eastshore State Park (Addison St and Bolivar Drive) to the west of the freeway (West Frontage Road and University Avenue).

[109] The SAFRR Tsunami Modeling Working Group, 2013, Modeling for the SAFRR Tsunami Scenario—Generation, propagation, inundation, and currents in ports and harbors, chap. D in Ross, S.L., and Jones, L.M., eds., The SAFRR (Science Application for Risk Reduction) Tsunami Scenario: U.S. Geological Survey Open-File Report 2013– 1170, 136 p., http://pubs.usgs.gov/of/2013/1170/d/.

[110] The Dona Spring animal shelter, opened in 2012, is built above the 100-year flood plain but is

still in the tsunami inundation zone

[111] Public Law 106-390

[112] Diurnal asymmetry to the observed global warming (Royal Meteorological Society, 2016) https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/joc.4688
[113] Our Changing Climate 2012 (California Climate Change Center, 2012) http://www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdf
[114] How Climate is Changing (NASA, Updated December 6, 2018) https://climate.nasa.gov/effects/
[115] San Francisco Bay Area 2017 Risk Profile (ABAG, 2017)
[116] Morello-Frosch, R; Pastor, M; Sadd, J; Shonkoff, S. The Climate Gap: Inequalities in How Climate Change Hurts Americans & How to Close the Gap. May 2009.
[117] Our Changing Climate 2012 (California Climate Change Center, 2012) http://www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdfhttp://www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdf
[118] McKenzie, D.; Heinsch, F.A.; Heilman, W.E. 2011. Wildland Fire and Climate Change. (January 17, 2011). U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. http://www.fs.fed.us/ccrc/topics/wildland-fire.shtml
[119] Our Changing Climate 2012 (California Climate Change Center, 2012).
[120] San Francisco Bay Area 2017 Risk Profile (ABAG, 2017, p58-59) http://resilience.abag.ca.gov/wp-content/documents/mitigation_adaptation/RiskProfile_4_26_2017_optimized.pdf
[121] Our Changing Climate 2012 (California Climate Change Center, 2012).
[122] Our Changing Climate 2012 (California Climate Change Center, 2012).
[123] San Francisco Bay Area 2017 Risk Profile (ABAG, 2017, p53)
[124] Ibid.
[125] Causes and Predictability of the 2011-14 California Drought (NOAA, 2014) https://cpo.noaa.gov/Meet-the-Divisions/Earth-System-Science-and-Modeling/MAPP/MAPP-Task-Forces/Drought/Drought-Task-Force-I/Causes-and-Predictability-of-the-2011-2014-California-Drought
[126] 2012-2016 California Drought: Historical Perspective (USGS, Updated 2018) https://ca.water.usgs.gov/california-drought/california-drought-comparisons.html
[127] "What Are Atmospheric Rivers? | National Oceanic and Atmospheric Administration." Accessed April 22, 2019. https://www.noaa.gov/stories/what-are-atmospheric-rivers.
[128] Ralph, F. Martin, Jonathan J. Rutz, Jason M. Cordeira, Michael Dettinger, Michael Anderson, David Reynolds, Lawrence J. Schick, and Chris Smallcomb. "A Scale to Characterize the Strength and Impacts of Atmospheric Rivers." *Bulletin of the American Meteorological Society* 100, no. 2 (February 1, 2019): 269–89. https://doi.org/10.1175/BAMS-D-18-0023.1.
[129] Staff, KRON4. "Another Atmospheric River to Batter Bay Area with Heavy Rain, Wind." KRON, February 26, 2019. https://www.kron4.com/weather/another-atmospheric-river-will-bring-heavy-rain-to-bay-area/1807183265.
[130] San Francisco Bay Conservation and Development Commission, 2011, p. 5
[131] Adapting to Rising Tides Bay Area Sea Level Rise Analysis and Mapping Project (ART, 2017) http://www.adaptingtorisingtides.org/project/regional-sea level-rise-mapping-and-shoreline-analysis/
[132] California's Fourth Climate Change Assessment San Francisco Bay Area Region Report (State of California, 2018) http://www.climateassessment.ca.gov/regions/docs/20180827-

SanFranciscoBayArea.pdf

[133] California's Fourth Climate Change Assessment San Francisco Bay Area Region Report (State of California, 2018) http://www.climateassessment.ca.gov/regions/docs/20180827-SanFranciscoBayArea.pdf

[134] California's Fourth Climate Change Assessment San Francisco Bay Area Region Report (State of California, 2018) http://www.climateassessment.ca.gov/regions/docs/20180827-SanFranciscoBayArea.pdf

[135] State of California Sea-Level Rise Guidance 2018 Update (California Ocean Protection Council, 2018). http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf. This is the median probabilistic projections, meaning 50% probability sea-level rise will meet or exceed this level.

[136] Adapting to Rising Tides (ART) Bay Shoreline Flood Explorer https://explorer.adaptingtorisingtides.org/explorer

[137] Assessment of California's Natural Gas Pipeline Vulnerability to Climate Change (California Energy Commission, 2017). http://www.energy.ca.gov/2017publications/CEC-500-2017-008/CEC-500-2017-008.pdf

[138] Land Subsidence in the United States, USGS Fact Sheet (USGS, 2000). https://water.usgs.gov/ogw/pubs/fs00165/

[139] http://www.adaptingtorisingtides.org/wp-content/uploads/2018/07/BATA-ART-SLR-Analysis-and-Mapping-Report-Final-20170908.pdf

[140] Adapting to Rising Tides Bay Area Sea Level Rise Analysis and Mapping Project (ART, 2017) http://www.adaptingtorisingtides.org/project/regional-sea level-rise-mapping-and-shoreline-analysis/

[141] California Adaptation Planning Guide, July 2012.

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[169] 2017 Clean Air Plan (BAAQMD, 2017, Chapter 3, pg 9).
[170] San Francisco Bay Area 2017 Risk Profile (ABAG, 2017).

[171] Both of these accident sites no longer store anhydrous ammonia.

[172] UC Berkeley and Berkeley Lab have since evaluated their storm water systems as potential hazardous materials conduits to the creeks.

[173] Of the 513 facilities indicated, 481 meet chemical minimums; the remainder are smaller hazardous waste only generators that do not meet volume thresholds quotes. There are many

more facilities that have some sort of hazardous materials on their sites, but they are not regulated by the City's Toxics Management Division (per Karl Busche, City Toxics Management Division, August 2018).

[174] These facilities have a minimum of 55 gallons of aggregate liquid chemicals, 500 pounds of aggregate solid chemicals, or 200 cubic feet of aggregate gaseous chemicals, or they may generate hazardous waste.

[175] City Toxics Management Division, as of July 2018.

[176] The Northridge earthquake derailed a train carrying 2,000 gallons of sulfuric acid that began leaking. Firefighters were on the scene within two hours and the situation was stabilized with three and a half hours.

[177] Berkeley Municipal Code Section 17.12.030.C.2 requires uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction. This requirement applies to future businesses but does address existing facilities. BMC 17.12.030 does not recognize areas exposed to sea-level rise in the flood exposure area.

[178] Per Nabil Al-Hadithy (March 2018), the engineering study is a Risk Management Plan, which includes safety information, process hazard analysis/hazard review, operating procedures, training, maintenance, compliance audits and incident investigations, along with documents and records showing that the facility is implementing the program.
Scenarios for release including earthquake, operator error and fire are studied and corrections are made. The technical severity of these studies depends on the quantity and type of hazardous substances at the facility.

[179] The City has limited regulatory authority over radioactive material use and management. Radioactive materials are managed by the federal Department of Energy and Nuclear Regulatory Commission.

[180] Per Karl Busche, Toxics Management Division, City of Berkeley: Per the State's Unified Hazardous Waste and Hazardous Materials Management Regulatory Program, the City's Toxics Management Division is the agency responsible for administering six of the State's hazardous materials and waste programs for Berkeley. The City of Berkeley regulates both UC Berkley and Berkeley Lab for the following six State programs:

1. Hazardous Materials Release Response Plans and Inventories (HMBP) Program, Health and Safety Code, Division 20, Chapter 6.95, Article 1, with supplemental regulations in California Code of Regulations Title 19, Sections 2620-2732.

2. California Accidental Release Prevention (CalARP) Program, Health and Safety Code, Division 20, Chapter 6.95, Article 2, with supplemental regulations in California Code of Regulations, Title 19, Sections 2735-2785.

3. Underground Storage Tank (UST) Program, Health and Safety Code, Division 20, Chapter 6.7, with accompanying regulations in the California Code of Regulations, Title 23.

4. Aboveground Petroleum Storage Act Requirement for Spill Prevention, Control and Countermeasure (SPCC) Plans, Health and Safety Code, Division 20, Chapter 6.67, Section 25270-25270.13.

5. Hazardous Waste Generator and Onsite Hazardous Waste Treatment (tiered permitting) Programs, Health and Safety Code, Division 20, Chapter 6.5, with accompanying regulations in the California Code of Regulations, Title 22.

6. California Fire Code: Hazardous Materials Management Plans (HMMP) and Hazardous Materials Inventory Statements, California Code of Regulations, Title 27, Division 2, Chapter 4.5.

The Toxics Management Division also enforces City codes regarding hazardous materials and waste. These codes are often more stringent than CUPA codes.

[181] Information provided by Dr. Tonya Petty, Emergency Manager and Continuity Manager, Lawrence Berkeley National Lab, as of October 2018.

[182] Information provided by Jeffrey Bowman, CHMM Senior Manager - Health, Safety, Environment, and Security

C. Mitigation Strategy

Berkeley aims to be a disaster-resilient community that can survive, recover from, and thrive after a disaster while maintaining its unique character and way of life. Berkeley envisions a community in which the people, buildings, and infrastructure, in and serving Berkeley, 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 within thirty days of 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.

Elements C.3-C.6 of this plan outline Berkeley's mitigation strategy, and how it connects to Berkeley's disaster resilience vision. The strategy identifies and analyzes a comprehensive range of specific mitigation actions and activities being considered to reduce the effects of each hazard described in Element B: Hazard Analysis. It is based on existing authorities, policies, programs, and resources, as well as Berkeley's ability to expand on and improve these existing mitigation tools as described in Elements C.1-C.2 of this plan.

C.1 *Authorities, Policies, Programs, and Resources*

The table on the following pages highlights some of the regulatory authorities, policies, programs and other resources that support Berkeley's hazard mitigation efforts. The "Category" columns indicate whether the resource includes Planning and Policy, Financial, Administrative and Technical, and Training and Outreach Elements. The "Ability to support Mitigation Activities" column overviews the City's ability to use the highlighted resource to expand on and improve mitigation activities.

Following the table is a detailed discussion of these and other authorities, policies, programs, and resources. Finally, this section provides a table of State and federal requirements related to hazard mitigation and describes how Berkeley complies with these requirements.

Name of Authority, Policy, Program, or Resource	Category				Ability to support mitigation activities
	Planning and Policy	Financial	Admin & Technical	Training & Outreach	
Guiding Policies and Goals	x				Many City policies shape Berkeley's growth. In addition to disaster resilience, City goals include protecting the environment, promoting sustainable development, providing low-income housing, preserving historic structures, and maintaining City infrastructure. Some of these policies directly support mitigation efforts; together they all ensure that mitigation activities account for City values.
Public Works	x		x		The City of Berkeley's Public Works Department is the largest department in the City and provides both direct services to the community, as well as critical support services to the City organization. Public Works is responsible for maintaining the City's physical assets and infrastructure in a safe and serviceable condition. Public Works provides services ranging from refuse and recycling collection, diversion and disposal, to property management, infrastructure improvements, and improving safety in the public right-of-way. Mitigation actions include the seismic retrofit of the North Berkeley Senior Center, the complete remodel of the City's Mental Health Clinic, implementing computerized maintenance management system for Operation's activities, and procuring a global positioning system for tracking the City's fleet.
Emergency Management	x		x	x	The City's Fire Department - Office of Emergency Services (OES) works to increase the Berkeley's readiness through community education, staff support to the Disaster and Fire Safety Commission, and coordination of the City's emergency management activities. OES staff meets regularly with City's designated emergency response staff to provide training and coordination. OES develops, maintains, and exercises the City's Emergency Operations Plan as well as the Local Hazard Mitigation Plan.
City Budget					The City's budget process assigns resources to address the goals, objectives, and community priorities set by the City Council. This process determines if and when money is spent on mitigation actions.

x

Name of Authority, Policy, Program, or Resource	Category				Ability to support mitigation activities
	Planning and Policy	Financial	Admin & Technical	Training & Outreach	
Municipal Building Improvements	x	x	x		The City, supported by an active public, local and State bond measure funding and FEMA grants, has strengthened and rebuilt numerous key buildings in Berkeley. Since 2014, the City has continued its program to strengthen or replace key at-risk structures.
Building Code	x		x		The City enforces disaster-resistant development through the application of the California Building Code, as well as more stringent local code amendments. The Provisions of the California Building Code are applicable to all new construction, additions, alterations and repairs. Mitigation actions include periodically updating the building code with local amendments based on the latest science and design standards.
Mandatory Retrofit Ordinances	x				The City has approved ordinances requiring owners of unreinforced masonry buildings and soft story buildings with five or more units to evaluate their buildings, obtain retrofit permits and complete seismic retrofits according to a schedule based on each building's risk categorization. Future mitigation actions include ensuring that these retrofits happen and exploring future ordinances for other hazardous buildings.
Financial Incentives	x	x	x	x	The Building and Safety Division developed a new Retrofit Grants program with funding from a Hazard Mitigation Grant from the Federal Emergency Management Agency (FEMA) and the California Governor's Office of Emergency Services (Cal OES). Mitigation actions include issuing the grants and expanding the programs to reach additional owners.

Name of Authority, Policy, Program, or Resource	Category				Ability to support mitigation activities
	Planning and Policy	Financial	Admin & Technical	Training & Outreach	
City Transfer Tax Rebate Program	x	x	x	x	By ordinance, the City created a program to rebate up to one-third of the transfer tax amount to be applied to earthquake upgrades on homes. The process begins once the homeowner makes seismic safety improvements. When the owner wishes to sell the house and the sale amount has been determined, the buyer and seller place a portion of the real estate transfer tax amount in an escrow account to be drawn down after improvements are complete. Mitigation actions include advertising this program and conducting outreach to homeowners.
Earthquake Brace + Bolt	x	x	x	x	The City participates in the Earthquake Brace + Bolt (EBB) program, a grant program administered by the California Earthquake Authority, providing grants of up to $3,000 for seismic retrofits of owner-occupied residential buildings with 1-4 dwelling units. Mitigation actions include advertising this program and conducting outreach to building owners.
Expanded Inventory of Seismically Vulnerable Buildings	x		x		With the launch of the Retrofit Grants Program, staff conducted extensive research to update and refine the City's inventory of seismically vulnerable buildings. In addition to soft story buildings not currently subject to mandatory retrofit such as those with 3-4 residential units or commercial uses, Berkeley has numerous non-ductile concrete and tilt-up or other rigid wall-flexible diaphragm (RWFD) buildings. These additional building types may also be highly susceptible to adverse effects from earthquakes. Mitigation actions include conducting research to determine other hazardous buildings that should be inventoried and exploring additional mandatory retrofit ordinances.

Name of Authority, Policy, Program, or Resource	Category				Ability to support mitigation activities
	Planning and Policy	Financial	Admin & Technical	Training & Outreach	
Hazardous Fire Area Zones	x		x		The City has established and adjusted fire zones in Berkeley. While the zones were initially established to address urban fire issues, they have evolved to designate the City's WUI fire hazard. Currently, the Berkeley Fire Department has divided the city into Fire Zones 1, 2, and 3, designated in order of ascending fire risk. Fire Zones 2 and 3 are in the hills area of the City. Mitigation actions include the strictest fire prevention standards and vegetation management measures.
Fire Inspections	x		x		The Berkeley Fire Department annually inspects designated high fire risk zones for hazards such as excess vegetation. The Fire Department inspects over 1,400 parcels in Fire Zones 2 and 3, in addition to complaint-driven inspections throughout the City. Future mitigation actions could include expanding the number of parcels, pending available resources.
Vegetation Management	x		x	x	The City also runs a number of vegetation management programs to reduce fuel loads. Future mitigation actions could include expanding resources available to help people with vegetation management.
Community Readiness	x		x	x	The City runs a number of programs aimed to help enhance the resilience of the people of Berkeley by providing disaster preparedness outreach, training, and materials. A number of these programs teach residents about mitigation actions that they could take individually, such as preparing their homes for wildfire season.

C.1.a. Guiding Policies and Goals

Many City policies shape Berkeley's growth. In addition to disaster resilience, City goals include protecting the environment, promoting sustainable development, providing low-income housing, preserving historic structures, and maintaining City infrastructure. Key policies impacting development are detailed below.

Sustainable Development

Berkley promotes sustainable development policies. The General Plan includes policies to maintain sufficient land zoned for high-and medium-density residential development. These policies allow for sufficient new construction to meet Berkeley's fair share of regional housing needs. Policies are coordinated to ensure that all new development is sensitive to Berkeley's unique physical character and scale, and that new housing and future development occur in areas of the city that are best served by public transportation services.

Affordable Housing

Berkeley also promotes affordable, seismically-safe housing. The General Plan includes policies promoting access to quality housing for people at the lowest income levels, and inclusion of low-income groups in new housing development. The General Plan also encourages maintenance and improvements to prepare buildings for a major seismic event, with the expectation that improvements do not necessitate substantial rent increases for tenants. In March 2016, the City Council modified the Demolition Ordinance to account for the loss of affordable housing that can occur with building demolition. That ordinance established the City's authority to set and collect a fee for each dwelling unit demolished in a building constructed prior to June 1980. It also allows for projects to provide one for one replacement units in lieu of fee payment as long as the units are restricted in perpetuity at a below market rate.

Restoration of Natural Waterways

The General Plan's Environmental Management section encourages the restoration of natural waterways. Many Berkeley streams were culverted in the 1960s as a flood control measure. Any change in the status of these culverts, already in a weakened state, would alter the Berkeley's flood risk.

Climate Mitigation and Adaptation

As outlined in Berkeley's 2009 Climate Action Plan, Berkeley has community-wide goals to reduce emissions and mitigate our impact on global anthropogenic climate change. This includes reducing energy and water usage, moving toward clean energy in our buildings and transportation, reducing our waste, and ensuring sustainable and equitable development. In addition, the Berkeley community must adapt to the current impacts the community is already facing from the changing climate, as well as plan for future impacts projected to occur. Climate mitigation strategies are outlined in the Climate Action Plan, and continue to be implemented City-wide. The City's climate adaptation strategies are included in the Local Hazard Mitigation Plan and Resilience Strategy, as they are closely aligned and should be integrated with hazard mitigation.

Preserving Historic Character

The City has a strong value for preserving historic character. Any hazard, and earthquakes and fires in particular, could destroy many historic structures, which tend to be more vulnerable to these hazards than newly-constructed buildings. The General Plan's Urban Design and Preservation Element encourages support of long-term protection of historically- or architecturally-significant buildings to preserve neighborhood and community character through maintenance of the historic resources inventory, and use of the State Historical Building Code, Rehabilitation Tax Credits, and Mills Act contracts preservation incentives.

Disaster Resilience

The Berkeley community recognizes that disasters have the potential to undercut all of the City's goals. As stated in the General Plan:

The city's healthy environment with its unique character and quality of life based on cultural, social and economic diversity could be dramatically and enduringly altered by a serious hazard event. Berkeley must protect what we already have as well as what we build through employing sound development practices and building and planning code enforcement, and continuously working to reduce the vulnerability of existing buildings and infrastructure, to improve emergency response and to prepare for recovery. Without these measures, disasters will occur and the other goals of the General Plan will be lost.

C.1.b. Public Works

The City of Berkeley's Public Works Department is the largest department in the City and provides both direct services to the community, as well as critical support services to the City organization. Public Works is responsible for maintaining the City's physical assets and infrastructure in a safe and serviceable condition. Public Works provides services ranging from refuse and recycling collection, diversion and disposal, to property management, infrastructure improvements, and improving safety in the public right-of-way.

Public Works Divisions and staffing allocations (measured in Full Time Equivalent (FTE) positions) are as follows:

- Office of the Director (6 FTE)
- Operations (98 FTE)
- Engineering (34 FTE)
- Zero Waste (90 FTE)
- Transportation (15.6 FTE)
- Administrative & Fiscal Services (16 FTE)

Significant objectives expected to be accomplished by the department during FY 2020 include the seismic retrofit of the North Berkeley Senior Center, the complete remodel of the City's Mental Health Clinic, implementing computerized maintenance management system for Operation's activities, and procuring a global positioning system for tracking the City's fleet. The Zero Waste Division has begun the feasibility process to replace the existing Transfer Station Facility. In addition the City plans to submit the Debris Management Plan to FEMA for approval.

Four publicly-staffed commissions provide community oversight over Public Works activities:

- Commission on Disability

- Public Works Commission
- Transportation Commission
- Zero Waste Commission

C.1.c. Emergency Management

The City's Fire Department - Office of Emergency Services (OES) works to increase the Berkeley's readiness through community education, staff support to the Disaster and Fire Safety Commission, and coordination of the City's emergency management activities. OES staff meets regularly with City's designated emergency response staff to provide training and coordination. OES develops, maintains and exercises the City's Emergency Operations Plan. OES has 3.5 FTE positions.

Emergency management is a shared responsibility among all City departments. Department Directors are responsible for ensuring their respective departments' readiness to contribute to disaster response activities. All City staff members are Disaster Service Workers and are required to provide services in the event of an emergency or disaster.

The Disaster and Fire Safety Commission provides community oversight over emergency management activities. The Commission participates in the review of emergency, disaster and mutual aid plans and agreements and makes recommendations to the City Council regarding legislation and regulations needed to implement such plans and agreements.

C.1.d. Taxing Authorities

The City's General Fund gets the majority of its money from: a) property taxes and property-based revenues; b) economically sensitive revenues such as sales tax, business license tax, transient occupancy tax, etc.; and c) interest and fees such as ambulance fees; and parking and traffic fines. The balance of the City budget is comprised of other funding sources such as grants, special tax revenue (e.g. parks, libraries and paramedic services), and fees for specific services (marina berth fees, garbage and sewer fees, building permits, etc.).

California property taxes are set at 1% of the assessed value of the property. The City receives about a third of every property tax dollar collected in Berkeley, and schools get 43% of every property tax dollar. These proportions have been about the same since 1979.

Sales tax is 9.75 cents on every dollar. Of that, the State gets 7 cents, Alameda County gets 1.75 cents, and the City gets a penny. Berkeley's sales tax revenue has decreased during the economic downturn, but is expected to remain steady going forward because of the City's efforts to retain its diverse retail mix.

The change in property transfer tax is an example of the impact of the economy on City budgets. Property tax revenue goes into the General Fund. This revenue is dependent on the fluctuating real estate market, and can vary dramatically from year to year. To protect City services from this volatility, much of this revenue is used for one-time infrastructure needs, such as streets and transportation projects.

C.1.e. City Budget

The City's budget process assigns resources to address the goals, objectives, and community priorities set by the City Council. The City's FY 2018 & FY 2019 budget was adopted by the Berkeley City Council at their June 27, 2017 meeting. The City's budget follows the fiscal year - beginning on July 1st and ending on June 30th.

The City's General Fund budget is approximately $184.2 million. The balance of the City's budget is made up of special funds ($277.4 million combined), which are dedicated to specific services. While special fund revenue is dedicated, it is not guaranteed. Special funds also shrink in tough economic times.

There are three broad categories of special funds:

1. Special Revenue and Grant Funds are legally restricted to a specific service, e.g.: Federal transportation funds, State public health funds, and the Parks, Library, and Paramedic Tax Funds.
2. Special Assessment Funds are for the financing of public improvements or services, such as the Clean Storm Water Fund and the Streetlight Assessment District Fund. Those two funds are examples of special funds where the revenues have not kept pace with the cost of delivering the service.
3. Enterprise Funds come from the collection of the fees associated with providing the service or program. For example, the Refuse Fund pays for the pickup and collection of garbage, recycling, and green waste. Services in this category include the Permit Service Center, the Sanitary Sewer Fund, and the Marina Enterprise Fund.

Additionally, the City has deferred maintenance on much of its capital infrastructure. As the economy begins to slowly recover, the City is being mindful of the need to address deferred maintenance, as well as to remain prepared to address the impacts of future cost increases in areas such as health and pension benefits.

The City Council has adopted budget development policies that have served Berkeley well over the long term, including:

- Focusing on the long-term fiscal health of the City by adopting a two-year budget and conducting multi-year planning;
- Building a prudent reserve;
- Developing long-term strategies to reduce unfunded liabilities;
- Controlling labor costs while minimizing layoffs;
- Allocating one-time revenue for one-time expenses;
- Requiring enterprise and grant funds to balance and new programs to pay for themselves; and
- Any new expenditure requires either additional revenue or expenditure reductions.

The City also used the "fix it first" approach in developing the budget, through which current capital improvements are funded before funding new projects.

C.1.f. City Buildings and Systems

Municipal Building Improvements

The City, supported by an active public, local and State bond measure funding and FEMA grants, has strengthened and rebuilt numerous key buildings in the city. Since 2014, the City has continued its program to strengthen or replace key at-risk structures.

In 2017, work was completed on the James Kenney Recreation Center and the Center Street Garage. The James Kenney Community Center Seismic Retrofit project was made possible by a Pre-Disaster Mitigation Program grant for $727,499 and involved seismic strengthening of the Recreation and Gym Building, as well as fire protection sprinklers throughout the building, and necessary ADA upgrades throughout. The replacement of the Center Street Garage was one of the City's high priority downtown projects. The preexisting 5-story structure did not meet current seismic standards and retrofit was determined to be infeasible.

Additionally, since 2004 the City has strengthened or rebuilt all seven of the City's fire stations, the historic Ratcliff Building (which houses the Public Works Department Operations Center), the Civic Center (which houses many key government functions), the Public Safety Building, a new animal shelter, and all libraries. The City is currently assessing vulnerabilities of other key City buildings and is developing funding strategies to upgrade buildings with known vulnerabilities.

Emergency Water Supply for Firefighting
In 2010, the City put into operation an aboveground, portable water system that can pump water from any source, including the San Francisco Bay, in the event of drained tanks or damaged pipelines. This system is designed to carry up to 20,000 gallons of water per minute for a distance of one mile and elevation gain of 100 feet; it will also carry smaller flows to higher elevations.

C.1.g. Privately-Owned Buildings
The City offers a comprehensive suite of programs to encourage the community to strengthen buildings to be more hazard-resistant. A number of City incentive programs and educational efforts promote seismic strengthening activities.

Building Codes
The City enforces disaster-resistant development through the application of the California Building Code, as well as more stringent local code amendments. The Provisions of the California Building Code are applicable to all new construction, additions, alterations and repairs.

Plan Set A
The City's adoption of Standard Plan Set A[1] educates homeowners and contractors about measures to improve seismic resistance of their homes. Contractors' adherence to this Standard simplifies the City's plan review and inspection process.

Mandatory Retrofit Ordinances
The City of Berkeley has worked diligently to enhance public safety and reduce physical threats from earthquakes by requiring owners of soft story and unreinforced masonry buildings to retrofit their structures. Berkeley Municipal Code (BMC) Chapter 19.39, effective January 4, 2014, mandated owners of soft story (also known as soft, weak or open front / "SWOF") buildings with five or more dwelling units to apply for a building permit for a seismic retrofit by December 31, 2016. Owners were given two years to complete the work upon submission of the permit application. Previously, the City approved an ordinance in 1991 (BMC 19.38) requiring owners of unreinforced masonry (URM) buildings to evaluate their buildings, obtain retrofit permits and complete seismic retrofits according to a schedule based on each building's risk categorization but in all cases no later than 2001.

Through these hazard mitigation measures, the City of Berkeley hopes to increase the safety and resilience of the city's building stock to prevent injury and loss of life and reduce post-disaster recovery time.

Soft Story Ordinance for Buildings with Five or More Dwelling Units

Soft story buildings are characterized as multi-story wood-frame buildings with extensive ground story openings such as windows, storefronts, garage openings, or open-air spaces such as parking. These buildings may have few perimeter or interior walls at the ground level, leading to a relatively soft or weak lateral load resisting system in this lower story. Since the collapse of soft story buildings in the 1989 Loma Prieta and the 1994 Northridge earthquakes, there has been considerable concern in California about tenant safety and the seismic deficiencies in these buildings. In 2005, Berkeley was the first city in the country to pass an ordinance to address this potentially unsafe condition.

Berkeley's original 2005 ordinance added Chapter 19.39 to the Berkeley Municipal Code, requiring owners of soft story buildings with five or more dwelling units to submit a seismic engineering evaluation report analyzing the ability of the building to resist earthquake forces and describing possible work to remedy weaknesses. The ordinance also required owners to notify tenants of the building's soft, weak or open front (SWOF) condition and post an earthquake warning notice at the building entrance. The initial wood-frame SWOF inventory included 321 buildings. The inventory has since increased to 332 buildings, containing 3,665 units.

On December 3, 2013, Council adopted amendments to Berkeley Municipal Code Section 19.39.110 establishing mandatory seismic retrofit requirements for soft story buildings with five or more dwelling units. The ordinance established December 31, 2016 as the deadline for property owners to apply for a building permit. Owners must complete retrofits within two years of submitting the permit application. The table below describes the status of the 332 soft story buildings subject to mandatory retrofit as of December 2018.

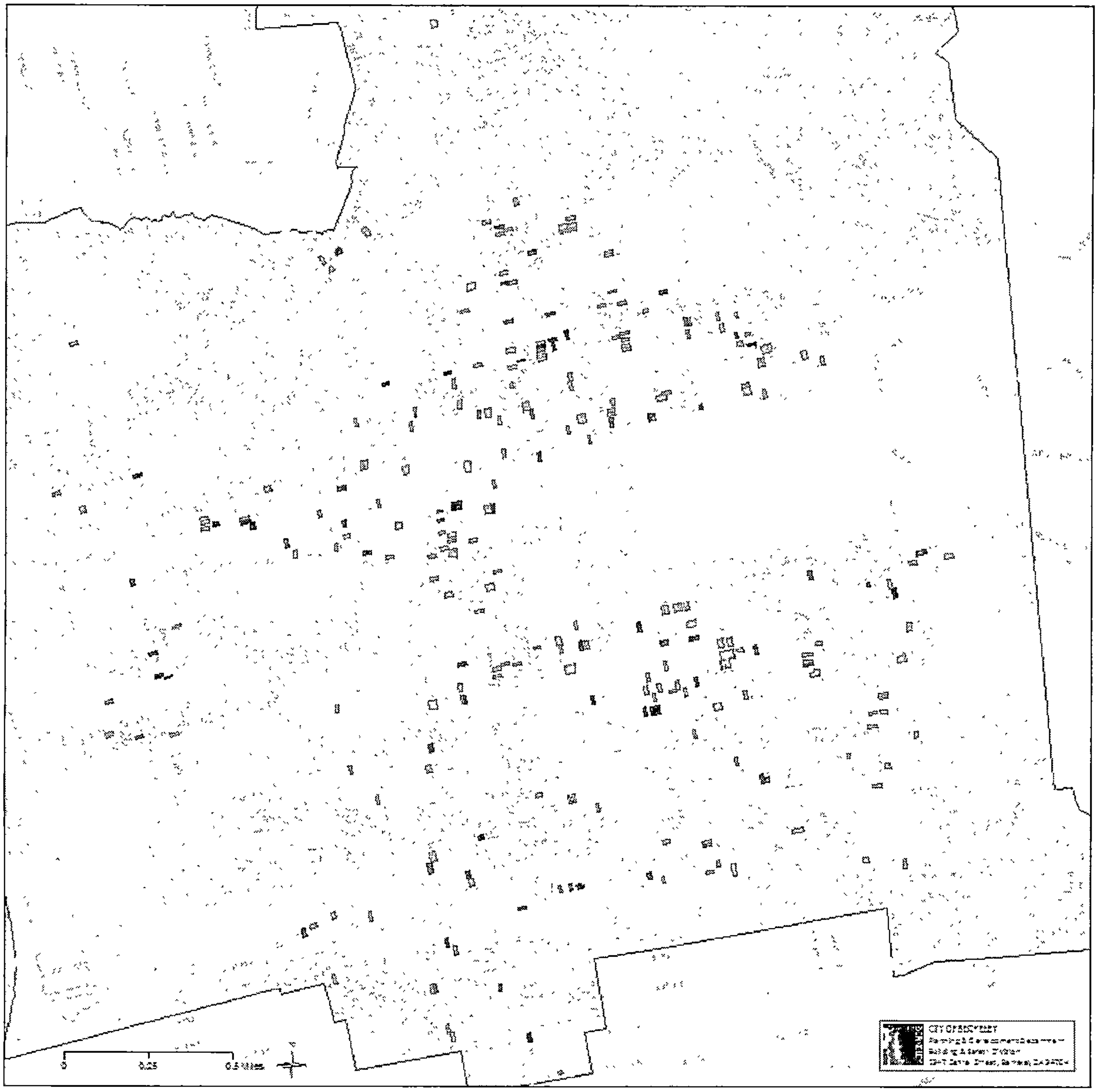
Table 1. Berkeley Soft-Story Building Status as of December 2018

Number of buildings	Percent*	Status
204	61	Retrofit Complete
34	10	Permit
30	9	Applied for Permit
6	2	Not Compliant or Received Extension
58	17	Removed from Inventory for Other Reasons
332	*100%*	*Total buildings identified as soft-story*

*Due to rounding, percentages do not add up to 100 percent.

Map 1 below shows the retrofit status of soft story buildings subject to mandatory retrofit, as of December 2018. Green symbols depict parcels with retrofit buildings, blue indicates parcels containing one or more buildings with permits issued or currently under review, and red shows parcels with extensions filed or buildings out of compliance.

Map 1. Status of Soft Story Buildings Subject to Mandatory Retrofit (December 2018)



RETROFIT COMPLETED

PERMIT ISSUED OR IN REVIEW

NOT COMPLIANT OR RECEIVED EXTENSIONS

Unreinforced Masonry (URM) Ordinance

Unreinforced masonry (URM) buildings are generally constructed of brick, block, tile, stone, or other types of masonry, and were built prior to modern earthquake-resistant design. During an earthquake, unreinforced masonry walls that were originally built with inadequate reinforcement (embedded steel bars) are susceptible to collapse. In addition, URM buildings often include unreinforced masonry parapets, chimneys, and high brick veneers that tend to disconnect from the building and fall outward, creating a hazard for people below and in some instances causing the building to collapse. Weak or nonexistent connections between the masonry walls and the floors and roofs place occupants, pedestrians, and adjacent buildings in harm's way.

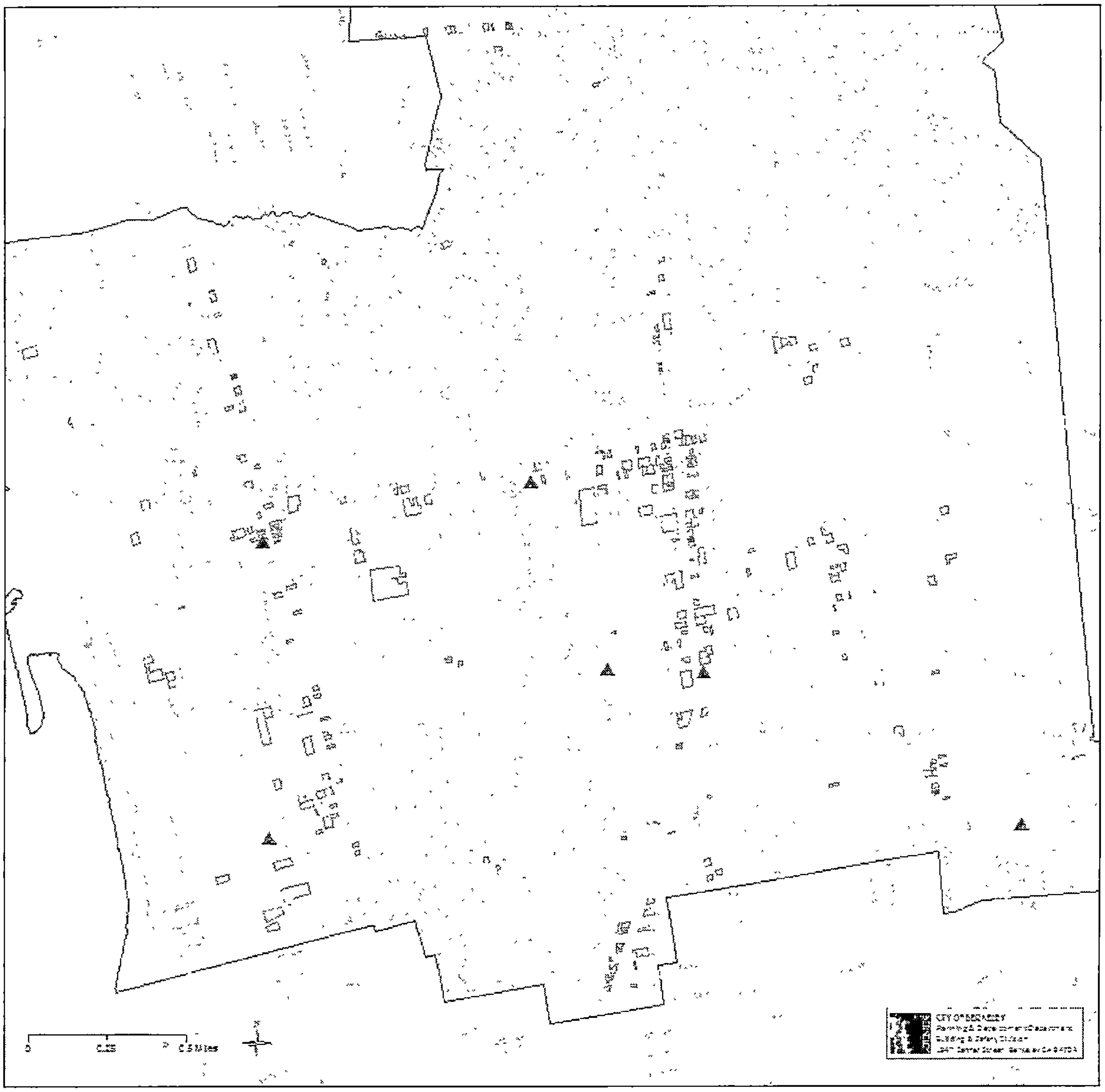
Although unreinforced masonry buildings are no longer constructed today, existing URM buildings can be retrofitted to reduce risks caused by earthquake activity. If these buildings are not retrofitted and suffer major damage in an earthquake, the costs of repair after the earthquake could be prohibitively high and may result in demolition or loss of use.

In response to State law, the City of Berkeley compiled an inventory of unreinforced masonry buildings in 1989, identifying approximately 700 residential and commercial URM buildings that were built prior to 1956. In 1991, the City adopted the Unreinforced Masonry Ordinance 6088-N.S. Subsequent amendments to the ordinance required owners of unreinforced masonry buildings to evaluate their buildings, obtain necessary permits and complete seismic retrofits by 2001.

Of the approximately 700 buildings originally included in the City's unreinforced masonry (URM) inventory, hundreds were removed from the list after owners provided evidence the buildings adequately met building standards or that the buildings were not unreinforced masonry structures. Of the original list, roughly 99% have been seismically retrofitted, demolished or demonstrated to have adequate reinforcement. As of August 2018, six buildings are still required to retrofit in order to avoid further penalties. Five of the six building owners have applied for retrofit permits.

Map 10 shows the unreinforced masonry (URM) inventory as of June 2018. Parcels in yellow contain buildings that are compliant with the Unreinforced Masonry Ordinance 6088-N.S. Red triangular symbols denote unreinforced masonry buildings still subject to mandatory retrofit, including those currently in the permitting process.

Map 2. Berkeley Parcels with Unreinforced Masonry Building Types (June 2018)



COMPLIANT WITH URM ORDINANCE

▲ NOT COMPLIANT WITH URM ORDINANCE (INCLUDING THOSE IN PERMIT REVIEW PROCESS)

C.1.a Financial Incentives

Retrofit Grants

In early 2017, the Building and Safety Division developed a new Retrofit Grants program with funding from a Hazard Mitigation Grant from the Federal Emergency Management Agency (FEMA) and the California Governor's Office of Emergency Services (Cal OES). In the first round of the Retrofit Grants program, the City offered grants of up to $25,000 to owners of soft story buildings with five or more units, and unreinforced masonry buildings. During the first round of the grant program, owners of 48 buildings containing over 400 housing units applied for grants, amounting to over $1 million in federal funding.

The Building and Safety Division launched the second round of grant funding in May 2018, offering design and construction grants to owners of other seismically vulnerable buildings: rigid wall - flexible diaphragm buildings (RWFD) with walls made of concrete or masonry and wood or steel roofs, non-ductile concrete buildings (NDC), and soft story buildings with 3-4 residential units and non-residential uses, which are not covered under the mandatory soft story retrofit program. In the second round of the grant program, as of August 2018, owners of 66 buildings applied for an additional $1.3 million in FEMA funding. These buildings contain almost 300 housing units in addition to a variety of retail, commercial, and educational occupancies.

In the spring of 2018, City staff conducted outreach to promote the second round of grant funding and assist owners with the application process. Information packets, including applications, fact sheets about relevant building types and grant program details were mailed to property owners of nearly 1,000 potentially vulnerable buildings. The application deadline for the second phase of the Retrofits Grants Program was June 25, 2018.

Although single-family homes and duplexes were not eligible for this program, other programs are available for property owners and are detailed below.

City Transfer Tax Rebate Program

By ordinance, the City created a program to rebate up to one- third of the transfer tax amount to be applied to earthquake upgrades on homes. The process begins once the homeowner makes seismic safety improvements. When the owner wishes to sell the house and the sale amount has been determined, the buyer and seller place a portion of the real estate transfer tax amount in an escrow account to be drawn down after improvements are complete. Since July 2002, the City has distributed over $12 million to homeowners through this program.

Table 2. Transfer Tax Rebate Program

Fiscal Year	Property Transfer Rebates	Total Funds Issued
2003	382	$1,133,047
2004	467	$ 1,539,738
2005	385	$ 1,459,510
2006	262	$ 1,168,654
2007	144	$ 611,433
2008	152	$ 681,002
2009	138	$ 533,061
2010	150	$ 592,539
2011	157	$ 593,974
2012	166	$ 623,502
2013	159	$ 766746
2014	164	$ 798,370
2015	138	$ 773,697
2016	147	$ 859,831
2017	55	$ 423,586
2018[1]	31	$ 165,010
Total (FY 2003-2018)	3,097	$12,723,700

Earthquake Brace + Bolt

The City participates in the Earthquake Brace + Bolt (EBB) program, a grant program administered by the California Earthquake Authority, providing grants of up to $3,000 for seismic retrofits of owner-occupied residential buildings with 1-4 dwelling units.

The EBB program provides incentives to homes most vulnerable to severe damage in an earthquake, typically those built before 1979 with raised foundations and unbraced "cripple walls," the wood-framed walls which surround the crawl space. Bracing the cripple walls with plywood and using

[1] As of September 2018. Taxpayers may still claim seismic-related refunds for properties purchased in FY 2018.

anchor bolts to improve the connection between a home's wood framing and its foundation are seismic improvements that can help reduce potential damage to a home during an earthquake.

The program supplements other programs to subsidize or finance seismic improvements in Berkeley homes; these programs can be used in combination or separately.

Property Assessed Clean Energy (PACE)
Additionally, the PACE program provides financing for seismic improvements, and allows owners to pay back costs over time on their property tax bills with no upfront costs.

C.1.b Expanded Inventory of Seismically Vulnerable Buildings
With the launch of the Retrofit Grants Program, staff conducted extensive research to update and refine the City's inventory of seismically vulnerable buildings. In addition to soft story buildings not currently subject to mandatory retrofit such as those with 3-4 residential units or commercial uses, Berkeley has numerous non-ductile concrete and tilt-up or other rigid wall-flexible diaphragm (RWFD) buildings. These additional building types may also be highly susceptible to adverse effects from earthquakes.

Although no ordinance currently requires property owners of these building types to retrofit, the City of Berkeley has encouraged owners to apply for grant money under the City's Retrofit Grants Program.

Non-Ductile Concrete Buildings
Non-ductile concrete buildings built prior to the mid-1970's and modern seismic code standards have performed very poorly in recent earthquakes, and have resulted in catastrophic collapses. In older concrete buildings, the detailing and construction of the reinforcing steel may be inadequate to safely resist large seismic forces caused by ground motions on these heavy structures. The most vulnerable buildings contain elements like columns, wall piers, and joints of beams and slabs that can fail in an earthquake. These buildings are considered "non-ductile" (i.e. brittle) concrete buildings and pose a high risk during a major earthquake. Retrofits of these buildings can vary widely in terms of scope and level of difficulty, and are often expensive to retrofit or rebuild.

Rigid Wall-Flexible Diaphragm (RWFD) Buildings Including Tilt-Up Buildings
Tilt-up or other rigid wall-flexible diaphragm building types are typically one or two story commercial buildings with reinforced concrete or reinforced masonry (brick or concrete block) walls. A "tilt-up" building is a specific type of building with precast concrete walls and is distinguished by its method of construction. RWFD have "flexible" roof diaphragms that consist of wood or steel beams, trusses, or rafters with wood sheathing or metal decking above. They may also have flexible diaphragms at intermediate floor levels. These buildings commonly include warehouses, manufacturing facilities, large retail stores, and other similar structures. The most common deficiency is an inadequate connection between the rigid walls and the roof (and floors) leading walls to pull away and collapse during ground shaking. Buildings designed under codes that predated the 1998 California Building Code are of primary concern.

Soft Story Buildings Not Subject to Mandatory Retrofit
Similar to Soft Story buildings subject Berkeley Municipal Code Section 19.39.110, those with only 3-4 unit or commercial uses are also vulnerable to collapse in the event of an earthquake due to weak lateral load resisting systems.

Since the initial phase of the project, the grant program has expanded to include Soft Story buildings with 3-4 residential units, and some mixed-use or nonresidential Soft Story buildings that are not mandated to retrofit.

Process for Updating the Inventory of Seismically Vulnerable Buildings

The City has worked diligently to update and broaden its inventory of seismically vulnerable buildings to include non-ductile concrete buildings, rigid wall-flexible diaphragm buildings, and soft story buildings with 3-4 residential units or commercial uses. This effort began with extensive staff research to identify vulnerable buildings using City and other data sources.[ii] It was followed by a field study with the Earthquake Engineering Research Institute (EERI) to assess a portion of the newly identified non-ductile concrete and rigid-wall flexible-diaphragm buildings[iii], and a "virtual survey" to identify potential soft story buildings.[iv]

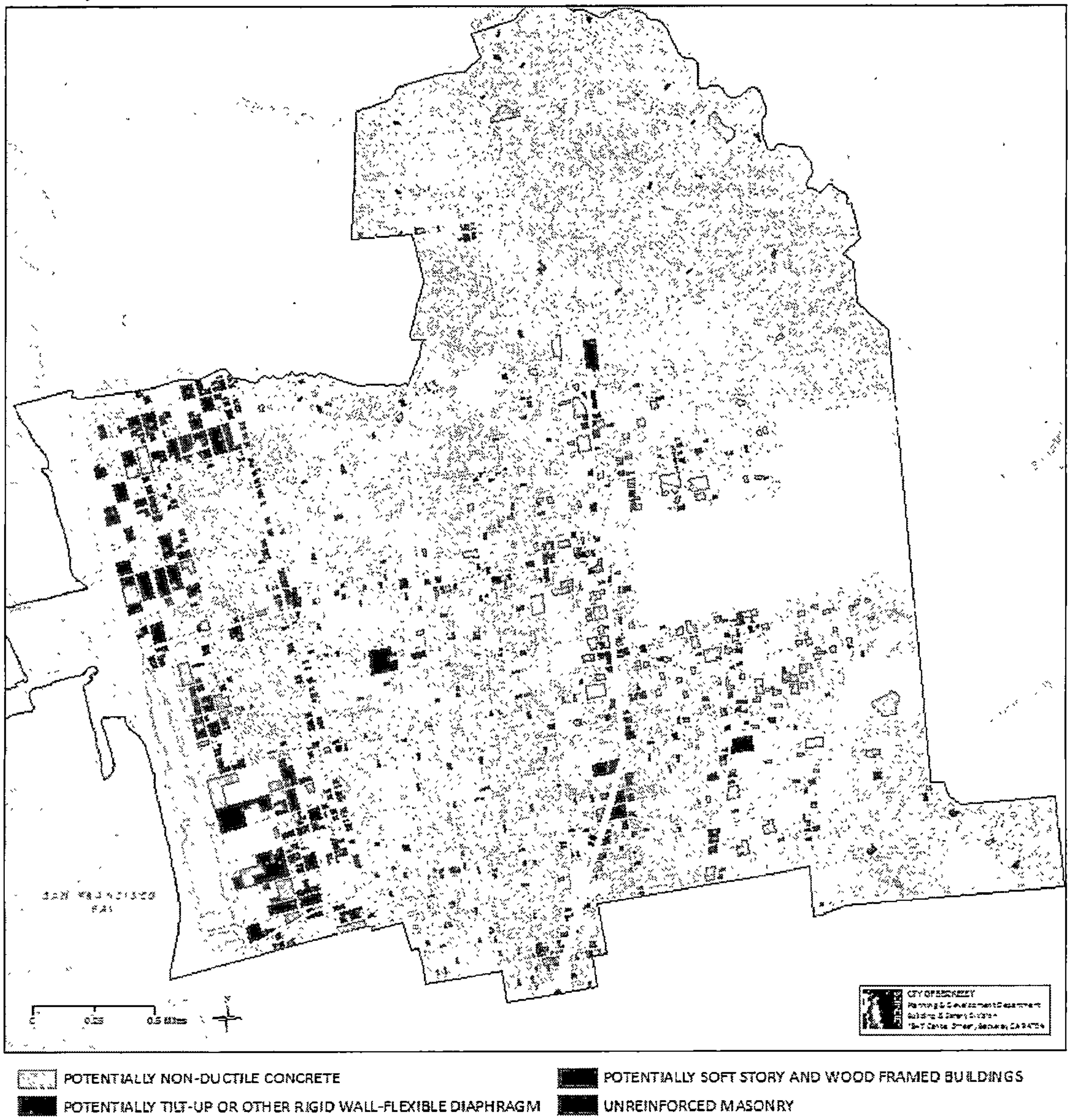
Updated Inventory of Seismically Vulnerable Buildings (2018)

As of June 2018, the City identified 1,047 potentially seismically vulnerable buildings that did not already appear on the soft story or URM inventories. The updated inventory includes 230 potentially non-ductile buildings and nearly 550 buildings that may be rigid wall-flexible diaphragm, including tilt-ups. The City has also added to the inventory approximately 240 soft story buildings not subject to mandatory retrofit under Chapter 19.39 of the Berkeley Municipal Code.

Map 11 shows Berkeley's updated Inventory of Seismically Vulnerable buildings, as of June 2018. Soft story buildings are somewhat evenly spread throughout the City. Potentially non-ductile concrete buildings and rigid wall-flexible diaphragm buildings are more heavily concentrated along commercial corridors and west of San Pablo Avenue. Non-ductile concrete buildings are also clustered in central Berkeley, and near the UC Berkeley Campus. Soft story buildings are depicted in blue, non-ductile concrete buildings in orange, rigid wall-flexible diaphragm buildings in purple, and unreinforced masonry buildings in red.

This map reflects properties that are eligible for the Cal OES/FEMA Grant Program.

Map 3. Updated Inventory of Potentially Seismically Vulnerable Buildings (June 2018)



C.1.h. Fire Risk Reduction

The City, working together with key partners, is using a comprehensive strategy to aggressively mitigate Berkeley's wildland-urban interface (WUI) fire hazard. These approaches include prevention through development regulations; natural resource protection through vegetation management; improvement of access and egress routes; and infrastructure maintenance and improvements to support first responders' efforts to reduce fire spread.

Hazardous Fire Area Zones

Since before the 1920s, the City of Berkeley has established and adjusted fire zones in Berkeley. While the zones were initially established to address urban fire issues, they have evolved to designate the City's WUI fire hazard. Currently, the Berkeley Fire Department has divided the city into Fire Zones 1, 2, and 3, designated in order of ascending fire risk. Fire Zones 2 and 3 are in the hills area of the City and have the strictest fire prevention standards for issues such as building materials for new structures. The City also enforces vegetation management measures in these areas.

Fire Inspections

The Berkeley Fire Department annually inspects designated high fire risk zones for hazards such as excess vegetation. The Fire Department inspects over 1,400 parcels in Fire Zones 2 and 3, in addition to complaint-driven inspections throughout the City. Residents must clear combustible brush and vegetation adjacent to building property lines and roadsides. Tree branches must be cleared from any chimney, stovepipe or overhang over a building. All leaves, needles, and dead vegetation must be swept from roofs. This program is done in cooperation with the East Bay Regional Park District, which has programs to limit combustible material in the wildland-urban interface zone on its property.

Vegetation Management Programs

The City also runs a number of vegetation management programs to reduce fuel loads, including:

- The Fire Fuel Chipper Program, a popular yard waste collection service. The Program serves properties in the hills from June through September each year. Since 2014, over 100 tons of vegetation was collected and recycled, on average, each year.[v]
- A fire fuel abatement program on public land. This Program was maintained in order to reduce fire fuel on public property. From May to mid-August each year, an average of 125 tons of debris are removed from approximately 98 public sites, including parks, pathways and landscaped medians.[vi]
- The Fire Fuel Debris Bin Program is coordinated by the Department of Public Works' Zero Waste Division, which delivers and removes 30 yard roll-off boxes from requesting neighborhoods. This effort yields an average of 132 tons of plant debris per year.[vii]
- Additionally, 30,000 tons of residential and commercial plant debris and commercial food waste[viii] is collected each year through weekly curbside collection and converted to compost.
- The City of Berkeley's Zero Waste Division has expanded staffing to include a full-time Recycling Program Manager, and is working to hire additional field representatives to help educate the community about its vegetation management programs. Additionally, the Division is performing a Feasibility Study to reimagine the City's Solid Waste and Recycling Transfer

Station to achieve its goal of Zero Waste. This re-envisioned facility will help to support outreach staff in their efforts to promote vegetation management programs.

C.1.i. Community Readiness

Community Emergency Response Team (CERT) Program

CERT classes are offered free through the Fire Department to all Berkeley residents and those who work in Berkeley. Trained volunteers can help douse small fires, conduct light search and rescue, help with first aid, and communicate with City emergency responders. Neighborhoods have organized response teams and conducted drills with City emergency responders.

Community Resilience Center Program (CRC)

The CRC Program's goal is to enhance the resilience of the people of Berkeley by strengthening the organizations they depend on day-to-day and providing disaster preparedness outreach and training through organizations they know and trust. CRC organizations agree to host trainings and participate in disaster preparedness-related events that are customized to fit their audiences. In return for hosting training they receive a cache of emergency supplies to help them serve their community following a disaster. The City selected CRC organizations based on their connection to Berkeley community members who have not been reached by the City's existing preparedness programs. Current Community Resilience Centers are:

- Ed Roberts Campus
- Berkeley Youth Alternatives
- McGee Baptist Church
- La Pena Cultural Center
- Harriet Tubman Terrace Apartments
- YMCA Head Start
- Easy Does It Emergency Services
- Oregon Park Apartments
- Berkeley Humane

Neighborhood Caches

The Disaster Cache Program incentivizes community-building for disaster readiness. To date, the City has awarded caches of disaster response equipment to neighborhoods, congregations, and UC Berkeley Panhellenic groups that have undertaken disaster readiness activities.

Community Oversight

The Disaster and Fire Safety Commission closely monitors the City's disaster readiness efforts. Members are safety advocates appointed by the Mayor and City Council.

C.1.j. State and Federal Programs

Many City ordinances and programs are based on State requirements. The State has numerous laws that regulate issues ranging from hospital seismic safety to coastal development. The table below highlights important State laws related to hazards, and describes how Berkeley complies with these laws.

Table 3. State Mitigation Requirement and Berkeley Implementation

Statewide Requirements	Berkeley Implementation
Mandatory Building Code. The State requires all communities to enforce the State-mandated building code. The building code applies to new buildings and additions, renovations and remodeling of existing buildings. The effectiveness of designs based on the code to resist earthquakes has improved incrementally over time. The code is not applied retroactively, meaning that building owners do not have to retrofit existing buildings to improve earthquake, fire or flood resistance unless the work proposed exceeds previously-defined thresholds. Certain types of buildings designed to early codes have characteristics that make them vulnerable to collapse in catastrophic earthquakes.	Berkeley enforces the State building code with additional local provisions for seismic and fire safety. The City has adopted the 2016 California Building Code and 2016 California Residential Code. Berkeley's application of WUI fire standards exceeds current State requirements.
Essential Services Buildings. State law requires that new essential services buildings, such as police, fire, and emergency operation and communications centers, meet a higher safety standard than other buildings. The standards include backup utilities and design and construction checks by inspectors following State guidelines.	The Public Safety Building, which houses the 9-1-1 emergency communications center and Emergency Operations Center, along with all seven fire stations, the Fire Warehouse and the Ratcliff building, have all been built or retrofitted to meet essential services requirements.
Safety Element and General Planning Requirement. State law requires all cities and counties to prepare, adopt and keep current a general plan. Part of the plan is the "Safety Element" which defines the community approach to disaster preparedness and mitigation.	Berkeley completed updates to the General Plan, including the Disaster Preparedness and Safety Element, in 2003. One of the plan's key goals is to make a disaster-resilient community. The Safety Element has a mitigation approach and significant policy and action recommendations. The 2004 mitigation plan built directly from the General Plan, and this 2019 update continues to use the General Plan as a strategic guide.

Environmental Review. The California Environmental Quality Act requires that government entities consider the environmental consequences of discretionary decisions having a substantial environmental impact. CEQA guidelines require evaluation of the effect of hazards on development and the resulting consequences for the environment. On occasion, certain emergency safety projects are exempted from the CEQA process.	The City of Berkeley complies with State CEQA requirements.
Fault Zones. Alquist-Priolo Earthquake Fault State requirements prohibit construction of public schools and buildings within the designated fault zones. Houses with three or fewer units are exempt from these provisions. Real estate law requires disclosure of the fault zone at the time of sale, and requires zone maps to be available for review by the public.	The California Geological Survey created maps that delineate a ¼-mile-wide fault zone through the east side of the city, where the Hayward Fault is located. The Hazard Analysis of this mitigation plan replicates these maps. Because of the well- defined surface expression of this fault, it is reasonable to expect ground surface rupture in this area during future earthquakes.
Seismic Hazards Maps. The California Geologic Survey mapped seismic zones where earthquake-induced landslides and liquefaction are likely. The State requires site-specific investigations for new building in these zones.	Seismically-induced landslide risk maps are available in the Hazard Analysis of this plan. The City enforces State requirements by requiring site-specific investigations and feasible mitigation measures.
Bayfront Development. The City of Berkeley abuts San Francisco Bay. All land inundated by the highest tides is within the jurisdiction of the San Francisco Bay Conservation and Development Commission (BCDC).	Developments within the City-owned and -operated Berkeley Marina require a permit from BCDC. The BCDC's Engineering Criteria Review Board subjected the restaurants, harbormaster building and piers to rigorous independent review before construction. Full consideration is given to the effects of deep- saturated, bay mud soils and fill material. All development in this zone must be elevated one foot over flood levels.

Hospital Seismic Safety Act. The Office of Statewide Health Planning and Development (OSHPD) regulates hospital construction and renovation. By 2013, all hospital buildings built before 1973 must be replaced or retrofitted so they can reliably survive earthquakes without collapsing or posing threats of significant loss of life. By 2030, all existing hospitals (including those built after 1973) must be seismically evaluated and retrofitted, if needed, so they are reasonably capable of providing services to the public after disasters.	There is one acute care hospital in Berkeley, Alta Bates, owned and operated by the Sutter Health Corporation. The corporation is planning to close by 2030.
Unreinforced Masonry Building Law. The State required all jurisdictions to identify unreinforced masonry (URM) buildings, to notify owners regarding the expected performance of these buildings, and to adopt a plan to deal with the threat.	Berkeley identified 700 URMs and designated a mandatory retrofit ordinance. Of the original list, roughly 99% have been seismically retrofitted, demolished or demonstrated to have adequate reinforcement.
Disclosure of Earthquake Risk. Four State laws work in tandem with State real estate requirements that mandate full disclosure of information pertinent to building purchase decisions. Owners of homes built before 1960 and certain commercial buildings are required to provide information on seismic vulnerability. Sellers must also disclose if the parcel is located in a mapped fault zone or seismic hazard area.	The City of Berkeley complies with this State law.
Emergency Response Plans. In the wake of the 1991 Tunnel Fire, the State requires that all jurisdictions practice the Standardized Emergency Management System (SEMS), a uniform approach to disaster response based on the fire service's Incident Command System (ICS).	The City complies with all State requirements.

Field Act. Originally passed in 1933, the Field Act regulates the design, construction and renovation of public school buildings, and the inspection of existing school buildings. Many subsequently adopted State laws, amendments to the Field Act, and supplementary laws, call for additional safety measures for all public K- 12 schools in the state. California has the most stringent safety codes for school buildings in the U.S.	All public schools have been upgraded to the standards of the Field Act and its amendments.

C.2 *National Flood Insurance Program*

Berkeley's creek flooding exposure is assessed through the National Flood Insurance Program (NFIP), which makes federally-backed flood insurance available to homeowners, renters, and business owners in participating communities. Participants in the NFIP must regulate development in floodplain areas in accordance with NFIP criteria.

Berkeley has participated in the NFIP since September 1, 1978 and is currently in good standing with the Program. NFIP compliance is monitored by FEMA regional staff and by the California Department of Water Resources under a contract with FEMA.

As part of Berkeley's effort to comply with the requirements of the NFIP, Berkeley has adopted various floodplain management measures. Thanks to the fact that the City has abided by and enforced federal flood insurance program requirements since the 1970s, flood insurance claims have been extremely low.

Berkeley's Flood Zone Development Ordinance regulates development in areas identified in the Flood Insurance Study and Flood Insurance Rate Maps.

Current Flood Insurance Rate Maps are presented in this Plan's Hazard Analysis (Element B.8.c *Exposure and Vulnerability* to review maps in detail.)

To file insurance claims with FEMA for flood damage, owners of parcels in this area must have FEMA flood insurance, and comply with the terms and conditions of the insurance. Few Berkeley homeowners are known to carry flood insurance, presumably because of negligible flood damage in recent decades, so those losses would be borne almost entirely by building owners.

The City last updated Berkeley Municipal Code (BMC) Chapter 17.12: *Flood Zone Development Ordinance* in September 2009 to maintain Berkeley's continued compliance with FEMA National Flood Insurance Program requirements. The Ordinance regulates all publicly- and privately-owned land within the areas of special flood hazard. BMC 17.12 automatically incorporates new FIRM panels. BMC 17.12 establishes the Director of the Public Works Department as the Floodplain Administrator for the City and addresses standards for construction, utilities, subdivisions, manufactured homes and recreational vehicles.

The City of Berkeley will maintain participation in the National Flood Insurance Program under the Public Works Department's Engineering Division and the Planning and Development Department's Land Use Planning and Building and Safety Divisions. The Supervising Civil Engineer will work with FEMA and other partners to continue to update and revise flood maps for the City, and to continue to incorporate FEMA guidelines and suggested activities into City plans and procedures for managing flood hazards. The Zoning Officer and Building Official are responsible for applying BMC requirements to private property projects.

C.3 *Disaster Mitigation Goals and Objectives*

Berkeley will focus on three goals to reduce and avoid long-term vulnerabilities to the hazards identified in Element B: *Hazard Analysis*:

1. The City will evaluate and strengthen all City-owned properties and infrastructure, particularly those needed for critical services, to ensure that the community can be served adequately after a disaster.
2. The City will establish and maintain incentive programs and standards to encourage local residents and businesses to upgrade the hazard resistance of their own properties.
3. The City will actively engage other local and regional groups to collaboratively work towards mitigation actions that help maintain Berkeley's way of life and its ability to be fully functional after a disaster event.

Five objectives guide the mitigation strategy:

A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts.

B. Increase City government's ability to serve the community during and after hazardous events by mitigating risk to key City functions.

C. Protect Berkeley's historically underserved populations from the impacts of hazardous events by applying an equity focus, including equal access, to mitigation efforts.

D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.

E. Preserve Berkeley's unique character and values from being compromised by hazardous events.

C.4 *Overview of Actions*

This plan identifies and analyzes 27 mitigation actions to reduce the impacts from hazards described in Element B: *Hazard Analysis.* This suite of actions addresses every natural hazard posing a threat to Berkeley, with an emphasis on new and existing buildings and infrastructure.

Plan actions were developed through a multi-step, broadly-inclusive process. The City convened an interdepartmental planning team, which reviewed the actions identified in the 2014 mitigation plan, as well as Berkeley's progress on these actions since 2014. This Team then revised these actions, created new actions, and established priorities to guide Berkley's mitigation strategy for the next five years. At a meeting in December 2018, staff presented proposed 2019 actions to Institutional Community Partners, who offered feedback and identified opportunities for collaboration to further strengthen these actions. Staff revised actions and incorporated them into the 2019 First Draft Plan, which went through further public review. Additional detail on the process used to identify 2019 actions is provided in Element A: *Planning Process*.

Tables 4, 5, and 6 below summarize all of the actions. The tables group actions by their priority level (see Element C.5.a for details on prioritization of actions), and identify the hazard(s) and each action addresses.

Table 4. ***High-Priority Actions in mitigation strategy***

Name	Action	Hazards
Building Assessment	Continue appropriate seismic and fire safety analysis based on current and future use for all City-owned facilities and structures.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat
Strengthen and Replace City Buildings	Strengthen or replace City buildings in the identified prioritized order as funding is available.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat
Buildings	Reduce hazard vulnerabilities for non-City-owned buildings throughout Berkeley.	Earthquake Wildland-Urban Interface Fire Landslide Floods Climate Change Extreme Heat
Retrofit Grants	Implementation of the Retrofit Grants Program which helps Berkeley building owners increase safety and mitigate the risk of damage caused by earthquakes	Earthquake
Soft Story	Continued Implementation of the Soft Story Retrofit Program, which mandates seismic retrofit of soft story buildings with 5+ residential units.	Earthquake

Name	Action	Hazards
Unreinforced Masonry (URM)	Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings.	Earthquake
Concrete Retrofit Ordinance Research	Monitor passage and implementation of mandatory seismic retrofit ordinances for concrete buildings in other jurisdictions to assess best practices.	Earthquake
Gas Safety	Improve the disaster-resistance of the natural gas delivery system to increase public safety and to minimize damage and service disruption following a disaster.	Earthquake Wildland-Urban Interface Fire Landslide Tsunami
Fire Code	Reduce fire risk in existing development through fire code updates and enforcement.	Wildland-Urban Interface Fire
Vegetation Management	Reduce fire risk in existing development through vegetation management.	Wildland-Urban Interface Fire Climate Change
Hills Pedestrian Evacuation	Manage and promote pedestrian evacuation routes in Fire Zones 2 and 3.	Earthquake Wildland-Urban Interface Fire
Hills Roadways and Parking	Improve responder access and community evacuation in Fire Zones 2 and 3 through roadway maintenance and appropriate parking restrictions.	Earthquake Wildland-Urban Interface Fire
Undergrounding	Coordinate with PG&E for the construction of undergrounding in the Berkeley Hills within approved Underground Utility Districts (UUDs).	Earthquake Wildland-Urban Interface Fire
EBMUD	Work with EBMUD to ensure an adequate water supply during emergencies and disaster recovery.	Earthquake Wildland-Urban Interface Fire
Extreme Heat	Reduce Berkeley's vulnerability to extreme heat events and associated hazards.	Climate Change Extreme Heat

Name	Action	Hazards
Hazardous Materials	Mitigate hazardous materials release in Berkeley through inspection and enforcement programs.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change
Air Quality	Define clean air standards for buildings during poor air quality events and use those standards to assess facilities for the Berkeley community.	Wildland-Urban Interface Fire Climate Change Extreme Heat
National Flood Insurance Program (NFIP)	Maintain City participation in the National Flood Insurance Program.	Floods
Hazard Information	Collect, analyze and share information with the Berkeley community about Berkeley hazards and associated risk reduction techniques.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat
Partnerships	Coordinate with and encourage mitigation actions of key City partners.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat

Table 5. Medium-Priority Actions in mitigation strategy

Name	Action	Hazards
Severe Storms	Reduce Berkeley's vulnerability to severe storms and associated hazards through proactive research and planning, zoning regulations, and improvements to stormwater drainage facilities.	Landslide Floods Climate Change
Energy Assurance	Implement energy assurance strategies at critical facilities.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat
Climate Change Integration	Mitigate climate change impacts by integrating climate change research and adaptation planning into City operations and services.	Earthquake Wildland-Urban Interface Fire Landslide Tsunami Climate Change Extreme Heat
Sea Level Rise	Mitigate the impacts of sea level rise in Berkeley.	Climate Change
Water Security	Collaborate with partners to increase the security of Berkeley's water supply from climate change impacts.	Climate Change

Table 6. Low-Priority Actions in mitigation strategy

Name	Action	Hazards
Tsunami	Mitigate Berkeley's tsunami hazard.	Tsunami
Streamline Rebuild	Streamline the zoning permitting process to rebuild residential and commercial structures following disasters.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami

C.5 *Details of Actions*

The 2019 LHMP Mitigation Strategy is detailed below. First, the document describes the process used to prioritize the actions. Next, the document overviews the constituent parts of each action, including responsibility, potential funding sources, and expected timeframes. Third, each action is presented in detail.

C.5.a Action Prioritization

The City incorporated eight key factors into the prioritization strategy used for 2019 mitigation actions. These criteria are described below and summarized in the table that follows.

Key Factors

1. Support of goals and objectives

Actions that support multiple goals and objectives are prioritized.

2. Cost/benefit relationship

A detailed benefit cost analysis is required for FEMA grant eligibility. A less formal approach is taken here to weigh the relative costs and benefits of various actions. Because some projects may not be implemented for up to 10 years, the associated costs and benefits may change significantly over time. The following parameters were used to establish high, medium and low costs and benefits.

Costs:

- *High*: Existing funding will not cover the cost of the project; implementation would require new revenue through an alternative source (for example, bonds, grants, and fee increases)
- *Medium*: The project could be implemented with existing funding but would require a reapportionment of the budget or a budget amendment, or the cost of the project would have to be spread over multiple years
- *Low*: The project could be funded under the existing budget. The project is part of or can be part of an ongoing existing program.

Benefits:

- *High*: Project will provide an immediate reduction of risk exposure for life of property.
- *Medium*: Project will have a long-term impact on the reduction of risk exposure for life of property, or project will provide an immediate reduction in the risk exposure for property.
- *Low*: Long-term benefits of the project are difficult to quantify in the short term.

Using this approach, projects with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly.

3. Funding availability

Actions with secured funding are prioritized.

4. Hazards addressed

Actions addressing the Plan's hazards of greatest concern (earthquake and wildland-urban interface fire) are prioritized.

5. Public and political support

Actions with public and political support are prioritized.

6. Adverse environmental impact

Actions with low environmental impact are prioritized.

7. Environmental benefit

Actions that provide an environmental benefit are prioritized.

8. Timeline for completion

Actions that are ongoing, or that can be completed in the short-term, are prioritized.

- Ongoing: Currently being funded and implemented under existing programs
- Short-term: To be completed in 1-5 years
- Long-term: To be completed in more than 5 years

The following table summarizes prioritization criteria. Using these factors, mitigation actions have been divided into high, medium, and low priorities. Some actions may not meet all criteria within their prioritization category. In these cases, the City's Core Planning Team assigned the most suitable category.

Table 7. 2019 Action Prioritization Structure

Factors	Priority		
	High	**Medium**	**Low**
1. Support of goals and objectives	Supports multiple goals and objectives	Supports goals and objectives	Will mitigate the risk of a hazard
2. Cost/benefit relationship[2]	Benefits exceed cost	Has benefits that exceed costs	Benefits do not exceed the costs or are difficult to quantify
3. Funding availability[3]	Funding has not been secured, but the action is grant eligible under identified grant programs	Funding has not been secured, but the action is grant eligible under identified grant programs	Funding has not been secured, and a grant funding source has not been identified
4. Hazards addressed	Addresses hazards of greatest concern	May not address hazards of greatest concern	Addresses hazards identified in Hazard Analysis
5. Public and political support	Has public and political support	Has public and political support	May not have public and political support
6. Adverse environmental impact	No environmental impact	Low environmental impact	May not have a low environmental impact
7. Environmental benefit	Environmental benefit	No environmental benefit	No environmental benefit
8. Timeline for completion	Can be completed in the short term (1 to 5 years) or is ongoing	Can be completed in the short-term, once funding is secured	Timeline for completion is long-term (6-10 years)

[2] Actions that address other hazards, but for which benefits exceed costs, may also be considered high priority.
[3] Medium priority projects will become high priority projects once funding is secured.

C.5.b Details of Actions

Mitigation actions identified by the Berkeley community are presented in the following pages. Actions are presented per their high, medium- or low-priority designation.

The following information is provided for each action:

- *Action Title*: Short title to identify the action
- *Action*: Proposed action
- *Proposed Activities*: Specific projects or efforts that support the action
- *Related Natural Hazard(s)*: Lists hazards whose impacts would be mitigated by the action
- *Associated LHMP Objective(s)*: Mitigation objectives that the action supports
- *Related Policies from the General Plan or Climate Action Plan*: General Plan or Climate Action Plan policies that the action supports
- *Lead Organization(s) and Staff Lead(s)*: City departments and divisions, along with particular City staff positions, which will be responsible for implementing and administering the action
- *Priority*: High, Medium or Low priority assigned to the action using criteria outlined in Appendix E: *Prioritization Structure*
- *Timeline*: Outlines expected timeframes for completion of the action
- *Additional Resources Required*: Identifies if funding is not yet available to complete the action
- *Potential Funding Sources*: Identifies potential funding sources to complete the action. Includes all sources that could possibly fund any element of the action, including staff time, contracted work, equipment purchase, etc. **Note: Funding allocations are made through the City-wide budget process. Listing a specific potential funding source does not commit resources to the action.**
- *Activity Type(s)*: If the action could be eligible for federal mitigation grant funding, identifies federally-defined activity type for grant purposes

C.5.b.i High-Priority Actions

2019 **Building Assessment**	**Continue appropriate seismic and fire safety analysis based on current and future use for all City-owned facilities and structures.**
Proposed Activities	a) Continue analysis of structures supporting critical emergency response and recovery functions, and make recommendations for structural and nonstructural improvements. b) Continue to prioritize analysis of remaining structures based on occupancy and structure type, taking historic significance into consideration. Use analysis to make recommendations for structural and nonstructural improvements. c) Continue to integrate unsafe structures into a prioritized program for retrofit or replacement.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. B. Increase City government's ability to serve the community during and after hazardous events by mitigating risk to key City functions.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-10, Action B General Plan Policy S-20, Actions G and H General Plan Policy UD-7, Actions A and B General Plan Policy UD-12, Actions A and C

Lead Organization(s) and Staff Lead(s)	Public Works Department: Facilities Division Staff Lead: Supervising Civil Engineer (for facilities)
Priority	High
Timeline	Ongoing
Additional Resources Required	Resources have been identified to perform some of this work; however, additional resources could allow for more facilities and structures to be analyzed in the coming five years.
Potential Funding Sources	General Fund T1 Bond

2019 **Strengthen or Replace City Buildings**	**Strengthen or replace City buildings in the identified prioritized order as funding is available.**
Proposed Activities	a) Retrofit North Berkeley Senior Center b) West Berkeley Service Center c) Old City Hall d) Veterans Memorial Building e) Live Oak Community Center f) Seek funding to seismically strengthen or replace additional City buildings in a prioritized order.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat

Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. B. Increase City government's ability to serve the community during and after hazardous events by mitigating risk to key City functions. C. Preserve Berkeley's unique character and values from being compromised by hazardous events.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-20, Action H General Plan Policy UD-12, Actions A and C
Lead Organization(s) and Staff Lead(s)	Public Works Department – Engineering Division Staff Lead: Supervising Civil Engineer (for facilities) Parks, Recreation and Waterfront Department Staff Lead: Department Director
Priority	High
Timeline	North Berkeley Senior Center: Completion in 2010 Other projects: Funding-dependent Live Oak Community Center: Start construction in 2019 (funding-dependent) Frances Albrier Community Center: Funding-dependent Seek funding: Ongoing
Additional Resources Required	North Berkeley Senior Center: No additional resources required West Berkeley Service Center: To be determined Old City Hall retrofit: To be determined Veterans Memorial Building retrofit: To be determined Live Oak Community Center: Additional resources required Frances Albrier Community Center: Additional resources required Seek funding: No additional resources required

Potential Funding Sources	Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP) General Fund T1 Bond Other City-Issued Bonds
Activity Type(s) (Federal Mitigation Grant Funding only)	Mitigation: Structural Retrofitting of existing buildings Mitigation: Nonstructural retrofitting of existing buildings and facilities

2019 Buildings	**Reduce hazard vulnerabilities for non-City-owned buildings throughout Berkeley.**
Proposed Activities	a) Periodically update and adopt the California Building Standards Code with local amendments to incorporate the latest knowledge and design standards to protect people and property against known seismic, fire, flood and landslide risks in both structural and non-structural building and site components. b) Explain requirements and provide guidance to owners of potentially hazardous structures to facilitate retrofit, including owners participating in the Earthquake Brace and Bolt program and those applying for Transfer Tax rebates.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Climate Change Extreme Heat
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. C. Preserve Berkeley's unique character and values from being compromised by hazardous events. D. Connect with residents, community-based organizations,

	institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-15, Action A General Plan Policy S-20, Actions D and E General Plan Policy UD-7, Actions A and B General Plan Policy UD-12, Actions A and C
Lead Organization and Staff Lead	Planning and Development Department – Building and Safety Division (Building Code and Retrofit Guidance) Staff lead: Building Official Planning and Development Department – Office of Energy and Sustainable Development (Earthquake Brace and Bolt Program) Staff lead: Sustainability Planner Finance Department – Revenue Collection Division (Transfer Tax Rebate Program) Staff lead: Revenue Collection Manager
Priority	High
Timeline	Enactment of 2019 Building Code: January 1, 2020 Technical assistance: Ongoing
Additional Resources Required	No additional resources required

2019 **Retrofit Grants**	**Implementation of the Retrofit Grants Program which helps Berkeley building owners increase safety and mitigate the risk of damage caused by earthquakes**
Proposed Activities	a) Assist participating property owners with the grant process, including dissemination of program rules and guidelines. b) Project Manager will: a. Respond to inquiries from owners, tenants, engineers and contractors about the grant

	program, including FEMA compliance procedures and requirements b. Environmental and Historic Preservation Reviews (EHP) for specified projects c. Review plan submittals for compliance with City guidelines and FEMA requirements d. If more funding is secured, conduct outreach to property owners to offer additional *Retrofit Grants* to increase tenant safety
Related Natural Hazard(s)	Earthquake
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. C. Preserve Berkeley's unique character and values from being compromised by hazardous events. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-20, Actions D General Plan Policy S-15, Action A General Plan Policy-17, Action A
Lead Organization(s) and Staff Lead(s)	Planning and Development Department: Building & Safety Division Staff Lead: Program and Administration Manager
Priority	High
Timeline	April 1, 2019: Building Permit deadline for Retrofit Grants applicants August 1, 2019: Deadline for obtaining building permit or permit with a status "ready for issuance" Complete construction within nine (9) months of receiving notification of FEMA approval If a second grant is secured, an additional three-year timeline will be established for that grant.

Additional Resources Required	The Planning and Development Department is seeking additional Hazard Mitigation Grant funding from Cal OES / FEMA.
Potential Funding Sources	Hazard Mitigation Grant Program (HMGP)
Activity Type(s) (Federal Mitigation Grant Funding only)	Mitigation: Structural Seismic Retrofitting of existing buildings

2019 **Soft Story**	**Continued Implementation of the Soft Story Retrofit Program, which mandates seismic retrofit of soft story buildings with 5+ residential units.**
Proposed Activities	a) Continue to inform impacted property owners of the requirement to seismically retrofit their building b) Designated project manager will: a. Respond to inquiries from owners, tenants, engineers, contractors and realtors about the mandatory program, compliance procedures and requirements b. Review plan submittals for soft-story seismic retrofits c. Issue permits and perform field inspections d. Remove retrofitted buildings from the Soft-Story Inventory e. Review appeals to accommodate unique circumstances preventing owners from meeting program requirements; consider time extensions, etc. f. Enforce soft story ordinance; issue citations to owners who are out of compliance.
Related Natural Hazard(s)	Earthquake
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. C. Preserve Berkeley's unique character and values from being compromised by hazardous events.

	D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community. E. Protect Berkeley's historically underserved populations from the impacts of hazardous events by applying an equity focus, including equal access, to mitigation efforts.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-20, Actions B, C, D, E, and F General Plan Policy S-15, Action A
Lead Organization and Staff Lead	Planning and Development Department – Building and Safety Division Staff Lead: Program and Administration Manager
Priority	High
Timeline	January 2017: Deadline for soft-story building owners to submit a permit application for retrofit January 2019 OR two years after permit application: Deadline for soft-story retrofit completion
Additional Resources Required	No additional resources required
Potential Funding Sources	Permit Service Center Enterprise Fund
Activity Type(s) (Federal Mitigation Grant Funding only)	Not eligible for federal mitigation grant funding

2019 **URM**	**Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings.**
Proposed Activities	a) Work with owners of remaining potentially hazardous URM buildings to obtain structural analyses of their buildings and to undertake corrective mitigation measures to improve seismic resistance or to remove the buildings and replace them with safer buildings. b) Apply available legal remedies, including but not limited to citations, to owners who fail to comply with the URM ordinance.
Related Natural Hazard(s)	Earthquake
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-20, Action A
Lead Organization and Staff Lead	Planning and Development Department - Building and Safety Division Staff Lead: Program and Administration Manager
Priority	High
Timeline	Complete all remaining URM retrofits/demolitions by January 2020
Additional Resources Required	No additional resources required
Potential Funding Sources	Permit Service Center Enterprise Fund Hazard Mitigation Grant Program (HMGP)

2019 **Concrete Retrofit Ordinance Research**	**Monitor passage and implementation of mandatory seismic retrofit ordinances for concrete buildings in other jurisdictions to assess best practices.**
Proposed Activities	a) Monitor mandatory seismic retrofit ordinances for concrete buildings passed by other municipalities for effectiveness and best practices b) Communicate and collaborate with other cities and Structural Engineers Association of California (SEAOC) regarding implementation challenges and successes
Related Natural Hazard(s)	Earthquake
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. C. Preserve Berkeley's unique character and values from being compromised by hazardous events. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-10, Action C
Lead Organization(s) and Staff Lead(s)	Planning and Development Department: Building & Safety Division Staff Lead: Program and Administration Manager
Priority	High
Timeline	Monitor effectiveness of mandatory seismic retrofit ordinances for concrete buildings: Ongoing Outreach to other municipalities regarding best practices: Ongoing

Additional Resources Required	No additional resources required

2019 **Gas Safety**	**Improve the disaster-resistance of the natural gas delivery system to increase public safety and to minimize damage and service disruption following a disaster.**
Proposed Activities	a) Maintain a program to provide free automatic gas shutoff valves to community members who attend disaster readiness training. Provide subsidized permit fee waivers for low-income homeowners. b) Promote electrification of buildings, both existing buildings and new construction, to mitigate hazards associated with natural gas usage and the impacts of damage to infrastructure after a hazard occurs.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Tsunami
Associated LHMP Objective(s)	B. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community. E. Protect Berkeley's historically underserved populations from the impacts of hazardous events by applying an equity focus, including equal access, to mitigation efforts.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-12, Action C
Lead Organization(s) and	Fire Department – Office of Emergency Services Staff Lead: Emergency Services Coordinator (Shutoff

Staff Lead(s)	Valve Program) Planning Department – Office of Energy and Sustainable Development (Electrification) Staff Lead: Climate Action Program Coordinator (Electrification)
Priority	High
Timeline	Ongoing
Additional Resources Required	Shutoff Valve Program: No additional resources required Promoting electrification: Additional funding required for implementation
Potential Funding Sources	General Fund Measure GG Special Revenue Fund Ratepayer funds from PG&E or East Bay Community Energy Grants from Energy Foundation, Urban Sustainability Directors Network, California Energy Commission, California Air Resources Board, Bay Area Air Quality Management District, U.S. Department of Energy

2019 **Fire Code**	**Reduce fire risk in existing development through fire code updates and enforcement.**
Proposed Activities	a) Periodically update the Berkeley Fire Code and adopt the California Fire Code with local amendments to incorporate the latest knowledge and State regulations to protect people and property against known risks in both structural and non- structural building and site components. b) Evaluate Fire Prevention Division staffing necessary to adequately perform and enforce required inspections for both Annual and HFA inspections. c) Consider expansion of the number of properties to be included in the Hazardous Fire Area inspection program. d) Explore possibility of a program to inspect vacant lots throughout the city. e) Maintain Fire Department efforts to reduce fire

	risk through inspections: a. Annual building inspections in all Fire Zones b. Hazardous Fire Area inspections c. Multi-unit-residential building inspections in all Fire Zones f) Create a standard for written vegetation management plans for major construction projects in Fire Zones 2 and 3. g) Evaluate inspection procedures and adjust inspection cycle annually based on changing climatic conditions. h) Develop and enforce Fire Code requirement for fire fuel clearance on public roadways.
Related Natural Hazard(s)	Wildland-Urban Interface Fire
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, heat waves, and their secondary impacts. C. Preserve Berkeley's unique character and values from being compromised by hazardous events.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-21: Fire Preventative Design Standards, Action A General Plan Policy S-23: Property Maintenance, Action B General Plan Policy UD-7, Actions A and B General Plan Policy UD-12, Actions A and C Climate Action Plan – Adaptation, Goal 1D, Action 3
Lead Organization(s) and Staff Lead(s)	Fire Department – Division of Fire Prevention Staff Lead: Fire Marshal
Priority	High
Timeline	Fire Code Adoption: May and November 2019, and November 2022 Staffing evaluation: Ongoing HFA expansion research: February 2019 Inspections: Ongoing/Funding-dependent Vegetation Management Standard: Funding-dependent

	Inspection system evaluation: Funding-dependent Roadway clearance: Conceptual Plan in 2020, Implement Pilot with Community Education in 2021, Plan Enforcement in 2022
Additional Resources Required	Inspections: Additional staffing required Vegetation Management Standard: Additional staffing required Inspection system evaluation: Additional staffing required Roadway clearance code: Additional staffing required
Potential Funding Sources	Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP) General Fund New City tax
Activity Type(s) (Federal Mitigation Grant Funding only)	Mitigation: Hazardous Fuels Reduction

2019 **Vegetation Management**	**Reduce fire risk in existing development through vegetation management.**
Proposed Activities	a) Maintain Fire Fuel Chipper Program b) Maintain Fire Fuel Abatement Program on Public Land c) Maintain Fire Fuel Debris Bin Program d) Maintain Weekly Curbside Plant Debris Collection e) Pursue external funding to increase education and awareness of vegetation management standards for fire fuel reduction f) Work with partners and stakeholders to identify fire fuel reduction zones and to promote and facilitate removal of vegetation in those zones to mitigate fire spread. g) Pursue external funding to perform vegetation management on public and private property h) Develop and enforce Fire Code requirement for fire fuel clearance on public roadways (see Fire Code action for

	details)
Related Natural Hazard(s)	Wildland-Urban Interface Fire Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, heat waves, and their secondary impacts. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-23, Action A
Lead Organization(s) and Staff Lead(s)	Department of Parks Recreation and Waterfront – Parks Division Fire Fuel Chipper Program Staff Lead: Senior Landscape Gardener (Senior Forestry Supervisor) Fire Fuel Abatement Program on Public Land Staff Lead: Senior Landscape Supervisor Fire Fuel Debris Bin Program and Weekly Curbside Plant Debris Collection: Department of Public Works – Zero Waste Division Staff Lead: Solid Waste and Recycling Manager Fire Department Staff Lead: Captain of Professional Standards Division (Pursue funding for education and vegetation management) Fire Chief (Fire Fuel Reduction Zones)
Priority	High
Timeline	Ongoing
Additional	Fire Fuel Chipper Program: Additional resources required,

Resources Required	amount to be determined Fire Fuel Abatement Program on Public Land: No additional resources required Vegetation management activities on public/private lands: Additional resources required, amount to be determined Fire fuel reduction zones: Additional resources required, amount to be determined
Potential Funding Sources	City General Fund Refuse Fee Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP) Assistance to Firefighters Grant California Climate Investments Fire Prevention Grant Program
Activity Type(s) (Federal Mitigation Grant Funding only)	Mitigation: Hazardous Fuels Reduction

2019 **Hills Pedestrian Evacuation**	**Manage and promote pedestrian evacuation routes in Fire Zones 2 and 3.**
Proposed Activities	a) Public Works Staff will maintain paths on an as-needed basis, and will coordinate with the Berkeley Path Wanderers to maintain public pathways to provide safe pedestrian evacuation routes from the hill areas. b) Maintain signage for public pathways to identify safe and accessible pedestrian evacuation routes from the hill areas. c) Update City maps of all emergency access and evacuation routes to include pedestrian pathways. d) Publicize up-to-date maps of all emergency access and evacuation routes.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire

Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-1 Response Planning, Action B General Plan Policy S-22 Fire Fighting Infrastructure, Action A General Plan Policy T-28 Emergency Access, Actions B and C
Lead Organization(s) and Staff Lead(s)	Department of Public Works (Maintenance) Paths: Engineering Division – Assistant Public Works Engineer Signage: Transportation Division – City Traffic Engineer Department of Information Technology (Mapping) GIS Division GIS Coordinator Fire Department (Outreach) Office of Emergency Services - Emergency Services Coordinator
Priority	High
Timeline	Ongoing
Additional Resources Required	No additional resources required (additional funding could facilitate additional activities)

2019 **Hills Roadways and Parking**	**Improve responder access and community evacuation in Fire Zones 2 and 3 through roadway maintenance and appropriate parking restrictions.**
Proposed Activities	a) Maintain and improve roadways in Fire Zones 2 and 3. b) Maintain community-driven process to identify and consider areas for parking restrictions and red curbing. c) Explore options for comprehensive parking restrictions in Fire Zones 2 and 3 during Red Flag and/or Extreme Fire Weather conditions.

	d) Develop and enforce Fire Code requirement for fire fuel clearance on public roadways (see Fire Code action for details)
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. B. Increase City government's ability to serve the community during and after hazardous events by mitigating risk to key City functions. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-16, Action A General Plan Policy T-25, Action A General Plan Policy T-28, Action D General Plan Policy S-22, Action A
Lead Organization(s) and Staff Lead(s)	Roadway maintenance Public Works Department: Engineering Division Staff Lead: Supervising Civil Engineer Community-driven parking restrictions Public Works Department: Transportation Division Staff Lead: Supervising Traffic Engineer Fire weather parking restrictions Fire Department: Office of Emergency Services Staff Lead: Assistant Chief Fire Department: Fire Prevention Division Staff Lead: Fire Marshal
Priority	High

Timeline	Roadway maintenance: Ongoing Community-driven parking restrictions: Ongoing Fire weather parking restrictions: Conceptual Plan in 2020, Implement Pilot with Community Education in 2021, Plan Enforcement in 2022
Additional Resources Required	No additional resources required

2019 **Undergrounding**	**Reduce the potential threat of overhead utility wires in the Berkeley Hills.**
Proposed Activities	a) Construction of undergrounding in the Berkeley Hills within UUD No. 48 (portions of Grizzly Peak Blvd., Summit Rd., Avenida Dr., Fairlawn Dr., and Senior Ave.) b) Construction of undergrounding of overhead utility wires within UUD No. 35A (Vistamont Ave., Rochdale Way, and Rosemont Ave from Woodmont Ave. to Vistamont Ave.) c) Construction of undergrounding of overhead utility wires on Bayview Place d) Complete the Phase 3 undergrounding study spearheaded by the Undergrounding Subcommittee in collaboration with Public Works Department, Fire Department, and Public Works Commission. This is a citywide study to underground overhead wires on arterial and collector streets as a component of maintaining ingress and egress on roads during a major disaster. e) Explore other strategies for reducing the potential threats of overhead utility wires
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire

Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. B. Preserve Berkeley's unique character and values from being compromised by hazardous events.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy T-28, Action E General Plan Policy S-1, Actions B and C General Plan Policy S-12, Action B General Plan Policy S-22, Action A General Plan Policy UD-8, Action A
Lead Organization(s) and Staff Lead(s)	Public Works Department- Engineering Staff Lead: City Engineer
Priority	High
Timeline	UUD No. 48 Hold Community Meeting for Lighting Selection: November 2018 Secure Easements for Above Ground Structures: November 2018 - March 2019 Advertise for Bids: February 2019 Construction Contract Award: Late Spring 2019 Construction Start: Summer 2019 UUD No. 35A On hold UUD Bayview Place On hold
Additional Resources Required	Funding for UUD No.48: General Fund for staff time, consultant services, lighting, and payment for easements if it is required Assessed fees for lighting Rule 20A Funds for construction

	Funding for UUD 35A: General Fund Remaining Rule 20A Funds Funding for UUD Bayview Place: Property Owner Funds (20B) General Fund for consultant services
Potential Funding Sources	Funding for UUD No.48: General Fund Rule 20A Funds Funding for UUD 35A: General Fund Rule 20A Funds Funding for UUD Bayview Place: Property Owner Funds
Activity Type(s) (Federal Mitigation Grant Funding only)	Federal mitigation grant funding is not anticipated

2019 **EBMUD**	**Work with EBMUD to ensure an adequate water supply during emergencies and disaster recovery.**
Proposed Activities	a) Coordinate with EBMUD regarding plans to install a new 48-inch aqueduct by 2020 to be able to continue potable and firefighting water supply following a seismic event. b) Explore project approaches with EBMUD to expedite replacement of problem pipelines in Berkeley neighborhoods exposed to wildland-urban interface fire and seismic ground failure. c) Coordinate with EBMUD to ensure that pipeline replacement projects and upgrades are coordinated with the City's five-year street paving program and other City programs.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire

Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-12: Utility and Transportation Systems, Action A
Lead Organization(s) and Staff Lead(s)	Department of Public Works – Engineering Division Staff Lead: City Engineer
Priority	High
Timeline	Ongoing
Additional Resources Required	No additional resources required

2019 **Extreme Heat**	**Reduce Berkeley's vulnerability to extreme heat events and associated hazards.**
Proposed Activities	a) Monitor and support regional and State-level efforts to forecast the impact of climate change on temperatures and incidence of extreme heat events in Berkeley and the region, and integrate extreme heat event readiness, focusing on the most vulnerable populations impacted and improving access to resources, into City operations and services. b) Continue to create and maintain shading by maintaining the health of existing trees and sustaining municipal tree planting with a focus on efforts in areas where there are fewer trees. c) Continue to implement energy efficiency ordinances for existing residential and commercial buildings to improve building comfort, including in extreme

	weather conditions, and to reduce energy use. d) Encourage cooling strategies for the built environment through voluntary programs to mitigate the urban heat island effect. This can include strategies like green roofs, cool roofs, and cool pavements, increased vegetation, as well as electric heat pumps and natural ventilation which can provide cooling to buildings in an extreme heat event.
Related Natural Hazard(s)	Climate Change Extreme Heat
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community. E. Protect Berkeley's historically underserved populations from the impacts of hazardous events by applying an equity focus, including equal access, to mitigation efforts.
Related Policies from the General Plan or Climate Action Plan	Climate Action Plan - Adaptation Goal 1, Policies A and D General Plan Policy EM-29: Street and Park Trees
Lead Organization(s) and Staff Lead(s)	Planning Department – Office of Energy and Sustainable Development (Monitor Impacts, Energy Efficiency Ordinances, Cooling Technologies) Staff Lead: Climate Action Program Coordinator Department of Parks, Recreation and Waterfront – Parks Division (Tree Planting) Staff Lead: Parks Superintendent
Priority	High
Timeline	Ongoing
Additional	Scientific monitoring, energy efficiency ordinances, cooling

Resources Required	technologies: Additional funding required for implementation Tree planting: Dependent on State of California Environmental Enhancement Mitigation Program Grant
Potential Funding Sources	City General Fund Tree planting grants City Parks Tax Fund 450 Ratepayer funds from PG&E or East Bay Community Energy Grants from Energy Foundation, Urban Sustainability Directors Network, California Energy Commission, California Air Resources Board, Bay Area Air Quality Management District, U.S. Department of Energy

2019 **Hazardous Materials**	**Mitigate hazardous materials release in Berkeley through inspection and enforcement programs.**
Proposed Activities	a) Implement Hazardous Materials Release Response Plans and Inventories (HMRRP) Program b) Implement California Accidental Release Prevention (CalARP) Program c) Implement Underground Storage Tank (UST) Program d) Implement Aboveground Petroleum Storage Act Requirement for Spill Prevention e) Implement Hazardous Waste Generator and Onsite Hazardous Waste Treatment Programs f) Implement Hazardous Materials Management Plans (HMMP) and Hazardous Materials Inventory Statements per California Fire Code g) Enforce California Fire Code for Hazardous Materials Compliance (See Fire Code Action)
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami

	Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy EM-12, Action A General Plan Policy EM-13, Action A General Plan Policy EM-14, Actions A and B
Lead Organization(s) and Staff Lead(s)	Planning: Toxics Division (all programs except Fire Code enforcement) Staff Lead: Hazardous Materials Manager Fire Department: Fire Prevention Division (Fire Code) Staff Lead: Fire Marshal
Priority	High
Timeline	Ongoing
Additional Resources Required	No additional resources required

2019 **Air Quality**	**Define clean air standards for buildings during poor air quality events and use those standards to assess facilities for the Berkeley community.**
Proposed Activities	a) Participate in regional efforts to define standards and tools to predict buildings' ability to deliver clean air to occupants during poor air quality events. b) Apply standards and tools to assess City facilities' ability

	to provide clean air to occupants during poor air quality events. c) Coordinate with willing Berkeley partners to apply standards and tools to partner facilities. d) Use findings to develop a list of potential clean air facilities (City-run and partner-run) to the community.
Related Natural Hazard(s)	Wildland-Urban Interface Fire Climate Change Extreme Heat
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community. E. Protect Berkeley's historically underserved populations from the impacts of hazardous events by applying an equity focus, including equal access, to mitigation efforts.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-20
Lead Organization(s) and Staff Lead(s)	Standards Development: Department of Health, Housing and Community Services: Public Health and Environmental Health Divisions Staff Leads: Health Officer/Environmental Health Division Manager Standards Implementation at City Facilities: Department of Public Works: Staff Lead: Facilities Division – Supervising Civil Engineer Staff Lead: Building Maintenance Supervisor Partner Coordination and Community Outreach: Fire Department: Office of Emergency Services

	Staff Lead: Chief of Special Operations
Priority	High
Timeline	To be determined
Additional Resources Required	To be determined

2019 NFIP	**Maintain City participation in the National Flood Insurance Program.**
Proposed Activities	a) Continue to use the most current FEMA information defining flood areas. b) Continue to incorporate FEMA guidelines and suggested activities into City plans and procedures for managing flood hazards.
Related Natural Hazard(s)	Floods
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. B. Increase City government's ability to serve the community during and after hazardous events by mitigating risk to key City functions. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-28 Flood Insurance, Actions B and C
Lead Organization(s) and Staff Lead(s)	Public Works Department: Engineering Division (NFIP application to City projects; Program Management)

	Staff Leads: Manager of Engineering, Director of Public Works Planning Department (application to private projects): Land Use Planning Division (determines if new project is subject to NFIP regulations) Staff Lead: Land Use Manager Building and Safety Division (coordinates to ensure that projects are compliant with Flood Zone Development Ordinance) Staff Lead: Senior Plan Check Engineer
Priority	High
Timeline	Ongoing
Additional Resources Required	No additional resources required

2019 **Hazard Information**	**Collect, analyze and share information with the Berkeley community about Berkeley hazards and associated risk reduction techniques.**
Proposed Activities	a) Track changes in hazard risk using the best-available information and tools. b) Collect and share up-to-date hazard maps identifying areas subject to heightened risk from hazards. c) Publicize financial and technical assistance resources for risk reduction.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from

	earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. B. Increase City government's ability to serve the community during and after hazard events by mitigating risk to key City functions. C. Preserve Berkeley's unique character and values from being compromised by hazard events. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community. E. Protect Berkeley's historically underserved populations from the impacts of hazardous events by applying an equity focus, including equal access, to mitigation efforts.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-13: Hazards Identification, Action A General Plan Policy S-19: Risk Analysis, Action A General Plan Policy UD-12, Actions A and C Climate Action Plan: Adaptation Action A
Lead Organization(s) and Staff Lead(s)	Fire Department – Office of Emergency Services Lead Staff: Emergency Services Coordinator Office of Energy and Sustainable Development (Climate Change Hazards) Lead Staff: Climate Action Program Coordinator
Priority	High
Timeline	Ongoing
Additional Resources Required	No additional resources required
Potential Funding Sources	General Fund Measure GG Special Revenue Fund

2019 Partnerships	**Coordinate with and encourage mitigation actions of key City partners.**
Proposed Activities	a) Coordinate with and encourage mitigation actions of: • Institutions serving the Berkeley community • Berkeley organizations and nonprofits • Other partners whose actions affect the Berkeley community
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. B. Increase City government's ability to serve the community during and after hazardous events by mitigating risk to key City functions. C. Preserve Berkeley's unique character and values from being compromised by hazardous events. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community. E. Protect Berkeley's historically underserved populations from the impacts of hazardous events by applying an equity focus, including equal access, to mitigation efforts.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-5 The City's Role in Leadership and Coordination, Actions A and B General Plan Policy UD-7, Actions A and B General Plan Policy UD-12, Actions A and C General Plan Policy S-12 Utility and Transportation

	Systems, Action A
Lead Organization(s) and Staff Lead(s)	Fire Department: Office of Emergency Services Staff Lead: Assistant Chief of Special Operations
Priority	High
Timeline	Ongoing
Additional Resources Required	To be determined
Potential Funding Sources	General Fund Measure GG Special Revenue Fund

C.5.b.ii Medium-Priority Actions

2019 **Severe Storms**	**Reduce Berkeley's vulnerability to severe storms and associated hazards through proactive research and planning, zoning regulations, and improvements to stormwater drainage facilities.**
Proposed Activities	a) Use development standards to ensure that new development does not contribute to an increase in flood potential. b) Complete the Watershed Management Plan to recommend improvements to problem areas in individual watersheds, and develop a Stormwater Master Plan to perform hydraulic analysis and condition assessment, and identify flow capacity and flooding issues as basis for the Watershed Management Plan. c) Design public improvements such as streets, parks and plazas, for retention and infiltration of stormwater by diverting urban runoff to bio-filtration systems.
Related Natural Hazard(s)	Landslide Floods Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-26, Actions B and C General Plan Policy S-27 New Development Climate Action Plan - Adaptation Goal 1, Policy C
Lead Organization and Staff Lead	Planning Department – Land Use Planning Division (Development Standards) Staff Lead: Land Use Manager Public Works Department – Engineering Division Staff Lead: Supervising Civil Engineer (Watershed Management Plan and Public Improvements)
Priority	Medium

Timeline	Ongoing
Additional Resources Required	Development Standards: To be determined Watershed Management Plan/Stormwater Master Plan: To be determined Public Improvements Design: To be determined
Potential Funding Sources	City General Fund Permit Service Center Enterprise Fund Measure M Bond Funds Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP)
Activity Type(s)	Mitigation: Infrastructure Retrofit

2019 **Energy Assurance**	**Implement energy assurance strategies at critical facilities.**
Proposed Activities	a) Identify potential actions to mitigate energy assurance vulnerabilities at critical City facilities during planning/conceptual design of both retrofits and new construction b) Provide guidance to help the City consider opportunities to design, finance and implement clean energy assurance strategies (e.g., photovoltaic-supplemented generation, energy efficiency activities, and/or mobile charging stations). c) Work with partners to identify additional non-City critical facilities and develop strategies to provide clean backup power at these sites.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change Extreme Heat

Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. B. Increase City government's ability to serve the community during and after hazardous events by mitigating risk to key City functions.
Related Policies from the General Plan or Climate Action Plan	General Plan - Disaster Preparedness and Safety Element: Objective 1 General Plan Policy S-8: Continuity of Operations Climate Action Plan – Chapter 4, Goal 5: Increase Energy Efficiency and Renewable Energy Use in Public Buildings – Policies 5a and 5b
Lead Organization(s) and Staff Lead(s)	Department of Public Works – Facilities Division (Identify actions) Staff Lead: Supervising Civil Engineer (for facilities) Planning Department – Office of Energy and Sustainable Development (Clean Energy Opportunities) Staff Lead: Climate Action Program Manager
Priority	Medium
Timeline	Ongoing
Additional Resources Required	Additional resources to analyze specific energy assurance options for individual projects.
Potential Funding Sources	General Fund T1 Bond Measure GG Special Revenue Fund Ratepayer funds from PG&E or East Bay Community Energy Grants from Energy Foundation, Urban Sustainability Directors Network, California Energy Commission, California Air Resources Board, Bay Area Air Quality Management District, U.S. Department of Energy

2019 **Climate Change Integration**	**Mitigate climate change impacts by integrating climate change research and adaptation planning into City operations and services.**
Proposed Activities	a) Determine staffing needs to monitor research and oversee integration of climate change adaptation into City operations and services b) Develop and implement a process to integrate adaptation planning into City operations. Activities include: a. Train City staff on the basic science and impacts of climate change and on climate adaptation strategies b. Develop policy and programs to address potential climate impacts in municipal capital and land use planning
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Tsunami Climate Change Extreme Heat
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts.
Related Policies from the General Plan or Climate Action Plan	• Climate Action Plan – Adaptation, Goal 1A • Climate Action Plan – Community Outreach and Empowerment, Goal 1A • Climate Action Plan – Implementation, Monitoring and Reporting, Goals 2, 3 and 4
Lead Organization(s) and Staff Lead(s)	Planning Department – Office of Energy and Sustainable Development Staff Lead: Climate Action Program Manager
Priority	Medium

Timeline	Determine staffing needs: 3-4 years Staff Training: Ongoing Address climate impacts in municipal planning processes: 1-2 years
Additional Resources Required	To be determined
Potential Funding Sources	General Fund Permit Service Center Enterprise Fund

2019 **Sea Level Rise**	**Mitigate the impacts of sea level rise in Berkeley.**
Proposed Activities	a) Monitor and participate in regional and State-level research on projected sea-level rise in Berkeley and the region. b) Develop guidelines, regulations, and review development standards to ensure new and existing public and private developments and infrastructure are protected from floods due to sea-level rise.
Related Natural Hazard(s)	Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts.
Related Policies from the General Plan or Climate Action Plan	Climate Action Plan, Adaptation Policies A and C General Plan Goal 6: Make Berkeley a disaster-resistant community that can survive, recover from, and thrive after a disaster – Utilize Disaster-Resistant Land Use Planning General Plan Policy S-27: New Development General Plan Policy S-14: Land Use Regulation, Action E
Lead Organization(s) and Staff Lead(s)	Planning Department – Office of Energy and Sustainable Development (Monitor Research/Integrate Considerations) Staff Lead: Climate Action Program Manager Planning Department – Land Use Planning Division

	(Development Regulations) Staff Lead: Division Director
Priority	Medium
Timeline	Research: Ongoing Policy Development: 2 years
Additional Resources Required	Research: Additional staff capacity or funding needed for further analysis. Policy Development: Additional staff capacity to develop regulations and standards.
Potential Funding Sources	General Fund Permit Service Center Enterprise Fund Adapting to Rising Tides, San Francisco Bay Conservation & Development Commission, National Oceanic & Atmospheric Administration, Urban Sustainability Director's Network, or Resource Legacy Fund

2019 **Water Security**	**Collaborate with partners to increase the security of Berkeley's water supply from climate change impacts.**
Proposed Activities	a) Partner with East Bay Municipal Utility District (EBMUD) to provide and market incentives for residents, businesses and institutions to conserve water. b) Partner with agencies such as EBMUD and StopWaste to encourage private property owners and public agencies (including the City government) to use sustainable landscaping techniques that require less water and energy to maintain. c) Encourage water efficiency and conservation in existing buildings, such as incorporating water assessments into existing policies or creating a compliance program for SB407.
Related Natural Hazard(s)	Climate Change
Associated LHMP	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from

Objective(s)	earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts. D. Connect with residents, community-based organizations, institutions, businesses, and essential lifeline systems in order to increase mitigation actions and disaster resilience in the community.
Related Policies from the General Plan or Climate Action Plan	Climate Action Plan - Adaptation Goal 1, Policy B General Plan Policy EM-25: Groundwater General Plan Policy EM-26: Water Conservation General Plan Policy EM-31: Landscaping
Lead Organization(s) and Staff Lead(s)	Planning Department – Office of Energy and Sustainable Development Staff Lead: Climate Action Program Coordinator (Water Recycling/Incentives) Staff Lead: Sustainability Planner (Landscaping Techniques) Staff Lead: Climate Action Program Coordinator (Water Efficiency and Conservation)
Priority	Medium
Timeline	Encourage water efficiency in existing policies: 2-3 years
Additional Resources Required	Additional staff capacity.
Potential Funding Sources	General Fund Permit Service Center Enterprise Fund

C.5.b.iii Low-Priority Actions

2019 **Tsunami**	**Mitigate Berkeley's tsunami hazard.**
Proposed Activities	a) Fund and replace damaged finger docks. b) Secure funding for replacement of D and E docks; begin the permitting process once funding is secure c) Begin the permitting process for piling replacement. d) Repair University Avenue, Marina Boulevard, and Spinnaker Way in order to mitigate tsunami vulnerabilities. e) Collaborate with the California Office of Emergency Services, the California Geological Survey, and the Federal Emergency Management Agency to document and explore additional tsunami hazard mitigation measures for Berkeley's maritime communities.
Related Natural Hazard(s)	Tsunami
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, extreme heat, and their secondary impacts.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-19: Risk Analysis, Action A
Lead Organization(s) and Staff Lead(s)	All activities: Parks, Recreation and Waterfront Department – Marina Division Staff Lead: Waterfront Manager, Alexandra Endress, and Waterfront Supervisor, Stephen Bogner. Cal OES/CGS/FEMA collaboration: Fire Department – Office of Emergency Services Staff Lead: Emergency Services Coordinator
Priority	Low

Timeline	Activities a) - d): funding-contingent Activity e) To be determined
Additional Resources Required	a) Finger Dock Replacement: estimated $100k-$500k b) D and E Dock Replacement: estimated $4-7 million c) Piling replacement: estimated $50k for permitting only d) Roadway repair: estimated $4-6 million e) No additional resources required
Potential Funding Sources	Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP) General Fund City-Issued Bonds
Activity Type(s) (Federal Mitigation Grant Funding only)	Mitigation: Infrastructure Retrofit

2019 **Streamline Rebuild**	**Streamline the zoning permitting process to rebuild residential and commercial structures following disasters.**
Proposed Activities	a) Explore a Zoning Amendment to BMC 23C.04.100 that streamlines the Zoning permitting process to allow damaged industrial and commercial buildings, and dwelling units to rebuild by right following disasters. b) Consider different treatment for buildings in high-risk areas, such as: a. Imposing higher standards of building construction for rebuilding that incorporate SRA Fire Safety Regulations (Title 14, CCR, Division 1.5, Chapter 7, Subtitle 2, Articles 1-5) and Fire Hazard Reduction Around Building and Structures Regulations (Title 14, CCR, Division 1.5, Chapter 7, Subchapter 3, Article 3). b. Excluding buildings in these areas from the amendment (by excluding buildings in high risk areas from the amendment proposed by this activity- rebuilding will need to be re-evaluated according to new code and new regulations. The city will

	therefore have discretion to evaluate future development). c) Define the standard for documentation of current conditions for residential and commercial property owners to rebuild by right (in conformity with current applicable codes, specifications and standards) following disasters. d) Define the process for the City to accept and file this documentation. e) Outreach to property owners about this documentation process. f) Evaluate location of essential public facilities prior to rebuild in order to prioritize development outside high risk areas when feasible. g) Explore how other cities provide protections for people that may be vulnerable during the rebuilding process
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami
Associated LHMP Objective(s)	C. Preserve Berkeley's unique character and values from being compromised by hazardous events. E. Protect Berkeley's historically underserved populations from the impacts of hazardous events by applying an equity focus, including equal access, to mitigation efforts.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy LU-26: Neighborhood Commercial Areas General Plan Policy LU-27: Avenue Commercial Areas General Plan S-9: Pre-Event Planning, Action B General Plan policy UD-7, Action C
Lead Organization(s) and Staff Lead(s)	Planning Department – Land Use Planning Division Staff Lead: Division Manager
Priority	Low
Timeline	2 years

Additional Resources Required	Staff with capacity to focus on this effort
Potential Funding Sources	General Fund

C.6 *Mitigation Plan Integration*

The 2014 Plan was well-integrated into the City's existing plans and planning mechanisms. Upon its adoption on December 16, 2014, it became an appendix to the City's Disaster Preparedness and Safety Element of the City's General Plan.

Many actions outlined in the 2014 Mitigation Strategy were funded by the City's Biennial Budget. Also included in the Biennial budget is the City's Capital Improvement Program Budget, which funded many building and infrastructure-related actions outlined in the 2014 Mitigation Strategy. The City Council adopted the FY 2016 and FY 2017 Biennial Budget on June 30, 2015. The City Council adopted the FY 2018 and FY 2019 Biennial Budget on June 27, 2017.

Actions from the 2014 LHMP were integrated into the City's Resilience Strategy, released in April 2016. The Resilience Strategy is a plan to advance preparedness and equity in Berkeley.

Additionally, each year, the City assessed potential capital improvement projects and available funding as it implemented its Five-Year Capital Improvement Plan. Capital improvement actions in this 2019 Plan will be assessed as part of this annual process.

As with prior LHMP updates, this Plan will be well-integrated into the City's existing and future plans and planning mechanisms.

C.6.a General Plan

Upon its adoption by the Berkeley City Council, the 2019 LHMP will be incorporated as an appendix to the Disaster Preparedness and Safety Element of the City's General Plan. The Berkeley General Plan is a comprehensive, and long-range statement of community priorities and values developed to guide public decision-making in future years. The Plan's goals, objectives, and policies serve as a guide day-to-day decisions that are essential for responsive government. Decisions made by Berkeley City Council and its advisory boards, and commissions about the physical development of the City should be consistent with the goals, objectives, and policies of the General Plan. The City Council and Planning Commission will use the General Plan when evaluating land use changes and making funding and budget decisions. It will be used by the Zoning Adjustments Board and City staff to help regulate development proposals and make decisions on projects. The policies of the Plan apply to all property, both public and private, within the Berkeley city limits.

C.6.b City of Berkeley Strategic Plan

On January 16, 2018, the City Council adopted the City of Berkeley 2018-2019 Strategic Plan. Many actions outlined in this Mitigation Strategy come from the Strategic Plan. For upcoming fiscal years, the City's Office of Emergency Services will be responsible for working with Department leaders to further incorporate actions from this Mitigation Strategy into the Strategic Plan. City staff indicated under "Lead Organizations and Staff Leads" will be responsible for further developing the project plans, schedules and budgets outlined for actions in the Mitigation Strategy. Implementation of many of these actions will be dependent on outside funding sources.

C.6.c Capital Improvement Plan

Each year, the City assesses potential capital improvement projects and available funding as it implements its Five-Year Capital Improvement Plan. Capital improvement actions in this Plan will be assessed as part of this annual process. Many actions presented in the 2019 LHMP Mitigation Strategy are already a part of the City's Five-Year Capital Improvement Plan. Implementation of many of these actions will be dependent on outside funding sources.

C.6.d Climate Action Plan

The 2014 and 2019 updates to the LHMP support concepts outlined in the Berkeley Climate Action Plan, which was written through a community-wide process and was adopted by City Council on June 2, 2009. The Climate Action Plan outlines a vision, goals and policies to reduce community-wide greenhouse gas emissions by 33 percent below 2000 levels.

Because climate change impacts can cause or exacerbate many of Berkeley's hazards of concern, in 2014 the LHMP was updated to include climate change as a hazard of concern. The City of Berkeley uses the Climate Action Plan to present activities to mitigate climate change itself, and the LHMP to present climate adaptation actions. In this way both plans reflect and support one another. The Mitigation Strategy of the LHMP identifies for each action the related policies from the Climate Action Plan.

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[i] The City has adopted Standard Plan Set A for wood frame homes of two stories or less that provides typical details and other guidance. This plan set simplifies the design of cripple wall retrofits for many homes in Berkeley.

[ii] To create the City's inventory of non-ductile concrete and rigid wall-flexible diaphragm buildings, staff did extensive research, including examining local Sanborn maps, Google Map images, building permit data obtained from Accela, real estate data from RealQuest, housing unit data from the Rent Stabilization Board, and City of Berkeley records such property cards, microfiche data, files from prior field surveys, and zoning data. Sanborn maps, which were originally created for assessing fire insurance liability, provide the approximate size, shape and construction material of each building within the city that existed at the time. The City of Berkeley's Sanborn maps were last updated in the early 1980's, and were therefore useful as a starting point for identifying older buildings constructed of concrete or reinforced masonry that may be vulnerable in a seismic event.

After identifying concrete buildings on the Sanborn maps, staff investigated each building's current status. Buildings confirmed to still be in existence were researched for construction material and year built, as well as for any permit history indicating whether alterations and/or seismic retrofits might have occurred. Information was also gathered for each building's use classification, APN, alternate addresses, square footage, number of stories and residential units, historic registry list data, and property ownership information required for conducting outreach.

[iii] During a sidewalk survey in November 2017, contracted EERI engineers visually assessed over 250 buildings to validate the City's inventory of seismically vulnerable buildings and

identify common structural deficiencies. Additionally, two teams of experienced structural engineers were hired to help develop engineering guidelines and establish minimum standards for retrofits of non-ductile concrete and other rigid wall-flexible diaphragm buildings supported by FEMA-funded Retrofit Grants, in an effort to improve their performance during an earthquake.

[iv] To help identify soft story buildings with 3-4 residential units or commercial uses, staff utilized a Rental Housing Safety Program database and field survey sheets of nonresidential buildings from the original Soft Story inventory conducted in the 1990s. Staff undertook a "virtual" survey of each building using Google maps aerial and street view imagery to identify potential Soft Story buildings, and then verified the unit count and building configuration for each property by consulting City and county property records.

[v] Per Dan Gallagher, Senior Forestry Supervisor, City of Berkeley: The Fire Fuel Chipper Program collected green waste vegetation in the following amounts in the following years:

2005: 264.35 tons

2006: 237.59 tons

2007: 189.06 tons

2008: 175.16 tons

2009: 167.17 tons

2010: 161.31 tons

2011: 187.24 tons

2012: 155.94 tons

2013: 141.27 tons

2014: 119.72 tons

2015: 130.26 tons

2016: 430 cubic yards of wood chips and 34.28 tons of loose vegetation

[vi] Information provided by Susan Ferrera, Superintendent of Parks, City of Berkeley, as of November 2018

[vii] Information provided by Greg Apa, Solid Waste and Recycling Manager of Zero Waste Division, City of Berkeley, as of September 2018

[viii] Information provided by Greg Apa, Solid Waste and Recycling Manager of Zero Waste Division, City of Berkeley, as of September 2018

D. Plan Review, Evaluation, and Implementation

D.1 *Community Profile and Trends*

The people and structures of Berkeley are continually changing. This section examines changes that have occurred in hazard-prone areas and increased or decreased the vulnerability of Berkeley since 2014. First, this section discusses changes to the group of people who make up the Berkeley community, and how their characteristics will influence the population's hazard vulnerability, necessary approaches to mitigation and response. Next, changes in development are discussed, including description of recent and potential development throughout Berkeley. Next, the effects of this development of population and structures on Berkeley's vulnerability to natural hazards are discussed. Last, key City policies and goals that affect development are outlined.

D.1.a Community

According to the 2010 Census, the number of people living in Berkeley grew by almost 10,000 people in the last decade, to 112,580. As Berkeley's population of Berkeley has grown, the number of jobs in the city has increased from about 50,000 in 1970 to approximately 64,500 today.[i] Additionally, UC Berkeley's Long Range Development Plan projects that as a result of growth in both education and research, by 2020 the total campus headcount during the regular academic year may increase to 51,260 – a 12% increase over 2001-2002 levels. These population increases means that more Berkeley residents and visitors will be exposed to the area's hazards.

Berkeley has a mobile population including many people moving to Berkeley from out of the area, meaning that community disaster awareness activities need to be ongoing to penetrate the population. This figure also reflects community members moving within Berkeley, meaning that community-building activities must be constant as residents join new neighborhoods.
Much of Berkeley's mobility is due to its large college student population, with about 30 percent of city residents (34,000 enrolled in college or graduate school according to the 2016 American Community Survey).

Students represent a significant portion of Berkeley's rental market and support a variety of local merchants. Large losses in rental units after an earthquake could force students to move to other nearby cities, which would profoundly affect Berkeley's character and economics. The University of California, Berkeley faces significant earthquake risks, and a closure of this campus for any length of time would greatly impact the city overall.

Over one quarter (28 percent according to the 2016 American Community Survey) of Berkeley residents use a language other than English at home. Over 10,000 people in Berkeley have disability status (9 percent according to the 2017 American Community Survey). As discussed throughout this plan, people with disabilities are disproportionately affected before, during, and after disasters. Nearly one quarter (24 percent according to the 2017 American Community Survey) of Berkeley residents are over the age of 55.It is critical for the city to make sure that emergency responders are prepared to communicate with limited- English speakers, people with disabilities, and seniors. This includes communicating emergency and evacuation warnings as well as mitigation strategies.

D.1.b Recent and Potential Development

Berkeley is a densely-populated city with well-established land use patterns. Many private homes have been expanded and renovated, but few new lots have been developed due to Berkeley's already built-up state.

Nonetheless, development activity is ongoing. Since 2014, Berkeley has seen a significant increase in housing units. Typically, this development represents densification of commercial areas, rather than development of new sites. Before the global recession of 2009, the City issued discretionary permits for many high-occupancy mixed-use commercial/residential structures in commercial corridors on Shattuck, San Pablo and University Avenues. In the years that followed, these projects were not pursued. Now in 2018, many projects are once again moving forward. Zoning changes from the City's Downtown Area Plan have encouraged upgrades to and replacement of vulnerable buildings in the downtown area. The plan also allows for construction of three 180-foot-tall buildings and four 120-foot-high building in the downtown core.

As reported in the October 31, 2017 Housing Pipeline Report,

- 910 units have been built since 2014 across 11 projects that are now occupied.
- 525 units are under construction, or with secured building permits, in nine projects.
- About 1,400 units, in 20 projects, have been submitted and are pending review.
- About 1,134 units have been approved since 1999 but are without building permits.

The University of California, Berkeley has expanded its facilities both on and off the campus. UC Berkeley's 2020 Long Range Development Plan projects space demands for campus academic and support programs may grow by up to 18%, or 2,200,000 GSF, over 2005 levels. This includes classrooms, libraries, research facilities and student services centers. These estimates of future space needs are both future growth and compensation for existing shortages.

D.1.c Effects on Berkeley's Risks and Vulnerabilities

As more people join the Berkeley community, the city will have more people who are exposed to the area's hazards. However, because of Berkeley's built-out nature, new development tends not to add new geographic areas of hazard exposure. All of Berkeley is exposed to earthquake shaking. While commercial corridors are becoming denser, density in the eastern hills, which are exposed to wildland-urban interface fire and landslides, is stable. The city's western edge will be exposed to sea-level rise from climate change. However, the actual areas of sea-level rise exposure, as well as the impacts of sea-level rise on the area's liquefaction and flooding hazards, are not yet clear.

New development generally reduces Berkeley's vulnerability to natural hazards. New construction adheres to modern design codes, including regulations for structural resistance to earthquakes, landslide mitigation efforts, fire-resistant materials, and elevation above flood levels. Replacing or significantly renovating older structures significantly increases the Berkeley community's protection from natural hazards. For example, pursuant to the Seismic Hazards Mapping Act codified in the Public Resources Code as Division 2, Chapter 7.8 and Guidelines for Evaluations and Mitigating Seismic Hazards in California (Special Publication 117), much of the new construction in the City's west must have site-specific geological and geotechnical investigations, due to the area's mapped potential liquefaction hazard. These investigations result in recommendations for design professionals to design new or rehabilitated buildings for human occupancy to mitigate the potential effects of liquefaction caused by earthquakes to a level that does not cause the collapse of the buildings. This means that a new or rehabilitated building will be equipped to better withstand potential liquefaction impacts than an old building.

D.2 *Progress in Mitigation Efforts: Status of 2014 Actions*

This Plan was last adopted on December 16, 2014. Since that date, Berkeley has made steady progress on implementing 2014 plan actions and supporting activities. This section describes Berkeley's progress on the actions and activities identified in the 2014 plan. It also identifies where some 2014 actions and activities have been incorporated into this new plan.

In the following pages, Berkeley's progress on each 2014 mitigation activity is described using a detailed narrative. Progress on each activity is summarized in Table 2 using the categories presented below.

Table 1. Progress Categories

Category	Description	2019 Inclusion
Completed	Activity has been completed as written.	No
Completed with Modifications	Over the course of completing this action, the City modified the activity to better meet the associated objective.	No
In progress	Progress has been made since 2014, but the activity has not been fully completed.	Yes
Deferred	Progress has not been made since 2014, but the activity is still relevant.	Yes
Deleted	Progress has not been made since 2014, and the activity is no longer relevant.	No

In Progress or *Deferred* activities have been incorporated into the 2019 plan's mitigation strategy. Table 2 shows where in the 2019 strategy the 2014 *In Progress* or *Deferred* activities have been incorporated. Following the table, progress on 2014 actions is presented in detail based on the order presented in the table.

Table 2. 2014 Actions and Activity Status Summary

2014 Actions/Priority	2014 Activity							
	a	b	c	d	e	f	g	h
High Priority Actions								
Building Assessment	In progress	Deferred	In progress	Completed with modifications				
Strengthen and Replace City Buildings	Deleted	Completed	In progress					
Soft-Story	Completed	Completed	In progress	Completed with modifications	In progress	In progress	In progress	In progress
URM	In progress	In progress	In progress					
Buildings	In progress	In progress						
Fire Code	Completed	Deferred	Completed with modifications	Deferred				
Vegetation Management	In progress	In progress	In progress	In progress	Deferred			
Hazard Information	In Progress	In Progress	Completed with modifications	In progress				
Partnerships	Completed with modifications	In progress						
EBMUD	In progress	In progress	In progress					
Hills Evacuation	In progress	In progress	Completed	In progress				
Climate Change Integration	In progress	Completed/In progress						
Medium Priority Actions								

2014 Actions/Priority	2014 Activity							
	a	b	c	d	e	f	g	h
Energy Assurance	Completed/in progress	In progress						
Gas Safety	Completed with modifications	Completed						
Stormwater System	Deferred	Completed						
Tsunami	Completed	In progress						
Extreme Heat	In progress	In progress	In progress					
Severe Storms	Completed	In progress/ Deferred/ Completed						
Water Security	Deleted	Completed	Completed with modifications	In progress	In progress			
NFIP	In progress	In progress						
Streamline Rebuild	Deferred	Deferred	Deferred	Deferred				
Low Priority Actions								
Sea-Level Rise	In progress	In progress						
HazMat Floods	Deleted	Deleted	Deleted					

D.2.a 2014 High-Priority Actions

2014 Building Assessment	**Perform appropriate seismic and fire safety analysis based on current and future use for all City-owned facilities and structures.**
Proposed Activities	a) First, complete analysis of structures supporting critical emergency response and recovery functions, and make recommendations for structural and nonstructural improvements. b) Prioritize analysis of remaining structures based on occupancy and structure type, taking historic significance into consideration. Use analysis to make recommendations for structural and nonstructural improvements. c) Integrate unsafe structures into a prioritized program for retrofit or replacement. d) Develop emergency guidelines for buildings with structural deficiencies.
Lead Organization and Staff Lead	Public Works Department: Facilities Division Staff Lead: Facility Maintenance Superintendent
Priority	High
Timeline	Analysis of critical structures: December 2013 Analysis of remaining structures: Funding-dependent Emergency guideline development: Ongoing as identified
Progress on Action Between 2014-2019	**a) First, complete analysis of structures supporting critical emergency response and recovery functions, and make recommendations for structural and nonstructural improvements.** **In Progress** In 2015, a contractor (Kitchell) completed the Facilities Condition Assessments Report. The report provided a comprehensive review of the maintenance and repair needs of 28 City-owned capital facilities. The assessed facilities included those supporting critical emergency response and recovery functions, such as community shelters. Elements studied included life safety and fire/life safety protection systems. The report did not specifically assess seismic vulnerabilities, however, identified vulnerabilities in substandard buildings could be exacerbated by seismic events. Seismic upgrades are performed for buildings as they undergo major maintenance and repair indicated in the Kitchell Report.

	b) **Prioritize analysis of remaining structures based on occupancy and structure type, taking historic significance into consideration. Use analysis to make recommendations for structural and nonstructural improvements.** **Deferred** As additional funding becomes available, the City will pursue further analysis of remaining structures not included in the 2015 Kitchell Report. Analysis is prioritized at the direction of Public Works staff based on known structural or general building deficiencies, as well as code requirements. c) **Integrate unsafe structures into a prioritized program for retrofit or replacement.** **In Progress (Ongoing)** The Kitchell Report established a list of maintenance and repair priorities among assessed facilities and analyzed cost implications based on facility life-cycle cost analysis or construction cost estimates, prepared for each facility. The City uses the Kitchell report as a first step in prioritizing capital projects; from there a project will go through a thorough public process for prioritization. d) **Develop emergency guidelines for buildings with structural deficiencies.** **Completed with Modifications** City Safety Officers in the Human Resources Department regularly update the Emergency Action Plan Manual, which addresses evacuation procedures and provides guidelines for response to various emergencies including earthquake and fire.

2014 Strengthen and Replace City Buildings	**Strengthen or replace City buildings in the identified prioritized order as funding is available.**
Proposed Activities	a) Seismically strengthen 2180 Milvia Civic Center b) Replace the Center Street Garage c) Seek funding to seismically strengthen or replace additional City buildings in a prioritized order
Lead Organization and Staff Lead	Public Works Department – Engineering Division Staff Lead: Supervising Civil Engineer
Priority	High
Timeline	2180 Milvia Civic Center retrofit by 2019

	Center Street Garage replacement by 2019 Funding identification: Ongoing
Progress on Action Between 2014-2019	a) **Seismically strengthen 2180 Milvia Civic Center** **Deleted** The Civic Center Building's isolation system and retrofit elements were designed to provide life safety and limited repairable damage in a Design Basis Earthquake (DBE), and life safety and repairable damage in the Maximum Considered Earthquake (MCE). This action refers to bringing the Civic Center building to Essential Services Standards. The City is focusing efforts on retrofit of hazardous buildings. b) **Replace the Center Street Garage** **Completed** Construction on the new Center Street Garage began in 2016. The garage is scheduled to reopen in October 2019. The new garage will meet current standards for seismic safety. c) **Seek funding to seismically strengthen or replace additional City buildings in a prioritized order** **In Progress** Construction of the new Center Street Garage is being funded by a combination of 2016 Parking Revenue Bond Funds ($28.3 million) and the Off Street Parking Fund (Fund 835) ($8.2 million). The City has sought out and received funding to strengthen/replace City buildings through the City of Berkeley Infrastructure and Public Facilities Bond Measure T1, which was approved by the voters in fall of 2016. Additionally, the City has received grants to seismically strengthen or replace additional facilities: • The James Kenney Retrofit ($3,050,512 total) was supported by grants from FEMA's Pre-Disaster Mitigation Program ($727,499), as well as a Department of Housing and Community Development grant of $1,036,700. • In 2016 the City was awarded a FEMA Pre-Disaster Mitigation Program Grant of $1.875 million for retrofit of North Berkeley Senior Center. Work on this project is expected to begin in February 2019. The City will continue to seek out funding for remaining projects.

2014 **Soft-Story** Proposed Activities	**Implement Phase Two of the Soft-Story Retrofit Program, mandating retrofit of soft-story residences.** a) Develop and publish Framework Guidelines calibrating, delineating and detailing technical requirements to be used for building retrofits. b) Inform impacted property owners of the requirement to retrofit their building c) Designated project manager will: • Prepare handouts and correspondence • Respond to inquiries from owners, tenants, engineers, contractors and realtors about the mandatory program, compliance procedures and requirements d) Investigate and adopt financial, procedural, and land use incentives to facilitate retrofit. • The Rent Board will review requests for pass-through of capital improvement expenses for seismic retrofits. They will determine on a case-by-case basis if rent increases to tenants can be approved. • Explore establishment of a loan program to assist landlords who cannot access financing to retrofit their buildings. e) Review plan submittals for soft-story seismic retrofits f) Issue permits and perform field inspections g) Remove retrofitted buildings from the Soft-Story Inventory h) Review appeals to accommodate unique circumstances preventing owners from meeting program requirements; consider time extensions, etc.
Lead Organization and Staff Lead	Planning and Development Department – Building and Safety Division Staff Lead: Program and Administration Manager
Priority	High
Timeline	January 2017: Deadline for soft-story owners to submit a permit application for retrofit January 2019: Final deadline for soft-story retrofit completion (2 years after permit application)
Progress on Action Between 2014-2019	**a) Develop and publish Framework Guidelines calibrating, delineating and detailing technical requirements to be used for building retrofits. Completed** Framework Guidelines were published in 2014.

b) **Inform impacted property owners of the requirement to retrofit their building**
Completed
Following passage of mandatory retrofit requirements in November 2013, the City mailed impacted property owners a notice informing them of the requirement to retrofit their buildings.

c) **Designated project manager will:**
- **Prepare handouts and correspondence**
- **Respond to inquiries from owners, tenants, engineers, contractors and realtors about the mandatory program, compliance procedures and requirements**

In Progress
Description: Owners were notified of the requirement to retrofit their buildings and sent handouts and correspondence. Staff continues to enforce the ordinance and provide information about compliance. When properties are sold, staff work with new owners to assist them with completing retrofits.

d) **Investigate and adopt financial, procedural, and land use incentives to facilitate retrofit.**
- **The Rent Board will review requests for pass-through of capital improvement expenses for seismic retrofits. They will determine on a case-by-case basis if rent increases to tenants can be approved.**
- **Explore establishment of a loan program to assist landlords who cannot access financing to retrofit their buildings.**

Completed with Modifications
Description: The Rent Board revised its capital pass-through requirements to allow pass-throughs in certain cases of seismic retrofit costs for mandatory retrofits for owners who own fewer than 12 residential units in Berkeley.
The City of Berkeley opted into the Property Assessed Clean Energy (PACE) program that provides financing for seismic retrofits.
The City obtained a Hazard Mitigation grant from FEMA and established a retrofit grant program, offering grants of up to $25,000 for mandatory soft story retrofits.

e) **Review plan submittals for soft-story seismic retrofits**
In Progress

		Description: The City is continuing to review plan submittals for soft story retrofits as building owners apply for permits.
	f)	**Issue permits and perform field inspections** **In Progress**
	g)	Description: The City is continuing to issue permits and perform inspections for the remaining required retrofits. As of November 2018, of the 331 buildings on the inventory of potentially hazardous Soft Story buildings, 72 owners still need to retrofit. Of those, 66 have either obtained permits or submitted permit applications, and 6 building owners have not yet applied for permits.**Remove retrofitted buildings from the Soft-Story Inventory** **In Progress** Description: As retrofits are completed, buildings are removed from the Soft Story Inventory. Since 2014, 95 buildings have been removed from the inventory and ten buildings have been added.
	h)	**Review appeals to accommodate unique circumstances preventing owners from meeting program requirements; consider time extensions, etc.** **In Progress** Owners who have submitted applications for a use permit to make changes to their property at the same time as completing a seismic retrofit have been granted extensions. Where properties have changed hands, new owners have also received additional time.

2014 **URM**	**Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings.**
Proposed Activities	a) Begin by working with owners of remaining potentially hazardous URM buildings to obtain structural analyses of their buildings and to undertake corrective mitigation measures to improve seismic resistance or to remove the buildings and replace them with safer buildings. b) Apply available legal remedies, including but not limited to citations, to owners who fail to comply with the URM ordinance. c) Maintain program notification to building occupants and owners.
Lead Organization and Staff Lead	Planning Department - Building and Safety Division Staff Lead: Program and Administration Manager
Priority	High

Timeline	Engage all remaining URM building owners by January 2015 Complete all remaining URM retrofits/demolitions by January 2019
Progress on Action Between 2014-2019	a) **Begin by working with owners of remaining potentially hazardous URM buildings to obtain structural analyses of their buildings and to undertake corrective mitigation measures to improve seismic resistance or to remove the buildings and replace them with safer buildings.** **In Progress** Description: Of 587 buildings placed on the URM inventory, 20 buildings remained on the inventory in 2014. Since 2014, 15 have complied and been removed. One additional URM building was identified and added to the inventory. There are currently six URM buildings that need to be retrofitted. All owners have received multiple communications from the City including citation penalties. Five of the six building owners have applied for permits. b) **Apply available legal remedies, including but not limited to citations, to owners who fail to comply with the URM ordinance.** **In Progress** Description: The Building and Safety Division continues to cite the remaining owners of unreinforced masonry buildings. In addition, staff established a Retrofit Grants program and has worked to incentivize retrofits with financial assistance. c) **Maintain program notification to building occupants and owners.** **In Progress** Description: Owners are required to post signs in the main entrance of the building indicating their building is on the URM inventory and constitutes a severe threat to life safety in the event of an earthquake of moderate to high magnitude. Additionally, the City maintains and regularly updates its List of Unreinforced Masonry Buildings that still need to be retrofitted, available for public review on the City website.

2014 Buildings	**Reduce hazard vulnerabilities for non-City-owned buildings throughout Berkeley.**

Proposed Activities	a) Periodically update and adopt the California Building Standards Code with local amendments to incorporate the latest knowledge and design standards to protect people and property against known seismic, fire, flood and landslide risks in both structural and non-structural building and site components. b) Explain requirements and provide guidance to owners of potentially hazardous structures to facilitate retrofit.
Lead Organization and Staff Lead	Planning Department – Building and Safety Division Staff lead: Building Official
Priority	High
Timeline	Enactment of 2013 Building Code: January 1, 2014 Enactment of 2016 Building Code: January 1, 2017 Technical assistance: Ongoing
Progress on Action Between 2014-2019	**a) Periodically update and adopt the California Building Standards Code with local amendments to incorporate the latest knowledge and design standards to protect people and property against known seismic, fire, flood and landslide risks in both structural and non-structural building and site components.** **In Progress** Description: Each three-year code cycle, the Building and Safety Division adopts local technical amendments and updated standards addressing local fire and seismic hazards. **b) Explain requirements and provide guidance to owners of potentially hazardous structures to facilitate retrofit.** **In Progress** The City has identified additional categories of potentially hazardous buildings including rigid wall - flexible diaphragm buildings, non-ductile concrete buildings and soft-story buildings with three or four residential units or commercial uses that are not subject to mandatory retrofit requirements. The City published technical guidelines regarding retrofits of these building types and eligible building owners were invited to apply for a FEMA-funded retrofit grant. The City also participated in the Earthquake Brace + Bolt program, a grant program administered by the California Earthquake Authority, providing grants of up to $3,000 for seismic retrofits of buildings with 1-4 dwelling units.

2014 **Fire Code**	**Reduce fire risk in existing development through fire code updates and enforcement.**
Proposed Activities	a) Periodically update and adopt the Berkeley Fire Code with local amendments to incorporate the latest knowledge and design standards to protect people and property against known risks in both structural and non-structural building and site components. b) Maintain Fire Department efforts to reduce fire risk through inspections: • Annual inspections in all Fire Zones • Hazardous Fire Area inspections • Multi-unit-residential building inspections in all Fire Zones c) Create a standard for written vegetation management plans for major construction projects in Fire Zones 2 and 3. d) Evaluate inspection procedures and adjust inspection cycle annually based on changing climatic conditions.
Lead Organization and Staff Lead	Fire Department – Division of Fire Prevention Staff Lead: Deputy Fire Chief (Fire Marshal)
Priority	High
Timeline	Fire Code Adoption: Complete by January 2014 and January 2017 Inspections: Ongoing Vegetation Management Standard: 1-2 years Inspection system evaluation: Ongoing
Progress on Action Between 2014-2019	**a) Periodically update and adopt the Berkeley Fire Code with local amendments to incorporate the latest knowledge and design standards to protect people and property against known risks in both structural and non-structural building and site components.** **Completed (Ongoing)** The City of Berkeley updated the Berkeley Fire Code on November 29, 2016 (Ordinance No. 7,518-N.S) **b) Maintain Fire Department efforts to reduce fire risk through inspections:** • **Annual inspections in all Fire Zones** **Deferred** The Fire Department was not able to complete all annual inspections in 2014 - 2018 due to lack of staff. The Fire Department has improved its efficiency and as of 2018 completed approximately 90% of required inspections.

While Fire Prevention Division staffing has not increased, Berkeley's population has grown and the city has seen a substantial increase in new construction and associated density. These additional services demand more staffing that has not yet been appropriated in the budget.

- **Hazardous Fire Area inspections**

Completed with modifications (Ongoing)
From 2014-2016, Fire Department personnel completed required inspections in the Hazardous Fire Area (HFA).
In 2017 and 2018, the Fire Prevention Division added over 300 properties to the HFA Program. This was an approximate increase of 30% without additional staffing allocations.
In 2017, the Fire Department completed inspections of all HFA properties and found violations in approximately half of the 300+ newly-added properties. These violations were subsequently abated.
The Fire Department will complete all HFA Program inspections in 2018.
The Fire Department is undergoing a thorough review of this program and will possibly further increase the number of properties to be included in the HFA Program if additional staffing is provided.

- **Multi-unit-residential building inspections in all Fire Zones**

Deferred
See item (a) above.

c) **Create a standard for written vegetation management plans for major construction projects in Fire Zones 2 and 3.**
Deferred
The Fire Prevention Division was unable to complete this activity due to lack of staffing resources. However, the City has adopted the State-mandated regulations, California Building Code Chapter 7A, which requires ignition-resistant exterior construction.

d) **Evaluate inspection procedures and adjust inspection cycle annually based on changing climatic conditions.**
Deferred

	The Fire Prevention Division was unable to carry out this activity due to lack of staffing resources.

2014 Vegetation Management	**Reduce fire risk in existing development through vegetation management.**
Proposed Activities	a) Maintain Fire Fuel Chipper Program b) Maintain Fire Fuel Abatement Program on Public Land c) Maintain Fire Fuel Debris Bin Program d) Maintain Weekly Curbside Plant Debris Collection e) Pursue external funding to increase education and awareness of vegetation management standards for fire fuel reduction
Lead Organization and Staff Lead	Department of Parks Recreation and Waterfront – Parks Division Fire Fuel Chipper Program Staff Lead: Senior Forestry Supervisor Fire Fuel Abatement Program on Public Land Staff Lead: Senior Landscape Supervisor Department of Public Works – Zero Waste Division (Fire Fuel Debris Bin Program and Weekly Curbside Plant Debris Collection) Staff Lead: Zero Waste Manager Fire Department – Division of Support Services (Funding for education) Staff Lead: Deputy Fire Chief (Fire Marshal)
Priority	High
Timeline	Ongoing
Progress on Action Between 2014-2019	**a) Maintain Fire Fuel Chipper Program** **In Progress (Ongoing)** The City maintained this yard waste collection program, which reduced fire fuels on private properties. The Program serves properties in the hills from June through September each year. Since 2014, over 100 tons of vegetation was collected and recycled, on average, each year.

	b) **Maintain Fire Fuel Abatement Program on Public Land** **In Progress/Ongoing** This Program was maintained in order to reduce fire fuel on public property. From May to mid-August each year, an average of 125 tons of debris are removed from approximately 98 public sites, including parks, pathways and landscaped medians. c) **Maintain Fire Fuel Debris Bin Program** **In Progress (Ongoing)** The Fire Fuel Debris Bin Program is coordinated by the Department of Public Works' Zero Waste Division, which delivers and removes 30 yard roll-off boxes from requesting neighborhoods. This effort yields an average of 132 tons of plant debris per year. d) **Maintain Weekly Curbside Plant Debris Collection** **In Progress (Ongoing)** 30,000 tons of residential and commercial plant debris and commercial food waste is collected each year through weekly curbside collection and converted to compost. e) **Pursue external funding to increase education and awareness of vegetation management standards for fire fuel reduction** **Deferred** The Fire Prevention Division was unable to carry out this activity due to lack of staffing resources. In September 2018, the Fire Department established the Professional Standards Division, which will support the Department in seeking out external funding to perform these activities.

2014 Hazard Information Proposed Activities	**Collect, analyze and share information with the Berkeley community about Berkeley hazards and associated risk reduction techniques.** a) Track changes in hazard risk using the best-available information and tools. b) Collect and share up-to-date hazard maps identifying areas subject to heightened risk from hazards. c) Partner with the Association of Bay Area Governments to incorporate Berkeley's vulnerabilities onto regionally-managed hazard maps.

	d) Publicize financial and technical assistance resources for risk reduction.
Lead Organization and Staff Lead	Fire Department – Office of Emergency Services Lead Staff: Emergency Services Coordinator Office of Energy and Sustainable Development (Climate Change Hazards) Lead Staff: Climate Action Coordinator
Priority	High
Timeline	Ongoing
Progress on Action Between 2014-2019	**a) Track changes in hazard risk using the best-available information and tools.** **In Progress (Ongoing)** Earthquake: The City of Berkeley is a HayWired Coalition Partner, having provided input in development of the USGS's HayWired Earthquake Scenario. USGS scientists presented findings to staff at two meetings in 2017. HayWired findings have been integrated into this 2019 Local Hazard Mitigation Plan. Additionally, emergency managers have used the HayWired scenario as a basis for staff emergency response exercises. Tsunami: The Office of Emergency Services adopted the *California Maritime Tsunami Response Playbook* and the *California Tsunami Evacuation Playbook.* These Playbooks address appropriate response actions for different tsunami scenarios, considering Berkeley's specific geography. These documents were produced by the California Geological Survey, National Oceanic and Atmospheric Administration, and California Office of Emergency Services. City staff met with representatives from these organizations in 2018 to discuss implementation of these products in Berkeley. These tools enable Berkeley to have scaled responses to different expected tsunami flood levels. Climate Science: The Office of Energy & Sustainable Development (OESD) continues to track the latest science, information and tools related to climate change impacts, including but not limited to sea-level rise and extreme heat. Some of this new research is incorporated into the 2019 LHMP Update. **b) Collect and share up-to-date hazard maps identifying areas subject to heightened risk from hazards.** **In Progress (Ongoing)**

The 2019 Local Hazard Mitigation Plan incorporates up-to-date hazard maps. Additionally, the Office of Emergency Services has created web pages with hazard maps for earthquake, seismic-induced landslide, wildfire, and tsunami.
Hazard maps have been incorporated into community outreach presentations, including the 1-hour Disaster Preparedness presentation and the 3-hour Community Emergency Response Team Disaster Preparedness Course.

OESD continues to track and share any new information that can inform hazard maps.

c) **Partner with the Association of Bay Area Governments to incorporate Berkeley's vulnerabilities onto regionally-managed hazard maps.**
Completed with Modifications
ABAG's website provides hazard maps for earthquake, flooding, wildfire, and landslide.
Berkeley vulnerabilities are presented in this 2019 Local Hazard Mitigation Plan update.

d) **Publicize financial and technical assistance resources for risk reduction.**
In progress
The Building & Safety Division has developed a comprehensive website for Seismic Safety Information and Programs, which links to resources for the following:

Funding for Seismic Retrofits:
- Transfer Tax Reductions for Qualifying Seismic Work
- Retrofit Grants for Seismically Vulnerable Buildings
- Earthquake Brace + Bolt
- PACE Financing for Seismic Retrofits

Berkeley's Mandatory Seismic Retrofit Programs
- Soft Story Program
- Unreinforced Masonry Program

Earthquake and Disaster Preparedness
- Building Occupancy Resumption Program (BORP)
- Community Emergency Response Team (CERT) Training

	The City has hosted multiple community workshops for these and other programs. OESD continues to promote Property Assessed Clean Energy (PACE) financing. More information at: https://www.cityofberkeley.info/PACE/

2014 Partnerships	**Ensure that the City provides leadership and coordinate with the private sector, public institutions, and other public bodies in disaster mitigation.**
Proposed Activities	a) Support and encourage efforts undertaken by key lifeline providers to plan for and finance seismic retrofit and other disaster-resistance measures, including: • Utility providers • Transportation agencies • Communication providers • Healthcare facilities b) Coordinate with and encourage mitigation actions of: • Institutions serving the Berkeley community • Berkeley organizations and nonprofits • Other partners whose actions affect the Berkeley community
Lead Organization and Staff Lead	City Manager's Office (Advocacy) Staff Lead: Deputy City Manager Fire Department – Office of Emergency Services (Coordination) Staff Lead: Office of Emergency Services Captain
Priority	High
Timeline	Ongoing
Progress on Action Between 2014-2019	**a) Support and encourage efforts undertaken by key lifeline providers to plan for and finance seismic retrofit and other disaster-resistance measures, including:** • **Utility providers** • **Transportation agencies** • **Communication providers** • **Healthcare facilities** **Completed with Modifications** City staff coordinate regularly on disaster planning and preparedness activities with emergency management staff from partner agencies. Support and encouragement as written in this action is primarily undertaken by elected officials.

	b) Coordinate with and encourage mitigation actions of: • **Institutions serving the Berkeley community** • **Berkeley organizations and nonprofits** • **Other partners whose actions affect the Berkeley community** **In Progress (Ongoing)** In 2018, the City of Berkeley Office of Emergency Services provided key support to Easy Does It, an agency serving community members with access and functional needs. Easy Does It successfully applied for a $30,000 grant from the Christopher and Dana Reeve Foundation to provide in-home non-structural mitigation services to people with spinal cord injuries. Through the Community Resilience Center Program and the Apartment Resilience Center Program, City staff maintain connections with organizations serving vulnerable populations in Berkeley. The City regularly shares information about upcoming mitigation opportunities with participating organizations.

2014 **EBMUD**	**Work with EBMUD to ensure an adequate water supply during emergencies and disaster recovery.**
Proposed Activities	a) Coordinate with EBMUD regarding plans to install a new 48-inch pipeline parallel to the existing north-south water main in 2015-2016. b) Explore project approaches with EBMUD to expedite replacement of problem pipelines in Berkeley neighborhoods exposed to wildland-urban interface fire and seismic ground failure. c) Coordinate with EBMUD to ensure that pipeline replacement projects and upgrades are coordinated with the City's five-year street paving program.
Lead Organization and Staff Lead	Department of Public Works – Engineering Division Staff Lead: City Engineer
Priority	High
Timeline	Ongoing
Progress on Action Between 2014-2019	**a) Coordinate with EBMUD regarding plans to install a new 48-inch pipeline parallel to the existing north-south water main in 2015-2016.** **In Progress** EBMUD has settled on a pipeline alignment, running north-south on Ellsworth Street between Bancroft Way and Stuart Street, then east-west on Stuart Street between Ellsworth Street and Benvenue

	Avenue. EBMUD produced 65% drawings for City review and comments. EBMUD's project timeline is for construction in 2019-2020 timeframe. b) **Explore project approaches with EBMUD to expedite replacement of problem pipelines in Berkeley neighborhoods exposed to wildland-urban interface fire and seismic ground failure.** **In Progress (Ongoing)** The City and EBMUD meet on a quarterly basis to exchange information on projects to allow timely coordination and minimize conflicts between City, EBMUD, and private projects within Berkeley. In 2018, EBMUD completed an extensive pipeline replacement project in the Panoramic Hill area, which is exposed to both wildland-urban interface fire hazards and seismic hazards. They have also prepared to construct a Pumping Plant Project on Panoramic Hill in late 2019 and 2020. c) **Coordinate with EBMUD to ensure that pipeline replacement projects and upgrades are coordinated with the City's five-year street paving program.** **In Progress (Ongoing)** In quarterly meetings the coordination of EBMUD projects with City stormwater projects, sanitary sewer projects, traffic management projects, paving projects, 5-year paving program, and known significant private projects is discussed. An example of this is coordinating the sequencing of the construction of the Panoramic Pumping Plant with the City's Panoramic Street Rehabilitation Project in an effort to minimize impacts to the residents and provide the residents with high quality paved streets in their neighborhood.

2014 **Hills Evacuation**	**Manage and promote pedestrian evacuation routes in Fire Zones 2 and 3.**
Proposed Activities	a) Ensure that all public pathways and associated signage are maintained to identify and provide safe and

	accessible pedestrian evacuation routes from the hill areas. b) Update City maps of all emergency access and evacuation routes to include pedestrian pathways. c) Coordinate with UC Berkeley and Berkeley Lab to ensure that evacuation route options account for paths on UC and Berkeley Lab property. d) Publicize up-to-date maps of all emergency access and evacuation routes.
Lead Organization and Staff Lead	Department of Public Works – Engineering Division (Maintenance) Public Works Staff Lead: Associate Civil Engineer Information Technology GIS Division (Mapping) IT Staff Lead: GIS Coordinator Fire Department Office of Emergency Services (Outreach) Fire-OES Staff Lead: Emergency Services Coordinator
Priority	High
Timeline	Maintenance: Ongoing Mapping: 1 year to include pathways in public maps, then ongoing updates Publicizing Maps: Ongoing
Progress on Action Between 2014-2019	**a) Ensure that all public pathways and associated signage are maintained to identify and provide safe and accessible pedestrian evacuation routes from the hill areas.** **In Progress (Ongoing)** In spring 2015 the City performed repair work on Bret Harte Path; work included the removal and replacement of damaged concrete stairs, removal and replacement of damaged concrete walkway, and the installation of handrails. In spring/summer 2016 the City developed the previously undeveloped John Muir Path. In winter 2017 the Berkeley Path Wanderers Association (BPWA) installed approximately thirty 4'-wide wooden stairs at the bottom steep section of Dwight Way Path. When the City develops a previously undeveloped path, a "street" sign is installed at either end with the path's name. Path name signs are maintained in the same manner as street name signs. Specifically if a sign is brought to the City's attention as needing replacement due to deterioration, damage, or theft, it is added to the work list and replaced as funding and competing priorities permit.

b) **Update City maps of all emergency access and evacuation routes to include pedestrian pathways.**
Complete
The City has worked with the Berkeley Path Wanderers to create a GIS map of Berkeley's pedestrian pathways. This map has been included in the 2019 LHMP.

c) **Coordinate with UC Berkeley and Berkeley Lab to ensure that evacuation route options account for paths on UC and Berkeley Lab property.**
Completed
Because the location and anticipated spread of a wildfire are by nature unpredictable, the City coordinates with UC Berkeley and the Lawrence Berkeley National Lab to be ready to consider evacuation route options through both UC Berkeley and LBNL property.

Authority to open or close these campuses rests with the campuses themselves. The City is ready to coordinate with these campuses at both the Field and Emergency Operations Center level should a fire threaten Berkeley community members in or proximal to these locations. The City coordinates regularly with these agencies. In December 2017, City staff supported the LBNL's Evacuation Exercise, including coordination between the City of Berkeley Police Department and the UC Berkeley Police Department (which provides protective services to LBNL.)

Additionally, the City instructs community members to select and practice multiple evacuation routes, considering both car-based and foot-based paths. These evacuation routes may cross into UC Berkeley territory. Because of the sensitive and hazardous materials at the LBNL site, the facility is not open to the community and would be unlikely to be opened during a wildfire evacuation.

d) **Publicize up-to-date maps of all emergency access and evacuation routes.**
In Progress (Ongoing)
The City's Wildfire Evacuation website recommends that community members be ready to evacuate on foot, and links to the Berkeley Path Wanderers (BPWA) website.

	The Office of Emergency Services (OES) produced a Household Wildfire Evacuation Plan flyer. OES uses this flyer in wildfire evacuation community meetings. The flyer is tailored to include a relevant selection from the Berkeley Path Wanderers Map, and instructs the user to highlight multiple car- and foot-based evacuation routes. BPWA regularly communicates path locations to Google, which makes them publicly available online through Google Maps.

2014 **Climate Change Integration**	**Mitigate climate change impacts by integrating climate change research and adaptation planning into City operations and services.**
Proposed Activities	a) Determine staffing needs to monitor research and oversee integration of climate change adaptation into City operations and services b) Develop and implement a process to integrate adaptation planning into City operations. Activities include: • Integrate climate change adaptation actions into the Citywide Work Plan • Integrate climate change adaptation considerations into templates for staff reports to City Council and City commissions • Train City staff on the basic science and impacts of climate change and on climate adaptation strategies • Develop a staff recognition and award program to encourage staff to integrate climate change considerations into City projects and programs
Lead Organization and Staff Lead	City Manager's Office through Sustainability Working Group (Process Management) Staff Lead: Deputy City Manager Planning Department – Office of Energy and Sustainable Development (Support) Staff Lead: Climate Action Coordinator
Priority	Medium
Timeline	Staffing: 2-3 years Work Plan Integration: 1 year Council/Commission Report Integration: 1 year Funding Mechanisms: 2-3 years Staff Training: 2-3 years
Progress on Action Between 2014-2019	- **Determine staffing needs to monitor research and oversee integration of climate change adaptation into City operations and services**

In Progress
OESD has a current staff of 7 part- and full-time employees, and 3 interns, but additional support is needed in order to achieve Climate Action Plan goals, including the integration of climate change adaptation into City operations and services. Transferred this action to Sustainability Office from the City Manager's Working Group.

- **Develop and implement a process to integrate adaptation planning into City operations. Activities include:**
  - **Integrate climate change adaptation actions into the Citywide Work Plan**
    Completed
    Sustainability was included in the Citywide Work Plan for one budget cycle. Climate adaptation is addressed in the City's Resilience Strategy, and resilience and sustainability are included as long-term goals of the City's Strategic Plan.

  - **Integrate climate change adaptation considerations into templates for staff reports to City Council and City commissions**
    Completed with modifications
    Environmental sustainability was incorporated to all staff reports as part of the City Council template.

  - **Train City staff on the basic science and impacts of climate change and on climate adaptation strategies**
    In Progress
    Sustainability staff will continue to develop training for staff on climate change and climate adaptation strategies. OESD has also applied for funding from the Urban Sustainability Directors Network to create a training for City staff on implementing adaptation practices with an equity lens.

  - **Develop a staff recognition and award program to encourage staff to integrate climate change considerations into City projects and programs**

	Completed with modifications In 2014, the City created the Berkeley Environmental Achievement Awards to recognize employees that showed innovation and creativity, leadership and collaboration, and achievement of a clear environmental benefit in their work. OESD plans to continue to coordinate this annual award program in the future.

D.2.b Medium-Priority Actions

2014 **Energy Assurance**	**Develop an Energy Assurance Plan for City operations.**
Proposed Activities	a) Develop a plan to assist the City of Berkeley to prepare for, respond to, and recover from disasters that include energy emergencies. • Identify the key City facilities that support emergency operations. • Estimate those facilities' energy supply and demand during emergencies to assess those facilities' vulnerabilities to power loss. • Identify potential actions to mitigate those vulnerabilities (e.g., photovoltaic-supplemented emergency generation, energy efficiency activities, and/or mobile charging stations). b) Integrate energy assurance actions into Citywide planning processes.
Lead Organization and Staff Lead	Fire Department – Office of Emergency Services (Plan Development and Gap Analysis) Staff Lead: Emergency Services Coordinator Planning Department – Office of Energy and Sustainable Development (Energy Profile) Staff Lead: Sustainability Outreach Specialist Department of Public Works – Facilities Division (City Infrastructure) Staff Lead: Facility Maintenance Superintendent
Priority	Medium
Timeline	Plan Development: 1 year Project implementation: To be determined
Progress on Action Between 2014-2019	**a) Develop a plan to assist the City of Berkeley to prepare for, respond to, and recover from disasters that include energy emergencies.** • **Identify the key City facilities that support emergency operations.** **Completed** The City identified 48 City facilities that support emergency operations in an assessment of Municipal Energy Assurance Vulnerabilities. • **Estimate those facilities' energy supply and demand during emergencies to assess those facilities' vulnerabilities to power loss.** **Completed**

	The assessment of Municipal Energy Assurance Vulnerabilities included a basic analysis of gas and electric usage at each facility, along with estimated runtimes for any generators positioned at these facilities. For four of the key City facilities (Center Street Garage, Public Safety Building, 2180 Milvia, and 1947 Center Street) more detailed analysis of energy supply and demand was created through the Berkeley Energy Assurance Transformation (BEAT) project. • **Identify potential actions to mitigate those vulnerabilities (e.g., photovoltaic-supplemented emergency generation, energy efficiency activities, and/or mobile charging stations).** **In Progress** OESD worked on feasibility analysis and design for downtown microgrid (BEAT project). The feasibility study completed as part of the BEAT project investigated the potential for a microgrid to connect critical facilities in downtown Berkeley. The results of the feasibility study now show that solar + storage at singular facilities is more feasible than a microgrid. OESD is now seeking to identify potential financing opportunities to expand this solution beyond downtown. OESD will also evaluate solar + storage options at critical facilities. b) **Integrate energy assurance actions into Citywide planning processes.** **In Progress (Ongoing)** Energy assurance planning is integrated into Citywide planning processes at the planning/conceptual design phase. For example, with the upcoming retrofit of the North Berkeley Senior Center, staff considered options for increasing energy efficiency and assurance of the facility, including keeping the building solar and generator ready. Solar battery backups were determined to be infeasible due to cost and challenges in placing the batteries on the site. Instead, the North Berkeley Senior

	Center will be constructed with hookups for portable generators.

2014 **Gas Safety**	**Improve the disaster-resistance of the natural gas delivery system to increase public safety and to minimize damage and service disruption following a disaster.**
Proposed Activities	a) Work with the Public Utilities Commission, utilities, and oil companies to strengthen, relocate, or otherwise safeguard natural gas and other pipelines where they extend through areas of high liquefaction potential, cross potentially active faults, or traverse potential landslide areas, or areas that may settle differentially during an earthquake. b) Establish a program to provide free automatic gas shutoff valves to community members who attend disaster readiness training. Provide subsidized permit fee waivers for low-income homeowners.
Lead Organization and Staff Lead	Fire Department – Office of Emergency Services Staff Lead: Office of Emergency Services Captain (Coordination) Staff Lead: Associate Management Analyst (Shutoff Valve Program)
Priority	Medium
Timeline	Coordination: Ongoing Gas Valve Shutoff Program: July 2014
Progress on Action Between 2014-2019	**a) Work with the Public Utilities Commission, utilities, and oil companies to strengthen, relocate, or otherwise safeguard natural gas and other pipelines where they extend through areas of high liquefaction potential, cross potentially active faults, or traverse potential landslide areas, or areas that may settle differentially during an earthquake.** **Completed with Modifications** City staff regularly coordinate with PG&E and EBMUD on emergency response planning, training, and exercise activities. Additionally, City staff participated in extensive discussions with Berkeley High School Safety Committee regarding opportunities to strengthen or add an automatic or electronic shutoff valves to the transmission pipeline on Allston Way. In June 2018, staff participated in PG&E exercise on the topic.

	b) Establish a program to provide free automatic gas shutoff valves to community members who attend disaster readiness training. Provide subsidized permit fee waivers for low-income homeowners. **Completed (Ongoing)** The Automatic Gas Shutoff Valve Program distributes valves to homeowners and renters with building owner approval. In order to qualify, applicants must take two City of Berkeley-offered disaster preparedness trainings. All qualified applicants receive a free shutoff valve, and low-income applicants do not have to pay for the permit. As of 10/15/18, 11 valves have been distributed through the program.

2014 **Stormwater System**	**Rehabilitate the City's stormwater system to reduce local flooding caused by inadequate storm drainage.**
Proposed Activities	a) Complete the hydraulic analysis of watersheds in the city to predict areas of insufficient capacity. b) Seek funding to perform system capacity and disaster resistance improvements.
Lead Organization and Staff Lead	Public Works Department – Engineering Division Staff Lead: Associate Civil Engineer
Priority	Medium
Timeline	Complete the hydraulic analysis: funding-dependent System improvements: funding-dependent
Progress on Action Between 2014-2019	**a) Complete the hydraulic analysis of watersheds in the city to predict areas of insufficient capacity.** **Deferred** The 2018 Clean Stormwater Fee was put to a vote of property owners in Spring 2018. The property owners approved the fee enabling City Council to adopt Resolution No. 68,483—N.S. on June 12, 2018 enabling the fee to be collected through the County Tax Roll for Fiscal Year 2018-2019. A portion of the revenue generated by the 2018 Clean Stormwater Fee will be used to complete the Watershed Management Plan and produce an overall storm water master plan. **b) Seek funding to perform system capacity and disaster resistance improvements.** **Completed** The 2018 Clean Stormwater Fee provides the City with much needed funding to operate and maintain stormwater

	drainage facilities, reduce pollutant discharges from the City, and improve the financial health of the stormwater program. Some funding will be available for system improvements, but this funding will not be enough to address all of the required improvements. The City continues to look for funding opportunities to supplement City funding sources.

2014 Tsunami	**Define and mitigate Berkeley's tsunami hazard.**
Proposed Activities	a) Collaborate with the California Office of Emergency Services to define Berkeley's different areas of inundation for different tsunami scenarios. b) Collaborate with the California Office of Emergency Services, the California Geological Survey, and the Federal Emergency Management Agency to document and explore potential tsunami hazard mitigation measures for Berkeley's maritime communities.
Lead Organization and Staff Lead	Fire Department – Office of Emergency Services (Scenarios) Staff Lead: Emergency Services Coordinator Parks, Recreation and Waterfront Department – Marina Division (Mitigation Measures) Staff Lead: Waterfront Manager
Priority	Medium
Timeline	Scenarios: 2 years Mitigation Measures: To be determined
Progress on Action Between 2014-2019	**a) Collaborate with the California Office of Emergency Services to define Berkeley's different areas of inundation for different tsunami scenarios.** **Completed** See *Hazard Information* Action above. **b) Collaborate with the California Office of Emergency Services, the California Geological Survey, and the Federal Emergency Management Agency to document and explore potential tsunami hazard mitigation measures for Berkeley's maritime communities.** **In Progress** The City of Berkeley met with the California Office of Emergency Services and the California Geological Survey to review tsunami playbooks. At this meeting

	State representatives provided a DRAFT Harbor Improvement Report for the Berkeley Marina, which mitigation measures that minimize loss of life and damage from future tsunamis. Staff plans to use this guidance to consider potential mitigation measures.

2014 Extreme Heat	**Reduce Berkeley's vulnerability to extreme heat events and associated hazards.**
Proposed Activities	a) Monitor and support regional and State-level efforts to forecast the impact of climate change on temperatures and incidence of extreme heat events in Berkeley and the region, and integrate extreme heat event readiness into City operations and services. b) Create and maintain shading by sustaining municipal tree planting efforts and continuing to maintain the health of existing trees. c) Continue to implement energy efficiency ordinances for existing residential and commercial buildings to improve building comfort, including in extreme weather conditions, and to reduce energy use.
Lead Organization and Staff Lead	Planning Department – Office of Energy and Sustainable Development (Monitor Impacts) Staff Lead: Climate Action Coordinator Department of Parks, Recreation and Waterfront – Parks Division (Tree Planting) Staff Lead: Parks Superintendent
Priority	Medium
Timeline	Other Activities: Ongoing
Progress on Action Between 2014-2019	**a) Monitor and support regional and State-level efforts to forecast the impact of climate change on temperatures and incidence of extreme heat events in Berkeley and the region, and integrate extreme heat event readiness into City operations and services.** **In Progress (Ongoing)** OESD continues to track the latest science and information related to extreme heat events. This includes tracking new reports, such as the San Francisco Bay Area 2017 Risk Profile by the Association of Bay Area Governments, the EPA's 2016 Extreme Heat Guidebook, and the Air District's 2017 Clean Air Plan. **b) Create and maintain shading by sustaining municipal tree planting efforts and continuing to maintain the health of existing trees.** **In Progress (Ongoing/Funding-Dependent)** Since 2014, at least 857 trees have been planted using funding from a State of California Environmental Enhancement Mitigation Program grant. Since July 18, 2014, over 5,743 trees have been pruned.

	c) **Continue to implement energy efficiency ordinances for existing residential and commercial buildings to improve building comfort, including in extreme weather conditions, and to reduce energy use.** **In Progress** The City continues implement the Building Energy Saving Ordinance (BESO), which aims to motivate upgrades in existing buildings in Berkeley. The ordinance requires an energy assessment for buildings less than 25,000 sq ft at time of sale. For buildings over 25,000 sq ft, BESO requires an assessment as well as annual energy benchmarking data. OESD is exploring opportunities to integrate building vulnerability to extreme heat events into BESO.

2014 **Severe Storms**	**Reduce Berkeley's vulnerability to severe storms and associated hazards.**
Proposed Activities	a) Support and monitor research on climate change impacts on local rainfall patterns and incidences of severe storms. b) Integrate considerations of severe storms into City operations and services: • Use development review to ensure that new development does not contribute to an increase in flood potential. • Complete the hydraulic analysis of watersheds in the city to predict areas of insufficient capacity. • Design public improvements such as streets, parks and plazas, for retention and infiltration of stormwater by diverting urban runoff to bio-filtration systems such as greenscapes. • Continue to encourage use of permeable surfaces and other techniques as appropriate in both greenscape and hardscape areas for retention and infiltration of stormwater. • Continue to encourage the development of green roofs by providing local outreach and guidelines consistent with the Building Code.
Lead Organization and Staff Lead	Planning Department – Office of Energy and Sustainable Development Staff Lead: Climate Action Coordinator (Monitor Research) Staff Lead: Sustainability Outreach Specialist (Green Roof outreach) Planning Department – Land Use Planning Division (Development Review)

	Staff Lead: Division Director Department of Public Works – Engineering Division (Watershed Management Plan, Permeable Surfaces, Public Improvements) Staff Lead: Supervising Civil Engineer
Priority	Medium
Timeline	Ongoing
Progress on Action Between 2014-2019	- **Support and monitor research on climate change impacts on local rainfall patterns and incidences of severe storms.** **Completed** Research has indicated that climate change will not significantly affect total rainfall, but may contribute to a more abbreviated and intense wet season, which has associated impacts. - **Integrate considerations of severe storms into City operations and services:** • **Use development review to ensure that new development does not contribute to an increase in flood potential.** **In Progress/Ongoing** Land Use Planning Division, Building and Safety Division, Office of Energy and Sustainable Development, and Department of Public Works coordinate efforts to ensure stormwater management best practices described below are followed. • **Complete the hydraulic analysis of watersheds in the city to predict areas of insufficient capacity.** **Deferred** The City is monitoring developing sea level rise discussions and requirements, and changes in rainfall event intensities. These characteristics will be incorporated in the Watershed Management Plan and other appropriate planning documents, and design standards for the City. • **Design public improvements such as streets, parks and plazas, for retention and infiltration of stormwater by diverting urban runoff to bio-filtration systems such as greenscapes.** **In Progress (Ongoing)**

	Public Works has been using Measure M funds and other City funds to implement green infrastructure retain, treat, and infiltrate stormwater. Since 2014 the City installed bioswales at the intersections of Rose Street/Hopkins Street and at Hearst Avenue/Oxford Street, and a permeable paver bus pad at the intersection of Shattuck Avenue/University Avenue. In addition the City will have the Woolsey LID project under construction in 2019. • **Continue to encourage use of permeable surfaces and other techniques as appropriate in both greenscape and hardscape areas for retention and infiltration of stormwater.** **In Progress (Ongoing)** The City requires green infrastructure on public and private regulated projects through the zoning and building permitting processes. These include bio-swales, permeable paving systems, and controlling peak runoff. The City continues to explore use of permeable surfaces such as permeable concrete and pavers in future projects. Ongoing guides will be available on City's sustainability website. • **Continue to encourage the development of green roofs by providing local outreach and guidelines consistent with the Building Code.** **Completed** The City maintains a webpage that serves as an introductory guide to green roofs including the benefits, types, building factors to consider and permit requirements.

2014 **Water Security**	**Collaborate with local, State, regional and federal partners to increase the security of Berkeley's water supply from climate change impacts.**
Proposed Activities	a) Support efforts by the U.S. Forest Service and its partners to improve water security through restoration of the Headwaters Forest and Mokelumne River.

	b) Encourage water recycling and gray water use through the distribution of outreach materials and local guidelines that are consistent with the Building Code. c) Encourage the use of water conservation technologies and techniques in the design of new buildings and landscapes, such as waterless urinals and cisterns, through the development of local guidelines that are consistent with the Building Code. d) Partner with East Bay Municipal Utility District (EBMUD) to provide and market incentives for residents, businesses and institutions to conserve water. e). Partner with agencies such as EBMUD and StopWaste.org to encourage private property owners and public agencies (including the City government) to use sustainable landscaping techniques that require less water and energy to maintain.
Lead Organization and Staff Lead	City Manager's Office via Sustainability Working Group (Partner Support) Staff Lead: Deputy City Manager Planning Department – Office of Energy and Sustainable Development Staff Lead: Climate Action Coordinator (Community Awareness) Staff Lead: Sustainability Outreach Specialist (Water Recycling/Incentives) Staff Lead: Sustainability Coordinator (Guidelines and Landscaping)
Priority	Medium
Timeline	Ongoing
Progress on Action Between 2014-2019	**a) Support efforts by the U.S. Forest Service and its partners to improve water security through restoration of the Headwaters Forest and Mokelumne River.** **Deleted** Regularly reached out to US Forest Service to understand actions being taken for water security, but ongoing efforts were not continued due to lack of resources. **b) Encourage water recycling and gray water use through the distribution of outreach materials and local guidelines that are consistent with the Building Code.** **Completed** Information will continue to be available on the City's sustainability website.

	c) **Encourage the use of water conservation technologies and techniques in the design of new buildings and landscapes, such as waterless urinals and cisterns, through the development of local guidelines that are consistent with the Building Code.** **Completed with modifications** The State Energy Code and Water Efficiency Landscape Ordinance incorporated minimum water requirements before local guidelines were developed. City staff now encourage water conservation technologies and techniques as part of implementation of the new code and encourage enforcement through roundtables. Note: Waterless urinals and cisterns are no longer considered best practice. d) **Partner with East Bay Municipal Utility District (EBMUD) to provide and market incentives for residents, businesses and institutions to conserve water.** **In progress** Although focused on during the recent drought, ongoing efforts remain to continue coordination. City staff continuously refer members of the public to available EBMUD resources, such as free water efficiency technologies or rebate programs. e) **Partner with agencies such as EBMUD and StopWaste.org to encourage private property owners and public agencies (including the City government) to use sustainable landscaping techniques that require less water and energy to maintain.** **In progress** Water Efficiency Landscape Ordinance (WELO) became effective December 2015 with new requirements that are being implemented. Jurisdictions are required to report annually to the State, and coordination with EBMUD on implementation is ongoing. StopWaste has prepared general materials that can be tailored by each jurisdiction and plans to do additional training on compliance and enforcement, which the City of Berkeley will utilize.

2014 **NFIP**	**Maintain City participation in the National Flood Insurance Program.**

Proposed Activities	a) Continue to update and revise flood maps for the City. b) Continue to incorporate FEMA guidelines and suggested activities into City plans and procedures for managing flood hazards.
Lead Organization and Staff Lead	Public Works – Engineering Division Staff Lead: Supervising Civil Engineer
Priority	Medium
Timeline	Ongoing
Progress on Action Between 2014-2019	**a) Continue to update and revise flood maps for the City.** **In Progress (Ongoing)** The most recent map updates took effect December 21, 2018. These maps were updated to include new detailed coastal analyses for the San Francisco Bay shoreline of Alameda County north of the San Mateo Bridge. **b) Continue to incorporate FEMA guidelines and suggested activities into City plans and procedures for managing flood hazards.** **In Progress (Ongoing)** The City performs the suggested actions by keeping the Berkeley Municipal Code Chapter 17.12: Flood Zone Development Ordinance in consistent with FEMA National Flood Insurance Program requirements. Most recently updated in 2009, the Ordinance regulates all publicly- and privately-owned land within the areas of special flood hazard. It establishes the Director of the Public Works Department as the Floodplain Administrator for the City. The Building Official ensures construction standards are addressed for projects in flood zones.

2014 **Streamline Rebuild**	**Streamline the zoning permitting process to rebuild residential and commercial structures following disasters.**
Proposed Activities	a) Explore a Zoning Amendment to BMC 23C.04.100 that streamlines the Zoning permitting process to allow industrial and commercial buildings, and multiple-family dwellings to rebuild by right following disasters. Consider different treatment for buildings in high-risk areas, such as: • Imposing higher standards of building construction for rebuilding • Excluding buildings in these areas from the amendment

	b) Define the standard for documentation of current conditions for residential and commercial property owners to rebuild by right (in conformity with current applicable codes, specifications and standards) following disasters. c) Define the process for the City to accept and file this documentation. d) Outreach to property owners about this documentation process.
Lead Organization and Staff Lead	Planning Department – Land Use Planning Division Staff Lead: Division Director
Priority	Medium
Timeline	1 year
Progress on Action Between 2014-2019	**a) Explore a Zoning Amendment to BMC 23C.04.100 that streamlines the Zoning permitting process to allow industrial and commercial buildings, and multiple-family dwellings to rebuild by right following disasters. Consider different treatment for buildings in high-risk areas, such as:** • **Imposing higher standards of building construction for rebuilding** • **Excluding buildings in these areas from the amendment** **Deferred** The Land Use Planning Division begun research to address this proposal. **b) Define the standard for documentation of current conditions for residential and commercial property owners to rebuild by right (in conformity with current applicable codes, specifications and standards) following disasters.** **Deferred** See (a) above. **c) Define the process for the City to accept and file this documentation.** **Deferred** See (a) above. **d) Outreach to property owners about this documentation process.** **Deferred** See (a) above.

D.2.c Low-Priority Actions

2014 **Sea-Level Rise**	**Mitigate the impacts of sea-level rise in Berkeley.**
Proposed Activities	a) Monitor and participate in regional and State-level research on projected sea-level rise in Berkeley and the region. b) Develop guidelines, regulations, and development review procedures to protect new and existing public and private developments and infrastructure from floods due to expected sea-level rise.
Lead Organization and Staff Lead	Planning Department – Office of Energy and Sustainable Development (Monitor Research/Integrate Considerations) Staff Lead: Climate Action Coordinator Planning Department – Land Use Planning Division (Development Regulations) Staff Lead: Division Director
Priority	Low
Timeline	To be determined
Progress on Action Between 2014-2019	**a) Monitor and participate in regional and State-level research on projected sea-level rise in Berkeley and the region.** **In Progress (Ongoing)** New research incorporated into the 2019 LHMP Hazard Analysis. This includes the Adapting to Rising Tides Bay Area Sea Level Rise Analysis and Mapping Project completed in 2017 for local mapping, as well as the State of California Sea-Level Rise Guidance document published in 2018. **b) Develop guidelines, regulations, and development review procedures to protect new and existing public and private developments and infrastructure from floods due to expected sea-level rise.** **In Progress (Ongoing)** Ongoing efforts to integrate consideration of climate impacts into capital and land use planning are underway, including research on other cities' similar efforts as well as beginning cross-departmental conversations on what such requirements would entail.

2014 **HazMat Floods**	**Explore local legislation to require hazardous materials stored in the flood zones to be elevated or otherwise protected from floodwaters.**

Proposed Activities:	a) Conduct cost/benefit evaluation to determine if hazardous materials should be elevated/protected in existing development in flood hazard zones: • Assess potential impacts from hazardous materials release due to flooding • Consult with federal, State and regional partners to identify legislative best practices and lessons learned • Work with Berkeley Building Official to identify engineering solutions and potential permitting requirements for hazardous materials • Identify potential costs to hazardous materials owners b) If cost/benefit evaluation is positive, work with City Manager's Office and City Council to determine and implement path forward. c) If cost/benefit is not positive, consider alternative methods of compliance such relocation or modification of business activities.
Lead Organization and Staff Lead:	Planning Department – Toxics Management Division Staff Lead: Hazardous Materials Specialist II
Priority:	Low
Timeline:	Complete assessment of existing legislation: January 2014 Complete Cost-benefit evaluation for assessment by City Manager's Office: To be determined
Progress on Action Between 2014-2019	**a) Conduct cost/benefit evaluation to determine if hazardous materials should be elevated/protected in existing development in flood hazard zones:** • **Assess potential impacts from hazardous materials release due to flooding** • **Consult with federal, State and regional partners to identify legislative best practices and lessons learned** • **Work with Berkeley Building Official to identify engineering solutions and potential permitting requirements for hazardous materials** • **Identify potential costs to hazardous materials owners** **b) If cost/benefit evaluation is positive, work with City Manager's Office and City Council to determine and implement path forward.** **c) If cost/benefit is not positive, consider alternative methods of compliance such relocation or modification of business activities.**

	Deleted This flooding scenario is unlikely and resources are not identified or likely to become available to perform this work.

D.3 *2019 Changes in Priorities*

While the City's goals and objectives have remained very similar to the 2014 plan, the 2019 LHMP reflects thorough revisions from the 2014 document. Those revisions have resulted in some actions in the 2019 Mitigation Strategy receiving different priority levels than in 2014. The 2019 Hazard Analysis accounts for newly-available science and research and emerging hazards. The associated 2019 mitigation actions account for progress made on mitigation actions since 2014, changes in development in Berkeley, and our new understanding of the hazards we face.

[1] https://www.labormarketinfo.edd.ca.gov/data/labor-force-and-unemployment-for-cities-and-census-areas.html#CCD

Element E: Plan Adoption

The public review process is considered a key step in the City Council's adoption of the 2019 Local Hazard Mitigation Plan. To that end, City staff has engaged with City Commissions and the City Council and throughout the process to develop this plan. Two City Commissions play a key role in plan review and adoption:

<u>Disaster and Fire Safety Commission</u>

The Disaster and Fire Safety Commission (DFSC) is made up of nine members appointed by the City Council, per the guidance of a local ordinance. This Commission meets in public monthly, and advises the City Council on all matters affecting fire safety and/or disaster resilience within Berkeley. For this reason, following FEMA's issuance of Approval Pending Adoption for the Final Draft 2019 LHMP, staff will request the Commission's recommendation to Council on the Final Draft 2019 LHMP.

<u>Planning Commission</u>

The Planning Commission oversees and reviews the planning process and planning issues. Revisions to the General Plan come before the Planning Commission, which meets twice each month in public. Because the Local Hazard Mitigation Plan is an appendix to the City of Berkeley's General Plan, following FEMA's issuance of Approval Pending Adoption for the Final Draft 2019 LHMP, staff will request the Commission's recommendation to Council on the Final Draft 2019 LHMP.

<u>Additional Commissions</u>

Concerned citizens staff nearly forty Berkeley commissions, boards and committees addressing a wide range of issues important to the community. All of these commissions meet in public.

Because of the wide scope of issues covered in the mitigation plan, the City invited all commissions to review the First Draft Plan during the public comment period from December 18, 2018, through February 28, 2019. In addition to the Planning Commission and the Disaster and Fire Safety Commission, 9 commissions reviewed the Plan's executive summary and mitigation strategy in detail and discussed it at a public meeting during this period.

Table 1. *LHMP Commission Meetings During the First Draft Plan Public Comment Period*

Date/Time	Commission
January 3, 2019	Housing Advisory Commission
January 9, 2019	Parks and Waterfront Commission
January 9, 2019	Commission on Disability
January 10, 2019	Public Works Commission
January 16, 2019	Commission on Aging
January 16, 2019	Planning Commission
January 23, 2019	Disaster and Fire Safety Commission
January 23, 2019	Energy Commission
February 4, 2019	Peace and Justice Commission
February 7, 2019	Landmarks Preservation Commission
February 14, 2019	Community Environmental Advisory Commission

Following the February 28 public feedback deadline, City staff reviewed feedback from Commissions and community members, and incorporated appropriate changes into the Final Draft Plan.

Following FEMA's issuance of approval pending adoption, City staff will bring the Final Draft 2019 LHMP to the City's Disaster and Fire Safety Commission and Planning Commission for their recommendations to City Council to adopt the Final Draft Plan. Following those meetings, staff will bring the Final Draft 2019 LHMP to the Berkeley City Council for adoption.