Taming Natural Disasters

Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area

2010 Update

of 2005 Plan

Association of Bay Area Governments

Taming Natural Disasters

Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area

2010 Update of 2005 Plan

Association of Bay Area Governments

Credits

Principal Plan Authors
Jeanne B. Perkins – Consultant, Earthquake and Hazards Program, ABAG
Danielle Hutchings – Earthquake and Hazards Specialist, ABAG

ABAG Staff Support
Michael Smith – GIS Manager
Brandon Soublet – Management Intern
Brian Kirking – Information Services Manager
Jonathan Strunin – Regional Planner (through 2006)

ABAG Management
Henry Gardner – Executive Director
Kenneth Kirkey – Planning Director

Cover Design
Vicki Rutherford - ABAG Communications Assistant

Cover Photos
Top right: San Pablo Dam Seismic Reconstruction Project. Courtesy of East Bay Municipal Utility District, 2009
Middle left: Seismic Retrofit of three story residential building. Courtesy of Anderson-Niswander Construction, Inc., 2009
Middle right: Construction of Bay Bridge bypass on east span. Courtesy of MTC and Caltrans, 2009
Bottom left: Vegetation clearance. Courtesy of Hills Emergency Forum, 2009

The writing and production of this report was funded by the Association of Bay Area Governments and, through in-kind services, the local governments of the Bay Area.

NOTE: It is expected that this report will be adopted by ABAG's Executive Board, as well as the participating local governments, and approved by FEMA in early 2010. Specific mitigation strategies proposed for adoption, as well as a digital version of this document, are available at http://quake.abag.ca.gov/mitigation.

ABAG Publication Number: P09001EQK
Available online at quake.abag.ca.gov/mitigation

Actively Participating Jurisdictions

The following is a list of jurisdictions that have participated in the development of this plan and have submitted a letter of commitment indicating that they are full participants in the plan. Documentation of how each jurisdiction was involved can be found in **Appendix H**, as well as in the individual Annex of the jurisdiction. A list of jurisdictions that participated in 2005, but chose not to participate this time, can also be found in **Appendix H**.

Lead Agency

Association of Bay Area Governments		

Alameda County

Alameda County	Hayward	Pleasanton
Alameda	Livermore	San Leandro
Albany	Newark	Union City
Dublin	Oakland	
Fremont	Piedmont	

Contra Costa County

Brentwood	Hercules	Moraga
Clayton	Lafayette	Orinda
Concord	Martinez	San Pablo

Marin County

Belvedere	Fairfax	San Rafael
Corte Madera	San Anselmo	Tiburon

San Mateo County

San Mateo County	East Palo Alto	Portola Valley
Atherton	Foster City	San Bruno
Belmont	Half Moon Bay	San Carlos
Brisbane	Hillsborough	San Mateo
Burlingame	Menlo Park	South San Francisco
Colma	Millbrae	Woodside
Daly City	Pacifica	

Santa Clara County

Santa Clara County	Los Gatos	San Jose
Campbell	Milpitas	Santa Clara
Cupertino	Monte Sereno	Saratoga
Gilroy	Morgan Hill	Sunnyvale
Los Altos	Mountain View	
Los Altos Hills	Palo Alto	

Solano County

Solano County	Fairfield	Vallejo
Benicia	Rio Vista	
Dixon	Vacaville	

Sonoma County

Cloverdale	Petaluma	Sebastopol
Cotati	Rohnert Park	Sonoma
Healdsburg	Santa Rosa	Windsor

School Districts

Chabot-Las Positas Community College District	Jefferson Unified School District	Ross School District
Fremont Union High School District (Santa Clara Co.)	Oakland Unified School District	

Transit Agencies

AC Transit	Golden Gate Bridge HTD	SMCTD- SamTrans
BART	LAVTA (Wheels)	Santa Clara Valley TA (VTA)
Central Contra Costa TA	MTC	Vallejo Transportation
TriDelta Transit Authority (ECCTA)	SF MTA (MUNI)	Water Emergency TA

Water/Sewer Districts

Alameda County Water District	Montara Water and Sanitary District	Solano Irrigation District
Contra Costa Water District	Purissima Hills Water District	Vallejo Sanitation and Flood Control
Dublin-San Ramon Services District	Santa Clara Valley Water District	Zone 7 Water Agency
East Bay MUD	Sewer Authority Mid-Coastside	
Mid-Peninsula Water District	Solano County Water Agency	

Other Special Districts

Bethyl Island Municipal Improvement District	San Francisquito Creek Joint Powers Authority	Silver Creek Valley Country Club Geologic Hazard Abatement District
East Bay Regional Park District		

Partnering Jurisdictions and Agencies

The following is a list of jurisdictions that have participated in the development of this plan, but have not submitted letters of commitment. Documentation of how each local jurisdiction was involved can be found in **Appendix H**. In addition many agencies, organizations and companies that are not eligible to participate in the LHMP have attended meetings and workshops, given presentations, sit on ABAG committees which are part of the planning team for this update, and have provided feedback on drafts of this plan. Those agencies are listed under *Additional Agencies, Organizations and Companies.*

School Districts

Castro Valley Unified School District	Cupertino Unified School District	

Cities and Counties

Berkeley	Marin County (including using ABAG strategies)	Redwood City
El Cerrito	Napa (city)	San Francisco

Fire Districts

Belmont-San Carlos Fire Department	Cordelia Fire Protection District	North County Fire Authority
Central County Fire	Livermore-Pleasanton Fire Dept.	Santa Clara County Department

Water/Sewer Districts

Bolinas Community PUD	North Coast County Water District	San Francisco PUC
Marin Municipal Water District		

Additional Agencies, Organizations and Companies

Bay Area Planning Directors Association	California Emergency Management Agency - Coastal Region	San Jose State University
Bay Area Earthquake Alliance	California Hospital Association	San Jose Water Company
BARC-First	California Preservation Foundation	Sierra Club
Bay Area CMA	California Seismic Safety Commission	Silicon Valley Leadership Group
Bay Area Council	California Teachers Association	SPUR
Bay Conservation and Development Commission (BCDC)	Earthquake Engineering Research Institute	Structural Engineers Association of Northern California
Business Recovery Managers Association (BRMA)	Hills Emergency Forum	UC Berkeley
Business Executives for National Security (BENS)	Homebuilders Association of Northern California	Urban Habitat Program
San Francisco Bay Conservation and Development Commission	League of Women Voters - Bay Area	Urban Land Institute
Cal Water Company	Office of Statewide Health Planning and Development (OSHPD)	US Coast Guard
California Geologic Survey	Pacific Gas and Electric	US Geological Survey

Table of Contents

page

CREDITS ii

PARTICIPATING JURISDICTIONS iii

TABLE OF CONTENTS vi

SUMMARY vii

INTRODUCTION 1

CHAPTERS

1 – Infrastructure (INFR) 1-1
2 – Health (HEAL) 2-1
3 – Housing (HSNG) 3-1
4 – Economy (ECON) 4-1
5 – Government Services (GOVT) 5-1
6 – Education (EDUC) 6-1
7 – Environment (ENVI) 7-1
8 – Land Use (LAND) 8-1

APPENDICES

A – The Planning Process A-1
B – The Plan Maintenance and Update Process B-1
C – Natural Hazards Risk Assessment C-1
D – Disaster History – 1950-2009 ..... D-1
E – Assessing Vulnerability – An Analysis of Land Use Development Trends and Hazards E-1
F – Assessing Vulnerability – Private Buildings and Value Exposure Estimates F-1
G – Summary List of Mitigation Strategies with Regional Priorities and Hazards Mitigated G-1
H – Record of Plan Participation H-1
I – Participating Jurisdictions Contact List I-1

ANNEXES

Annexes for ABAG and other local governments in the Bay Area are appended to this Local Hazard Mitigation Plan.

Summary

GOAL: To maintain and enhance a disaster-resistant region by reducing the potential loss of life, property damage, and environmental degradation from natural disasters, while accelerating economic recovery from those disasters.

COMMITMENTS: *Together, the cities, counties and special districts of the San Francisco Bay Area are committed to increasing the disaster resistance of the infrastructure, health, housing, economy, government services, education, environment, and land use systems in the Bay Area.*

1. Infrastructure: Bay Area transportation and utility facilities and networks are vital lifelines during and following disasters, as well as in the functioning of our region and its economy.

2. Health: Bay Area facilities, networks, and systems providing care of sick and those with special needs need to be resilient after disasters for these systems will need to care for additional injured at the same time as those currently cared for are stressed.

3. Housing: Bay Area residents need to have safe and disaster-resistant housing that is architecturally diverse and serves a variety of household sizes and incomes.

4. Economy: Safe, disaster-resilient, and architecturally diverse downtown commercial areas, business and industrial complexes, and office buildings are essential to the overall economy of the Bay Area.

5. Government Services: Bay Area city and county governments, as well as community services agencies, provide essential services during and immediately following disasters, as well as critical functions during recovery, that need to be resistant to disasters.

6. Education: Safe and disaster-resistant school, education, and childcare-related facilities are critical to the safety of our children, as well as to the quality of life of Bay Area families.

7. Environment: Disaster resistance needs to further environmental sustainability, reduce pollution, strengthen agriculture resiliency, and avoid hazardous material releases in the Bay Area.

8. Land Use: Land use change needs to be accompanied by a respect for hazardous areas and facilities, as well as recognize the interconnected nature of the Bay Area.

This document, the multi-jurisdictional Local Hazard Mitigation Plan (MJ-LHMP) for the San Francisco Bay Area, should serve as a catalyst for a dialog on public policies needed to mitigate the natural hazards that affect the San Francisco Bay Area.

This multi-jurisdictional effort should not only maintain and enhance the disaster resistance of our region, but also fulfill the requirements of the Disaster Mitigation Act of 2000 for all local governments to develop and adopt this type of plan.

For purposes of this plan, local governments include not only the cities and counties of our region, but also special districts and other government agencies.

The chapters which follow describe the mitigation actions that can be taken to mitigate hazards and ensure these eight commitments, together with the regional priorities on taking those actions agreed upon by those local governments.

For additional information used to develop this MJ-LHMP by the Association of Bay Area Governments (ABAG), including interactive hazard mapping and risk assessment, see *quake.abag.ca.gov/mitigation*.

Introduction

Bay Area Region Overview

The San Francisco Bay Area, located in Northern California, is home to more than 7 million people. The area consists of nine counties, 101 cities. All of the region's nine counties touch the San Francisco Bay[1].

The Bay Area has a land area of 4.4 million acres (excluding bay waters and large lakes). The major type of land use varies strongly by county, from completely urbanized San Francisco County to Napa County, which has only a few medium-sized towns and one small city. Contra Costa, Alameda, and Santa Clara Counties all are highly urbanized along the Bay shore, with varying degrees of development further inland. San Francisco County is by far the most urbanized county in the region, with virtually all of its land characterized as urban in 2005.

Like many urban areas, the Bay Area will continue to grow in the foreseeable futures. An estimated additional 1.7 million people will live here and over 1.6 million new jobs will be created by 2030, attracting an additional 850,000 residents to the region. An additional 600,000 homes will be built. This region faces the challenges of serving this growth with efficient transportation, housing, and infrastructure, while balancing it with the natural disasters that threaten our region and economy.

The economy of the Bay Area is diverse and dynamic. Major industries include high tech and information, professional services, financial, education and health services, agricultural, tourism, manufacturing and wholesale, construction and transportation. The high tech industry drives employment in the South Bay, while the University of California and two national laboratories drive employment in the East Bay. In the North Bay, tourism, agriculture, and distribution and manufacturing dominate employment. The Peninsula receives spillover from San Francisco and the South Bay. Its economy is largely high tech and biotech. Major employers on the Peninsula include Oracle, Stanford University, and United Airlines (due to San Francisco International Airport).

Natural Hazards, Geography and Climate

The San Francisco Bay Area is in a spectacular region with valleys and ridges, views and access to rivers, the ocean, and the Bay, and a mild climate.

But many of those ridges and valleys have been formed by active earthquake faults that can generate devastating shaking and ground failures. The typically mild climate is subject to occasional severe winter and spring storms leading to landslides in the hills and flooding of the valleys. During the fire season, typically from May through November, the region is subject to periods of Diablo Winds bringing high temperatures, gusting winds, and low humidity. Tinder-dry trees, brush, and grasslands are subject to fires that can become catastrophic on the edges of urban development. Given an increasingly mobile population, our citizens and crops are subject to disease epidemics. Natural disasters can lead to secondary events that are disasters in of themselves, including hazmat releases and dam failures. During the period from 1950 – 2009, all or part of the Bay Area was subjected to 59 disasters, or about a third of over 200 disasters occurring in the entire State of California during that 60-year period[2].

The nine most significant of hazards affecting the Bay Area, based on our past history, as well as on the State Hazard Mitigation Plan, are related to:

- earthquakes (***surface faulting***, ***ground shaking***, ***liquefaction***, ***landslides***, and ***tsunamis***), or
- weather (***flooding***, ***landslides***, ***wildfires***, ***drought,*** and ***climate change***).

The focus of this effort is on ***natural*** hazards, that is, natural occurrences that can pose a risk of injury, loss of life, or damage to property. Other hazards relate to man-made conditions, including releases of hazardous materials, dam failures, energy shortages, and weapons of mass destruction. These other hazards are only

[1] Fassinger and others, 2003 – ***ABAG's Projections 2007 and 2009***. Economy is based on annual Gross Regional Product (GRP).
[2] California Governor's Office of Emergency Services database of disasters and major states of emergencies.

addressed in this plan as they relate to earthquake and weather-related hazards. The only one of these additional hazards that is readily mapped and analyzed is ***dam failure***.

Finally, people and the food they eat are subject to disease. These concerns are also not addressed in great detail, except as they relate to earthquake and weather-related hazards.

As part of the hazard identification process, ABAG has created a web site with access to 53 hazard maps. These maps are referenced to the "hard copy" maps in this document. However, these maps can be interactively zoomed by address, zip code, city, county, school district, fire jurisdiction, and water district for use in the preparation of local Annexes to this plan. They also are all publicly accessible on the web at http://quake.abag.ca.gov/mitigation/.

What Are Disasters and How Are They Related to Hazard Mitigation?

A disaster is a natural or man-made emergency whose response needs exceed available resources. When local government resources are exceeded, the California Governor's Office of Emergency Services (State OES) is contacted and the Governor is requested to declare a State Disaster. When State resources are exceeded, State OES contacts the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA) and the President is requested to declare a National Disaster. This Presidential Declaration triggers funding resources for the public, the state, and local governments to use for clean-up, repair, recovery, and mitigation.

There are two ways to deal with disasters.

1. We can increase emergency ***response*** capability. Thus, more damage needs to occur for those capabilities to be exceeded. Large incidents become manageable emergencies.
2. Projects can be undertaken to prevent or lessen the impacts of future incidents, reducing the need for larger and larger response capability. Homes can be moved from areas suffering repeated floods. Buildings and infrastructure can be built to reduce expected damage in earthquakes. Wood shakes on homes in woodland areas can be replaced with asphalt shingles or tile. These actions are called ***mitigation***.

More specifically, the Stafford Act defines mitigation as "***any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards.***"[3] As mitigation activities are undertaken, the risks associated with disasters decrease.

Goal

To maintain and enhance a disaster-resistant region by reducing the potential loss of life, property damage, and environmental degradation from natural disasters, while accelerating economic recovery from those disasters.

We need to continue to work to reduce and avoid risks from natural hazards to protect lives, property, the environment, and our economy.

This natural hazard mitigation plan is a joint effort by the cities, counties, and special districts in the Bay Area to build a more disaster-resistant region. We recognize that disasters do not respect the boundaries between our individual jurisdictions and have worked together to identify our hazards, assess our risks, and develop this goal, eight commitments, and a comprehensive list of strategies (or actions) to mitigate the identified risks.

We view this plan as a shared mental model of our overall goal, commitments, and mitigation actions. ***We can no longer afford random acts of preparedness and mitigation.***

Commitments

The overall goal is being addressed by asking all local governments in the Bay Area to adopt formal resolutions in support of the following eight ***commitments areas***. These commitments are not organized by hazard, but by the

[3] Source – 44 CFR Section 201.2 pertaining to Section 322 of the Stafford Act, 42 U.S.C. 5165.

types of services supplied either directly, or indirectly, by local governments. Chapters accompany each of the commitment areas, outlining the problem and highlighting mitigation activities that are currently taking place to address the problem. With this organization, ***each*** of the Bay Area's cities and counties should find ways to address these major commitments by reducing identified risks. In addition, the Bay Area's special districts can address many of these commitments, depending on the role and responsibilities of that district. ***Together, we are committed to increasing the disaster resistance of the infrastructure, health, housing, economy, government services, education, environment, and land use systems in the Bay Area.***

1. Infrastructure
Bay Area transportation and utility facilities and networks are vital lifelines during and following disasters, as well as in the functioning of our region and its economy.

2. Health
Bay Area facilities, networks, and systems providing care of sick and those with special needs need to be resilient after disasters for these systems will need to care for additional injured at the same time as those currently cared for are stressed.

3. Housing
Bay Area residents need to have safe and disaster-resistant housing that is architecturally diverse and serves a variety of household sizes and incomes.

4. Economy
Safe, disaster-resilient, and architecturally diverse downtown commercial areas, business and industrial complexes, and office buildings are essential to the overall economy of the Bay Area.

5. Government Services
Bay Area city and county governments, as well as community services agencies, provide essential services during and immediately following disasters, as well as critical functions during recovery, that need to be resistant to disasters.

6. Education
Safe and disaster-resistant school, education, and childcare-related facilities are critical to the safety of our children, as well as to the quality of life of Bay Area families.

7. Environment
Disaster resistance needs to further environmental sustainability, reduce pollution, strengthen agriculture resiliency, and avoid hazardous material releases in the Bay Area.

8. Land Use
Land use change needs to be accompanied by a respect for hazardous areas and facilities, as well as recognize the interconnected nature of the Bay Area.

Implementation Strategies for Mitigation

Background on Implementation Strategy Organization

The implementation strategies, or action items, are listed under the eight major commitments identified on the previous page, rather than by hazard. Within each commitment area, the strategies are grouped by topic and each group is addressed individually in the chapter text. The accompanying text helps put the strategies into a larger context and provides some additional information about many of the problem areas. As stated in the previous section, with this organization, ***each*** of the Bay Area's cities and counties should find ways to address these major commitments by reducing identified risks. In addition, the Bay Area's special districts can address many of these commitments, depending on the role and responsibilities of that district.

Any scheme to identify a comprehensive list of potential strategies is bound to have some overlaps. This list is no exception. Because those ideas listed under housing and economy have, at their core the relationship, between

government and the people who live and work in their jurisdictions, there is overlap. City and counties, as well as special districts handling lifelines and schools, have buildings that are critical to their functioning, so there is duplication in the discussion of these issues.

Most of the strategies listed are clearly within the definition of "hazard mitigation," that is, "any action taken to reduce or eliminate the long-term risk to human life and property from natural hazards."[4] The strategies address all of the hazards identified when performing the risk assessment work described in Appendix C. In addition, there are four notable areas where we have "pushed" this definition.

- The first is in the area of public education. Author Stephen Flynn notes in his 2004 book[5] in a plea for greater public education following 9/11 that federal "security officials often act as though members of the American public are either potential recruits for an easily panicked mob or a passive part of a haystack that must constantly be sifted through to find terrorist needles." The Bay Area learned this lesson twelve years earlier in 1989 as a result of the Loma Prieta earthquake. People who live and work in our region also need to understand our hazards so that they can take appropriate mitigation measures in their homes, schools, and work places.
- Second, we have included under ***Government Services*** several ideas to "*Maintain and Enhance Local Government's Emergency Response and Recovery Capacity*.**"** These ideas have been included because we believe that many go well beyond the traditional response activities of city and county police and fire services.
- Several strategies are drafted so that they apply to natural – and security – hazards, such as the mitigation of disasters resulting from weapons of mass destruction. Hazmat releases and dam failures due to flooding, earthquakes, or terrorism have some similar impacts and therefore some similar mitigation strategies. Some methods of combating "common" crime and violence may deter major terrorist actions.
- Finally, the strategies dealing with health, both under the Health commitment, as well as sprinkled elsewhere in this document, have traditionally been funded by the Centers for Disease Control and Prevention (CDC), rather than FEMA. They also may involve the use of the National Disaster Medical System under U.S. Health and Human Services (including both uniformed and non-uniformed medical personnel under the U.S. Surgeon General). We view this Local Hazard Mitigation Plan, while a requirement of the Disaster Mitigation Act of 2000 being administered by FEMA, as an opportunity to build administrative bridges in the public health field. For example, local government actions to deal with managing "natural" deadly pathogens such as SARS, AIDS, West Nile, and mad cow disease in an increasingly mobile world can also assist in the response to bioterrorism.

Status and Priorities

For each of the following potential mitigation strategies, local governments have been asked to choose their own priority for this strategy. The priorities in each of these local government Annexes were selected based on:

- the level of hazards identified in Appendix C,
- the Bay Area preliminary risk assessment conducted and described in Appendix C,
- supplementary hazard and risk assessment information developed by ABAG for each local government on the interactive internet site *http://quake.abag.ca.gov/mitigation*, and
- any specific studies conducted by the local government and included in that local government's Annex to this plan.

---

[4] Stafford Act (44 CFR 206:401)

[5] Flynn, Stephen. 2004. ***America the Vulnerable: How Our Government Is Failing to Protect Us from Terrorism***. HarperCollins Publishers, New York, page 160.

The priorities for each local government participating in this multi-jurisdictional plan are in that local government's ***Annex*** to this plan. Priorities are defined as follows. The annexes provide additional information on the activities as noted after each priority.

- Existing program
  - Responsible agency or department
  - Provide ordinance or resolution number, if applicable
- Existing program, underfunded (new priority added to reflect the current economic climate of recession)
  - Responsible agency or department
  - Provide ordinance or resolution number, if applicable
- Very High priority – to be adopted by local government immediately
  - Responsible agency or department
- High priority – to be adopted by local government as soon as funding and resources allow
  - Agency responsible for seeking and administering funding
  - Sources of potential funding
  - Estimated amount of funding needed
- Moderate priority – will be adopted by local government as funding and resources allow
- Under study
  - Responsible agency or department
  - Provide estimated date of completion
- Not applicable, not appropriate, or not cost effective
- Not yet considered

This list is a "work in progress". It will expand and change over time, hopefully becoming as dynamic as the restless earth whose hazards demand our attention. It is not meant to discourage local experimentation with alternative strategies. Rather, it is meant to be a list of both common and innovative practices. In addition, local governments choosing to reword specific strategies to meet their local needs, or to be more specific in their strategies, are encouraged to do so.

Some of the strategies will not be appropriate for some jurisdictions, but all jurisdictions should be able to address the general commitments with identifiable actions. Valid risk management requires a careful weighing of the advantages and disadvantages of action. ***While some strategies may be appropriate for some jurisdictions, those same strategies may not be appropriate or may not be cost effective for others.*** Over time, we are committed to developing better hazard and risk information to use in making those trade-offs. We are not trying to create a disaster-proof region, but a disaster-resistant one. Finally, the cost of strategies varies greatly. Some of the most cost-effective relate to building and maintaining partnerships, not buildings.

Following approval of this plan by FEMA, ABAG will include the comprehensive strategies identified by all of these local governments Annexes as an interactive searchable database on that same internet site at *http://quake.abag.ca.gov/mitigation***.*** This interactive capability should begin to assist the California Office of Emergency Services in its efforts to monitor the effectiveness of this Local Hazard Mitigation Plan. For example, since this list of strategies has been conceived as a comprehensive list of "best practices," strategies given relatively lower priorities by most local governments might be viewed as a multi-jurisdictional weakness, while those utilized and given a relatively high priority by most local governments might be viewed as a multi-jurisdictional strength.

Decisions on those strategies utilized and given a relatively high priority have been based on a variety of criteria, not simply on an economic cost-benefit analysis. These criteria include being technically and administratively feasible, politically acceptable, socially appropriate, legal, economically sound, and not harmful to the environment or our heritage.

Scope of Mitigation Strategies - New and Existing Development

Not only are the mitigation strategies designed to cover all of the hazards identified during the development of the natural hazard risk assessment for the plan as described in Appendix C, but the strategies also are designed to apply to existing development, new development, and even land use planning. For example, many of the strategies in infrastructure, housing, and economy focus on existing buildings, while many of those in land use focus on new development and general land use planning.

Highlighted Mitigation Activities in the Region

The hazards the Bay Area faces are not new, and neither are the risks to lives, property, the environment, and our economy. The knowledge that an earthquake will strike the region in the near future drives Bay Area local governments, together with private utilities and various State of California agencies, have created programs and regulations that are as creative and comprehensive as any region in the world.

Major mitigation projects are currently underway in the Bay Area. The San Francisco-Oakland Bay Bridge, which partially collapsed in the 1989 Loma Prieta earthquake, is undergoing replacement of its east span and retrofit of the west span. Retrofit of the BART Transbay Tube, which carries passengers underneath the Bay for 3.6 miles from Oakland to San Francisco, is ongoing, as is strengthening of the elevated portions of the BART track. Many other transportation retrofit projects have been completed all over the Bay Area to protect our transportation system from damage in an earthquake.

Most cities near faults have retrofitted their own city halls and major government buildings. Oakland and San Francisco city halls were both damaged in the Loma Prieta Earthquake. These historic buildings were repaired and put on base isolators to protect them from future damage. Hayward, due its proximity to the Hayward fault and major structural deficiencies in its city hall, replaced that building. Many other local governments have undertaken similar measures for their own government facilities. Examples of these can be found in the individual jurisdictions' annexes.

Soft-story multi-family residential buildings have become a major concern to local cities since the 2005 plan due to the large number of people residing in these buildings and their likelihood to collapse in an earthquake. San Francisco, Oakland, Fremont, Berkeley, Alameda, Santa Clara County, and all the cities in Santa Clara County have inventoried their buildings (or are in the process of doing so) and are developing programs to retrofit these buildings. A major challenge for these cities is that in the current economic climate of recession, mandatory retrofits programs are not feasible, and money to provide incentives to building owners is not available.

Chapter 1 – Infrastructure (INFR)

COMMITMENT: Bay Area transportation and utility facilities and networks are vital lifelines during and following disasters, as well as in the functioning of our region and its economy.

Damage to infrastructure in a disaster can lead to damage to other systems and delayed recovery.

The August 2005 Hurricane Katrina Disaster on the Gulf Coast has reinforced existing knowledge on the role of infrastructure before and after disasters.
(1) Infrastructure systems, including roads and highways, ports and airports, pipelines carrying water, sewage, and natural gas, as well as power and communications systems are all interconnected.
(2) Infrastructure is critical to a safe and resilient economy.
(3) The impacts of major catastrophes are not simply linearly related to the size of the impacted area, but rather can explode exponentially if infrastructure is impacted.
(4) People who are impacted if infrastructure is damaged are disproportionately the young, the elderly, and those with special needs.

These impacts are seen in most large earthquakes, as well storms. Emergency and utility repair vehicles were caught in the gridlock following the earthquake in Kobe, Japan.

The owners of infrastructure systems need to work together to increase the resiliency of these systems.

One of the main reasons for the interdependencies of infrastructure systems is that they tend to be geographically located in the same areas. For example, water, sewer, and natural gas pipelines tend to be under local roads. Communications and electrical cables are either located under those roads or adjacent to them. All have similar exposures to hazards that are related to serving the developed portions of the region. The responsible agencies and hazard exposures of each infrastructure system are described separately on the following pages.

Roadways flooded in Hurricane

Cities, counties, transit districts, water suppliers, wastewater system operators, and other utilities have worked together to set regional priorities for the mitigation of hazards associated with these systems. Because of the large number of special districts involved in operating utility and lifeline systems, a variety of responsible agencies have been identified following each mitigation strategy.

Bay Area transportation and utility facilities and networks are vital lifelines during and following disasters, as well as in the functioning of our region and its economy.

These agencies understand that it is far easier to try to fix problems before a disaster than to deal with the numerous interdependent problems afterwards.

The Existing Transportation System

The Bay Area's transportation system is a complex network of federal and state highways, local roads, light and heavy rail, bus transit, airports, ports, and ferries.

- The system contains over 20,800 miles of highways and roads, with 9,000 miles of bus routes, and 470 miles of rail transit, and 750 miles of bikeways.
- As a region located on San Francisco Bay, the system includes eight toll bridges – seven owned by the state, and one, the Golden Gate Bridge, owned by the Golden Gate Bridge and Highway Transportation District. It also includes approximately 2,000 state-owned and an additional 2,000 locally-owned road structures, including overpasses, interchanges, and smaller bridges.
- There are three international airports, a federal airfield, an air force airport, and 36 public general aviation airports and private airstrips.
- Finally, the region has five public ports, several private ports, and five commuter ferry lines.

Golden Gate Bridge

The entire system is planned and coordinated by the Metropolitan Transportation Commission (MTC), an organization whose job is to ensure that this system functions smoothly and effectively, as well as to plan responsibly to meet the future mobility needs of the region's growing population.

Dozens of other organizations work together to build and maintain this system, including the federal Department of Transportation (DOT), the Federal Highway Administration (FHWA), the Federal Aviation Administration (FAA), the state agencies of Caltrans and the California Transportation Commission (CTC), city and county governments, and special transit districts.

Participating Agencies

Local government agencies actively participating in this transportation portion of the MJ- LHMP include the transportation agencies participating in the original 2005 MJ-LHMP:

- MTC
- BART
- Tri-Delta Transit (ECCTA)

City and county representation has been essential, for many have extensive transportation systems, including:

- City and County of San Francisco (port, SFO airport, and SF MTA or MUNI)
- City of Oakland (port and OAK airport)
- City of San Jose (SJC airport)
- City of Vallejo (Transportation)

Additional transit agencies actively participating in this updated plan include:

- AC Transit
- Contra Costa County Transit (County Connection)
- Golden Gate Bridge, Highway and Transportation District
- Livermore-Amador Valley Transit
- San Mateo County Transit (SamTrans/ Caltrain)
- Santa Clara Valley Transportation Authority (VTA)
- San Francisco Water Emergency Transportation Authority (WETA)

As a multi-jurisdictional plan, this effort makes use of the hazard maps contained in the overall plan, with the additional hazard exposure data documented in this paper.

The various agencies participating in this plan coordinated their efforts through the TRP Steering Committee of MTC. This group, in turn, participated in the overall lifeline effort of the MJ-LHMP through two representatives to the ABAG Lifeline Infrastructure and Hazards Advisory Committee.

Earthquake Hazards and the Bay Area Transportation System

The largest hazard to which the transportation system is exposed is earthquake-generated **ground shaking**. The western U.S. is one of the most seismically active areas of the country, and the Bay Area is one of the West's most active seismic areas.

For transportation systems, **94.3%** of local and state bridges and interchanges are exposed to high shaking levels (peak accelerations of greater than 40% of gravity [g] with a 10% chance of being exceeded in the next 50 years), and **65.2%** exposed to extremely high shaking levels (60% g). In addition, **92.2%** of roads and highways are exposed to high shaking levels (peak accelerations of greater than 40% g with a 10% chance of being exceeded in the next 50 years), and **58%** are exposed to extremely high shaking levels (60% g).

The percentage of rail and fixed transit systems in these hazard levels is similar, with **92.6%** of rail, **85.5%** of ACE, **84.8%** of Amtrak, **97%** of BART, **100%** of Caltrain, **100%** of SF MTA (MUNI), and **100%** of the VTA lines in the high or extremely high shaking areas. The most vulnerable portions of these networks to shaking are bridges, interchanges, and the elevated portions of rail and fixed transit lines. Facilities at the three international airports and the major ports are also in vulnerable locations. **The functioning of all of these systems is critical during emergency response to and recovery from an earthquake.** Thus, most of the hazard mitigation strategies that follow deal with this earthquake shaking hazard.

When **faults** rupture and generate earthquakes, the rupture can extend to the surface, offsetting roads, highways, and rail lines. Existing state law prohibits the construction of structures intended for human occupancy across the trace of an active fault. Although no existing buildings owned by transportation agencies are astride an active fault, freeways, roads, rail, and BART lines do cross these faults.

Hayward fault trace

For example, if the Hayward fault ruptures from San Pablo Bay to its southern end near the Santa Clara County border, fault surface rupture could close approximately 520 roads, including I-80, I-680, Hwy. 4, Hwy. 13, and Hwy. 24. In some cases, local roads have been intentionally placed astride faults as a land-use decision to avoid the placement of buildings astride the fault.

Liquefaction occurs when loose, water-saturated, sand and silt behave like liquid quicksand when shaken in an earthquake. The exposure to liquefaction is far less than shaking. In addition, not all areas of very high susceptibility to liquefaction will actually behave like quicksand in any individual earthquake. The percentage of roads in these areas is **5.5%,** along with **16%** of rail, **1.8%** of ACE, **20.2%** of Amtrak, **7.9%** of BART, **10.4%** of Caltrain, **24.3%** of SF MTA (MUNI), and **2.4%** of the VTA lines. Because liquefaction can result in the buckling and bending of road surfaces, as well as at-grade rail and fixed transit lines, the damage to at-grade routes is likely to be more significant than from shaking.

Damage to road in Northridge earthquake

Landslides can be generated as a result of earthquakes. This hazard is discussed with rainfall-induced landslides later in this document.

Tsunamis can be generated as a result of earthquake fault rupture or underground landslides triggered by earthquakes. After extensive modeling by a number of organizations, maps of the potential inundation areas impacted by tsunamis near the Bay or Pacific Ocean were released in December 2009 for purposes evaluation planning. The most at-risk transportation routes are those bordering the Pacific Ocean and next to San Francisco Bay.

Current Earthquake Hazard Transportation Mitigation Highlights

The amount of effort and money currently being spent on the mitigation of earthquake impacts is higher than any of the other natural hazards.

State and federal agencies, local governments, and all transit agencies routinely take into account predicted earthquake forces in the design of new structures, including office and operations buildings, bridges, and interchanges. BART and Caltrans have even helped to fund the development of innovative new technologies to make transportation networks and structures even more resistant to shaking and liquefaction.

MTC, as the Bay Area Toll Authority, is directing the $8.5 billion program to make the region's state-owned toll bridges more resistant to earthquake shaking and potential problems of liquefaction.

Bay Bridge deck replacement

BART, with $980 million in bonds authorized by voters in its core three-county service area, and an additional $240 million from other sources, is seismically strengthening older portions of its system, including elevated track, 20 passenger stations - and the Transbay Tube. A $3 million grant from the Federal Emergency Management Agency (FEMA) Pre-Disaster Mitigation (PDM) program is helping to fund the dismantling of the Lake Merritt Administration facility as part of the strengthening of the Operations Control Center at that location. The total budget for the BART Earthquake Safety Program is $1.22 billion (in 2004 dollars).

MetroCenter (the administrative office building for ABAG and MTC, as well as the location of the Emergency Operations Center (EOC) for BART and MTC), was retrofitted in 2008. Funding for the **$5** million seismic retrofit was completed, in part, using a **$3** million grant from FEMA.

Regional Priorities for Future Earthquake Hazard Mitigation

In spite of the effort currently spent on earthquake hazard mitigation, more needs to occur. MTC is currently focusing on creating a plan for disaster recovery of the Bay Area transportation system. Through this effort, it has become clear that mitigation efforts targeted at speeding up post-disaster recovery are particularly critical.

Emergency Operations Centers (EOCs) and communications centers for some of the bus and light rail systems operators are of an age and type of construction that makes them susceptible to damage in future earthquakes. The transit operators who own these facilities are examining the potential for structural retrofit or replacement of these key facilities. This task is a high priority for the mitigation of the earthquake hazard. Meanwhile, as retrofit options are examined, another task is focusing on speeding up the post-disaster inspection and re-occupancy of those buildings that are safe.

At **BART**, construction is underway and is scheduled to be completed in 2014. Among the most important tasks in that effort are strengthening of the 1,981 supports for the elevated portions of track, the Transbay tube, and core-system stations.

The **Golden Gate Bridge** and **Doyle Drive** are undergoing retrofits. The Doyle Drive project, estimated to be completed by 2014, is led by Caltrans, with an estimated cost of $1.045 billion, of which $405 is a local contributions, including $80 million from MTC, $75 million from Golden Gate HBTD, and $245 million from several sources in San Francisco, including SF MTA (MUNI). Work completed to date on the Golden Gate Bridge approaches and anchorages has cost $245 million. Work on the Marin Anchorage ($119 million) will be completed in 2011. The suspension bridge should be completed by 2015.

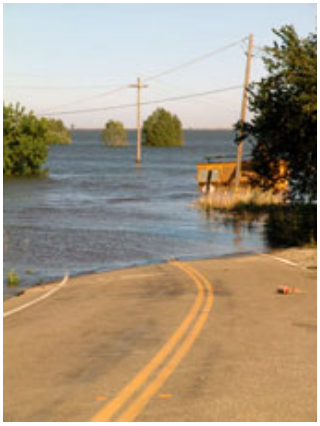
While Caltrans has almost completed the seismic retrofit of bridges and interchanges on state and federal highways, little progress has been made on the retrofit of locally owned bridges. Of the 2,214 locally-owned bridges in the Bay Area, it identified 355 that needed to be have seismic retrofit work as of 2006. Few bridges have been retrofitted in the past 5 years due to lack of funding.

Weather-Related Hazards and the Bay Area Transportation System

The Bay Area has historically had a mild Mediterranean climate characterized by mild rainy winters and dry summers. Flooding and landsliding occurred during the wet season, while wildfires and drought occurred in the dry season.

Climate change has been shown to exacerbate all of these hazards. Thus, the region can expect more flooding and landsliding due to a more abrupt runoff in the spring, as well as increased potential for wildfires any time of year and multi-year drought conditions. The various port facilities, as well as both the Oakland and San Francisco International Airports, are subject to the threat of sea level rise.

Flooding can occur when occasional intense winter storms result in local stream flooding, as well as when particularly warm rains in the Sierras can also result in sudden snow melting. Occasionally strong winter storms can close roads in the Bay Area. However, flooding is a lesser hazard than earthquakes to the region's transportation system. Only **5.2%** of the roads (versus **58%** in extremely high ground shaking areas) are in 100-year flood zones. The percentage of rail in these hazard areas is **15.9%,** along with **14.5%** of ACE, **21%** of Amtrak, **2%** of BART, **6.5%** of Caltrain, **none** of SF MTA (MUNI), and **4.8%** of the VTA lines.



Flooding of road due to Jones Tract levee failure just east of Bay Area

In addition to these traditionally flood-prone areas, some portions of the region, particularly in the Bay-Delta, are actually below sea level.

Of particular concern, much of the Oakland International Airport is below sea level and is protected by a levee that may be vulnerable to earthquake damage and sea level rise.

Road damage due to landslides in 1997-98 El Nino winter in Santa Cruz Mountains –

Landslides can be generated as a result of earthquakes or severe winter storms. While **23.1%** of the region's land is located in areas that are mostly active or ancient landslides, a much smaller percentage of the urban land (**8.3%**) and roads (**7.2%**) are located in these hazardous areas. **None** of the MUNI or VTA light rail lines are located in these areas, and only **1.6%** of rail, **7.3%** of ACE, **1.7%** of Amtrak, **4%** of BART, and **1.3%** of Caltrain lines are in these areas. Landslides have not ever been a significant hazard to these transit systems.

Wildfire hazards are shown in two separate hazard maps – wildland-urban-interface fire threat (WUI) maps and wildfire threat maps. The WUI maps show the wildfire threat in urban areas, while the wildfire threat maps focus on more rural areas.

Oakland Hills firestorm in 1991

Based on the WUI maps, **44.8%** of the roads and **28.1%** of the rail lines, along with **25.5%** of ACE, **21%** of Amtrak, **38.6%** of BART, **32.5%** of Caltrain, **32.4%** of SF MTA (MUNI), and **19%** of the VTA lines, are in wildland-urban-interface fire threat areas. However, only **4.5%** of these areas have burned in the past 130 years. In addition, in much of these hazard areas, the BART system is in a freeway median or underground.

The wildfire threat maps indicate that **7.1%** of the roads and **4.9%** of the rail lines, along with **12.7%** of ACE, **0.8%** of Amtrak, **3%** of BART, **none** of Caltrain, **none** of SF MTA (MUNI), and **none** of the VTA lines, are in areas of very high or extreme wildfire threat.

Drought in the Sierras, as well as the region itself, can cause water shortages. However, this hazard does not directly impact the region's transportation system.

Current Weather-Related Hazard Mitigation Highlights

The amount of effort and money currently being spent on the mitigation of weather-related hazards is far lower than for earthquake-related hazards. Reasons for this difference include (1) infrastructure facilities, roads, and rail systems have a much lower exposure to these hazards and (2) potential weather-related disasters are less regional in scope, making the functioning of transportation systems less critical.

VTA's headquarters buildings are in a flood plain. Due to the efforts of the Santa Clara Valley Flood Control and Water District, the drainage and flooding problems at this facility have been reasonably mitigated.

Landslides are not a major concern to the regional transit systems, rail lines, port, or airport systems. Roads built in landslide hazard areas are currently designed to minimize the likelihood of damage and tend to be less exposed to this hazard than the overall urban areas that they serve. One exception is Highway 1 along the San Mateo and Marin County coastlines. Caltrans worked with local governments to better design roadway alignments. For example, in San Mateo County, bridges and a tunnel are being built to bypass Devil's Slide between Pacifica and Half Moon Bay. The project will be completed in 2011.

Wildfire is a concern in the areas served by the transportation system. However, there is no well-established way to mitigate any hazards associated with the transportation system itself.

Local governments can adapt to climate change by mitigation of sea level rise, flooding, drought, and wildfire hazards. However, climate change itself can be mitigated through efforts at direct control of greenhouse gases and carbon emissions. Fully one half of the Bay Area's greenhouse gas emissions are the result of transportation sources, particularly on-road private vehicles. Efforts to develop greener transportation have been initiated by various transit and transportation agencies in the region.

In particular, MTC is emphasizing transit investments and maintenance of existing infrastructure seeking to moderate growth of private vehicle usage. Other programs encourage increased transit ridership and more walking and biking for short trips. MTC's congestion management and intelligent transportation system programs seek to reduce emissions through smoother, more efficient traffic flow.

Regional Priorities for Future Weather-Related Hazard Mitigation

Additional ways are available to mitigate the impacts of weather-related hazards.

The bus yards of AC Transit and, to a lesser extent, SamTrans that are located near the Bay have experienced flooding and may need redesigned drainage systems to better mitigate the problem. (Flooding has not impacted the buildings.)

MTC, ABAG, the Bay Area Air Quality Management District (BAAQMD), and the Bay Conservation and Development Commission (BCDC) have initiated a **Joint Policy Committee** that has mitigation and adaptation to climate change as a principal focus. One of the main goals of this regional group is reduce carbon emissions through a variety of innovative programs, including encouraging smart growth, initiation of congestion pricing schemes, and other pilot projects.

VTA and SamTrans have been participating in a California Air Resources Board (CARB) pilot program in which a portion of their bus fleet is fueled by **hydrogen cell technology**. AC Transit has been using hydrogen-hybrid busses in its fleet on an experimental basis. These efforts are viewed as the beginning of a process of making transit a cleaner solution to reducing carbon emissions and associated global warming.

The side effect of this effort is that planning for fuel interruption as a result of a disaster has become more critical, and more complex.

Hydrogen fueled bus

Bay Area Commercial and General Aviation Airports

The Bay Area airports are managed independently by the individual cities that own and operate them. However, the Regional Airport Planning Committee (RAPC) is an organization set up by, and operated by, the staff of three regional agencies: the Metropolitan Transportation Commission (MTC), the Association of Bay Area Governments (ABAG) and the Bay Conservation and Development Commission (BCDC).

For purposes of this multi-jurisdictional plan, the discussion of the hazards, risks, and applicable mitigation efforts has been overseen by these three regional agencies on behalf of RAPC, and in turn by the various airports themselves (as owned and operated by the cities).

The Bay Area is home to three international commercial airports:
San Francisco International (SFO);
San Jose International (SJC); and
Oakland International (OAK).

In addition, there are over 30 general aviation airports serving the Bay Area.

RAPC has representatives from all of these key constituencies.

While the following discussion focuses on the three international airports, it also describes related issues at general aviation airports and other airports.

Hazard and Risk Assessment

Earthquake: In 2000, with a grant from FAA through MTC, ABAG performed a hazard and risk assessment of the three major international airports, and a preliminary evaluation of the general aviation airports. Based on past experience in California and other recent earthquakes, the threats to Bay Area airport operations following future earthquakes fall into four general categories:

- liquefaction damage to airport runways, particularly at Oakland, San Francisco, and, perhaps, Moffett Federal Airfield (given that liquefaction mitigation occurred to the runways at SJC);
- shaking damage to air control and terminal facilities, particularly older facilities that may be present at Oakland, Moffett, Hayward, San Francisco, Half Moon Bay, Buchanan, and Livermore airports;
- power and communications disruptions; and
- disruptions to the transportation systems serving the airports.

Flooding: **None** of the three **international** airports are in the 100-year floodplain. However, SJC is surrounded by this floodplain, which may hamper access to and use of the facility in a flood-related disaster. In addition, large portions of the runways of OAK are below sea level, protected only by levees that do not meet current engineering design levels. However, overall, 15% of the land used for general aviation airports are in the 100-year floodplain, including, for example, Buchanan and Palo Alto.

Tsunamis: The tsunami evacuation planning maps released in December 2009 indicate that, within the Bay, OAK would be impacted, but not SFO, SJC, or Moffett Field. A portion of the Half Moon Bay airport also is expected to be impacted.

Landsliding: **None** of these international OR general aviation facilities are in an area of existing landslides.

Wildfire: **None** of these facilities are in an area subject to high wildfire threat, but **27%** of airport land is in a wildland-urban interface (WUI) threat area.

Hazard Conclusion and Risk Assessment: The two significant threats to the international airports are flooding (particularly levee failure and sea level rise) and earthquakes (shaking and liquefaction). WUI threat is **not** significant due to proximity to the Bay.

Existing Mitigation Programs

Earthquake: SJC has had an extensive program to effectively "bridge" ancient stream channels that lie under its runways and are the source of the liquefaction hazard for that airport. OAK and SFO are currently investigating the options for decreasing the liquefaction risk to their runways.

The planned program to tackle this issue as part of runway expansion efforts is on indefinite hold.

Flooding: OAK is upgrading its runway levee as it adds facilities to account for sea level rise and levee failure. It has not been successful in getting the necessary funds to improve the entire levee system at this time.

Bay Area Commercial and General Aviation Airports (continued)

Priorities for Future Mitigation Programs

1. Focus on better understanding and mitigation of the liquefaction hazard to runways. We need to expand on the liquefaction analysis conducted for the runways at the three major airports (OAK, SFO, and SJC) to (a) gain further information on the vulnerability of other major airports, particularly Moffett Federal Airfield on the Peninsula and Travis Air Force Base in Solano County, and, if feasible, Buchanan, Hayward, and Livermore in the East Bay; and (b) incorporate more recent geotechnical information becoming available for OAK, SJC and SFO.

2. Ensure that the design of new runways also mitigates liquefaction hazards associated with the connections to the existing runway system. Any runway expansions at SFO and OAK that tie into sections of existing runways which are vulnerable to liquefaction will make the expansions vulnerable as well. Runway work at SJC has been designed to minimize the liquefaction hazard.

3. Improve emergency planning at individual airports and to better coordinate emergency planning among airports and with other forms of transportation. Airport participation in coordinated emergency planning is essential. MTC is starting this planning as part of the integrated Trans Response Plan (TRP) for earthquakes. The Regional Airport Planning Committee has also discussed this issue, particularly as it relates to potential funding.

4. Identify alternate locations capable of handling large commercial and cargo jets after an earthquake should Bay Area commercial airports lose capacity due to road transportation system disruptions, runway damage, or structural damage. Travis AFB will have increased air and vehicle traffic during the post-earthquake emergency response phase because the federal government plans on using Travis AFB as the primary mobilization center for their response to the disaster. With the normal operations that Travis has in addition to this major role, emergency planners should not believe that Travis has additional capacity for other commercial or cargo needs. Options include neighboring commercial airports (Sacramento, Stockton, Monterey, etc.), as well as larger general aviation airports.

5. Identify funding mechanisms for the retrofit or replacement of critical levee systems protecting the runway at OAK. The levee system at this airport is currently vulnerable to both earthquake damage and damage due to sea level rise.

Other mitigation activities related to the airports and their facilities are covered in the individual mitigation strategies of the various cities which own and manage the airports in the Bay Area.

Further airport information: Perkins, J., with William Lettis and Associates (WLA) (Bachhuber, J., Baldwin, J., and Knudsen, K.), 2000. ***Don't Wing It: Airports and Bay Area Earthquakes:*** Association of Bay Area Governments, Oakland, CA. Excerpts are available online at *http://quake.abag.ca.gov/eqtrans/eqtrans.html*.

The Existing Water and Wastewater System

The regional water and wastewater systems are managed by a network of public special districts, city and county departments, and private companies. There are over 100 water retailers and wholesalers in the Bay Area. While most wastewater collection and treatment is handled by cities and counties, some special districts treat wastewater. ABAG estimates that there are 32,000 miles **each** of water and sewer pipes.

Some communities within the Bay region derive their urban, suburban and rural water supplies from groundwater and surface waters within the nine-county region (Napa River, Russian River, Guadalupe River, numerous creeks and springs). Others rely on groundwater and surface waters that are imported from watersheds and basins outside the region (including the Tuolumne, Mokelumne, Sacramento, San Joaquin and Eel River watersheds). The State of California Water Project and the U.S. Bureau of Reclamation Central Valley Project are large suppliers of water to the Bay region.

The Bay Area contains over 400 watersheds, including a portion of the Sacramento/San Joaquin watershed system. Water is distributed from these watersheds via a series of open and closed conveyances within the region, and inter-regionally. A significant amount of annual supply is impounded in 260 major reservoirs and behind numerous small check dams scattered throughout the region. **75%** of the water supplies for the Bay Area are from water agencies that obtain all or part of their water either (1) from aqueducts or canals passing through the Sacramento-San Joaquin Delta or (2) by extracting water from that Delta.

The Bay Area also contains a series of dedicated groundwater recharge areas where groundwater can accumulate for current and future use. Some groundwater recharge areas are employed to begin arresting the decline of groundwater levels in some basins, or to cope with salt water intrusion. These declines can, and do, lead to land subsidence, cones of depression, damaged infrastructure, and altered soil chemistry, which in turn can affect the region's groundwater carrying capacity. Groundwater basins outside the region act as significant storage sites for some Bay Area water needs during dry years.

Conserved and recycled water is another source of water and estimates of its potential are provided in the State of California Water Plan and in a range of Urban Water Management Plans in the Bay Region. The State's Recycled Water Task Force recently estimated that building additional water recycling plants could meet 30 percent of the region's water needs by 2030. Recycled water in the region is used in a wide range of applications, including landscape irrigation, industrial cooling, and agricultural needs, as well as an environmental water source for wetlands restoration. The Department of Water Resources estimates that close to 50 million gallons per day (GPD) of recycled water is produced here, and planned projects have the potential to double this amount in ten years.

Participating Agencies

Special-purpose agencies directly participating in this water supply and wastewater portion of the MJ-LHMP include several special districts:

- Alameda County Water District
- Contra Costa Water District
- Dublin-San Ramon Services District
- East Bay Municipal Utility Dist.
- Mid-Peninsula Water District
- Montara Water & Sanitary Dist.
- Purissima Hills Water Dist.
- Santa Clara Valley Water Dist.
- Sewer Authority Mid-Coastside
- Solano Co. Water Agency
- Solano Irrigation District
- Vallejo Sanitation & Flood Control District
- Zone 7 Water Agency

City and county water departments are represented on the committee overseeing this process by the San Francisco Public Utility District which operates the Hetch-Hetchy system.

Private companies partnering in this updated plan include:

- San Jose Water Company
- Cal Water

As a multi-jurisdictional plan, this effort makes use of the hazard maps contained in the overall plan, with the additional hazard exposure data documented in this chapter.

The various agencies participating in this plan coordinated their efforts through the overall lifeline effort of the MJ-LHMP through representatives to the ABAG Lifeline Infrastructure and Hazards Advisory Committee.

Earthquake Hazards and the Bay Area Water and Wastewater Systems

Examining the locations of dams, water and wastewater treatment facilities, and pipeline networks that make up the water supply and wastewater collection system, shows earthquakes to be the greatest hazard. Because these systems have to be located in urban areas to serve those communities, their general hazard exposure is similar to that of the areas they serve.

While **93.4%** of critical water system facilities and **88.8%** of critical wastewater system facilities are exposed to high **ground shaking** levels (peak accelerations of greater than 40% of gravity [g] with a 10% chance of being exceeded in the next 50 years), **68.1%** of critical water system facilities and **67.5%** of critical wastewater system facilities are exposed to extremely high shaking levels (60% g). In addition, **95.2%** of pipelines are estimated to be exposed to high shaking levels (peak accelerations of greater than 40% g with a 10% chance of being exceeded in the next 50 years), and **62.8%** are exposed to extremely high shaking levels (60% g). Thus, most of the mitigation strategies that follow deal with this hazard. While shaking will not damage pipelines in the same manner as buildings, the ground waves associated with shaking will damage those pipelines.

The ability of the levees in the **Sacramento-San Joaquin Delta** to withstand strong shaking is being studied, as discussed in the box on the following page. The hazards associated with failure of these levees, both directly and indirectly, on the region's water supply could be catastrophic.

When **faults** rupture and generate earthquakes, that rupture can extend to the surface, rupturing aqueducts and pipelines. Existing state law prohibits the construction of structures intended for human occupancy across the trace of an active fault. However, water aqueducts and pipelines cross these faults. For example, if the Hayward fault ruptures from San Pablo Bay to its southern end near the Santa Clara County border, fault surface rupture could severely damage the Hetch-Hetchy aqueducts, the EBMUD aqueducts, the South Bay aqueduct, and numerous local pipelines. Some dams are also on or near faults. In some cases, local roads have been intentionally placed astride faults as a land-use decision to avoid the placement of buildings astride the fault. When this occurs, the water and sewer pipelines are placed in this same alignment.

Liquefaction occurs when loose, water-saturated, sand and silt behave like liquid quicksand when shaken in an earthquake. The exposure to liquefaction is far less than shaking. In addition, not all areas of very high susceptibility to liquefaction will actually behave like quicksand in any individual earthquake. A much higher percentage of wastewater (**35.8%)** than water (**5.4%)** facilities are located in the highest hazard categories for this hazard. As liquefaction results in buckling and bending of the ground, pipelines can be damaged. While the percentage of pipe distribution lines in these areas is only **5.9%**, they tend to serve the largest population centers.

An ABAG analysis of damaged pipelines following the 1989 Loma Prieta earthquake indicated that pipelines in areas subject to liquefaction AND exposed to violent ground shaking were the most likely to have broken or leaked as a result of that earthquake. ABAG has estimated that there could be, for example, **6,000 - 10,000** water pipeline breaks or major leaks in an earthquake on the Hayward fault (compared to 507 in the Loma Prieta earthquake). Rapid repair and replacement of these pipelines is essential to recovery from an earthquake.

San Pablo Dam and Reservoir Upgrade

Landslides can be generated as a result of earthquakes. This hazard is discussed with rainfall-induced landslides later in this document.

Tsunamis can be generated as a result of earthquake fault rupture or underground landslides triggered by earthquakes. After extensive modeling by a number of organizations, maps of the potential inundation areas impacted by tsunamis near the Bay or Pacific Ocean were released in December 2009 for evaluation planning. The most at-risk areas are those bordering the Pacific Ocean and next to San Francisco Bay. An estimated **1.7%** of critical water facilities and **16%** of critical wastewater facilities are in these areas.

Current Earthquake Hazard Water-Wastewater Mitigation Highlights

The amount of effort and money currently being spent on the mitigation of earthquake impacts is higher than any of the other natural hazards.

All water and wastewater special districts, as well as cities and counties, routinely take account of predicted earthquake forces in the **design of new structures,** including office and operations buildings, as well as wastewater and water treatment plants and conveyance networks.

Bay Area residents have **funded major improvements to the San Francisco PUC Hetch-Hetchy, EBMUD, and Contra Costa Water District (CCWD)** systems, particularly related to storage tanks, treatment plants, and fault crossings. However, with these major systems, as well as with smaller agencies, the capital improvements budgets are limited. These financial issues are have been exacerbated by the 2008-09 recession.

Dam owners and operators, under the regulation of the State Division of **Safety of Dams**, routinely inspect their facilities and reevaluate their safety in light of current engineering and seismology. Based on these assessments, EBMUD is retrofitting San Pablo Dam and Reservoir at a cost of $75 million dollars. The San Francisco PUC Calaveras Dam Replacement Project has an estimated total cost of $409 million dollars.

EBMUD, CCWD, and Santa Clara Valley Water District have installed, and SFPUC and Alameda County Water District are in the process of installing, shut-off valves in pipelines that cross active faults. These valves, installed on each side of the fault, enable above-ground potable water bypass lines to be rapidly installed.

Water and wastewater agencies have started to plan for speeding the repair and functional restoration of water and wastewater systems through joining the Water/Wastewater Agency Response Network (WARN). The plan is to stockpile shoring materials, temporary pumps, surface pipelines, portable hydrants, and other supplies. Some water suppliers have also purchased equipment to bag emergency drinking water for customers.

ABAG's Sewer Smart Program, with water and wastewater districts, has developed innovative materials to help the public cope with disrupted storm drains, sewer lines, and wastewater treatment. This program grew out of the exposure of the wastewater system to earthquake hazards and the information gap identified as part of this project.

Future Regional Mitigation Priorities Related to the Delta

The levee failures resulting from Hurricane Katrina, combined with the Jones Tract levee failures in the **Sacramento-San Joaquin Delta**, have led to an evaluation of the potential impact of a major earthquake or flood on that Delta system. As previously stated, **75%** of the water supplies for the region are from water agencies that obtain all or part of their water from the Delta or have conveyances that pass through it.

The State of California has conducted a Delta Risk Management Study (DRMS) that has explained the problem and associated risks. The State, the water agencies, and other organizations are currently working to identify mitigation options that would protect the water supply and environmental quality of the Delta. At this point, various strategies are being reviewed. While the Governor's administration favors a canal bypass, this option would partially protect Southern California water interests, but, as currently envisioned, would not protect the water supply of the Bay Area. The cities, counties, and special districts in the Bay Area are, and will continue to be, involved in this multi-billion dollar discussion.

From the standpoint of risk, damage to the Delta levees from a major earthquake that would also cripple portions of the urban Bay Area (such as one on the Hayward fault) is more problematic than damage from a Delta-area fault because the region's resources would be more heavily impacted. ***Thus, a disaster mitigation effort for the Delta that incorporates recovery goals is essential.***

Future Regional Mitigation Priorities Related to Pipelines

The **pipeline distribution systems** for water and sewer lines typically have not been replaced since they were originally installed, in some cases almost 100 years ago. These pipelines will break and leak. Ways to mitigate this damage through repair and replacement of the most susceptible lines has started, but will not be completed for several years.

Weather-Related Hazards and the Bay Area Water and Wastewater Systems

The Bay Area has historically had a mild Mediterranean climate characterized by mild rainy winters and dry summers. Flooding and landsliding occurred during the wet season, while wildfires and drought occurred in the dry season.

Climate change has been shown to exacerbate all of these hazards. Thus, the region can expect more flooding and landsliding due to a more abrupt runoff in the spring, as well as increased potential for wildfires any time of year and multi-year drought conditions. Some wastewater treatment facilities may be subject to the threat of sea level rise.

Flooding can occur when occasional intense winter storms result in local stream flooding, as well as when particularly warm rains in the Sierras result in sudden snow melting. Flooding is a lesser hazard than earthquakes to the region's water and wastewater systems. A significant **11.5%** of the wastewater and **3.8%** water critical facilities in the region are in the 100-year flood plain. While an estimated **3.7%** of pipelines are in these areas, flooding of areas above pipelines is not a significant hazard because areas are not expected to be flooded for weeks at a time.

Occasionally strong winter storms can close roads in the Bay Area.

Finally, warm storms in the Sierras can cause rapid snow melt, which can lead to high water levels that can damage levees in the Sacramento-San Joaquin Delta. Delta islands can also be flooded due to damage **not** associated with storms because of the poor quality of some Delta levees. In addition to these traditionally flood-prone areas, some portions of the region, particularly in the Bay-Delta, are actually below sea level and other areas are subject to sea level rise.

Landslides can be generated as a result of earthquakes or severe winter storms. While **23.1%** of the region's land is located in areas that are mostly active or ancient landslides, a much smaller percentage of the urban land (**8.3%**) and water and wastewater system pipelines (**3.9%**) are located in these hazardous areas. While **0.6%** of the major wastewater facilities are located in these areas, **11%** of the water facilities are located in these areas. However, erosion and siltation can also impact the storage capacity of critical reservoirs.

Wildfire hazards are shown in two separate hazard maps – the wildland-urban-interface fire threat (WUI) maps and the wildfire threat maps. The WUI maps show the wildfire threat in urban areas, while the wildfire threat maps focus on more rural areas.

Based on the WUI maps, an estimated **51.1%** of the water and wastewater pipelines are in fire hazard areas, as well as **66.8%** of the critical water facilities and **44.4%** of the critical wastewater facilities. While only **4.5%** of these areas have actually burned in the past 130 years, this indicates a build-up in fuel loads.

The wildfire threat maps indicate that **14.7%** of the critical water facilities and only **1.5%** of the critical wastewater facilities are in areas of high, very high, and extremely high wildfire threat, as well as **6%** of the pipelines.

Drought in the Sierras, as well as the region itself, can cause water shortages because of the large dependency of the Bay Area on imported water.

Current Weather-Related Hazard Mitigation Highlights for Water and Wastewater Systems

The amount of effort and money currently being spent on the mitigation of the impacts of weather-related hazards is far less than for earthquake-related hazards due to the much lower exposure of water and wastewater facilities, storage tanks, aqueducts, and pipelines to these hazards. In addition, the potential disasters have tended to be less regional in scope, making the functioning of these systems less critical.

However, climate changes may greatly increase the potential need for additional funding. For example, because wastewater treatment plants tend to be located in the lowest areas of the region, planning has started to include adaptation to sea level rise on the part of these facility operators. In addition, water agencies have begun planning for water quality degradation.

The principal exception to this assessment is the potential for catastrophic flooding of islands in the Sacramento-San Joaquin Delta. The State Department of Water Resources has taken the lead in working with reclamation districts to strengthen those levees for flooding damage.

Landslides are not a major concern, in general, for water and wastewater systems. Damage tends to be localized. The exposure of these systems is similar to that of the transportation network. One solution is to install flexible pipelines in areas of past landslides as part of the capital improvements budget, a practice being implemented by water agencies and now being discussed by wastewater agencies.

Regional Priorities for Future Weather-Related Hazard Mitigation

Additional ways to mitigate these weather-related hazards are available, particularly the following.

Wildfire is a concern in the areas served by the water and wastewater systems. This hazard is particularly of concern in areas that would be exposed to fire caused by an earthquake because the water supply could be temporarily crippled by the earthquake. Thus, the water supply agencies need to develop a coordinated approach with fire jurisdictions to identify needed improvements to the water distribution system, initially focusing on areas of highest wildfire hazard (including wildfire threat areas and in wildland-urban-interface areas).

Pipe elbow being installed to avoid a landslide area

Interrelationships with electrical, natural gas, and telecommunications systems

The San Francisco Bay Area is serviced by the Pacific Gas and Electric Company (PG&E), a private utility. PG&E, as a private utility, is not directly covered by this MJ-LHMP. However, this company has been actively involved in hazard mitigation both before and after the 1989 Loma Prieta earthquake. Such mitigation efforts are crucial to the operations of water and wastewater systems due to requirements for power for systems operations. For example, the water requires power for pumping and the wastewater system requires power at the treatment plants.

PG&E has completed structural mitigation on 73% of its buildings, an effort scheduled for completion in 2014. The Gas Pipeline Replacement Program has the objective of replacing 10% of the most at-risk steel pipeline system by 2014. As of 2009, 89% of the effort was complete.

PG&E electrical system substation buildings are being retrofitted; mitigation has been completed on 83% of the buildings and the remainder of the work is scheduled for completion by 2010. Equipment in those buildings is being anchored and seismically qualified equipment is being installed.

Telecommunications facilities and equipment are the most resilient of the infrastructure systems and are expected to return to service most rapidly.

In the case of all of infrastructure systems, however, operators should plan for interruptions in service during the response and recovery phases of a disaster and pre-plan to mitigate those risks.

Lifeline System Interdependencies and Disaster Recovery

As mentioned earlier, one of the main reasons for the interdependencies of infrastructure systems is that they tend to be geographically located in the same areas. For example, water, sewer, and natural gas pipelines tend to be under local roads. Communications and electrical cables are either located under those roads or adjacent to them. All have similar exposures to hazards that are related to serving the developed portions of the region.

However, in addition to geographic interdependencies, lifeline systems also have system interdependencies. Examples include the relatively flexible use of the transportation system to deliver water treatment chemicals to a water treatment facility and the short-term relatively inflexible use of the electric power system to run pumps at that water treatment facility. Such interdependent analyses therefore need to address the length of time required to restore various services or interdependences to a level adequate for recovery. The length of time of a disruption increases the impacts. However, typically, doubling the time of disruption more than doubles the impacts. In addition, the disruption of one infrastructure system delays the recovery of other systems because the infrastructure systems are not available. Thus, speeding recovery of infrastructure systems and focusing on interdependencies of those systems is critical.[1]

The following linkages between the water supply systems and other infrastructure lifeline systems are critical:

Water ◄-► Transportation –
(◄ = needed by water from transportation; ►= needed from water by transportation)
◄-► Co-location hazard exposure of distribution pipelines beneath roads
◄ Transport of repair and maintenance vehicles to locations for repairing pipelines
◄ Transport of repair, customer service, and operations facility crews to-and-from their homes
◄ Delivery of chemicals to water treatment facilities
◄ Delivery of fuel to run critical facilities
◄ Delivery of emergency drinking water in bags to customers at emergency distribution points
► Water for concrete construction and dust control

Water ◄-► Telecommunications –
(◄ = needed by water from telecommunications; ►= needed from water by telecom)
◄-► Co-location hazard exposure of distribution pipelines beneath roads with cable and underground wiring; above ground networks also aligned with roads (and thus pipeline corridors)
◄ Automated systems and process control equipment for treatment and operations
◄ Communication with repair and maintenance crews
◄ Communication with customers for repair and maintenance requests
◄ Emergency communications with emergency operations centers
► Water for communication equipment cooling systems

Water ◄-► Petroleum, natural gas, and electrical systems –
(◄ = needed by water from energy systems; ►= needed from water by energy systems)
◄-► Co-location hazard exposure of natural gas and some other fuel lines beneath roads, as well as electric power lines both beneath and adjacent to road corridors
◄ Gasoline and lubricants for use in repair and maintenance vehicles repairing pipelines
◄ Gasoline and lubricants for vehicles of repair, customer service, and operations facility crews to-and-from their homes
◄ Electric power for pump and lift stations, treatment plant operations, and control systems

---

[1] See, for example, Peerenboom, J., Fisher, R., and Whitfield, R., 2001. "Recovering from Disruptions of Interdependent Critical Infrastructures" presented at the ***CRIS/DRM/IIIT/NSF Workshop on Mitigating the Vulnerability of Critical Infrastructures to Catastrophic Failures***" Lyceum, Alexandria, Virginia.

◄ Fuel to run back-up generators at some critical facilities
► Water for refinery production, pumps, compressors, cooling, emissions reduction, and fire suppression
► Water for electric power plant operations, including cooling and emissions reduction
The following figure shows these linkages.

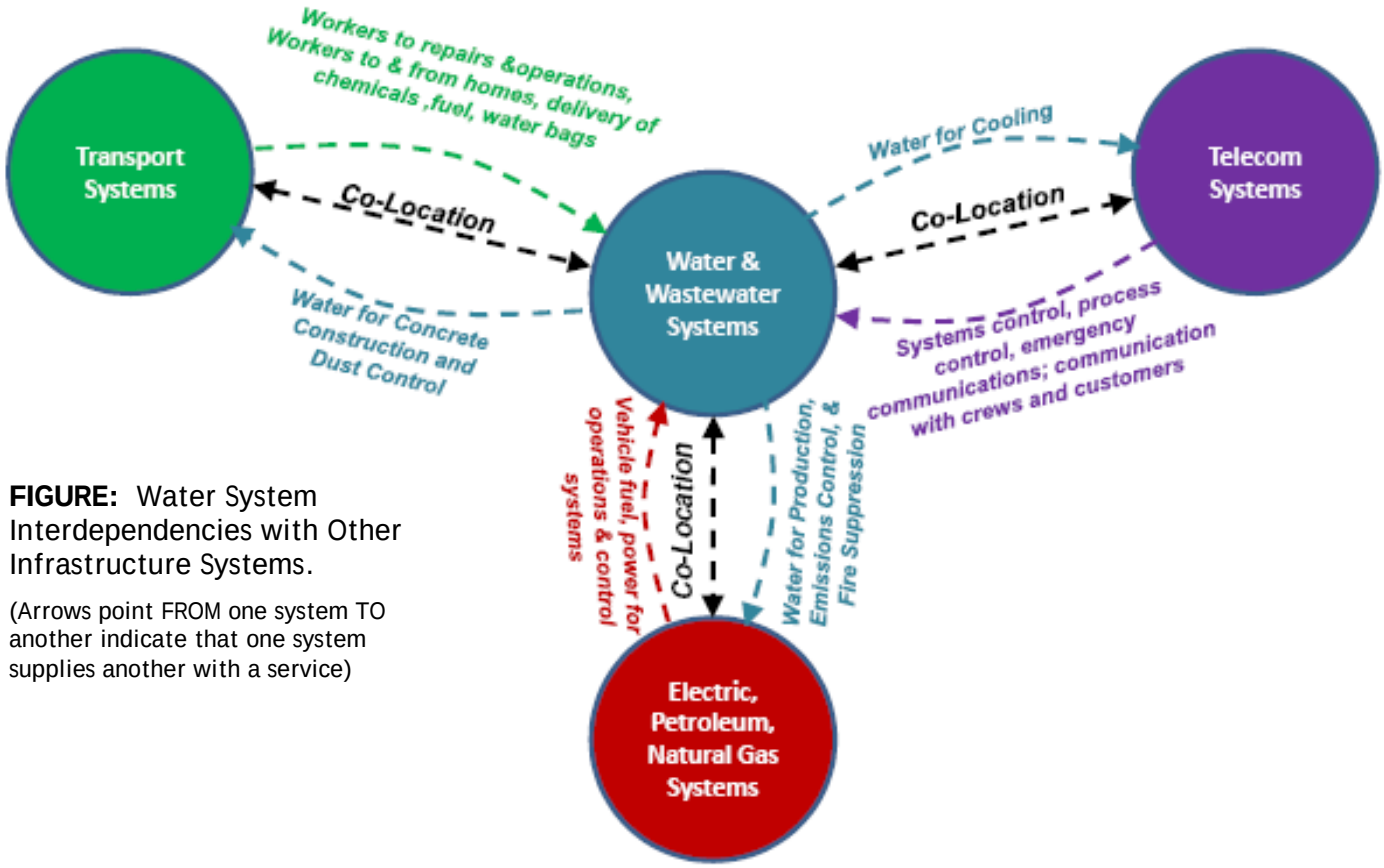


FIGURE: Water System Interdependencies with Other Infrastructure Systems.

(Arrows point FROM one system TO another indicate that one system supplies another with a service)

The following linkages between transportation systems (including airports) and other lifeline systems also are critical:

Transportation ◄-► Water – (repeated for completeness)

◄-► Co-location hazard exposure of distribution pipelines beneath roads
(◄ = needed by transportation from water; ►= needed from transportation by water)
◄ Water for concrete construction and dust control
► Transport of repair and maintenance vehicles to locations for repairing pipelines
► Transport of repair, customer service, and operations facility crews to-and-from their homes
► Delivery of chemicals to water treatment facilities
► Delivery of fuel to run critical facilities

Transportation ◄-► Telecommunications –
(◄ = needed by transportation from telecommunications; ►= needed from transportation by telecom)
◄-► Co-location hazard exposure of cables and underground wiring beneath roads or along roads
◄ Automated systems and process control equipment for trains
◄ Communication between transit operators and bus/train drivers
◄ Communication with repair and maintenance crews of roads, ports, and airports
◄ Communication with people needing to travel to and from work (or using airports and ports)
◄ Emergency communications with emergency operations centers

► Transport of repair and maintenance vehicles to locations for repairing cables, wires, and equipment
► Transport of repair, customer service, and operations facility crews to-and-from their homes
► Delivery of replacement specialized equipment to critical facilities

Transportation ◄-► Petroleum, natural gas, and electrical systems –
(◄ = needed by transportation from energy systems; ►= needed from transportation by energy systems)
◄-► Co-location hazard exposure of natural gas and some other fuel lines beneath roads, as well as electric power lines both beneath and adjacent to road corridors
◄ Gasoline and lubricants for use in road and highway repair and maintenance vehicles
◄ Gasoline & lubricants for buses & vehicles of repair & operations facility crews to-and-from their homes
◄ Electric power for train operations, some buses, street lights, gas station pumps, credit card machines, and control systems
◄ Fuel to run back-up generators at some critical operations facilities
► Transport of repair and maintenance vehicles to locations for repairing pipelines, power lines, & equipment
► Transport of repair, customer service, and operations facility crews to-and-from their homes
► Delivery of fuel to gas stations and delivery of replacement equipment to refineries and critical facilities

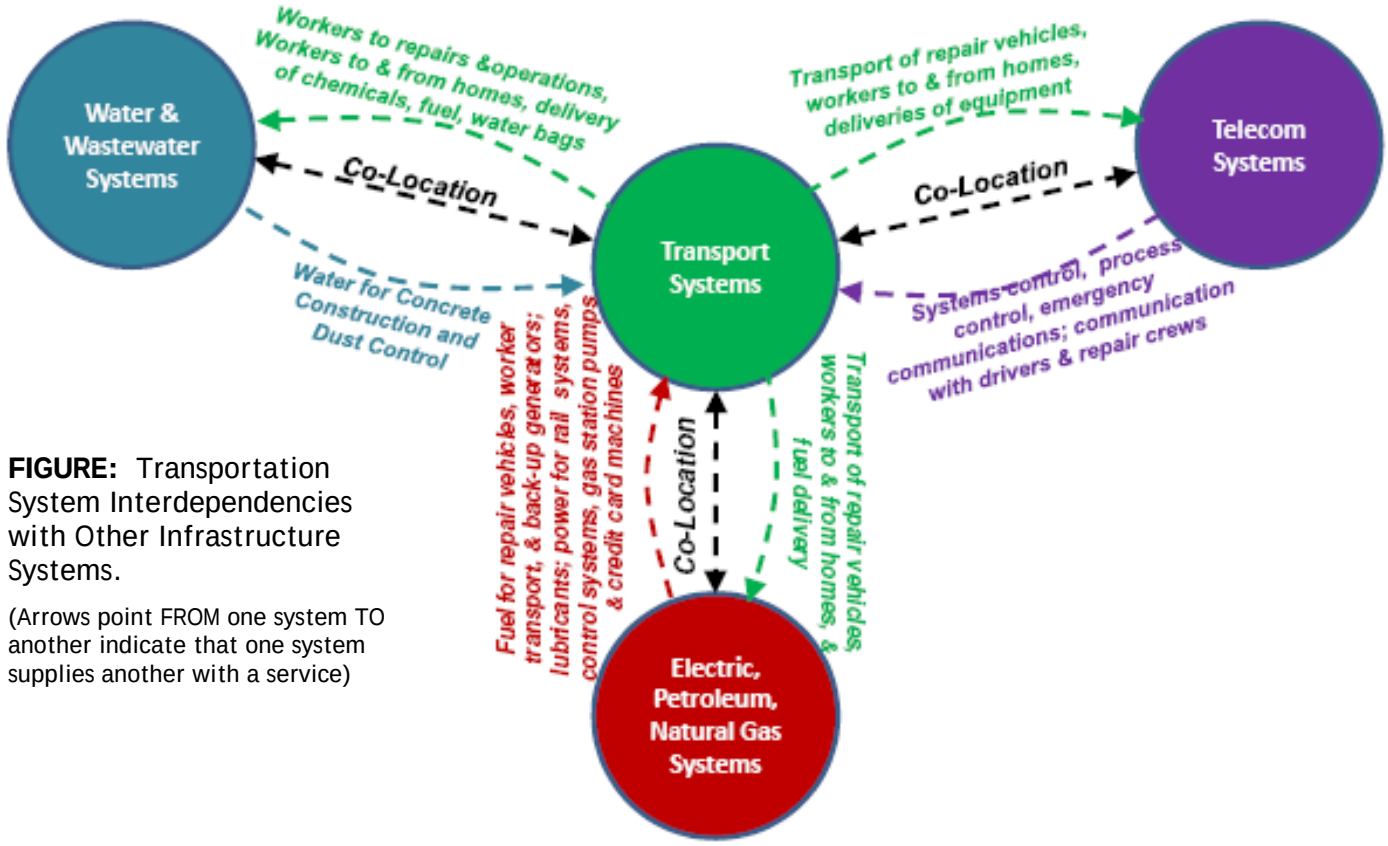


FIGURE: Transportation System Interdependencies with Other Infrastructure Systems.

(Arrows point FROM one system TO another indicate that one system supplies another with a service)

Combining these two figures creates a more complete picture of the interdependencies of water and transportation systems (typically managed by local governments) than the original Peerenboom and others (2001) figure, even though the distinctions among natural gas, electric power, and oil are not highlighted. This combined figure is shown below.

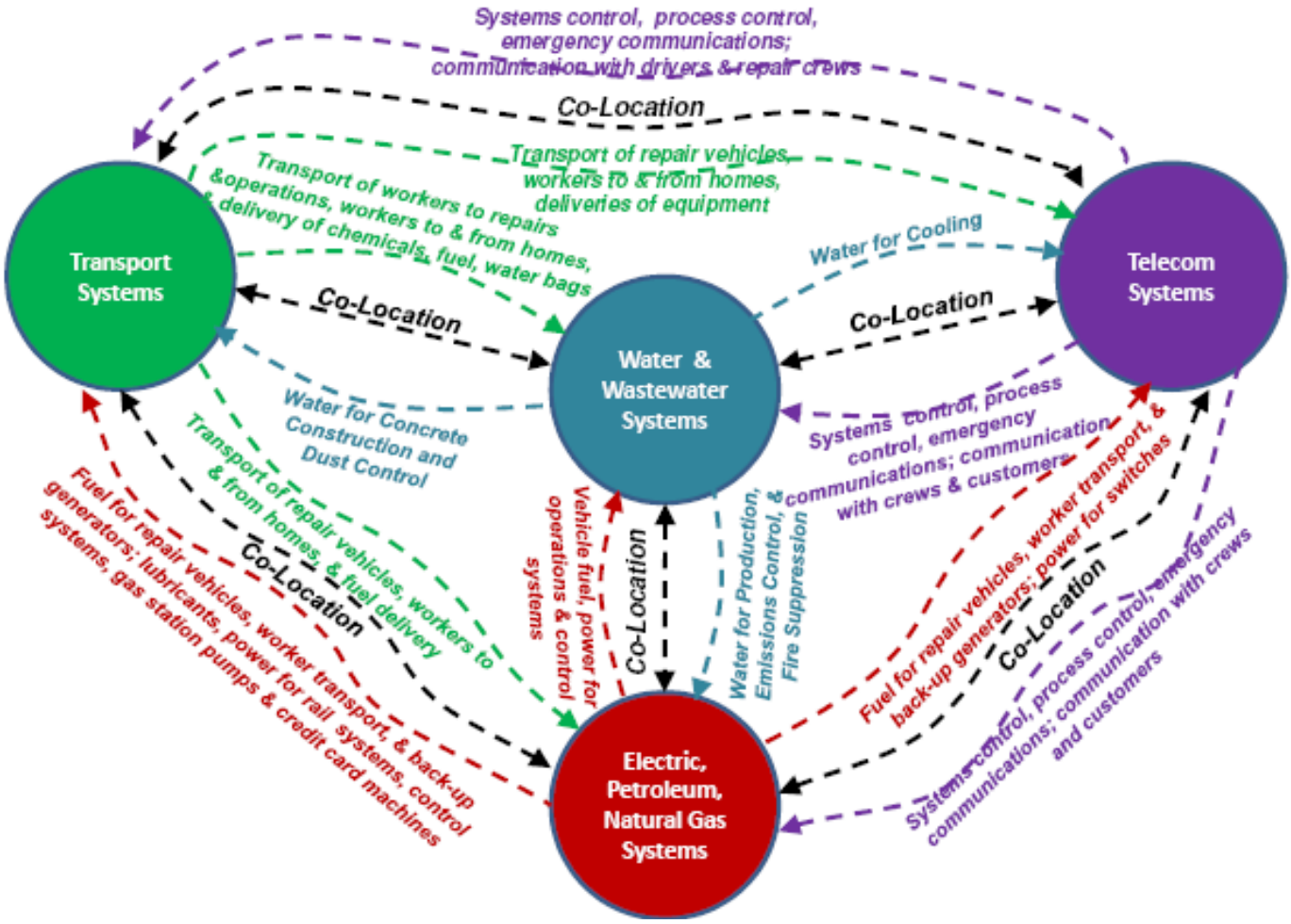


FIGURE: Transportation System Interdependencies with Other Infrastructure Systems.

(Arrows point FROM one system TO another indicate that one system supplies another with a service)

Certain Mitigation Practices Apply to All Hazards.

There are various steps that cities, counties, and infrastructure providers take to mitigate the hazards posed by multiple disasters. For example, all large-scale disasters can cause problems due to interdependencies and common issues of reoccupancy and recovery. Other actions may specifically relate to one type of infrastructure, but can mitigate multiple hazards. Finally, infrastructure providers, cities, and counties all need to communicate with the public.

ACTIONS APPLYING TO MULTIPLE HAZARDS AND INTERDEPENDENCIES OF INFRASTRUCTURE

In the event of a large-scale disaster, multiple infrastructure and utility system operators will all be scrambling to repair damage to return those systems to functioning. To the extent that roads are damaged or closed, pipeline and other repair crews will have difficulties in accessing their damaged systems. These and other interdependencies of infrastructure systems are addressed in the following coordinated strategies for systems mitigation.

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy INFR a-1): Assess the vulnerability of critical facilities owned by infrastructure operators subject to damage in natural disasters or security threats, including fuel tanks and facilities owned outside of the Bay Area that can impact service delivery within the region. Note - Infrastructure agencies, departments, and districts are those that operate transportation and utility facilities and networks.	Existing program, underfunded	All infrastructure providers, including cities and counties
2–(a-4): Retrofit or replace critical lifeline infrastructure facilities and/or their backup facilities that are shown to be vulnerable to damage in natural disasters.	Existing program, underfunded	All infrastructure providers, including cities and counties
3–(a-3): Encourage the cooperation of utility system providers and cities, counties, and special districts, and PG&E to develop strong and effective mitigation strategies for infrastructure systems and facilities.	Existing program	Cities, counties, regional agencies, and infrastructure providers
4–(a-5): Support and encourage efforts of other (lifeline infrastructure) agencies as they plan for and arrange financing for seismic retrofits and other disaster mitigation strategies. (For example, a city might pass a resolution in support of a transit agency's retrofit program.)	Existing program	Cities, counties, regional agencies, and infrastructure providers
5–(a-7): Engage in, support, and/or encourage research by others (such as USGS, universities, or Pacific Earthquake Engineering Research Center-PEER) on measures to further strengthen transportation, water, sewer, and power systems so that they are less vulnerable to damage in disasters.	Existing program	Cities, counties, regional agencies, and infrastructure providers
6–(a-14): Encourage communication between State Emergency Management Agency (CalEMA), FEMA, and utilities related to emergencies occurring outside of the Bay Area that can affect service delivery in the region.	Existing program	Cities, counties, regional agencies, and infrastructure providers
7–(f-1): Ensure that critical buildings owned or leased by special districts or private utility companies participate in a program similar to San Francisco's Building Occupancy Resumption Program (BORP). The BORP program permits owners of buildings to hire qualified engineers to create facility-specific post-disaster inspection plans and allows these engineers to become automatically deputized as City/County inspectors for these buildings in the event of an earthquake or other disaster. This program allows rapid reoccupancy of the buildings. Note - A qualified engineer is a California licensed engineer with relevant experience.	Existing program	Cities, counties, regional agencies, and infrastructure providers

ACTIONS APPLYING TO MULTIPLE HAZARDS BUT FOCUSED ON A SINGLE TYPE OF SYSTEM —

Some mitigation policies may apply to multiple hazards, but may be focused on a single type of infrastructure system, such as water and wastewater, power and communications, or transportation. The following strategies are organized in this manner.

Water and Wastewater: These systems require mitigation of hazards to critical facilities, including dams, water and wastewater treatment facilities, pumps, and pipelines. Projects can often be developed that mitigate problems associated with multiple hazards.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-2): If a dam owner, comply with State of California and federal requirements to assess the vulnerability of dams to damage from earthquakes, seiches, landslides, liquefaction, or security threats.	Existing program	Dam owners
2–(a-13): If you own a dam, coordinate with the State Division of Safety of Dams to ensure an adequate timeline for the maintenance and inspection of dams, as required of dam owners by State law, and communicate this information to local governments and the public.	Existing program	Dam owners
3–(a-6): Develop a plan for speeding the repair and functional restoration of water and wastewater systems through stockpiling of shoring materials, temporary pumps, surface pipelines, portable hydrants, and other supplies, such as those available through the Water /Wastewater Agency Response Network (WARN). Communicate that plan to local governments and critical facility operators.	Existing program	Water and wastewater agencies

Power and communications: While power is typically supplied by Pacific Gas and Electric Company (PG&E), a private utility, power users can work to mitigate the impacts of power loss, regardless of type of disaster by renting or owning back-up equipment. Communications systems also are private companies, but impacts of damage to those systems also can be mitigated.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-8): Pre-position emergency power generation capacity (or have rental/lease agreements for these generators) in critical buildings of cities, counties, and special districts to maintain continuity of government and services.	Existing program, underfunded	Cities, counties, regional agencies, and infrastructure providers
2–(a-11): Minimize the likelihood that power interruptions will adversely impact lifeline utility systems or critical facilities by ensuring that they have adequate back-up power.	Existing program, underfunded	Cities, counties, regional agencies, and infrastructure providers
3–(a-12): Encourage replacing above ground electric and phone wires and other structures with underground facilities, and use the planning-approval process to ensure that all new phone and electrical utility lines are installed underground.	Existing program, underfunded	Cities and counties
4–(a-21): As an infrastructure operator, designate a back-up Emergency Operations Center with redundant communications systems.	Existing program, underfunded	All infrastructure providers

Transportation: The regional transportation system is critical to evacuation, medical transport, and delivery of chemicals and fuel to other infrastructure operators, as identified in the following mitigation strategies.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-9): Ensure that critical intersection traffic lights function following loss of power by installing battery back-ups, emergency generators, or lights powered by alternative energy sources such as solar. Proper functioning of these lights is essential for rapid evacuation, such as with hazmat releases resulting from natural disasters.	Existing program, underfunded	Cities and counties
2–(a-10): Develop unused or new pedestrian rights-of-way as walkways to serve as additional evacuation routes (such as fire roads in park lands).	Existing program, underfunded	Cities, counties, and infrastructure system land owners
3–(a-15): Ensure that transit operators, private ambulance companies, cities, and/or counties have mechanisms in place for medical transport during and after disasters that take into consideration the potential for reduced capabilities of roads following these same disasters.	Existing program	Cities, counties, and transit districts
4–(a-16): Recognize that heat emergencies produce the need for non-medical transport of people to cooling centers by ensuring that (1) transit operators have plans for non-medical transport of people during and after such emergencies including the use of paratransit and (2) cities, counties, and transit agencies have developed ways to communicate the plan to the public.	Existing program, underfunded	Cities, counties, and transit districts
5–(a-17): Effectively utilize the Regional Transportation Management Center (TMC) in Oakland, the staffing of which is provided by Caltrans, the CHP and MTC. The TMC is designed to maximize safety and efficiency throughout the highway system. It includes the Emergency Resource Center (ERC) which was created specifically for primary planning and procedural disaster management.	Existing program	MTC only
6–(a-18): Develop (with the participation of paratransit providers, emergency responders, and public health professionals) plans and procedures for paratransit system response and recovery from disasters.	Existing program, underfunded	Cities, counties, MTC, and transit districts
7–(a-19): Coordinate with other critical infrastructure facilities to establish plans for **delivery** of water and wastewater treatment chemicals.	Existing program	Water and wastewater agencies
8–(a-20): Establish plans for **delivery** of fuel to critical infrastructure providers.	Existing program, underfunded	Infrastructure agencies with transportation agencies

ACTION APPLYING TO MULTIPLE HAZARDS AND FOCUSED ON THE DELTA AREA ----------

The Sacramento-San Joaquin Delta is critical to several infrastructure systems. Yet, as identified in several recent technical documents, the Delta as it is now managed and configured is not sustainable. Specific mitigation actions are premature at this time. However, the following strategy, which focuses on monitoring those efforts, is appropriate, even for those infrastructure agencies that are not located in this area, because the impacts of damage to the Delta would have indirect consequences for the remainder of the region. Delta issues will be reviewed when this Plan is updated in five years.

Strategy	*Regional Priority*	*Responsible Agency*
16–(a-22): Monitor scientific studies of the Sacramento-San Joaquin Delta and policy decisions related to the long-term disaster resistance of that Delta system to ensure that decisions are made based on comprehensive analysis and in a scientifically-defensible manner. Levee failure due to earthquakes, flooding, and climate change (including sea level rise and more frequent and more severe flooding) are all of concern. The long-term health of the Delta area is critical to the Bay Area's water supply, is essential for the San Francisco Bay and estuary's environmental health, provides recreation opportunities for Bay Area residents, and provides the long-term sustainability of Delta communities. While only part of the Delta is within the nine Bay Area counties covered by this multi-jurisdictional LHMP, the Delta is tied to the infrastructure, water supply, and economy of the Bay Area.	Existing program, underfunded	Cities, counties, regional agencies, and all infrastructure providers

ACTIONS APPLYING TO MULTIPLE HAZARDS AND PUBLIC EDUCATION ----------

Bay Area residents should be made aware of the significant threats posed by various natural disasters. As such, jurisdictions should work to make sure that residents are well prepared for the broad spectrum of potential hazards as related to infrastructure system.

Strategy	*Regional Priority*	*Responsible Agency*
1–(g-1): Provide materials to the public related to planning for power outages.	Existing program	Cities, counties, and power suppliers
2–(g-2): Provide materials to the public related to family and personal planning for delays due to traffic or road closures, or due to transit system disruption caused by disasters.	Existing program	Cities, counties, and transportation agencies
3–(g-3): Provide materials to the public related to coping with reductions in water supply or contamination of that supply BEYOND regulatory notification requirements.	Existing program	Cities, counties, and water suppliers
4–(g-4): Provide materials to the public related to coping with disrupted storm drains, sewage lines, and wastewater treatment (such as materials developed by ABAG's Sewer Smart Program).	Existing program	Cities, counties, and sewer agencies
5–(g-5): Facilitate and/or coordinate the distribution of emergency preparedness or mitigation materials that are prepared by others, such as by making the use of the internet or other electronic means, or placing materials on community access channels or in city or utility newsletters, as appropriate.	Existing program	Cities, counties, regional agencies, and all infrastructure providers

6–(g-6): Sponsor the formation and training of Community Emergency Response Teams (CERT) for the employees of your agency. [Note – these programs go by a variety of names in various cities and areas.]	Existing program	Cities, counties, regional agencies, and all infrastructure providers
7–(g-7): Develop and distribute culturally appropriate materials related to disaster mitigation and preparedness, such as those on the http://www.preparenow.org website related to infrastructure issues.	Existing program	Cities, counties, regional agencies, and all infrastructure providers

Hazard-Specific Vulnerabilities of Infrastructure Systems

Damage from earthquakes, flooding, wildfire, and landsliding is sometimes best mitigated through hazard-specific strategies.

The following section will discuss strategies for mitigating the hazards posed by these specific threats to various infrastructure systems.

ACTIONS RELATED TO EARTHQUAKE HAZARDS AND VULNERABILITIES

The most pressing and potentially dangerous hazard facing Bay Area infrastructure is from earthquakes. The probability of a major earthquake is high. Many infrastructure systems remain vulnerable to shaking, faulting, landsliding, and liquefaction resulting from such an earthquake. Finally, the probability of cascading failures of multiple systems creating a mega-catastrophe is higher than for other disasters.

Functional infrastructure systems are the arteries of the Bay Area during the response and recovery process. Thus, it is extremely important that these systems undergo mitigation. Damage from earthquakes is the largest risk facing these systems. Thus, the number of strategies related to earthquake hazard mitigation is large. Some strategies apply to multiple systems, while others are specific to transportation systems, and still others to water and wastewater systems.

Multiple infrastructure systems: The retrofit of critical facilities requires large amounts of money; priorities for mitigation must be set. These priorities should be based on servicing existing development prior to servicing new development, a set of priorities that can result in more compact development. New and existing infrastructure projects also need to comply with applicable codes. If a facility is found to be a hazard, it is important that workers in these facilities be kept informed of the retrofit and mitigation status.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-2): Establish a higher priority for funding seismic retrofit of existing transportation and infrastructure systems (such as BART) than for expansion of those systems.	Existing program, underfunded	Cities, counties, regional agencies, and all infrastructure providers
2–(b-8): Comply with all applicable building and fire codes, as well as other regulations (such as state requirements for fault, landslide, and liquefaction investigations in particular mapped areas) when constructing or significantly remodeling infrastructure facilities.	Existing program	Cities, counties, regional agencies, and all infrastructure providers

3–(b-9): Clarify to workers in critical facilities and emergency personnel, as well as to elected officials and the public, the extent to which the facilities are expected to perform only at a life safety level (allowing for the safe evacuation of personnel) or are expected to remain functional following an earthquake.	Existing program	Cities, counties, regional agencies, and all infrastructure providers

Transportation systems: Transportation systems have special mitigation strategies related to bridges and road structures. In addition, to the extent that a water-based system is created, this system can serve as a back-up for BART and the toll bridges.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-1): Expedite the funding and retrofit of seismically-deficient city- and county-owned bridges and road structures by working with Caltrans and other appropriate governmental agencies.	Existing program, underfunded	Cities and counties
9–(b-10): Develop a water-based transportation "system" across the Bay for use in the event of major earthquakes. Implementation of such a system could prove extremely useful in the event of structural failure of either the road-bridge systems or BART and might serve as an adjunct to existing transportation system elements in the movement of large numbers of people and/or goods.	Existing program	San Francisco Water Emergency Transportation Agency (WETA)

Water and wastewater systems: Both water and wastewater systems rely on critical facilities and pipeline networks that are vulnerable to various earthquake-related hazards.

Strategy	*Regional Priority*	*Responsible Agency*
2–(b-3): Include "areas subject to high ground shaking, earthquake-induced ground failure, and surface fault rupture" in the list of criteria used for determining a replacement schedule for pipelines (along with importance, age, type of construction material, size, condition, and maintenance or repair history).	Existing program	Water and wastewater agencies
3–(b-4): Install specially-engineered pipelines in areas subject to faulting, liquefaction, earthquake-induced landsliding, or other earthquake hazard.	Existing program, underfunded	Water and wastewater agencies
4–(b-5): Replace or retrofit water-retention structures that are determined to be structurally deficient, including levees, dams, reservoirs and tanks.	Existing program, underfunded	Water and wastewater agencies and dam owners
5–(b-6): Install portable facilities (such as hoses, pumps, emergency generators, or other equipment) to allow pipelines to bypass failure zones such as fault rupture areas, areas of liquefaction, and other ground failure areas (using a priority scheme if funds are not available for installation at all needed locations).	Existing program, underfunded	Water and wastewater agencies
6–(b-7): Install earthquake-resistant connections when pipes enter and exit bridges and work with bridge owners to encourage retrofit of these structures.	Existing program, underfunded	Water and wastewater agencies

ACTIONS RELATED TO WILDFIRE AND STRUCTURAL FIRE HAZARDS AND VULNERABILITIES

Water supply: Providing a reliable source of water for fire suppression requires the cooperation of cities, counties, fire districts, and water supply agencies.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-1): Ensure a reliable source of water for fire suppression (meeting acceptable standards for minimum volume and duration of flow) for existing and new development.	Existing program, underfunded	Cities, counties, and water suppliers
2–(c-2): Develop a coordinated approach between fire jurisdictions and water supply agencies to identify needed improvements to the water distribution system, initially focusing on areas of highest wildfire hazard (including wildfire threat areas and in wildland-urban-interface areas).	Existing program, underfunded	Cities, counties, fire agencies, and water suppliers

Vegetation management: One of the simplest, yet most important aspects of a wildfire hazard mitigation strategy is vegetation management. The specific vegetation management program called for in the following strategy is designed to project critical facilities owned by infrastructure operators.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-3): Develop a defensible space vegetation program that includes the clearing or thinning of (a) non-fire resistive vegetation within 30 feet of access and evacuation roads and routes to critical facilities, or (b) all non-native species (such as eucalyptus and pine, but not necessarily oaks) within 30 feet of access and evacuation roads and routes to critical facilities.	Existing program, under funded	Cities, counties, and infrastructure operators

Access and transportation: Access is critical in ensuring that development is protected from wildfires.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-4): For new development, ensure all dead-end segments of public roads in high hazard areas have at least a "T" intersection turn-around sufficient for typical wildland fire equipment.	Existing program	Cities and counties
2–(c-5): For new development, enforce minimum road width of 20 feet with an additional 10-foot clearance on each shoulder on all driveways and road segments greater than 50 feet in length in wildfire hazard areas.	Existing program	Cities and counties
3–(c-6): Require that development in high fire hazard areas provide adequate access roads (with width and vertical clearance that meet the minimum standards of the Fire Code or relevant local ordinance), onsite fire protection systems, evacuation signage, and fire breaks.	Existing program	Cities and counties
4–(c-7): Ensure adequate fire equipment road or fire road access to developed and open space areas.	Existing program	Cities and counties
5–(c-8): Maintain fire roads and/or public right-of-way roads and keep them passable at all times.	Existing program, underfunded	Cities and counties

ACTIONS RELATED TO FLOODING HAZARDS AND VULNERABILITIES

Coordination, cooperation, and watershed analysis: Local jurisdictions and flood control agencies can work most effectively if they cooperate. Conducting watershed analyses is a prime example of the need for cooperation.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-16): Work for better cooperation among the patchwork of agencies managing flood control issues.	Existing program	Cities, counties, & flood control agencies
2–(d-1): Conduct a watershed analysis of runoff and drainage systems to predict areas of insufficient capacity in the storm drain and natural creek system.	Existing program, underfunded	Cities, counties, & flood control agencies
3–(d-2): Develop procedures for performing a watershed analysis to examine the impact of development on flooding potential downstream, including communities outside of the jurisdiction of proposed projects.	Existing program, underfunded	Cities, counties, & flood control agencies
4–(d-3): Conduct a watershed analysis at least once every ten years unless there is a major development in the watershed or a major change in the Land Use Element of the General Plan of the cities or counties within the watershed.	Existing program, underfunded	Cities, counties, & flood control agencies
5–(d-15): Work cooperatively with water agencies, flood control districts, Caltrans, and local transportation agencies to determine appropriate performance criteria for watershed analysis.	Existing program, underfunded	Cities, counties, transportation & flood control agencies

Role for new flood control projects: As the Bay Area grows, sometimes it is essential that new flood control projects are constructed, assuming that they have high benefit-cost ratios and have appropriate environmental mitigation.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-4): Assist, support, and/or encourage the U.S. Army Corp of Engineers, various Flood Control and Water Conservation Districts, and other responsible agencies to locate and maintain funding for the development of flood control projects that have high cost-benefit ratios (such as through the writing of letters of support and/or passing resolutions in support of these efforts).	Existing program	Cities, counties, regional agencies, and all infrastructure agencies
2–(d-5): Pursue funding for the design and construction of storm drainage projects to protect vulnerable properties, including property acquisitions, upstream storage such as detention basins, and channel widening with the associated right-of-way acquisitions, relocations, and environmental mitigations.	Existing program, underfunded	Cities, counties, & flood control agencies

Role for maintenance of existing flood control projects: Once flood control projects are built, a mechanism needs to be in place to insure that they are maintained. In addition, some of these projects need to be reevaluated on an on-going basis.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-6): Continue to repair and make structural improvements to storm drains, pipelines, and/or channels to enable them to perform to their design capacity in handling water flows as part of regular maintenance activities. (This strategy has the secondary benefit of addressing fuel, chemical, and cleaning product issues.)	Existing program, underfunded	Cities, counties, & flood control agencies

2–(d-7): Continue maintenance efforts to keep storm drains and creeks free of obstructions, while retaining vegetation in the channel (as appropriate) to allow for the free flow of water.	Existing program, underfunded	Cities, counties, & flood control agencies
3–(d-8): Enforce provisions under creek protection, stormwater management, and discharge control ordinances designed to keep watercourses free of obstructions and to protect drainage facilities to conform with the Regional Water Quality Control Board's Best Management Practices.	Existing program, underfunded	Cities, counties, & flood control agencies
4–(d-9): Develop an approach and locations for various watercourse bank protection strategies, including for example, (1) an assessment of banks to inventory areas that appear prone to failure, (2) bank stabilization, including installation of rip rap, or whatever regulatory agencies allow (3) stream bed depth management using dredging, and (4) removal of out-of-date coffer dams in rivers and tributary streams.	Existing program, underfunded	Cities, counties, & flood control agencies
5–(d-10): Use reservoir sediment or reed removal as one way to increase storage for both flood control and water supply.	Existing program, underfunded	Dam owners & flood control agencies
6–(d-12): Provide or support the mechanism to expedite the repair or replacement of levees that are vulnerable to collapse from earthquake-induced shaking or liquefaction, rodents, and other concerns, particularly those protecting critical infrastructure.	Existing program, underfunded	Levee owners & flood control agencies

Flooding and infrastructure systems: Some assets of infrastructure operators cannot be moved. These facilities need to be protected from flooding, or redesigned to minimize damage caused by flooding.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-11): Identify critical locally-owned bridges affected by flooding and either elevate them to increase stream flow and maintain critical ingress and egress routes or modify the channel to achieve equivalent objectives.	Existing program, underfunded	Cities, counties, & flood control agencies
2–(d-13): Ensure that utility systems in new developments are constructed in ways that reduce or eliminate flood damage.	Existing program	Cities, counties, & infrastructure providers
3–(d-14): Determine whether or not wastewater treatment plants are protected from floods, and if not, investigate the use of flood-control berms to not only protect from stream or river flooding, but also increase plant security.	Existing program, underfunded	Wastewater agencies

Flood monitoring systems: Flood monitoring can play a key role in some mitigation strategies for infrastructure systems. For example, with appropriate monitoring, key trucks, buses, and other movable equipment can be transported out of areas that are about to be flooded.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-17): Improve monitoring of creek and watercourse flows to predict potential for flooding downstream by working cooperatively with landowners and the cities and counties in the watershed.	Existing program, underfunded	Flood control agencies with cities and counties
2–(d-18): Using criteria developed by EPA for asset management, inventory existing assets, the condition of those assets, and improvements needed to protect and maintain those assets. Capture this information in a Geographic Information System (GIS) and use it to select locations for creek monitoring gauges.	Existing program, underfunded	Flood control agencies with cities and counties

ACTIONS RELATED TO LANDSLIDE HAZARDS AND VULNERABILITIES

The following two strategies concerning landslides relate specifically to infrastructure systems.

Strategy	*Regional Priority*	*Responsible Agency*
1–(e-1): Include "areas subject to ground failure" in the list of criteria used for determining a replacement schedule (along with importance, age, type of construction material, size, condition, and maintenance or repair history) for pipelines.	Existing program	Water and wastewater agencies
2–(e-2): Establish requirements in zoning ordinances to address hillside development constraints in areas of steep slopes that are likely to lead to excessive road maintenance or where roads will be difficult to maintain during winter storms due to landsliding.	Existing program	Cities and counties

Sources: page 1-2 MTC, page 1-3-USGS and Google Earth, page 1-4 MTC (Noah Berger), page 1-5 Stockton Library, Monterey County Office of Emergency Services, USGS (R. Baum), page 1-6 VTA, pages 10 & 13 EBMUD, page 12 CalFIRE.

Chapter 2 – Health Care (HEAL)

COMMITMENT: Bay Area facilities, networks, and systems providing care of sick and those with special needs need to be resilient after disasters for these systems will need to care for additional injured at the same time as those currently cared for are stressed.

The Problem Is…

In one scenario, if the 1868 Hayward earthquake (which occurs about once every 140 years on the southern Hayward fault) were to happen today, it could result in thousands of serious injuries. This example is not the worst case, but since it has been 141 years since this earthquake, this is a likely scenario.

Damage to hospital in
1971 San Fernando Earthquake

At the same time, our health care delivery system is undergoing major changes that make many of our hospitals outdated. Finally, more procedures are occurring in out-patient clinics and in medical offices.

Hospitals no longer have medical supplies for weeks stored on site. As with manufacturing facilities, these facilities are working under "just-in-time" supply strategies. Supplies are delivered from outside of the Bay Area and are pre-ordered for normal operation, not for disaster situations.

While the Bay Area may pride itself in being more prepared for a disaster than Louisiana or Mississippi in Hurricane Katrina, we are unprepared to manage long-term recovery of health care delivery, due, in part, to an emphasis on hospitals rather than a comprehensive view of all services. We also need to ensure the delivery of adequate mental health services following disasters.

Background and History

- In 1973, as a direct result of the devastation caused by the 1971 Sylmar quake (65 deaths and a hospital collapse), the Legislature passed the Alfred E. Alquist Hospital Seismic Safety Act. The act requires that acute care hospitals be designed and constructed to withstand a major earthquake and **remain operational** immediately after the quake. Further modifications of the Act occurred following the Northridge earthquake, with the passage of SB 1953 in 1994.
- SB 1953 requires that all hospitals use standards developed by the California Office of Statewide Health Planning and Development (OSHPD) to measure the ability of these buildings to withstand a major earthquake. In 2001, plans submitted by the hospital owners determined that 37% of California's hospitals are subject to collapse. OSHPD is focusing on monitoring the billions of dollars needed to retrofit or replace the region's hospitals.
- OSHPD noted that, in 2008, the average age of the dangerous hospital buildings was from 45-49 years – and that the average useful life of a hospital is typically only 40-50 years. Thus, some of the billions of dollars being attributed to seismic safety upgrades are actually being driven by the upgrading of outdated buildings.
- Additional planning is needed at the city and county levels to identify and work with the ancillary health facilities in the region, including pharmacies, doctor and dentist offices, offices that sell hearing aids and eye glasses, dialysis centers, and emergency clinics. Currently there is NO state law that states that the buildings these facilities are located in must be structurally sound or that they have business continuity plans.
- While hospitals are licensed by the State, ancillary facilities obtain their building permits and business licenses from cities and counties, ensuring that this effort remains local. There is a critical need for coordination of business recovery planning between local governments, facility operators and owners.

Local Government Actions to Mitigate Natural Hazards

The following recommendations for action, if adopted by cities, counties, county health departments, and hospital agencies, will help to ensure a more rapid recovery of the delivery of health care following a disaster.

The exposure of Bay Area critical health care facilities to earthquake shaking is the greatest hazard, with **98.1%** exposed to high shaking levels peak accelerations of greater than 40% of gravity [g] with a 10% chance of being exceeded in the next 50 years) as compared to **93%** of housing), and **75.1%** being exposed to extremely high shaking levels (60% g) as compared to **53%** of housing). Thus, most of the hazard mitigation strategies that follow deal with this hazard.

Wildland-urban-interface fire threat (WUI) exposure is much less. While **38.3%** of critical health care facilities are located in WUI areas (as compared to **58%** of housing), only **4.5%** of all WUI areas have burned in the past 130 years. Even though global warming may result in more fires in the next 50 years, the exposure is still less than that of earthquake shaking. In addition, **0.1%** critical health care facilities are located in areas of extreme or very high wildfire threat (versus **9%** of housing).

The exposure to storm-related hazards is even smaller. Only **1.7%** of critical health care facilities are located in 100-year flood areas (as compared to **4%** of housing), and only **0.8%** of critical health care facilities are located in areas of significant past landslides (versus **10%** of housing).

Actions Related to Hospitals and Other Critical Health Care Facilities (including those facilities licensed by OSHPD)

The following strategies focus on ensuring that efforts led by the State of California to strengthen hospitals and other state-licensed facilities are coordinated with cities and counties. While work on these actions is largely on-going, the efforts are often underfunded, particularly in the economic climate of a recession.

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy HEAL a-1): Work to ensure that cities, counties, county health departments, and hospital operators coordinate with each other (and that hospitals cooperate with the California Office of Statewide Health Planning and Development - OSHPD) to comply with current state law that mandates that critical facilities are structurally sound and have nonstructural systems designed to remain functional following disasters by 2013. In particular, this coordination should include understanding any problems with obtaining needed funding.	Existing program, underfunded	Cities, counties, county health departments, and hospitals
2–(a-2): Encourage hospitals in your community to work with OSHPD to formalize arrangements with structural engineers to report to the hospital, assess damage, and determine if the buildings can be reoccupied. The program should be similar to San Francisco's Building Occupancy Resumption Program (BORP) that permits owners of buildings to hire qualified structural engineers to create building-specific post-disaster inspection plans and allows these engineers to become automatically deputized as inspectors for these buildings in the event of an earthquake or other disaster. OSHPD, rather than city/county building departments, has the authority and responsibility for the structural integrity of hospital structures.	Existing program, underfunded	Cities, counties, county health departments, and hospitals
3–(a-3): Ensure health care facilities are adequately prepared to care for victims with respiratory problems related to smoke and/or particulate matter inhalation.	Existing program	Cities, counties, county health departments, and hospitals

4–(a-4): Ensure these health care facilities have the capacity to shut off outside air and be self-contained.	Existing program	Cities, counties, county health departments, and hospitals
5–(a-5): Ensure that hospitals and other major health care facilities have auxiliary water and power sources.	Existing program, underfunded	Cities, counties, county health departments, water suppliers, and hospitals
6–(a-6): Work to ensure that county health departments work with health care facilities to institute isolation capacity should a need for them arise following a communicable disease epidemic. Isolation capacity varies from a section of the hospital for most communicable diseases to the entire hospital for a major pandemic flu.	Existing program, underfunded	Cities, counties, county health departments, and hospitals
7–(a-7): Develop printed materials, utilize existing materials (such as developed by FEMA, the American Red Cross, and others, including non-profit organizations), conduct workshops, and/or provide outreach encouraging employees of these critical health care facilities to have family disaster plans and conduct mitigation activities in their own homes.	Existing program	Cities, counties, county health departments, and hospitals

ACTIONS RELATED TO ANCILLARY HEALTH-RELATED FACILITIES

The following strategies focus on planning by cities and counties, **coordinated regionally**, focusing on the ancillary health facilities in the region, including pharmacies, doctor and dentist offices, offices that sell hearing aids and eye glasses, dialysis centers, and emergency clinics. As stated in the introduction to this chapter, there is currently NO state law that states that the buildings these facilities are located in must be structurally sound or that they have business continuity plans. This effort will require new funding.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-1): Identify these ancillary facilities in your community. These facilities are not regulated by OSHPD in the same way as hospitals.	High - actively looking for funding	Cities, counties, and county health departments
2–(b-2): Encourage these facility operators to develop disaster mitigation plans.	High - actively looking for funding	Cities, counties, and county health departments
3–(b-3): Encourage these facility operators to create, maintain, and/or continue partnerships with local governments to develop response and business continuity plans for recovery.	High - actively looking for funding	Cities, counties, and county health departments

ACTIONS RELATED TO COORDINATION INITIATIVES

Most of the following strategies have the principal focus of responding to pandemic flu or terrorism, but they also have the added function of assisting with response to natural disasters, particularly those involving mass casualties or contamination of food. While these strategies' principal function is related to disaster response, not mitigation or recovery, the coordination activities needed to develop these programs are useful in identifying actions that can increase mitigation and speed recovery. The final strategy deals with mental health issues that became particularly apparent following Hurricane Katrina.

Hospital parking structure collapse crushes ambulance

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-1): Designate locations for the distribution of antibiotics to large numbers of people should the need arise, as required to be included in each county's Strategic National Stockpile Plan.	Existing program	County health departments
2–(c-2): Ensure that you know the Metropolitan Medical Response System (MMRS) cities in your area. Fremont, Oakland, San Francisco, and San Jose (plus Sacramento and Stockton) are the MMRS cities in or near the Bay Area. MMRS cities are provided with additional federal funds for organizing, equipping, and training groups of local fire, rescue, medical, and other emergency management personnel to respond to a mass casualty event. (The coordination among public health, medical, emergency management, coroner, EMS, fire, and law enforcement is a model for all cities and counties.)	Existing program	Cities, counties, county health departments, and hospitals
3–(c-3): Know that National Disaster Medical System (NDMS) uniformed or non-uniformed personnel are within one-to-four hours of your community. These federal resources include veterinary, mortuary, and medical personnel. Teams in or near the Bay Area are headquartered in the cities of Santa Clara and Sacramento.	Existing program	Cities, counties, county health departments, and hospitals
4–(c-4): Plan for hazmat related-issues due to a natural or technological disaster. Hazmat teams should utilize the State of California Department of Health Services laboratory in Richmond for confirmation of biological agents and Lawrence Livermore National Laboratory or Sandia (both in Livermore) for confirmation of radiological agents.	Existing program	Cities, counties, county health departments, and hospitals
5–(c-5): Create discussion forums for food and health personnel (including, for example, medical professionals, veterinarians, and plant pathologists) to develop safety, security, and response strategies for food supply contamination (at the source, in processing facilities, in distribution centers, and in grocery stores).	Existing program	County environmental health departments
6–(c-6): Ensure mental health continuity of operations and disaster planning is coordinated among county departments, (including Public Health and Emergency Services), private sector mental health organizations, professional associations, and national and community-based non-profit agencies involved in supporting community mental health programs. First, such planning should ensure that the capability exists to provide both immediate on-site mental health support at facilities such as evacuation centers, emergency shelters, and local assistance centers, as well as to coordinate on-going mental health support during the long-term recovery process. Second, this planning should ensure that mental health providers, in collaboration with the county agencies responsible for providing public information, are prepared to provide consistent post-disaster stress and other mental health guidance to the public impacted by the disaster.	Existing program	County health and emergency services departments

Chapter 3 – Housing (HSNG)

COMMITMENT: Bay Area residents need to have safe and disaster-resistant housing that is architecturally diverse and serves a variety of household sizes and incomes.

Damage to housing in a disaster has implications beyond just housing damage.

Residents are the foundation of any vibrant community, and a key to keeping the region strong during the disaster recovery process. Residents are the fuel of an economy, providing the labor and consumption required for productivity. One of the most important aspects in a person's life is his or her home. The loss of a home can lead to job loss, as moving from one place to another and searching for a home is likely to detract from one's work. Home loss can also lead to poor medical and mental health.

In a large scale disaster, many homes can become uninhabitable. A sharp and sustained reduction in available housing during a disaster may result in a mass exodus from the area, as occurred in New Orleans after Hurricane Katrina. The Bay Area's large immigrant population compounds this issue, as they have fewer lasting ties to the area and are less likely to stay and wait for the region to recover. The 1994 Northridge earthquake demonstrated that neighborhoods with large numbers of damaged multifamily homes can become "ghost towns," allowing for increased criminal activity that, in turn, can spiral out of control. Finally, rebuilt housing is likely to be more expensive, leading to gentrification, changes in neighborhood character, and loss of affordable housing.

For these reasons, it is essential that steps be taken to mitigate the impact of a large scale disaster on the Bay Area's housing stock.

Soft-story apartment collapsed due to the Northridge earthquake

A key aspect of any hazard mitigation plan is protecting the housing stock from excessive damage in disasters.

The Bay Area currently has **2,686,148** housing units spread across **557,664** acres of residential land in nine counties. These residential lands are covered by a variety of different use densities, ranging from single-unit rural areas to multi-unit urban areas.

Just as diverse as the housing stock of the Bay Area is the variety of hazards facing it. In addition to being in the heart of "Earthquake Country," communities all around the Bay are faced with the threats of flooding, wildfire, and landslides.

As quantified in Appendices C and E, the exposure of Bay Area housing to earthquake hazards is the greatest hazard, with **93%** of the housing exposed to high shaking levels (peak accelerations of greater than 40% of gravity [g] with a 10% chance of being exceeded in the next 50 years), and **53%** being exposed to **extremely** high shaking levels (60% g). Thus, most of the hazard mitigation strategies that follow deal with this hazard.

Wildland-urban-interface fire threat exposure is less than earthquake exposure. Over half **(58%)** of the residential land is located in these hazard areas. While only **4.5%** of these hazard areas burned in the past 130 years, this indicates a build-up in fuel loads. While global warming may result in more fires in the next 50 years, the exposure is still less than that of earthquake shaking. Areas of extreme and very high wildfire threat only account for **0%** and **9%** of the residential areas; **23%** of these areas have burned in the past 130 years.

The exposure of residential land to other weather-related hazards is less. Only **4%** of residential land is located in the 100-year flood plain, and only **10%** is located in areas of significant past landslides.

In summary, while floods and fires occur more frequently, earthquakes are rarer but will damage far more houses in the region. Thus, the focus of this chapter will be to assess the potential impacts of various disasters on the Bay Area's housing stock, to outline priorities for preserving and rehabilitating the housing stock prior to a disaster, and to present steps that have already been made toward mitigating the impact of various disasters on that housing stock.

Certain Mitigation Strategies Apply to All Hazards

There are various steps that local jurisdictions can take to mitigate the hazards posed by multiple disasters. For example, all large-scale disasters pose a risk to home occupancy, so plans for interim sheltering and re-occupancy must be developed.

Similarly, public education on the general importance of hazard mitigation is not specific to one particular disaster, and a hazard mitigation plan regarding public education can and should include general hazard mitigation strategies.

Actions Applying to Multiple Hazards and Public Education

Bay Area residents should be made aware of the significant threats posed by various natural disasters. As such, jurisdictions should work to make sure that residents are well-prepared for the broad spectrum of potential hazards. Preparation for hazards includes full disclosure to residents in hazard-prone areas such as flood plains and fire-susceptible areas, as well as education of proper hazard mitigation and disaster preparedness. Public education and disclosure strategies are essential.

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy HSNG a-1): Assist in ensuring adequate hazard disclosure by working with real estate agents to improve enforcement of real estate disclosure requirements for residential properties with regard to seven official natural hazard zones: 1) Special Flood Hazard Areas (designated by FEMA), 2) Areas of Potential Flooding from dam failure inundation, 3) Very High Fire Hazard Severity Zones, 4) Wildland Fire Zones, 5) Earthquake Fault Zones (designated under the Alquist-Priolo Earthquake Fault Zoning Act), and the 6) Liquefaction and Landslide Hazard Zones (designated under the Seismic Hazard Mapping Act).	Existing program	Cities and counties
2–(k-1): Provide information to residents of your community on the availability of interactive hazard maps showing your community on ABAG's web site.	Existing program	Cities and counties
3–(k-2): Develop printed materials, utilize existing materials (such as developed by FEMA and the American Red Cross), conduct workshops, and/or provide outreach encouraging residents to have family disaster plans that include drop-cover-hold earthquake drills, fire and storm evacuation procedures, and shelter-in-place emergency guidelines.	Existing program, underfunded	Cities and counties
4–(k-3): Inform residents of comprehensive mitigation activities, including elevation of appliances above expected flood levels, use of fire-resistant roofing and defensible space in high wildfire threat and wildfire-urban-interface areas, structural retrofitting techniques for older homes, and use of intelligent grading practices through workshops, publications, and media announcements and events.	Existing program, underfunded	Cities and counties
5–(k-4): Develop a public education campaign on the cost, risk, and benefits of earthquake, flood, and other hazard insurance as compared to mitigation.	Not yet considered	Cities and counties
6–(k-5): Use disaster anniversaries, such as April (the 1906 earthquake), September (9/11), and October (Loma Prieta earthquake and Oakland Hills fire), to remind the public of safety and security mitigation activities.	Existing program	Cities and counties
7–(k-6): Sponsor the formation and training of Community Emergency Response Teams (CERT) for residents in your community. [Note – these programs go by a variety of names in various cities and areas.]	Existing program, underfunded	Cities and counties

8–(k-8): Institute the neighborhood watch block captain and team programs outlined in the Citizen Corps program guide.	Existing program, underfunded	Cities and counties
9–(k-10): Train homeowners to locate and shut off gas valves if they smell or hear gas leaking.	Existing program	Cities and counties
10–(k-16): Distribute appropriate materials related to disaster mitigation and preparedness to residents. Appropriate materials are (1) culturally appropriate and (2) suitable for special needs populations. For example, such materials are available on the *http://www.preparenow.org* website and from non-governmental organizations that work with these communities on an on-going basis.	Existing program	Cities and counties

ACTIONS APPLYING TO MULTIPLE HAZARDS AND REOCCUPANCY

In the event of a large-scale disaster, hundreds or even thousands of Bay Area housing units will become uninhabitable. Should this occur, jurisdictions must have a plan for temporarily housing displaced residents. Some will only need shelter for a short period as their homes are prepared for reoccupancy. Others will have longer-term interim shelter needs, especially those in larger-scale apartment complexes and soft-story buildings. Once temporary shelter needs are met, cities and counties must have plans in place to expedite the repair of damaged homes for reoccupancy. A longer reoccupancy process means longer interim housing needs, which place a significant burden on local jurisdictions. The following strategies are related to interim sheltering and speeding reoccupancy.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-2): Create incentives for private owners of historic or architecturally significant residential buildings to undertake mitigation to levels that will minimize the likelihood that these buildings will need to be demolished after a disaster, particularly if those alterations conform to the federal Secretary of the Interior's *Guidelines for Rehabilitation*.	Existing program, underfunded	Cities and counties
2–(a-3): Develop a plan for short-term sheltering of residents of your community in conjunction with the American Red Cross.	Existing program	Cities and counties
3–(a-4): Develop a plan for interim housing for those displaced by working with the Regional Catastrophic Planning Grant Program (CPGP) that funded this effort in 2009. (Estimated completion is 2011.)	Under Study	Major cities in conjunction with the UASI program
4–(j-1): Develop and enforce a repair and reconstruction ordinance to ensure that damaged buildings are repaired in an appropriate and timely manner and retrofitted concurrently. This repair and reconstruction ordinance should apply to all public and private buildings, and also apply to repair of all damage, regardless of cause. See *http://quake.abag.ca.gov/recovery/info-repair-ord.html*.	Existing program	Cities and counties
5–(j-2): Establish preservation-sensitive measures for the repair and reoccupancy of historically significant privately-owned structures, including requirements for temporary shoring or stabilization where needed, arrangements for consulting with preservationists, and expedited permit procedures for suitable repair or rebuilding of historically or architecturally valuable structures.	Existing program, underfunded	Cities and counties

Living in Earthquake Country

The most pressing and potentially dangerous hazard facing the Bay Area is the constant threat of earthquakes. With many area faults overdue for major seismic activity, it is essential that the potential impact of a major earthquake on the region's housing stock be emphasized.

Structural damage to housing is most commonly caused by ground shaking. Although ground shaking can be felt for as many as hundreds of miles away in a major earthquake, shaking is most violent near fault segments that moved, causing the earthquake, as well as on soils that can amplify that shaking and make the shaking last longer.

For example, the Hayward fault has experienced major earthquakes, on average, every 140 years. As of 2009, it has been 141 years since the 1868 Hayward earthquake on the southern segment of the Hayward fault. Because this fault runs through one of the densest part of the Bay Area, and the housing in this area is older, ABAG has estimated that such an earthquake would create over 150,000 uninhabitable housing units.

The amount of damage to housing varies greatly across building construction types and building age. Two adjacent buildings can suffer dramatically different amounts of damage due to shaking. Buildings with "soft stories" (multi-story buildings with open or mostly open lower floors with parking or commercial space built prior to about 1990), unreinforced masonry buildings (built before the building code changed in 1933), and older single-family homes (typically built before about 1970) are extremely susceptible to severe shaking damage. In addition to sustaining substantial property damage, these buildings are more likely to be uninhabitable after earthquakes, resulting in large numbers of displaced residents.

In addition to shaking, earthquakes also can cause soil liquefaction, landslides, and surface rupture. However, these related hazards are typically handled through land use controls on new development described in Chapter 8.

The following section will discuss strategies for mitigating the hazards posed by earthquake shaking to various housing types.

ACTIONS APPLYING TO EXISTING SINGLE-FAMILY HOMES VULNERABLE TO EARTHQUAKES

Single-family homes are the cornerstone of most Bay Area communities. Over half (54%) of the Bay Area housing stock is in single-family homes. As such, it is essential that damage to these homes be minimized to the greatest extent possible. Structural damage is the largest earthquake-related risk facing single-family homes. The amount and type of potential structural damage that a home faces depends upon the type of construction, its age and condition, and its location. The highest risk homes include unretrofitted homes built before 1978 (prior to the adoption of the most important earthquake-resistant building code changes), homes on hillsides, and homes with living space above a garage (these are subject to collapse due to structural weaknesses due to the garage door openings), but all homes are at risk.

Conducting a proper retrofit using a standard plan set: For a typical older house with a crawl space underneath the home, a retrofit consists of **no less** than three separate actions.

(1) The base of the house (mudsill) is secured to the foundation using bolts to prevent the house from slipping off of the foundation.
(2) If the house has a cripple wall (which forms the perimeter of the crawl space below the first floor), it is strengthened by adding plywood panels (shear walls) along the interior surface of all perimeter walls. Unbraced crawl space walls are the most likely part of the home to collapse in an earthquake.
(3) The floor framing is secured to theses walls to prevent the floor from slipping off them. (If the home does not have cripple walls, then the floor framing is secured directly to the mudsills.)

If any one of these actions does not occur, then there remains a large risk that the house will still suffer significant structural damage.

Unfortunately, just because a house has been retrofitted does not necessarily mean that it has been retrofitted properly or that all three actions have been taken. In a 1999 survey of 341 homes, ABAG found that anywhere from 1/3 to 2/3 of retrofitted homes were not adequately prepared for a future quake (the percentage varied by city). In a 2006 survey of 35 homes published in the ***Contra Costa Times*** on March 5, 2006, 2/3 of **retrofitted** homes were not adequately retrofitted to prevent collapse and limit damage.

Anecdotal evidence suggests that there are two primary reasons for this problem: lack of knowledge and lack of funds. Doing something is not always better than doing nothing.

Contractors may be untrained in retrofits and may therefore be unaware of proper retrofit procedure. The work they do may therefore be inadequate (for example, they may only add bolts to the foundation and not perform the other two actions). In addition, some unscrupulous contractors may intentionally deceive clients even if they are aware of proper retrofit procedure, as few homeowners would know how to inspect the work.

Home inspectors may be untrained in retrofits and therefore unable to judge whether the contractor has performed a proper retrofit. In addition home inspectors may be unable to judge whether a home needs a retrofit in the first place.

Licensed professionals (engineers or architects with seismic retrofit experience) are required for homes on hillsides or with living spaces above garages. If these professionals are not included in the design process when retrofitting these homes, it is unlikely that the home will be protected against collapse.

A retrofit standard clearly establishes the requirements for a retrofit, and gives local governments the power to enforce the standard. The standard applies not only to what is done in the retrofit, but also who is involved in the retrofit. Local governments can also require that engineers be involved in complex retrofits of homes on hillsides or on split-level homes with living spaces above a garage.

In order to simplify and make more uniform retrofit standards, ABAG, three chapters of the International Code Council (ICC), the California Building Officials (CALBO), the Structural Engineers Association of Northern California (EERI-NC), the Northern California Chapter of the Earthquake Engineering Research Institute, and retrofit contractors jointly developed a standard plan set to cover one type of single-family home. This standard "Plan Set A" applies to 1- or 2-family light construction wood-frame homes that are two stories or less in height, have a continuous perimeter concrete foundation, and crawl space walls no higher than four feet. This plan set greatly simplifies the retrofit process, as homeowners do not have to hire engineers to design retrofit plans, and city building departments do not have to individually review custom plans for each home.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-1): Utilize or recommend adoption of a retrofit standard that includes standard plan sets and construction details for voluntary bolting of homes to their foundations and bracing of outside walls of crawl spaces ("cripple" walls), such as Plan Set A developed by a committee representing the East Bay-Peninsula-Monterey Chapters of the International Code Council (ICC), California Building Officials (CALBO), the Structural Engineers Association of Northern California (SEAONC), the Northern California Chapter of the Earthquake Engineering Research Institute (EERI-NC), and ABAG's Earthquake Program.	Existing program, underfunded	City and county building departments
2–(b-4): Encourage local government building inspectors to take classes on a periodic basis (such as the FEMA-developed training classes offered by ABAG) on retrofitting of single-family homes, including application of Plan Set A.	Existing program	City and county building departments
3–(b-5): Encourage private retrofit contractors and home inspectors doing work in your area to take retrofit classes on a periodic basis (such as the FEMA-developed training classes offered by ABAG or additional classes that might be offered by the CALBO Training Institute) on retrofitting of single-family homes.	Existing program	City and county building departments
4–(b-9): Provide financial incentives to owners of single-family homes to retrofit if those retrofits comply with Plan Set A or IEBC 2006 in addition to that provided by existing State law that makes such retrofits exempt from increases in property taxes.	Existing program, underfunded	Cities and counties

Retrofitting homes not covered by a standard plan set: Unfortunately, not all homes can be covered by one standard plan set. These homes include those more than two stories in height, homes on hillsides, homes with living spaces over garages, split-level homes, crawl space walls over four feet, and other common single-family home types. Although ABAG and the other organizations involved in the development of Plan Set A are looking into developing more standard plan sets to apply to a wider range of homes, local jurisdictions can and should still take steps to encourage proper retrofits of these homes.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-2): Require engineered plan sets for seismic retrofitting of heavy two-story homes with living areas over garages, as well as for split level homes (that is, homes not covered by Plan Set A), until standard plan sets and construction details become available.	Existing program	City and county building departments
2–(b-3): Require engineered plan sets for seismic retrofitting of homes on steep hillsides (because these homes are not covered by Plan Set A).	Existing program	City and county building departments

Public education related to retrofitting homes: Although most residents are aware that both structural and non-structural earthquake damage can be severe, many are unaware of specific measures that should be taken to mitigate the impact to their homes. Local jurisdictions should develop a comprehensive plan to inform residents of specific mitigation procedures that can and should be undertaken.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-6): Conduct demonstration projects on common existing housing types demonstrating structural and nonstructural mitigation techniques as community models for earthquake mitigation.	Moderate	City and county building departments
2–(b-7): Provide retrofit classes or workshops for homeowners in your community, or help promote utilization of sub regional workshops in the South Bay, East Bay, Peninsula, and North Bay as such workshops become available through outreach using existing community education programs.	Existing program, underfunded	City and county building departments
3–(b-8): Establish tool-lending libraries with common tools needed for retrofitting for use by homeowners with appropriate training.	Moderate	City and county building departments
4–(g-18): Create a mechanism to require the bracing of water heaters and flexible couplings on gas appliances, and/or (as specified under "b. Single-family homes vulnerable to earthquakes" above) the bolting of homes to their foundations and strengthening of cripple walls to reduce fire ignitions due to earthquakes.	Existing program	City and county building departments
5–(k-12): Make use of the materials on the ABAG web site at *http://quake.abag.ca.gov/fixit* and other web sites to increase residential mitigation activities related to earthquakes. (ABAG plans to continue to improve the quality of those materials over time.)	Existing program	Cities and counties

Actions Applying to Existing Soft-Story Multifamily Residential Buildings Vulnerable to Earthquakes

Some of the most susceptible structures to shaking damage are "soft-story" apartments and condominiums. A soft story residential building is one that has open parking or commercial space on the first floor and housing on higher floors built prior to modern codes. In an earthquake, ground shaking causes such structures to sway and sometimes collapse.

A soft-story collapse can have particularly disastrous consequences considering that they can crush cars and kill people

occupying the open areas.

A large portion of the Bay Area housing stock is in soft-story multifamily residences. A magnitude 7 earthquake on the Hayward fault could cause as many as 26,000 housing units in the City of Oakland alone to become uninhabitable, and over half of those failures would be of soft-story buildings. In addition to the obvious risk of shaking creating uninhabitable homes, soft-story buildings can also suffer gas main breaks, which can cause fires that will be particularly difficult to fight due to the other damage in an earthquake disaster.

Historically, multi-family housing is particularly slow to rebuild, as is low-income housing. Thus, the most vulnerable populations and the most vulnerable housing types are hit hardest and longest.

Conducting an inventory of soft-story buildings: An initial step to developing a soft-story earthquake hazard mitigation plan is to conduct an inventory of soft-story buildings. Without a comprehensive list, mitigating the hazards posed by soft-story buildings in an earthquake becomes difficult.

While potential soft-story multifamily residential buildings occur throughout the Bay Area, they predominate in areas where densities make parking within a building more common. For example, as housing densities increase and apartments replace single-family homes, these ***initial*** multifamily residential buildings constructed tend to have parking external to the building (in carports or in separate structures). But as housing densities continue to increase, that parking tends to be located within the building.

San Francisco itself has the largest number of soft-story buildings in the Bay Area. The San Francisco Department of Building Inspection for San Francisco worked with volunteers to inventory multifamily buildings containing 5 or more units, with three or more stories, and built prior to 1973. It identified approximately 4,400 buildings with parking or commercial on the first floor, of which about 2,800 buildings (containing 29,000 housing units), had openings spanning 80% of one side or 50% or more of two or more sides of that first floor. San Francisco has also estimated that there are an additional 4,600 4-unit buildings and 3,400 3-unit buildings in the City three stories or taller (Applied Technology Council, 2009).

However, the East Bay cities of Oakland, Berkeley, Alameda, Fremont, and San Leandro also have a significant number of potential soft-story buildings. In Oakland alone there are 1,479 potential soft-story multifamily buildings containing 24,273 housing units based on an inventory conducted by ABAG. This inventory defines such a building as having 2 or more stories, containing 5 or more units, and built prior to 1990. ABAG also has estimated, based on a statistical sample, that there are about 1,060 4-unit buildings and 370 3-unit buildings with parking on the first floor that were built prior to 1990 in Oakland (Perkins and others, 2009). Berkeley inventoried multifamily buildings containing 5 or more units, with 2 or more stories, and built prior to 1995. The City identified approximately 400 buildings containing about 5,000 units (D. Lambert, City of Berkeley, personal communication, 2009).

San Jose has the largest number of potential soft-story buildings in the South Bay, accounting for 10,923 units in 1,093 buildings (as compared to a total of 33,119 units in 2,630 potential soft-story buildings in that county). This inventory defines a multifamily building as one containing 4 or more units (Selvaduray and others, 2003).

Cities on the San Francisco Bay side of the Peninsula between San Francisco and San Jose also tend to have large number of these buildings. However, no specific numbers are available. Finally, these buildings are more common in the denser portions of Marin County than in the other North Bay counties. Again, no specific numbers are available.

An inventory can be expensive and time consuming. The effort by ABAG in the City of Oakland has worked to develop techniques that can be used to simplify and speed up the inventory process in other vulnerable Bay Area cities.

Once an inventory has been conducted, it can be used to develop and enforce retrofit programs and notify residents and landlords of the dangers of shaking damage to soft-story buildings. Although development of a comprehensive strategy for soft-story retrofits may take time, these inventories can be used immediately to inform residents that their homes are structurally suspect.

The process of conducting a soft-story inventory and disclosing information to the public about soft-story buildings is captured by the following strategies. While they focus on privately-owned buildings rather than government-owned office space (covered in Chapter 5-Government), ***it is not the intent of these strategies to ignore housing owned by city housing authorities and non-profit groups.***

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-4): Conduct an inventory of privately-owned existing or suspected soft-story residential structures as a first step in establishing voluntary or mandatory programs for retrofitting these buildings.	Existing program, underfunded	Cities and counties with ABAG
2–(c-5): Use the soft-story inventory to require private owners to inform all existing tenants (and prospective tenants prior to signing a lease agreement) that they may live in this type of building.	High	Cities and counties
3–(c-6): Use the soft-story inventory to require private owners to inform all existing and prospective tenants that they may need to be prepared to live elsewhere following an earthquake if the building has not been retrofitted.	Moderate	Cities and counties

Retrofit standards: Another step in mitigating the soft-story earthquake hazard is to develop and enforce specific retrofit standards. Since the range of soft-story buildings is wide, there is no easy way to develop the soft-story building equivalent of Plan Set A for single-family homes. Thus, use of a qualified engineer with seismic design experience is essential before undertaking major alternations of these buildings.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-1): Require engineered plan sets for voluntary or mandatory soft-story seismic retrofits by private owners until a standard plan set and construction details become available.	Existing program	City and county building departments
2–(c-2): Adopt the 2009 International Existing Building Code or the latest applicable standard for the design of voluntary or mandatory soft-story building retrofits for use in city/county building department regulations. In addition, allow use of changes to that standard recommended by SEAOC for the 2012 IEBC.	Existing program	City and county building departments

Retrofit incentives: Unless cities and counties offer strong effective incentives and remove disincentives, many soft-story buildings will not get retrofitted. Different incentives may be appropriate for residential buildings of 5 or more units, since these buildings may be defined as commercial, whereas 3- or 4- unit apartments may be classified as residential. Many jurisdictions view building departments as logical leads for all activities associated with earthquake retrofits. However, incentive programs work best if a variety of departments are involved. Planning and community development can also encourage retrofits though the imaginative use of financial, procedural, and land use incentives. Examples of such incentives include parking, zoning, and density tradeoffs; use of redevelopment and CDBG funds to encourage retrofits; tax credits; transfer of development rights; reducing setbacks; coordination with rent control boards; and waiving or reducing building permit fees.

While the following strategies refer to existing materials available through ABAG and the City of San Jose, there remains a need to upgrade and update those materials.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-3): Work to educate building owners, local government staff, engineers, and contractors on privately-owned soft-story retrofit procedures and incentives using materials such as those developed by ABAG and the City of San Jose (see *http://quake.abag.ca.gov/eqhouse.html*).	High	Cities and counties and ABAG
2–(c-7): Investigate and adopt appropriate financial, procedural, and land use incentives (such as parking waivers) for private owners of soft-story buildings to facilitate retrofit such as those described by ABAG (see *http://quake.abag.ca.gov/fixit*).	High	Cities and counties and ABAG

3–(c-8): Explore development of State regulations or legislation to require or encourage private owners of soft-story structures to strengthen them.	Moderate	Cities and counties and ABAG
4–(c-9): Provide technical assistance in seismically strengthening privately-owned soft-story structures.	Under study	Cities and counties and ABAG

ACTIONS APPLYING TO UNREINFORCED MASONRY HOUSING STOCK

Unreinforced masonry buildings comprised of brick or stone are also vulnerable to collapse in an earthquake. **U**n**r**einforced **m**asonry structures, or URMs) consist of a wood roof and floor with unreinforced brick walls. The walls are often not properly anchored to the floor and roof, often resulting in complete collapse when shaken violently. They were built largely before the 1930s when changes in the building code after the 1933 Long Beach Earthquake prevented further construction of URMs. Although URMs made up only 1% of the Bay Area housing stock in 1989, they accounted for over 15% of destroyed or significantly damaged housing units. According to ABAG projections, URM building failures could account for as many as 13,000 of the projected 156,000 uninhabitable housing units in a magnitude 7 event on the Hayward fault. While the most severe damage is experienced closest to the epicenter, earthquakes can cause damage to URMs miles away. For example, in the Loma Prieta earthquake, URMs over 80 miles away in Martinez suffered damage.

Given the severity of URM collapses, local jurisdictions must take positive steps to make sure that these homes are structurally sound and that residents know the potential dangers of living in one. For example, as explained further in Chapter 4-Economy, the common "*bolts-plus*" standard for retrofit in San Francisco and Oakland will mean that people will confront the risk of falling masonry when evacuating them after a damaging earthquake and many of these buildings will need to be torn down. Thus, disclosure programs, including installation of placards, become important.

While the following strategies focus on privately-owned buildings rather than government-owned office space (covered in Chapter 5-Government), ***it is not the intent of these strategies to ignore housing owned by city housing authorities and non-profit groups.***

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-1): Continue to actively implement existing State law that requires cities and counties to maintain lists of the addresses of unreinforced masonry buildings and inform private property owners that they own this type of hazardous structure.	Existing program	Cities and counties
2–(d-2): Accelerate retrofitting of privately-owned unreinforced masonry structures that have not been retrofitted, for example, by (a) actively working with owners to obtain structural analyses of their buildings, (b) helping owners obtain retrofit funding, (c) adopting a mandatory versus voluntary, retrofit program, and/or (d) applying penalties to owners who show inadequate efforts to upgrade these buildings.	Existing program, underfunded	Cities and counties
3–(d-3): Require private owners to inform all existing tenants (and prospective tenants prior to signing a lease agreement) that they live in an unreinforced masonry building and the standard to which it may have been retrofitted.	Existing program, underfunded	Cities and counties
4–(d-4): As required by State law, require private owners to inform all existing tenants that they may need to be prepared to live elsewhere following an earthquake even if the building has been retrofitted, because it has probably been retrofitted to a life-safety standard, not to a standard that will allow occupancy following major earthquakes.	Existing program	Cities and counties

ACTIONS APPLYING TO OTHER PRIVATELY-OWNED STRUCTURALLY VULNERABLE RESIDENTIAL BUILDINGS AND EARTHQUAKES

In addition to soft-story buildings and unreinforced masonry structures, there are various other housing types that can be particularly vulnerable to shaking damage during an earthquake, including mobile homes, non-ductile concrete, and tilt-up concrete structures.

The most prevalent type of construction is mobile homes. As of 2005, ABAG had identified 5,458 acres of mobile home parks in the Bay Area, or 1% of the residential land in the region. In addition, mobile homes can be located areas outside of mobile home parks, particularly in rural areas. Their exposure to violent shaking is equivalent to that of residential land as a whole. Based on data from the 2000 Census, there are an estimated 57,129 mobile homes in the region, accounting for 2.2% of the housing stock. In September, 1985, regulations became effective requiring the Department of Housing and Community Development to certify earthquake resistant bracing systems for mobile homes. The sale or installation of systems not certified by the Department is unlawful. All certified bracing systems are required to bear a label indicating the manufacturer's name, the product name, the model number, and a statement that indicates “This system complies with the California Administrative Code, Title 25, Chapter 2, Article 7.5.”

Local jurisdictions should have a plan for ensuring that these homes remain safe during earthquakes. While the following strategies focus on privately-owned buildings rather than government-owned office space (covered in Chapter 5-Government), ***it is not the intent of these strategies to ignore housing owned by city housing authorities and non-profit groups.***

Strategy	*Regional Priority*	*Responsible Agency*
1–(e-1): Identify and work toward tying down mobile homes used as year-round permanent residences using an appropriate cost-sharing basis (for example, 75% grant, 25% owner).	Existing program, underfunded	Cities and counties
2–(e-2): Inventory non-ductile concrete, tilt-up concrete (such as converted lofts), and other privately-owned potentially structurally vulnerable residential buildings.	Existing program, underfunded	Cities and counties
3–(e-3): Adopt the 2009 International Existing Building Code or the latest applicable standard for the design of voluntary or mandatory retrofit of privately-owned seismically vulnerable buildings.	Existing program	Cities and counties
4–(e-4): Adopt one or more of the following strategies as incentives to encourage retrofitting of privately-owned seismically vulnerable residential buildings: (a) waivers or reductions of permit fees, (b) below-market loans, (c) local tax breaks, (d) grants to cover the cost of retrofitting or of a structural analysis, (e) land use (such as parking requirement waivers) and procedural incentives, or (f) technical assistance.	Existing program, underfunded	Cities and counties

ACTIONS APPLYING TO NEW CONSTRUCTION AND EARTHQUAKES

As the Bay Area continues to grow, local jurisdictions must remain vigilant about hazard mitigation. As more new residents settle in the region, we must ensure that the housing that is built will withstand the earthquakes we know will happen. Cities and counties must enforce building codes to ensure that the Bay Area’s new homes are structurally sound. The following strategies relate to new construction and earthquakes. In addition, the requirements need to be combined with public education to ensure that alterations, additions, and repairs of existing buildings, when those changes exceed 50% of the value of the building, are enforced.

Strategy	*Regional Priority*	*Responsible Agency*
1–(f-1): Continue to require that all new housing be constructed in compliance with requirements of the most recently adopted version of the *California Building Code*.	Existing program	Cities and counties
2–(f-2): Conduct appropriate employee training and support continued education to ensure enforcement of building codes and construction standards, as well as identification of typical design inadequacies of housing and recommended improvements.	Existing program	Cities and counties

Wildfire Threat and Wildland-Urban-Interface Threat and Housing

During the past 50 years, the Bay Area has experienced wildfire disasters in 1961, 1962, 1964, 1965, 1970, 1981, 1985, 1988, and 1991. By far the most damaging was the 1991 fire in the East Bay Hills, which resulted in $1.7 billion in losses. In that fire, 3,354 family dwellings and 456 apartments were destroyed, while 25 people were killed and 150 people were injured.

While it is unlikely that any single fire disaster in the Bay Area would exceed the 1991 East Bay Hills Fire in total homes lost, increases in the value and size of homes in hillside areas can make the total losses greater.

The California Department of Forestry maps wildfire hazard in two ways – wildland-urban-interface (WUI) fire threat for areas where local fire agencies have jurisdiction, and wildfire threat for areas that the State has jurisdiction. Based on an analysis of data on wildfires during the past 130 years, **0.2%** of the areas mapped as an extreme wildfire threat have burned, **22.8%** of those mapped as very high, and **18.5%** of those mapped as high. While, only **4.5%** of the areas in WUI fire threat areas have burned in the past 50 years, this past experience is not an indicator of risk for the next 50 years due to the availability of increased fuel loads and the potential impact of global climate change.

Wildfires remain a pervasive and continuing concern. As noted in Chapter 8-Land Use, while **18.5%** of the region's land is in a wildland-urban-interface (WUI) fire threat area, amazingly, **51.8%** of the land newly developed or redeveloped from 2000-2005 is in these areas.

The following strategies do not cover all of the mitigation needed for residential development in these areas. Additional strategies related to access, for example, are covered in Chapter 1-Infrastructure. In addition, while a fire can offer the opportunity to rebuild in a more sustainable manner, such a result is not guaranteed. For example, new housing built in the Oakland Hills after the 1991 fire now have more fire-resistant roofs and siding, but access issues were not solved.

One of the largest concerns for local governments is the risk of fire following an earthquake, whether that fire is triggered by downed power lines or broken gas lines. Problems will be exasperated by broken water lines and lack of available emergency response vehicles. Thus, while the following strategies target mitigation of hazards posed to housing by wildfires and structural fires, they are also mitigation for fire following earthquakes.

Actions Applying to Wildfires and Structural Fires

Existing construction: Local jurisdictions can take various steps to mitigate the hazards posed to existing homes by wildfire in their areas.

Strategy	*Regional Priority*	*Responsible Agency*
1–(g-1): Increase efforts to reduce hazards in existing private development in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat through improving engineering design and vegetation management for mitigation, appropriate code enforcement, and public education on defensible space mitigation strategies.	Existing program	Cities and counties

New construction or significant remodeling: As the Bay Area continues to grow, homes will inevitably be built in areas that are susceptible to wildfires. Local governments must take steps to ensure that this new construction does not become a liability that will devastate Bay Area communities in the event of a wildfire. New communities must be planned in a way that structures are built of fire-retardant materials and with fire suppression mechanisms. In addition, residents should have easy evacuation routes. Finally, the requirements need to be combined with public education to ensure that alterations, additions, and repairs of existing buildings, when those changes exceed 50% of the value of the building, are enforced.

Strategy	*Regional Priority*	*Responsible Agency*
1–(g-3): Require that new homes in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat be constructed of fire-resistant building materials (including roofing and exterior walls) and incorporate fire-resistant design features (such as minimal use of eaves, internal corners, and open first floors) to increase structural survivability and reduce ignitability. **Note -** See Structural Fire Prevention Field Guide for Mitigation of Wildfires at *http://cdfdata.fire.ca.gov/fire_er/fpp_engineering_view?guide_id=11*.	Existing program	Cities and counties
2–(g-5): Consider fire safety, evacuation, and emergency vehicle access when reviewing proposals to add secondary units or additional residential units in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat.	Existing program	Cities and counties
3–(g-6): Adopt and amend as needed updated versions of the *California Building* and *Fire Codes* so that optimal fire-protection standards are used in construction and renovation projects of private buildings.	Existing program	Cities and counties
4–(g-12): Require fire sprinklers in new homes located more than 1.5 miles or a 5-minute response time from a fire station or in an identified high hazard wildland-urban-interface wildfire area.	Existing program	Cities and counties
5–(g-13): Require fire sprinklers in all new or substantially remodeled multifamily housing, regardless of distance from a fire station.	Existing program	Cities and counties
6–(g-14): Require sprinklers in all mixed use development to protect residential uses from fires started in non-residential areas.	Existing program	Cities and counties

Vegetation management: One of the simplest, yet most important aspects of a wildfire hazard mitigation strategy is vegetation management. Fires without volatile fuel are less likely to spread, and homes with defensible space are more likely to survive a wildfire. A number of non-native plant species in wildfire-susceptible areas, namely eucalyptus trees, significantly raise the threat to homes in wooded areas. As such, local jurisdictions can take steps to encourage proper vegetation management and defensible space clearing as explained by the following strategies.

Strategy	*Regional Priority*	*Responsible Agency*
1–(g-9): Expand vegetation management programs in wildland-urban- interface fire-threatened communities or in areas exposed to high-to-extreme fire threat to more effectively manage the fuel load through roadside collection and chipping, mechanical fuel reduction equipment, selected harvesting, use of goats or other organic methods of fuel reduction, and selected use of controlled burning.	Existing program, underfunded	Cities and counties
2–(g-10): Establish special funding mechanisms (such as Fire Hazard Abatement Districts or regional bond funding) to fund reduction in fire risk of existing properties through vegetation management that includes reduction of fuel loads, use of defensible space, and fuel breaks.	Existing program, underfunded	Cities and counties

3–(g-17): Ensure that city/county-initiated fire-preventive vegetation-management techniques and practices for creek sides and high-slope areas do not contribute to the landslide and erosion hazard. For example, vegetation in these sensitive areas could be thinned, rather than removed, or replanted with less flammable materials. When thinning, the non-native species should be removed first. Other options would be to use structural mitigation, rather than vegetation management in the most sensitive areas.	Existing program, underfunded	Cities and counties
4–(k-9): Assist residents in the development of defensible space through the use of, for example, "tool libraries" for weed abatement tools, roadside collection and/or chipping services (for brush, weeds, and tree branches) in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat.	Existing program, underfunded	Cities and counties

Public education: Residents must be made aware of the significant hazard posed by wildfires. While necessary, government vegetation management programs will not be sufficient if private citizens are not shown the importance of proper mitigation techniques. For example, a new deck may meet existing requirements for setbacks from existing trees on an individual's own property, but not from the trees on a neighbor's property.

Strategy	*Regional Priority*	*Responsible Agency*
1–(g-2): Tie public education on defensible space and a comprehensive defensible space ordinance to a field program of enforcement.	Existing program	Cities and counties
2–(g-4): Create or identify "model" properties showing defensible space and structural survivability in neighborhoods that are wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat.	Moderate	Cities and counties
3–(g-11): Work with residents in rural-residential areas to ensure adequate plans are developed for appropriate access and evacuation in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat. For example, in some areas, additional roads can be created, and in other areas, the communities will need to focus on early warning and evacuation because additional roads are not feasible.	Existing program, underfunded	Cities and counties
4–(k-14): Encourage the formation of a community- and neighborhood-based approach to wildfire education and action through local Fire Safe Councils and the *Fire Wise Program*. This effort is important because grant funds are currently available to offset costs of specific council-supported projects.	Existing program, underfunded	Cities and counties

Multi-agency coordination: Many necessary functions in fire hazard mitigation planning cannot be handled by local jurisdictions acting alone. Some mitigation strategies require that local jurisdictions work with one another, as well as with state and private agencies to reduce the risk of serious damage to the Bay Area housing stock. Mutual aid agreements and multi-agency coordination and communication become particularly important when the number of fires exceeds the number of fire trucks. In particular, the issue of fires triggered in an earthquake can be particularly problematic. As local governments struggle with decisions on reducing those ignitions, it is important that they work with PG&E and understand that electrical shorts, not gas leaks, are responsible for most earthquake-triggered fires.

Strategy	*Regional Priority*	*Responsible Agency*
1–(g-8): Work to ensure a reliable source of water for fire suppression in rural-residential areas through the cooperative efforts of water districts, fire districts, and residents.	Existing program, underfunded	Cities and counties and water agencies

2–(g-19): Work with the State Fire Marshall, the California Seismic Safety Commission, Pacific Earthquake Engineering Research Center (PEER), and other experts to identify and manage gas-related fire risks of soft-story residential or mixed use buildings that are prone to collapse and occupant entrapment consistent with the natural gas safety recommendations of Seismic Safety Commission Report SSC-02-03. **Note** - See *http://www.seismic.ca.gov/pub/CSSC_2002-03_Natural% 20Gas%20 Safety.pdf*. **Also note** - any valves that are installed may need to have both excess flow and seismic triggers ("hybrid" valves).	Moderate	Cities and counties and ABAG
3–(g-20): Work with insurance companies to create a public/private partnership to give a discount on fire insurance premiums to "Forester Certified" *Fire Wise* landscaping and fire-resistant building materials on private property.	Existing program, underfunded	Cities and counties

Enforcement and inspection for fire hazard mitigation: A fire hazard mitigation plan will not be effective if jurisdictions do not maintain rigorous enforcement of new and existing mitigation practices. For example, they should ensure that ensure that alterations, additions, and repairs of existing buildings meet these requirements when those changes exceed 50% of the value of the building.

Strategy	*Regional Priority*	*Responsible Agency*
1–(g-7): Create a mechanism to enforce provisions of the *California Building* and *Fire Codes* and other local codes that require the installation of smoke detectors and fire-extinguishing systems on existing residential buildings by making installation a condition of (a) finalizing a permit for any work valued at over a fixed amount and/or (b) on any building over 75 feet in height, and/or (b) as a condition for the transfer of property.	Existing program	Cities and counties
5–(g-15): Compile a list of privately-owned high-rise and high-occupancy buildings which are deemed, due to their age or construction materials, to be particularly susceptible to fire hazards, and determine an expeditious timeline for the fire-safety inspection of all such structures.	Existing program	Cities and counties
6–(g-16): Conduct periodic fire-safety inspections of all multi-family buildings, as required by State law.	Existing program	Cities and counties

Flooding and Housing

Only 4% of the residential land is located in the 100-year flood plain. These homes lie along the various rivers and streams that form the Bay Area watershed, as well as around significant portions of the Bay and Delta. Most of the most vulnerable housing is located along the Russian River in Sonoma County.

Sometimes the same homes flood again and again. The Federal Emergency Management Agency (FEMA) insures properties against flooding losses in the Bay Area through the National Flood Insurance Program.

Those properties that have had more than one insured flood loss are called repetitive loss properties. Based on the most recent data obtained from FEMA, there are 1,417 repetitive flood properties in the Bay Area. While 1,417 is a large number of properties, it is only 0.1% of the 1,663,498 residential parcels in the Bay Area (as of 2005). These property owners have made 4,269 claims totaling $98,159,564, of which $65,454,919 was in Sonoma County.

ACTIONS APPLYING TO FLOODING

Existing construction: Local jurisdictions with significant portions of its housing stock located in flood-prone areas should develop a plan to mitigate the hazard posed by flooding to the Bay Area housing stock. Potential plans can range from such basic activities as providing sandbags and plastic sheeting to area residents, to more in-depth programs for elevation and relocation. Note that activities such as maintenance of creeks and existing drainage infrastructure are covered in Chapter 1-Infrastructure.

Strategy	*Regional Priority*	*Responsible Agency*
1–(h-4): Provide sandbags and plastic sheeting to residents in anticipation of rainstorms, and deliver those materials to vulnerable populations upon request.	Existing program	Cities and counties
2–(h-5): Provide public information on locations for obtaining sandbags and/or deliver those sandbags to those various locations throughout a city and/or county prior to and/or during the rainy season.	Existing program	Cities and counties
3–(h-8): Encourage home and apartment owners to participate in home elevation programs within flood hazard areas.	Moderate	Cities and counties
4–(h-9): As funding opportunities become available, encourage home and apartment owners to participate in acquisition and relocation programs for areas within floodways.	Moderate	Cities and counties

Role for flood insurance: Although Federal regulations require flood insurance for those homes in designated high-risk flood zones (those areas with a 1% or greater chance of flooding in any given year), there are still steps local jurisdictions can take to ensure that the financial hazards posed by floods to residents are mitigated. Although flood insurance is not required in moderate- to low-risk flood areas, jurisdictions can encourage residents in these areas to purchase flood insurance, as FEMA estimates that 25% of flood loss claims each year are from homeowners in moderate- to low-risk areas. Jurisdictions can also work to lower the cost of obtaining flood insurance by working with the National Flood Insurance Program.

Strategy	*Regional Priority*	*Responsible Agency*
1–(h-1): To reduce flood risk, thereby reducing the cost of flood insurance to private property owners, work to qualify for the highest-feasible rating under the Community Rating System of the National Flood Insurance Program.	Existing program	Cities and counties
2–(h-10): Encourage owners of properties in a floodplain to consider purchasing flood insurance. For example, point out that most homeowners' insurance policies do not cover a property for flood damage.	Existing program	Cities and counties

New construction: As the Bay Area grows, homes may continue to be built in flood hazard areas. While simply not building homes in flood-prone areas would be the easiest solution, it is not practical in a growing urban region. Because construction in flood planes is inevitable, local jurisdictions must ensure that new development in such areas is planned in a way that does not contribute to flood hazards. New development in flood zones must be planned considering storm water and flood management infrastructure, as additional homes without increased water runoff management can cause problems.

Strategy	*Regional Priority*	*Responsible Agency*
1–(h-2): Balance the housing needs of residents against the risk from potential flood-related hazards.	Existing program	Cities and counties

2–(h-3): Ensure that new private development pays its fair share of improvements to the storm drainage system necessary to accommodate increased flows from the development, or does not increase runoff by draining water to pervious areas or detention facilities.	Existing program	Cities and counties
3–(h-6): Apply floodplain management regulations for private development in the floodplain and floodway.	Existing program	Cities and counties
4–(h-7): Ensure that new subdivisions are designed to reduce or eliminate flood damage by requiring lots and rights-of-way be laid out for the provision of approved sewer and drainage facilities, providing on-site detention facilities whenever practicable.	Existing program	Cities and counties

Public education: Local jurisdictions can play a key role in informing residents of flood hazards. They can emphasize the importance of proper storm water runoff management, and provide resources to residents regarding flood preparation and notification.

Strategy	*Regional Priority*	*Responsible Agency*
1–(k-7): Include flood fighting technique session based on California Department of Water Resources training to the list of available public training classes offered by CERT.	Existing program, underfunded	Cities and counties
2–(k-11): Develop a program to provide at-cost NOAA weather radios to residents of flood hazard areas that request them, with priority to neighborhood watch captains and others trained in their use.	Moderate	Cities and counties
3–(k-13): Develop a "Maintain-a-Drain" campaign, similar to that of the City of Oakland, encouraging private businesses and residents to keep storm drains in their neighborhood free of debris.	Existing program	Cities and counties
4–(k-15): Inform shoreline-property owners of the possible long-term economic threat posed by rising sea levels.	Under study	Cities and counties and ABAG

Housing, Landslides, and Erosion

Only 10% of the Bay Area housing stock is located in areas that are exposed to very high risk of future landslides (because they are in areas where many landslides have occurred in the past. However, when a landslide occurs, it can be just as devastating and dangerous as the various other hazards facing the Bay Area housing stock, but to smaller geographic areas.

Intense storms in January of 1982 caused over 18,000 separate landslides in the Bay Area, destroying over 100 homes and causing 25 fatalities. In all, the slides resulted in $66 million in damage. The hazard posed by landslides is increased when soil becomes eroded.

ACTIONS APPLYING TO LANDSLIDES AND EROSION

The following strategies on landslides and erosion relate specifically to housing. However, additional strategies related to landslides are listed in Chapter 8-Land Use, and a discussion of erosion during vegetation management is included above as Strategy g-17. In addition, appropriate vegetation management practices listed in the wildfire section above can also reduce the risk of erosion and shallow landslides. Education of owners is also critical.

Strategy	*Regional Priority*	*Responsible Agency*
1–(i-1): Increase efforts to reduce landslides and erosion in existing and future development by improving appropriate code enforcement and use of applicable standards for private property, such as those appearing in the *California Building Code*, California Geological Survey *Special Report 117 – Guidelines for Evaluating and Mitigating Seismic Hazards in California*, *American Society of Civil Engineers (ASCE) report Recommended Procedures for Implementation of DMG Special Publication 117: Guidelines for Analyzing and Mitigating Landslide Hazards in California*, and the California Board for Geologists and Geophysicists *Guidelines for Engineering Geologic Reports.* Such standards should cover excavation, fill placement, cut-fill transitions, slope stability, drainage and erosion control, slope setbacks, expansive soils, collapsible soils, environmental issues, geological and geotechnical investigations, grading plans and specifications, protection of adjacent properties, and review and permit issuance.	Existing program	Cities and counties
2–(i-2): Increase efforts to reduce landslides and erosion in existing and future private development through continuing education of design professionals on mitigation strategies.	Existing program, underfunded	Cities and counties

Chapter 4 – Economy (ECON)

COMMITMENT**:** Safe, disaster-resilient, and architecturally diverse downtown commercial areas, business and industrial complexes, and office buildings are essential to the overall economy of the Bay Area.

Damage to commercial and industrial facilities can be devastating to the economy.

The aftermath of a large-scale disaster will hardly be normal for Bay Area businesses. Commercial and industrial businesses can lose buildings, inventories, data systems, and other valuable assets. They can also lose customers and suppliers if damage is widespread and disaster areas are slow to recover, turning a disaster into a catastrophe.

A large portion of the Bay Area's economic activity is based on small businesses. Small businesses are valuable contributors to the economic and cultural vitality of the region, but they can struggle to recover from disasters. Because they rely more on local consumers, small businesses can be particularly devastated by prolonged recovery. A blow to local small businesses is a blow to the entire region's economy.

Large businesses have a different effect on the economy of a region. Large-scale enterprises can be major employers in a city or region. These businesses are essential to many local economies. During a disaster, however, large national corporations, unlike small local businesses, have the capital necessary to completely and permanently move their operations out of the region. Such an exodus can have disastrous consequences for local employment, as well as for a city or county's tax base.

Whether small or large, local or national, businesses are a large part of what keeps the Bay Area thriving. For this reason, it is essential that steps be taken to mitigate the impact of a large-scale disaster on the region's business community. (The steps that local governments can do to speed the long-term recovery of their own operations are discussed in Chapter 5-Government.)

No business community can completely escape hazard exposure.

Be it from earthquakes, flooding, wildfires, landslides, or other hazards, nearly all commercial or industrial land in the Bay Area is exposed to some sort of natural disaster. In addition, as described in Chapter 8-Land Use, the exposure to most hazards is not decreasing as the Bay Area continues to grow.

The hazard facing the largest proportion of Bay Area businesses is earthquakes. Almost all (**94%**) of these areas are exposed to high shaking levels (peak accelerations of greater than 40% of gravity [g] with a 10% chance of being exceeded in the next 50 years), and **63%** are exposed to extremely high shaking levels (60% g). Thus, most of the hazard mitigation strategies that follow deal with this hazard.

Earthquakes can also cause surface rupture and liquefaction, in addition to the obvious shaking damage, which can cripple the infrastructure businesses need. These issues are discussed in more detail in Chapter 1-Infrastructure. Additionally, some Bay Area businesses are located in types of structures that are extremely vulnerable to earthquake damage.

Wildland-urban-interface fire threat exposure is much less. While **35%** of the commercial and industrial land is located in these hazard areas, only **4.5%** of these hazard areas burned in the past 130 years. While global warming may result in more fires in the next 50 years, the exposure is still less than that of earthquake shaking. Areas of extreme and very high wildfire threat only account for **0%** and **4%** of the commercial and industrial areas; **23%** of these areas have burned in the past 130 years.

The exposure to weather-related hazards is also small. Only **10%** of commercial and industrial land is located in the 100-year flood plain (slightly higher than for residential), and only **4%** is located in areas of significant past landslides (slightly lower than for residential).

This chapter will discuss the potential impacts of various disasters on Bay Area commercial and industrial buildings, as well as outline priorities for the preservation and rehabilitation of businesses during a disaster.

Pacific Garden Mall in downtown Santa Cruz following 1989 Loma Prieta earthquake

Certain Mitigation Practices Apply to All Hazards

Though the hazards facing Bay Area businesses are serious and diverse, certain steps can be taken to ensure proper preparation and quick recovery. Local jurisdictions can ensure that damage to commercial buildings is minimized through comprehensive public education campaigns for business owners. They can also work with structural engineers and the local business community to ensure that all parties are adequately prepared to assess and repair damage done to commercial buildings, no matter what sort of disaster may occur.

ACTIONS APPLYING TO MULTIPLE HAZARDS AND PUBLIC EDUCATION

Local business and commercial property owners must be made aware of the natural hazards facing the Bay Area, both as a region and for the neighborhoods in which there businesses are located. In addition to earthquakes, Bay Area businesses can be subject to tsunamis, wildfires, flooding, landslides, and sea-level rise. While each of these hazards has its own set of mitigation strategies, without proper information and guidance about the hazards and risks, the business community is unlikely to be fully prepared for a disaster. As such, local jurisdictions can take steps to improve disclosure of hazards, and increase awareness among local businesses and business districts on mitigation practices. Public information programs can also explain the importance of obtaining a building permit when altering, repairing, or adding onto existing construction.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-1): Assist in ensuring adequate hazard disclosure by working with real estate agents to improve enforcement of real estate disclosure requirements for commercial and industrial properties with regard to seven official natural hazard zones: 1) Special Flood Hazard Areas (designated by FEMA), 2) Areas of Potential Flooding from dam failure inundation, 3) Very High Fire Hazard Severity Zones, 4) Wildland Fire Zones, 5) Earthquake Fault Zones (designated under the Alquist-Priolo Earthquake Fault Zoning Act), and the 6) Liquefaction and Landslide Hazard Zones (designated under the Seismic Hazard Mapping Act).	Existing program	Cities and counties
2–(j-1): Provide information to private business owners and their employees on the availability of interactive hazard maps on ABAG's web site.	Existing program	Cities and counties
3–(j-2): Develop printed materials, utilize existing materials (such as developed by FEMA and the American Red Cross), conduct workshops, and/or provide outreach encouraging private businesses' employees to have family disaster plans that include drop-cover-hold earthquake drills, fire and storm evacuation procedures, and shelter-in-place emergency guidelines.	Existing program, underfunded	Cities and counties
4–(j-3): Develop and print materials, conduct workshops, and provide outreach to Bay Area private businesses focusing on business continuity planning.	Existing program, underfunded	Cities and counties
5–(j-4): Inform Bay Area private business owners of mitigation activities, including elevation of appliances above expected flood levels, use of fire-resistant roofing and defensible space in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat, structural retrofitting techniques for older buildings, and use of intelligent grading practices through workshops, publications, and media announcements and events.	Existing program, underfunded	Cities and counties
6–(j-5): Sponsor the formation and training of Community Emergency Response Teams (CERT) training for other than your own employees through partnerships with local private businesses. [Note – these programs go by a variety of names in various cities and areas.]	Existing program, underfunded	Cities and counties

7–(j-13): Distribute appropriate materials related to disaster mitigation and preparedness to private business owners. Appropriate materials are (1) culturally appropriate and (2) suitable for special needs populations. For example, such materials are available on the *http://www.preparenow.org* website and from non-governmental organizations that work with these communities on an on-going basis.	Existing program, underfunded	Cities and counties

ACTIONS APPLYING TO MULTIPLE HAZARDS AND REOCCUPANCY

After a disaster, many Bay Area businesses will be unable to operate because their buildings are damaged. Getting these businesses up and running again will be a key part of restoring the region's economy to its full potential. Buildings evacuated in a disaster will need to be inspected for structural stability before they can be reoccupied.

Full economic recovery requires a more strategic and concerted effort than housing recovery. Whereas a residential neighborhood with a handful of occupied homes can mean a return to normal life for a few families after a disaster, the same is not necessarily true for a devastated business district. Since so many of the region's businesses are dependent on one another for goods, services, and customers, piecemeal efforts to get a small number of businesses operating after a disaster will not be effective in softening the blow to the area's economy.

Local jurisdictions can take a variety of steps in order to mitigate the impact of a slow disaster recovery on the Bay Area economy. Creating incentives for private owners to comply with the federal Secretary of the Interior's *Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings* (from an aesthetic perspective) need to be coupled with compliance with safety regulations, such as the California 2007 *Historical Building Code*. Programs like San Francisco's *Building Occupancy Resumption Program* (BORP) are meant to expedite the recovery and reoccupancy processes by creating plans before a disaster occurs. Such efforts are key to ensuring rapid recovery. BORP has the added benefit of creating a process where owners, including owners of historic buildings, can work together with engineers to develop ways to engage in pre-disaster mitigation. Engineers with a pre-existing knowledge of buildings are also most effective in post-earthquake structural evaluations.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-2): Create incentives for private owners of historic or architecturally significant commercial and industrial buildings to undertake mitigation to levels that will minimize the likelihood that these buildings will need to be demolished after a disaster, particularly if those alterations conform to the federal Secretary of the Interior's *Guidelines for Rehabilitation.*	Existing program, underfunded	Cities and counties
2–(i-1): Institute a program to encourage owners of private buildings to participate in a program similar to San Francisco's Building Occupancy Resumption Program (BORP). This program permits owners of private buildings to hire qualified structural engineers to create building-specific post-disaster inspection plans and allows these engineers to become automatically deputized as City/County inspectors for these buildings in the event of an earthquake or other disaster.	Existing program, underfunded	Cities and counties
3–(i-2): Actively notify private owners of historic or architecturally significant buildings of the availability of the local BORP-type program and encourage them to participate to ensure that appropriately qualified structural engineers are inspecting their buildings, thus reducing the likelihood that the buildings will be inappropriately evaluated following a disaster.	Existing program, underfunded	Cities and counties
4–(i-3): Actively notify owners of educational facility buildings of the availability of the local BORP-type program and encourage them to participate to ensure that appropriately qualified structural engineers are inspecting their buildings, thus reducing the likelihood that the buildings will be inappropriately evaluated following a disaster.	Existing program, underfunded	Cities and counties

5–(i-4): Allow private building owners to participate in a BORP-type program as described above, but not actively encourage them to do so.	Existing program, underfunded	Cities and counties
6–(i-5): Develop and enforce a repair and reconstruction ordinance to ensure that damaged buildings are repaired in an appropriate and timely manner and retrofitted concurrently. This repair and reconstruction ordinance should apply to all public and private buildings, and also apply to repair of all damage, regardless of cause. See *http://quake.abag.ca.gov/recovery/info-repair-ord.html*.	Existing program	Cities and counties
7–(i-6): Establish preservation-sensitive measures for the repair and reoccupancy of historically significant privately-owned structures, including requirements for temporary shoring or stabilization where needed, arrangements for consulting with preservationists, and expedited permit procedures for suitable repair or rebuilding of historically or architecturally valuable structures.	Existing program, underfunded	Cities and counties

Earthquakes and the Economy

Of the natural disasters covered in this plan, the one affecting the largest number of Bay Area businesses is earthquakes. Whereas other disasters like wildfires and flooding are more localized, an earthquake can strike a substantial portion of Bay Area commercial buildings in a less than a minute.

This fact can be extremely problematic considering that commercial districts tend to have larger buildings and have denser zoning than residential areas.

Such business districts are also more likely to contain vulnerable structural types: unreinforced masonry buildings, non-ductile concrete buildings, and tilt-ups. While most of these building types are not used for housing, they are still present in many Bay Area commercial settings.

The following section will discuss strategies for mitigating the hazards posed by earthquake shaking to various commercial business types.

Actions Related to Earthquakes and Existing Construction

Existing construction poses more of a problem for hazard mitigation than new construction. While new buildings can be constructed to safe seismic codes, existing commercial buildings in the Bay Area have been built over decades to various standards. Furthermore, lack of maintenance and non-code-compliant alterations can compromise earthquake resistance in existing buildings. The following two strategies for existing commercial and industrial areas apply regardless of construction type. These strategies are often implemented through the buildings departments. If other local government departments work with these owners, they can refer them to the building department, and, at the same time, explain the importance of obtaining a building permit when altering, repairing, or adding onto existing construction, particularly for earthquake mitigation.

Strategy	*Regional Priority*	*Responsible Agency*
1–(h-3): Work with private building owners to help them recognize that many strategies that increase earthquake resistance also decrease damage in an explosion. In addition, recognize that ventilation systems can be designed to contain airborne biological agents.	Existing program, underfunded	Cities and counties
2–(j-7): Make use of the materials developed by others (such as found on ABAG's web site at *http://quake.abag.ca.gov/business*) to increase mitigation activities related to earthquakes by groups other than your own agency. ABAG plans to continue to improve the quality of those materials over time.	Existing program	Cities and counties

ACTIONS RELATED TO EXISTING SOFT-STORY COMMERCIAL BUILDINGS

As discussed earlier in Chapter 3-Housing, soft-story buildings are some of the most susceptible structures to earthquake damage. Some of the Bay Area's soft-story residential buildings have businesses on the first floor in addition to, or instead of, parking. Most of the soft-story structures that contain commercial use are in San Francisco. In addition, some downtown commercial areas have buildings that are soft-story commercial structures with offices, rather than housing, on upper floors. Although the greatest impact in past earthquakes has been on housing, the damage caused by earthquake shaking to soft-story structures in commercial areas should not be overlooked by local governments as they work toward a more resilient business community.

Soft-story hazard mitigation for commercial buildings follows the same main themes as for housing: conducting an inventory, developing retrofit standards, and creating incentives for owners to retrofit. In particular, use of a qualified engineer with seismic design experience is essential before undertaking major alterations. For a more in-depth discussion of the specific hazards and mitigation practices relating to soft-story buildings, see Chapter 3-Housing.

Conducting an Inventory:

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-4): Conduct an inventory of privately-owned existing or suspected soft-story commercial or industrial structures as a first step in establishing voluntary or mandatory programs for retrofitting these buildings.	High	Cities and counties with ABAG
2–(b-5): Use the soft-story inventory to require private owners to inform all existing tenants (and prospective tenants prior to signing a lease agreement) that they may work in this type of building.	High	Cities and counties
3–(b-6): Use the soft-story inventory to require private owners to inform all existing and prospective tenants that they may need to be prepared to work elsewhere following an earthquake if the building has not been retrofitted.	Moderate	Cities and counties

Retrofit Standards:

Strategy	*Regional Priority*	*Responsible Agency*
1(b-1): Require engineered plan sets for voluntary or mandatory soft-story seismic retrofits by private owners until a standard plan set and construction details become available.	Existing program	City and county building departments
2–(b-2): Adopt the 2009 International Existing Building Code or the latest applicable standard for the design of voluntary or mandatory soft-story building retrofits for use in city/county building department regulations. In addition, allow use of changes to that standard recommended by SEAOC for the 2012 IEBC.	Existing program	City and county building departments

Retrofit Incentives:

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-3): Work to educate building owners, local government staff, engineers, and contractors on privately-owned soft-story retrofit procedures and incentives using materials such as those developed by ABAG and the City of San Jose (see *http://quake.abag.ca.gov/eqhouse.html*).	Moderate	Cities and counties with ABAG
2–(b-7): Investigate and adopt appropriate financial, procedural, and land use incentives (such as parking waivers) for private owners of soft-story buildings to facilitate retrofit such as those described by ABAG (see *http://quake.abag.ca.gov/fixit*).	High	Cities and counties with ABAG

3–(b-8): Explore development of State regulations or legislation to require or encourage private owners of soft-story structures to strengthen them.	Moderate	Cities and counties with ABAG
4–(b-9): Provide technical assistance in seismically strengthening privately owned soft-story structures.	Under study	Cities and counties with ABAG

ACTIONS RELATED TO EXISTING UNREINFORCED MASONRY BUILDINGS

Unreinforced masonry buildings (URMs), comprised of brick or stone, are extremely susceptible to shaking damage. These buildings are the structures that have been responsible for deaths and injuries in many past earthquakes, including the 1989 Loma Prieta earthquake. In addition, the impact of URM damage on the local economy can be much larger than that on housing. This disproportional impact is because most of the Bay Area's URMs tend to be in older downtown areas where commercial uses dominate. In the 1989 Loma Prieta event, a major part of the business district in Santa Cruz was decimated due, in large part, to the presence of a significant number of unreinforced masonry buildings.

Because URM damage will likely have such a disproportionate impact on commercial buildings, jurisdictions with this type of structure should develop comprehensive plans to mitigate the impact of URM failures on their local economies. This plan should include complete adherence to state laws requiring lists of URMs, disclosure of the dangers URM failures, and promotion of URM retrofit programs, whether mandatory or voluntary.

One of the prevalent myths is that common URM retrofits will ensure the continued habitability of these structures. Most current ordinances have an earthquake performance objective of improving the buildings to a considerably lower standard than ensuring life safety. The objective is to allow occupants to leave the building when the shaking stops, assuming that the building will then be torn down. Such low retrofit standards make older downtown areas, even when the buildings have been retrofitted, economically vulnerable and slow to recover.

Based on tracking of local inventories of these buildings by the State Seismic Safety Commission, the Bay Area has 6,576 URMs, as shown in the table below. The cities with the largest number of these structures (that is, greater than 500) include San Francisco (1,984), Oakland (1,612), and Berkeley (587). Almost all of the buildings in these three cities have been retrofitted. Those remaining are largely vacant. However, the common "*bolts-plus*" standard for retrofit in San Francisco and Oakland will mean that people will confront the risk of falling masonry when evacuating them after a damaging earthquake and many of these buildings will need to be torn down. Additional cities with over 100 such buildings include Emeryville (101) and San Jose (146). San Jose has fewer buildings than might be expected (since it is the largest city in the Bay Area) because many were torn down during redevelopment. San Jose has had an aggressive and successful program for retrofitting the remaining buildings.

County	**Alameda**	**Contra Costa**	**Marin**	**Napa**	**San Mateo**	**Santa Clara**	**Solano**	**Sonoma**	**San Francisco**	***Total***
Number of URMS	2,601	424	124	122	167	384	174	596	1,984	*6,576*
Number retrofitted to city standard or demolished	1,030	101	53	53	123	289	16	215	1,713	*3,583*
Remaining number vulnerable (incl. vacant buildings)	1,571	323	71	69	44	95	158	381	271	*2,983*

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-1): Continue to actively implement existing State law that requires cities and counties to maintain lists of the addresses of unreinforced masonry buildings and inform private property owners that they own this type of hazardous structure.	Existing program	Cities and counties
2–(c-2): Accelerate retrofitting of privately-owned unreinforced masonry structures that have not been retrofitted, for example, by (a) actively working with owners to obtain structural analyses of their buildings, (b) helping owners obtain retrofit funding, (c) adopting a mandatory (rather than voluntary) retrofit program, and/or (d) applying penalties to owners who show inadequate efforts to upgrade these buildings.	Existing program, underfunded	Cities and counties
3–(c-3): Require private owners to inform all existing tenants (and prospective tenants prior to signing a lease agreement) that they work in an unreinforced masonry building and the standard to which it may have been retrofitted.	Existing program, underfunded	Cities and counties
4–(c-4): As required by State law, require private owners to inform all existing tenants that they may need to be prepared to work elsewhere following an earthquake even if the building has been retrofitted, because it has probably been retrofitted to a life-safety standard, not to a standard that will allow occupancy following major earthquakes.	Existing program	Cities and counties

ACTIONS RELATED TO OTHER PRIVATELY-OWNED STRUCTURALLY VULNERABLE BUILDINGS

In addition to soft-story and unreinforced masonry buildings, there are many other types of structures that are extremely susceptible to earthquake damage.

One such type is non-ductile concrete. These buildings were constructed largely before the code changes following the 1971 San Fernando earthquake and perform poorly in earthquakes due to the lack of reinforcing steel and brittleness of concrete. Although there are relatively few non-ductile concrete buildings in the Bay Area, they are disproportionately institutional and high-occupancy structures. Local jurisdictions can take steps to ensure that they are properly retrofitted to better withstand a large earthquake. These efforts, as explained in Chapter 5-Government, should apply to buildings owned by cities and counties, as well. An effort led by the Concrete Coalition is in the process of estimating the number of pre-1980 concrete buildings in several California cities, as shown in the table below. Because this survey is being conducted by volunteers and has not included all Bay Area cities (such as San Jose), no “total” is provided.

City	Estimated Number Pre-1980 Concrete Buildings	City	Estimated Number Pre-1980 Concrete Buildings
Emeryville	44	San Rafael	53
Fairfax	18	Alameda	140-160
Piedmont	8	Napa	14
Mill Valley	13	San Leandro	40
Albany	36	Daly City	30
Millbrae	52	Berkeley	275
El Cerrito	22	Santa Rosa	55
Burlingame	240	Oakland	1,300
Novato	18	San Francisco	3,100

A more prevalent vulnerable type is the "tilt-up." For this type of structure, a floor slab is cast, and then used as a base for forming exterior walls. The concrete exterior walls are constructed on top of the floor slab, and then tilted up vertically. The walls are then bolted to the roof. When the tilt-up method was first widely used in the 1950s, its main application was to warehouses. Now, more commercial building types are constructed in this fashion, especially low-rise structures in suburban business parks. The Silicon Valley area has a substantial number of tilt-up office buildings. Although standards for tilt-ups have been improved over the decades, the City of Los Angeles estimates that nearly 400 of the 1200 tilt-ups in the San Fernando Valley suffered at least a partial collapse during the 1994 Northridge event. As such, Bay Area jurisdictions should take steps to ensure that these, and other structurally vulnerable structures, are earthquake-resistant.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-1): Inventory non-ductile concrete, tilt-up concrete, and other privately-owned structurally vulnerable buildings.	Existing program, underfunded	Cities and counties
2–(d-2): Adopt the 2009 International Existing Building Code or the latest applicable standard for the design of voluntary or mandatory retrofit of privately-owned seismically vulnerable buildings.	Existing program	Cities and counties
3–(d-3): Adopt one or more of the following strategies as incentives to encourage retrofitting of privately-owned seismically vulnerable commercial and industrial buildings: (a) waivers or reductions of permit fees, (b) below-market loans, (c) local tax breaks, (d) grants to cover the cost of retrofitting or of a structural analysis, (e) land use (such as parking requirement waivers) and procedural incentives, or (f) technical assistance.	Existing program, underfunded	Cities and counties

ACTIONS RELATED TO EARTHQUAKES AND NEW CONSTRUCTION

As the Bay Area grows, so will its number of commercial buildings susceptible to earthquake hazards. Fortunately, California's history of devastating earthquakes has led to the development of strict standards for new construction. The *California Building Code* ensures that new construction is as safe and disaster resistant as possible. This code, however, cannot protect the region's commercial buildings if it is not rigorously enforced. Local jurisdictions must ensure that the inspectors in their building departments are properly and continuously trained in the requirements and enforcement of the most up-to-date version of building codes. In addition, the requirements need to be combined with public education to ensure that alterations, additions, and repairs of existing buildings, when those changes exceed 50% of the value of the building, are enforced.

Strategy	*Regional Priority*	*Responsible Agency*
1–(h-1): Continue to require that all new privately-owned commercial and industrial buildings be constructed in compliance with requirements of the most recently adopted version of the *California Building Code*.	Existing program	Cities and counties
2–(h-2): Conduct appropriate employee training and support continued education to ensure enforcement of construction standards for private development.	Existing program	Cities and counties

Wildfires and the Economy

Wildfire danger is another hazard facing Bay Area businesses and commercial buildings. Although the proportion of commercial buildings exposed to high wildfire threat is smaller than that of housing, local jurisdictions must still be vigilant about mitigating wildfire hazards.

Wildfire hazard mitigation practices follow much the same patterns as those for housing. For example, vegetation management in wildfire-prone areas and public education regarding wildfire hazards are beneficial to all building uses.

One of the largest concerns for local governments is the risk of fire following an earthquake, whether that fire is triggered by downed power lines or broken gas lines. Problems will be exasperated by broken water lines and lack of available emergency response vehicles. Thus, while the following strategies target wildfires, they are also mitigation for fire following earthquakes.

This section will discuss strategies to mitigate hazards posed to commercial buildings by fires.

Actions Related to Wildfires and Structural Fires

Existing Construction: Some of the Bay Area's businesses will always be in fire hazard zones. As such local jurisdictions should take steps to ensure that these businesses are as fire-resistant as possible. Cities and counties can promote proper vegetation management, rigorously enforce building codes, and inform business-owners in high fire risk areas of the potential dangers of wildfires. In addition, the requirements need to ensure that alterations, additions, and repairs of existing buildings trigger appropriate action.

Strategy	*Regional Priority*	*Responsible Agency*
1–(e-1): Increase efforts to reduce hazards in existing private development in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat through improving engineering design and vegetation management for mitigation, appropriate code enforcement, and public education on defensible space mitigation strategies.	Existing program	Cities and counties

New Construction: Local governments generally have greater leeway to regulate new construction than existing construction. In addition to strict enforcement of building codes, Bay Area cities and counties can require that new commercial developments be engineered and built with fire safety in mind. They can encourage or require new commercial buildings be built out of fire-resistant materials, and limit design features that encourage the spread of fires. These practices are captured by the following strategies.

Strategy	*Regional Priority*	*Responsible Agency*
1–(e-3): Require that new privately-owned business and office buildings in high fire hazard areas be constructed of fire-resistant building materials and incorporate fire-resistant design features (such as minimal use of eaves, internal corners, and open first floors) to increase structural survivability and reduce ignitability.	Existing program	Cities and counties
2(e-4): Adopt and amend as needed updated versions of the *California Building and Fire Codes* so that optimal fire-protection standards are used in construction and renovation projects of private buildings.	Existing program	Cities and counties

Vegetation Management and Defensible Space: Creation of defensible space through removing ignitable vegetation is one of the simplest and most important aspects of wildfire hazard mitigation. With less vegetation to serve as fuel, wildfires are less likely to spread. With more defensible space surrounding them, businesses are less likely to burn. Although vegetation management is an easy and effective way to reduce fire hazards, it can be difficult for individual businesses to undertake, especially for small businesses in less urban areas. Local jurisdictions can encourage business-

owners to undertake vegetation management practices by providing technical assistance, such as tool libraries, and by increasing their own community-wide vegetation management programs.

Strategy	*Regional Priority*	*Responsible Agency*
1(e-6): Expand vegetation management programs in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat to more effectively manage the fuel load through roadside collection and chipping, mechanical fuel reduction equipment, selected harvesting, use of goats or other organic methods of fuel reduction, and selected use of controlled burning.	Existing program, underfunded	Cities and counties
2–(e-7): Establish special funding mechanisms (such as Fire Hazard Abatement Districts or regional bond funding) to fund reduction in fire risk of existing properties through vegetation management that includes reduction of fuel loads, use of defensible space, and fuel breaks.	Existing program, underfunded	Cities and counties
3(j-6): Assist private businesses in the development of defensible space through the use of, for example, "tool libraries" for weed abatement tools, roadside collection and/or chipping services (for brush, weeds, and tree branches) in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat.	Existing program, underfunded	Cities and counties

Public Education: Though necessary, code enforcement and vegetation management practices will not be sufficient to reduce fire hazards if the local community is not made aware of the importance of wildfire hazard mitigation. If they are not informed of the importance of clearing defensible space, local business-owners are unlikely to voluntarily clear defensible space. Local jurisdictions should inform the local community of the potential hazards posed by wildfires and proper mitigation techniques.

Strategy	*Regional Priority*	*Responsible Agency*
1–(e-2): Tie public education on defensible space and a comprehensive defensible space ordinance to a field program of enforcement.	Existing program	Cities and counties
2–(j-9): Encourage the formation of a community- and neighborhood-based approach to wildfire education and action through local Fire Safe Councils and the Fire Wise Program. This effort is important because grant funds are currently available to offset costs of specific council-supported projects.	Moderate	Cities and counties

Coordination with Other Agencies: Not all mitigation practices can be undertaken by local jurisdictions acting separately. Some strategies require extensive coordination with other local jurisdictions, structural experts, state and federal government agencies, and insurance companies, to ensure that the Bay Area business community is well prepared for wildfires. Some strategies regarding coordination with other agencies are detailed below.

Strategy	*Regional Priority*	*Responsible Agency*
1–(e-11): Work with the State Fire Marshall, the California Seismic Safety Commission, Pacific Earthquake Engineering Research Center (PEER), and other experts to identify and manage gas-related fire risks of privately-owned soft-story mixed use buildings that are prone to collapse and occupant entrapment consistent with the natural gas safety recommendations of Seismic Safety Commission Report SSC-02-03. Note - See *http://www.seismic.ca.gov/pub/CSSC_2002-03_Natural% 20Gas%20 Safety.pdf*. Also note - any valves that are installed may need to have both excess flow and seismic triggers ("hybrid" valves).	Moderate	Cities and counties with ABAG
2–(e-13): Work with insurance companies to create a public/private partnership to give a discount on fire insurance premiums to "Forester Certified" *Fire Wise* landscaping and fire-resistant building materials on private property.	Existing program, underfunded	Cities and counties

Inspections and Enforcement: No mitigation plan will be effective if its provisions are not actively and rigorously enforced. Building codes for existing construction will not be adhered to if structures are not inspected routinely and completely. If standards for new constructions are not enforced, new commercial developments will be left extremely vulnerable to the threat of wildfire damage. As such, local jurisdictions must maintain strict enforcement of building and fire codes and conduct regular inspections to ensure that these codes are being followed.

Strategy	*Regional Priority*	*Responsible Agency*
1–(e-5): Create a mechanism to enforce provisions of the *California Building and Fire Codes* and other local codes that require the installation of smoke detectors and fire-extinguishing systems on existing privately-owned buildings by making installation a condition of (a) finalizing a permit for any work valued at over a fixed amount and/or (b) on any building over 75 feet in height, and/or (b) as a condition for the transfer of property.	Existing program	Cities and counties
2–(e-8): Establish special funding mechanisms (such as Fire Hazard Abatement Districts or regional bond funding) to fund fire-safety inspections of private properties, roving firefighter patrols on high fire-hazard days, and public education efforts.	Existing program	Cities and counties
3–(e-9): Compile a list of privately owned high-rise and high-occupancy buildings that are deemed, due to their age or construction materials, to be particularly susceptible to fire hazards, and determine an expeditious timeline for the fire-safety inspection of all such structures.	Existing program	Cities and counties
4–(e-10): Conduct periodic fire-safety inspections of all privately owned commercial and industrial buildings.	Existing program	Cities and counties

Flooding and the Economy

Only a small portion of the Bay Area's commercial lands lie within flood zones. Still, flooding can cause significant losses to buildings, inventories, and data systems. Recovery after a flood can be slow and expensive, and can be made even more so if a business does not have flood insurance or if it was not properly sheeted or sandbagged before a flood.

Given the severity of potential flood hazards, there are a variety of steps that local jurisdictions can take to reduce the impact of flooding on their businesses. Flood hazard mitigation strategies pertain to flood insurance, new construction, existing construction, and public education and disclosure.

Actions Related to Mitigating Flood Hazards

Flood Insurance: Many insurance plans do not cover flood losses. As such, it is important for business-owners in potential flood areas to purchase flood insurance. Without insurance, businesses can struggle to recover lost inventories and facilities. Local jurisdictions can take steps to reduce the cost of flood insurance in their communities, increasing the likelihood that business-owners will purchase flood insurance. One effective way to lower the cost of flood insurance is detailed below.

Strategy	*Regional Priority*	*Responsible Agency*
1–(f-1): To reduce flood risk, thereby reducing the cost of flood insurance to private property owners, work to qualify for the highest-feasible rating under the Community Rating System of the National Flood Insurance Program.	Existing program	Cities and counties

New Construction: The Bay Area is growing continuously, and with it, the need for new commercial development. Some of this development will inevitably take place in flood-prone areas. Local jurisdictions have a responsibility to ensure that this new development does not contribute to the existing flood hazard.

Strategy	*Regional Priority*	*Responsible Agency*
1–(f-2): Balance the needs for private commercial and industrial development against the risk from potential flood-related hazards.	Existing program	Cities and counties
2–(f-3): Ensure that new private development pays its fair share of improvements to the storm drainage system necessary to accommodate increased flows from the development, or does not increase runoff by draining water to pervious areas or detention facilities.	Existing program	Cities and counties
3–(f-6): Apply floodplain management regulations for private development in the floodplain and floodway.	Existing program	Cities and counties

Existing Construction: In addition to minimizing the contribution of new commercial construction to flood hazards, local jurisdictions should also adopt strategies to secure existing construction. One simple, yet effective way to minimize damage to existing businesses is to provide sandbags and plastic sheeting ahead of heavy rainfall. These items can significantly reduce the likelihood that a business suffers severe losses in a flood, and can be provided at relatively low cost. For certain businesses, no quantity of sandbags will dramatically reduce the likelihood of flood losses. For these businesses, cities and counties can implement building elevation and relocation programs. These and other mitigation strategies regarding existing construction are listed below.

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy ECON f-4): Provide sandbags and plastic sheeting to private businesses in anticipation of rainstorms, and deliver those materials to vulnerable populations upon request.	Existing program	Cities and counties
2–(f-5): Provide information to private business on locations for obtaining sandbags and deliver those sandbags to those various locations throughout a city and/or county.	Existing program	Cities and counties
3–(f-7): Encourage private business owners to participate in building elevation programs within flood hazard areas.	Existing program	Cities and counties
4–(f-8): As funding becomes available, encourage private business owners to participate in acquisition and relocation programs for areas within floodways.	Moderate	Cities and counties
5(f-9): Require an annual inspection of approved flood-proofed privately owned buildings to ensure that (a) all flood-proofing components will operate properly under flood conditions and (b) all responsible personnel are aware of their duties and responsibilities as described in their building's *Flood Emergency Operation Plan* and *Inspection & Maintenance Plan*.	Existing program	Cities and counties

Public Education: The strategies below related to flood hazard mitigation through public education.

Strategy	*Regional Priority*	*Responsible Agency*
1–(j-8): Develop a "Maintain-a-Drain" campaign, similar to that of the City of Oakland, encouraging private businesses and residents to keep storm drains in their neighborhood free of debris.	Existing program	Cities and counties
2–(j-12): Inform private shoreline-property owners of the possible long-term economic threat posed by rising sea levels.	Under study	Cities and counties with ABAG

Landslides, Erosion, and the Economy

Another hazard facing the region's economy is landslides. Relative to housing, landslides threaten only a small portion of the Bay Area's commercial buildings. Still, the damage to businesses can be significant. The following three strategies regarding landslides and erosion are specific to commercial developments. For more general landslide-prevention strategies, see ***Chapter 8 – Land Use***.

ACTIONS RELATED TO MITIGATING LANDSLIDE AND EROSION HAZARDS

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy ECON g-1): Increase efforts to reduce landslides and erosion in existing and future development by improving appropriate code enforcement and use of applicable standards for private property, such as those appearing in the *California Building Code*, California Geological Survey *Special Report 117 – Guidelines for Evaluating and Mitigating Seismic Hazards in California*, American Society of Civil Engineers (ASCE) report *Recommended Procedures for Implementation of DMG Special Publication 117: Guidelines for Analyzing and Mitigating Landslide Hazards in California*, and the California Board for Geologists and Geophysicists *Guidelines for Engineering Geologic Reports*. Such standards should cover excavation, fill placement, cut-fill transitions, slope stability, drainage and erosion control, slope setbacks, expansive soils, collapsible soils, environmental issues, geological and geotechnical investigations, grading plans and specifications, protection of adjacent properties, and review and permit issuance.	Existing program	Cities and counties
2–(g-2): Increase efforts to reduce landslides and erosion in existing and future private development through continuing education of design professionals on mitigation strategies.	Existing program, underfunded	Cities and counties
3–(e-12): Ensure that city/county-initiated fire-preventive vegetation-management techniques and practices for creek sides and high-slope areas do not contribute to the landslide and erosion hazard.	Existing program, underfunded	Cities and counties

Security and Hazardous Materials Facilities

Some Bay Area businesses work with hazardous materials, including those that are flammable, corrosive, irritating, oxidizing, explosive, radioactive, infectious, thermally unstable or reactive, or poisonous. In past disasters, releases have occurred due to building structural failures, asbestos problems, pipeline breaks, tank failures (both structural failures and due to sloshing), valves, falling containers or shelves, sliding and overturning of industrial equipment, transportation accidents, and special response problems.

To prevent hazardous material releases as a secondary impact of a natural disaster, it is important to enforce the plans and procedures instituted to prevent such releases during normal operations.

In this regard, fire departments and others can work with companies to encourage some of the structural and non-structural measures discussed earlier in this chapter.

Most hazardous materials releases in past earthquakes have occurred in smaller companies, rather than in major petro-chemical installations. Interviews conducted by ABAG and others following the Loma Prieta, Northridge, and other recent earthquakes shown that earthquakes have generated the same number of hazmat releases that have occurred in the entire year before the earthquake – except these releases have occurred during a few seconds. It is also essential to keep these materials safe and secure at all times.

ACTIONS RELATED TO MITIGATING RELEASES OF HAZARDOUS MATERIALS

The local jurisdictions that are home to businesses handling hazardous materials should work with the business community to ensure that proper measures are being taken to reduce the chance that dangerous materials do not become a safety and health hazard. Mitigation strategies pertaining to hazardous materials facilities are outlined below.

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy j-10): Encourage private businesses and laboratories handling hazardous materials or pathogens increase security to a level high enough to create a deterrent to crime and terrorism, including active implementation of cradle-to-grave tracking systems.	Existing program, underfunded	Cities and counties with hazardous material facilities
2–(j-12): Encourage joint meetings of security and operations personnel at major private employers to develop innovative ways for these personnel to work together to increase safety and security.	Existing program, underfunded	Cities and counties with hazardous material facilities

Chapter 5 – Government Services (GOVT)

COMMITMENT: Bay Area city and county governments, as well as community services agencies, provide essential services during and immediately following disasters, as well as critical functions during recovery, that need to be resistant to disasters.

Continuing function of government is critical after a disaster.

After a disaster, a city, county, or special district may find its overworked staff dealing with the recovery of its own facilities and functionality, at the same time it is trying to help the community and their own families to recover as a whole.

The ability of a community to recover after a disaster will depend, in part, on the continuing functioning of the government. Mitigation strategies need to focus on more than administration, police, and fire departments. They also need to cover planning and permitting as well as social services necessary for community recovery. Using this definition, Bay Area cities and counties own almost **4,236** critical facilities, not including the transportation/transit and water/wastewater facilities described in Chapter 1 – Infrastructure.

The greatest hazard to these critical facilities is earthquake shaking, with **94.6%** of them exposed to high shaking levels (peak accelerations of greater than 40% of gravity [g] with a 10% chance of being exceeded in the next 50 years), and **73.4%** being exposed to extremely high shaking levels (60% g). Most of the hazard mitigation strategies that follow deal with this hazard. In addition, **14.9%** of government facilities are located in areas of very high liquefaction susceptibility. Finally, **6.5%** of these facilities are located in tsunami evacuation planning areas.

Exposure of critical government facilities to the threat of wildland-urban-interface fires is much less. While **45.9%** of these facilities are located in these hazard areas, only **4.5%** of these hazard areas burned in the past **130** years. While global warming may result in more fires in the next 50 years, the exposure is still less than that of earthquake shaking. Only **2.6%** of the facilities are exposed to very high or extreme wildfire threat; **23%** of these areas have burned in the past **130** years.

The exposure to storm-related hazards is less. Only **7.7%** of these critical facilities are located in the 100-year flood plain, and only **2.8%** are located in areas of significant past landslides.

Bay Area governments have been proactive.

The first step in ensuring quick recovery from a disaster is retrofitting critical government buildings, such as city halls, to ensure that they can withstand earthquake-generated ground shaking.

Many cities in the Bay Area have been proactive about retrofitting their own facilities, particularly since the 1989 Loma Prieta earthquake. In 1998, the City of Hayward replaced the old City Hall building being damaged by active creep on the Hayward fault with a new base-isolated building 700 feet from the fault meeting current building codes. The City of Fremont tore down its “modern” five-story City Hall when it was discovered after completion in 1968 that it was close to the Hayward fault. The building was completely demolished and replaced in 2004. Both Oakland’s and San Francisco’s city halls were badly damaged in the 1989 Loma Prieta earthquake. Repairs to those structures also included base-isolation to withstand future earthquakes and preserve the historic integrity of the buildings. Many other governments have taken similar actions to ensure that their city halls and other vital government buildings will be able to withstand the next major earthquake the Bay Area will face.

Ensuring that departments have a plan for resumption of services and coordinating with outside agencies and private organizations will also ensure that governments can quickly recover from any natural disaster.

Damage to San Francisco City Hall in 1906

Focus on Critical Facilities Owned by Government

Governments and special districts own buildings that will be critical following a disaster. Office buildings often house important records. Employees will need a place to continue doing their job to help with government recovery from disaster. In addition, governments provide many essential services that should continue functioning after a disaster.

The following section discusses ways to protect buildings owned by governments and special districts. These critical facilities include city halls, as well as police and fire stations. But they also are community centers and social services facilities essential to community recovery.

ACTIONS RELATED TO REDUCING DAMAGE TO CRITICAL FACILITIES OWNED BY GOVERNMENT

Facilities owned by cities, counties and special districts might be damaged in a disaster. When this occurs, the normal response and recovery actions of the city, county or special district are hampered. Damage may occur to the structure of buildings, equipment, building contents, and financial records. In addition, vulnerable buildings may pose a danger to the safety of the public as well as the employees who work in them. Government structures that may be of particular importance after disasters include city halls, fire stations, operations and communications headquarters, and community service centers. Government can increase its resiliency to natural disasters using the following strategies.

Oakland City Hall retrofitted after Loma Prieta earthquake

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy GOVT a-1): Assess the vulnerability of critical facilities (such as city halls, fire stations, operations and communications headquarters, community service centers, seaports, and airports) to damage in natural disasters and make recommendations for appropriate mitigation.	Existing program, underfunded	Cities, counties, and special districts
2–(a-2): Retrofit or replace critical facilities that are shown to be vulnerable to damage in natural disasters.	Existing program, underfunded	Cities, counties, and special districts
3–(a-9): As a secondary focus, assess the vulnerability of non-critical facilities to damage in natural disasters based on occupancy and structural type, make recommendations on priorities for structural improvements or occupancy reductions, and identify potential funding mechanisms.	Moderate priority	Cities, counties, and special districts
4–(a-12): Prior to acquisition of property to be used as a critical facility, conduct a study to ensure the absence of significant structural hazards and hazards associated with the building site.	Existing program	Cities, counties, and special districts

ACTIONS RELATED TO COMMUNICATING VULNERABILITY OF GOVERNMENT BUILDINGS

One of the issues that occur as local governments evaluate the vulnerability of their own facilities to damage in disasters is what to do with that information. It is important that local elected officials and the public are informed of the findings of such analyses for a number of reasons, including making the best public policy decision. The decision on how to address specific vulnerabilities can then be made by using as much relevant information as possible. In addition, because employees working in such buildings should make plans for operating post-disaster; these workers need to understand those vulnerabilities.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-3): Clarify to workers in critical facilities and emergency personnel, as well as to elected officials and the public, the extent to which the facilities are expected to perform only at a life safety level (allowing for the safe evacuation of personnel) or are expected to remain functional following an earthquake.	Existing program	Cities, counties, special districts

ACTIONS RELATED TO NONSTRUCTURAL MITIGATION OF GOVERNMENT BUILDINGS

Even if a building is not structurally damaged, nonstructural building contents, particularly file cabinets, bookshelves, computers, servers, and other key equipment, can fall and shift in an earthquake harming occupants rendering the building non-functional. These non-structural assets are typically not expensive to secure, and yet will significantly slow the pace of recovery following a disaster. The following strategy will help governments mitigate against these losses.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-4): Conduct comprehensive programs to identify and mitigate problems with facility contents, architectural components, and equipment that will prevent critical buildings from being functional after major natural disasters. Such contents and equipment includes computers and servers, phones, files, and other tools used by staff to conduct daily business.	Existing program, underfunded	Cities, counties, and special districts

ACTIONS RELATED TO ENSURING GOVERNMENT AND NON-GOVERNMENT BUILDINGS ARE BOTH COMPLIANT WITH APPLICABLE REGULATIONS

Governments can act as an example of good practices for the rest of the community. Ensuring that private businesses and homes are also prepared for disasters will reduce strain on government services after a disaster, speed the economic recovery of the community and save lives. Conversely, government should ensure that they are as prepared as the private community. The following strategies will help government accomplish these complementary goals.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-10): Ensure that new government-owned facilities comply with and are subject to the same or more stringent regulations as imposed on privately-owned development.	Existing program	Cities and counties
2–(a-13): Ensure that any regulations imposed on private-owned businesses related to repair and reconstruction (see Economy Section) are enforced and imposed on local government's own buildings and structures.	Existing program	Cities and counties

3–(a-11): Comply with all applicable building and fire codes, as well as other regulations (such as state requirements for fault, landslide, and liquefaction investigations in particular mapped areas) when constructing or significantly remodeling government-owned facilities.	Existing program	Cities, counties, and special districts

ACTIONS RELATED TO IMPROVING SECURITY

Some measures undertaken by governments to improve security of their buildings and critical infrastructure can serve the secondary function of helping to mitigate against natural hazards. The following strategies improve security while mitigating hazards.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-5): Encourage joint meetings of security and operations personnel at critical facilities to develop innovative ways for these personnel to work together to increase safety and security.	Existing program	Cities, counties, and special districts
2–(a-6): When installing micro and/or surveillance cameras around critical public assets tied to web-based software, develop a surveillance protocol to monitor these cameras, and investigate the possibility of using the cameras for the secondary purpose of post-disaster damage assessment.	Moderate	Cities, counties, and special districts
3–(a-7): Identify and undertake cost-effective retrofit measures related to security on critical facilities (such as moving and redesigning air intake vents and installing blast-resistant features) when these buildings undergo major renovations related to other natural hazards.	Moderate	Cities, counties, and special districts

Focus on Efforts to Identify and Mitigate Hazards

Many organizations within the State and Federal governments, as well as research institutions and professional organizations study natural hazards and disaster mitigation techniques. Local governments can benefit from participating in and encouraging these efforts. Continued research on the hazards our region faces will improve our ability to plan and prepare for them. In addition, many hazards affect more than one local government or jurisdiction simultaneously. To the extent that mitigation strategies can be coordinated among various agencies, the Bay Area will be better prepared for disasters.

ACTIONS RELATED TO COORDINATION AMONG LOCAL GOVERNMENTS

The following strategies are available to local governments to encourage information sharing and coordinated planning among various local agencies.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-1): Promote information sharing among overlapping and neighboring local governments, including cities, counties, and special districts, as well as utilities.	Existing program	Cities, counties, and special districts
2–(d-2): Recognize that emergency services is more than the coordination of police and fire response; it also includes planning activities with providers of water, food, energy, transportation, financial, information, and public health services.	Existing program	Cities, counties, and special districts

3–(d-3): Recognize that a multi-agency approach is needed to mitigate flooding by having flood control districts, cities, counties, and utilities meet at least annually to jointly discuss their capital improvement programs for most effectively reducing the threat of flooding. Work toward making this process more formal to insure that flooding is considered at existing joint-agency meetings.	Very high	Cities, counties, and special districts
4–(d-6): Participate in multi-agency efforts to mitigate fire threat, such as the Hills Emergency Forum (in the East Bay), various *FireSafe* Council programs, and city-utility task forces. Such participation increases a jurisdiction's competitiveness in obtaining grants.	Existing program, underfunded	Cities, counties, and special districts
5–(d-7): Work with major employers and agencies that handle hazardous materials to coordinate mitigation efforts for the possible release of these materials due to a natural disaster such as an earthquake, flood, fire, or landslide.	Existing program	Cities, counties, and special districts

ACTIONS RELATED TO COORDINATION WITH FEDERAL GOVERNMENT

The following strategies are available to local governments to participate in hazard mitigation programs led by the federal government.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-4): As new flood-control projects are completed, request that FEMA revise its flood-insurance rate maps and digital Geographic Information System (GIS) data to reflect flood risks as accurately as possible.	Existing program	Cities, counties, and special districts
2–(d-5): Participate in FEMA's National Flood Insurance Program.	Existing program	Cities, counties

ACTIONS RELATED TO PARTICIPATION IN HAZARD RESEARCH AND EDUCATION

The following strategies are available to local governments to encourage research by others on hazards that affect their region as well as to encourage their own employees to learn about the hazards their jurisdiction faces.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-8): Encourage staff to participate in efforts by professional organizations to mitigate earthquake and landslide disaster losses, such as the efforts of the Northern California Chapter of the Earthquake Engineering Research Institute, the East Bay-Peninsula Chapter of the International Code Council, the Structural Engineers Association of Northern California, and the American Society of Grading Officials.	Existing program	Cities, counties, and special districts
2–(d-9): Conduct and/or promote attendance at local or regional hazard conferences and workshops for elected officials and staff to educate them on the critical need for programs in mitigating earthquake, wildfire, flood, and landslide hazards.	Existing program, underfunded	Cities, counties, and special districts
3–(d-10): Cooperate with researchers working on government-funded projects to refine information on hazards, for example, by expediting the permit and approval process for installation of seismic arrays, gravity survey instruments, borehole drilling, fault trenching, landslide mapping, flood modeling, and/or damage data collection.	Existing program	Cities, counties, and special districts

Focus on Government Emergency Response Capability

Governments provide emergency services such as fire and police that will be essential immediately following a disaster. The ability of these departments to respond will depend on having the right equipment and communications. In addition, a particular disaster will affect many jurisdictions at once and may overwhelm the capacity of any one emergency response department. For this reason, the ability to share resources and communicate with other departments is essential. In addition, it is essential that city employees are able to return to work quickly after a disaster, which means that their families need to be sheltered so they don't leave the region to stay with family and friends. The following section focuses on the ability of governments to respond to disasters.

ACTIONS RELATED TO EMPLOYEE PREPAREDNESS

The primary function of local government immediately after a disaster will be emergency response. Government employees are a major asset of any local government and their ability to report to work after a disaster will greatly affect the ability of a local government to respond to a disaster. The following strategies will help governments protect their employees.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-1): Develop a plan for short-term and intermediate-term sheltering of your employees.	Existing program	Cities, counties, and special districts
2–(c-2): Encourage your employees to have a family disaster plan.	Existing program	Cities, counties, and special districts
3–(c-3): Offer CERT/NERT-type training to your employees.	Existing program, underfunded	Cities, counties, and special districts

ACTIONS RELATED TO MONITORING AND EARLY WARNING OF DISASTERS

Some disasters can be mitigated by monitoring the warning signs of these disasters. For example, weather forecasts can help governments anticipate flooding events and prepare sandbags other or emergency shelters for residents. Similarly, during times of hot, dry weather when there has been little rain, governments can place restrictions on activities that are likely to cause wildfires. These efforts can prevent incidents from turning into disasters and allow governments time to warn or evacuate residents in dangerous areas. Developing unified messages and protocols among neighboring local jurisdictions will ensure that residents are not confused by conflicting information. While some disasters, such as hazmat releases cannot necessarily be predicted ahead of time, early detection and warning can help to quickly control the release and protect residents. The following strategies can be employed by local governments to monitor and prevent disasters.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-17): Monitor weather during times of high fire risk using, for example, weather stations tied into police and fire dispatch centers.	Existing program	Cities, counties, and special districts
2–(c-18): Establish regional protocols on how to respond to the NOAA Monterey weather forecasts, such as the identifying types of closures, limits on work that could cause ignitions, and pre-positioning of suppression forces. A multi-agency coordination of response also helps provide unified messages to the public about how they should respond to these periods of increased fire danger. Response should also be modified based on knowledge of local micro-climates. Local agencies with less risk then may be available for mutual aid.	Existing program	Cities, counties, and special districts
3–(c-19): Increase local patrolling during periods of high fire weather.	Existing program, underfunded	Cities, counties, and special districts
4–(c-20): Create and maintain an automated system of rain and flood gauges that is web enabled and publicly accessible. Work toward creating a coordinated regional system.	Existing program, underfunded	Cities, counties, and special districts
5–(c-21): Place remote sensors in strategic locations for early warning of hazmat releases or use of weapons of mass destruction, understanding that the appropriate early warning strategy depends on the type of problem.	Existing program, underfunded	Cities, counties, and special districts

ACTIONS RELATED TO EMERGENCY EVACUATION PLANNING

Quickly and effectively informing residents of imminent disasters is essential in protecting residents. Early warning systems, such as reverse 911, that can reach large quantities of people quickly are essential in areas prone to hazmat releases, fires and floods and dam releases. Continued maintenance of these systems and familiarizing residents in their use through practice drills will help ensure that these systems work effectively in the event of a real disaster. The following strategies will assist local governments in preparing and maintaining early warning systems.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-14): Install alert and warning systems for rapid evacuation or shelter-in-place. Such systems include outdoor sirens and/or reverse-911 calling systems.	Existing program, underfunded	Cities, counties, and special districts
2–(c-15): Conduct periodic tests of the alerting and warning system.	Existing program, underfunded	Cities, counties, and special districts
3–(c-22): Review and update, as necessary, procedures pursuant to the *State Dam Safety Act* for the emergency evacuation of areas located below major water-storage facilities.	Existing program	Dam owners with cities and counties
4–(c-23): Improve coordination among cities, counties, and dam owners so that cities and counties can better plan for evacuation of areas that could be inundated if a dam failed, impacting their jurisdiction.	Existing program	Dam owners with cities and counties
5–(a-8): Coordinate with the State Division of Safety of Dams to ensure that cities and counties are aware of the timeline for the maintenance and inspection of dams whose failure would impact their jurisdiction.	Existing program, underfunded	Dam owners with cities and counties
6–(c-24): Develop procedures for the emergency evacuation of areas identified on tsunami evacuation maps as these maps become available.	Existing program	Cities, counties, and special districts

ACTIONS RELATED TO FIRST RESPONDERS

First responders, including fire, police and other emergency personnel, will be at the front lines of any major disaster. Ensuring they have adequate tools and equipment will greatly increase their ability to respond to a disaster.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-6): Ensure that fire, police, and other emergency personnel have adequate radios, breathing apparatuses, protective gear, and other equipment to respond to a major disaster.	Existing program, underfunded	Cities, counties, and special districts
2–(c-8): Harden emergency response communications, including, for example, building redundant capacity into public safety alerting and/or answering points, replacing or hardening microwave and simulcast systems, adding digital encryption for programmable radios, and ensuring a plug-and-play capability for amateur radio.	Existing program, underfunded	Cities, counties, and special districts

3–(c-9): Purchase command vehicles for use as mobile command/EOC vehicles if current vehicles are unsuitable or inadequate.	Existing program, underfunded	Cities, counties, and special districts
4–(c-10): Maintain the local government's emergency operations center in a fully functional state of readiness.	Existing program, underfunded	Cities, counties, and special districts
5–(c-16): Regulate and enforce the location and design of street-address numbers on buildings and minimize the naming of short streets (that are actually driveways) to single homes.	Existing program	Cities, counties

Actions Related to Coordination and Communications

The Bay Area typically has several special districts operating within one city or county. Local governments are skilled at including various special districts and major employers in emergency planning efforts. Additional funding could help these local governments expand the reach of their efforts and ensure interoperability of equipment and communications between jurisdictions. The following strategies support efforts being undertaken by local governments to coordinate with emergency response planning efforts with other jurisdictions.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-7): Participate in developing and maintaining a system of interoperable communications for first responders from cities, counties, special districts, state, and federal agencies.	Existing program, underfunded	Cities, counties, and fire districts
2–(c-11): Expand or participate in expanding traditional disaster exercises involving city and county emergency personnel to include airport and port personnel, transit and infrastructure providers, hospitals, schools, park districts, and major employers.	Existing program, underfunded	Cities, counties, and special districts
3–(c-13): Continue to participate not only in general mutual-aid agreements, but also in agreements with adjoining jurisdictions for cooperative response to fires, floods, earthquakes, and other disasters.	Existing program	Cities and counties
4–(c-25): Support and encourage planning and identification of facilities for the coordination of distribution of water, food, blankets, and other supplies, coordinating this effort with the American Red Cross.	Existing program, underfunded	Cities, counties, and special districts

Actions Related to Emergency Response Plan Maintenance

As the needs and demands of the community change over time due to increased population or ageing infrastructure, emergency response plans should adapt to these changes. The following strategies focus on ways that governments can keep their emergency response plan up to date.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-4): Periodically assess the need for new or relocated fire or police stations and other emergency facilities.	Existing program	Cities, counties, and fire districts
2–(c-5): Periodically assess the need for changes in staffing levels, as well as for additional or updated supplies, equipment, technologies, and in-service training classes.	Existing program	Cities, counties, and special districts

3–(c-12): Maintain and update as necessary the local government's Standardized Emergency Management System (SEMS) Plan and the National Incident Management System (NIMS) Plan, and submit an appropriate NIMSCAST report.	Existing program	Cities and counties

Focus on Maintaining and Enhancing Local Government's Disaster Recovery Planning

After a disaster, many government buildings may no longer be safe for occupation. Plans should be made for the emergency relocation of local government facilities critical in emergency response, as well as any government facilities with known structural deficiencies or in hazardous areas. Such plans should include ways to work with local telephone companies to set up phone systems that either preserve pre-disaster phone numbers, or include call forwarding provisions. In addition, these plans should include public outreach and education on the new locations of these facilities. The relocation plan should include access to back-ups of key records and other documents from alternate locations. Finally, local governments should have plans and back-up procedures to enable them to pay employees, social service recipients, and vendors if normal finance department operations are disrupted.

ACTIONS RELATED TO DISASTER RECOVERY

The following strategies are available to local governments to ensure that they are able to recover more quickly from disasters.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-1): Establish a framework and process for pre-event planning for post-event recovery that specifies roles, priorities, and responsibilities of various departments within the local government organization, and that outlines a structure and process for policy-making involving elected officials and appointed advisory committees.	Existing program	Cities, counties, and special districts
2–(b-2): Prepare a basic Recovery Plan that outlines the major issues and tasks that are likely to be the key elements of community recovery, as well as integrate this planning into response planning (such as with continuity of operations plans).	Existing program, underfunded	Cities, counties, and special districts
3–(b-3): Establish a goal for the resumption of local government services that may vary from function to function.	Existing program	Cities, counties, and special districts
4–(b-4): Develop a continuity of operations plan that includes back-up storage of vital records, such as plans and back-up procedures to pay employees and vendors if normal finance department operations are disrupted, as well as other essential electronic files.	Existing program, underfunded	Cities, counties, and special districts
5–(b-5): Plan for the emergency relocation of government-owned facilities critical to recovery, as well as any facilities with known structural deficiencies or in hazardous areas.	Existing program, underfunded	Cities, counties, and special districts

Taking a Regional Leadership Role

ABAG is the regional planning agency for the Bay Area, representing all 101 cities and 9 counties in the region. Through its earthquake and hazards program, natural disasters that affect the region as a whole are studied from a regional context and regional solutions to mitigation. ABAG also models predicted losses develops risk assessments. In this role, ABAG has taken the lead in coordinating the development of the local hazard mitigation plan with approximately 100 cities, counties and special districts in the region. Developing a comprehensive plan in this matter ensures that regional hazards are dealt with in a unified manner throughout the region and that local governments can coordinate their activities with neighboring jurisdictions.

Actions Related to Taking a Lead in Loss and Risk Assessment Activities

The following mitigation strategies will ensure that ABAG will continue to take a regional leadership role in understanding, characterizing and planning for natural disasters.

Strategy	*Regional Priority*	*Responsible Agency*
1–(e-1): Work with the cities, counties, and special districts in the Bay Area to encourage them to adopt a Local Hazard Mitigation Plan and to assist them in integrating it into their overall planning process.	Existing program, underfunded	ABAG only
2–(e-2): Improve the risk assessment and loss estimation work in the ***Taming Natural Disasters*** report and multi-jurisdictional plan related to natural disasters.	Existing program, underfunded	ABAG only

Photo Credits – MCEER–page 5-2; ATC–page 5-3; Moraga-Orinda Fire District–page 5-5; BBC News–page 5-7

Chapter 6 – Schools and Education (EDUC)

COMMITMENT: Safe and disaster-resistant school, education, and childcare-related facilities are critical to the safety of our children, as well as to the quality of life of Bay Area families.

Are Schools Safe?

There are over 2,000 K-12 schools in the Bay Area, along with 80 colleges and universities and numerous day care providers and pre-schools.

As a result of the 1933 Long Beach earthquake, in which 70 schools were destroyed and another 120 suffered major structural damage, California adopted the Field Act.

School damaged in the 1933 Long Beach earthquake

"The Field Act requires that the building designs be based on high level building standards adopted by the state and plans and specifications be prepared by competent designers qualified by state registration. The quality of construction was to be enforced through independent plan review and independent inspection. Finally, the design professionals, independent inspector and the contractor had to verify under penalty of perjury that the building was constructed according to the approved plans" (Dennis Bellet, Department of General Services, Division of the State Architect).

The first problem with the Field Act is that it applies only to new construction; not to existing pre-1933 school buildings. While the 1939 Garrison Act covered the criteria for continued use or abandonment of these pre-1933 school buildings, they were not retrofitted to conform to current codes until funding was made available shortly after the 1971 San Fernando Earthquake.

The second problem is that the Act is not retroactive. Many schools do not meet current codes. School districts and the Division of the State Architect are now grappling with the problem of evaluating and retrofitting thousands of school buildings constructed before 1976 (due to major changes in building codes following the 1971 San Fernando earthquake).

A third problem is that this Act has gaps; it does not cover private schools, pre-schools, and day care facilities. Many of these facilities needed to be retrofitted to withstand shaking.

Role of Schools Before and After Disasters

Our schools are critical to our ability to recover following an earthquake or other major disaster in the Bay Area. While their principal mission prior to a disaster is education – whether they are a K-12 school or a university – their mission is more complex after a disaster hits.

- We rely on K-12 schools to shelter those displaced from their homes.
- We use K-12 schools as conduits for information to parents and others in the community, including post-disaster information.
- Some have suggested that schools become locations for distribution of water and other services after a disaster.
- Parents who work are relying on their younger children attending school and after-school programs as day care while they work, a role that is disrupted if schools close for extended periods of time.
- Children and teens need the stability of school and sports programs to restore a sense of normalcy, at the same time as gyms and auditoriums are used as shelters.
- Our universities are a major employer and driver of the Bay Area economy and thus their continued post-disaster functioning is critical to regional recovery.

Local county offices of education, school personnel, the American Red Cross, and various state agencies need to work together to ensure that we speed up the long-term recovery process so that schools can return to their mission of education. (Long-term recovery is that period from a few hours to several years after the disaster when buildings, infrastructure, and communities are rebuilt.)

Emergency sheltering in school gym

Local Government Actions to Mitigate Natural Hazards

The following recommendations for action, if adopted by school districts, in conjunction with county offices of education, various state agencies and the American Red Cross, will help ensure safe school facilities for students, emergency shelters, and communities.

The recommendations have been developed with the goals of encouraging mitigation and disaster preparedness before disasters, as well as to speed up long-term recovery after disasters. The recommendation focus on creating safer facilities, working with private, as well as public, schools, and speeding up post-disaster structural inspection of school facilities.

The exposure of Bay Area public school facilities to earthquake shaking is the greatest hazard, with **97.3%** of schools exposed to high shaking levels (peak accelerations of greater than 40% of gravity [g] with a 10% chance of being exceeded in the next 50 years) as compared to **93%** of housing), and **67.9%** being exposed to extremely high shaking levels (60% g) as compared to **53%** of housing). Thus, most of the hazard mitigation strategies that follow deal with this hazard.

Local governments have not imposed retrofit requirements on private schools, pre-schools, and day care facilities. While this type of action might occur in the future, it is not something that is a moderate or higher priority in the next five years for inclusion in this MJ-LHMP.

Wildland-urban-interface fire threat (WUI) exposure is much less. While **47.4%** of public school facilities are located in WUI areas (as compared to **58%** of housing), only **4.5%** of all WUI areas have burned in the past 130 years. Even though global warming may result in more fires in the next 50 years, the exposure is still less than that of earthquake shaking. In addition, **1.0%** public school facilities are located in areas of extreme or very high wildfire threat (versus **9%** of housing)

The exposure to storm-related hazards is even smaller. Only **2.5%** of public school facilities are located in 100-year flood areas (as compared to **4%** of housing), and only **1.9%** of public school facilities are located in areas of significant past landslides (versus **10%** of housing).

Actions Focusing on Education Facilities Owned by School Districts

The State of California has the lead in strengthening public schools. However, the following strategies focus on ensuring these State efforts are coordinated with counties. While work on these actions is largely on-going, the efforts are often underfunded, particularly in the economic climate of a recession.

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy EDUC a-1): Assess the vulnerability of critical public education facilities to damage in natural disasters and make recommendations for appropriate mitigation.	Existing program, underfunded	School districts, county offices of education, Div. of State Architect
2–(a-2): Retrofit or replace critical public education facilities that are shown to be vulnerable to damage in natural disasters.	Existing program, underfunded	School districts, county offices of education, Div. of State Architect
3–(a-3): Conduct comprehensive programs to identify and mitigate problems with facility contents, architectural components, and equipment that will prevent critical public education buildings from being functional after major disasters.	Existing program, underfunded	School districts, county offices of education, Div. of State Architect

4–(a-4): As a secondary focus, assess the vulnerability of non-critical educational facilities (that is, those that do not house students) to damage in natural disasters based on occupancy and structural type, make recommendations on priorities for structural improvements or occupancy reductions, and identify potential funding mechanisms.	Moderate	School districts, county offices of education
5–(a-5): Assess the vulnerability of critical private education, pre-school, and day care facilities to damage in natural disasters and make recommendations for appropriate mitigation.	Moderate	County offices of education
6–(a-6): Work with CalEMA and the Division of the State Architect to ensure that there will be an adequate group of Safety Assessment Program (SAP) inspectors trained and deployed by CalEMA to schools for post-disaster inspection. In addition, if a school district is uncomfortable with delays in inspection due to too few SAP inspectors available in catastrophic disasters, formalized arrangements can also be created with those inspectors certified by the Division of the State Architect as construction inspectors to report to the district, assess damage, and determine if the buildings can be reoccupied.	Existing program, underfunded	School districts, county offices of education, Div. of State Architect, CalEMA

Use of Educational Facilities as Emergency Shelters

As noted, schools have the additional function following a disaster of serving as emergency shelters. The following mitigation strategies focus on ensuring that they are available for that role.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-1): Work cooperatively with the American Red Cross, cities, counties, and non-profits to set up memoranda of understanding for use of education facilities as emergency shelters following disasters.	Existing program	School districts, county offices of education
2–(b-2): Work cooperatively to ensure that school district personnel and relevant staff understand and are trained that being designated by the American Red Cross or others as a potential emergency shelter does NOT mean that the school has had a hazard or structural evaluation to ensure that it can be used as a shelter following any specific disaster.	Existing program	School districts, county offices of education
3–(b-3): Work cooperatively to ensure that school district personnel understand and are trained that they are designated as disaster service workers and must remain at the school until released.	Existing program	School districts, county offices of education

Actions Related to Disaster Preparedness and Recovery Planning

School districts cannot mitigate hazards, respond to disasters, or recover except as part of a larger community. The following strategies relate to the unique role of schools in the community.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-1): Encourage employees of schools to have family disaster plans and conduct mitigation activities in their own homes.	Existing program	School districts, county offices of education

2–(c-2): Develop plans, in conjunction with fire jurisdictions, for evacuation or sheltering in place of school children during periods of high fire danger, thereby recognizing that overloading of streets near schools by parents attempting to pick up their children during these periods can restrict access by fire personnel and equipment.	Existing program	School districts, county offices of education
3–(c-3): Offer the 20-hour basic CERT training to teachers and after-school personnel.	Existing program, underfunded	School districts, county offices of education
4–(c-4): Offer the 20-hour basic Student Emergency Response Training (SERT, rather than CERT) training to middle school and/or high school students as a part of the basic science or civics curriculum, as an after school club, or as a way to earn public service hours.	Existing program, underfunded	K-12 school districts, county offices of education
5–(c-5): Offer the 20-hour basic CERT training course through the Adult School system and/or through the Community College system (either using instructors with teaching credentials or by making facilities available for classes not run by school personnel themselves).	Existing program, underfunded	Community college school districts, county offices of education
6–(c-6): Develop and maintain the capacity for schools to take care of the students for the first 48 hours after a disaster, and notify parents that this capacity exists.	Existing program	School districts, county offices of education
7–(c-7): Develop a continuity of operations and disaster recovery plan using models such as that developed by the University of California Berkeley. (The American Red Cross has a role in promoting this activity, as well, in schools that they plan to use as shelters.)	High priority, actively looking for funding	School districts, county offices of education

ACTIONS RELATED TO SCHOOLS AS CONDUITS FOR INFORMATION TO FAMILIES ABOUT EMERGENCIES

School districts have a role in assisting with the preparedness and recovery of that larger community. The following strategies relate to the unique role of schools in the community.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-1): Utilize the unique ability of schools to reach families through educational materials on hazards, mitigation, and preparedness, particularly after disasters and at the beginning of the school year. These efforts will not only make the entire community more disaster-resistant, but speed the return of schools from use as shelters to use as teaching facilities, particularly if coordinated with cities, counties, the American Red Cross and others.	Very high priority, unofficial program	School districts, county offices of education
2–(d-2): Develop and distribute culturally appropriate materials related to disaster mitigation and preparedness, such as those on the *http://www.preparenow.org* website.	Existing program	School districts, county offices of education

Chapter 7 – Environment (ENVI)

COMMITMENT: Disaster resistance needs to further environmental sustainability, reduce pollution, strengthen agriculture resiliency, and avoid hazardous material releases in the Bay Area.

Ways to Incorporate Environmental Goals into Hazard Mitigation Policy

The following strategies relate to three ways in which environmental goals mesh with natural hazard mitigation:

- enforcing environmental quality laws and regulations
- initiating climate change strategies
- developing and maintaining resilient agriculture and aquaculture.

Environmental Sustainability and Safety: It is essential that local governments effectively balance the dual goals of environmental protection and hazard mitigation. For example, local governments must continue to enforce State-mandated requirements, such as the California Environmental Quality Act. In addition, they need to work together to develop and implement a comprehensive program for watershed management. Finally, ecosystem preservation is consistent with the preservation of riverine habitats, which is also consistent with preserving areas that may be more likely to be subject to liquefaction in an earthquake and with preserving trees that contribute to reductions in erosion.

Climate Change: The Bay Area is one small part of the Earth. However, by being a leader in striving for reducing hydrocarbon emissions, it can set an example for other regions in the country, as well as contribute directly to emission reductions. Thus, one set of mitigation strategies that follow deal with mitigation of these impacts. (The adaptation strategies for climate change are incorporated into the weather-related strategies discussed in other chapters of this Plan.)

Agricultural Resiliency: Finally, while the Bay Area is often viewed as an urban area, it is also still a vibrant agricultural area. One of the keys to continuing that vibrancy is to improve agricultural resiliency. Such efforts should improve the likelihood that agricultural pests are contained and that early warnings for food contamination are reduced.

Combining Environmental Sustainability and Hazard Mitigation

Creating a region that is both environmentally sustainable and in which significant natural hazards are mitigated will improve the quality of life and the economic resilience of the Bay Area.

Thus, far from being contradictory goals, these two objectives should be viewed as complementary.

It is essential that actions taken to mitigate natural hazards not contribute significantly to environmental degradation. In fact, the most innovative and comprehensive mitigation activities can also create a cleaner, greener, and more sustainable environment. The following strategies seek to ensure these outcomes.

ACTIONS RELATED TO ENVIRONMENTAL SUSTAINABILITY AND POLLUTION REDUCTION

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy ENVI a-1): Continue to enforce State-mandated requirements, such as the California Environmental Quality Act, to ensure that mitigation activities for hazards, such as seismic retrofits and vegetation clearance programs for fire threat, are conducted in a way that reduces environmental degradation such as air quality impacts, noise during construction, and loss of sensitive habitats and species, while respecting the community value of historic preservation.	Existing program	Cities and counties
2–(a-3): Continue to enforce and/or comply with State-mandated requirements, such as the California Environmental Quality Act and environmental regulations to ensure that urban development is conducted in a way to minimize air pollution. For example, air pollution levels can lead to global warming, and then to drought, increased vegetation susceptibility to disease (such as pine bark beetle infestations), and associated increased fire hazard.	Existing program	Cities and counties
3–(a-4): Develop and implement a comprehensive program for watershed management optimizing ecosystem health with water yield to balance water supply, flooding, fire, and erosion concerns.	Under study	Cities, counties, and flood control districts
4–(a-6): Comply with applicable performance standards of any National Pollutant Discharge Elimination System municipal stormwater permit that seeks to manage increases in stormwater run-off flows from new development and redevelopment construction projects.	Existing program	Cities, counties, and flood control districts
5–(a-7): Enforce and/or comply with the grading, erosion, and sedimentation requirements by prohibiting the discharge of concentrated stormwater flows by other than approved methods that seek to minimize associated pollution.	Existing program	Cities, counties, and flood control districts
6–(a-8): Explore ways to require that hazardous materials stored in the flood zone be elevated or otherwise protected from flood waters.	Existing program	Cities and counties
7–(a-9): Enforce and/or comply with the hazardous materials requirements of the State of California Certified Unified Program Agency (CUPA).	Existing program	Cities and counties
8–(a-10): Provide information on hazardous waste disposal and/or drop off locations.	Existing program	Cities and counties

ACTIONS RELATED TO ENVIRONMENTAL SUSTAINABILITY AND HABITAT PRESERVATION

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-5): Balance the need for the smooth flow of storm waters versus the need to maintain wildlife habitat by developing and implementing a comprehensive Streambed Vegetation Management Plan that ensures the efficacy of flood control efforts, mitigates wildfires and maintains the viability of living rivers.	Existing program	Cities, counties, and flood control districts
2–(a-12): Develop and implement a program to control invasive and exotic species that contribute to fire and flooding hazards (such as eucalyptus, cattails, and cordgrass). This program could include vegetation removal, thinning, or replacement in hazard areas where there is a direct threat to structures.	Existing program, underfunded	Cities, counties, and flood control districts
3–(a-13): Enforce provisions under creek protection, stormwater management, and discharge control ordinances designed to keep watercourses free of obstructions and to protect drainage facilities to conform with the Regional Water Quality Control Board's Best Management Practices.	Existing program, underfunded	Cities, counties, and flood control districts

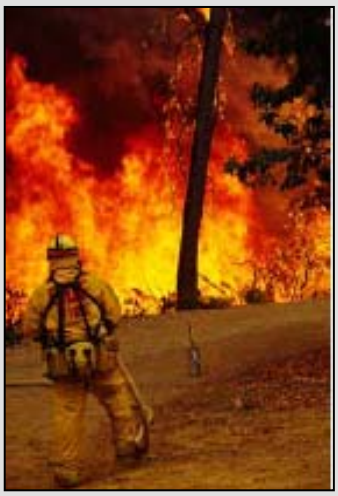
ACTIONS RELATED TO ENVIRONMENTAL SAFETY

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-2): Encourage regulatory agencies to work collaboratively with safety professionals to develop creative mitigation strategies that effectively balance environmental and safety needs, particularly to meet critical wildfire, flood, and earthquake safety levels.	Existing program	Cities and counties
2–(a-11): When remodeling existing government and infrastructure buildings and facilities, remove asbestos to speed up clean up of buildings so that they can be reoccupied more quickly.	Under study	Cities, counties, regional agencies and special districts

Climate Change

The earth's climate has been warming due to the emission of greenhouse gases. These gases are primarily the result of the burning of fossil fuels (such as gasoline and diesel in our cars and trucks, as well as coal and other petrochemical products used to produce electricity and in industrial production). These processes produce emissions of carbon dioxide and other pollutants.

Impact of climate change on natural hazards



Wildfires – According to analyses performed by scientists at the Lawrence Berkeley National Laboratory (LBNL), "Climatic change would cause fires to spread faster and burn more intensely in most vegetation types. The biggest impacts were seen in grassland, where the fastest spread rates already occur. In forests, where fires move much more slowly, impacts would be less severe. The reason that faster fuels respond more is that fire behavior in these fuels is more sensitive to wind speed and elevated wind speed during fire season was a striking feature of the changed climate weather data. The response of chaparral and oak woodlands fell between that of grass and forest." [1]

The scientists studied Santa Clara County and predict a 51% increase in the number of fires that escape, as well as a 41% increase in the amount of acres burned in the average "contained" fire.

The scientists also note: "In a feedback with potentially alarming consequences, wildfires may create conditions that set the stage for subsequent wildfires. … More frequent or extensive fires would mean more land area covered by grass and shrub vegetation. These ecosystems show the greatest susceptibility to fire, and also the greatest response to climatic change."

Flooding – According to analyses performed by scientists at LBNL, peak flows on the American River will be a month earlier (in February rather than March) due to increased early-season snowmelt and a higher snowline.

In an associated press release, Dr. Norman Miller notes that "the results suggest that 50 percent of the season runoff will have occurred early in the year for many snow melt driven watersheds in the west, and the resulting early snow melt implies higher stream flow increases and an increased likelihood of more flood events in future years." [2]

Sea Level Rise – Based on research conducted by scientists at the U.S. Geological Survey, a sea level rise of 20 – 80 cm over the next century will affect the shoreline of the Bay and Delta, and increase the risk of levee failures.[3] While most potentially inundated areas are inter-tidal, other areas are not, particularly those areas along the Bay shoreline and in the inner and outer Delta areas currently protected by levees. Many of these areas are currently farmland, but key bridge and aqueduct supports, airport, and port facilities are also at risk.

---

[1] Torn, M.S., Mills, E., and Fried, J., 1998. "Will Climate Change Spark More Wildfire Damage?" LBNL Report No. 42592.

[2] Miller, N., 2003. "California Climate Change, Hydrologic Response, and Flood Forecasting" presented at the International Expert Meeting on Urban Flood Management, November 2003, The World Trade Center, Rotterdam. LBNL Repot No. 54041.

[3] Knowles, N., 2006. "Projecting Inundation Due to Sea Level Rise in the San Francisco Bay and Delta" presented at the Third Annual Climate Change Research Conference, September 2006, Sacramento, California.

ACTIONS APPLYING TO CLIMATE CHANGE

In the 2005 version of this multi-jurisdictional Local Hazard Mitigation Plan, the conclusion was that climate change should be studied and monitored, but that no specific actions related to climate change should occur at that time. In this version of the MJ-LHMP, the original strategy related to keeping informed has been retained. However, twelve specific strategies have been added. They are identical to those of the U.S. Conference of Mayors' Climate Protection Agreement and are intended as a commitment of cities and other local governments to strive to meet or exceed Kyoto Protocol targets for reducing global warming pollution by taking actions in their own operations and communities.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-1): Stay informed of scientific information compiled by regional and state sources on the subject of rising sea levels and global warming, especially on additional actions that local governments can take to mitigate this hazard including special design and engineering of government-owned facilities in low-lying areas, such as wastewater treatment plants, ports, and airports.	Existing program	Cities, counties, regional agencies and special districts
2–(b-2): Inventory global warming emissions in your own local government's operations and in the community, set reduction targets and create an action plan.	Existing program	Cities, counties, regional agencies and special districts
3–(b-3): Adopt and enforce land-use policies that reduce sprawl, preserve open space, and create compact, walkable urban communities.	Existing program, underfunded	Cities, counties, and regional agencies
4–(b-4): Promote transportation options such as bicycle trails, commute trip reduction programs, incentives for car pooling and public transit.	Existing program, underfunded	Cities, counties, and regional agencies
5–(b-5): Increase the use of clean, alternative energy by, for example, investing in "green tags", advocating for the development of renewable energy resources, recovering landfill methane for energy production, and supporting the use of waste to energy technology.	Existing program, underfunded	Cities and counties
6–(b-6): Make energy efficiency a priority through building code improvements, retrofitting city facilities with energy efficient lighting and urging employees to conserve energy and save money.	Existing program, underfunded	Cities, counties, regional agencies and special districts
7–(b-7): Purchase only Energy Star equipment and appliances for local government use.	Existing program, underfunded	Cities, counties, regional agencies and special districts
8–(b-8): Practice and promote sustainable building practices using the U.S. Green Building Council's LEED program or a similar system.	Existing program, underfunded	Cities, counties, regional agencies and special districts
9–(b-9): Increase the average fuel efficiency of municipal fleet vehicles; reduce the number of vehicles; launch an employee education program including anti-idling messages; convert diesel vehicles to bio-diesel.	Existing program, underfunded	Cities, counties, regional agencies and special districts

10–(b-10): Evaluate opportunities to increase pump efficiency in water and wastewater systems; recover wastewater treatment methane for energy production.	Existing program, underfunded	Cities, counties, water and wastewater agencies
11–(b-11): Increase recycling rates in local government operations and in the community.	Existing program, underfunded	Cities and counties
12–(b-12): Maintain healthy urban forests; promote tree planting to increase shading and to absorb CO2.	Existing program, underfunded	Cities and counties
13–(b-13): Help educate the public, schools, other jurisdictions, professional associations, business and industry about reducing global warming pollution.	Existing program, underfunded	Cities and counties

Agricultural and Aquaculture Resilience

Several of the disasters in the Bay Area in the last few decades are related to heat and insect infestation, particularly as they relate to agricultural production.

When there is an agricultural emergency, it remains necessary to comply with CEQA. In addition, the State may issue special regulations for local governments.

Policies related to agriculture and aquaculture instituted by county offices of the Agricultural Commissioner and county health departments do have a role to play, as identified in the following three strategies

Actions Related to Crop Diversity and Resiliency

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-1): Maintain a variety of crops in rural areas of the region to increase agricultural diversity and crop resiliency.	Moderate priority	County Offices of the Agricultural Commissioner.
2–(c-2): Promote and maintain the public-private partnerships dedicated to preventing the introduction of agricultural pests into regionally-significant crops, such as the glassy-winged sharpshooter into vineyards.	Existing program	County Offices of the Agricultural Commissioner.
3–(c-3): Encourage livestock operators to develop an early-warning system to detect animals with communicable diseases (due to natural causes or bioterrorism).	Existing program	County Health Department and Office of the County Agricultural Commissioner.

Chapter 8 – Land Use (LAND)

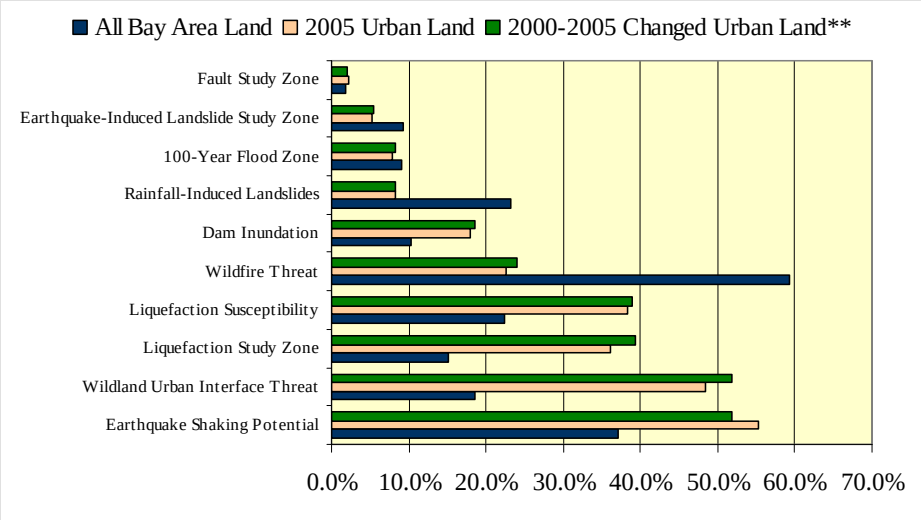
COMMITMENT: Land use change needs to be accompanied by a respect for hazardous areas and facilities, as well as recognize the interconnected nature of the Bay Area.

The Bay Area is growing in hazard areas.

From 2000 to 2005, Bay Area added 312,738 people and 117,060 new households. Urban land* totaled 1,075,200 acres in 2000. The region added 63,700 acres of new or significantly denser urban development from 2000 to 2005. The Bay Area is projected to continue to grow, adding 1,977,200 more people, 719,700 new households, and 1,657,650 new jobs between 2005 and 2035 (Source: ABAG's **Projections 2009** and ABAG's **Existing Land Use in 2005**).

This growth continues to place increasing pressure on the region to expand urban development, both by increasing the density of areas of existing urban and inner suburban housing, and by the conversion of agricultural and grazing lands to suburban development.

As shown on the following graph, during the period from 2000 to 2005, we continued to build in hazardous areas – in spite of numerous regulations. Part of the reason for this trend is that we are convinced that actions, such as those identified in Chapter 3-Housing and Chapter 4-Economy, can be taken to mitigate the impacts of those hazards.



For example, while **22.3%** of the region's land is subject to liquefaction (based on **2000** liquefaction susceptibility mapping), **39.9%** of the land newly developed or redeveloped from 2000-2005 is in these areas. In addition, while **18.5%** of the region's land is in a wildland-urban-interface (WUI) fire threat area (again, based on mapping available **at that time**), amazingly, **51.8%** of the land newly developed or redeveloped from 2000-2005 is in these areas.

---

* Urban land is non-agricultural developed land, that is, residential, commercial, industrial, infrastructure, military, and public/institutional uses.

** See Appendix E for definitions of areas on maps defined as "hazard areas" and for more specific information on land use and land use change in these areas. The maps used for this analysis were maps available in 2005 because they would have been available at that time to guide land use decisions. Thus, the most current hazard maps were not used in this assessment.

Ways to improve disaster-resistance in hazard areas.

While the best solution would be to completely avoid hazardous areas, this is not always practical in urban areas. Therefore, the State of California, in a desire to build more disaster-resistant communities and create more environmentally-sensitive growth, has adopted building and fire codes, as well as three laws related to land use and disaster mitigation.

Building codes, fire codes, and landslide mitigation can mitigate the effects of these hazards, but cannot eliminate the threat of damage – no building is earthquake, fire or flood "proof".

It is essential that local governments not only implement existing state laws, but also institute additional local regulations, particularly related to hillside areas and areas next to the Bay on Bay mud.

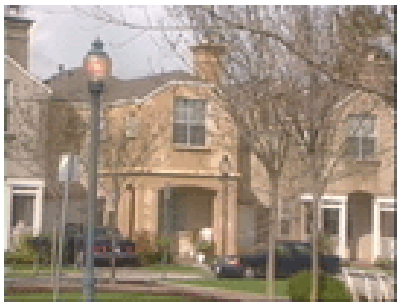
The following pages list some of the types of regulations and policy strategies that local governments can use to mitigate the increased hazard exposure associated with building in areas subject to earthquake, wildfires, flooding, and landslides.

Certain Mitigation Practices Apply to All Hazards

Land use planning can effectively mitigate the risks from multiple hazards simultaneously. For example, limiting growth in outlying areas is a useful tool for promoting sustainable practices as well as reducing risk to wildfire, landslides and flooding.

Similarly, zoning laws to limit development on hillsides has the dual benefits of reducing risks from landslides and wildfires. Funding of hazard mitigation efforts for any natural hazard can be taken on by a local community or neighborhood collectively.

ACTIONS RELATED TO SMART GROWTH



Smart Growth programs are intended to revitalize urban areas and promote sustainability **as an alternative to developing in outlying and hazard-prone areas**. ABAG and the other regional agencies in the region, including the Metropolitan Transportation Commission (MTC) and the Bay Area Air Quality Management District, have adopted polices to promote Smart Growth. In addition, boards of supervisors of all nine Bay Area counties and city councils of 66 of the regions cities have taken action in support of the objectives of the Bay Area Alliance for Sustainable Communities, is a multi-stakeholder coalition established in 1997 to develop and implement an action plan that will lead to a more sustainable region. The following strategies meld Smart Growth and sustainability concepts with hazard mitigation.

Strategy	*Regional Priority*	*Responsible Agency*
1–(Strategy LAND f-1): Prioritize retrofit of infrastructure that serves urban areas (or urban services areas) over constructing new infrastructure to serve outlying areas.	Existing program	Cities, counties, transit districts with fixed lines, and water/sewer agencies
2–(f-2): Work to retrofit homes in older urban neighborhoods to provide safe housing close to job centers.	Existing program, underfunded	Cities and counties
3–(f-3): Work to retrofit older downtown areas and redevelopment districts to protect architectural diversity and promote disaster-resistance.	Existing program, underfunded	Cities and counties
4–(f-4): Work with non-profits and through other mechanisms to protect as open space those areas susceptible to extreme hazards (such as through land acquisition, zoning, and designation as priority conservation areas).	Existing program, underfunded	Cities and counties
5–(f-5): Strive to provide and preserve existing buffers between development and existing users of large amounts of hazardous materials, such as major industry, due to the potential for catastrophic releases or fires due to an earthquake, accident, or terrorism. (Flooding might also result in release or spread of these materials; however, it is unlikely.) In areas where buffers do not exist or cannot be created, provide alternative mitigation.	Under study	Cities and counties

ACTIONS RELATED TO HILLSIDE DEVELOPMENT

Hillside development can be problematic due to the potential hazards of wildfire and landsliding. However, the pressure to convert hillside areas to urban uses is great in inner suburban communities that have no remaining non-urban land, as well as in communities actively preserving agricultural land (particularly in the North Bay where vineyards are prevalent). The following tools to mitigate risks are available to local governments.

Strategy	*Regional Priority*	*Responsible Agency*
1–(e-1): For new development, require a buffer zone between residential properties and landslide or wildfire hazard areas.	Existing program	Cities and counties
2–(e-2): Discourage, add additional mitigation strategies, or prevent new construction or major remodels on slopes greater than a set percentage, such as 15%, due to landslide or wildfire hazard concerns.	Existing program	Cities and counties

ACTIONS RELATED TO HAZARD ABATEMENT FUNDING

Mitigating hazards through land use changes is a process that can take time and money. Often, the hazard is not limited to one governmental jurisdiction. On a smaller scale neighbors may want to pool resources to implement and enforce mitigation techniques for common hazards. This mechanism can allow high risk areas to develop reserve funds to mitigate their hazards at no cost to the city or county. Use of Geologic Hazard Abatement Districts also allows the sale of public bonds to mitigate hazards on private property (such as: construct a retaining wall on private property for public good without purchasing property), all other assessment districts cannot use their funds in this way. The use of abatement districts is currently limited in the Bay Area, but more widespread use could be a very effective way to mitigate locally significant hazards. The following strategy provides a funding mechanism for mitigating hazards at a local level.

Strategy	*Regional Priority*	*Responsible Agency*
1–(g-1): Use hazard abatement districts as a funding mechanism to ensure that mitigation strategies are implemented and enforced over time.	Under study	Cities and counties

Some Earthquake Hazards Can Be Mitigated Through Laws and Regulations on Land Use

Several California State laws deal directly with land use and earthquake mitigation. These laws restrict development in areas near an earthquake fault or where there are other mapped hazards, such as liquefaction and landslides.

Many other regulations have been adopted by local governments to mitigate specific hazards in their jurisdiction. Some additional regulations have not yet been considered in the Bay Area, but may be very effective in mitigating the risk from earthquakes.

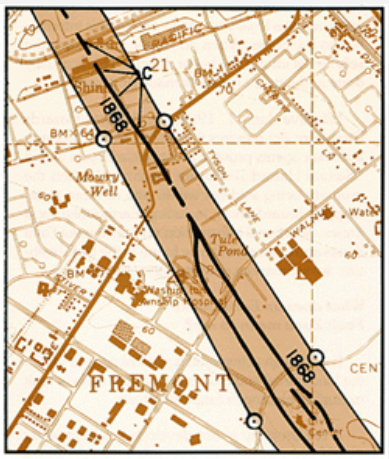
LOCAL ENFORCEMENT OF STATE LAWS APPLYING TO EARTHQUAKE GROUND FAILURE

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-1): Enforce and/or comply with the State-mandated requirement that site-specific geologic reports be prepared for development proposals within Alquist-Priolo Earthquake Fault Zones, and restrict the placement of structures for human occupancy. (This Act is intended to deal with the *specific* hazard of active faults that extend to the earth's surface, creating a surface rupture hazard.)	Existing program	Cities and counties with mapped surface fault rupture hazard.

The ***Alquist-Priolo Earthquake Fault Zoning Act*** of 1972 was passed by the legislature as a result of the San Fernando earthquake in southern California. This Act is intended to deal with the specific hazard of active faults that extend to the earth's surface, creating a ***surface rupture hazard***. The Act requires that the State Geologist (the head of the California Geological Survey – CGS) designate zones approximately ¼-mile wide along known active faults.

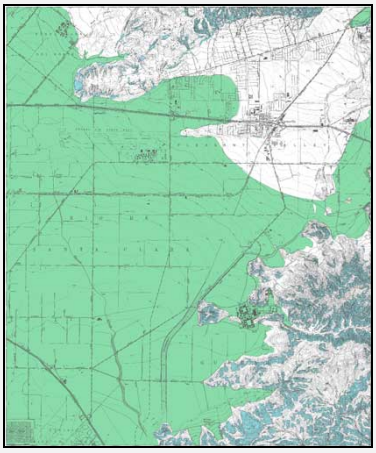
Within these zones, site-specific geologic reports must be prepared for development proposals (except for housing developments of less than four units or not involving structures intended for human occupancy). Alternations and additions to non-residential property that exceed 50% of the property value are also covered by this Act. Typically, at a minimum, structures intended for human occupancy cannot be placed within 50 feet of an active fault trace.

Finally, the Act requires disclosure to potential buyers in these zones. Every city and county with a mapped surface rupture hazard is required to implement this Act. In 2009, this included eight counties (all but San Francisco) and 31 cities in the Bay Area.



2–(a-2): Require preparation of site-specific geologic or geotechnical reports for development and redevelopment proposals in areas subject to earthquake-induced landslides or liquefaction as mandated by the State Seismic Hazard Mapping Act in selected portions of the Bay Area where these maps have been completed, and condition project approval on the incorporation of necessary mitigation measures related to site remediation, structure and foundation design, and/or avoidance.	Existing program	Cities and counties with mapped hazards

The ***Seismic Hazards Mapping Act*** of 1990 requires the preparation of site-specific geotechnical reports for development proposals in areas identified as Zones of Required Investigation for ***earthquake-induced landslides or liquefaction*** as designated by the State Geologist. Cities and Counties are also required to incorporate the Official Seismic Hazard Zone Maps into their Safety Elements. Lastly, the Seismic Hazards Mapping Act, as well as the Natural Hazard Disclosure Statement, requires sellers of real property to disclose to buyers if property is within a Zone of Required Investigation. Due to funding, Seismic Hazard Zone maps have only been completed in selected portions of the Bay Area. As maps become available, affected cities and counties are required to enforce the preparation of these reports and condition project approval on the incorporation of necessary mitigation measures related to site remediation, structure and foundation design, and/or avoidance. In 2005, San Francisco and parts of Alameda, Contra Costa, San Mateo, and Santa Clara counties, as well as 43 cities had hazards mapped by CGS.



LOCAL REGULATIONS APPLYING TO EARTHQUAKES

The Bay Area has been a leader in earthquake mitigation techniques that go above and beyond state requirements. These strategies help contribute to our goal of creating a disaster resistant region. The following strategies exemplify these policies.

Strategy	*Regional Priority*	*Responsible Agency*
1–(a-3): Recognizing that some faults may be a hazard for surface rupture, even though they do not meet the strict criteria imposed by the Alquist-Priolo Earthquake Fault Zoning Act, identify and require geologic reports in areas adjacent to locally-significant faults.	Existing program	Cities and counties
2–(a-6): Recognizing that the California Geological Survey has not completed earthquake-induced landslide and liquefaction mapping for much of the Bay Area, identify and require geologic reports in areas mapped by others as having significant liquefaction or landslide hazards.	Existing program	Cities and counties
3–(a-7): Support and/or facilitate efforts by the California Geological Survey to complete the earthquake-induced landslide and liquefaction mapping for the Bay Area.	Existing program	Cities and counties
4–(a-8): Require that local government reviews of geologic and engineering studies are conducted by appropriately trained and credentialed personnel.	Existing program	Cities and counties
5–(a-4): Ensure that development proposed near faults with a history of complex surface rupture (multiple traces, warping, thrusting, etc.) has larger setbacks than the minimum fifty feet.	Under study	Cities and counties
6–(a-5): Consider imposing requirements similar to the Alquist-Priolo Earthquake Fault Zoning Act for structures without human occupancy if these buildings are still essential for the economic recovery of the community or region.	Under study	Cities and counties

Weather-related hazards.

Risks from wildfire, flooding and landslides can be effectively mitigated through land use policies. As the Bay Area continues to grow the pressure to develop in hazardous areas will increase.

Avoiding construction in these areas is an effective tool to mitigate disasters. For existing development in hazardous areas, evacuation planning can help manage the risk posed from these weather-related hazards.

ACTIONS RELATED TO WILDFIRE AND STRUCTURAL FIRES

Dry summer conditions combined with increasing encroachment of urban lands into the wilderness in the Bay Area make wildfires a dangerous hazard in much of the Bay Area. The following mitigation strategies are available to local governments to mitigate wildfire risks through land use and planning. Other strategies related to road access, power lines, and water supplies are covered in Chapter 1-Infrastructure. Strategies related to fire-resistant construction are covered in Chapter 3-Housing and Chapter 4-Economy.

Strategy	*Regional Priority*	*Responsible Agency*
1–(b-1): Review new development proposals to ensure that they incorporate required and appropriate fire-mitigation measures, including adequate provisions for occupant evacuation and access by emergency response personnel and equipment.	Existing program	Cities and counties
2–(b-2): Develop a clear legislative and regulatory framework at both the state and local levels to manage the wildland-urban-interface consistent with *Fire Wise* and sustainable community principles.	Existing program	Cities and counties

ACTIONS RELATED TO FLOODING

Local government can also mitigate flooding hazards using one or more of the following strategies.

Strategy	*Regional Priority*	*Responsible Agency*
1–(c-1): Establish and enforce requirements for new development so that site-specific designs and source-control techniques are used to manage peak storm water runoff flows and impacts from increased runoff volumes.	Existing program	Cities and counties
2–(c-2): Incorporate FEMA guidelines and suggested activities into local government plans and procedures for managing flood hazards.	Existing program	Cities and counties
3–(c-3): Provide an institutional mechanism to ensure that development proposals adjacent to floodways and in floodplains are referred to flood control districts and wastewater agencies for review and comment (consistent with the NPDES program).	Existing program	Cities and counties
4–(c-4): Establish and enforce regulations concerning new construction (and major improvements to existing structures) within flood zones in order to be in compliance with federal requirements and, thus, be a participant in the Community Rating System of the *National Flood Insurance Program*.	Existing program	Cities and counties
5–(c-5): Encourage new development near floodways to incorporate a buffer zone or setback from that floodway to allow for changes in storm water flows in the watershed over time.	Very high priority	Cities and counties

6–(c-6): For purposes of creating an improved hazard mitigation plan for the region as a whole, ABAG, and Bay Area cities and counties, jointly request geographically defined repetitive flooding loss data from FEMA for their own jurisdictions.	NFIP program, very high priority	Cities and counties

Repetitive loss data is collected by FEMA annually for all properties for which two or more losses of at least $1000 has been paid by the National Flood Insurance Program (NFIP) within any 10-year period since 1978. While the names of policyholders or recipients of financial assistance and the amount of their claim payment or assistance are protected under the Privacy Act of 1974, the location of the properties is not protected. Mapping this data at a scale which is viewable at the neighborhood level, but not necessarily individual streets is very useful to cities and counties planning flood mitigation programs and for identifying areas prone to flooding which may not be identifiable on a floodplain map. All counties in the Bay Area except for San Francisco participate in the NFIP program. **Repetitive loss information, however, does not make its way back to the cities on a consistent basis.**

ACTIONS RELATED TO LANDSLIDES AND EROSION

Finally, local governments can establish regulations mitigating rainfall-induced landsliding hazards and erosion.

Strategy	*Regional Priority*	*Responsible Agency*
1–(d-1): Establish and enforce provisions (under subdivision ordinances or other means) that geotechnical and soil-hazard investigations be conducted and filed to prevent grading from creating unstable slopes, and that any necessary corrective actions be taken prior to development approval.	Existing program	Cities and counties
2–(d-2): Require that local government reviews of these investigations are conducted by appropriately trained and credentialed personnel.	Existing program	Cities and counties
3–(d-3): Establish and enforce grading, erosion, and sedimentation ordinances by requiring, under certain conditions, grading permits and plans to control erosion and sedimentation prior to development approval.	Existing program	Cities and counties
4–(d-4): Establish and enforce provisions under the creek protection, storm water management, and discharge control ordinances designed to control erosion and sedimentation.	Existing program	Cities and counties
5–(d-5): Establish requirements in zoning ordinances to address hillside development constraints, especially in areas of existing landslides.	Existing program	Cities and counties

PHOTO CREDITS – ABAG–page 8-1 and page 8-2; USGS–page 8-3; CGS–page 8-4; CalFIRE–page 8-6; EPA–page 8-7; USGS–page 8-8.

Plate 1

Alquist-Priolo Earthquake Fault Zones

Earthquake Fault Zones

- San Andreas-North Golden Gate
- San Andreas -- Peninsula
- San Andreas -- Santa Cruz
- Rodgers Creek
- North Hayward
- South Hayward
- Northern Calaveras
- Central Calaveras
- Sargent
- Maacama
- West Napa
- Concord/Green Valley
- Greenville
- Northern San Gregorio
- Major Roads
- Local Roads
- Water

N

Scale: 1 inch equals 18.52 miles

Reproduced with permission, California Geological Survey from CD-ROM 2001-04 (2001), Official Map of Alquist-Priolo Earthquake Fault Zones

This interactive map was created using digital files of AP EFZ quadrangles and is considered an electronic facsimile of the Official Alquist-Priolo Earthquake Fault Zone map. If there is any doubt or conflict with respect to the location of EFZ boundaries, the original clear-film overlay compiled by and on file with CGS is the official version of the map. Fault information in these digital files is not sufficient to serve as a substitute for the geological site studies required under Chapter 7.5 of Division 2 of the California Public Resources Code.

For more information visit:
http://www.consrv.ca.gov/CGS/rghm/ap/

This map is available at:
http://quake.abag.ca.gov/

ABAG Geographic Information Systems

Plate 2

San Andreas-North Golden Gate Earthquake - Magnitude 7.5

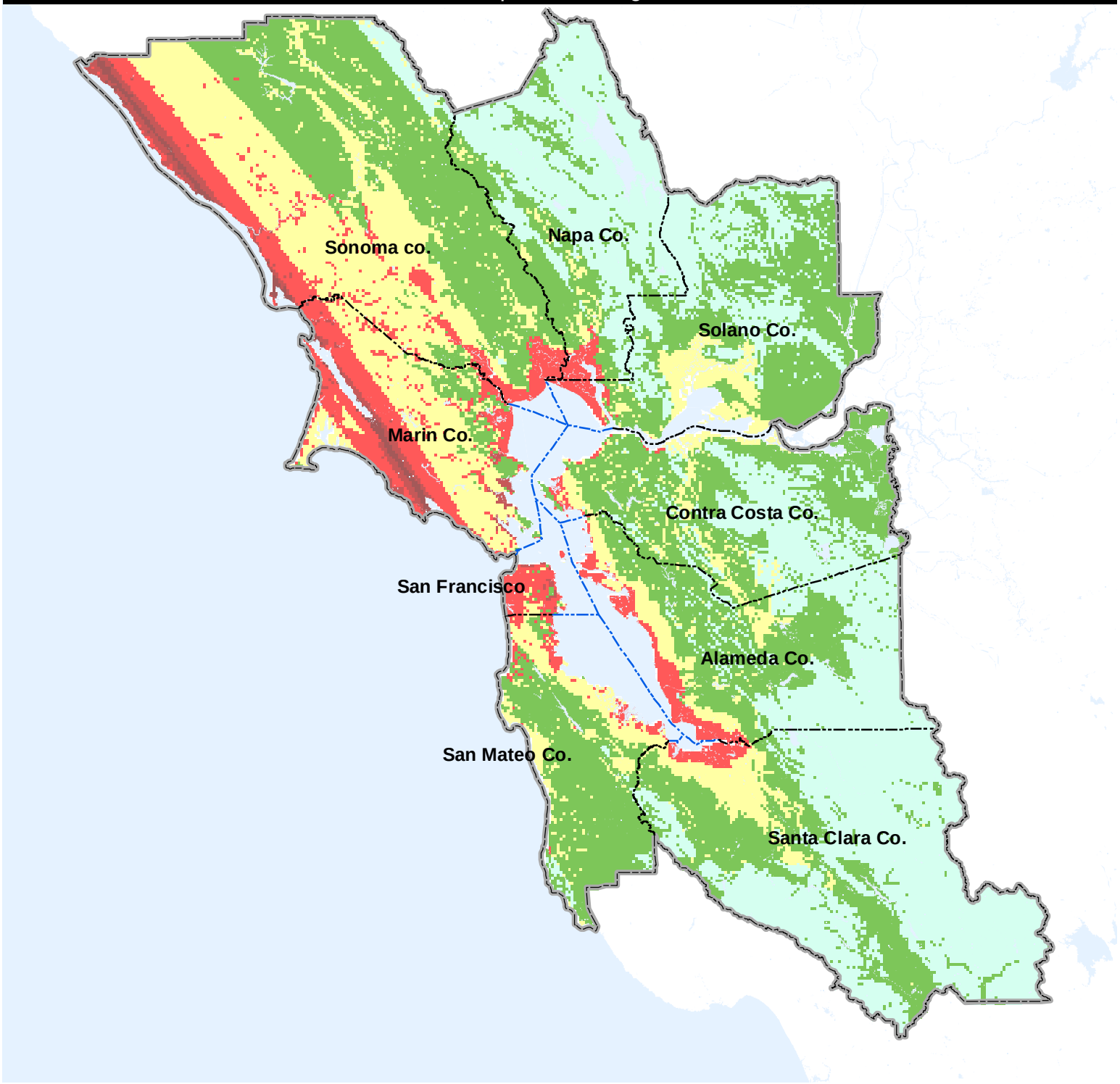
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 3

ABAG
Earthquake Shaking Scenario

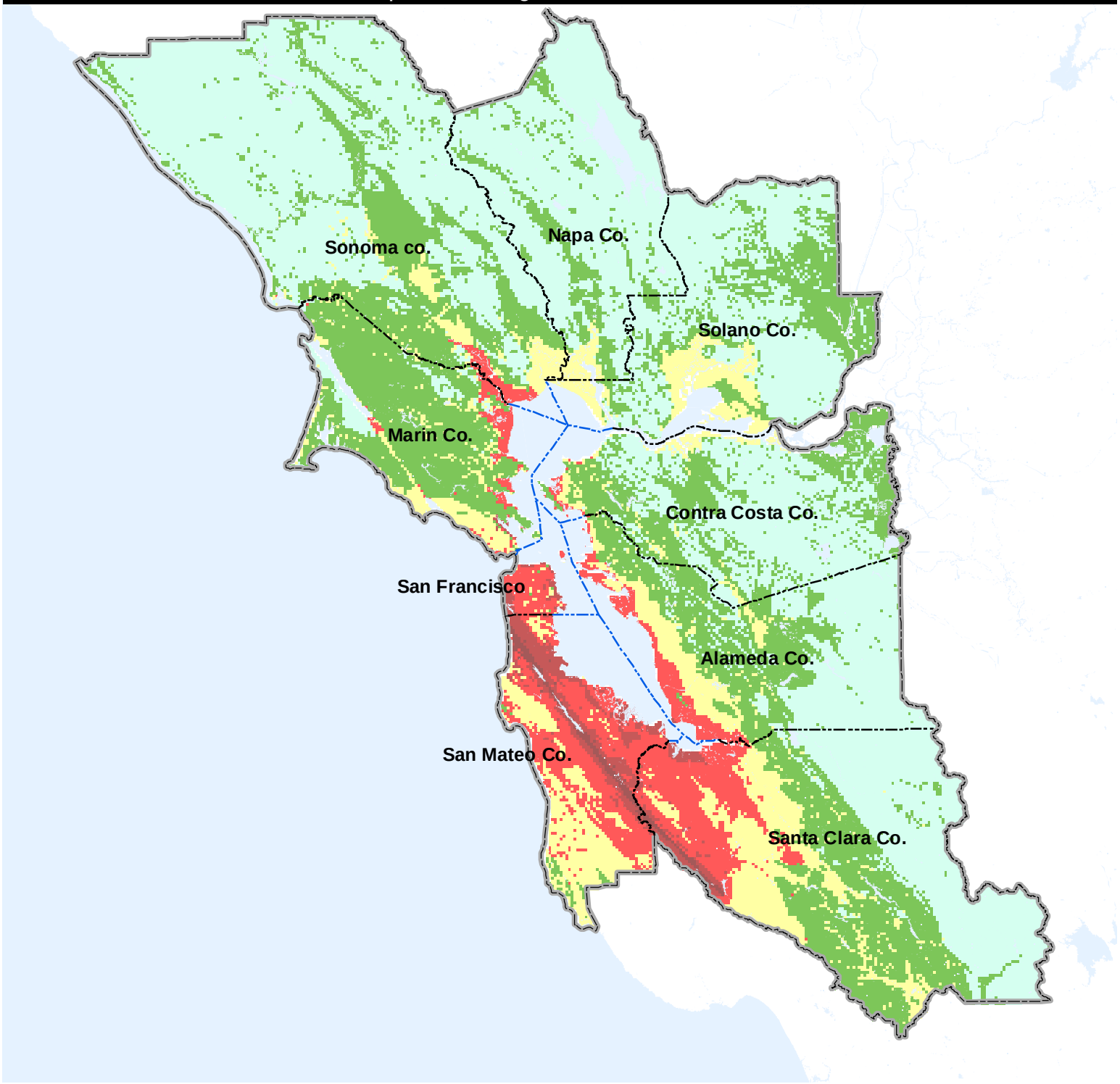
San Andreas-Peninsula Earthquake - Magnitude 7.2

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 4

Model of the 1989 Loma Prieta Earthquake - Magnitude 6.9

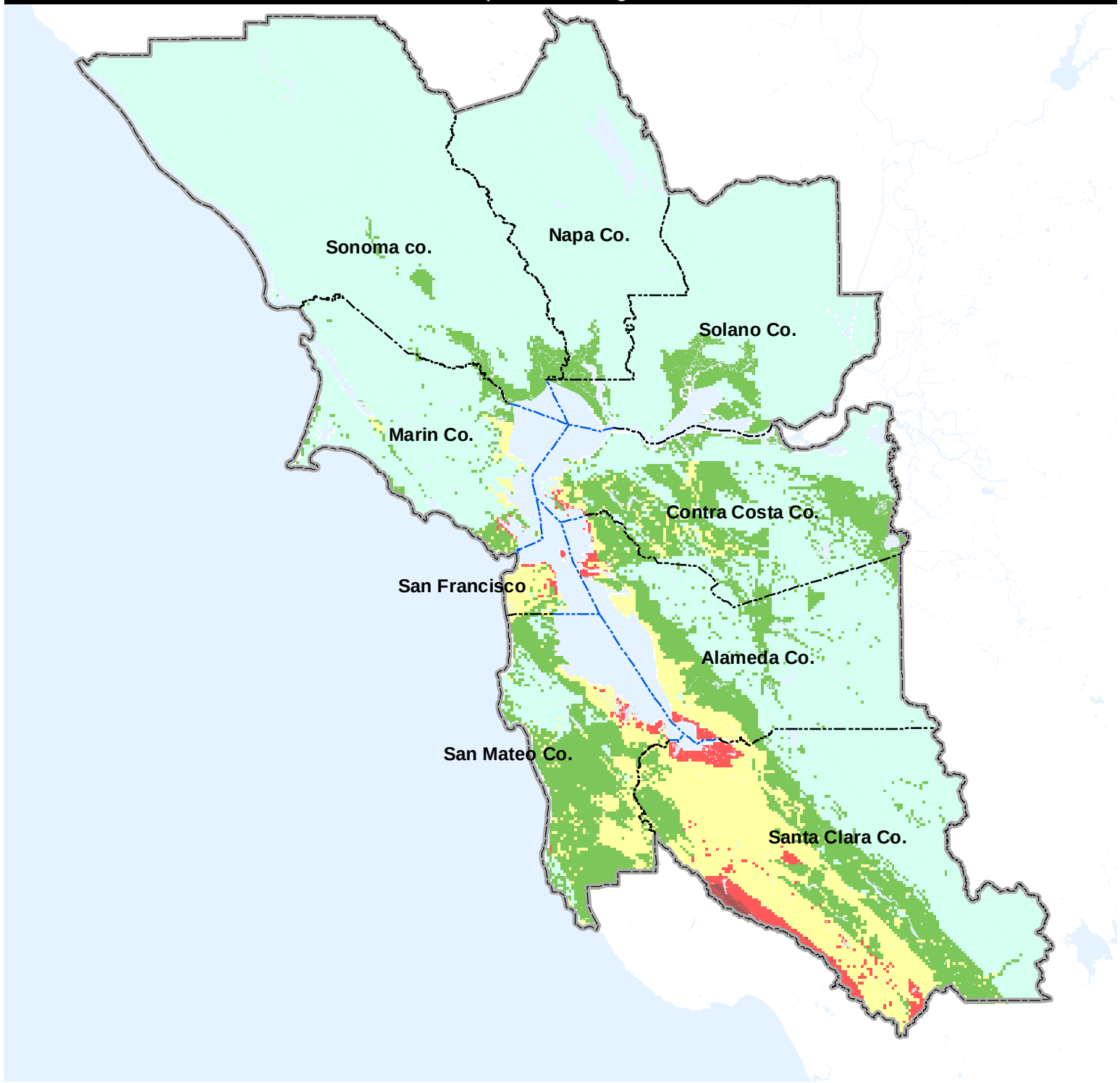
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 5

ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

Scale: 1 inch equals 18.31 miles

This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Entire San Andreas (1906 Quake) - Magnitude 7.9

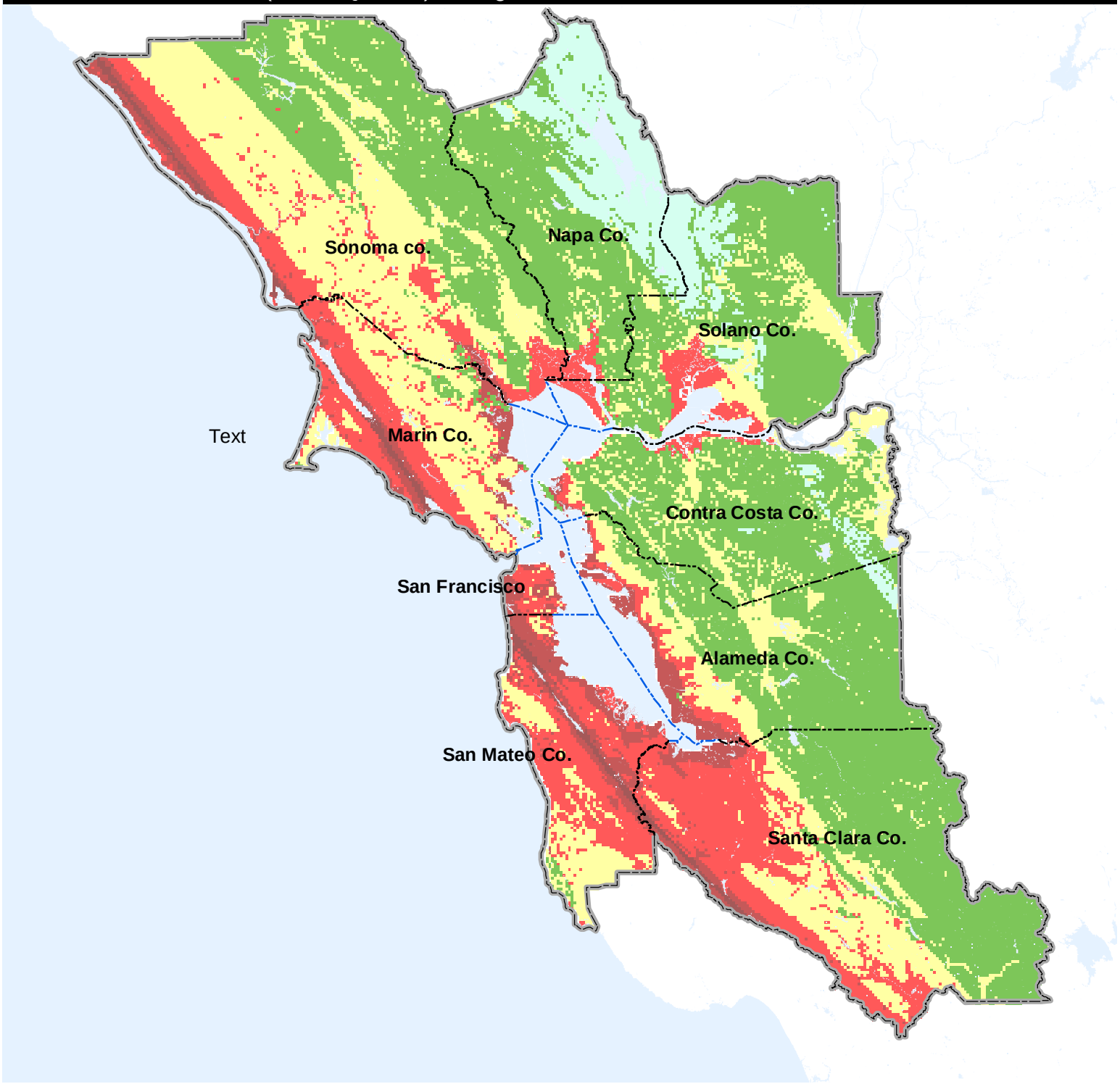


Plate 6

Rodgers Creek Earthquake - Magnitude 7.0

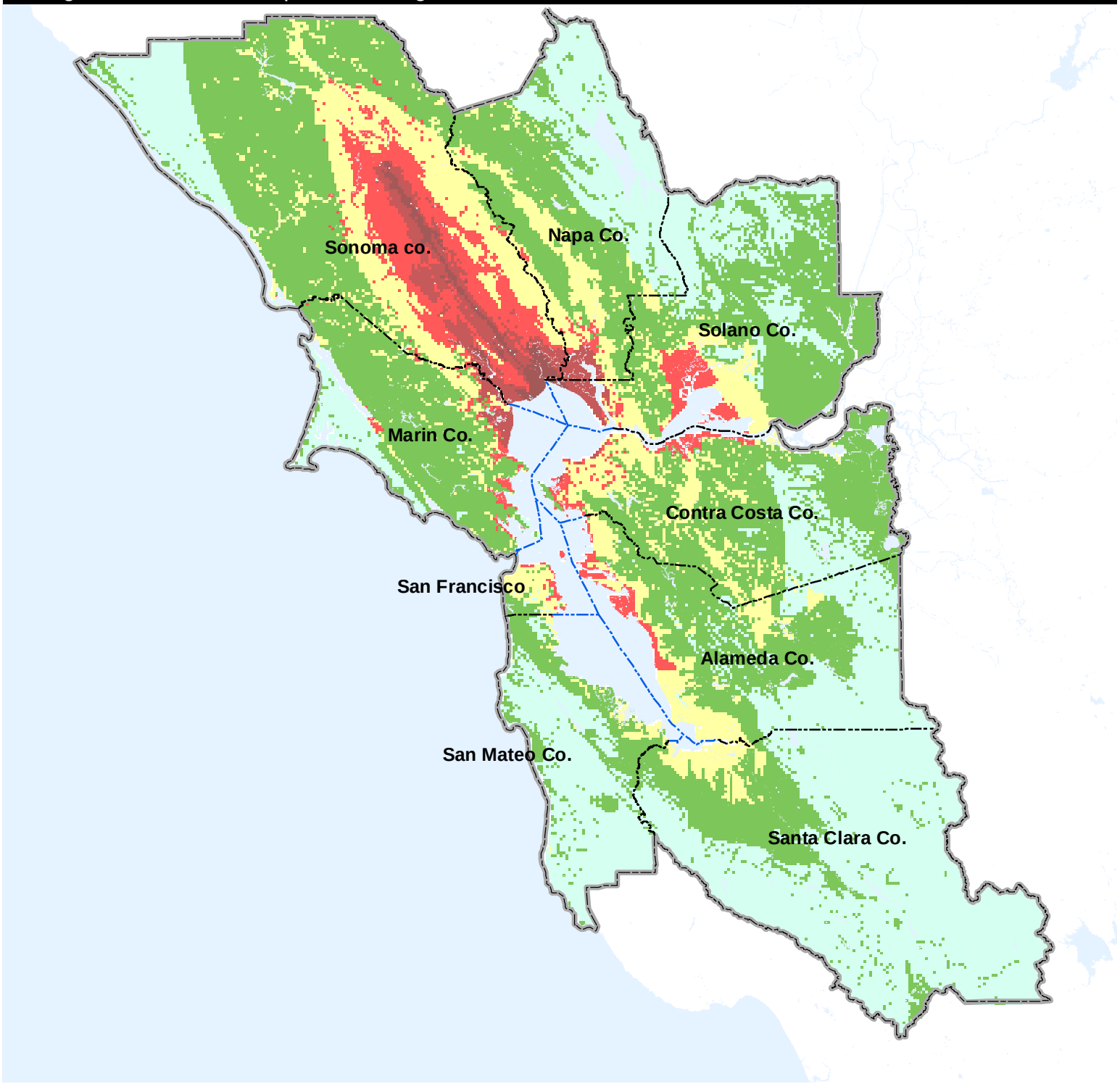
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 7

Rodgers Creek and North Hayward Earthquake - Magnitude 7.1

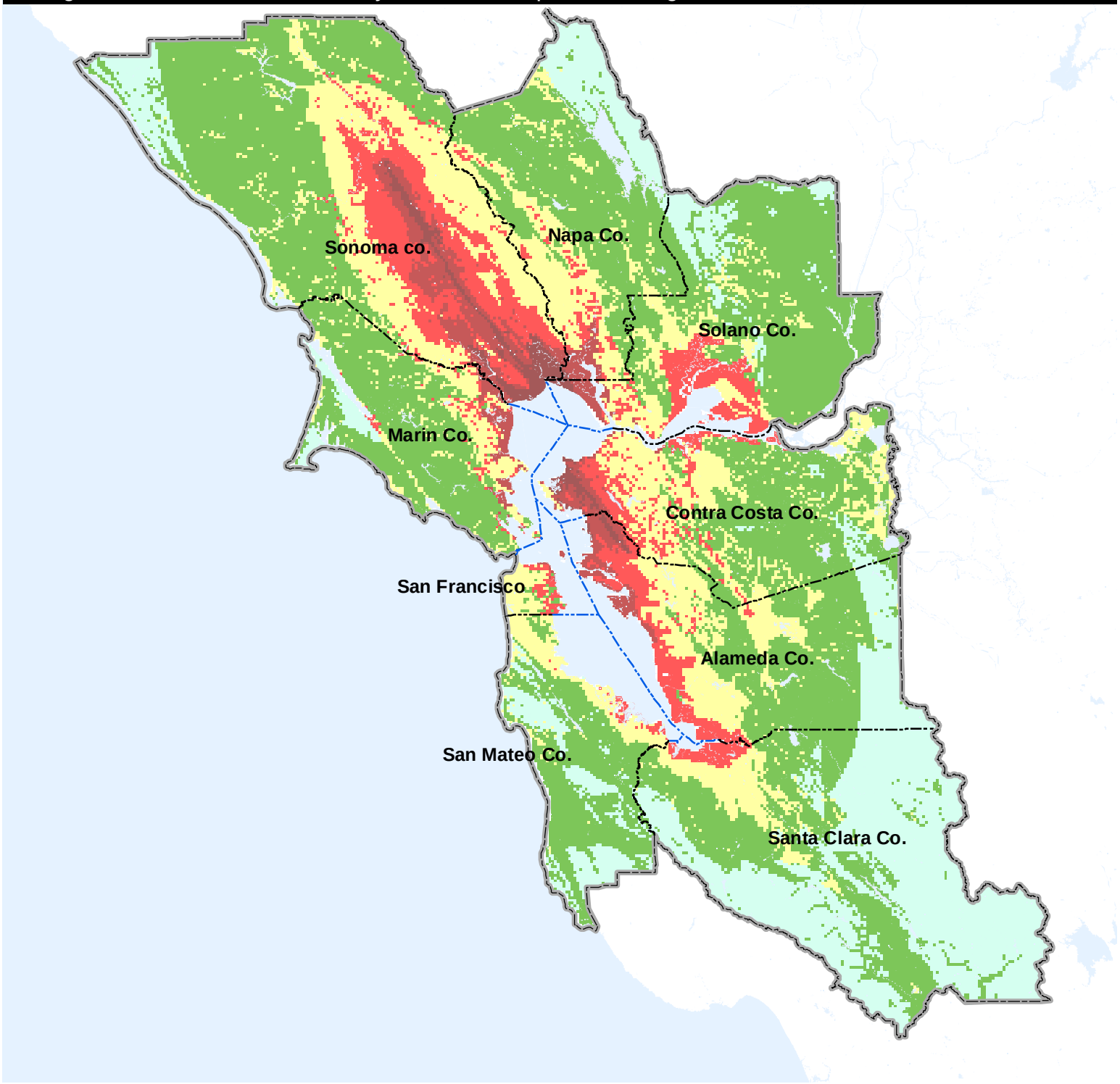
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 8

North Hayward Earthquake - Magnitude 6.5

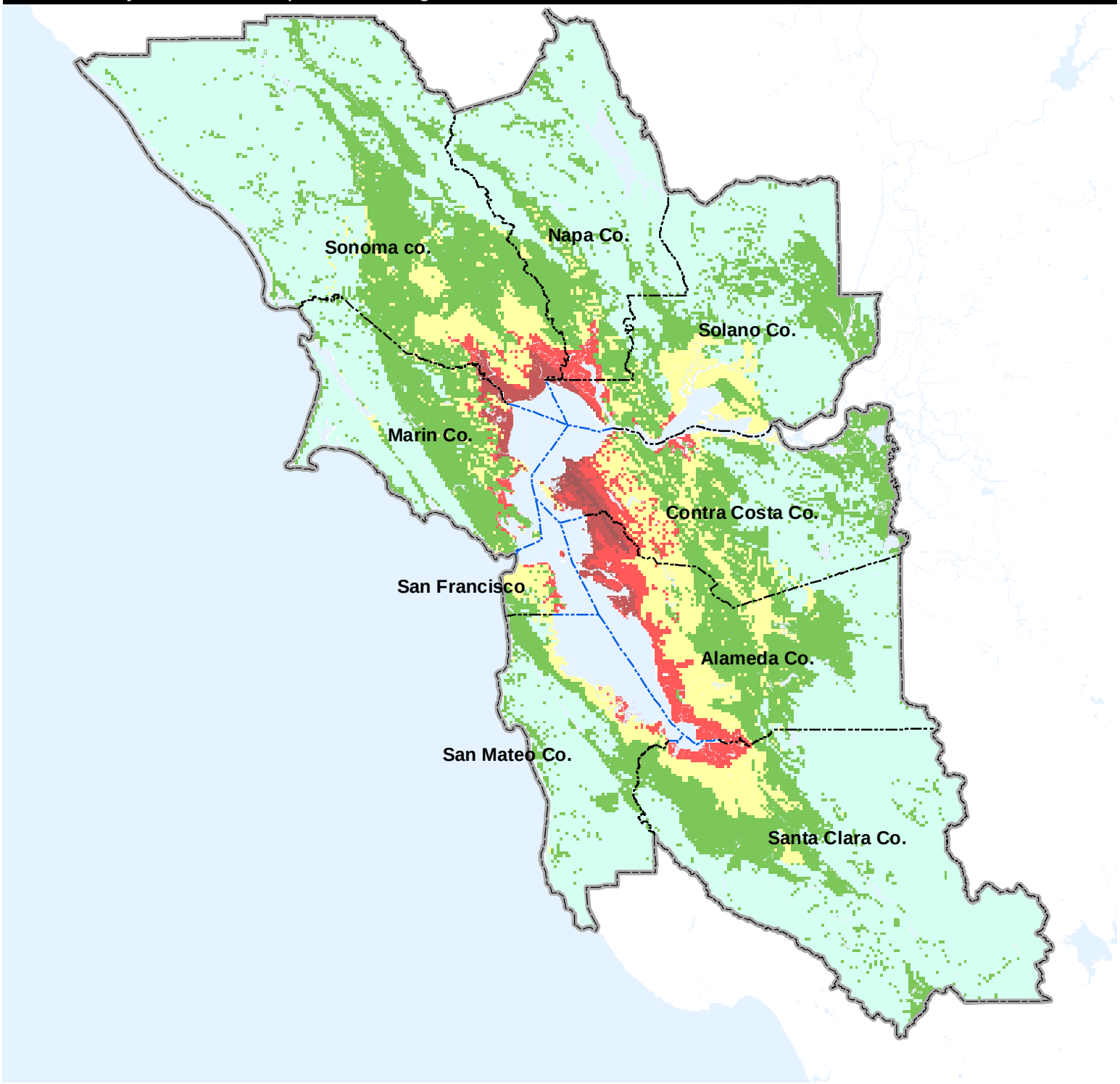
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 9

South Hayward Earthquake - Magnitude 6.7

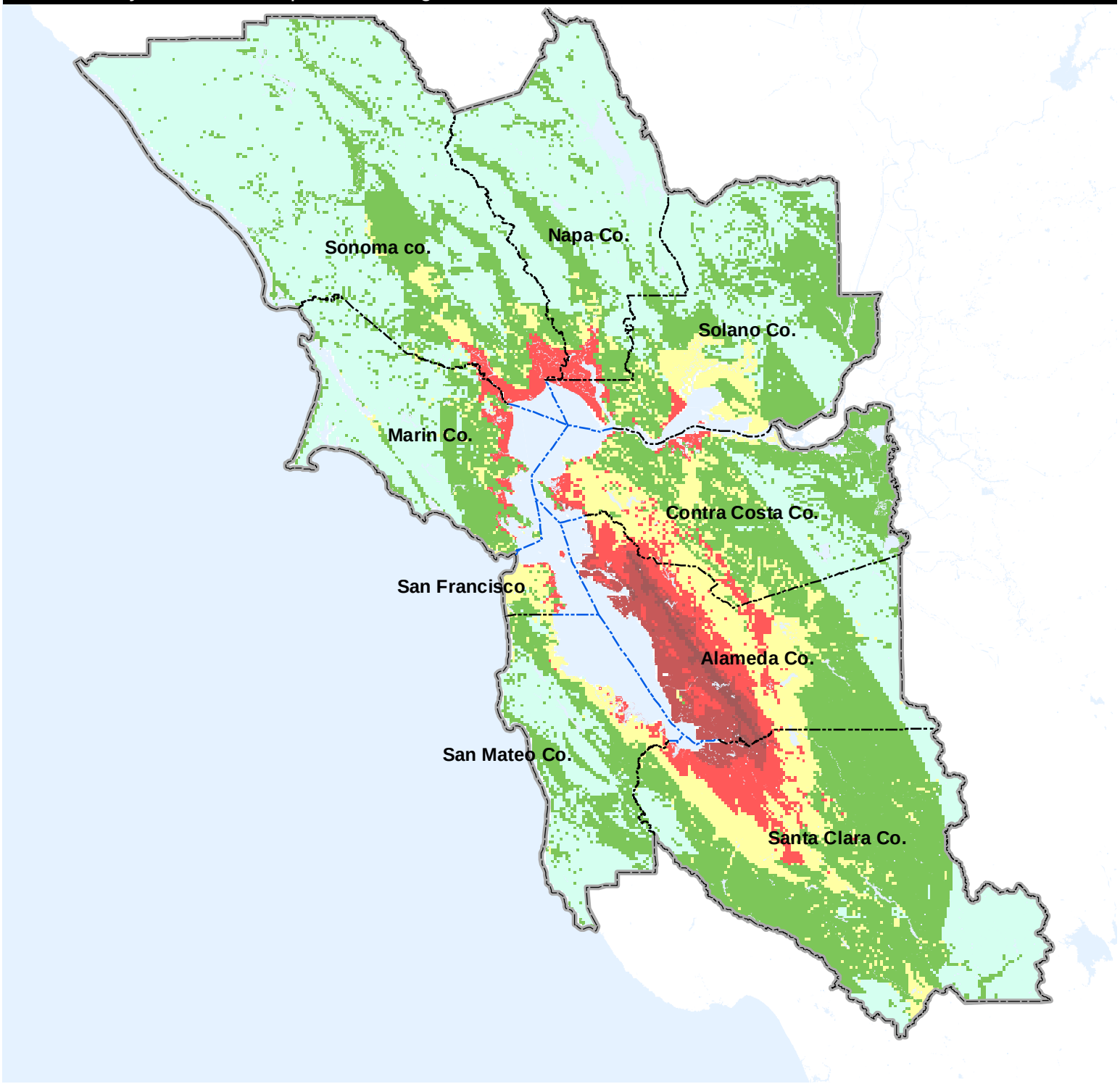
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 10

North and South Hayward Earthquake - Magnitude 6.9

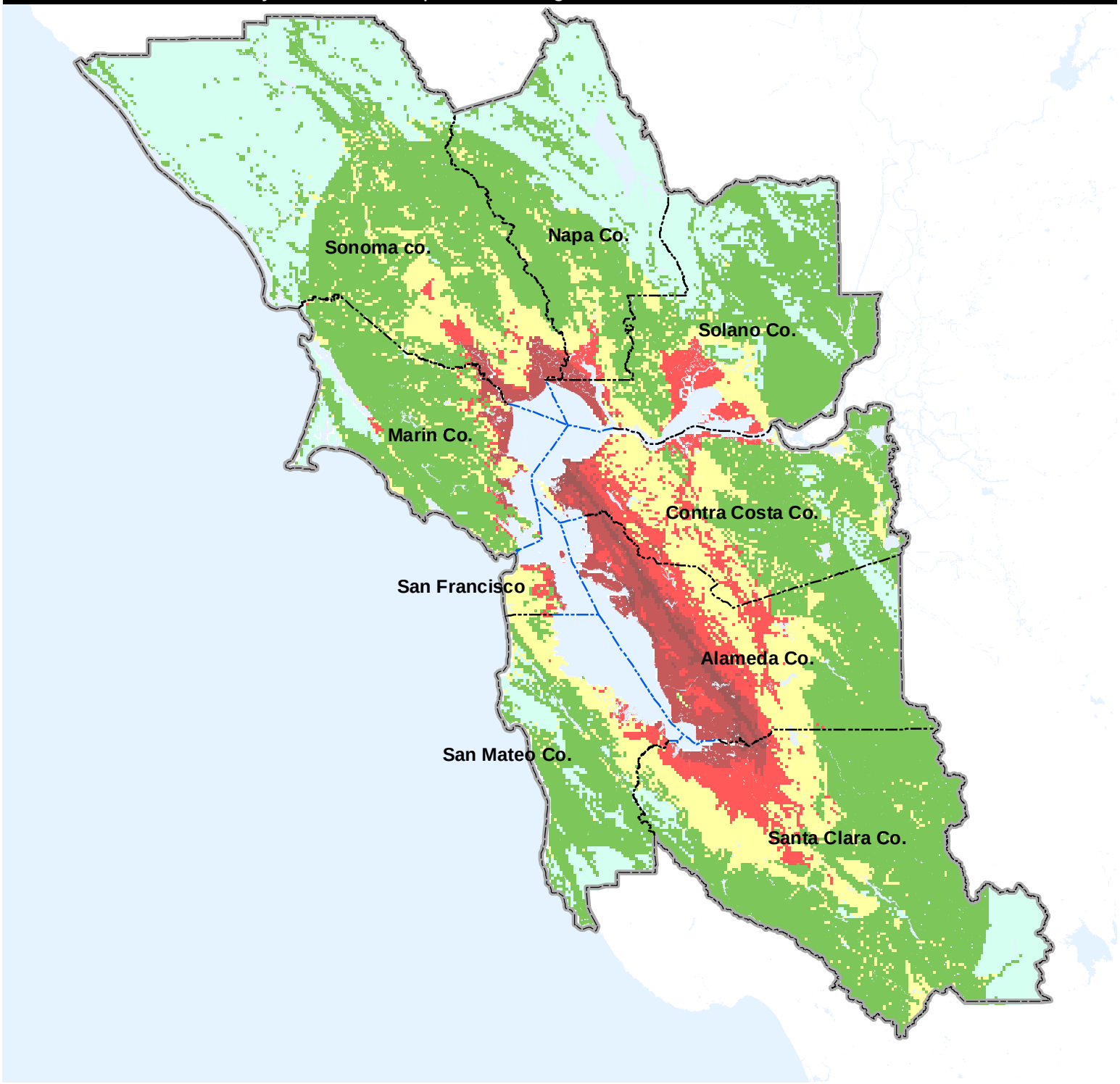
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 11

Northern Calaveras Earthquake - Magnitude 6.8

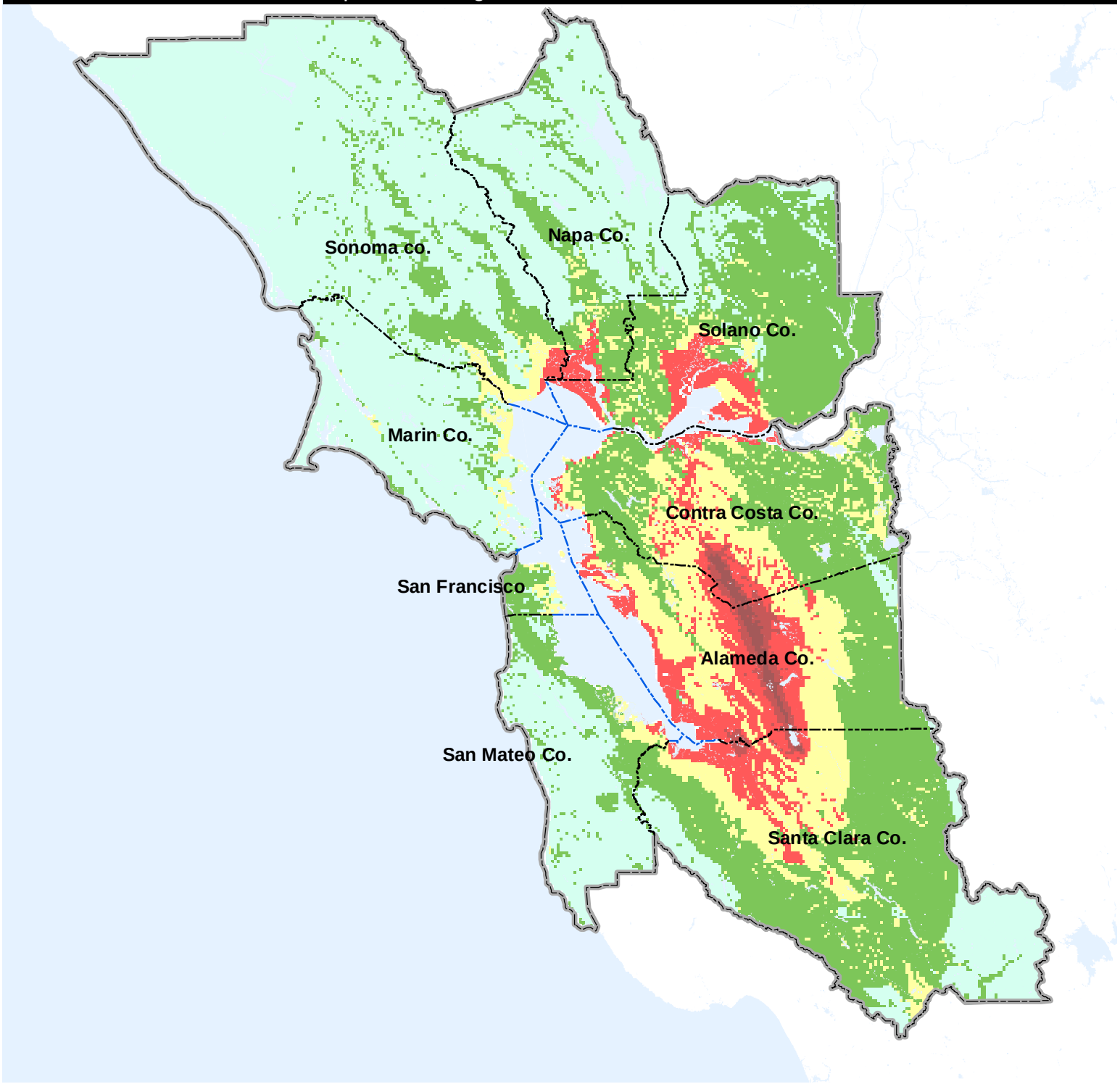
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 12

Central Calaveras Earthquake - Magnitude 6.2

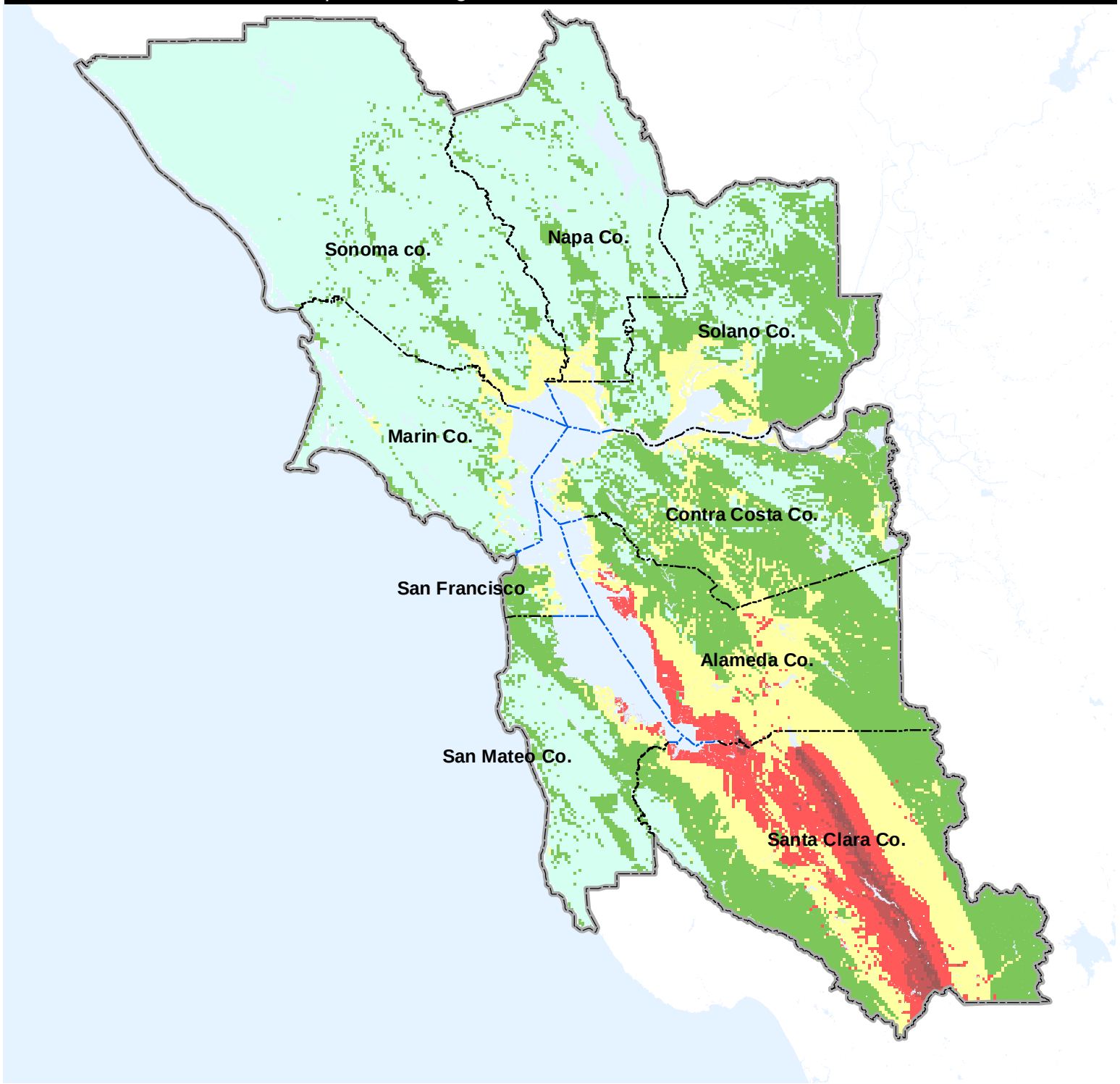
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Maacama Earthquake - Magnitude 6.6

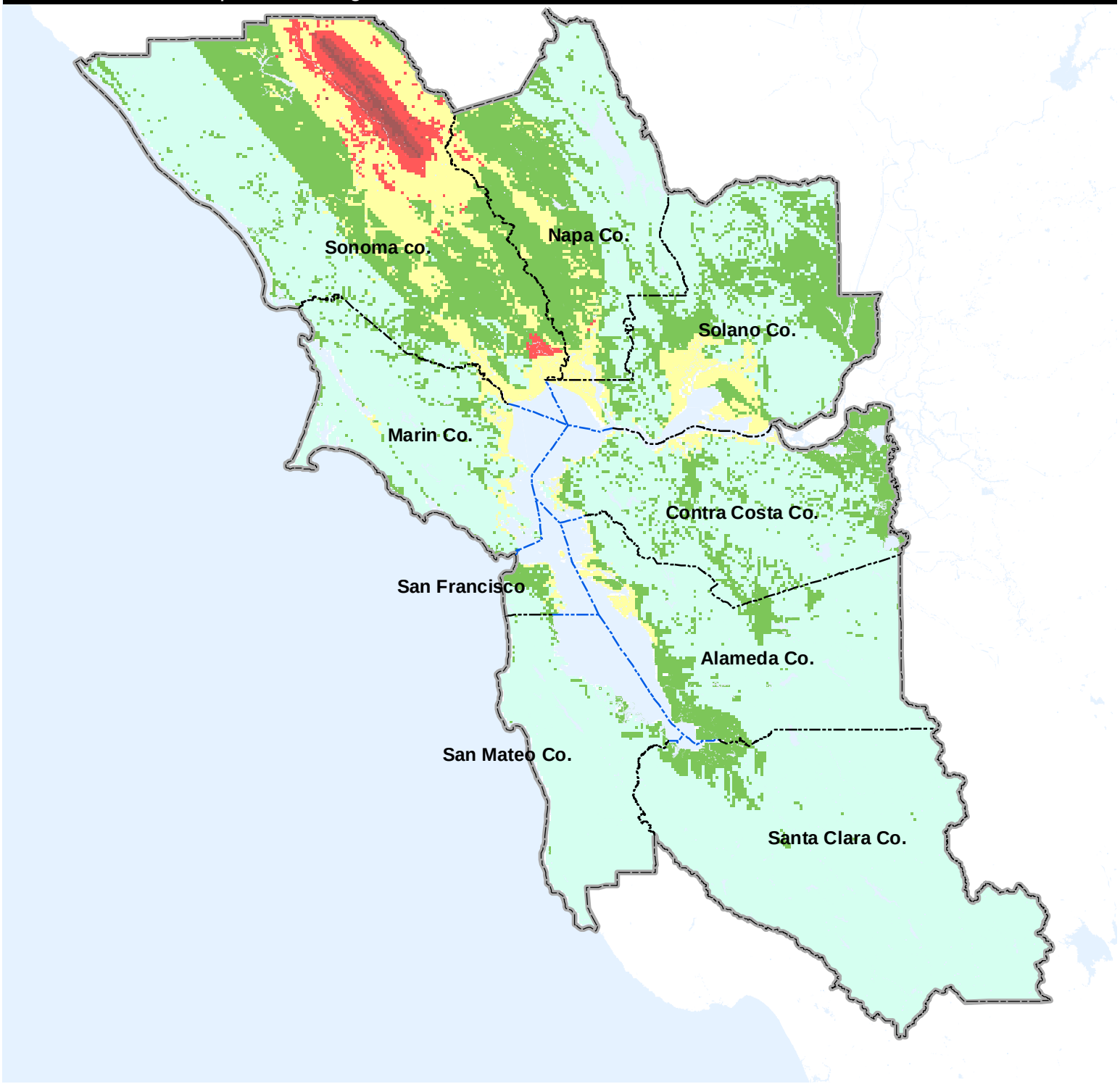
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

West Napa Earthquake - Magnitude 6.5

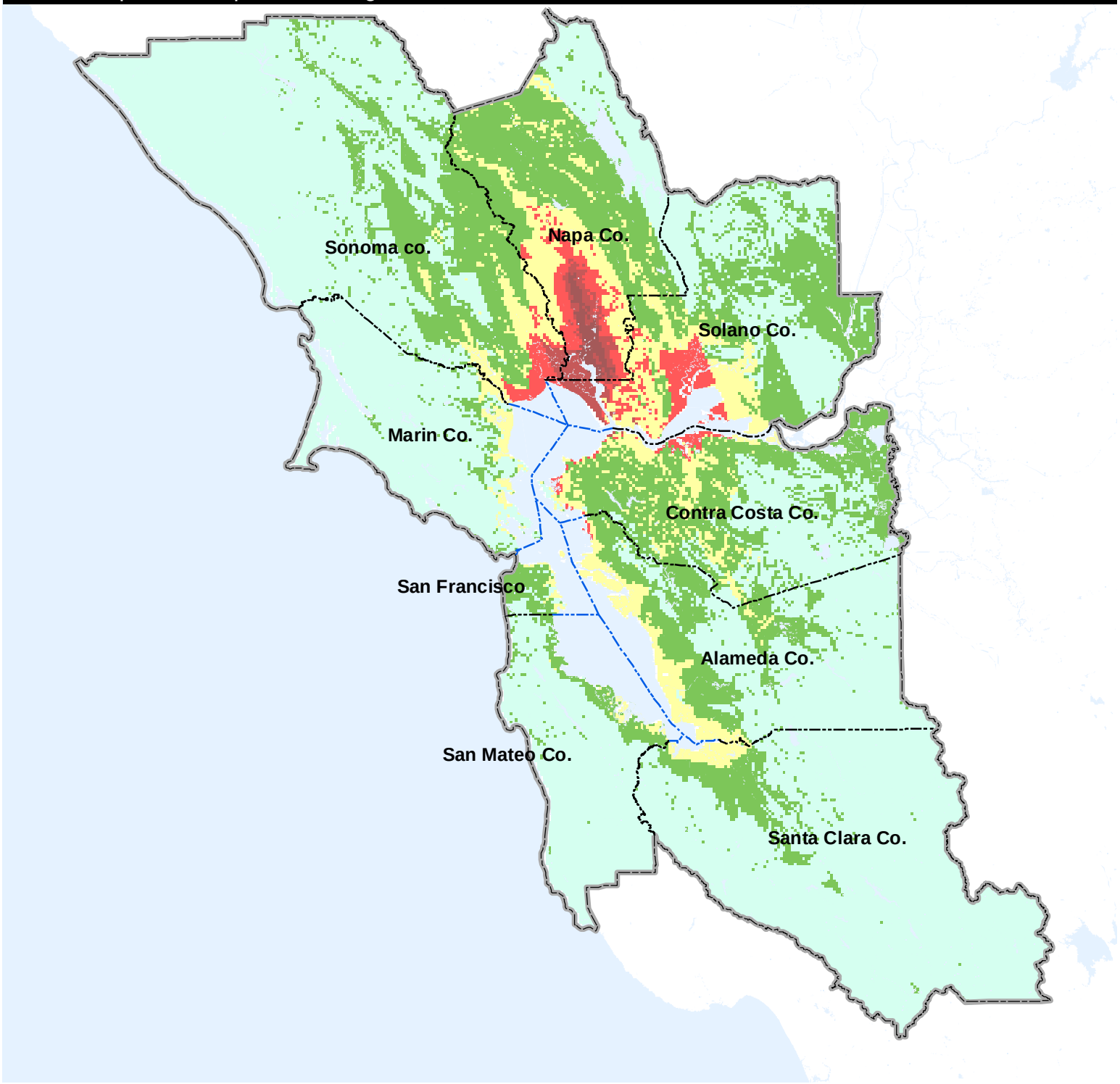
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 15

Concord-Green Valley Earthquake - Magnitude 6.7

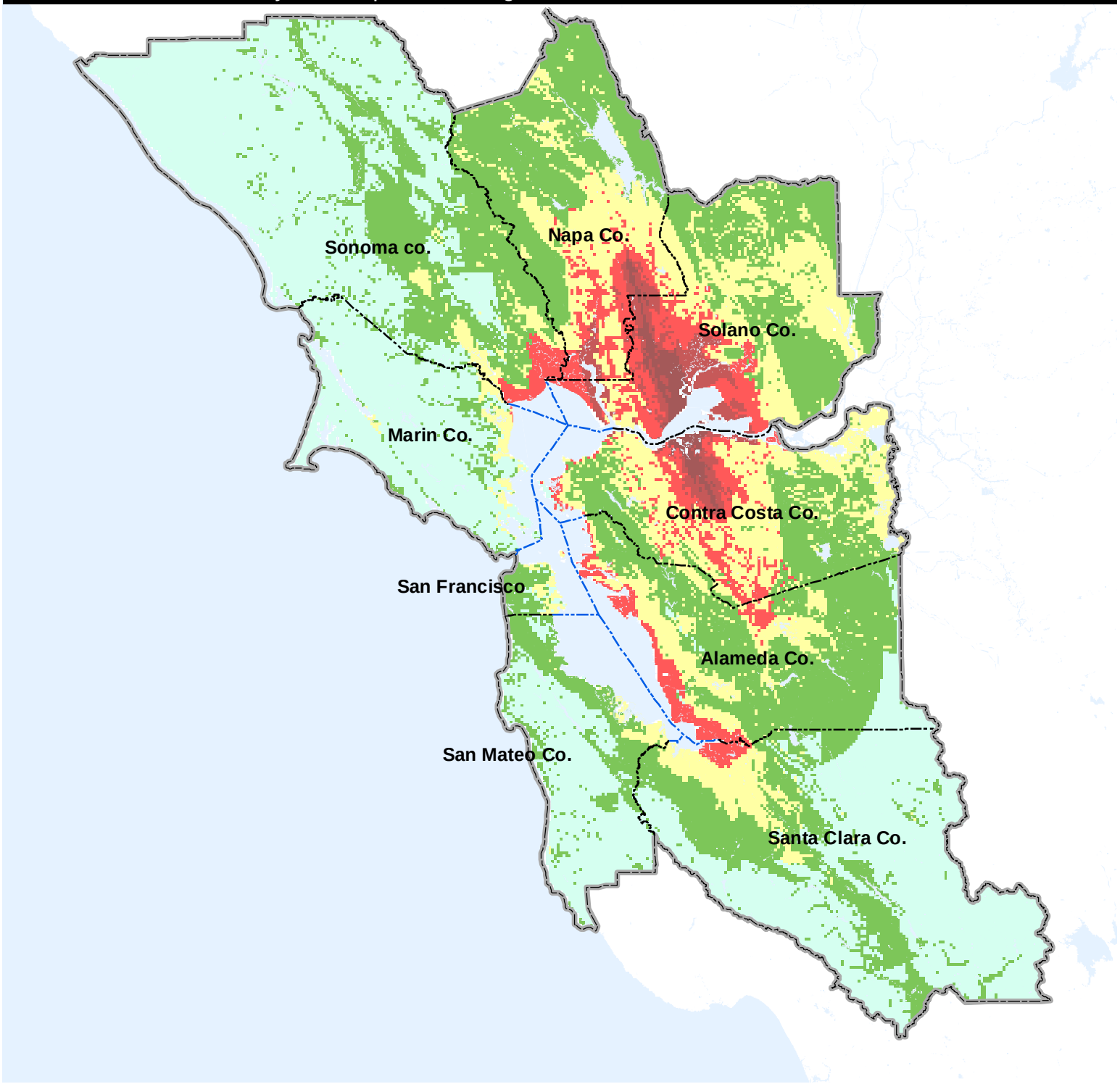
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 16

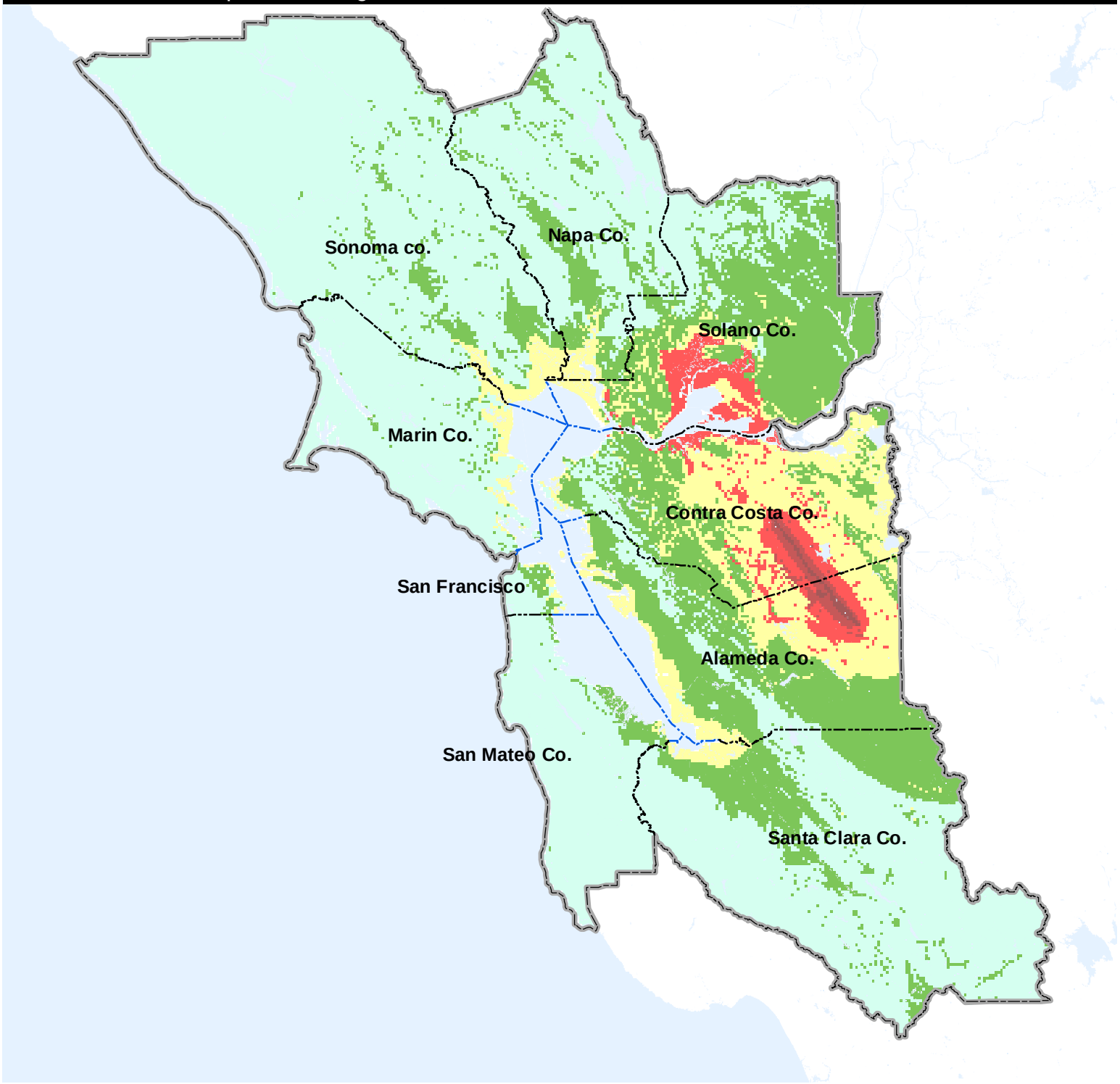
ABAG
Earthquake Shaking Scenario

Greenville Earthquake - Magnitude 6.9

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

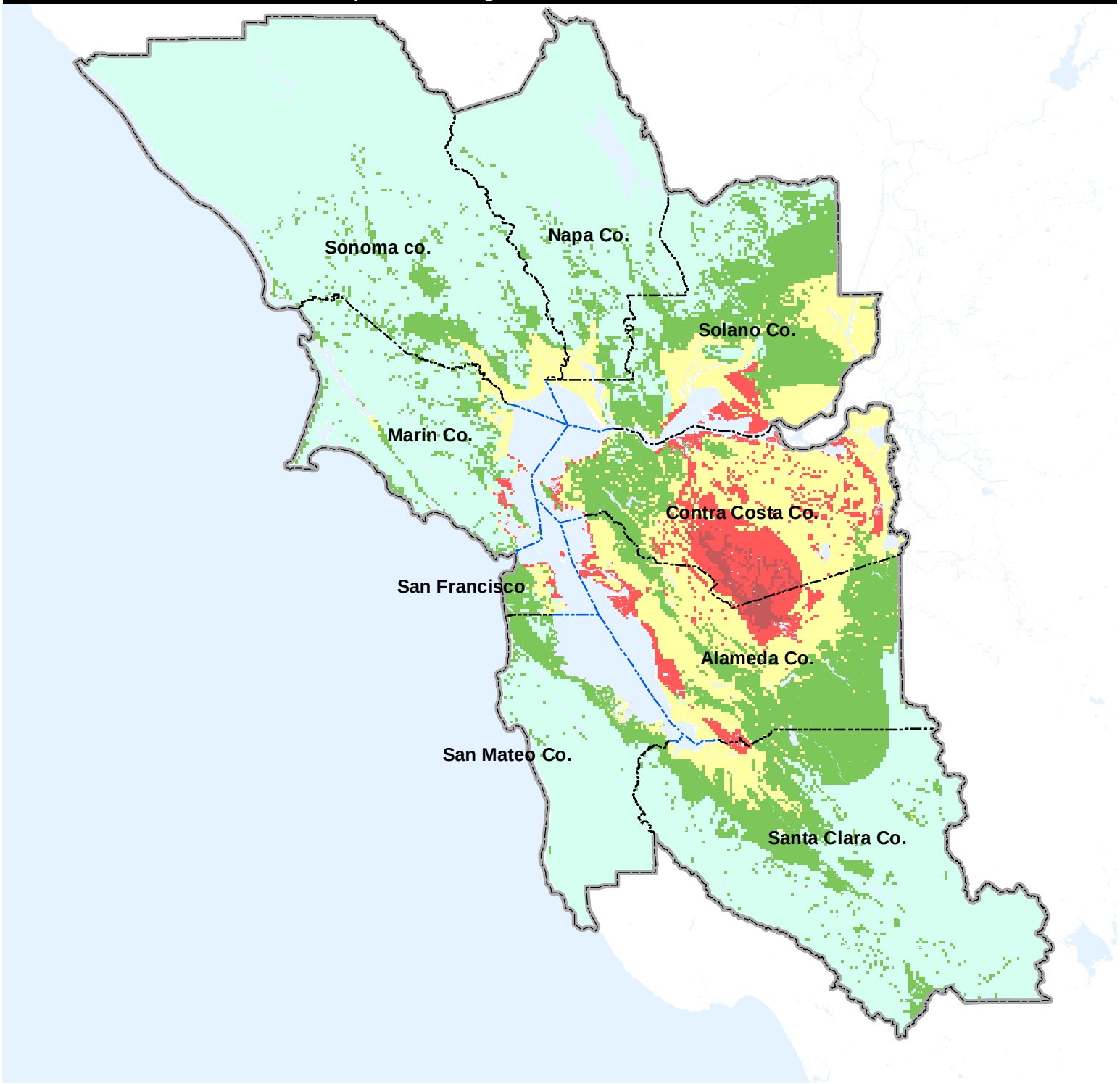
ABAG Geographic Information Systems

Mount Diablo Thrust Earthquake - Magnitude 6.7

ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light



Scale: 1 inch equals 18.31 miles

This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Northern San Gregorio Earthquake - Magnitude 7.2

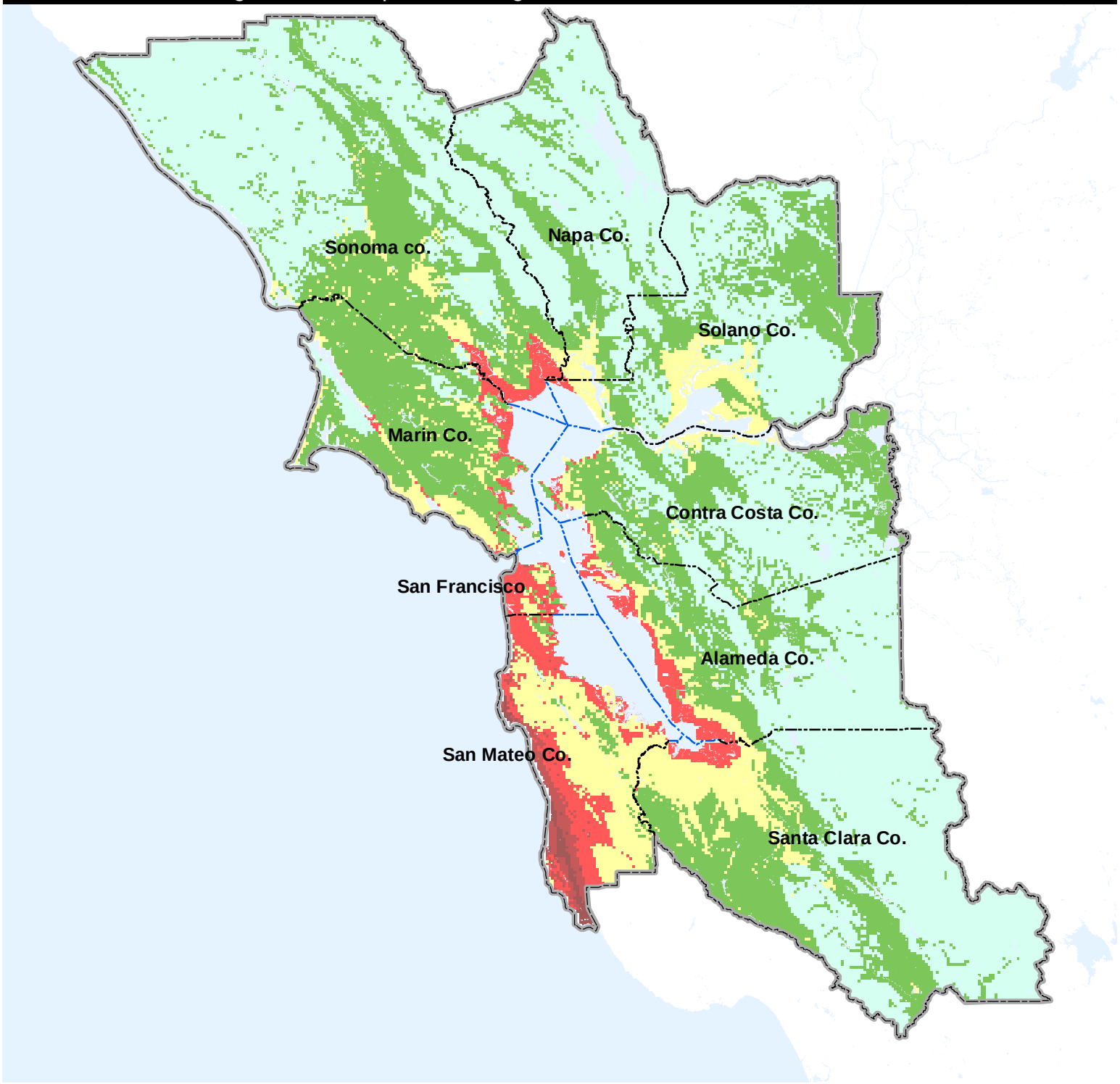
ABAG
Earthquake Shaking Scenario

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 19

ABAG
Earthquake Shaking Scenario

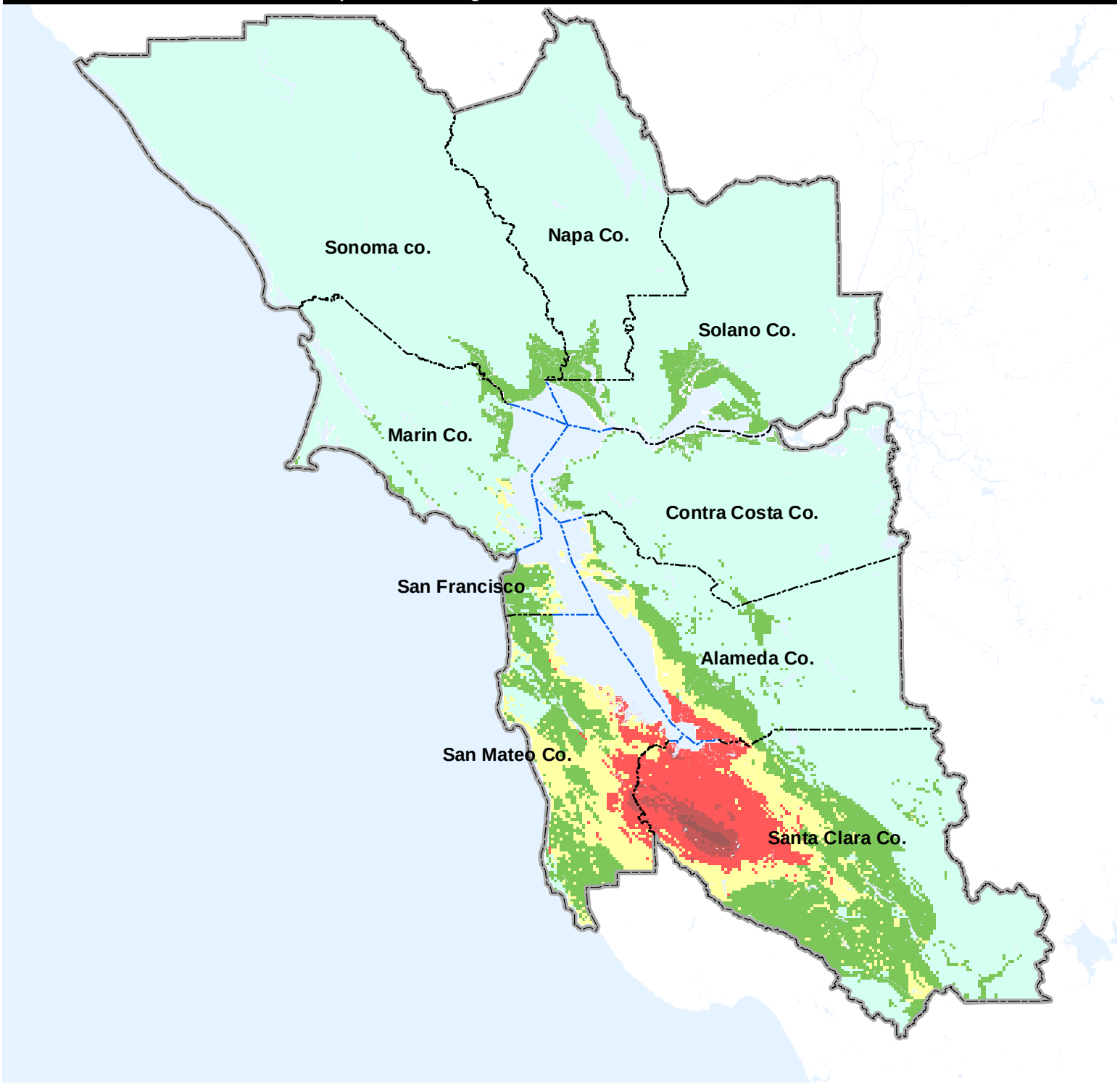
Monte Vista Thrust Earthquake - Magnitude 6.6

Modified Mercalli Intensity
Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.31 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. Intensities may be incorrect by one unit higher or lower.

This map is available at http://quake.abag.ca.gov

Source: ABAG Earthquake Program, June 2004

ABAG Geographic Information Systems

Plate 20

North and South Hayward Earthquake - Magnitude 6.9

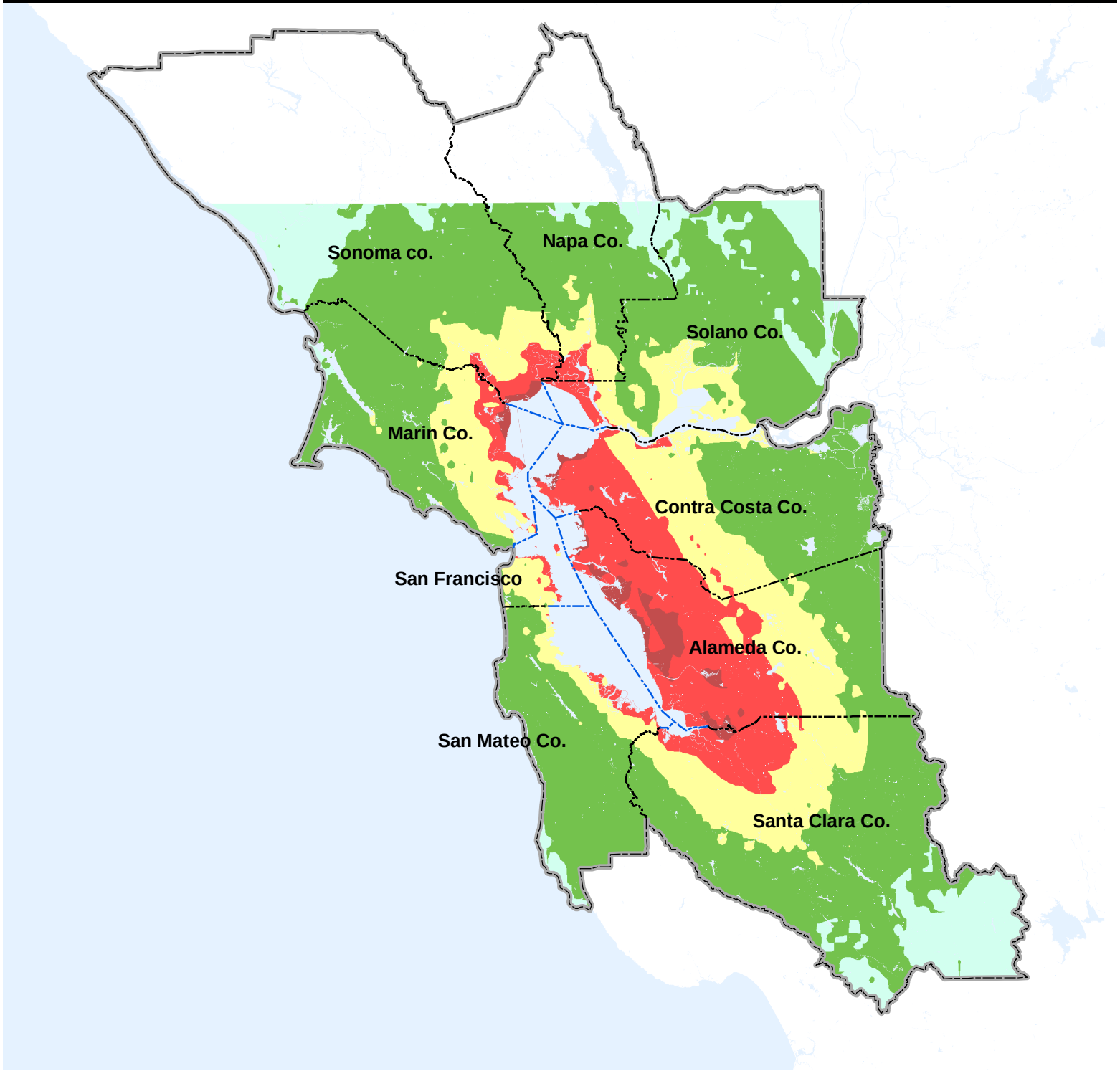
USGS ShakeMap Scenario

Modified Mercalli Intensity Shaking Severity Level

- X-Very Violent
- IX-Violent
- VIII-Very Strong
- VII-Strong
- VI-Moderate
- V-Light

N

Scale: 1 inch equals 18.86 miles



Source: USGS, 2003

The USGS ShakeMap scenario is provided for comparison with the ABAG earthquake shaking scenario. For ease of comparison, ABAG changed the colors and legend of the ShakeMap to make them consistent with our map. The ShakeMap scenario lacks data for the northern sections of Sonoma and Napa counties. These sections appear blank on the map. For more information regarding ShakeMaps for earthquake scenarios visit: http://earthquake.usgs.gov/shakemap/nc/shake/archive/scenario.html

This map is for planning use only.

This map is available at http://quake.abag.ca.gov

ABAG Geographic Information Systems

Plate 21

Earthquake Shaking Potential for the San Francisco Bay Region

Level of Earthquake Hazard

These regions are near major, active faults and will on average experience stronger earthquake shaking more frequently. This intense shaking can damage even strong, modern buildings.

Increasing Intensity

These regions are distant from known, active faults and will experience lower levels of shaking less frequently. In most earthquakes, only weaker, masonry buildings would be damaged. However, very infrequent earthquakes could still cause strong shaking here.

Major Roads

Local Roads

Water

N

Scale: 1 inch = 17.13 miles

Source:
This interactive map is a derivative of the Probabilistic Seismic Hazard Map that was produced by the California Seismic Safety Commission, California Geological Survey, California Office of Emergency Services and US Geological Survey, 2003

The colors on this map have been changed from the original map. For more information visit: http://www.consrv.ca.gov/CGS/rghm/psha/

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community.

This map is available at http://quake.abag.ca.gov/

ABAG Geographic Information Systems

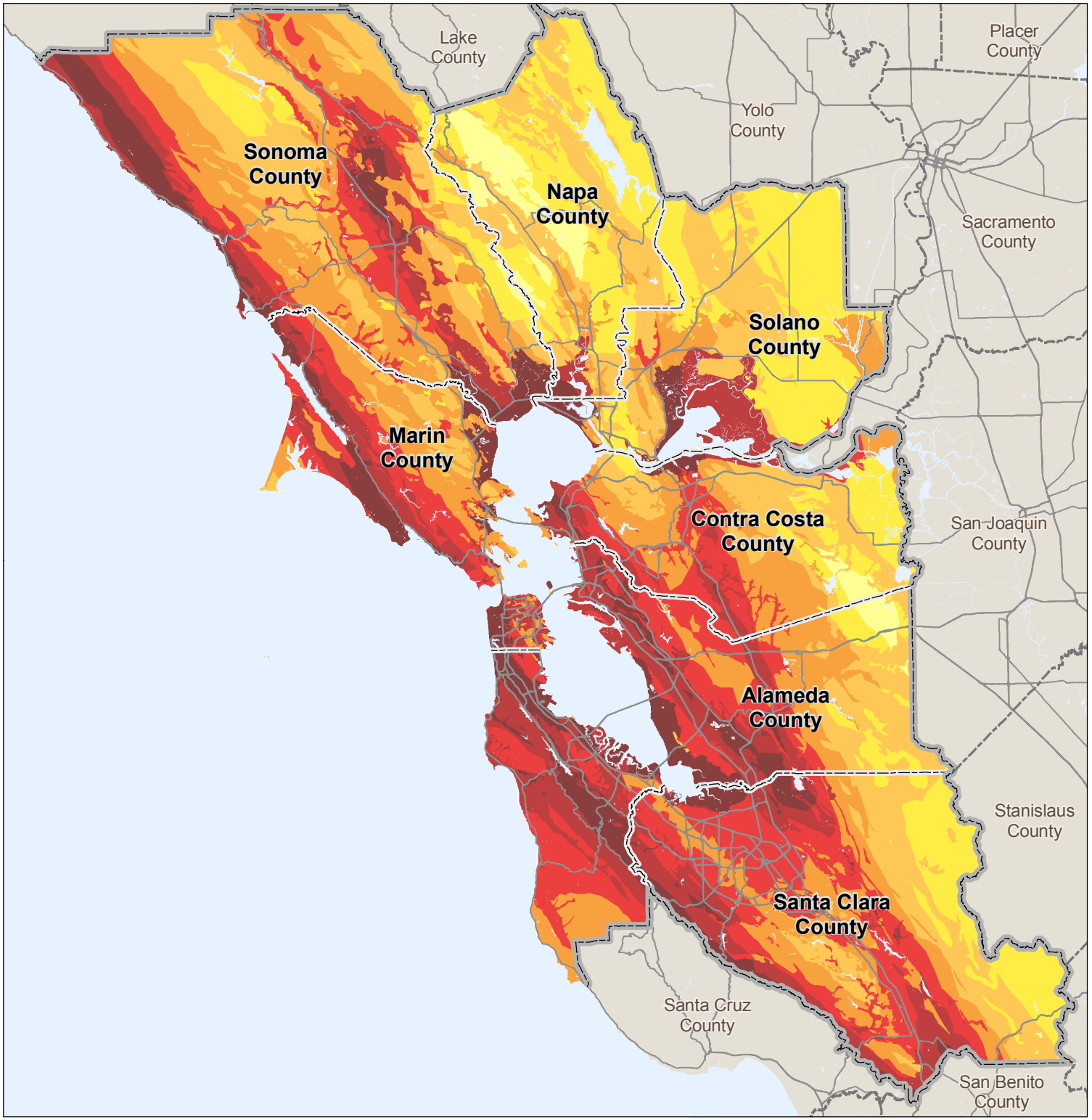


Plate 22

Liquefaction Susceptibility Map

Susceptibility Level

- Very High
- High
- Moderate
- Low
- Very Low

- Major Roads
- Local Roads

Scale: 1 inch = 16.96 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions.

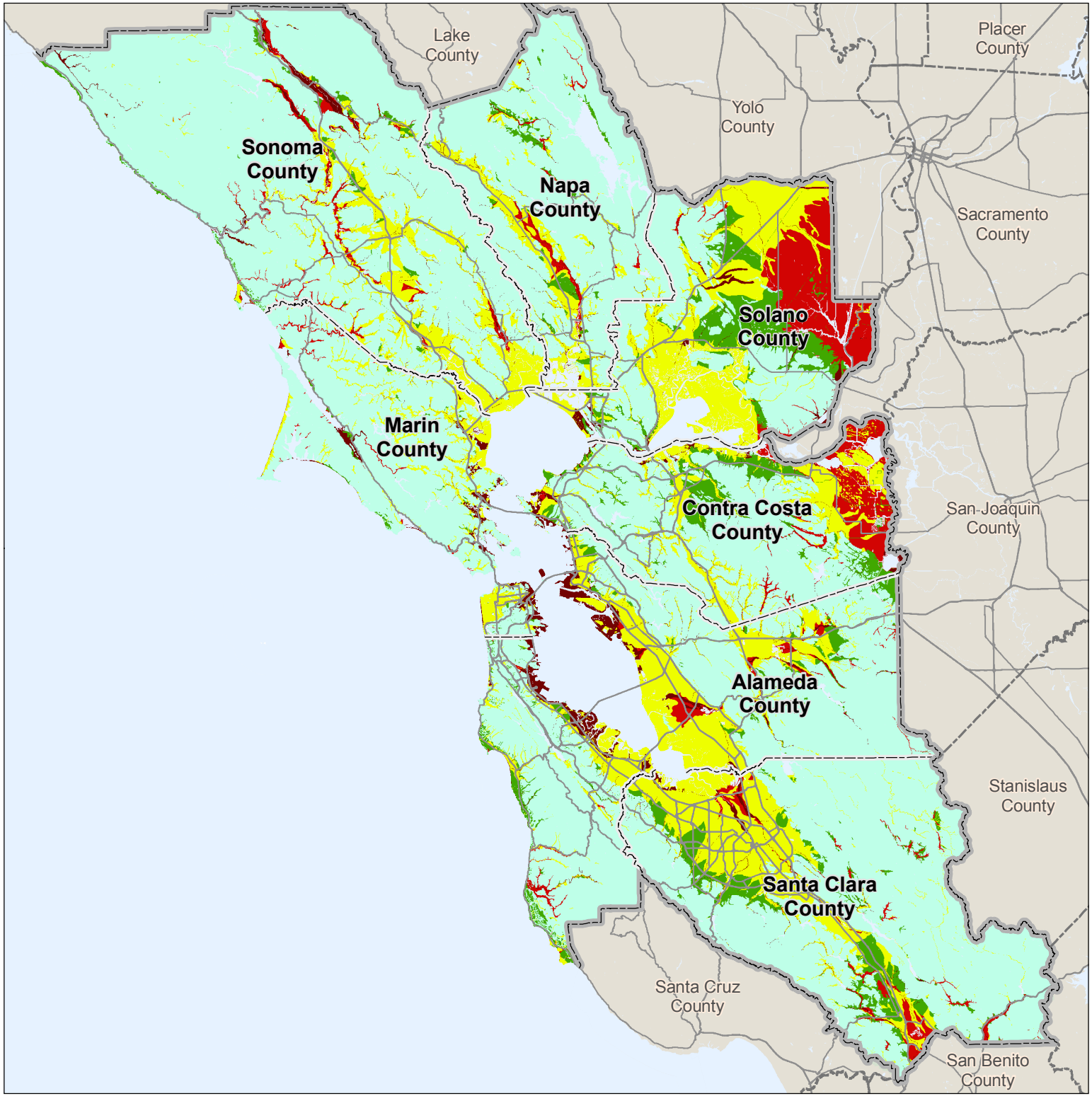
This map is available at http://quake.abag.ca.gov

Sources:
This map is based on work by William Lettis & Associates, Inc. and USGS.
USGS Open-File Report 00-444, Knudsen & others, 2000 and
USGS Open-File Report 2006-1037, Witter & others, 2006

For more information visit:
http://pubs.usgs.gov/of/2000/of00-444/
http://pubs.usgs.gov/of/2006/1037/

Map Prepared by the ABAG Earthquake Program.
June 2009.

ABAG Geographic Information Systems



California Geological Survey Seismic Hazard Zones of Required Investigation

Liquefaction Zones

Areas where historical occurrence of liquefaction, or local geological, geotechnical and ground-water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

Mapping in progress

Mapping Planned

Area Not Yet Evaluated

N

Scale: 1 inch equals 9.42 miles

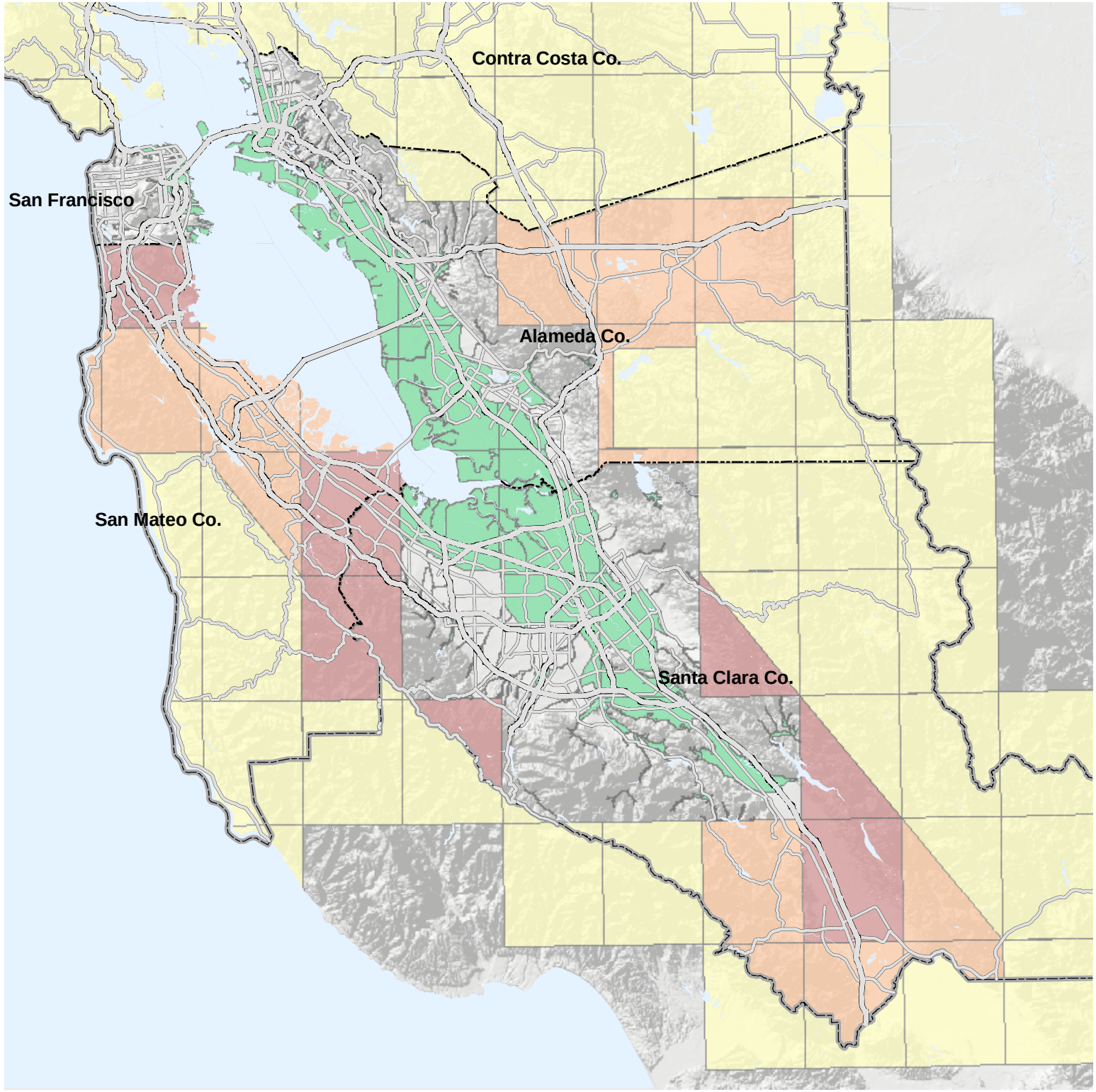
This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community.

For more detailed information regarding this map, please visit the CGS website at http://gmw.consrv.ca.gov/shmp/

Source:
California Geological Survey, 2004

This map is available at
http://quake.abag.ca.gov

ABAG Geographic Information Systems



Liquefaction Hazard Map

San Andreas-North Golden Gate Earthquake - Magnitude 7.5

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low
- Major Roads
- Local Roads

Scale: 1 inch equals 18.85 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low
- Major Roads
- Local Roads

N

Scale: 1 inch equals 18.85 miles

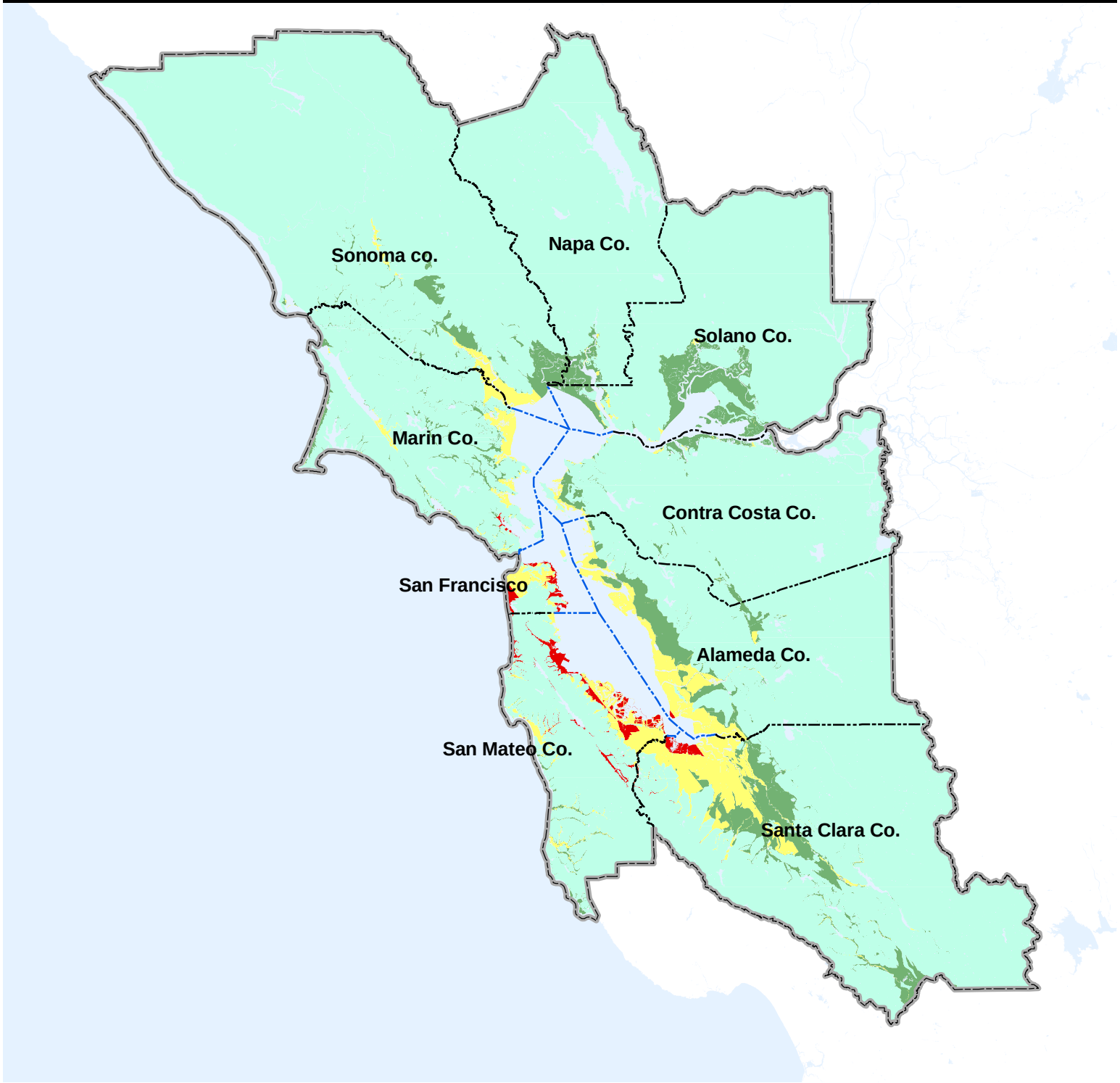
This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

San Andreas-Peninsula Earthquake - Magnitude 7.2



Model of the 1989 Loma Prieta Earthquake - Magnitude 6.9

Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low

- Major Roads
- Local Roads

N

Scale: 1 inch equals 18.85 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low
- Major Roads
- Local Roads

Scale: 1 inch equals 18.83 miles

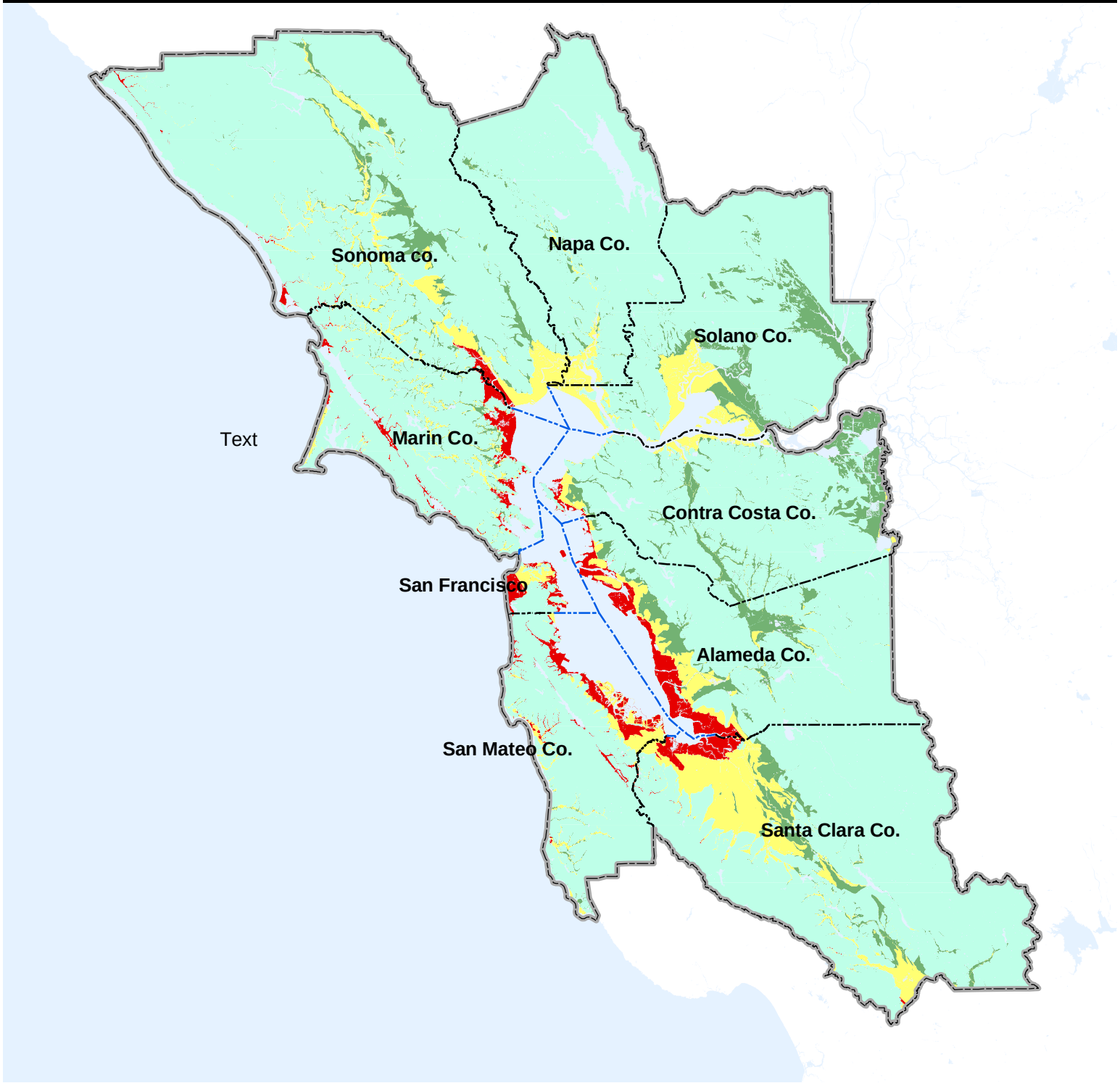
This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Entire San Andreas (1906 Quake) - Magnitude 7.9



Rodgers Creek Earthquake - Magnitude 7.0

Liquefaction Hazard Map

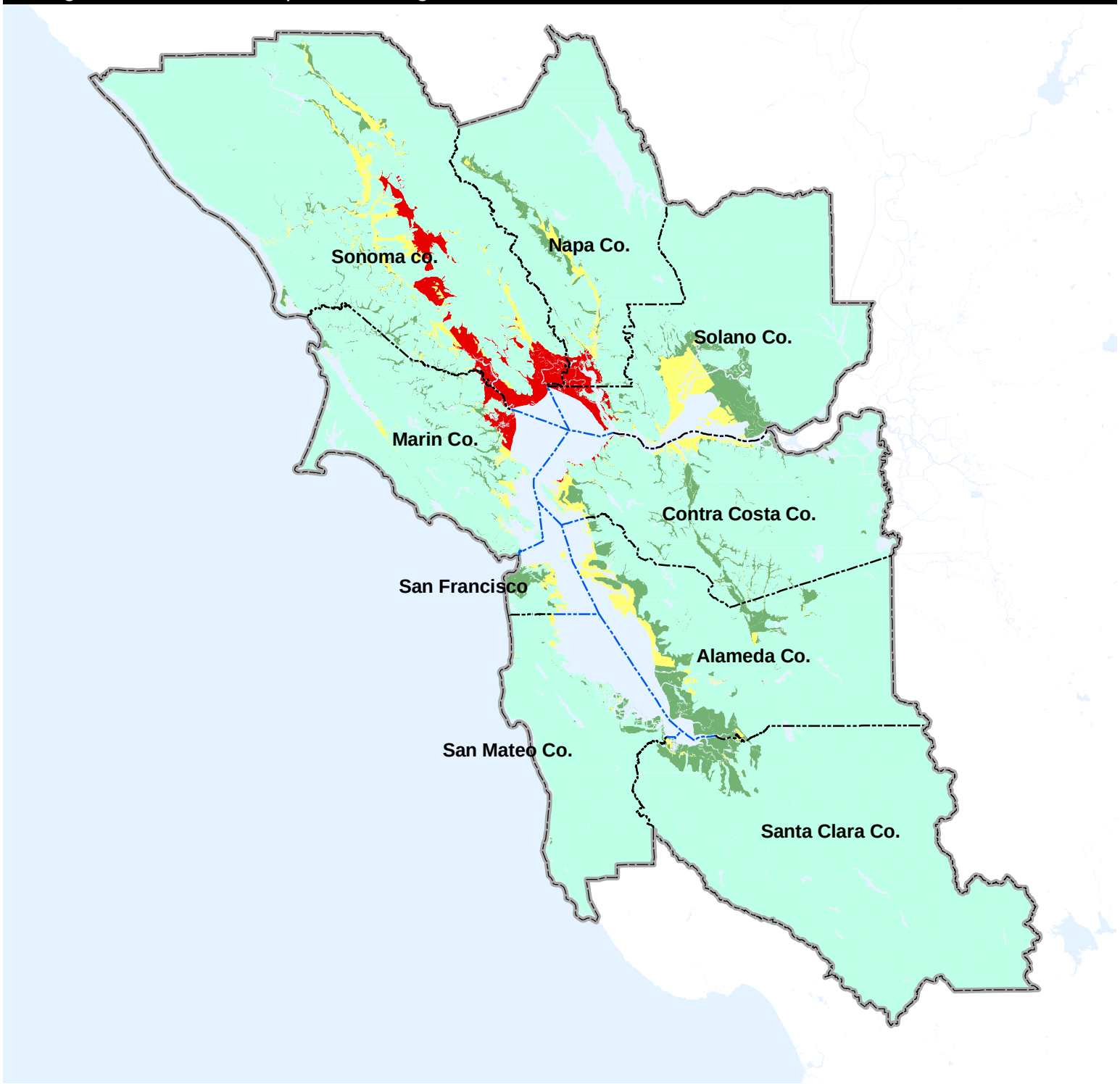
Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low

Major Roads

Local Roads

Scale: 1 inch equals 18.83 miles



This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low

Major Roads

Local Roads

Scale: 1 inch equals 18.83 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Rodgers Creek and North Hayward Earthquake - Magnitude 7.1

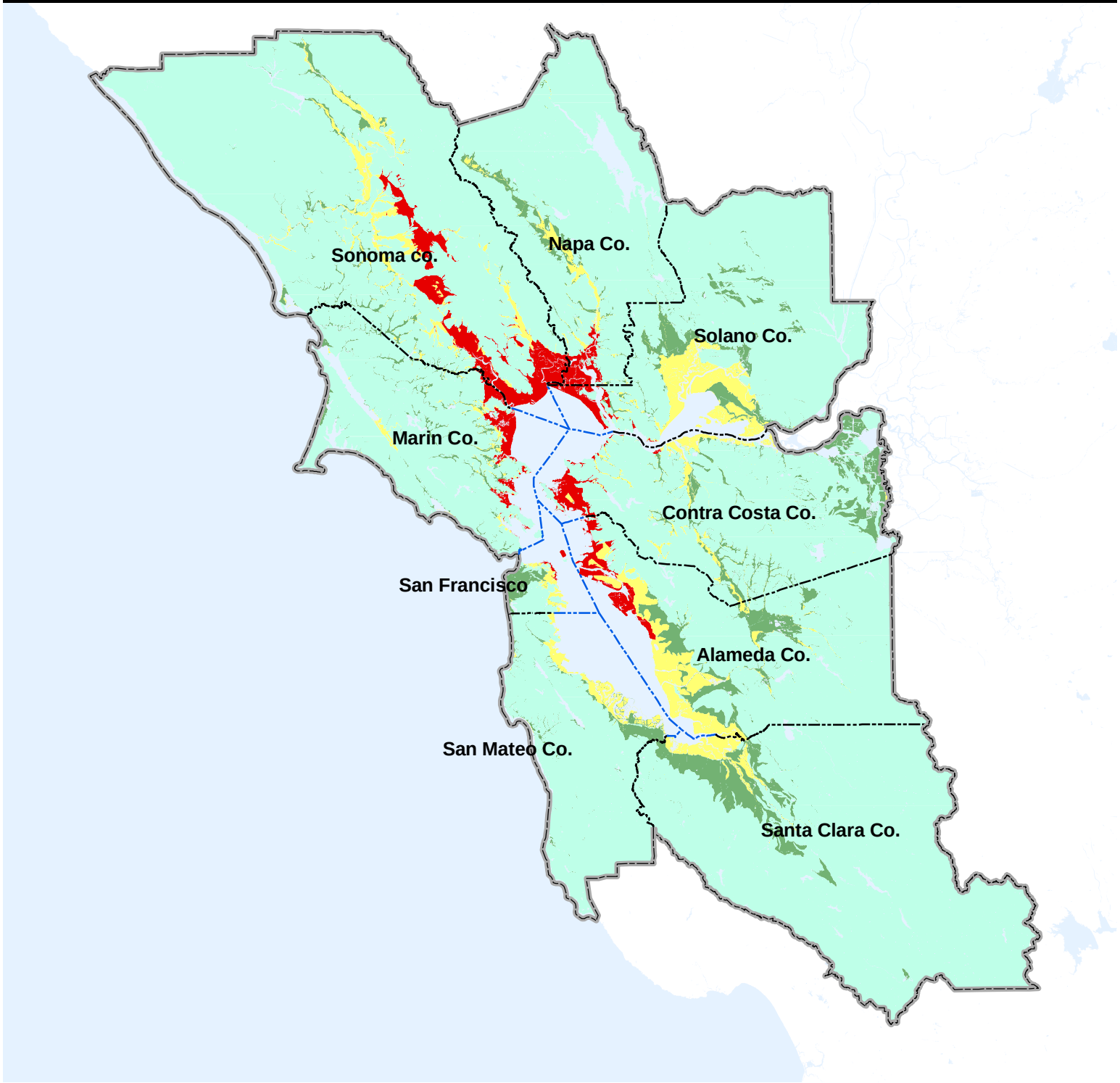


Plate 30

Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low

- Major Roads
- Local Roads

Scale: 1 inch equals 18.83 miles

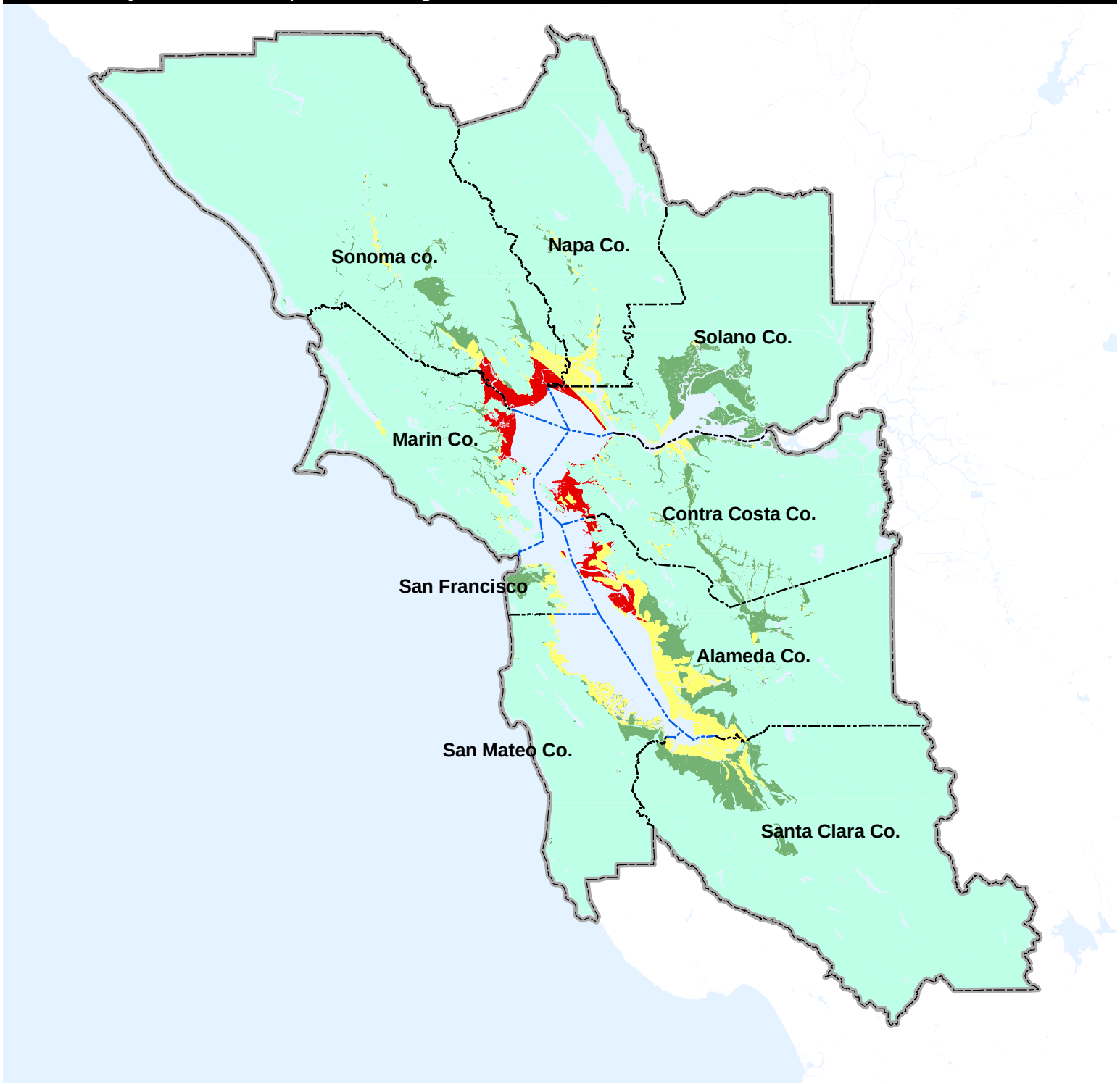
This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

North Hayward Earthquake - Magnitude 6.5



Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low

Major Roads

Local Roads

N

Scale: 1 inch equals 18.83 miles

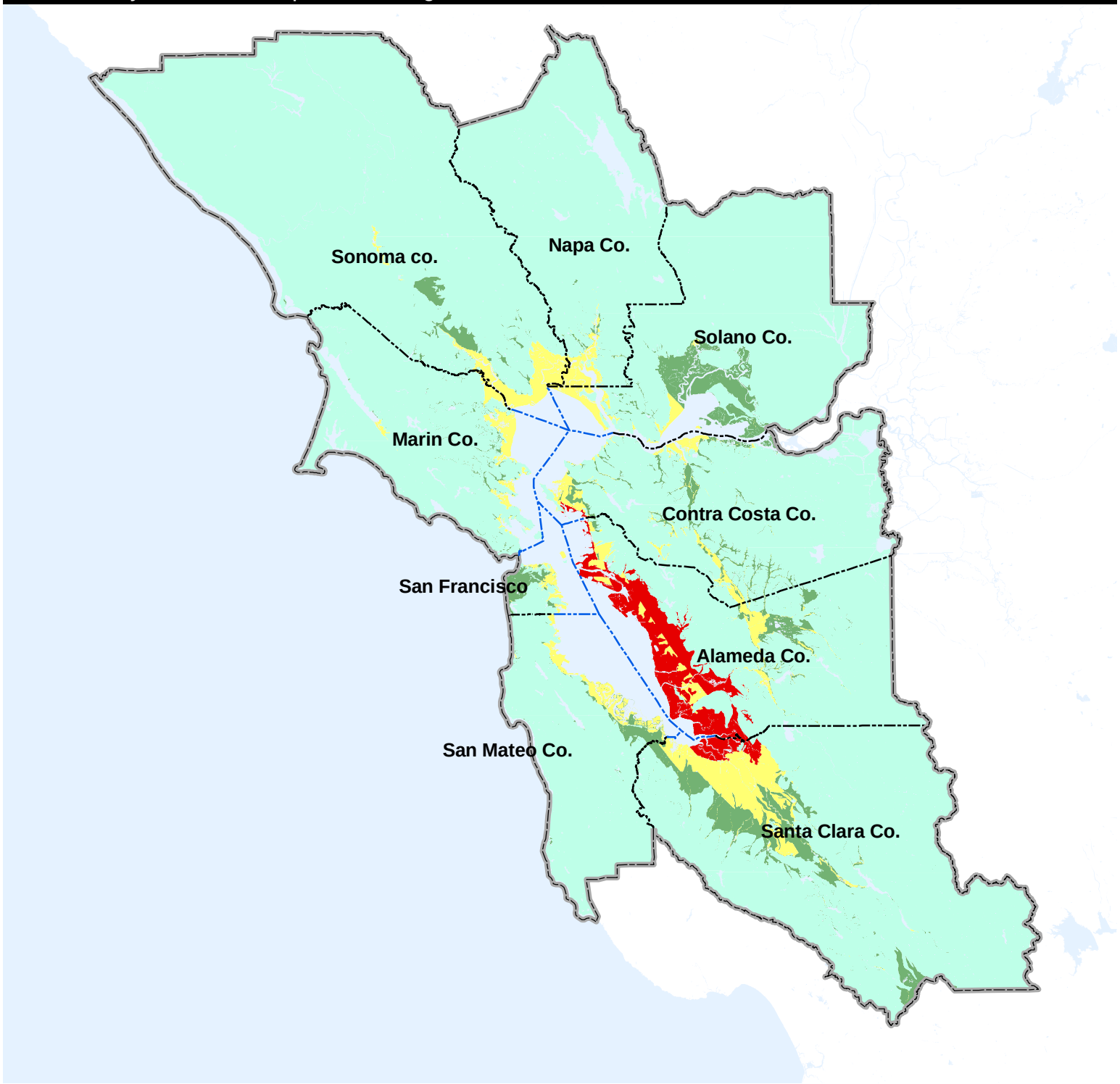
This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

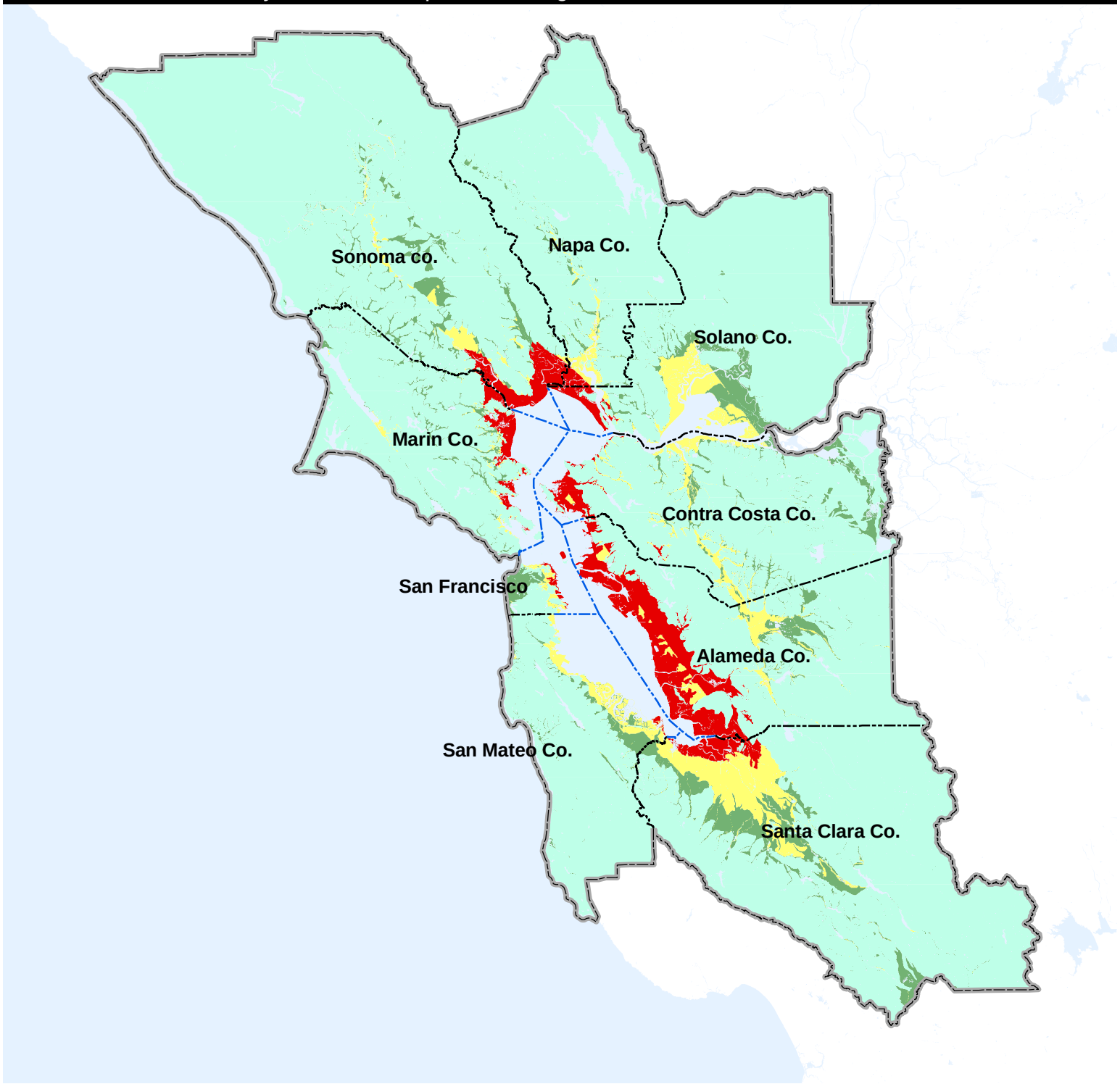
ABAG Geographic Information Systems

South Hayward Earthquake - Magnitude 6.7



Liquefaction Hazard Map

North and South Hayward Earthquake - Magnitude 6.9



Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low
- Major Roads
- Local Roads

N

Scale: 1 inch equals 18.83 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Northern Calaveras Earthquake - Magnitude 6.8

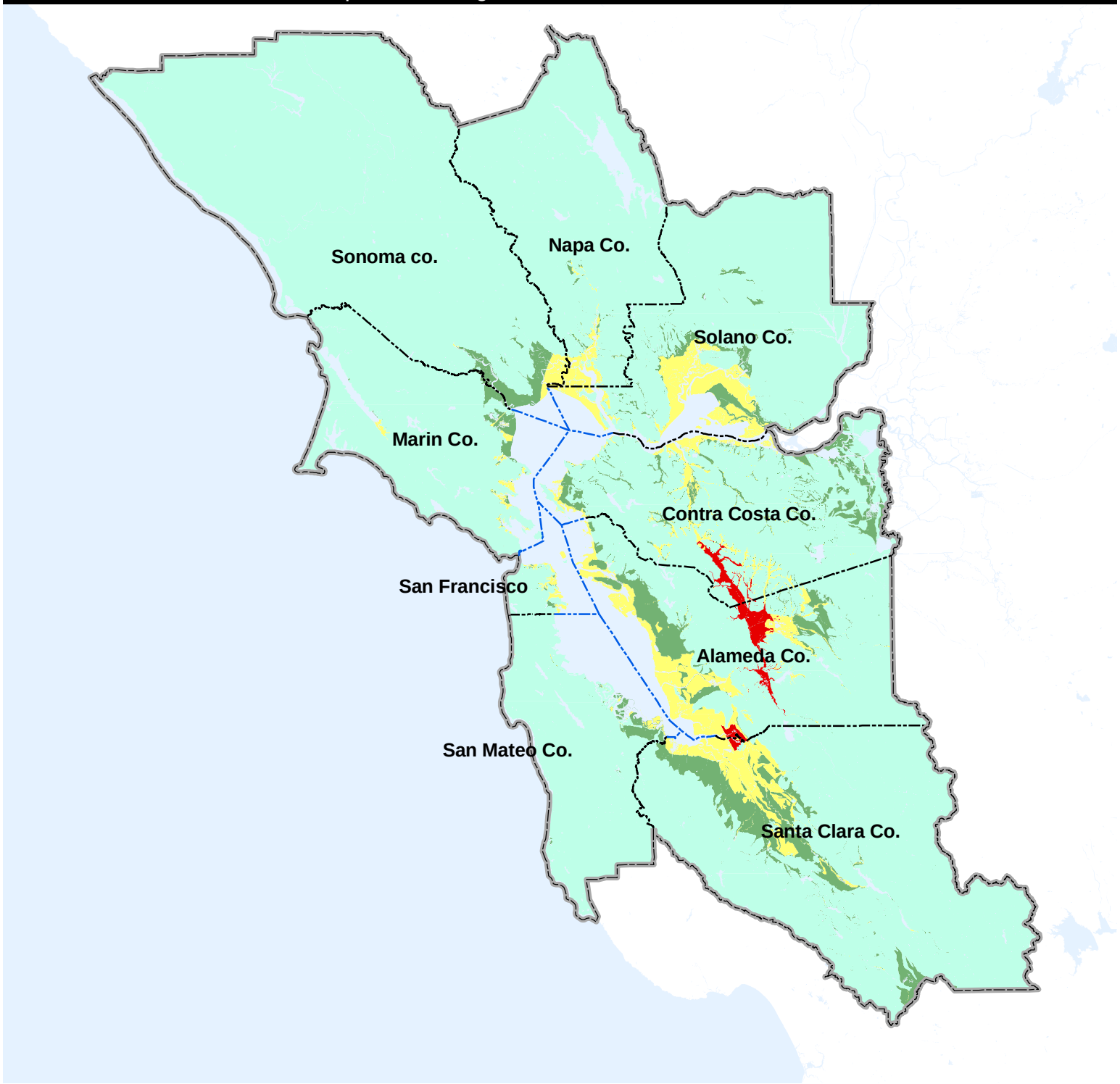
Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low
- Major Roads
- Local Roads

N

Scale: 1 inch equals 18.83 miles



This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low

Major Roads

Local Roads

Scale: 1 inch equals 18.83 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

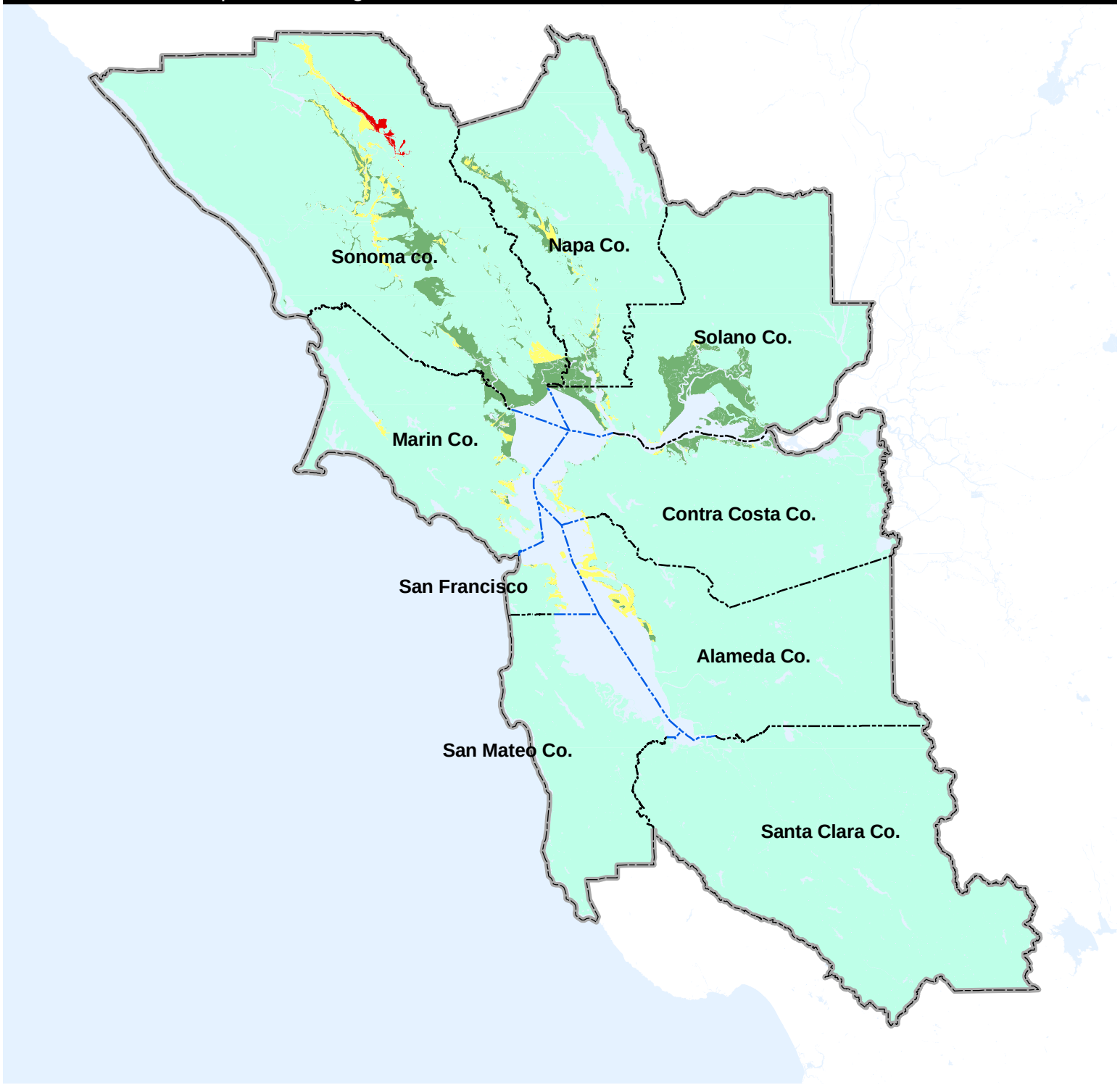
Source:
ABAG, 2001

ABAG Geographic Information Systems

Central Calaveras Earthquake - Magnitude 6.2

Liquefaction Hazard Map

Maacama Earthquake - Magnitude 6.6



Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low
- Major Roads
- Local Roads

N

Scale: 1 inch equals 18.83 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

West Napa Earthquake - Magnitude 6.5

Liquefaction Hazard Map

Liquefaction Hazard Level

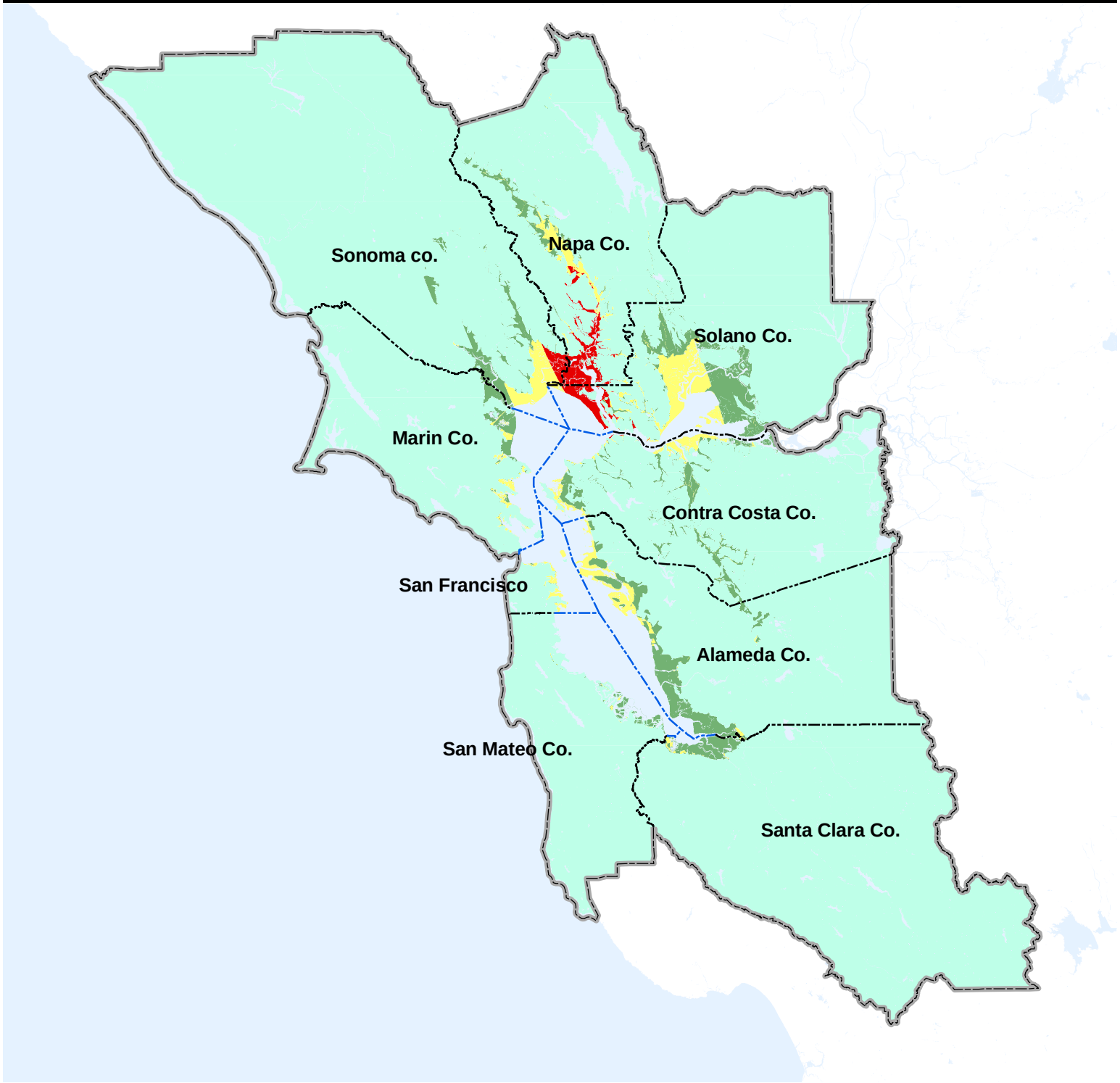
- High
- Moderate
- Moderately Low
- Very Low

Major Roads

Local Roads

N

Scale: 1 inch equals 18.83 miles



This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

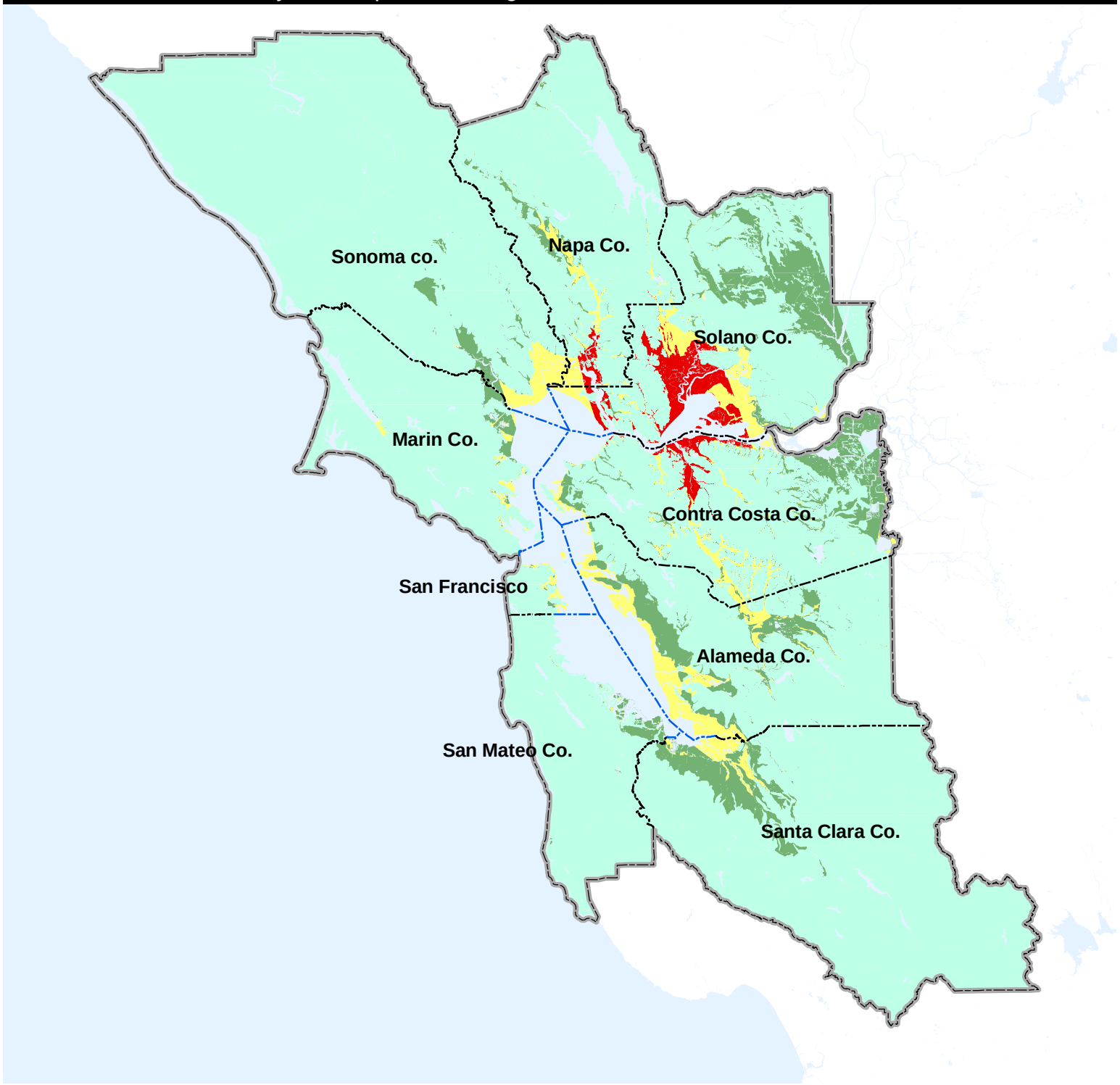
This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Liquefaction Hazard Map

Concord-Green Valley Earthquake - Magnitude 6.7



Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low
- Major Roads
- Local Roads

N

Scale: 1 inch equals 18.83 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low

- Major Roads
- Local Roads

Scale: 1 inch equals 18.83 miles

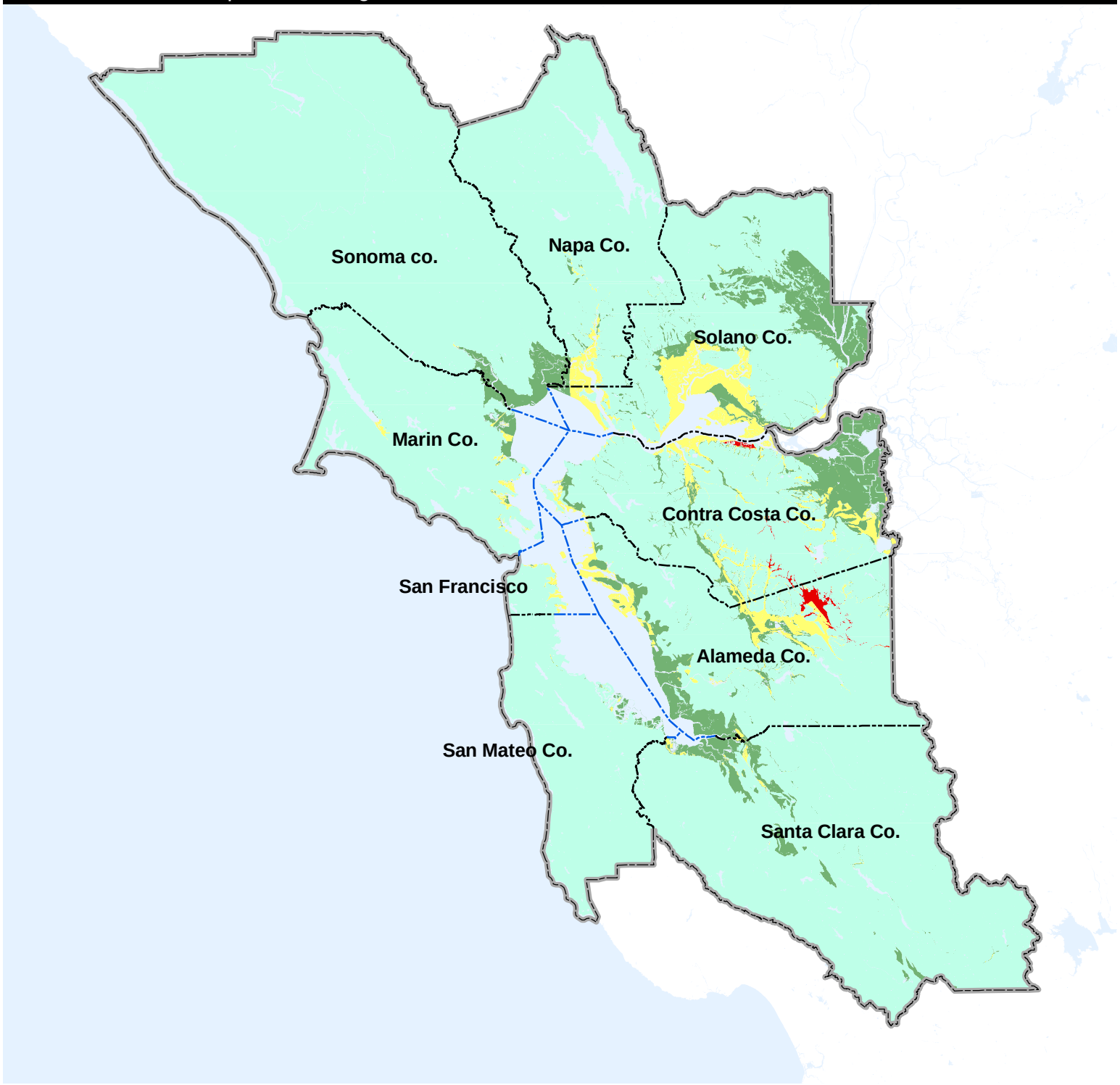
This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Greenville Earthquake - Magnitude 6.9



Mount Diablo Thrust Earthquake - Magnitude 6.7

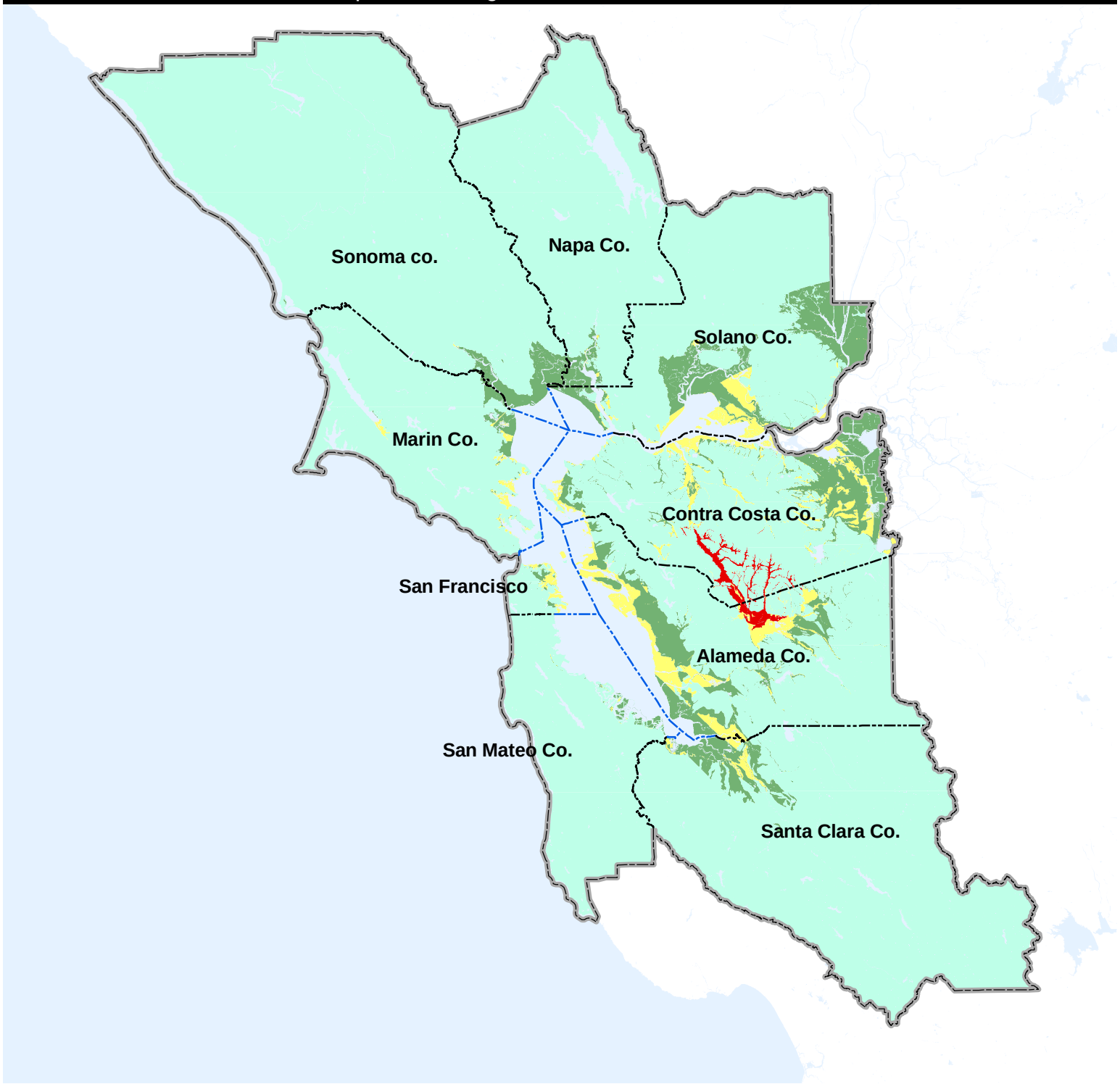
Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low

- Major Roads
- Local Roads

Scale: 1 inch equals 18.83 miles



This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Northern San Gregorio Earthquake - Magnitude 7.2

Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low
- Major Roads
- Local Roads

N

Scale: 1 inch equals 18.83 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Liquefaction Hazard Map

Liquefaction Hazard Level

- High
- Moderate
- Moderately Low
- Very Low
- Major Roads
- Local Roads

Scale: 1 inch equals 18.83 miles

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community. More detailed maps are needed for site development decisions. Hazard levels may be incorrect by one unit higher or lower

This map is available at http://quake.abag.ca.gov

Source:
ABAG, 2001

ABAG Geographic Information Systems

Monte Vista Thrust Earthquake - Magnitude 6.6

California Geological Survey Seismic Hazard Zones of Required Investigation

Landslide Zones

Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

Mapping In Progress

Mapping Planned

Area Not Yet Evaluated

1 inch equals 9.30 miles

N

Scale:

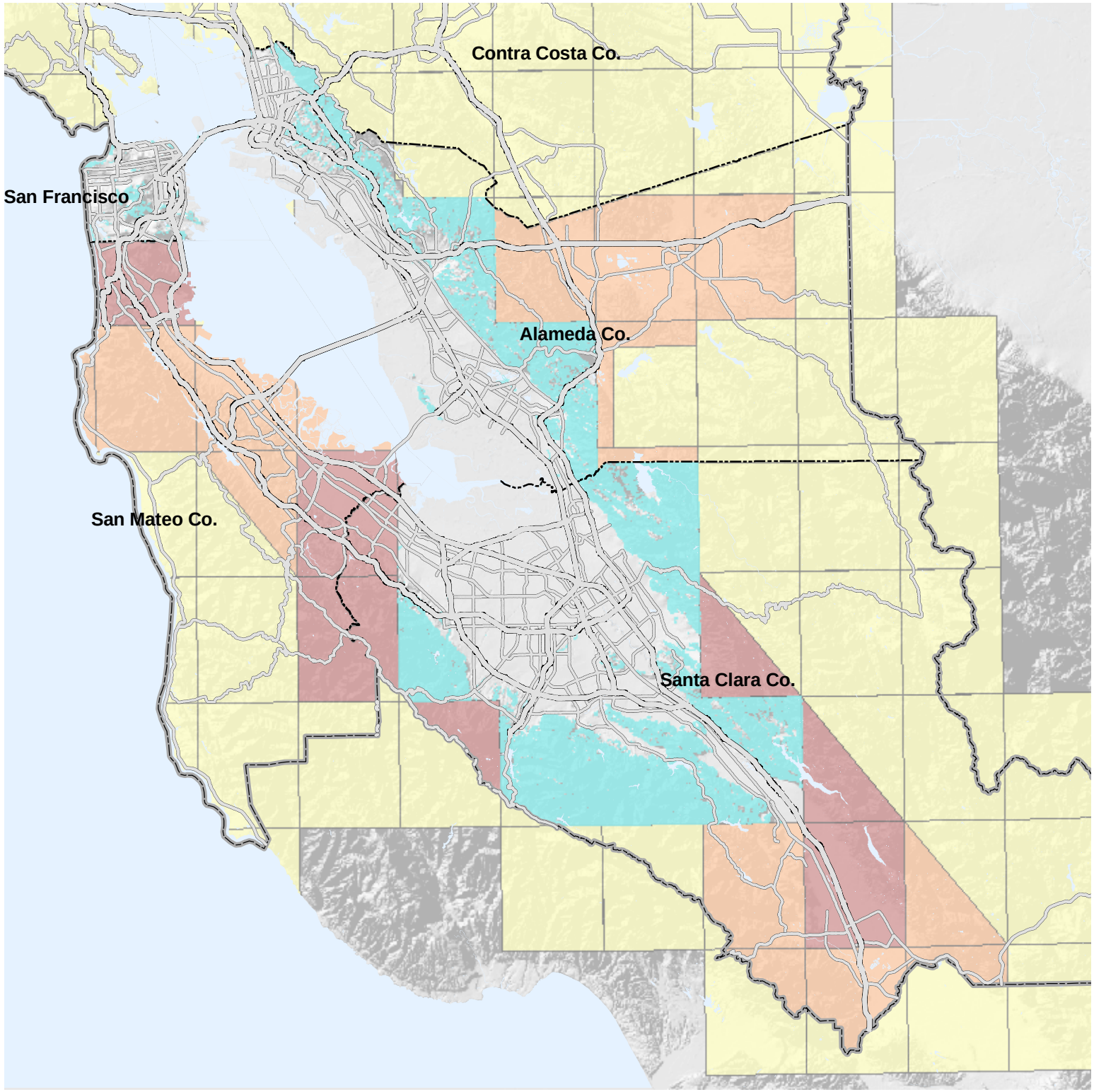
This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community.

For more detailed information regarding this map, please visit the CGS website at http://gmw.consrv.ca.gov/shmp/

Source:
California Geological Survey, 2004

This map is available at http://quake.abag.ca.gov

ABAG Geographic Information Systems



Tsunami Evacuation Planning Map for San Francisco & San Mateo Counties

Tsunami Evacuation Area

Urbanized Area

Shaded to show topographical relief

N

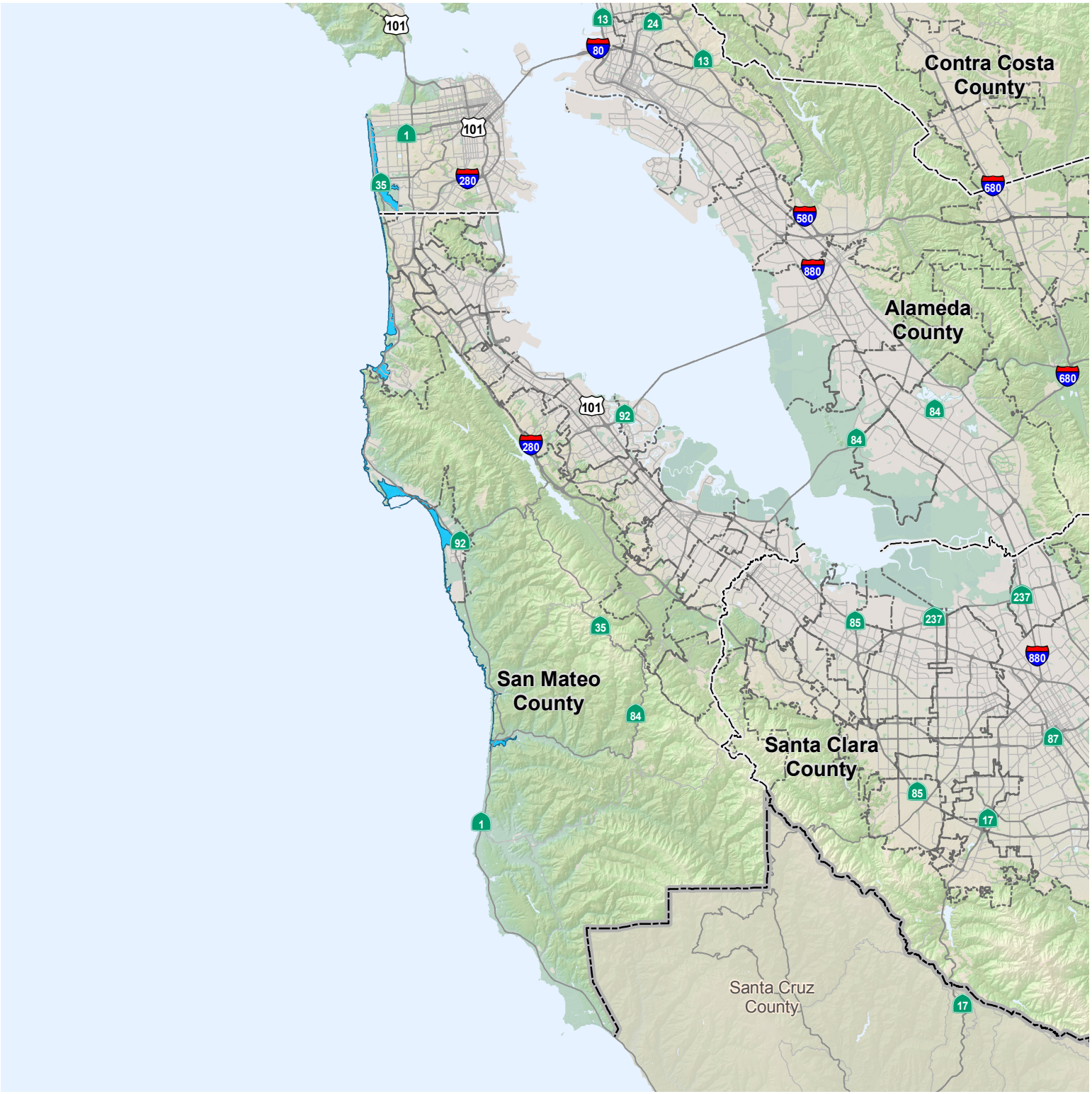
Scale: 1 inch = 6.83 miles

These tsunami evacuation planning maps for the ocean side of San Francisco and San Mateo counties are based on modeling of potential earthquake sources and hypothetical extreme undersea, near-shore landslide sources. Maximum run-up to a specific contour was determined to be reasonable. This contour is 12.8 meters (42 feet) in these two counties. These maps were produced by OES and are intended for local jurisdictional, coastal evacuation planning uses only. Maps for Marin and Sonoma counties are not yet available. For more information visit http://quake.abag.ca.gov/tsunami.

Source: California Office of Emergency Services, Coastal Region (2004)

This map is available at http://quake.abag.ca.gov

ABAG Geographic Information Systems



FEMA
Flood Hazard Areas

Flood Hazard Areas

- Zone V- (100 yr. Flood Zone)
- Zone A- (100 yr. Flood Zone)
- Zone X500- (500 yr. Flood Zone or other concerns)
- Urbanized Area

Shaded to show topographical relief

Detailed FEMA Explanation

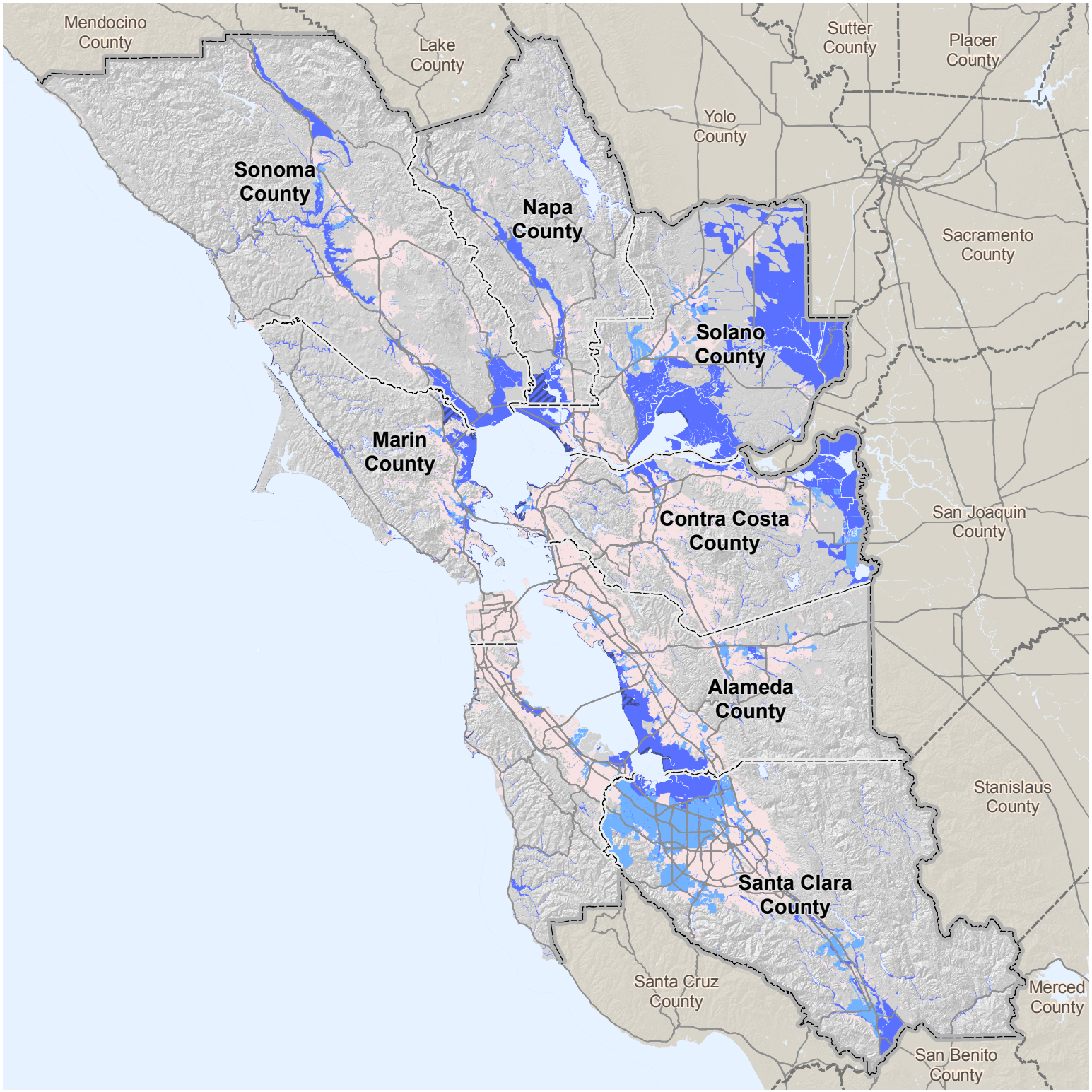
Flood Zone	Description
Zone V	This code identifies an area inundated by 1% annual chance flooding with velocity hazard (wave action).
Zone A	This code identifies an area inundated by 1% annual chance flooding.
Zone X500	This code identifies an area inundated by 0.2% annual chance flooding; an area inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; or an area protected by levees from 1% annual chance flooding.

N

Scale: 1 inch = 17.53 miles

Sources:
Flood Zones - FEMA Q3 (2003) and DFIRM (2009)
Base Data - TeleAtlas (2008)
The product has been designed to support planning activities.
A more detailed version of this map is available at http://quake.abag.ca.gov

ABAG Geographic Information Systems



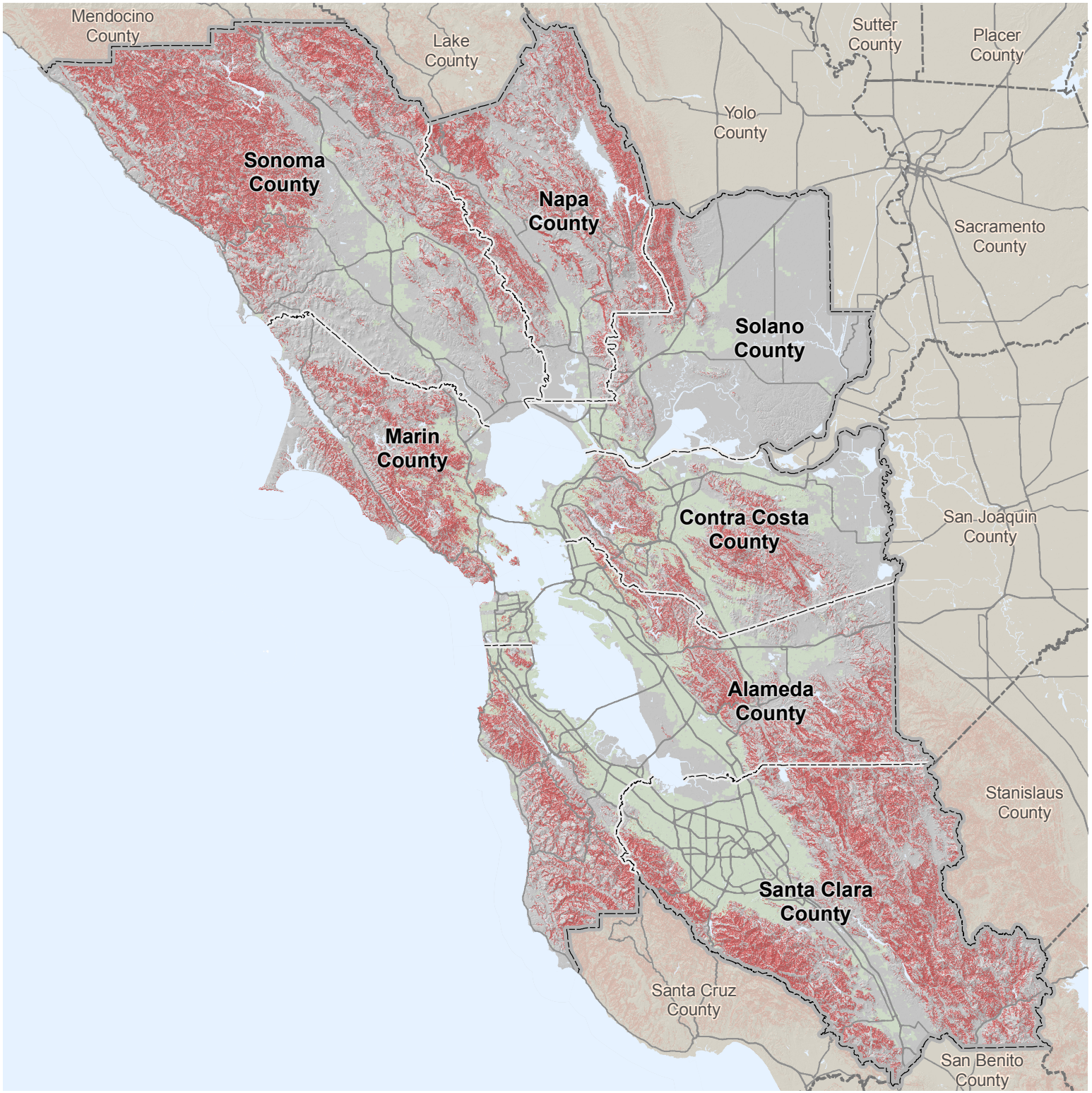
Principal Debris-Flow Source Areas in the San Francisco Bay Region

Debris-Flow Source Area

Urban Footprint

N

Scale: 1 inch = 17.13 miles



This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community.

This map is available at http://quake.abag.ca.gov

For more detailed informtion regarding this map, please visit the USGS website at http://wrgis.wr.usgs.gov/open-file/of97-745/

Source:
USGS Open File Report 97-745 E, 1997

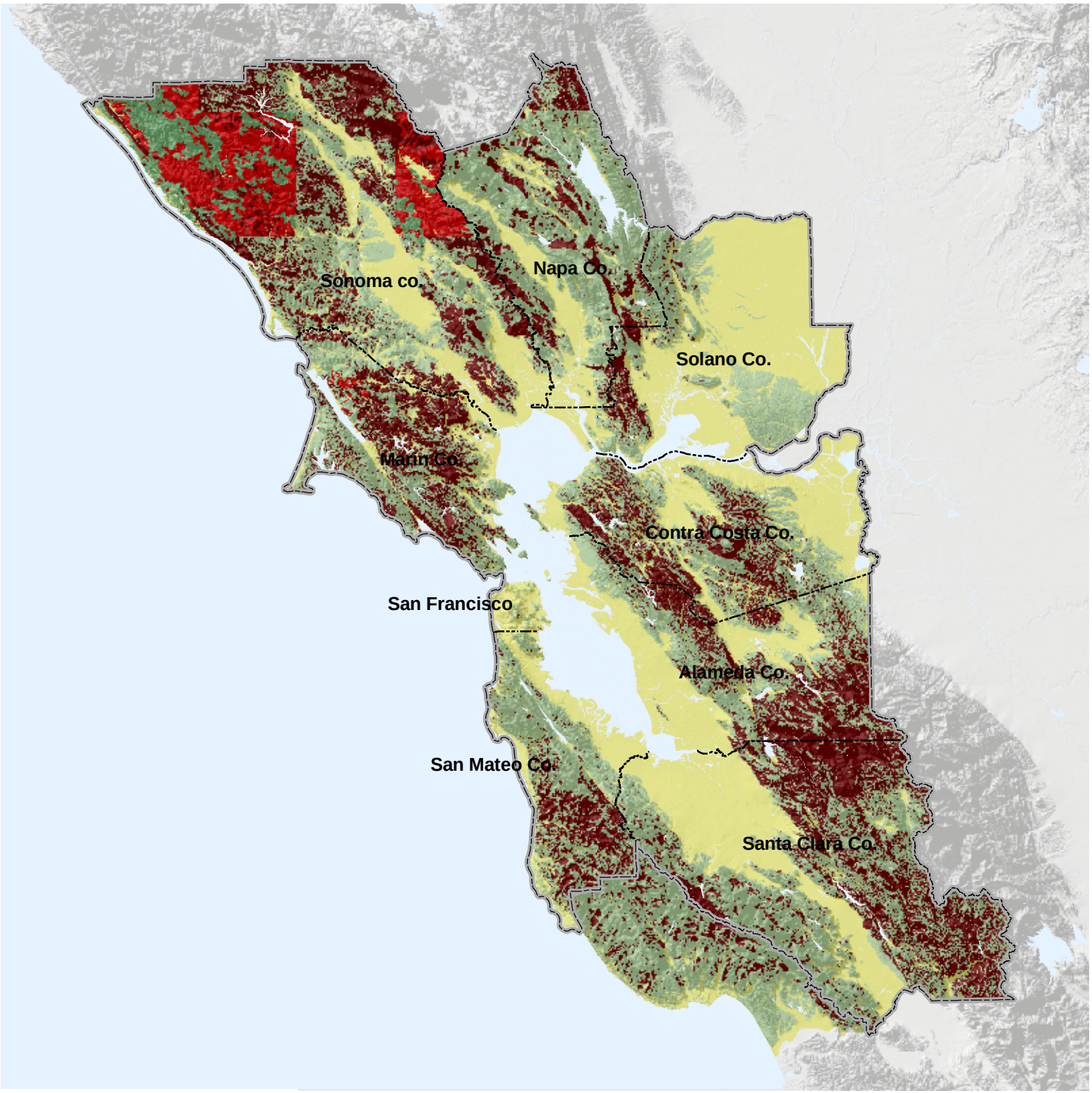
ABAG Geographic Information Systems

Summary Distribution of Slides and Earth Flows in the San Francisco Bay Region

- Mostly Landslides
- Many Landslides
- Flatland
- Few Landslides
- Very Few Landslides

N

Scale: 1 inch equals 18.67 miles



This map is intended for planning use only, and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community.

This map is available at http://quake.abag.ca.gov

For more detailed informtion regarding this map, please visit the USGS website at http://wrgis.wr.usgs.gov/open-file/of97-745/

Source:
USGS Open File Report 97-745 E, 1997

ABAG Geographic Information Systems

Wildland Urban Interface - Fire Threatened Communities

Community at Risk

Urbanized Area

N

1 inch = 17.81 miles

Local fire jurisdictions may have identified additional fire hazard areas, especially in communities adjacent to wildland.

This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community.

This map is available at http://quake.abag.ca.gov

Source:
California Department of Forestry and Fire Protection, 2003

ABAG Geographic Information Systems

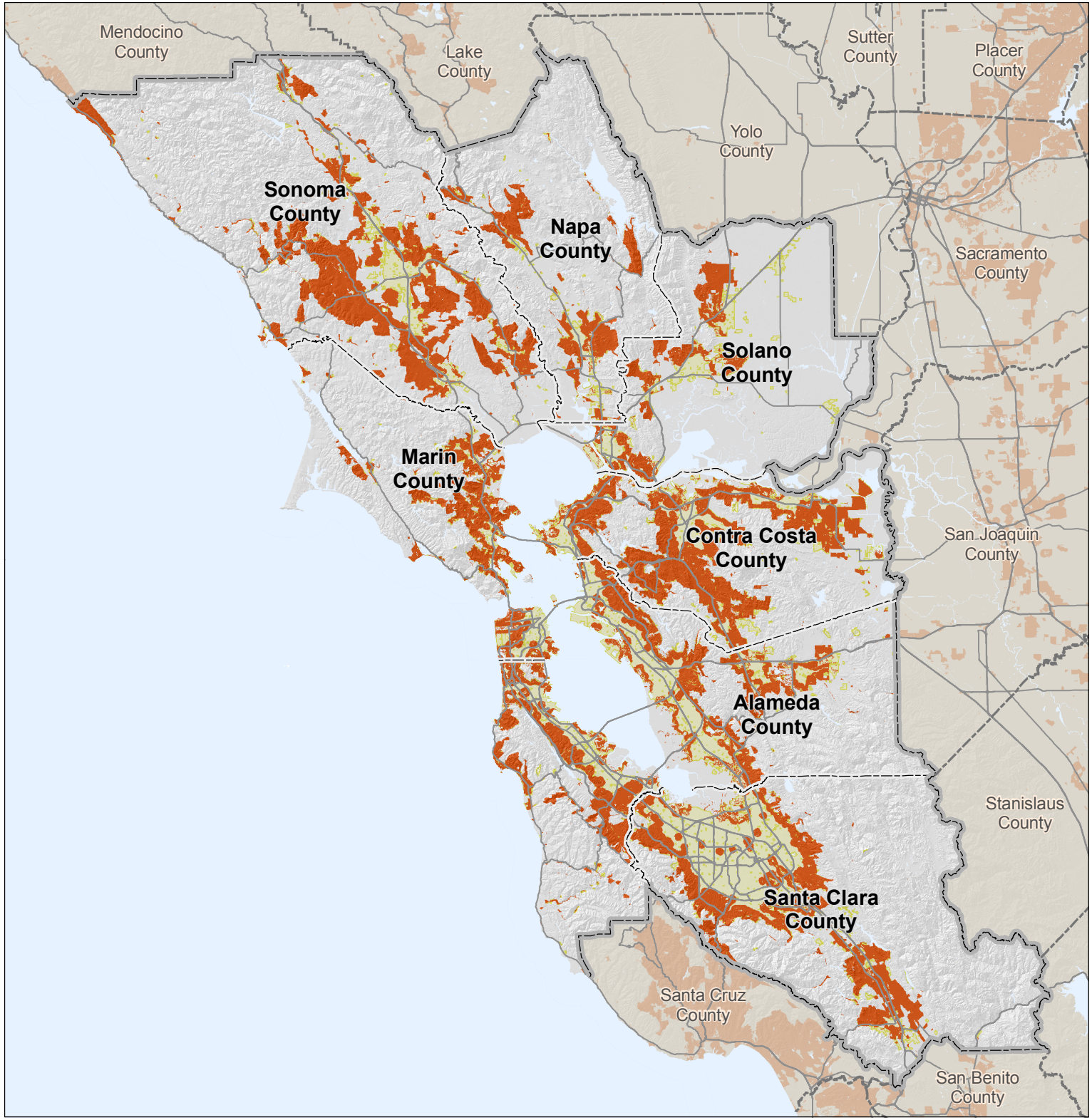


Plate 48

Fire Threat in the San Francisco Bay Region

- Extreme
- Very High
- High
- Moderate
- Little or No Threat

N

1 inch = 17.54 miles

This map focuses on wildland fuels in State Responsibility Areas, that is, where the California Department of Forestry has primary jurisdiction for wildland fire response. Local fire jurisdictions may have identified additional fire hazard areas, especially in communities adjacent to wildland.

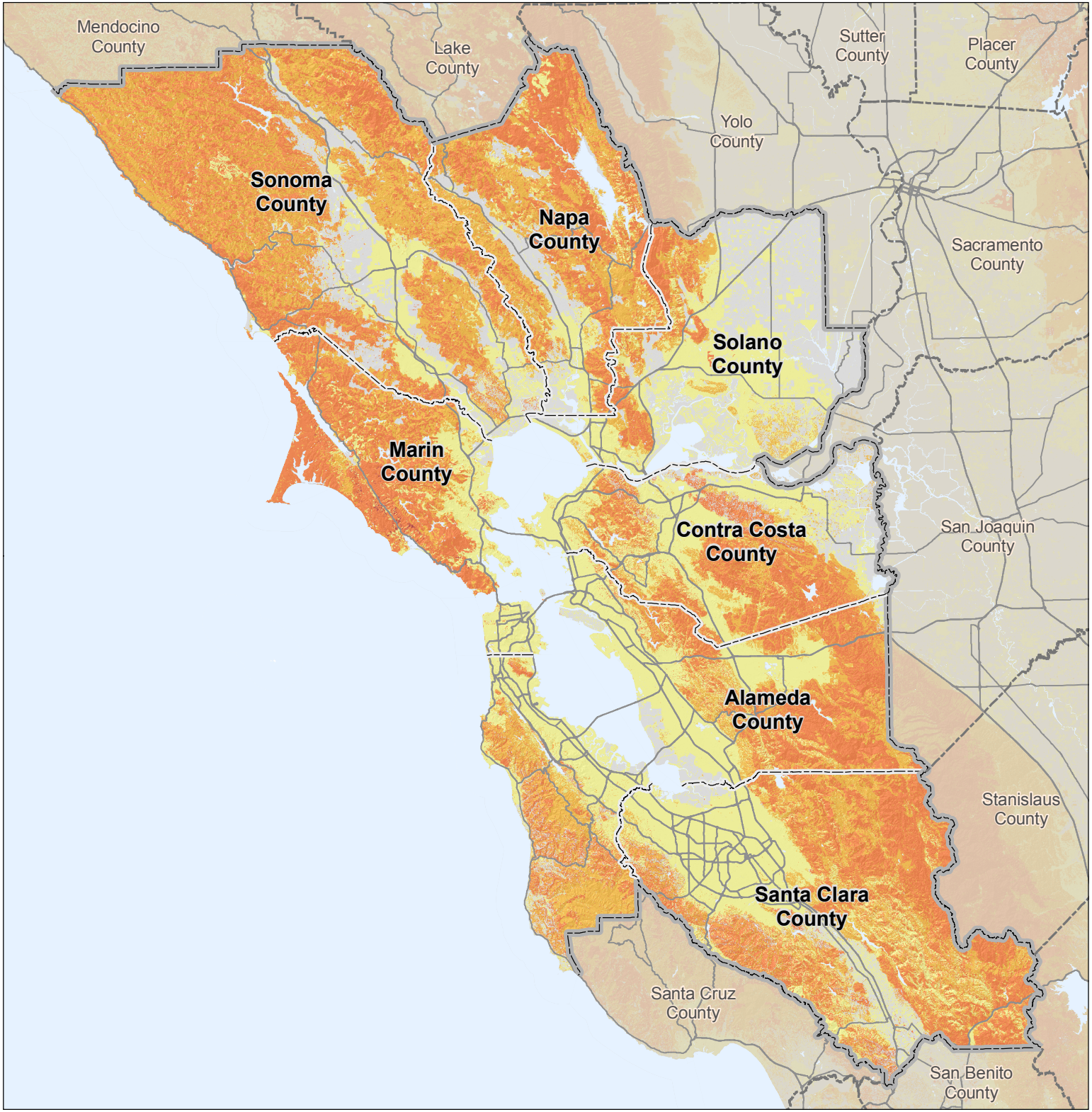
This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community.

This map is available at http://quake.abag.ca.gov

Combines expected fire frequency with potential fire behavior to create 4 threat classes

Source:
California Department of Forestry and Fire Protection, 2005

ABAG Geographic Information Systems



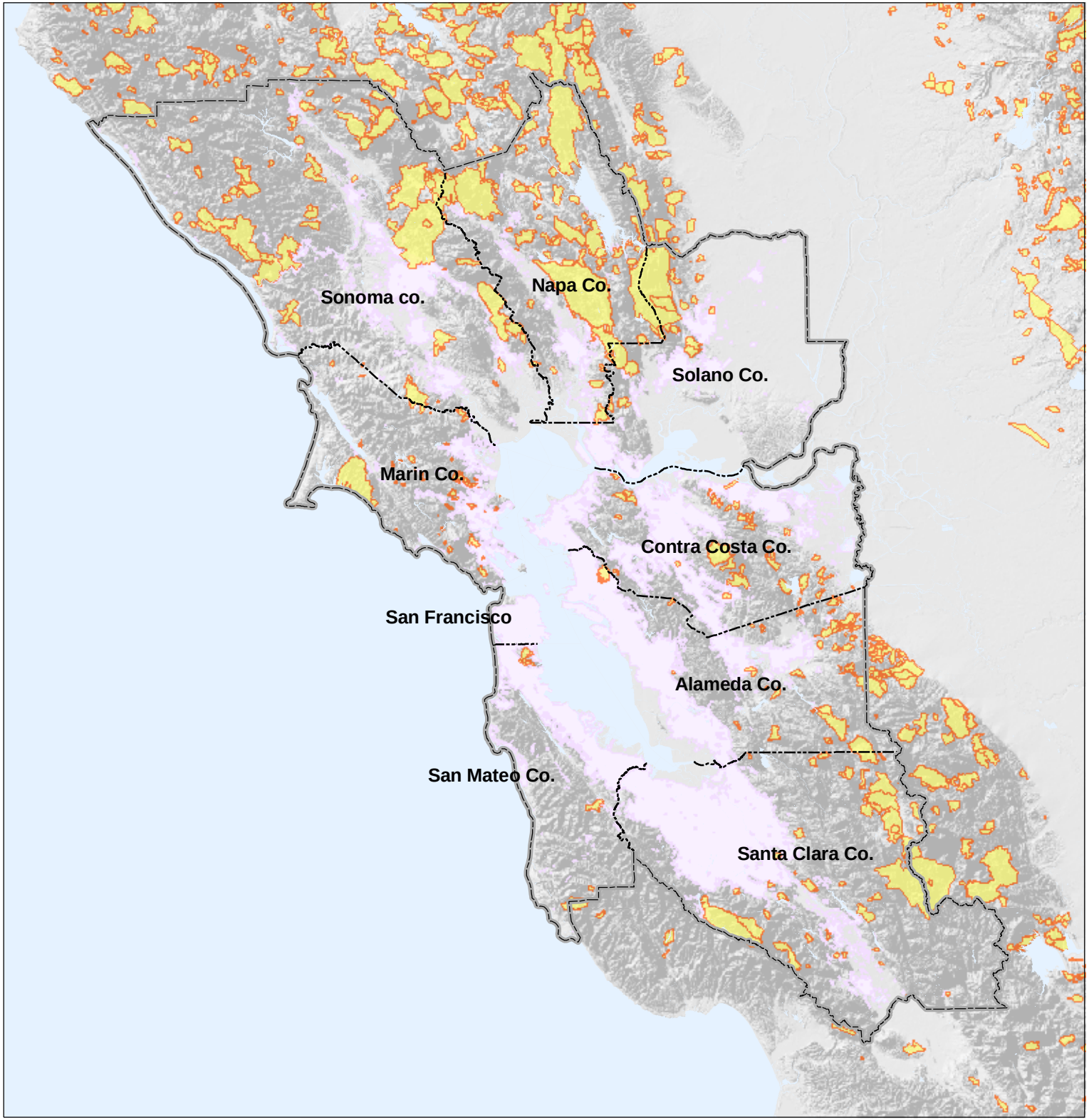
Fire Perimeters - 1950 to Present

Fire Perimeter

Urbanized Area

N

1 inch equals 19.09 miles



This map is intended for planning use only and is not intended to be site-specific. Rather, it depicts the general risk within neighborhoods and the relative risk from community to community.

This map is available at http://quake.abag.ca.gov

Source:
California Department of Forestry and Fire Protection, 2004

ABAG Geographic Information Systems

Distribution of Wildland-Urban Interface Housing Unit Density

- Rural (1 unit/5 acres to 1 unit/20 acres)
- Interface (1 unit/acre to 1 unit/5 acres)
- Urban (greater than 1 unit/acre)

N

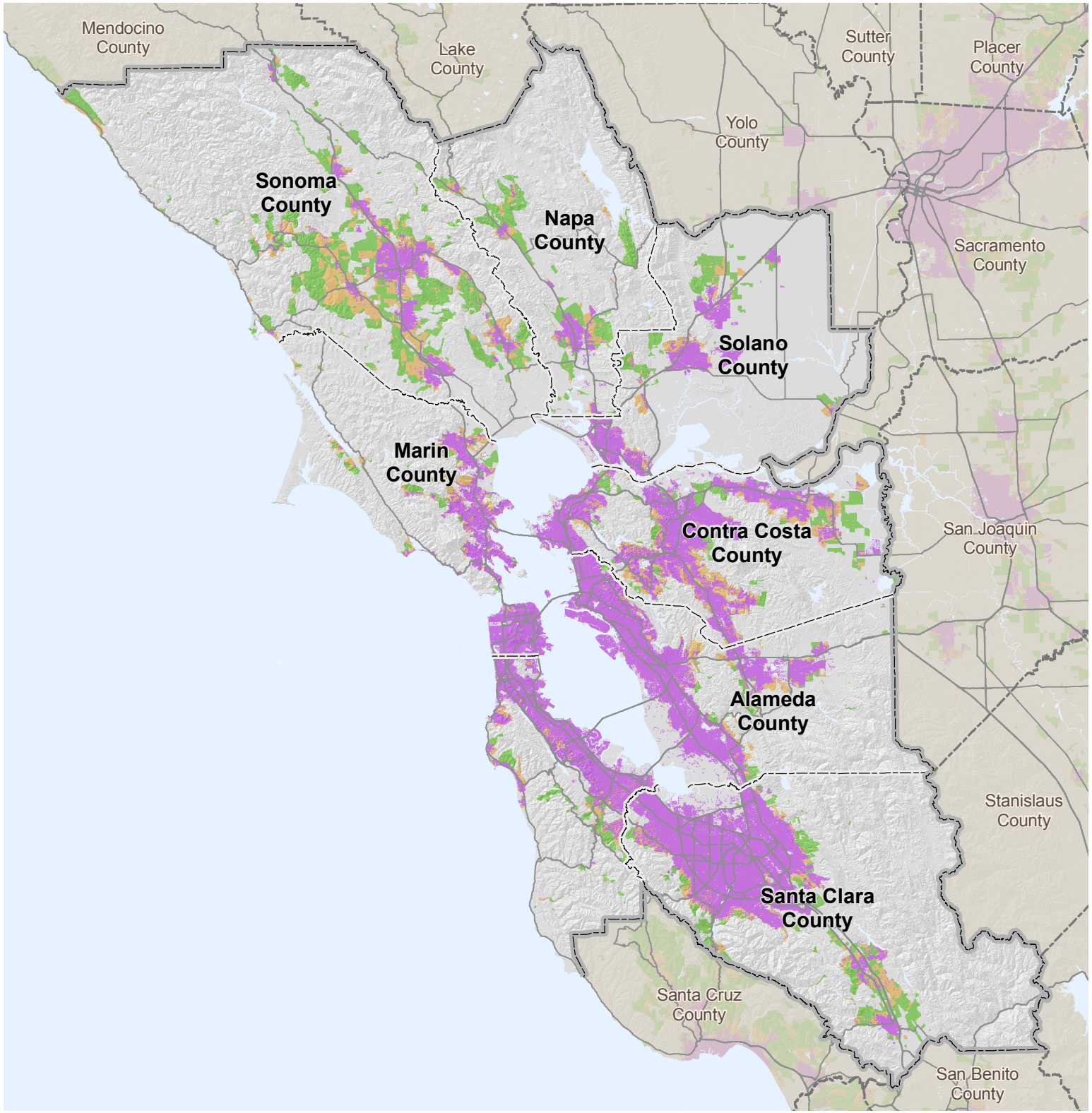
1 inch = 17.47 miles

This map is intended for planning use only.

Map is available at
http://quake.abag.ca.gov

Source:
California Department of Forestry and Fire Protection, 2003
http://frap.cdf.ca.gov/

ABAG Geographic Information Systems



Fire-related Risks to Ecosystem Health as Measured by Condition Class

- Low - Condition Class 1
- Moderate - Condition Class 2
- High - Condition Class 3
- Non-Forests & Rangelands

N

1 inch = 17.07 miles

Condition Classes are defined as the relative risk of losing key components that define an ecosystem (Hardy et al., 2001).

This map is intended for planning use only.

Map is available at http://quake.abag.ca.gov

Source:
California Department of Forestry and Fire Protection, 2003
http://frap.cdf.ca.gov/

ABAG Geographic Information Systems

Post-Wildfire Soil Erosion Potential

- Area without a Fuel Rank (generally Ag or Barren)
- Water and Urban Areas
- Low
- Moderate
- High

N

1 inch = 16.74 miles

This map is based on data created by CDF's Fire and Resource Assessment Program that shows estimated erosion potential after a wildfire, based on the Universal Soil Loss Equation.

This map is intended for planning use only and is not intended to be site specific.

Map is available at http://quake.abag.ca.gov

Source:
California Department of Forestry and Fire Protection, 2004
http://frap.cdf.ca.gov/

ABAG Geographic Information Systems

Dam Failure Inundation Areas

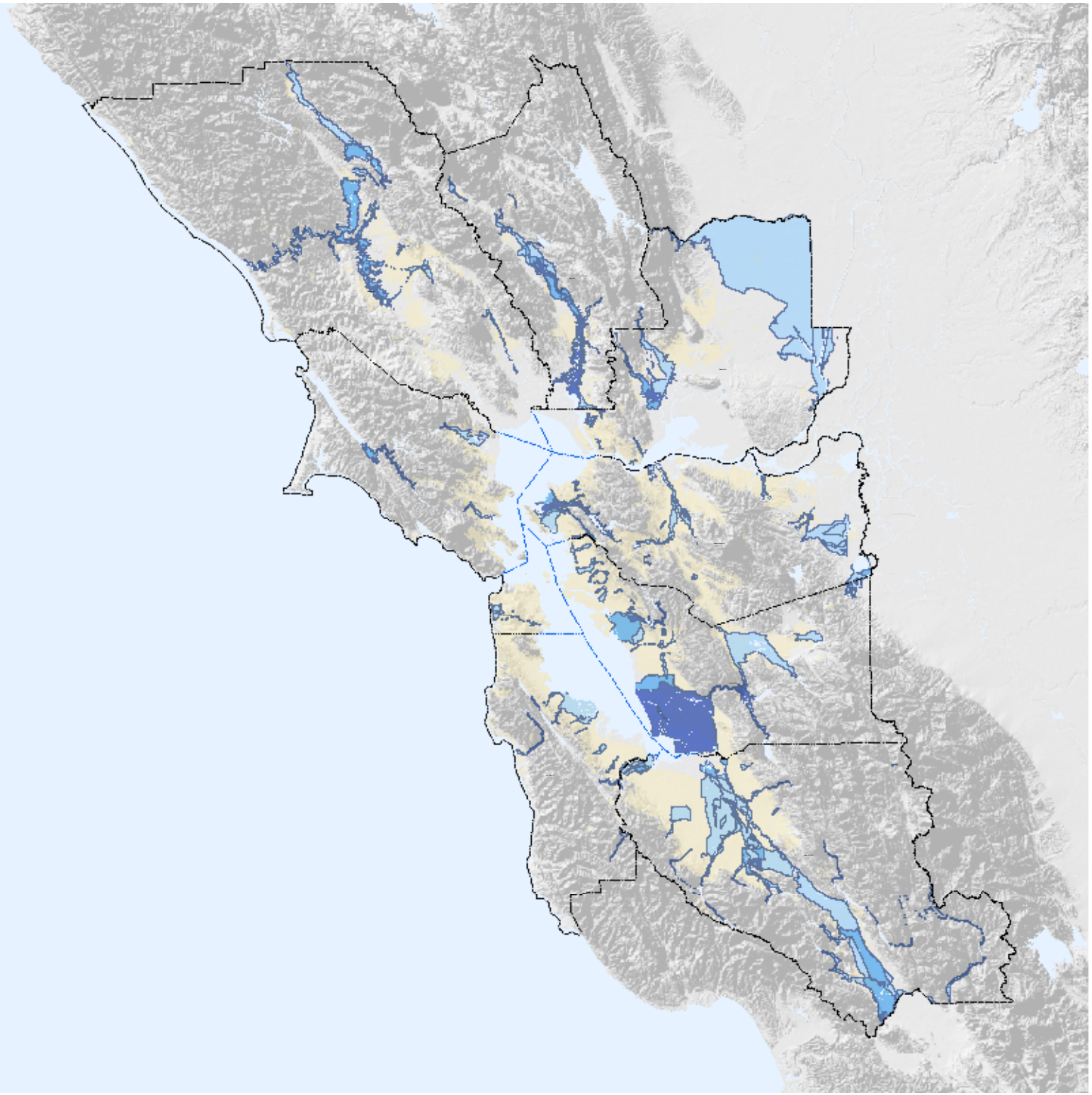
Areas that can be inundated by any one of:

- 5 different dams
- 4 different dams
- 3 different dams
- 2 different dams
- 1 dam only
- Urbanized Area
- Dam Location

Shaded to show topographical relief

N

Scale: 1 inch equals 18.74 miles



This map is intended for planning use only and is not intended to be site specific. Rather it depicts the general risk within neighborhoods and the relative risk from community to community.

This hazard map is generalized from maps dam owners are required to prepare and file with the State Office of Emergency Services.

Source: ABAG, 1995

This map is available at http://quake.abag.ca.gov

ABAG Geographic Information Systems

Repetitive Loss Properties in Floods

- Repetitive Loss Property
- Creeks, Streams and Rivers
- Urbanized Area

FEMA Flood Hazard Areas

- Zone V- (100 yr. Flood Zone)
- Zone A- (100 yr. Flood Zone)
- Zone X500- (500 yr. Flood Zone or other concerns)

Shaded to show topographical relief

Detailed FEMA Explanation

Flood Zone	Description
Zone V	This code identifies an area inundated by 1% annual chance flooding with velocity hazard (wave action).
Zone A	This code identifies an area inundated by 1% annual chance flooding.
Zone X500	This code identifies an area inundated by 0.2% annual chance flooding; an area inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; or an area protected by levees from 1% annual chance flooding.

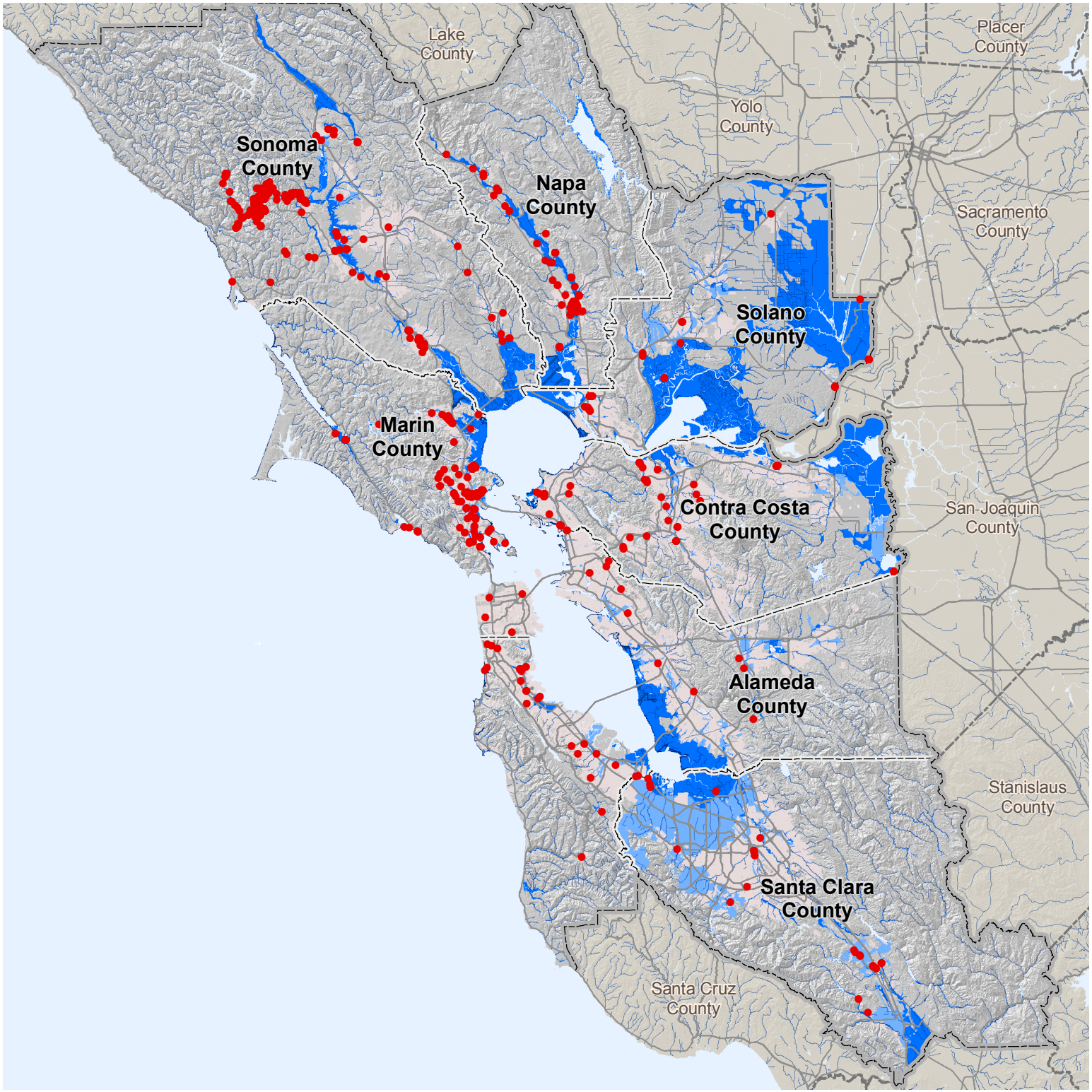
N

Scale: 1 inch = 16.84 miles

Sources:
Repetitive Loss Properties - FEMA National Flood Insurance Program and ABAG (2004)
Flood Zones - FEMA Q3 (2003) and DFIRM (2009) Flood Data
Base Data - TeleAtlas (2008)

The product has been designed to support planning activities.
A more detailed version of this map is available at http://quake.abag.ca.gov

ABAG Geographic Information Systems



APPENDIX A
The Planning Process

Introduction

Development of this multi-jurisdictional plan addressing the diverse concerns and challenges of a region of seven million people has required a multi-layered planning process that employs a variety of forums and techniques. These are described in the sections that follow.

The development of the initial plan in 2004-2005 began with a discussion of the overall scope of work and selection of the key hazards to be addressed and our vulnerabilities. The process then proceeded to a framing of policy goals and finally to a selection of specific mitigation strategies to address the hazards and risks.

The update of the plan that resulted in this 2010 document began in 2007. While the update has been comprehensive in scope, two issues have been most in need of expansion:

- disaster recovery and the need for speeding up the recovery process as one of the criteria used in designing mitigation strategies; and
- climate change as related to impacts on wildfires, drought, and flooding (including sea level rise).

Climate change is the only new hazard in the updated LHMP. No hazards from the original plan were removed in the updated plan. A complete list of hazards evaluated in the plan can be found in Appendix C. In addition, a major effort was undertaken to determine the overall regional priority for implementing these mitigation strategies. The planning process has been designed to accomplish these improvements. 114 local governments are full participants in the 2010 LHMP. See **Section (4) of the Planning Team** for an explanation of the requirements for participating jurisdictions. An additional 16 local governments have participated in the planning process, but are not full participants in the plan. These local governments have been termed "partnering jurisdictions." In general, the difference is due to the addition of new cities, counties, and special districts that did not participate in the original LHMP. However, some jurisdictions are no longer participating, including Contra Costa County, and the City and County of San Francisco. Our update effort has focused on building upon these pre-existing efforts and identifying gaps that may lead to disaster vulnerabilities in order to work on ways to address risks through mitigation.

It is anticipated that this Local Hazard Mitigation Plan will be adopted at a public meeting of ABAG's Executive Board in March 2010 following conditional approval of the plan by FEMA.

ABAG Background

By submitting letters of commitment to ABAG, the participating cities, counties, and special districts of the Bay Area have authorized ABAG to lead the update of this multi-jurisdictional Local Hazard Mitigation Plan. ABAG is a unique regional entity, well-suited to lead this effort. ABAG was formed as a Council of Governments by the cities and counties of the Bay Area to address social, environmental and economic issues that transcend local borders. ABAG is a local government as defined by 44 CFR sec. 201.2. The mission of ABAG is to facilitate and strengthen cooperation and coordination among local governments. The mission of ABAG is carried out by ABAG staff and overseen by ABAG's General Assembly and Executive Board. The General Assembly adopts the annual budget and work program of ABAG and reviews policy actions of the Executive Board. Delegates to the Assembly are member cities and counties, each having one vote.

The Planning Team

Instead of developing a planning team from scratch, several existing committees involved in disaster mitigation were used. This LHMP has been prepared using a Combination Model. The committees described below provided authorized representation for local jurisdictions in the Bay Area. In addition, Direct Representation was required for each jurisdiction participating in the plan update. The planning team developed to update this multi-jurisdictional LHMP is comprised of:

1. ABAG staff
2. ABAG Executive Board
3. existing ABAG committees
    a. Regional Planning Committee (RPC)
    b. Earthquake and Hazards Outreach Committee
    c. Lifeline Infrastructure and Hazards Committee
4. local participating jurisdictions

The roles and responsibilities are described in the following sections.

(1) ABAG Staff

ABAG staff (see **Credits**) led the update process of this multi-jurisdictional Local Hazard Mitigation Plan. Their role was to facilitate coordination and collaboration between the various members and components of the planning team. This included facilitating committee meetings, hosting regional workshops for local jurisdiction staff and developing a public outreach campaign. In addition, ABAG led the effort to develop chapters for each functional area and update the Appendices. All of the work produced by ABAG staff was extensively reviewed and approved by the planning team and members of the public.

(2) ABAG Executive Board

The Executive Board is composed of elected officials- members of county boards of supervisors and city councils. The function of the Executive Board is to receive, review, and act on recommendations from other Association committees, including RPC and to carry out policies established by the General Assembly. For purposes of the LHMP, the Executive Board's responsibility is to adopt the plan upon conditional approval by FEMA. The membership of the Executive Board is composed of 38 voting members. Thirty-five of these members are appointed to reflect the population size of each county, as follows:

- Alameda County (7) two for the county; two for the cities; three for the City of Oakland
- Contra Costa County (4) two for the county; two for the cities
- Marin County (2) one for the county; one for the cities
- Napa County (2) one for the county; one for the cities
- San Francisco County (5) two for the county; two for the city; one alternating appointment
- San Mateo County (4) two for the county; two for the cities
- Santa Clara County (7) two for the county; two for the cities; three for the City of San José
- Solano County (2) one for the county; one for the cities
- Sonoma County (2) one for the county; one for the cities

The president, vice president, and immediate past president also serve as voting members of the Executive Board. Advisory, non-voting members representing state or federal agencies may be invited to serve at the pleasure of the Executive Board. County representatives are selected by their boards of supervisors. City representatives are appointed by the mayors of member cities in each county. (Those officials representing the City of Oakland and the City of San José are appointed by their respective councils; the City of San Francisco representative is appointed by the mayor.) Each of these appointing

authorities may appoint alternates to the members selected.

(3) Existing ABAG Committees

Three ABAG committees were extensively involved in the planning process of the original development and update of the Local Hazard Mitigation Plan. These committees are composed of a cross section of elected officials, local jurisdiction staff, state and federal government staff, members of academia, private companies, NGOs and members of the public. ABAG, using these and other committees, has been committed to actively reducing the risk of natural hazards in the Bay Area for over 30 years. These committees have all been meeting regularly throughout the planning process to provide input, make recommendations, finalize regional priorities, and review chapters and appendices. The following is a description of the function of each committee. A roster of committee members can be found at the end of **Appendix A**. The Section, **Process for Updating the Plan**, describes in more detail the specific actions taken by each of the following committees.

RPC meetings are always publicly noticed. When the LHMP was an agenda item for the Lifelines or Outreach committee, the meetings were opened to the public and local jurisdictions not on the committee.

(a) Regional Planning Committee (RPC)

RPC is a unique regional forum composed of a minimum of 18 elected officials, including at least one elected county supervisor from each member county and a city elected official from each county. Members also include the Chairperson of the Bay Area Planning Directors' Association or designee; one representative each from the Bay Area Air Quality Management District (BAAQMD), Bay Conservation and Development Commission (BCDC), Metropolitan Transportation Commission (MTC), Regional Water Quality Control Board; and not less than ten citizens to represent the following categories: business, minorities, economic development, recreation/open space, environment, housing, labor, public interest, special districts. The function of RPC is to study regional issues of environmental management, housing, and infrastructure planning. **All RPC meetings were open to the public, advertised, and the public was allowed and encouraged to comment on the discussion.**

(b) Earthquake and Hazards Outreach Review Committee

Membership of this committee is split between technical experts and potential users of the hazard information, including elected officials, building officials, contractors, engineers, state and federal government staff, and members of the public. The purpose of this committee is to study and review background materials, reports and maps being prepared by ABAG related to earthquake hazards outreach including: housing vulnerability and retrofit, small business preparedness.

(c) Lifelines Infrastructure and Hazards Review Committee

Members of this committee represent a mix of lifeline planners and transportation users, including representatives from water districts, transit districts, California Geologic Survey, USGS, PG&E, MTC, and members of the public. The purpose of this committee is to

- Studies and reviews materials related to planning for transportation and lifeline system disruptions following future earthquakes:
- Review modeling approaches for estimating disruptions to the regional transportation and water system
- Review techniques for estimating the importance of various transportation and lifeline facilities to post-earthquake repines
- Review and propose recommendations for improving transportation and lifeline systems

(3) Participating Local Jurisdictions

Many local jurisdictions participated in the development of the update to the Local Hazard Mitigation Plan, but only jurisdictions that have met the following requirements set forth by ABAG and CalEMA are considered an **Actively Participating Jurisdiction**:

- submitted a letter of commitment to this effort to ABAG and CalEMA;
- submitted a list of critical facilities to ABAG for its use in developing this plan that included, at a minimum, the location and use of the facility (additional information included structural system type, insured value, capacity, year built, number of stories, roofing material, sprinkler system, alternate power, anchorage of equipment and contents, recent seismic retrofitting, and configuration irregularities);
- as applicable, submitted information on unique local hazards, vulnerabilities, and risks not identified or evaluated regionally;
- submitted comments and feedback on the multi-jurisdictional plan at a minimum of two workshops or other forums (including written or oral comments) as priorities for regional hazards, risks, and mitigation activities were identified.
- submitted a spreadsheet showing the local priorities for implementation of the various mitigation strategies, including department or group responsible for implementation;
- provide at least two opportunities for the public to comment on the local priorities for implementation of the mitigation strategies.
- an understanding that, for FEMA approval, they must supply ABAG, CalEMA, and FEMA with a formal resolution adopting both the multi-jurisdictional Local Hazard Mitigation Plan and their local annex.

Descriptions of how these requirements were implemented are detailed in the following sections. The individual contributions of each local government to the development of this overall plan are detailed in **Appendix H.** The tables in this appendix specify which local governments attended which ABAG forum or workshop, those that provided written or oral comments on various aspects of the overall plan. Meeting minutes for RPC or Executive Board meetings described in this section and in **Appendix H** may be obtained by visiting the ABAG website http://www.abag.ca.gov/meetings/. Minutes for all other meetings are available upon request to ABAG. **Appendix I** provides the name and contact information for those individuals who worked directly on this effort.

The 2007-2010 Planning Process for Updating the Plan

In order to achieve the goal of the Local Hazard Mitigation Plan to maintain and enhance a disaster-resistant region, extensive involvement from local governments, special districts and the public was considered crucial. Therefore, the planning process has been designed to:

- encourage genuine, collaborative planning where local governments, special districts, residents, and ABAG work together to identify regional hazards, mitigation strategies, and mitigation priorities.
- help ensure that through collaboration those identified needs are incorporated into a comprehensive regional plan as well as locally adopted plans and policies
- ensure that strong connections are made between local and regional mitigation activities.

The planning process included several phases: (1) reevaluate the functional areas of the plan based on prioritizing mitigation strategies that facilitate long-term recovery, (2) mitigation priority setting by cities, counties, special districts, and the public, (3) developing chapters highlighting the functional areas of the plan, (4) raising public awareness, and (5) focused outreach activities in partnership with local jurisdictions or community-based organizations.

(1) Reevaluate the Functional Areas of the Plan Based on Prioritizing Mitigation for Long-Term Recovery Issues

ABAG understands that recovery and mitigation are different processes and that mitigation takes place before a disaster while recovery is the long process of rebuilding after a disaster. Mitigation is intimately tied to recovery as mitigation actions, such as retrofitting structures, speed the process of recovery. If mitigation only addresses strengthening of facilities needed for immediate disaster response, the recovery process will be delayed. Thus, in order to meet the goal of a disaster resistant region, this LHMP must focus on mitigation as it ties to both disaster recovery and disaster response.

Starting in December 2007, ABAG began a series of issue-oriented workshop forums at meetings of its main policy standing committee, the Regional Planning Committee (RPC) relating to long-term disaster recovery. These workshops were the result of several factors, including the need to go beyond the short-term recovery planning of the Bay Area Urban Area Security Initiative (UASI), as well as the painful recovery process currently being conducted following Hurricane Katrina. **These meetings were open to the public, advertized, and the public was allowed and encouraged to comment on the discussion.** In addition, to ensure that a broad spectrum of perspectives has been brought forward, speakers from both government and public and private sectors have presented their views in these workshops. RPC has had meetings discussing the issues related to six of the functional areas of this plan, including:

- Overall financing of long-term disaster recovery (December 5, 2007)
- Long-term recovery of housing (April 2, 2008)
- Long-term recovery of business (particularly smaller local-servicing business) (June 4, 2008)
- Long-term recovery of government services and facilities (August 6, 2008)
- Long-term recovery of utilities and transportation systems (December 3, 2008)
- Long-term recovery of school and education (April 1, 2009)
- Long-term recovery of health systems (June 3, 2009)
- Land use change and long-term recovery (December 2, 2009)

(2) Regional Mitigation Priority Setting by Cities, Counties, and Special Districts, with Public Involvement

One of the shortcomings of the 2005 plan was the lack of consistent priorities which detracted from the quality of that plan. To correct that deficiency, ABAG staff created a multi-tiered process that focused on workshops and outreach. These workshops also provided an opportunity for local governments to participate in the planning process for the multi-jurisdictional plan.

At these workshops, attended by local jurisdiction staff, each of the strategies was reviewed for its relevance. Decisions were made by local jurisdictions about which strategies should be deleted, where wording needed to be changed to reflect current conditions, made clarifications and decided when new strategies should be added. At each workshop consensus was reached on what the regional priority for each strategy should be. The decision on priority was made based on a variety of criteria, not simply on an economic cost-benefit analysis. These criteria include being technically and administratively feasible, politically acceptable, socially appropriate, legal, economically sound, and not harmful to the environment or our heritage.

a. To ensure broad representation from transit agencies, sewer agencies, and water districts, separate forums were created for those staff.
   - *The sewer district forum*, on October 9, 2008, was attended by 78 staff from 30 sewer agencies and departments. Four members of the public were also in attendance at this meeting.
   - *The water forum*, on March 25, 2009, was attended by 30 staff from 17 water agencies and departments.

- *The transit district forum*, on February 12, 2009, was attended by 17 staff representing 10 transit agencies.

b. Five sub-regional meetings held from April 27, 2009 to May 12, 2009 were attended by a total of 110 staff from 83 cities, counties, and special districts, including:
   - 15 staff from 9 jurisdictions on April 27, 2009 in Fairfield, Solano County;
   - 15 staff from 13 jurisdictions on April 30, 2009 in Corte Madera, Marin County;
   - 15 staff from 14 jurisdictions on May 4, 2009 in Santa Clara, Santa Clara County;
   - 36 staff from 30 jurisdictions plus one member of the public on May 8, 2009 in Oakland, Alameda County, and;
   - 28 staff from 21 jurisdictions on May 12, 2009 in Redwood City, San Mateo County.

c. Three regional workshops were held to review these draft priorities and receive additional feedback from subject area experts and additional local government staff. Participants at each of these workshops reached consensus on regional priorities where there were discrepancies between the priorities designated in each of the previous workshops. Participants also further refined the language of the strategies and added some new strategies based on their expertise. **These meetings were open to the public, advertized, and the public was encouraged to comment on the discussion.**
   - The workshop on earthquake issues in conjunction with the ABAG Earthquake and Hazards Outreach Committee meeting was held on May 27, 2009, in which several retrofit contractors, private engineers, and members of the public commented on the process.
   - The workshop on wildfire held on July 2, 2009, was attended by 16 staff from 13 local governments and fire departments. Three members of the public were also in attendance and commented on the process.
   - The workshop on flooding was held on July 7, 2009, was attended by 21 staff from 16 water agencies, local governments, and a school district. Six members of the public were also in attendance and commented on the process.

d. The entire revised mitigation strategies and draft priorities were posted online **for public comment** from August 17, 2009 to September 17, 2009. These strategies were announced on ABAG's website, through announcements at public meetings and in newspapers contacted by participating agencies.

e. The revised mitigation strategies and draft priorities were recommended by ABAG's RPC for endorsement by ABAG's Executive Board in a public meeting on August 5, 2009 and during which the public had an opportunity to comment. One member of the public was in attendance at this meeting, but no comments were made. Several comments were given by RPC members that pertained to the need to include strategies to deal with public health issues and that there needs to be a strategy to deal with issues in the Sacramento-San Joaquin Delta. As a result of these comments, strategies INFR a-22 and HEAL c-6 were added. See Appendix G or Chapters 1-Infrastructure and 2- Health for the wording and discussion of these strategies. RPC also commented on the need to incorporate non-profits into the mitigation planning process. This issue is dealt with in strategies HSNG k-16 and ECON j-13.

f. The final mitigation strategies and regional priorities were endorsed by ABAG's Executive Board in a public meeting advertized for public comment and during which the public had an opportunity to comment on September 17, 2009. No members of the public were in attendance at this meeting. The Executive Board moved to endorse the strategies and regional priorities with only minor comments. One member requested that we focus more on the impact of the climate change on infrastructure. As a result of that comment and at the request of water agencies at the September 2, 2009 Lifelines

(3) Developing Chapters to Highlight the Functional Areas

The decision was made by ABAG staff and members of ABAG's committees, that in order to better make the connection between hazards, risks and mitigation actions, chapters should be developed for the updated LHMP to address in more detail the issues that the mitigation strategies were meant to address. The chapters are organized around each of the eight functional areas. The strategies are grouped together by the common issue they address and are preceded by a short summary of the issue and how it is being addressed by different jurisdictions in the Bay Area today or where more needs to be done. The chapters were drafted by ABAG staff and reviewed at a series of workshops with LHMP participants, partners and the public. All chapters have been posted on ABAG's website for comment since August 30, 2009. These meetings are outlined below:

a. ABAG's Lifelines Infrastructure and Hazards Committee met May 6, 2009 to review the outcomes of the Water Forum on March 25, 2009. On September 2, 2009, the committee to review the Infrastructure and Environment chapters developed by ABAG staff. This meeting was attended by 16 people representing 12 local lifeline infrastructure providers and local governments. A representative from the Bay Conservation and Development District was also in attendance and commented on the process. The major comments at this meeting had to do with the importance of climate change and its effect on other natural hazards which affect lifeline infrastructure providers. The Infrastructure chapter was updated to incorporate these comments. The update of both chapters was posted online for public comment. Updates to the chapters were reviewed at subsequent meetings of the Lifelines Committee on October 7, 2009 and December 8, 2009.

b. ABAG's Earthquake and Hazards Outreach Committee met on September 23, 2009 to review the Housing, Economy and Land Use Chapters. This meeting was attended by 15 people representing local governments, retrofit contractors, engineers, the State Seismic Safety Commission, San Jose State University. Two members of the public with no specific affiliations were also in attendance and commented on the chapters. Comments from the meeting were incorporated in the chapters and posted online for further public comment.

c. ABAG's Regional Planning Committee reviewed all of the LHMP chapters at its meeting on October 7, 2009, focusing on the Government Chapter. While the meeting was advertised and open to the public, no members of the public were in attendance at this portion of the RPC meeting. In general, the Committee agreed with the formatting of the chapters. The priorities identified for ABAG itself were also endorsed. The RPC continued with this process, particularly as related to existing and proposed land uses and land use change following disasters, at a workshop on land use change and disaster recovery at its December 2009 meeting.

d. The Schools and Health chapters were based on Issue Papers developed for RPC meetings on issues related to Recovery and Health and School systems. These chapters were reviewed by the invited speakers of the meetings and the members of RPC.

(4) Raising Public Awareness

While every effort has been made to make this entire process open and accessible for public participation, the general low level of interest and knowledge of hazards and mitigation by a many members of the public makes outreach more difficult than for other issues, such as traffic, education, or crime. Thus, an extensive effort was made to supplement typical outreach efforts with extensive interaction with "publics" that, by definition, are more interested in this process – existing ABAG committees, local governments, and professional organizations. This conclusion does not mean that the public did not examine the plan.

For example, the "home page" for the "web site" set up for this effort, http://quake.abag.ca.gov/mitigation, received thousands of "hits" from 2007 to 2009.

In addition to the information on the website, public information campaigns or "messages" were developed to inform the public about update to the Local Hazard Mitigation Plan and to educate them about the issues addressed in the plan. This was accomplished by:

- Preparing an op-ed piece on the mitigation plan in conjunction with the 20th anniversary of the Loma Prieta earthquake published on September 29, 2009 by the Oakland Tribune, the Hayward Daily Review, and the Contra Costa Times.
- Securing opportunity for free print ad/community service space in local media in print and online, a task accomplished by cities, counties, and special districts participating in the update process.
- Posting information on ABAG's popular earthquake and hazards website providing background information of the plan, advertising upcoming public meetings, and inviting public comment
- Working with organizations, local governments and special districts to schedule public meetings to discuss aspects of the plan specific to a particular sub-region or interest group that would also give the community opportunity to comment. Such events included (1) the Earthquake Alliance Meeting on mitigation opportunities for health and school systems on August 27, 2009 and (2) the joint conference on business economic and infrastructure system mitigation and recovery sponsored by the Business Executives for National Security (BENS) Northern California, the Bay Area Response Coalition (of financial institutions) (BARCFirst), and the Business Recovery Managers Association (BRMA) on Thursday, June 25, 2009.

(5) Focused Outreach Activities in Partnership with Local Jurisdictions

To ensure that the public has had an opportunity to review the draft priorities of these cities, counties, and special districts, two opportunities were provided for **public comment.**

a. Each of the cities, counties, and special districts participating in this LHMP held at least one meeting in conjunction with a meeting of their City Council, Board of Supervisors, Planning Commission, or held a separate advertised public meeting. The workshops were held in August, September and October 2009 **and were open to the public**. In general, the focus of the meetings was on the draft mitigation strategies of each of these jurisdictions. While members of the public attended many of these meetings, they largely attended to be briefed on the issues and had no substantive comments. In those cases where members of the public were in attendance, there comments were considered and incorporated into the strategy priorities. Records of these meetings and public comments, if any, are on file with the local governments. Any comments related to the MJ-LHMP were forwarded to ABAG. Most comments had to do with unclear sentences or misspelled words. The only substantive comment related to the need to discuss mobile homes more fully. This change was made in Chapter 3 – Housing.

b. Finally, the draft strategy priorities were posted online **for public comment** on individual city, county, and special district web sites in August, September and October 2009. Announcements in local newspapers were placed to highlight the need for public comment. Some local governments advertised these meetings through local cable access channels. Those organizations participating in the hazard workshops also participated in advertising the opportunity for public comment.

c. The strategies were then posted on ABAG's web site at http://quake.abag.ca.gov/mitigation/strategy.html. The only substantive comment received from a member of the public related to the need to discuss private schools more fully. This change was made in Chapter 6 – Schools and Education.

Implementation of Mitigation Strategies

Each local government assigned tentative priorities for the 371 mitigation strategies based on the regional priorities, as well as its own local hazards and risks, as well as on its authority and functions. For example, strategies focused on soft-story apartment buildings are not applicable to a small community with no multifamily housing. In addition, some strategies are appropriate for water districts, others for school districts, and others for county health departments. These preliminary priorities were assigned by local government staff based on a review by people from various agency departments within the local government. The decision on priority was made based on a variety of criteria, not simply on an economic cost-benefit analysis. These criteria include being technically and administratively feasible, politically acceptable, socially appropriate, legal, economically sound, and not harmful to the environment or our heritage.

Cities, counties, and special districts held meetings and workshops as part of the process needed to identify their specific hazards, risks, and appropriate mitigation strategies as described in the previous section. At a minimum, the mitigation strategies were reviewed at an public meeting of the organization's Council, Commission, or Board, as well as posted online for comment prior to submission of the draft LHMP and annexes to CalEMA and FEMA. For more information on each jurisdiction's planning process, see the specific annexes prepared by that local government.

The implementation mechanism varies by jurisdiction. General planning policies are being incorporated into the Safety Element of the General Plan by cities and counties. These strategies are typically those implemented by planning, building, and community development departments. Incorporating these mitigation strategies into the Safety Element has become a major priority of cities and counties because of the state legislation waiving local match for Public Assistance funds. Special districts, as well as cities and counties, typically work to retrofit existing facilities and build new or replacement facilities using capital improvement budgeting processes.

Incorporating Comments

Each of the workshops detailed in the above section had as one of its primary purposes to solicit comments on the development of the plan and mitigation strategies. Many of the workshops focused on developing the chapters. These involved a page-by-page review of the text of the chapters by committee members. In addition, some jurisdictions read chapters of particular interest to them and submitted comments via email to ABAG staff. In all cases, whenever comments or suggestions were received, they were incorporated into the text of the plan through a consensus process. Minutes of committee meetings indicate that suggestions translated directly into changes in the text of the chapters. Public comments were also received from the ABAG public outreach campaign, as well as at the public meetings held by local jurisdictions. In general, the public had questions rather than specific comments on the plan. Whenever comments were provided they were incorporated into the plan.

Opportunities for Other Interested Parties Involvement

While outreach to neighboring local governments might normally be appropriate in the development of a plan such as this, because the area covered by this plan is so large, the logical neighboring entity is the State of California. Staff members of the State Seismic Safety Commission, California Geological Survey, OSHPD, Division of the State Architect, and Coastal Regional Office of Emergency Services were all informed of this update and most were actively involved in the development of this plan. In addition, review of the committee rosters provided at the end of this Appendix will demonstrate that

extensive involvement was sought from a variety of parties on the LHMP. This includes non-profits, universities, local businesses, the State.

Review and Incorporation of Earlier Plans and Studies

Because this is an update to an existing LHMP, that was the main document used in this update process. However, this process was familiar to the local governments of the Bay Area even before the development of the original LHMP. All of the local governments involved in the development of this plan have plans, policies, and/or programs that predate this plan because of:

- the vulnerability of the Bay Area to natural hazards;
- our experiences with past disasters;
- the requirements of the State of California for Safety (and, earlier, Seismic Safety)
- Elements in city and county General Plans since the early 1970s;
- California Environmental Quality Act (CEQA) requirements (particularlysince1988);
- the need to develop sophisticated risk and mitigation information on infrastructure as transportation providers and utilities have worked to gain public acceptance for major programs to strengthen the disaster resistance of these facilities; and
- ABAG's long history of developing hazard maps and risk assessment information.

Our effort has focused on building on these pre-existing efforts and identifying gaps that may lead to disaster vulnerabilities in order to work on ways to address risks through mitigation.
ABAG directed local governments to review the plans and studies described above and provide ABAG with relevant information. In addition, ABAG itself examined the existing technical information available on the various hazards affecting the Bay Area and their impacts. ABAG is very familiar with this information because of the extensive amount of research it has conducted with funding from the U. S. Geological Survey, the National Science Foundation, and others. However, many of the relevant flooding, landsliding, and wildfire data and reports were provided to ABAG following extensive outreach to state and federal agencies, as well as to relevant professional organizations. The result was an extensive library of publications, including plans, studies, reports, and technical data. The most relevant are referenced as footnotes or are summarized briefly in **Appendix C**.

Additional reports that are more relevant to specific local government issues and are cited in specific local annexes to this overall plan. In general, local jurisdictions do not have the capability to develop hazard maps and technical documents specifically for their jurisdictions.

Decision Process for Updating Plan Sections

Following the process outlined in the Plan Maintenance and Update Process (Appendix B of the 2005 Plan) ABAG determined that an update of the plan was not required until 2010 because none of the requirements for an update were triggered prior to the required five-year update.

Hazard and Risk Assessment – The first step that ABAG took in the update of this plan was to contact all developers of hazard maps used in the original LHMP to see if there had been any updates. When an update had occurred, it was incorporated into the plan. These new hazard maps were used to update the information on exposures of critical facilities and land uses to hazards. These updated hazard maps were then used to update the Risk Assessment portion of the plan. Although several of the maps had been updated, there was no major change to any of the maps. However, during the last five years, the failure of the levees in New Orleans resulted in a major new section in the Risk Assessment (**Appendix C**). Finally, **Appendix E** and **F** on Assessing Vulnerability were added.

Mitigation Strategies – Early in the process it was decided that to better make the connection between hazards, risks and mitigation strategies, chapters would be developed on each functional area that explain the rational for each group of mitigation strategies. This decision was supported by the whole planning team and they served as reviewers of the chapters as they were developed by ABAG staff. Wording of some of the strategies were changed, some strategies (particularly related to climate change) were added, others were deleted (largely due to being redundant or no longer applicable), and the regional priorities for those strategies were established for the first time.

Planning Process – The planning process section (this Appendix) was updated to describe the revision of the hazards and risk assessment, the mitigation strategies and chapter development, local jurisdictional involvement, and public involvement.

Plan Maintenance Process –Appendix B was reviewed and only minor changes made.

The 2004-2005 Planning Process

The planning process for the development of the initial plan involved: (1) workshops and interactions with local government staff to identify regional and local hazards and risks, (2) development of a comprehensive list of mitigation strategies or actions, and (3) public outreach.

(1) Interactions with Local Government Staff Focused on Regional and Local Hazard Identification

Sub-Regional Workshops

From June 1 through August 5, 2004, ABAG staff held a series of nine 3-hour forums, one in each of the nine counties in the San Francisco Bay Area. Email invitations were sent to city and town managers, county administrators, planning directors, public works directors, building officials, fire chiefs, and emergency managers of cities and counties. Separate invitations were emailed and faxed to all of the city and county elected officials on ABAG standing committees and the ABAG Executive Board, which represents all 9 counties and 101 cities of the Bay Area. County emergency managers forwarded the information to their contacts in special districts. ABAG worked with staff of the Metropolitan Transportation Commission (MTC) so that transit districts would be notified. A total of 260 staff (and two elected officials) from counties, cities, and special districts attended these workshops.

At these meetings, ABAG staff spent approximately two hours discussing the scope of work in developing this plan, demonstrating proposed Internet-based hazard mapping capabilities, discussing the types of risk assessments to be performed, and talking about the general format of the plan.

An hour during each of these three-hour workshops was spent discussing hazards to be addressed, hazard mapping, risk assessment, and hazard mitigation strategies. Each person was individually queried regarding their views on the process, their concerns, and what they viewed as the most important outcomes of this process. This hour-long discussion became even more focused and interactive in the subsequent workshops than in the earlier ones. It should be noted that the issues identified in later workshops were brought to the attention of the attendees of the earlier workshops through email to ensure adequate feedback.

The immediate result of these workshops and follow-up emails was the “finalization” of the key hazards to be addressed, as well as the draft list of 53 hazard maps to be put into ABAG’s on-line geographic information system (GIS). In addition to the more general issues, some specific concerns were also

addressed. For example, several attendees stressed the need to provide adequate explanatory materials on the hazard maps being developed for non-technical local government staff members, elected officials, and the general public. They had discovered this problem while showing hazard maps at past city council meetings. This discussion resulted in a redesign of the map layouts on the website, making them easier for the public to review and comment.

ABAG outlined the existing technical reports and studies that have been used as a basis for the hazard assessment, exposure, and vulnerability portion of this plan and encouraged feedback to ensure that they are the most comprehensive and technically accurate reports and studies available. These specific reports are discussed and referenced in the applicable plan sections.

ABAG staff also outlined the pros and cons of organizing the mitigation section of the plan based on the traditional categories of hazards versus organizing this section along functional areas. The consensus of these groups was to organize the plan by functional area (health, housing, education, etc. – not fire, earthquake, flood, etc.). The advantages of this organization scheme were viewed as:

- stressing opportunities for multi-hazard mitigation;
- focusing on the positive aspects of what we want to have (housing and a functional transportation system, for example), rather than what we do not want (a fire or earthquake disaster, for example);
- providing stronger opportunities to integrate hazard mitigation into other areas of planning, such as transportation, housing, and land use, rather than isolating it as an offshoot of emergency response; and
- creating ways to have a large and diverse region containing numerous cities, counties, and special districts identify what we can do together.

Local Governments Review and Add to Existing Hazard Information

ABAG directed local governments to review the plans and studies described in the *Introduction* to this appendix and provide ABAG with relevant information. In addition, ABAG itself examined the existing technical information available on the various hazards affecting the Bay Area and their impacts. ABAG is very familiar with this information because of the extensive amount of research it has conducted with funding from the U. S. Geological Survey, the National Science Foundation, and others. However, many more of the relevant flooding, landsliding, and wildfire data and reports were provided to ABAG following extensive outreach to state and federal agencies, as well as to relevant professional organizations. The result was an extensive library of publications, including plans, studies, reports, and technical data. The most relevant are referenced as footnotes or are summarized briefly in Appendix C. Additional reports are more relevant to specific local government issues and are cited in specific local annexes to this overall plan.

(2) Development of Comprehensive Range of Mitigation Strategies or Actions

Mitigation Policy Outline and Review

Having reviewed the discussions at eight of the nine county forums, as well as the draft plans of Berkeley, Napa, and the State of California, ABAG staff developed a draft overall goal and eight basic commitments for the plan. These general policies were presented for comment at the July 15, 2004 meeting of ABAG's Executive Board. This Board is the principal policy Board for ABAG. It meets once every two months and is composed of County Supervisors and City Council members representing all of the nine counties in the Bay Area and the 101 cities in those counties. Meeting agendas are publicly

announced as required by California's Brown Act and are mailed to hundreds of individuals who have requested to receive the agendas. The meetings of this Board are open to the public. While there was considerable discussion regarding the need to address hazard issues, no substantive changes in the goal or commitments were made.

Next, the goal and policies were presented to ABAG's Regional Planning Committee (RPC) at the September 1, 2004 meeting. RPC is the planning policy committee for ABAG. It meets once every two months and is composed of County Supervisors and City Council members representing all of the counties in the Bay Area and the cities in those counties, as well as environmental, economic, and equity groups. Meeting agendas are publicly announced as required by California's Brown Act and are mailed to hundreds of individuals who have requested to receive the agendas. The meeting was also open to the public and the public had the opportunity to comment. The group discussed the general commitments, recommended a change in the way the commitments were ordered, which is reflected in their current order, and supported the commitments in concept.

Use of Two ABAG Special-Issue Review Committees for Mitigation Strategy Development

Two committees were used to develop the sections of the plan that address housing safety, business risk, and lifeline issues.

The ABAG Earthquake and Hazards Outreach Committee was tasked to help with development and review of the mitigation strategies related to housing and business. The committee is chaired by an elected official and has members consisting of city staffs, private construction contractors, California Geological Survey and U.S. Geological Survey scientists, and structural engineers (including both private-sector engineers and an engineer from the State Seismic Safety Commission staff).

At the meetings of this Outreach Committee on June 30, 2004 and September 15, 2004, the continued integration with the International Code Council (ICC) Joint East Bay-Peninsula Chapter effort to develop housing retrofit standards was discussed, and supported. ABAG's proposed new effort to coordinate with the American Association of Grading Officials on landslide mitigation was also presented and discussed. Concerns for soft-story apartments were closely reviewed and the need for a full-day charrette and policy forum was expressed. ABAG has been working with, and was encouraged to continue to work with, Lakeshore Ave. businesses in Oakland in an effort to identify ways to improve the resiliency of downtown retail businesses.

The second committee, the ABAG Lifelines Infrastructure and Hazards Review Committee, is also chaired by an elected official and has members from city and county staffs, local transit districts, the California Highway Patrol (CHP), Caltrans District 4, local water districts, PG&E, SBC Communications, the American Red Cross-Bay Area, the U.S. Geological Survey, and the Coastal Region office of the California Office of Emergency Services. This group met on July 26, 2004, to discuss the development of this plan and to brainstorm potential mitigation strategies, particularly those related to transportation, water supply, sewage, power, and communications systems. The ways these issues interrelate to health, education, and the environment were also discussed. A particular effort was made to develop additional, and improve existing, mitigation strategies related to flooding hazards. Additional comments and ideas were obtained from this committee at its meeting of September 16, 2004.

Creation of First Draft of Mitigation Strategies

ABAG staff drafted an outline of mitigation strategies and circulated the strategies to all participating local government agencies and various professional organizations during September 2004. The strategies

were created based on comments and discussions of the groups listed above, as well as from a review of the State Hazard Mitigation Plan and draft (at the time) Local Hazard Mitigation Plans of Berkeley, Napa (City), Napa County, and Oakland.

Interaction with Professional Groups for Technical Feedback on Mitigation Strategies

From late July 2004 through November 2004, ABAG staff actively approached various professional organizations and advocacy groups to obtain feedback on the preliminary commitment policy statements and mitigation strategies in the plan. These meetings and workshops were invaluable, in part because they generated active involvement of staff members of consulting firms, construction contractors, universities, and non-governmental agencies.

Formal and informal presentations were given to meetings or workshops of:

- the Earthquake Engineering Research Institute Northern California Chapter (EERI-NC) Government Committee (July 26, 2004),
- the ICC East Bay/Peninsula Chapter (July 21, 2004),
- the American Society of Grading Officials (July 21, 2004), and
- the FireSafe Councils (August 25, 2004).

At these meetings, ABAG staff stressed the need for feedback and assistance in drafting mitigation strategies that could be incorporated into the general outline of the eight key commitments of this multi-jurisdictional plan. The EERI-NC meeting resulted in a revised draft of the mitigation strategies related to various types of privately-owned and local government buildings vulnerable to earthquake damage. The ICC meeting resulted in an outline of the mitigation strategies related to vulnerability of single-family homes. The ASGO meeting resulted in strategies related to mitigation of landslides. Finally, the FireSafe Councils meeting resulted in the development of the range of strategies related to fire.

Additional outreach to professional organizations occurred in October and November after the first formal plan release on October 6, 2004. (More information on the October 6th event is included in the following section.) These efforts focused on obtaining comments and peer review for the draft strategies and were more outreach than plan development. Presentations were made to the following groups:

- the Geotechnical Engineering Earthquake Reconnaissance (GEER) group (October 7, 2004) related to landslide mitigation strategies,
- the Earthquake Engineering Research Institute Northern California Chapter (EERI-NC) Lifeline Committee (October 28, 2004) related to the ***Infrastructure*** area,
- San Francisco Community Agencies Responding to Disasters (SF-CARD) (November 4, 2004) related to the ***Health*** area,
- the Structural Engineers Association of Northern California (SEAONC) (November 9, 2004), and
- the California Preservation Foundation (November 18, 2004) related to historic issues under the ***Housing***, ***Economy***, and ***Government*** areas.

(3) Public Participation

Initial General Public Outreach

The DRAFT Local Hazard Mitigation Plan was distributed at the ABAG General Assembly conference on “Taming Natural Disasters” on October 6, 2004. This conference was widely advertised with printed and email fliers sent to 60,000 people representing local governments, business, social services,

engineering, and environmental groups. Comments on additional strategies were solicited at the conference. More than 200 conference attendees were encouraged to submit comments.

ABAG used the October 6th conference to encourage the media to help publicize the plan and posted a request for comments on our web site to collect comments from the public. Additional press outreach occurred before October 17, 2004, the 15th anniversary of the Loma Prieta earthquake, including an article in the San Jose Mercury News, the largest circulation newspaper in the region. We encouraged the public to mail in or email suggestions.

Based on the comments received, the DRAFT Local Hazard Mitigation Plan was revised. All of the comments were addressed. Most were incorporated directly in the plan. People who suggested changes that were not incorporated into the plan were sent replies explaining why the changes were not made. Largely the changes that were not made would have added duplication or would have put the plan's focus on emergency response, rather than on mitigation. The revised Local Hazard Mitigation Plan was forwarded to FEMA Region IX and the California Office of Emergency Services on October 27, 2004.

Focused Issue Workshops and Additional Outreach and Review

Based on the comments received on the Draft Local Hazard Mitigation Plan distributed at the October General Assembly on "Taming Natural Disasters," four issues were identified that would benefit from immediate further work – health and disasters, education and schools, historic structures, and soft-story multi-family residential buildings. ABAG held focused workshops were held on each of these issues:

- Health and Disasters on December 14, 2004 – attended by 8 people (including local government public health experts and non-profits),
- Education and schools on December 16, 2004 – attended by 22 people (largely school district employees), and
- Soft-Story Residential January 27, 2005 – attended by 45 people (including private contractors, architects, and engineers as well as local government building officials, planners, and elected officials).

ABAG staff used an existing forum organized by the City and County of San Francisco on historic buildings attended by approximately 20 people on January 12, 2005, to gain insight on how to modify the plan rather than holding the meeting at ABAG.

Comments received from OES, FEMA, and professional organization outreach in late October and November, and the first two of the focused workshops listed above, were incorporated into another version of this Local Hazard Mitigation Plan. These revisions were provided to cities, counties, and special districts for a final round of comment in early January 2005.

Again, ***all*** of the comments received were reviewed and most suggestions were incorporated directly in the plan. People who suggested that changes be made that were not incorporated into the plan were sent replies explaining why the changes were not made. Almost all suggested changes that were not incorporated were not made because they would have added duplication or made the plan's focus on emergency response, rather than on mitigation. All changes to the mitigation portion of this plan were finalized on January 28, 2005.

A Note on General Public Participation and Outreach during Plan Development

While every effort has been made to make this entire process open and accessible for public participation, the general low level of interest and knowledge of hazards and mitigation by a many members of the

public makes outreach more difficult than for other issues, such as traffic, education, or crime. Thus, an extensive effort was made to supplement typical outreach efforts with extensive interaction with "publics" that, by definition, are more interested in this process – existing ABAG committees, local governments, and professional organizations. This conclusion does not mean that the public did not examine the plan. For example, the home page for the web site set up for this effort, http://quake.abag.ca.gov/mitigation, received 2,870 hits from October-December 2004. In addition, the plan was developed by focusing outreach both on each ***hazard***, and on each commitment (or ***functional area***).

While outreach to local governments in adjacent regions might normally be appropriate in the development of a plan such as this, because the area covered by this plan is so large, we determined that the logical neighboring entity is the State of California. Staff members of the State Seismic Safety Commission, California Geological Survey, California Department of Forestry, and Coastal Regional Office of Emergency Services were all involved in the development of this plan. It was also determined that some additional outreach with reclamation districts that own levees in the delta areas will be brought into future workshops held by the ABAG Lifelines Infrastructure and Hazards Review Committee. In addition, extensive outreach occurred with Bay Area local governments that developed independent plans, including Napa County and its cities, Sonoma County, Marin County, and the City of Berkeley.

EARTHQUAKE AND HAZARDS OUTREACH REVIEW COMMITTEE

ABAG ROSTER • JUNE 2009

FUNCTIONS Studies and reviews background materials, reports and maps being prepared by ABAG related to earthquake and hazards outreach including:

- Housing vulnerability and retrofit
- Small business vulnerability and preparedness

COMPOSITION Members are split between technical experts and potential users of the hazard information.

STAFF LEAD Jeanne Perkins, Earthquake and Hazards Program Consultant

MEETINGS Generally meets once every three months

MEMBERS	TITLE/ORGANIZATION	REPRESENTING
Nancy Nadel, *Chair*	Councilmember, City of Oakland	Elected Officials
Jim Aldrich	Emergency Manager (*Retired*)	SPUR; Concerned Residents
Jeff Bailey	Retrofit Contractor, Bay Area Retrofit	Retrofit Contractors
Howard Cook (alt)	Retrofit Contractor (*Retired*)	Retrofit Contractors
Kathleen Bailey	Program Manager, OES Coastal Region	State OES
Jack Boatwright	Geophysicist, U.S. Geological Survey	USGS
David Bonowitz	Structural Engineer	SEAONC – Existing Buildings
Colin Blaney (alt)	Structural Engineer	SEAONC – Existing Buildings
Pat Buscovich	Structural Engineer	Retrofit Engineer
Michael Cadrecha	Architect, Alameda County GSA	Local Government
Kathleen Crawford	Assistant Emergency Manager, Office of Emergency Services, City of Oakland	Emergency Management
Coleen Bell (alt)	Emergency Planning Coordinator, Office of Emergency Services, City of Oakland	Emergency Management
Amy Gaver	Community Preparedness Director, American Red Cross – Bay Area	American Red Cross
Dave Johnson	Executive Director, Oakland Commerce Corporation	Small Businesses
Jim Curtis (alt)	Owner, The Art Sign Company	Small Businesses
Paul Johnson	Retrofit Contractor	Retrofit Contractors
Stephan Kiefer	Building Official, City of Livermore	City Building Officials
William Lepere	Deputy Director, Alameda County Public Works Agency	Local Government
Allen Lang (alt)	Building Official, Alameda County Public Works Agency	Local Government

EARTHQUAKE AND HAZARDS OUTREACH REVIEW COMMITTEE CONTINUED

ABAG ROSTER • JUNE 2009

MEMBERS	TITLE/ORGANIZATION	REPRESENTING
Raymond R. Lui	Building Inspector, City and County of San Francisco	City Building Officials
Laurence Kornfield (alt)	Chief Building Inspector, City and County of San Francisco	City Building Officials
Sherry Niswander	Owner, Anderson-Niswander Construction	Retrofit Contractors
Tom Anderson (alt)	Owner, Anderson-Niswander Construction	Retrofit Contractors
Ed Pilling	Plan Checker, Building Department, City of Hayward	City Building Officials
Sue Piper	Policy Analyst, Office of Oakland Councilmember Jean Quan	Local Government Policy
Charles Real	California Geological Survey	CGS
Doug Sandy	American Red Cross, Bay Area	Housing Response Services
Roger Sharpe	Member, Berkeley Disaster and Fire Safety Commission	Concerned Residents
Mainini Leah Cabute	San Jose Housing Department	Local Government
William Schock	Building Official, Development Services City of San Leandro	City Building Officials
Keith Weiner (alt)	Supervising Building Inspector, Development Services, City of San Leandro	City Building Officials
Fred Turner	Structural Engineer, California Seismic Safety Commission	CSSC
Bob Anderson (alt)	Senior Engineering Geologist, California Seismic Safety Commission	CSSC
Zan Turner	City Building Inspector and Contractor (Retired)	EERI – Northern California

LIFELINE INFRASTRUCTURE AND HAZARDS REVIEW COMMITTEE

ABAG ROSTER • JUNE 2009

FUNCTIONS

- Studies and reviews materials related to planning for water, transportation, and other lifeline system disruptions following future earthquakes and other disasters
- Reviews modeling approaches for estimating disruptions to the regional water, transportation, and other lifeline systems
- Reviews techniques for estimating the importance of various critical lifeline infrastructure facilities in disasters
- Proposes recommendations for improving transportation and lifeline system recovery
- Such other matters as may be viewed as appropriate by Earthquake and Hazards Program staff

COMPOSITION Members represent a mix of lifeline planners and transportation users from a variety of geographic areas and were appointed by staff

STAFF LEAD Jeanne Perkins, Earthquake and Hazards Program Consultant

MEETINGS Generally meets once every three months

MEMBERS	**TITLE/ORGANIZATION**	**REPRESENTING**
Sandi Potter, *Chair*	Councilmember, City of El Cerrito	Elected Officials
Jim Aldrich	Emergency Manager (*Retired*)	SPUR; Concerned Residents
Kathleen Bailey	Project Officer, CalEMA	CalEMA
Bill Cain	Associate Civil Engineer, EBMUD	Water Districts
Ed Sullivan (alt)	Emergency Manager, EBMUD	Water Districts
Kathleen Crawford	Assistant Emergency Manager, Office of Emergency Services, City of Oakland	Local Emergency Management
Coleen Bell (alt)	Emergency Planning Coordinator, Office of Emergency Services, City of Oakland	Local Emergency Management
Timothy Dawson	Geologist, California Geological Survey	California Geological Survey
Steve Dennis	Emergency Service Supervisor, Alameda Country Water District	Water Districts
John Eidinger	President, G&E Engineering Systems Inc.	Infrastructure Systems Engineering
Tom Holzer	Geologist	U.S. Geological Survey
Tracy Johnson	Manager, Seismic Engineering	Bay Area Rapid Transit District
Juan Ledesma	Santa Clara Valley Water District	Water Districts
Carl Mortensen	Geophysicist (retired)	Concerned Residents
Stu Nishenko	Sr. Seismologist	Pacific Gas & Electric Company

LIFELINE INFRASTRUCTURE AND HAZARDS REVIEW COMMITTEE CONT.

ABAG ROSTER • JUNE 2009

MEMBERS	TITLE/ORGANIZATION	REPRESENTING
Nancy Okasaki	Transportation Planner	Metropolitan Transportation Commission
Ray Riordan	Emergency Preparedness Program Manager, City of San Ramon	Local Emergency Management
John Rodgers	Emergency Planning Coordinator, San Francisco Public Utilities Commission	Water Districts
Kerrie Romanow	Assistant Director, Environmental Services, City of San Jose	Cities and Counties
Kim Shunk (alt)	Director, Office of Emergency Services, City of San Jose	Cities and Counties
Chris Salkeld	Director of National Security	AT&T
John Ummel	Bay Area Water Supply and Conservation Agency	Water Districts
Vacant	Operations and/or Public Affairs	Caltrans District 4
Vacant	Traffic Management and Control	California Highway Patrol

APPENDIX B
The Plan Maintenance and Update Process

Monitoring Process

Monitoring of the plan will be ongoing and will be the responsibility of the ABAG's Planning Department, specifically the Earthquake and Hazards Program. As mitigation projects outlined in the LHMP are implemented, ABAG will share this information with the public and other participating jurisdictions on its website. ABAG will continue to highlight the mitigation work of local jurisdictions in its reports and publications as they relate to other ABAG projects. The responses of local governments to the mitigation strategy priorities may help ABAG focus its mitigation planning efforts in the coming years. Monitoring the activities of jurisdictions around these identified issues will be an important part of that process. The existing ABAG committees on the Planning Team will be an appropriate forum to learn about the ongoing mitigation activities and accomplishments of local jurisdictions.

Evaluation Process

Within the five-year update cycle, ABAG will annually evaluate the need for an updated plan prior to the required five-year update. Evaluation will be the responsibility of ABAG's Earthquake and Hazard Program. Discussions at meetings of ABAG's Lifelines Infrastructure and Hazards Committee and Hazards Outreach Committee annually will inform the decision on the need for an update of the plan. A plan evaluation may become necessary after a natural disaster occurs in the region or as major shifts in resources, objectives or goals occur. The evaluation process will assess, among other things, whether:

- The goals and objectives address current and expected conditions.
- The nature, and/or type of risks have changed.
- The current resources are appropriate for implementing the plan.
- There are implementation problems, such as technical, political, legal, or coordination issues with other agencies.
- The outcomes have occurred as expected (a demonstration of progress).
- The agencies and other partners participated as originally proposed.

Updating Process

ABAG will continue to update this plan over time. The plan will be updated at least every five years, as required by DMA 2000. The update process will begin at least one year prior to the expiration of this plan. However, it will be updated more frequently as time and money allow. ABAG's Earthquake and Hazards Program will take the lead in updating hazard mapping and risk information, while participating local governments will take the lead in developing and updating mitigation goals and strategies.

For example, ABAG will continue to update its geographic information system based on new information from state and federal agencies, as well as from research projects conducted by ABAG and others. The lead in this effort at ABAG will be the Earthquake and Hazards Program.

When an update occurs, participating local governments will be notified of the planned update and encouraged to provide comments in a manner similar to the process they went through for the update of this plan as outlined in **Appendix A**. A list of the lead person and department that will be contacted in each jurisdiction can be found in **Appendix I**. If changes are significant (that is, involve more than minor changes to, for example, the hazard mapping), all participating local governments will be involved in any

needed updates in mitigation strategies and all will be asked to submit another resolution approving the plan.

If ABAG is unwilling or unable to act as the lead agency in the multi-jurisdictional effort, participating local governments will contact each County's Office of Emergency Services. Counties should then work together to identify another regional forum for developing a multi-jurisdictional plan. Unlike in other metropolitan areas of the country, the Bay Area has no single dominant city or county. Many special districts, including BART, MTC, AC Transit, and the East Bay Regional Park District also have multi-county service areas. Thus, although counties could be used as lead agencies in updating the plan, this option is not as appropriate as in other areas of the country.

Incorporation into Existing Planning Mechanisms

Typically, cities and counties have three major mechanisms for integrating the programs and policies identified in this plan: the Safety Element of their local General Plan, the requirements for project review of the California Environmental Quality Act (CEQA), and on-going capital improvement programs. The components of some of these other programs are identified as "Existing Programs" in the Annex of each participating local government. In addition, the recommendation of this overall plan is for local governments to adopt the specific mitigation strategies identified as an "Implementation Appendix" of their Safety Element.

The situation for special districts and other governmental agencies is slightly different. However, the recommendation of this overall plan is to identify a variety of funding sources and implementation mechanisms for the higher priority mitigation strategies identified in each local government's annex.

Continued Public Involvement

As the LHMP is evaluated and updated over time public participation will be encouraged at specific issue-oriented workshops and forums as time and funding allow. As at the numerous workshops and forums held during the development of this initial plan, a wide variety of participation will be encouraged, including:

- local and state government staff and elected officials,
- private engineers, construction contractors, financial experts, and business owners,
- professional organizations,
- university professors, and
- nonprofits.

Whenever a comprehensive update of the plan occurs, the public will be notified on ABAG's hazards homepage, local government websites and through public notices of the process.

APPENDIX C
Natural Hazard Risk Assessment

Why Are We Concerned with Exposure and Probability, Not Just Hazards?

If a river overflows its bank in an uninhabited area with no roads and no buildings, it is a flood, but not a flood disaster. If a major earthquake occurs in the desert of southeastern California where no one lives, it is still an earthquake, but not an earthquake disaster. Thus, this hazard mitigation plan is concerned about the location of people, buildings, and infrastructure relative to the hazards of floods, earthquakes, wildfires, and landslides – our hazard exposure.

Hazards also need to be expressed with some sort of probability. Typically, hazards that cause disasters are not common, or these disasters would have long ago triggered an increase in response capability and hazard mitigation. For example, Bay Area cities and counties have adopted mitigation strategies and building codes that allow moderate earthquakes to occur with minimal damage. Because disasters are rare, the probability information on their future occurrence is incomplete or subject to large errors. The probability that a hazard will result in a disaster is our risk.

A complete risk assessment should identify:

- the existing land uses, buildings, infrastructure, and critical facilities located in each of these hazard areas (exposure);
- a general description of land use and development trends along with associated anticipated changes in exposure;
- an estimate of the potential deaths and injuries, property damages (dollar losses), and functional losses (disruption) based on exposure and vulnerability of various types of structures; and
- estimates of the probabilities of these losses over time.

The risk assessment ABAG has created for the Bay Area is incomplete. However, ABAG and the local governments that have created this plan are committed to improving the risk assessment over time. The risk assessment in this 2009-2010 MJ-LHMP is much more complete and comprehensive than that included in the 2004-2005 MJ-LHMP. For example, better information is included on the vulnerability of local governments' own facilities, as well as the region's housing stock and commercial/industrial buildings. But the structural vulnerability information is incomplete; thus, information on improving that information is including in several in the mitigation strategies including, for example, infrastructure systems (INFR a-1), soft-story housing (HSNG c-4), and government facilities (GOVT a-1). The structural vulnerability information also changes over time; for example, the MetroCenter headquarters facility of MTC and ABAG was designed to meet current codes in 1983, but improvements to those codes and structural assessment techniques showed the facility to be a "partial collapse hazard." Retrofit completed in 2007 has strengthened the facility. The hazard maps change over time; for example, FEMA has been upgraded the older Flood Insurance Rate Maps (Q3 FIRMs) to create more modern D-FIRMs (digital FIRMs).

The following sections focus on describing the most significant natural hazards affecting the San Francisco Bay Area related to earthquakes and weather (fire, flooding, landslides, drought, and climate change), as well as tsunamis, dam failure, and levee failure.

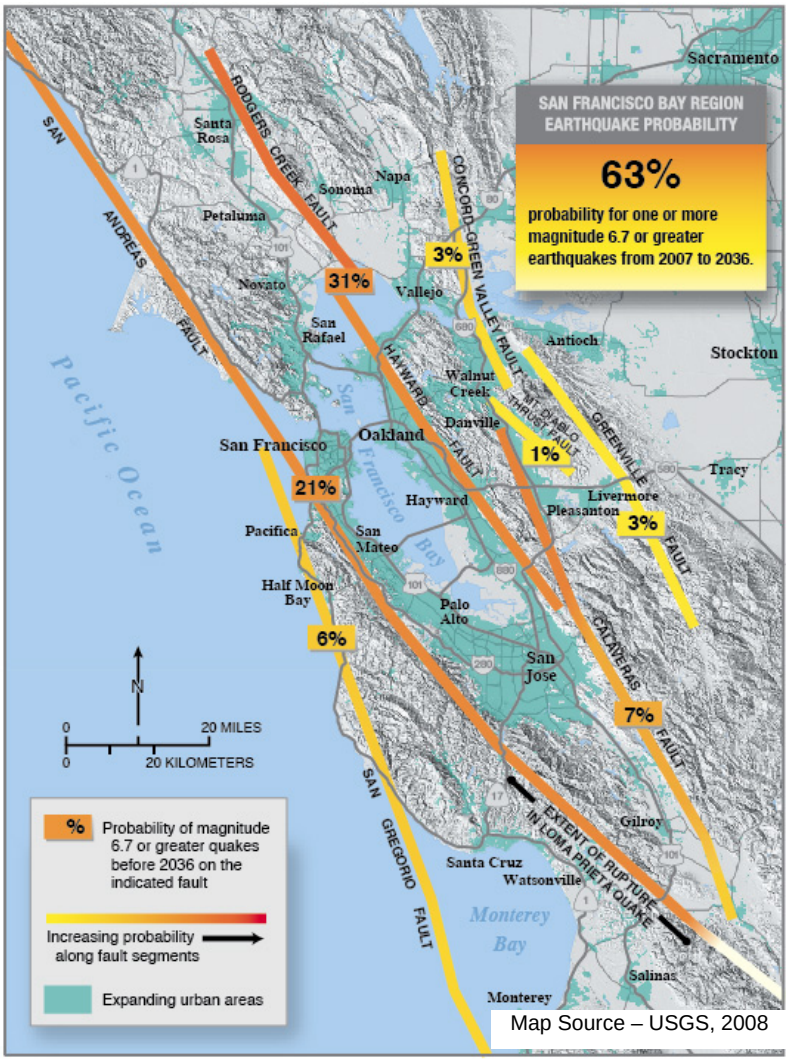
Earthquakes

Probability of earthquake-related hazards

The Bay Area is in the heart of Earthquake Country. The Bay Area is crossed by many active faults. This map figure shows that major active faults run through or adjacent to all nine Bay Area counties.

While research by the U.S. Geological Survey (USGS) has provided more reliable probability information for future Bay Area earthquakes than for any other area of the country (63% probability of a magnitude 6.7 or larger earthquake), it has a wide error range – plus or minus 22%[1]! Smaller earthquakes are more likely to occur and can still produce significant damage over localized areas.

Probability of the rupture of individual faults has also been prepared by USGS, as shown in Table 1.[2]



Map Source – USGS, 2008

Probability information for the West Napa, Monte Vista and Maacama faults unavailable in the 2005 MJ-LHMP plan has been included in this MJ-LHMP update. Probability estimates for these faults was developed by the 2008 USGS Working Group on Earthquake Probability.

Location and extent of earthquake-related hazards

Earthquakes result in five different hazards that have been mapped in the Bay Area. The following sections describe those hazards, as well as reference the map plates showing the location and extent of the hazard in the Bay Area.

---

[1] Source – 2008. USGS Working Group on Earthquake Probabilities. ***Forecasting California's Earthquake- What Can We Expect in the Next 30 Years?***– USGS Fact Sheet 2008-3027 at http://pubs.usgs.gov/fs/2008/3027/ and ***The Uniform California Earthquake Rupture Forecast, Version 2*** - USGS Open-File Report 2007-1437 at http://pubs.usgs.gov/of/2007/1437/.

[2] The probability information provided by the USGS for earthquakes on each fault also applies to the associated earthquake-related hazards (ground shaking, liquefaction, landslides, and, except for faults that do not extend to the surface, fault surface rupture). Tsunamis probabilities are more complicated, however, as noted on page C-24.

TABLE 1 – Probabilities of Selected Earthquake Scenarios Occurring in the Next 30 Years and Slip Rates on Associated Fault Segments [*based on USGS Working Group on Earthquake Probabilities, 2003 and 2008**], [*Scenario maps on ABAG web site are shaded.*]

Fault	Segment (s)	Average Long-Term Slip Rate (mm / year)	% Probability of Characteristic Quake 2002-2031	% Probability of Quake ≥ 6.7 2007-2036
N. San Andreas	Santa Cruz Mountains (SAS)	17	2.6	4.0*
	Peninsula (SAP)	17	4.4	0.6*
	North Bay (SAN)	24	0.9	0.04*
	Ocean (north of Bay Area – SAO)	24	0.9	1.9*
	South Bay Segments (SAS + SAP)	17	3.5	4.4*
	Central Bay Segments (SAP + SAN)	17 – 24	0.0	0.0*
	Northern Segments (SAN + SAO)	24	3.4	4.1*
	Bay Area Segments (SAS+SAP+SAN)	17 – 24	0.1	0.05*
	Central + North (SAP + SAN + SAO)	17 – 24	0.2	0.2*
	Entire – Repeat of 1906 (SAS + SAP + SAN + SAO)	17 – 24	4.7	3.8*
	Floating M6.9	17 – 24	7.1	6.8
Hayward/Rogers Creek	Southern (HS)	9	11.3	4.8*
	Northern (HN)	9	12.3	1.2*
	Entire (HS + HN)	9	8.5	8.8*
	Rogers Creek (RC)	9	15.2	16.3*
	HN + RC	9	1.8	2.1*
	HS + HN + RC	9	1.0	1.2*
	Floating M6.9	9	0.7	0.7
Calaveras	Southern (Outside Bay Area - CS)	15	21.3	0.0*
	Central (CC)	15	13.8	0.0*
	CS + CC	15	5.0	0.1*
	Northern (CN)	6	12.4	2.4*
	CC + CN	6 – 15	0.3	0.3*
	CS + CC + CN	6 – 15	2.0	3.6*
	Floating M6.2	6 – 15	7.4	0.0
	Floating M6.2 on CS + CC	15	7.4	0.0
Concord/Green Valley	Concord (CON)	4	5.0	0.1
	Southern Green Valley (GVS)	5	2.3	0.0
	CON + GVS	4 – 5	1.6	0.3
	Northern Green Valley (GVN)	5	6.1	0.0
	Entire Green Valley (GVS + GVN)	5	3.2	0.4
	Entire (CON + GVS + GVN)	4 – 5	6.0	2.7
	Floating M6.2	4 – 5	6.2	0.0
San Gregorio	Southern (Outside Bay Area - SGS)	3	2.3	2.1
	Northern (SGN)	7	3.9	3.9
	SGS + SGN	3 – 7	2.6	2.6
	Floating M6.9	3 – 7	2.1	2.0
Greenville	Southern (GS)	2	3.1	0.7
	Northern (GN)	2	2.9	1.0
	Entire (GS + GN)	2	1.5	1.4
	Floating M6.2	2	0.4	0.0
Mt. Diablo Thrust	Mt. Diablo Thrust (MTD)	2	7.5	0.7*
Maacama - Garberville	Southern (only part in Bay Area)	9*	*Not available*	*12.6**
Monte Vista - Shannon	Monte Vista Segment	0.4*	*Not available*	*0.02**
West Napa	Entire Segment	1*	*Not available*	*0.3**

Location and Extent of Surface Rupture

Earthquakes occur in the Bay Area when forces underground cause the faults beneath us to rupture and suddenly slip. If the rupture extends to the surface, we see movement on a fault (***surface rupture***). Because faults are weaknesses in the rock, earthquakes tend to occur over and over on these same faults.

The California Geological Survey (CGS) publishes maps of the active faults in the Bay Area that reach the surface as part of its work to implement the requirements of the Alquist-Priolo Earthquake Fault Zone Act. These maps show not only the most comprehensive depiction of fault traces that can rupture the surface, but also the zones in which cities and counties must require special geologic studies to prevent the building of structures intended for human occupancy from being built ***and*** in which the surface rupture hazard must be disclosed in real estate transactions. The regional depiction of the location of this hazard is on ***Plate 1 – Fault Surface Rupture Hazard***.

In some respects, fault rupture is a relatively minor problem in earthquakes. For example, strong earthquakes can occur when the fault rupture does not extend to the surface, and fault-related damage is rare when compared to shaking-related damage. Neither the Loma Prieta nor the Northridge earthquakes resulted in surface rupture. In addition, the major thrust faults listed in Table 1 have not experienced surface rupture. While the faults shown on Plate 1 only include those faults that have experienced surface rupture, only structures that are ***directly astride*** the rupturing fault trace will be damaged in a future earthquake, not all of the structures in the study zones.

On the other hand, while houses and other buildings can avoid building astride a fault, roads and pipelines for gas, water, and wastewater, as well as electrical and telecommunications utilities that serve those buildings, cannot avoid crossing faults. Some pipeline rupture can be mitigated through engineering design if some parameters are known about the fault.

Many of the faults in the Bay Area are well studied, but there is still much that is unknown about them, including how much they will slip in the location of a pipeline crossing during a future earthquake or the exact location of a fault trace. Furthermore while the slip zone in rock is very localized, in thick soils the zone can be quite wide when the surrounding soil is dragged along with the fault, called warping. Much study continues to be done in this area, including the development of a fault displacement hazard assessment, an effort being led by the California Geological Survey.

The amount of ground displacement can be quite large, particularly when a major strike-slip fault is involved. For example, in a study conducted by ABAG examining the potential impact of this hazard on road closures[3], the amount of horizontal displacement on the large strike-slip faults was estimated as 2 – 4 meters, and the amount of vertical displacement was estimated as 0 – 0.4 meters, with actual values sometimes reaching double these values.

Maps of fault rupture hazard for individual local governments are on line at http://quake.abag.ca.gov/faults.

[3] Source – 1997. Perkins, J., and others. ***Riding Out Future Quakes*** – ABAG, 198 pp. See fault rupture discussion on pages 15-19.

Location and Extent of Ground Shaking

The fault rupture of the ground generates vibrations or waves in the rock that we feel as ***ground shaking***. Larger magnitude earthquakes generally cause a larger area of ground to shake hard, and to shake longer. As a result, one principal factor in determining shaking hazard is the magnitude of expected earthquakes. However, an earthquake shakes harder in one area versus another based not only on the magnitude, but also on other factors, including the distance of the area to the fault source of the earthquake and the type of geologic materials underlying the site, with stronger shaking occurring on softer soils. Earthquake intensity measures the strength of ground shaking in an individual earthquake at a particular location. ABAG and the U.S. Geological Survey (USGS) have developed several maps to aid in depicting shaking intensity, and thus ground shaking hazard.

- ABAG, in conjunction with scientists at USGS, has developed shaking intensity maps for 18 likely future earthquakes, as shown on ***Plates 2 – 19 – ABAG Earthquake Shaking Scenarios***. These maps are appropriate for use in disaster exercises and in earthquake disaster planning.
- USGS has also developed several earthquake shaking intensity maps for anticipated future earthquakes. These maps are based on the ground motion models that are used to generate ShakeMaps for large and moderate earthquakes immediately after these earthquakes occur. A comparison of the USGS ShakeMap versus ABAG Earthquake Shaking Scenario map for the North and South Hayward fault scenario has been included as ***Plate 20*** for information. As can be seen from this comparison, the ABAG Earthquake Shaking Scenario maps show higher shaking near the fault than the ShakeMaps for the large strike-slip faults that are common in the Bay Area. Estimating ground motions near rupturing faults is an active area of earthquake research. Records of strong ground motions with peak velocities consistent with the ABAG model were obtained from near-fault stations for the recent 2002 Denali and 1999 Chi-Chi earthquakes. Because of our desire to be conservative, ABAG is using the ABAG Earthquake Shaking Scenario maps for this disaster planning effort.

As is obvious when examining the explanation on these maps, higher modified Mercalli intensities translate into higher shaking. The impact of this increased shaking varies. For example, higher shaking can translate into higher numbers of landslides, greater areas of liquefaction, and more damaged buildings. More information on this subject is available at http://www.abag.ca.gov/bayarea/eqmaps/doc/mmi.html for the modified Mercalli intensity (MMI) scale itself, and at http://www.abag.ca.gov/bayarea/eqmaps/doc/1998gs.html for what higher ground shaking means in a way that is more quantified than the MMI scale itself. This information was developed by ABAG for the U.S. Geological Survey in 1998[4].

Finally, it is often useful to have a single hazard map containing the shaking hazard information for the Bay Area for long-term risk analysis because an earthquake can happen on any fault at any given time, and a composite maps shows the greatest potential for shaking at any location from all faults. USGS cooperated with CGS, the California Seismic Safety Commission (CSSC),

[4] Source – 1998. Perkins, J. ***The San Francisco Bay Area – On Shaky Ground - Supplement*** – ABAG, 28 pp. See discussion on meaning of MMI on pages 2-11. Note – this information is also on the web at http://www.abag.ca.gov/bayarea/eqmaps/doc/1998gs.html.

TABLE 2 – SUPPLEMENTARY INFORMATION FOR PLATES 2-20: Modified Mercalli Intensity Scale Summary Descriptions and "Official" Full Description

MMI Value	Description of Shaking Severity Used on Current Maps	Summary Damage Description Used on 1995 Maps	"Official" Full Description (from Richter, C.F., 1958. Elementary Seismology. W.H. Freeman and Company, San Francisco, pp. 135-149; 650-653.)
I.			Not felt. Marginal and long period effects of large earthquakes.
II.			Felt by persons at rest, on upper floors, or favorably placed.
III.			Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV.			Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frame creak.
V.	Light	Pictures Move	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
VI.	Moderate	Objects Fall	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle).
VII.	Strong	Nonstruc-tural Damage	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
VIII.	Very Strong	Moderate Damage	Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX.	Violent	Heavy Damage	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluvial areas sand and mud ejected, earthquake fountains, sand craters.
X.	Very Violent	Extreme Damage	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI.			Rails bent greatly. Underground pipelines completely out of service.
XII.			Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

and State OES to develop such a "composite" scenario map. There are two principal caveats to use of this probabilistic seismic hazard map.

(1) It incorporates probability information that has a wide margin of error. As stated earlier, while recent research by USGS has provided more reliable probability information for future Bay Area earthquakes than for any other area of the country (63% of a magnitude 6.7 or larger earthquake), it has a wide error range (from a low of 41% to a high of 84%, or plus or minus 22%[5])! In addition, the December 2003 San Simeon earthquake occurred in an area shown on this map as having less potential for strong shaking than many other areas of coastal California.

(2) The shaking intensity levels are based on the ShakeMap models, and may underestimate the hazard near the Bay Area's large strike-slip faults, as noted above.

See ***Plate 21 – Earthquake Shaking Potential*** for a regional depiction of this hazard map. The map used in this updated plan remains the 2003 version of this map. A newer map based on the 2008 probabilities is undergoing development, but the newer map (1) is not available, as of October 2009, in digital form, and (2) does not incorporate local ground conditions, making it less suitable for local city and county uses than the 2003 map.

We anticipate that improved versions of the Earthquake Shaking Potential map will become available for future updates of this plan. In addition, shaking hazard maps associated with individual faults are being improved over time.

See http://quake.abag.ca.gov/mapsba.html for more information and local government-specific depictions of the 20 earthquake shaking hazard maps for individual earthquake scenarios, as well as the Earthquake Shaking Potential map..

Location and Extent of Liquefaction

Ground shaking can lead to ***liquefaction.*** When the ground liquefies in an earthquake, sandy or silty materials saturated with water behave like a liquid, causing pipes to leak, roads and airport runways to buckle, and building foundations to be damaged. As with ground shaking, several types of maps aid in depicting this hazard.

- Liquefaction susceptibility maps show areas with water-saturated sandy and silty materials. ***Plate 22*** shows a map of liquefaction susceptibility for the Bay Area published by USGS showing various levels of liquefaction susceptibility (as updated in 2006). ***Plate 23*** shows the liquefaction susceptible areas as depicted by CGS as part of its mapping program mandated by the Seismic Hazards Mapping Act. Unlike Plate 22, the CGS map groups most of the moderate to very high susceptible areas shown on the USGS map into official seismic hazard map zones where real estate disclosure and hazard analysis are required. Note, however, that this type of map is only available for a portion of the Bay Area.
- Liquefaction hazard maps for specific earthquake scenarios show areas where the ground is both susceptible to liquefaction and that are likely to be shaken hard enough in a particular earthquake to trigger liquefaction. These maps are depicted in ***Plates 24 – 41*** and are a combination of the liquefaction susceptibility mapping and the ground shaking exposure mapping.

[5] Source – 2003. USGS Working Group on Earthquake Probabilities. ***Is a Powerful Earthquake Likely to Strike in the Next 30 Years?*** – USGS Fact Sheet 039-03 at http://geopubs.wr.usgs.gov/fact-sheet/fs039-03/fs039-03.pdf.

TABLE 3 –
SUPPLEMENTARY INFORMATION FOR PLATE 22: Liquefaction Susceptibility Map

MMI Value	**Full Description** (from Knudsen and others, 2000.(Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M., and Helley, E.J., 2000. ***Preliminary Maps of Quaternary Deposits and Liquefaction Susceptibility, Nine-County San Francisco Bay Region, California***: U. S. Geological Survey Open-File Report 00-444. Digital Database by Wentworth, C.M., Nicholson, R.S., Wright, H.M., and Brown, K.H. Online Version 1.0.) and Witter and others, 2006 (USGS Open-File Report 2006-1037. See http://pubs.usgs.gov/of/2006/1037/)
Very High	Very High
High	High
Moderate	Moderate
Low	Low
Very Low	Very Low

The following additional information on liquefaction affects is from Perkins, 2001.[6]

Liquefaction damage, Marina District, 1989 Loma Prieta, California, Earthquake
Source – M. Bennett, U.S. Geological Survey

When the ground **liquefies**, *sandy materials saturated with water can behave like a liquid, instead of like solid ground. The ground may sink or even pull apart. Sand boils, or sand "volcanoes," can appear.*

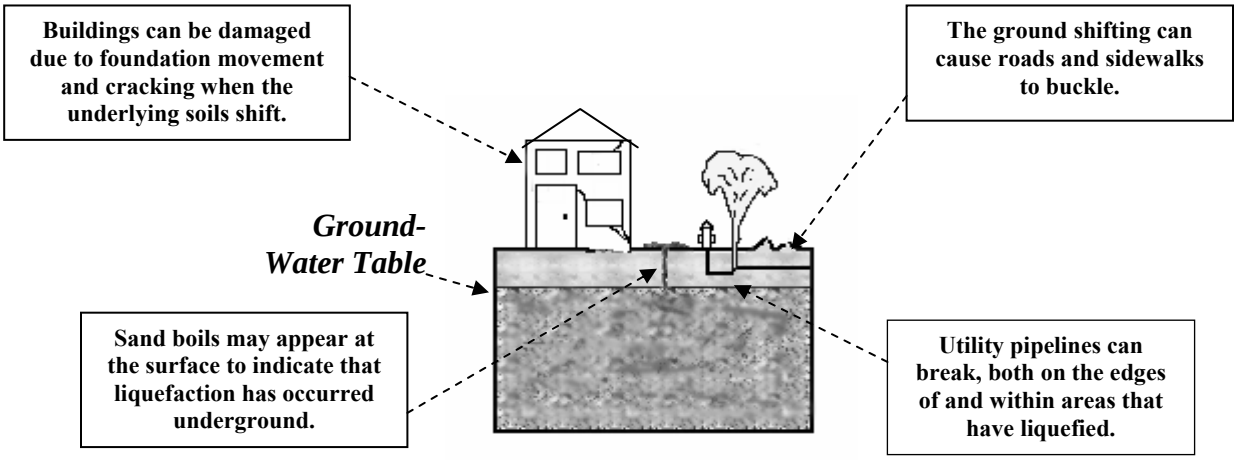
Liquefaction can cause ground displacement and ground failure such as lateral spreads (essentially landslides on nearly flat ground next to rivers, harbors, and drainage channels) and flows.

Our most vulnerable land falls into two general categories:

1. *areas covered by the huge amount of fill poured into San Francisco Bay since 1845 to transform 77 square miles (200 square km) of tidal and submerged areas into land; and*
2. *areas along existing and filled stream channels and flood plains, particularly those areas with deposits less than 10,000 years old.*

Overall, **shaking does more damage** *to buildings and highway structures than liquefaction.* **But liquefaction damage can be a significant threat for underground pipelines, airports (especially runways), harbor facilities, and road or highway surfaces.**

FIGURE - POTENTIAL EFFECTS OF LIQUEFACTION



CGS is developing hazard maps for more areas as further research is completed. When these maps become available ABAG will incorporate them into its hazard analysis. The list of mitigation strategies includes several relating to ways in which local governments can increase the speed of completion of hazard maps, particularly GOVT-d-10 and LAND-a-7.

ABAG has conducted extensive studies looking at the ways that liquefaction could potentially impact the Bay Area summarized in an ABAG report.[7] In general, the potential impacts to infrastructure are more significant than to building structures.

See http://quake.abag.ca.gov/liquefac/liquefac.html for more information and local government-specific depictions of these two liquefaction susceptibility and 18 liquefaction hazard maps.

TABLE 4 – SUPPLEMENTARY INFORMATION FOR PLATES 24-41: Liquefaction Hazard Maps (for Earthquake Scenarios)

Liquefaction hazard maps were created using a combination of liquefaction susceptibility maps and ground shaking scenario maps depicting modified Mercalli intensity. The following table shows how the maps were generated.

MMI Value	Description of Shaking Severity	Summary Damage Description Used on Perkins and Boatwright, 1995 Shaking Maps	Liquefaction Susceptibility Category				
			Very Low	Low	Moderate	High	Very High
V	Light	Pictures Move					
VI	Moderate	Objects Fall					
VII	Strong	Nonstructural Damage			Moderately Low	Moderately Low	Moderate
VIII	Very Strong	Moderate Damage			Moderate	Moderate	Moderate
IX	Violent	Heavy Damage			**High**	**High**	**High**
X	Very Violent	Extreme Damage			**High**	**High**	**High**

TABLE 5 – SUPPLEMENTARY INFORMATION FOR PLATES 24-41: Pipeline Leaks per Kilometer of Pipeline Exposed to Various Combinations of Modified Mercalli Intensity and Liquefaction Susceptibility in the Loma Prieta Earthquake

Showing qualitative descriptions of high, moderate, and moderately low are based, in part, on pipeline leak information from the Loma Prieta and Northridge earthquakes

MMI Value	Description of Shaking Severity	Summary Damage Description Used on Perkins and Boatwright, 1995 Shaking Maps	Liquefaction Susceptibility Category				
			Very Low	Low	Moderate	High	Very High
V	Light	Pictures Move	0.001	0.002	0.002	0.000	0.004
VI	Moderate	Objects Fall	0.011	0.007	0.010	0.002	0.005
VII	Strong	Nonstructural Damage	0.032	0.011	0.036	0.008	0.086
VIII	Very Strong	Moderate Damage	0.028	0.063	0.182	0.019	0.278
IX	Violent	Heavy Damage	**No Data**	**No Data**	**No Data**	**No Data**	**No Data**
X	Very Violent	Extreme Damage	**No Data**	**No Data**	**No Data**	**No Data**	**No Data**

[6] Perkins, J.P., 2001. ***The REAL Dirt on Liquefaction***. ABAG: Oakland, CA. 25 pp.
[7] Source – 2001. Perkins, J. ***The San Francisco Bay Area – The Real Dirt on Liquefaction*** – ABAG, 25 pp. See discussion on "What Happens to Our Built Environment" on pages 11-19. Note – this information is also on the web at http://quake.abag.ca.gov/liquefac/liquefac.html.

Location and Extent of Earthquake-Induced Landslides

Ground shaking can also lead to ground failure on slopes, or ***earthquake-induced landslides***. While USGS has created several demonstration maps for this type of hazard, the best depiction is shown in ***Plate 42***, the CGS seismic hazard map for earthquake-induced landslides. As with the CGS liquefaction susceptibility map, this map is only available for a portion of the Bay Area.

CGS is developing hazard maps for more areas as further research is completed. As these maps become available, ABAG is continuing to incorporate them into its hazard analysis. The list of mitigation strategies includes several relating to ways in which local governments can increase the speed of completion of hazard maps, particularly GOVT-d-10 and LAND-a-7.

More detailed maps for individual local governments and additional landslide hazard information are available on line at http://quake.abag.ca.gov/landslide.

Past occurrences of Bay Area earthquake-related disasters

The fact that a devastating earthquake occurred in 1906 – the San Francisco earthquake – is common knowledge. Larger earthquakes generally affect larger areas; the San Francisco earthquake caused extensive damage in Oakland, San Jose and Santa Rosa. More recently, the 1989 Loma Prieta earthquake caused extensive damage in the Santa Cruz Mountains, as well as in Oakland and San Francisco tens of miles away. But many moderate to great earthquakes (over magnitude 6.0) have affected the Bay Area; Twenty-two such events have occurred in the last 165 years – for an average of one every seven and a half years.

There have been only three earthquake-related natural disasters in the Bay Area since 1950 – the September 3, 2000 Napa earthquake (declared a disaster in only Napa County), the 1989 Loma Prieta earthquake (declared a disaster in Alameda, Contra Costa, Marin, San Francisco, San Mateo, Santa Clara, and Solano counties), and the April 1984 Morgan Hill earthquake (declared a disaster in Santa Clara County). In addition, the April 1964 Good Friday Alaskan earthquake triggered mitigation conducted for the tsunami warning in Marin County. See MJ-LHMP Appendix D.

Exposure of the Bay Area to earthquake hazards

ABAG has focused its assessment of Bay Area earthquake vulnerability assessment by conducting several major analyses – three exposure analyses as part of its development of this multi-jurisdictional Local Hazard Mitigation Plan (with plans to conduct additional ones when more complete mapping is available), and three as part of earlier efforts.

Fault surface rupture hazard and exposure of existing land use –

The analysis of the types of land use and facilities focuses on the California Geological Survey's map of surface fault rupture hazard study zones (***Plate 1***) described earlier under the Alquist-Priolo Earthquake Fault Zoning Act. These zones are not fault zones, but zones in which studies are required to ensure that no structures intended for human occupancy are placed across active faults. Thus, only a small fraction of the land use areas and infrastructure miles in these zones are actually subject to fault rupture.

- Of the 4.39 million acres of land in the Bay Area, **1.8%** is in areas designed as subject to the study requirement of the Alquist-Priolo Earthquake Fault Zoning Act.
- **2.3%** of the urban land is in one of these areas, versus **1.7%** of the non-urban land.
- Types of existing urban land uses with the highest percentages in these areas are urban open (**3.3%**) infrastructure (**2.3%**), and residential use (**2.3%**).
- The percentage of urban land located in these areas ranged from a high of **4.4%** in both Alameda and San Mateo counties to a low of **0%** in San Francisco.

These percentages are based on information in ***Table 6: Surface Rupture Hazard and Existing Land Use***. See Plate 1 and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Fault surface rupture hazard and exposure of existing infrastructure –

Rather than discuss the percentages of road miles in these areas, it is useful to note the number of road closures in these areas in various earthquake scenarios. See http://www.abag.ca.gov/bayarea/eqmaps/eqtrans/result.html and select a specific scenario. For example, of the 1,734 road closures expected in a future North-South Hayward fault earthquake, 520 will be due to surface rupture. (These estimates are from the 2003 update of the ***Riding Out Future Quakes*** report discussed earlier.)

Pipelines have different issues, particularly the large water importation aqueducts of the East Bay Municipal Utility District (EBMUD), the Hetch-Hetchy system administered by the Public Utility Commission of the City and County of San Francisco (SF-PUC), and the Santa Clara Valley Water District (SCVWD). These local government agencies have unique issues with each major fault crossing. While the average movement of a fault in an earthquake particular, the slip in a particular location is not well understood. The exact location of a future surface rupture is also not precisely known. Both of these issues make design of these pipelines difficult. EBMUD and other agencies are continuing to work on their fault crossing issues, in spite of major construction projects that have already been completed. Additional information on these projects is contained in Chapter 1 – Infrastructure.

TABLE 6 – Surface Rupture Hazard and Existing (2005) Land Use

	Total Acres	In Alquist-Priolo Earthquake Fault Rupture Study Zones	% of Land in Study Zones
Total	4,387,602	80,598	1.8%
Urban	1,139,000	26,040	2.3%
Non-Urban	3,248,602	54,557	1.7%
URBAN ONLY:			
Residential	555,463	12,581	2.3%
Mixed R+C	1,775	30	1.7%
Commercial/ Services	110,502	2,145	1.9%
Mixed C+I	3,344	26	0.8%
Industrial	72,125	1,208	1.7%
Military	30,549	92	0.3%
Infrastructure	205,807	4,667	2.3%
Urban Open	159,435	5,291	3.3%
URBAN ONLY:			
Alameda	180,056	7,914	4.4%
Contra Costa	184,775	3,490	1.9%
Marin	54,146	753	1.4%
Napa	35,727	402	1.1%
San Francisco	29,273	0	0.0%
San Mateo	104,530	4,635	4.4%
Santa Clara	221,865	4,072	1.8%
Solano	100,720	1,039	1.0%
Sonoma	227,908	3,735	1.6%
	Total Miles	In Alquist-Priolo Earthquake Fault Rupture Study Zones	% of Miles in Study Zones
INFRASTRUCTURE:			
Roads	33,021	751	2.3%
Transit	433	5	1.2%
Rail	940	11	1.2%
Pipelines	21,851	411	1.9%
	Total Number	In Alquist-Priolo Earthquake Fault Rupture Study Zones	% of Facilities in Study Zones
CRITICAL FACILITIES:			
Health Care	840	14	1.7%
Schools	2,000	22	1.1%
Bridges	4,158	101	2.4%
Water Facilities	2,095	113	5.4%
Wastewater Facilities	338	3	0.9%
Cities and Counties	4,236	102	2.4%

See http://quake.abag.ca.gov/mitigation/pickdbh2.html and http://quake.abag.ca.gov/pickcrit.html for more specific information.

Fault surface rupture hazard and exposure of existing critical facilities –

- Of the **840** critical health care facilities in the Bay Area, **1.7%** are in areas designed as subject to the study requirement of the Alquist-Priolo Earthquake Fault Zoning Act.
- Only **1.1%** of the **2,000** public schools are in these areas.
- Of the **6,669** critical facilities owned by cities, counties, water, wastewater, transit, and other special districts, **3.3%** are in these areas.

Due to the long-standing nature of the Alquist-Priolo Earthquake Fault Zoning Act, few of these facilities are actually located astride faults. They have been rebuilt off the fault, and no new facilities have been built on the fault since the early 1970s when the law went into effect.

Of greater concern than a facility actually being astride a fault, however, is that the fault rupture will impede access and the functioning of infrastructure service to those facilities.
These percentages are based on information in ***Table 6: Surface Rupture Hazard and Existing Land Use***. See **Plate 1** and http://quake.abag.ca.gov/mitigation/pickcrit.html for more specific information for individual counties and cities.

Shaking hazard and exposure of existing land use –

Rather than perform this analysis for each of the many earthquake scenarios developed by USGS and ABAG, we have used the shaking potential map (**Plate 21**) described earlier.

- Of the 4.39 million acres of land in the Bay Area, **80%** is exposed to **high shaking levels** (peak accelerations of greater than 40% of gravity [g] with a 10% chance of being exceeded in the next 50 years), and **37%** is exposed to **extremely** high shaking levels (>60% g).
- **92%** of the urban land exposed to **high shaking levels** (>40% g), and **75%** is exposed to **extremely** high shaking levels (>60% g), while **75%** of the non-urban land is exposed to high shaking levels (>40% g), and **38%** is exposed to **extremely** high shaking levels (>60% g). Thus, urban land is exposed to significantly higher shaking hazard than non-urban land.
- Types of existing urban land uses with the highest percentages exposed to **extremely** high shaking levels (>60% g) are mixed commercial-industrial complexes (**88.6%**), mixed residential-commercial (**71.9%**).
- The percentage of urban land exposed to **extremely** high shaking levels (>60% g) ranged from a high of over **75%** in Alameda, San Francisco, San Mateo, and Santa Clara counties to lows of less than **7%** in Napa and Solano counties.

These percentages also are based on information in ***Table 7: Shaking Hazard and Existing Land Use***. See **Plate 21** and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Shaking hazard and exposure of existing infrastructure –

Rather than perform this analysis for each of the many earthquake scenarios developed by USGS and ABAG, this MJ-LHMP uses the shaking potential map (Plate 21) described earlier.

TABLE 7 – Shaking Potential and Existing (2005) Land Use

	Total Acres	Highest Shaking Potential (<80% g)	Next to Highest Shaking Potential (60-80%g)	Middle Category of Shaking Potential (40-60% g)	% of Land in Extreme Shaking Potential	% of Land in Very High or Extreme Shaking Potential
Total	4,387,602	356,083	1,273,510	1,865,773	37.1%	79.7%
Urban	1,139,000	122,485	506,799	423,465	55.2%	92.4%
Non-Urban	3,248,602	233,598	766,711	1,442,309	30.8%	75.2%
URBAN ONLY:						
Residential	555,463	51,099	240,318	224,387	52.5%	92.9%
Mixed R+C	1,775	401	876	461	71.9%	97.9%
Commercial/ Services	110,502	12,922	58,778	32,999	64.9%	94.7%
Mixed C+I	3,344	819	2,144	237	88.6%	95.7%
Industrial	72,125	6,577	36,796	23,403	60.1%	92.6%
Military	30,549	4,981	4,729	17,758	31.8%	89.9%
Infrastructure	205,807	25,351	100,912	61,840	61.4%	91.4%
Urban Open	159,435	20,335	62,245	62,380	51.8%	90.9%
URBAN ONLY:						
Alameda	180,056	27,395	116,255	32,784	79.8%	98.0%
Contra Costa	184,775	7,538	72,201	91,188	43.2%	92.5%
Marin	54,146	9,170	13,357	31,136	41.6%	99.1%
Napa	35,727	119	957	21,157	3.0%	62.2%
San Francisco	29,273	9,106	14,092	5,306	79.2%	97.4%
San Mateo	104,530	37,613	55,887	7,367	89.4%	96.5%
Santa Clara	221,865	9,376	161,297	50,551	76.9%	99.7%
Solano	100,720	3,153	3,235	59,339	6.3%	65.3%
Sonoma	227,908	19,014	69,517	124,636	38.8%	93.5%
	Total Miles	Highest Shaking Potential (<80% g)	Next to Highest Shaking Potential (60-80%g)	Middle Category of Shaking Potential (40-60% g)	% of Miles in Extreme Shaking Potential	% of Miles in Very High or Extreme Shaking Potential
INFRASTRUCTURE:						
Roads	33,021	3,614	15,550	11,294	58.0%	92.2%
Transit	433	84	249	70	76.9%	93.1%
Rail	940	152	394	324	58.1%	92.6%
Pipelines	21,851	2,465	11,258	7,085	62.8%	95.2%
	Total Number	Highest Shaking Potential (<80% g)	Next to Highest Shaking Potential (60-80%g)	Middle Category of Shaking Potential (40-60% g)	% Facilities in Extreme Shaking Potential	% Facilities in Very High or Extreme Shaking Potential
CRITICAL FACILITIES:						
Health Care	840	142	489	193	75.1%	98.1%
Schools	2,000	266	1,092	587	67.9%	97.3%
Bridges	4,158	512	2,198	1,210	65.2%	94.3%
Water Facilities	2,095	244	1,183	530	68.1%	93.4%
Wastewater Fac.	338	49	179	72	67.5%	88.8%
Cities & Counties	4,236	645	2,464	897	73.4%	94.6%

See http://quake.abag.ca.gov/mitigation/pickdbh2.html and http://quake.abag.ca.gov/pickcrit.html for more specific information.

- **93.1%** of the fixed transit in the Bay Area is exposed to extremely high or very high shaking potential (>40%g), including **85.5%** of ACE, **84.8%** of Amtrak, **97%** of BART, **100%** of Caltrain, **100%** of SF MTA (MUNI), and **100%** of the VTA lines. This finding on exposure is consistent with the BART effort to upgrade and strengthen its facilities.
- In comparison, **92.2%** of the miles of roads, **92.6%** of the rail lines, and **95.2%** of the pipelines are in these areas.

These percentages are based on information in ***Table 7: Shaking Hazard and Existing Land Use***. See Plate 21 and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Shaking hazard and exposure of existing critical facilities –

Rather than perform this analysis for each of the many earthquake scenarios developed by USGS and ABAG, we have used the shaking potential map (Plate 21) described earlier.

- Of the **840** critical health care facilities in the Bay Area, over three-quarters (**75.1%**) are exposed to extremely high shaking potential (>60%g).
- In addition, **67.9%** of the **2,000** public schools are exposed to extremely high shaking potential (>60%g).
- Of the **6,669** critical facilities owned by owned by cities, counties, and other special districts in the Bay Area, **71.4%** are exposed to extremely high shaking potential (>60%g).

These vulnerabilities show the need for more detailed risk assessment of these critical facilities, as addressed in the mitigation strategies and described in Chapter 6 – Education and Chapter 5 – Government. Many of these facilities have been seismically retrofitted or will require seismic retrofitting. These percentages are based on information in ***Table 7: Shaking Hazard and Existing Land Use***. See **Plate 21** and http://quake.abag.ca.gov/mitigation/pickcrit.html for more specific information for individual counties and cities.

Liquefaction susceptibility and exposure of existing land use –

Rather than perform this analysis for each of the earthquake scenarios developed by USGS and ABAG, we used the liquefaction susceptibility map (**Plate 22**) described earlier. The areas mapped as having moderate, high, and very high liquefaction susceptibility are roughly equivalent to the areas mapped by CGS as areas where studies are required (Plate 23).

- Of the 4.39 million acres of land in the Bay Area, **2.2%** is in areas mapped as having very high liquefaction susceptibility, while **23.8%** is the areas mapped in the combined moderate-high-very high liquefaction susceptibility category.
- **5.6%** of the urban land is in the areas mapped as having very high liquefaction susceptibility, versus only **1.0%** of the non-urban land.
- **42.4%** of the urban land is in the areas mapped in the combined moderate-high-very high liquefaction susceptibility category, versus only **17.3%** of the non-urban land.
- Types of existing urban land uses with the highest percentages in those areas mapped as having very high liquefaction susceptibility are mixed commercial-industrial complexes (**17.8%**), military use (**15.1%**), and industrial (**11.3%**).

TABLE 8 – Liquefaction Susceptibility and Existing (2005) Land Use

	Total Acres	Very High Liquefaction Susceptibility	High Liquefaction Susceptibility	Moderate Liquefaction Susceptibility	% in Very High	% in High	% in Moderate
Total	4,387,602	95,428	205,262	744,293	2.2%	4.7%	17.0%
Urban	1,139,000	64,057	33,252	385,482	5.6%	2.9%	33.8%
Non-Urban	3,248,602	31,370	172,010	358,812	1.0%	5.3%	11.0%
URBAN ONLY:							
Residential	555,463	14,960	12,624	165,964	2.7%	2.3%	29.9%
Mixed R+C	1,775	162	32	714	9.1%	1.8%	40.2%
Commercial/ Services	110,502	7,927	3,184	51,935	7.2%	2.9%	47.0%
Mixed C+I	3,344	595	64	1,817	17.8%	1.9%	54.3%
Industrial	72,125	8,180	2,727	32,542	11.3%	3.8%	45.1%
Military	30,549	4,609	1,790	7,178	15.1%	5.9%	23.5%
Infrastructure	205,807	17,454	7,559	84,199	8.5%	3.7%	40.9%
Urban Open	159,435	10,169	5,272	41,133	6.4%	3.3%	25.8%
URBAN ONLY:							
Alameda	180,056	16,414	7,921	86,626	9.1%	4.4%	48.1%
Contra Costa	184,775	5,483	5,923	46,049	3.0%	3.2%	24.9%
Marin	54,146	5,811	643	10,926	10.7%	1.2%	20.2%
Napa	35,727	1,002	712	11,454	2.8%	2.0%	32.1%
San Francisco	29,273	5,044	228	10,155	17.2%	0.8%	34.7%
San Mateo	104,530	13,515	1,177	20,881	12.9%	1.1%	20.0%
Santa Clara	221,865	5,913	7,269	114,829	2.7%	3.3%	51.8%
Solano	100,720	5,827	3,743	31,414	5.8%	3.7%	31.2%
Sonoma	227,908	4,179	4,765	46,826	1.8%	2.1%	20.5%
	Total Miles	Very High Liquefaction Susceptibility	High Liquefaction Susceptibility	Moderate Liquefaction Susceptibility	% in Very High	% in High	% in Moderate
INFRASTRUCTURE:							
Roads	33,021	1,820	1,282	13,004	5.5%	3.9%	39.4%
Transit	433	51	9	240	11.8%	2.1%	55.4%
Rail	940	150	48	443	16.0%	5.1%	47.1%
Pipelines	21,851	1,286	558	9,816	5.9%	2.6%	44.9%
	Total Number	Very High Liquefaction Susceptibility	High Liquefaction Susceptibility	Moderate Liquefaction Susceptibility	% in Very High	% in High	% in Moderate
CRITICAL FACILITIES:							
Health Care	840	61	6	481	7.3%	0.7%	57.3%
Schools	2,000	83	36	1069	4.2%	1.8%	53.5%
Bridges	4,158	401	204	1,986	9.6%	4.9%	47.8%
Water Facilities	2,095	114	20	531	5.4%	1.0%	25.3%
Wastewater Facilities	338	121	23	72	35.8%	6.8%	21.3%
Cities & Counties	4,236	632	120	1,848	14.9%	2.8%	43.6%

See http://quake.abag.ca.gov/mitigation/pickdbh2.html and http://quake.abag.ca.gov/pickcrit.html for more specific information.

- The percentage of urban land located in these areas mapped as having very high liquefaction susceptibility ranged from a high of **17.2%** in San Francisco to lows of less than **6%** in Contra Costa, Napa, Santa Clara, Solano, and Sonoma counties.

These percentages are based on information in ***Table 8: Liquefaction Susceptibility and Existing Land Use***. See **Plate 22** and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Liquefaction susceptibility and exposure of existing infrastructure –

Again, we have used the liquefaction susceptibility map (Plate 22) described earlier.

- Of the 33,021 miles of roads in the Bay Area, **5.5%** are in areas mapped as having very high liquefaction susceptibility, while **48.8%** are the areas mapped in the combined moderate-high-very high liquefaction susceptibility category.
- In comparison, **16%** of the miles of rail, **11.8%** of transit lines (**1.8%** of ACE, **20.2%** of Amtrak, **7.9%** of BART, **10.4%** of Caltrain, **24.3%** of SF MTA (MUNI), and **2.4%** of the VTA lines). Finally, **5.9%** of pipelines are in the very high liquefaction susceptibility category. These exposures are of concern because of the potential vulnerability of these lines to damage.

These percentages are based on information in ***Table 8: Liquefaction Susceptibility and Existing Land Use***. See Plate 22 and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Liquefaction susceptibility and exposure of existing critical facilities –

Again, we have used the liquefaction susceptibility map (Plate 22) described earlier.

- Of the **840** critical health care facilities in the Bay Area, **7.3%** are in areas mapped as having very high liquefaction susceptibility, while **65.2%** are the areas mapped in the combined moderate-high-very high liquefaction susceptibility category.
- Of the **2,000** public schools in the Bay Area, **4.2%** are in areas mapped as having very high liquefaction susceptibility, while **59.4%** are the areas mapped in the combined moderate-high-very high liquefaction susceptibility category.
- Of the **6,669** critical facilities owned by cities, counties, and other districts, **13%** are in areas mapped as having very high liquefaction susceptibility, while **52.2%** are the areas mapped in the combined moderate-high-very high liquefaction susceptibility category.

These percentages are based on information in ***Table 8: Liquefaction Susceptibility and Existing Land Use***. See Plate 22 and http://quake.abag.ca.gov/mitigation/pickcrit.html for more specific information for individual counties and cities.

Earthquake-induced landslide susceptibility and exposure of existing land use, infrastructure, and critical facilities –

The best available map for showing earthquake-induced landslide susceptibility is the one prepared by CGS showing the areas where studies are required (Plate 42). The problem with any type of regional assessment using this map is that it does not cover the entire Bay Area. Thus, while the database of exposed land uses exists at http://quake.abag.ca.gov/mitigation/pickdbh2.html, the data for the region does not exist in a format for a regional analysis. However, in areas where this mapping has not been completed, the rainfall-induced landslide hazard map is an acceptable substitute. The hazard exposure for this mapping is described in the "Weather" section of this Appendix.

Vulnerability of the Bay Area to earthquake hazards

Uninhabitable housing due to earthquake ground shaking damage –

ABAG has been modeling uninhabitable housing units and resulting shelter populations beginning shortly after the Loma Prieta earthquake with a contract with the Bay Area Chapter of the American Red Cross. This initial effort was expanded and improved with three separate grants from the National Science Foundation and the U.S. Geological Survey.

The models use estimates of numbers of older single family homes, mobile homes, soft-story multifamily buildings, unreinforced masonry buildings, and other vulnerable housing types, the locations of those structures, shaking exposure, and damage data from past earthquakes to create estimates of uninhabitable housing units for the region. Although the models produce estimates by census tract and city, the models lose accuracy as the modeled area becomes smaller.

The 1989 Loma Prieta earthquake caused a total of over 16,700 units to be uninhabitable throughout the Monterey and San Francisco Bay Areas (including almost 13,000 in the Bay Area). As shown in ***Table 9***: ***Predicted Uninhabitable Units for Bay Area Counties and Selected Earthquake Scenarios***, thirteen of 18 potential Bay Area earthquakes analyzed are expected to have a far larger impact than the Loma Prieta earthquake. In fact, ***eight*** of these earthquakes will probably have a greater impact than the 1994 Northridge earthquake in the Los Angeles area, where over 46,000 housing units were made uninhabitable. See http://www.abag.ca.gov/bayarea/eqmaps/eqhouse.html for additional information.

Transportation system disruption due to earthquakes –

ABAG has been modeling road closures beginning in 1994 with a grant from Caltrans. This initial effort was expanded with additional funding from a grant from the U.S. Geological Survey.

The models separately calculate the number of road closures from a variety of sources: fault rupture, liquefaction, earthquake-triggered landslides, shaking damage to bridges and highway structures, as well as indirect causes of closures such as building damage, hazmat releases, and utility pipeline breaks. The models are based on the locations of roads and transportation structures, shaking exposure, and hazard maps of faults, slides, and liquefaction, locations of buildings that might fall to close roads, sources of hazmat releases, and pipeline locations, as well as damage data from past earthquakes. Although the models produce estimates by census tract and city, the models lose accuracy as the modeled area becomes smaller.

The 1989 Loma Prieta earthquake caused a total of only 142 road closures throughout the Monterey and San Francisco Bay Areas, whereas the Northridge earthquake resulted in only 140 road closures.

As shown in ***Table 10***: ***Predicted Road Closures for Bay Area Counties and Selected Earthquake Scenarios***, 16 of 18 potential Bay Area earthquakes analyzed are expected to have a far larger impact than either the Loma Prieta or the Northridge earthquake. In fact, ***five*** of these earthquakes are predicted to have over 1,000 road closures. One of the major causes of potential road and transit closures is BART.

See http://www.abag.ca.gov/bayarea/eqmaps/eqtrans/eqtrans.html for additional information.

Water and wastewater system disruption due to earthquakes –

Pipelines break and leak as a result of earthquakes. An ABAG analysis of damaged pipelines following the 1989 Loma Prieta earthquake indicated that pipelines in areas subject to liquefaction AND exposed to violent ground shaking were the most likely to have broken or leaked as a result of that earthquake.

In 2009, ABAG re-estimated the number of kilometers (and miles) of water distribution pipeline based on assuming that all roads **within a water supply retailer's service area** are underlain by a pipeline. (In the **previous** research performed by ABAG (Perkins and others, 2001), **all roads** were assumed to be underlain by a pipeline, which led to an overestimation of the number of kilometers of water distribution pipeline.)

TABLE 1 – Data on Number of Water Pipeline Breaks or Leaks from Past Earthquakes

Shaking		O'Rourke Northridge Data*		1991	ABAG Loma Prieta Data vs. Liquefaction Susc.			
Intensity	PGV	Brittle Pipe	Flexible Pipe	Eguchi	Total	Very High	High-Mod.	Low-Very Low
1 - V	6	0.010	0.013	0	0.001	0	0	0.001
2 - VI	13	0.025	0.030	0.003	0.005	0.013	0.005	0.005
3 - VII	30	0.070	0.072	0.03	0.026	0.084	0.022	0.021
4 - VIII	61	0.164	0.152	0.3	0.182	0.386	0.064	0.05
5 - IX	130	0.411	0.337	0.4	n/a	n/a	n/a	n/a
6 - X	286	1.066	0.770	1.2	n/a	n/a	n/a	n/a

*Note: O'Rourke data for MMI IX and X is based on statistical regressions in his research, not on published data.

In addition, in 2009, ABAG has re-calculated the number of pipeline breaks associated with the Loma Prieta earthquake based on the 2006 liquefaction susceptibility mapping (Witter and others, 2006 versus the earlier **Knu**dsen and others, 2000, mapping). The following table compares the number of pipeline breaks based on Eguchi (1991), Jeon and O'Rourke (2005), and ABAG (Perkins, 2001, updated 2009).

Based on pipeline repair rates determined by ABAG in the 1989 Loma Prieta earthquake, including damage due to shaking, liquefaction, landsliding, and fault rupture, the number of pipeline repairs would be approximately 6,000 in an earthquake on the Hayward fault (compared to **507** in the Loma Prieta earthquake). However, some pipeline materials, such as concrete asbestos and cast iron, are significantly more prone to breaking and leaking. In addition, if the earthquake occurs in the winter when the ground is saturated, many more repairs will be necessary than during the dry conditions present during the October Loma Prieta event or the extremely dry January Northridge event. These changes could increase the number of estimated repairs to 10,000 or more. Thus, the estimate for water pipeline repairs in a large Hayward fault earthquake is **6,000 to 10,000**. This range is consistent with system-specific engineering evaluations conducted by water suppliers impacted by this East Bay earthquake.

There will be more leaks and breaks in sewer system collection pipelines because these pipes are more brittle.

Rapid repair and replacement of water and sewer pipelines is essential to recovery from an earthquake.

The various approaches to mitigation of water and wastewater system disruption are described in Chapter 1 - Infrastructure. EBMUD, CCWD, and Santa Clara Valley Water District have installed, and SFPUC and Alameda County Water District are in the process of installing, shut-off valves in pipelines that cross active faults. These valves, installed on each side of the fault, enable above-ground potable water bypass lines to be rapidly installed.

The **pipeline distribution systems** for water and sewer lines typically have not been replaced since they were originally installed, in some cases almost 100 years ago. These pipelines will break and leak. Ways to mitigate this damage through repair and replacement of the most susceptible lines has started, but will not be completed for many years. Some water suppliers have also purchased equipment to bag water for customers if pipelines are broken.

Assessment of options for earthquake loss estimation –

The 1994 Northridge earthquake caused over $40 billion in losses, while the 1989 Loma Prieta earthquake caused about $6 billion in losses.

ABAG collaborated with USGS, CGS, and OES to write a 2003 paper on the results of several HAZUS[8] runs for earthquake-related losses associated with future scenario earthquakes. ABAG staff identified several potentially significant problems with using a combination of ShakeMap scenarios (which, as explained earlier, tend to produce shaking levels lower than the ABAG Shaking Scenario maps), the existing vulnerability formulas (which are prone to underestimate housing losses and losses to wood-frame structures such as dominate the building stock in the Bay Area), and incomplete building inventory data. ***These HAZUS loss estimates are inadequate for planning purposes at the present time.*** See http://quake.abag.ca.gov/mitigation/HAZUS_Paper.pdf for the entire paper.

Risk Management Solutions (RMS), a private corporation which produces loss estimates for the insurance industries, prepared a loss estimate for a repeat of the 1868 Hayward earthquake (2008). The RMS estimate for housing-related losses alone totaled $90 billion, of which only $4.4 billion would be covered by earthquake insurance. In comparison, the HAZUS estimate for building losses from ALL sources (just part of which was residential) for this same earthquake was only $8 billion!

Earthquake Impacts –

The natural disasters with the largest potential impacts on the Bay Area are earthquakes. Most of the damage is due to ground shaking, with relatively little due to liquefaction and landsliding. For example, in the Loma Prieta earthquake, only 1.6% of the $6 billion in losses could be attributed to liquefaction[9], and an even smaller percentage to landsliding. Surface fault rupture can do significant damage to infrastructure systems, depending on the earthquake. (The fault

[8] HAZUS is a software package developed by FEMA for loss modeling.

[9] Holzer, T.L., ed., 1998. "Introduction" in ***The Loma Prieta, California, Earthquake of October 17, 1989 – Liquefaction.*** U.S. Geological Survey Prof. Paper 1551-B: Reston, VA, pp. B4.

that caused the Loma Prieta earthquake, for example, did not rupture the surface, so there were no losses associated with fault rupture in that earthquake.)

The extent of the impact of earthquake disasters can best be explained using various earthquake scenario events. For example, in a magnitude 6.9 earthquake on the entire Hayward fault (extending from San Pablo Bay to the border of Alameda and Santa Clara counties), ABAG has estimated over 150,000 uninhabitable housing units and 1,700 road closures. In 2003, the FEMA-developed HAZUS software only estimated 24,000 displaced households, a factor of 6 lower than the ABAG estimates. Part of this discrepancy is due to uncertainty on the impact on wood-frame apartments with parking in the ground floor ("soft-story" apartments). HAZUS estimates the total losses for that earthquake as only $23 billion (versus actual losses of over $40 billion in the Northridge earthquake, a smaller magnitude earthquake with a less vulnerable building stock). The Bay Area Economic Forum produced a 2002 report on the impact of this earthquake on ***Hetch-Hetchy Water and the Bay Area Economy***[10], estimating that the losses associated with failure of that system alone would be $17.2 billion. Finally, the HAZUS software predicts from 100-700 fatalities in that earthquake scenario, depending on the time of day. These estimates are difficult to evaluate, particularly because they are so tied to the vulnerability of particular systems. For example, fatalities in the BART tube alone could exceed that value if the tube were to rupture catastrophically. Obviously, the current HAZUS estimates are inadequate.

Thus, ABAG will be working to develop different ways to either refine those estimates or develop alternative ways to express losses and risk. As mentioned earlier, RMS proprietary software used to estimate residential losses produced an estimate of $90 billion given a repeat of the 1868 Hayward earthquake on the southern Hayward fault in 2008, versus an estimate of only $8 billion from the 2003 HAZUS run. This MJ-LHMP estimates that the RMS estimate is much closer to reality. See ABAG mitigation strategy GOVT-e-2. Any remaining gaps in knowledge following that effort will be identified as part of that effort. The goal is for future loss estimates to be city-specific. Interestingly, the final report conducted by ABAG for the City of Oakland on soft-story housing in Oakland focused not on dollar damage losses, but on issues of habitability and community-level impacts, such as loss of property tax and business tax, for these data were more valuable than estimated dollar losses.

Additional earthquake risk assessment plans –

ABAG is continually examining options for improving risk assessments over time, such as risk assessments on privately-owned hazardous buildings in earthquakes. The results of these risk assessments are incorporated into the applicable chapters of the MJ-LHMP as this plan is updated over time. Some of the initial results of that effort are described in Chapter 3 – Housing and Chapter 4 – Economy.

[10] See http://www.bayeconfor.org/pdf/hetchhetchyfinal2.pdf to view the entire report.

TABLE 9 – Predicted Uninhabitable Units for Bay Area Counties and Selected Earthquake Scenarios

Earthquake Scenario	Alameda	Contra Costa	Marin	Napa	San Francisco	San Mateo	Santa Clara	Solano	Sonoma	TOTAL
Santa Cruz Mts. San Andreas	1,968	159	297	0	11,781	223	1,277	2	3	15,710
Peninsula-Golden Gate San Andreas	3,820	188	1,485	3	65,316	22,525	15,094	11	42	108,484
Northern Golden Gate San Andreas	4,345	560	2,988	19	62,654	1,904	449	127	1,804	74,851
Entire Bay Area San Andreas	16,048	1,173	3,495	20	82,354	24,472	29,593	185	2,530	159,870
No. San Gregorio	3,104	238	1,176	4	38,306	9,040	589	12	45	52,514
So. Hayward	64,451	1,760	1,030	16	13,940	245	11,892	126	37	93,497
No. Hayward	43,132	7,686	1,653	19	11,464	210	303	128	74	64,669
N + S Hayward	88,265	10,102	2,125	36	37,670	1,616	14,273	1,046	559	155,692
Rodgers Creek	3,688	1,418	1,549	53	11,460	151	100	1,148	13,988	33,555
Rodgers Creek-No. Hayward	49,284	9,786	2,691	713	29,758	363	402	1,386	14,115	108,498
So. Maacama	325	17	27	22	1,986	11	11	15	825	3,239
West Napa	1,382	286	27	4,284	2,011	15	29	1,668	126	9,828
Concord-Green Valley	3,511	11,363	29	1,307	3,191	76	325	2,868	37	22,707
No. Calaveras	7,836	3,509	27	18	3,191	78	4,882	181	6	19,728
Central Calaveras	3,037	75	27	3	3,191	182	10,145	13	4	16,677
Mt. Diablo	6,128	4,868	751	3	10,489	23	109	17	4	22,392
Greenville	2,701	2,637	27	19	2,005	16	101	190	6	7,701
Monte Vista	323	5	16	1	2,429	2,392	27,223	2	2	32,393

TABLE NOTES – This table is based on ABAG's modeling of uninhabitable housing units in future earthquake scenarios ***(Shaken Awake!,*** Perkins and others, 1996) that was last updated in 2003 for consistency with U.S. Geological Survey earthquake scenarios of 2003 as well as 2008. This modeling is based on an extensive statistical analysis of the housing damage which occurred as a result of the 1989 Loma Prieta and 1994 Northridge earthquakes. However, the expected percentage of pre-1940 single-family homes rendered uninhabitable used to generate this table is larger than published in 1996. New data on lack of retrofitting and reasons for low damage in the Northridge earthquake caused ABAG to increase the uninhabitable percentages used to create this table for pre-1940 single-family homes to 19% and 25% for MMI IX and X, respectively.

Note that several fault segments listed above have new segment end points or were not included in the 1996 report. They are included in this table to reflect ground shaking information published by USGS in 2003. The Santa Cruz Mts.–San Andreas is similar, but not identical, to the fault causing the Loma Prieta earthquake. The Monte Vista and West Napa faults have been added to the faults analyzed by USGS to illustrate the impact of an earthquake in these areas. The Maacama fault could impact the North Bay, but too little was known about the fault for the USGS to issue probabilities for it in 2003. It, too, has been added to illustrate possible damage. On the other hand, the Southern Calaveras, the Southern San Gregorio, and the northern North Coast–San Andreas faults are outside of the Bay Area. The Bay Area impacts of earthquakes on these fault segments are dwarfed by their Bay Area segments so they are not included. Additional information on earthquakes and housing is available in ***Shaken Awake!*** and on the ABAG Earthquake Program Internet site at http://quake.abag.ca.gov.

TABLE 10 – Predicted Road Closures for Bay Area Counties and Selected Earthquake Scenarios

Earthquake Scenario	Alameda	Contra Costa	Marin	Napa	San Francisco	San Mateo	Santa Clara	Solano	Sonoma	TOTAL
Santa Cruz Mts. San Andreas	24	10	3	0	44	9	64	0	1	154
Peninsula-Golden Gate San Andreas	50	9	22	0	335	300	146	1	4	866
Northern Golden Gate San Andreas	62	20	70	1	321	24	10	4	69	581
Entire Bay Area San Andreas	146	30	77	3	429	315	250	6	75	1,332
No. San Gregorio	43	11	20	0	164	144	13	1	6	401
So. Hayward	901	43	15	1	72	8	90	4	4	1,138
No. Hayward	335	238	20	1	48	5	7	5	8	667
N + S Hayward	1,081	268	28	2	214	16	99	10	16	1,734
Rodgers Creek	54	34	20	4	48	3	3	12	223	4
Rodgers Creek-No. Hayward	363	256	34	9	157	11	10	14	230	1,084
So. Maacama	8	3	1	3	6	0	1	1	53	74
West Napa	22	20	1	89	6	1	1	14	5	159
Concord-Green Valley	56	201	1	19	11	3	7	83	4	386
No. Calaveras	180	107	1	1	11	3	53	6	1	363
Central Calaveras	51	10	1	0	11	4	132	1	1	210
Mt. Diablo	94	78	7	0	41	2	4	2	1	228
Greenville	70	47	1	1	6	1	4	6	1	138
Monte Vista	10	1	0	0	8	23	283	0	1	326

TABLE NOTES – This table is based on ABAG's modeling of road closures in future earthquake scenarios ***(Riding Out Future Quakes,*** Perkins and others, 1997) that was last updated in 2003 for consistency with U.S. Geological Survey earthquake scenarios of 2003 as well as 2008. This modeling is based on an extensive statistical analysis of the road closures which occurred as a result of the 1989 Loma Prieta and 1994 Northridge earthquakes.

Note that several fault segments listed above have new segment end points or were not included in the 1996 report. They are included in this table to reflect ground shaking information published by USGS in 2003. The Santa Cruz Mts.–San Andreas is similar, but not identical, to the fault causing the Loma Prieta earthquake. The Monte Vista and West Napa faults have been added to the faults analyzed by USGS to illustrate the impact of an earthquake in these areas. The Maacama fault could impact the North Bay, but too little was known about the fault for the USGS to issue probabilities for it in 2003. It, too, has been added to illustrate possible damage. On the other hand, the Southern Calaveras, the Southern San Gregorio, and the northern North Coast–San Andreas faults are outside of the Bay Area. The Bay Area impacts of earthquakes on these fault segments are dwarfed by their Bay Area segments so they are not included. Additional information on earthquakes and housing is available in ***Riding Out Future Quakes*** and on the ABAG Earthquake Program Internet site at http://quake.abag.ca.gov.

Tsunamis

Probability of tsunami-related hazards

Tsunamis can result from off-shore earthquakes within the Bay Area, or from distant events. Probabilities are in the process of being developed for these various events in a major project being undertaken by CalEMA and the Pacific Earthquake Engineering Research Center (PEER). These maps and data are not available as of October 2009.

The existing and planned CalEMA tsunami maps are not even officially called a hazard map, but an evacuation planning map, because it is not based on probabilities. This map is a worst-case scenario. ABAG continues to work with CalEMA and the affected counties and cities to encourage this process to move forward. ABAG and the cities and counties of the region covered by this MJ-LHMP will use the new hazard maps once they become available. The *Purpose of the Map* section on the CalEMA maps notes:

> The inundation map has been compiled with best currently available scientific information. The inundation line represents the maximum considered tsunami runup from a number of extreme, yet realistic, tsunami sources. Tsunamis are rare events; due to a lack of known occurrences in the historical record, this map includes no information about the probability of any tsunami affecting any area within a specific period of time.

Location and extent of tsunami-related hazards

As of October 2009, only evacuation planning maps showing only a portion of the Bay Area ocean coastline from San Gregorio in San Mateo County to Lincoln Park in San Francisco have been released as part of a CalEMA-led effort. This first-generation map is based on a maximum run-up to a specific contour, in the case of the first set of maps, 12.8 meters (42 feet). The map is ***Plate 43 – Tsunami Evacuation Planning Areas***. As with the other maps, more detailed maps for individual local governments, and additional tsunami hazard information is available at http://quake.abag.ca.gov/tsunami.

While no maps have been released as part of this CalEMA effort for the area within San Francisco Bay, an ongoing study[11] indicates that if the run-up height is 10 meters at the Golden Gate, it might be half as high when it reaches the East Bay, and only 10% as high (1 meter) by the time it reaches the northern and southern ends of the Bay.

CalEMA estimates that a revised second-generation map showing the entire Bay Area coastline, as well as the area within San Francisco Bay, will be available by December 2009 or January 2010. Since the updated maps have still not been publically released, they have not been used in this MJ-LHMP. ABAG has been in on-going conversations with CalEMA so that these second-generation maps will be made publically available once they are officially released. When released, more detailed maps for individual local governments, and additional tsunami hazard information will become publicly available at http://quake.abag.ca.gov/tsunami.

[11] Dengler, L., Borrero, J., Patton, J., 2004. "The Tsunami Hazard in San Francisco Bay" in ***Eos Trans***. AGU, 85(47), Fall Meet. Suppl., Abstract OS23D-1354.

Both the first-generation and second-generation maps show a "worst case" tsunami event for evacuation planning, not hazard maps.

It is important to understand that, even when the current CalEMA mapping is complete, ***no probability information is available for the Bay Area tsunami hazard as part of the tsunami evacuation planning maps***. ABAG and others are encouraging the continued efforts of CalEMA and PEER to create probabilistic tsunami hazard maps for the Bay Area. Such maps are expected in 2010 or 2011. When available, ABAG will also use these hazard maps in its hazard mitigation planning.

Tsunami mitigation strategies are limited due to the lack of hazard maps and include evacuation planning (GOVT c-24) and cooperation to increase the speed of completion of hazard maps (GOVT-d-10).

Past occurrences of Bay Area tsunami -related disasters

Tsunamis have not been a major problem in the Bay Area. The tsunami generated by the 1964 Alaskan earthquake caused high water within San Francisco Bay. However, damage was virtually non-existent. Past tsunamis have caused some localized problems in the Alviso area, as well. Data are extremely limited.

Exposure and vulnerability of the Bay Area to tsunami hazards

Large underwater displacements from major earthquake fault ruptures or underwater landslides can lead to ocean waves called ***tsunamis***.[12] Since tsunamis have high velocities, the damage from a particular level of inundation is far greater than with a normal flood event.

ABAG has not performed any analysis of the land use and infrastructure exposure within the tsunami evacuation areas as part of this multi-jurisdictional Local Hazard Mitigation Plan. This exposure data is also not available on ABAG's internet site. While the tsunami evacuation planning maps released by CalEMA in December 2009 cover the Bay Area's coastline (except for northern Sonoma County) and inside the Bay, CalEMA has stressed that these maps are NOT appropriate for anything but evacuation planning.

Only exposure information for locally owned ***critical facilities*** will become available on ABAG's website. In summary, 36 of the 2,095 water facilities (1.7%), 54 of the 338 wastewater facilities (16%), and 276 of the 4,236 facilities owned by cities, counties, and other special districts (6.5%) are located in these areas.

When the maps being prepared by PEER are released by PEER and CalEMA in one to two years, then it will be appropriate for ABAG and the other local governments in the Bay Area to use these maps in ways similar to the other earthquake hazard maps described in this Appendix.

[12] Waves in enclosed bodies, such as lakes or Bays, are called ***seiches***. There are no published maps or hazard information on seiche hazards in the Bay Area.

Flooding

Flooding probabilities, location, and extent

The Federal Emergency Management Agency (FEMA) has mapped ***flooding*** hazards in the Bay Area's low-lying areas. These flood hazard maps have built-in probability information – the 100-year floodplain or the 500-year floodplain. ***Plate 44*** depicts the 100-year flood zone for the Bay Area, as well as the zone for 500-year floods and other concerns. In general, these maps are based on the updated and improved FEMA digital Flood Insurance Rate Maps (D-FIRMs), However, as of October 2009, only the older Q3 data were available for San Mateo County. D-FIRMs for San Mateo County are not expected to be released until September 2010.

More detailed maps for individual local governments and additional flood hazard information are available on line at http://www.abag.ca.gov/bayarea/eqmaps/eqfloods/floods.html.

The maps available on the ABAG web site do not include information on depth of flooding, except that the 500-year flood areas also include areas subject to 100-year flood events with flooding depths expected to be less than one foot.

FEMA's National Flood Insurance Program provides insurance to homeowners in declared flood areas. As part of this program FEMA keeps data on repetitive loss properties. These are properties that have submitted claims for flood reimbursement 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. ***Plate 54*** depicts the locations of repetitive loss properties in the Bay Area.

[*Note – flooding associated with tsunami hazards are covered above under earthquake-related hazards, not as part of flooding in this discussion. Similarly, flooding from dam inundation is covered in its own section in this document*]

Past occurrences of Bay Area flood-related disasters

Flooding and landsliding associated with severe storms have been among the most common disasters in the Bay Area during the period from 1950 to 2009.

Extensive flooding and/or landslides occurred in 1950, 1955, 1957, 1958, 1959,1962, 1963, 1964, 1965, 1966, 1969, 1970, 1973, 1980, 1982, 1983, 1992, 1995, 1996, 1997, 1998, 2005, 2006, and 2008.

See Appendix D and http://quake.abag.ca.gov/mitigation/disaster-history.html for more specific information.

Exposure and vulnerability of the Bay Area to flooding-related disasters

One method of assessing vulnerability is to examine existing land uses in mapped hazard areas.

TABLE 11 – Flooding Hazard and Existing (2005) Land Use

`	Total Acres	Within 100-Year Flood Zone	Within 500-Year Flood Zone or Other Area of Concern	% of Land Within 100-Year Flood Zone	% of Land Within 500-Year Flood Zone or Other Area of Concern
Total	4,387,602	424,920	153,407	9.7%	3.5%
Urban	1,139,000	72,811	121,688	6.4%	10.7%
Non-Urban	3,248,602	352,109	31,719	10.8%	1.0%
URBAN ONLY:					
Residential	555,463	19,145	53,881	3.4%	9.7%
Mixed R+C	1,775	96	67	5.4%	3.8%
Commercial/ Services	110,502	7,310	19,209	6.6%	17.4%
Mixed C+I	3,344	617	388	18.5%	11.6%
Industrial	72,125	10,797	11,297	15.0%	15.7%
Military	30,549	3,727	274	12.2%	0.9%
Infrastructure	205,807	15,960	26,456	7.8%	12.9%
Urban Open	159,435	15,160	10,116	9.5%	6.3%
URBAN ONLY:					
Alameda	180,056	9,720	12,520	5.4%	7.0%
Contra Costa	184,775	11,724	6,297	6.3%	3.4%
Marin	54,146	5,899	4,038	10.9%	7.5%
Napa	35,727	3,829	624	10.7%	1.7%
San Francisco	29,273	0	0	0.0%	0.0%
San Mateo	104,530	4,946	4,089	4.7%	3.9%
Santa Clara	221,865	14,253	84,448	6.4%	38.1%
Solano	100,720	11,564	6,585	11.5%	6.5%
Sonoma	227,908	10,877	3,086	4.8%	1.4%
	Total Miles	Within 100-Year Flood Zone	Within 500-Year Flood Zone or Other Area of Concern	% of Miles Within 100-Year Flood Zone	% of Miles Within 500-Year Flood Zone or Other Area of Concern
INFRASTRUCTURE:					
Roads	33,021	1,731	3,972	5.2%	12.0%
Transit	433	42	74	9.7%	17.1%
Rail	940	149	117	15.9%	12.4%
Pipelines	21,851	809	3,264	3.7%	14.9%
	Total Number	Within 100-Year Flood Zone	Within 500-Year Flood Zone or Other Area of Concern	% Within 100-Year Flood Zone	% Within 500-Year Flood Zone or Other Area of Concern
CRITICAL FACILITIES:					
Health Care	840	14	137	1.7%	16.3%
Schools	2,000	50	271	2.5%	13.6%
Bridges	4,158	469	638	11.3%	15.3%
Water Facilities	2,095	80	128	3.8%	6.1%
Wastewater Facilities	338	39	26	11.5%	7.7%
Cities & Counties	4,236	328	708	7.7%	16.7%

See http://quake.abag.ca.gov/mitigation/pickdbh2.html and http://quake.abag.ca.gov/pickcrit.html for more specific information.

Flooding and exposure of existing land use –

- Of the 4.39 million acres of land in the Bay Area, **9.7%** is in the 100-year flood zone, while only **3.5%** is in the 500-year flood zone or area of other flooding concern.
- **6.4 %** of the urban land is in the 100-year flood zone, versus **10.8%** of the non-urban land.
- **10.7%** of the urban land is in the 500-year flood zone or area of other concern, versus only **1.0%** of the non-urban land. The fact that over ten times the percentage of urban versus non-urban land is in these areas is because lands protected from 100-year flooding are in these areas of "other flooding concerns."
- Types of existing urban land uses with the highest percentages in 100-year flood zones are mixed commercial-industrial complexes (**18.5%**), industrial (**15%**), and military use (**12.2%**).
- The percentage of urban land located in the 100-year flood zone ranged from a high of **11.5%** in Solano County and **10.9%** in Marin County to lows of **0%** in San Francisco and **4.7%** in San Mateo County.

These percentages are based on information in ***Table 11: Flooding Hazards and Existing Land Use***. See Plate 44 and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Flooding and exposure of existing infrastructure –

- Rail is disproportionately located in zones subject to 100-year floods, with **15.9%** of the miles of track located in these areas.
- Pipelines, as underground lines, should not be impacted by flooding even though **3.7%** of the miles of pipelines in the region are in these areas.
- **9.7%** of the transit lines are in these areas, including **14.5%** of ACE, **21%** of Amtrak, **2%** of BART, **6.5%** of Caltrain, **none** of SF MTA (MUNI), and **4.8%** of the VTA lines. This statistic points to a need for further assessment on the part of transit operators. For example, underground BART stations are more vulnerable to potential flooding than are elevated track.

These percentages are based on information in ***Table 11: Flooding Hazards and Existing Land Use***. See Plate 44 and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Flooding and exposure of existing critical facilities –

- Of the **840** critical health care facilities in the Bay Area, **1.7%** are in zones subject to 100-year floods.
- Of the **2,000** public schools in the Bay Area, **2.5%** are in zones subject to 100-year floods.
- Of the **6,669** critical facilities owned by cities, counties, and other districts, **6.7%** are in zones subject to 100-year floods.

These percentages are based on information in ***Table 11: Flooding Hazards and Existing Land Use***. See Plate 44 and http://quake.abag.ca.gov/mitigation/pickcrit.html for more specific information for individual counties and cities.

Repetitive flood losses –

The Federal Emergency Management Agency (FEMA) insures properties against flooding losses in the Bay Area through the National Flood Insurance Program. Those properties that have had more than one insured flood loss are called "repetitive loss properties." There are 1,417 properties that have experienced repetitive losses in the Bay Area, resulting in a total of 4,269 claims totaling $98,159,564, of which $65,454,919 was in Sonoma County. Almost all of these losses occurred in the unincorporated portion of that county. See ***Table 12: Repetitive Flood Losses*** for data on the impacted cities.

TABLE 12 – Repetitive Loss Summary

Data as of 3/31/09

City and County	Total Payments ($)	Average Payment ($)	Losses	Properties	Properties (as of 2004)
Alameda County					
Alameda County (unincorporated)	70,136.24	17,534.06	4	2	1
Alameda	-	-	-	-	-
Albany	-	-	-	-	-
Berkeley	-	-	-	-	-
Dublin	-	-	-	-	-
Emeryville	-	-	-	-	-
Fremont	-	-	-	-	-
Hayward	25,797.84	12,898.92	2	1	1
Livermore	-	-	-	-	-
Newark	-	-	-	-	-
Oakland	50,540.72	4,211.73	12	6	5
Piedmont	10,015.62	5,007.81	2	1	1
Pleasanton	17,639.42	8,819.71	2	1	1
San Leandro	-	-	-	-	-
Union City	385,555.39	192,777.70	2	1	1
Contra Costa County					
Contra Costa County (unincorporated)	348,428.46	15,149.06	23	10	8
Antioch	1,022,300.38	35,251.74	29	10	5
Brentwood	-	-	-	-	-
Clayton	-	-	-	-	-
Concord	67,154.16	8,394.27	8	3	2
Danville	-	-	-	-	-
El Cerrito	17,994.04	4,498.51	4	2	2
Hercules	-	-	-	-	-
Lafayette	50,613.36	12,653.34	4	2	2
Martinez	365,453.52	13,535.32	27	13	7
Moraga	-	-	-	-	-
Oakley	5,134.79	1,711.60	3	1	0
Orinda	155,106.69	19,388.34	8	2	2
Pinole	-	-	-	-	-
Pittsburg	8,606.62	4,303.31	2	1	0
Pleasant Hill	180,282.96	22,535.37	8	4	2

TABLE 12 – Repetitive Loss Summary (cont.)

Richmond	127,146.46	9,780.50	13	6	6
San Pablo	252,198.88	16,813.26	15	6	5
San Ramon	-	-	-	-	-
Walnut Creek	499,979.81	26,314.73	19	7	5
Marin County					
Marin County (unincorporated)	3,922,078.96	17,052.52	230	86	55
Belvedere	71,271.84	17,817.96	4	2	1
Corte Madera	470,210.34	31,347.36	15	7	4
Fairfax	464,153.24	22,102.54	21	6	3
Larkspur	295,608.01	14,780.40	20	6	4
Mill Valley	404,816.78	13,058.61	31	11	8
Novato	1,204,606.78	12,291.91	98	37	29
Ross	1,582,514.94	37,678.93	42	13	4
San Anselmo	97,285.14	13,897.88	7	3	3
San Rafael	1,746,590.19	17,642.33	99	33	31
Sausalito	205,535.01	13,702.33	15	5	4
Tiburon	47,255.39	7,875.90	6	3	3
Napa County					
Napa County (unincorporated)	3,651,710.92	27,875.66	131	43	31
American Canyon	-	-	-	-	-
Calistoga	-	-	-	-	-
Napa	6,982,483.92	33,092.34	211	72	58
St. Helena	446,665.75	44,666.58	10	4	4
Yountville	104,240.33	11,582.26	9	3	2
City and County of San Francisco					
San Francisco City and County	109,663.73	9,969.43	11	4	4
San Mateo County					
San Mateo County (unincorporated)	103,179.64	11,464.40	9	4	2
Atherton	-	-	-	-	-
Belmont	26,990.11	6,747.53	4	2	2
Brisbane	-	-	-	-	-
Burlingame	25,829.85	6,457.46	4	2	2
Colma	-	-	-	-	-
Daly City	109,883.62	13,735.45	8	3	3
East Palo Alto	-	-	-	-	-
Foster City	-	-	-	-	-
Half Moon Bay	-	-	-	-	-
Hillsborough	-	-	-	-	-
Menlo Park	12,141.66	6,070.83	2	1	0
Millbrae	123,354.54	8,223.64	15	5	3
Pacifica	96,812.63	19,362.53	5	2	2
Portola Valley	522,164.53	130,541.13	4	2	1
Redwood City	73,033.16	18,258.29	4	2	2
San Bruno	48,118.22	16,039.41	3	1	1
San Carlos	28,081.97	7,020.49	4	2	1
San Mateo	22,906.57	5,726.64	4	2	0

TABLE 12 – Repetitive Loss Summary (cont.)

South San Francisco	815,490.80	54,366.05	15	5	4
Woodside	-	-	-	-	-
Santa Clara County					
Santa Clara County (unincorporated)	341,585.74	12,651.32	27	10	8
Campbell	-	-	-	-	-
Cupertino	49,259.62	24,629.81	2	1	1
Gilroy	-	-	-	-	-
Los Altos	-	-	-	-	-
Los Altos Hills	-	-	-	-	-
Los Gatos	5,393.99	2,697.00	2	1	1
Milpitas	-	-	-	-	-
Monte Sereno	-	-	-	-	-
Morgan Hill	106,064.04	11,784.89	9	4	3
Mountain View	-	-	-	-	-
Palo Alto	692,067.82	40,709.87	17	5	6
San Jose	154,455.70	8,129.25	19	7	7
Santa Clara	-	-	-	-	-
Saratoga	-	-	-	-	-
Sunnyvale	30,730.37	15,365.19	2	1	0
Solano County					
Solano County (unincorporated)	1,790,593.63	40,695.31	44	17	6
Benicia	-	-	-	-	-
Dixon	10,487.54	5,243.77	2	1	0
Fairfield	417,634.31	41,763.43	10	4	0
Rio Vista	464,008.39	58,001.05	8	3	3
Suisun City	349,740.27	21,858.77	16	4	3
Vacaville	589,867.88	42,133.42	14	6	0
Vallejo	227,990.96	8,142.53	28	12	11
Sonoma County					
Sonoma County (unincorporated)	60,354,563.70	22,613.17	2669	830	719
Cloverdale	-	-	-	-	-
Cotati	-	-	-	-	-
Healdsburg	398,506.82	13,283.56	30	10	8
Petaluma	3,250,630.77	33,169.70	98	34	32
Rohnert Park	-	-	-	-	-
Santa Rosa	234,392.07	14,649.50	16	5	2
Sebastopol	1,090,447.52	49,565.80	22	10	8
Sonoma	126,378.43	21,063.07	6	2	3
Windsor	-	-	-	-	-
Total	**98,159,563.50**	**22,993.57**	**4,269**	**1,417**	**1,148**

The use of this information is limited because the data are not geo-located. Thus, no map of these properties can be produced and no assessment of the location of these properties versus either Q3 or D-FIRM flood hazard maps can be generated. However, using older data, ABAG examined these properties relative to the Q3 maps. As shown in Table 13, below, a total of 921 of the properties are located in the 100-year flood plain. An additional 80 are located in the areas

mapped as a 500-year flood zone or area of other concern. The remaining 157 properties are located outside of these mapped hazard areas.

See **http://quake.abag.ca.gov/mitigation/pickflood.html** for more information for individual counties and cities on the repetitive flood losses versus Q3 flood mapping.

TABLE 13 – 2005 Repetitive Flood Losses versus Q3 FIRMS

	Total Number of Properties	Within 100-Year Flood Zone	Within 500-Year Flood Zone or Other Area of Concern	Not Within the Mapped Flood Zone	Number of Claims
Total	1,158	921	80	157	3,218
Alameda	10	2	0	8	20
Contra Costa	46	29	9	8	103
Marin	149	124	6	19	398
Napa	95	67	7	21	247
San Francisco	4	0	0	4	11
San Mateo	23	8	4	11	56
Santa Clara	27	19	4	4	67
Solano	28	22	5	1	76
Sonoma	776	650	45	81	2,240

Past flood losses as an indicator of future vulnerability –

Past flooding losses have been significant, but not as large as for earthquakes. For example, the January 1997 floods resulted in $1.8 billion in total damage in California, while the El Nino storms of early 1998 resulted in $550 million in losses in the entire state, including both flooding and landslides impacts. FEMA documents over $98 million in total repetitive losses in the Bay Area that have been paid by their insurance program since its inception, most of which (over $65 million) has occurred in Sonoma County. The Holland and Webb Tracts levee breaks in 1980 impacted Contra Costa, Sacramento, and San Joaquin counties and resulted in $17.4 million in damage. However, since **6.4%** of the urban land in the Bay Area is within the 100-year flood plain, and climate change may increase the size of spring runoff, future losses could be more significant than in the past. Note that some of the repetitive loss claims have occurred in areas outside of the Q3-mapped 100-year flood plain. Thus, it is clear that other areas are susceptible to flooding, but to a lesser extent.

Landsliding

Landsliding probabilities, location, and extent

These same storms also impact our hillsides by triggering debris flows and more slow-moving traditional landslides. The U.S. Geological Survey has developed maps depicting both ***debris flow*** source areas (***Plate 45***) and ***existing landslides*** (***Plate 46***). The map of existing landslides covers areas of severe coastal erosion.

No formal estimates of probability are associated with these maps and there is no way to estimate these probabilities within the scope of this Local Hazard Mitigation Plan. In general, landslides are most likely during periods of higher than average rainfall or El Nino winter storms. In addition, the ground must be saturated prior to the onset of a major storm for significant landsliding to occur. But there is also no way to estimate the scale of individual landslides in terms of size or extent based on these maps, or to assign specific probabilities to these areas in terms of the likelihood of future landslides. In general, USGS continues to devote fewer resources to landslide mapping (and no resources to probability modeling) than to earthquake hazard mapping because landslides tend to have much more isolated impacts. Thus, qualitatively, the probability of a specific mapped area experiencing a slide in a given year is low and typically localized. On the other hand, there are some known areas of higher than average problems including Devil's Slide on the San Mateo County coast, Mission Peak landslide above Fremont, the Oakland-Berkeley Hills, and the hills of Marin County. None of ABAG's applications for funding of landslide hazard risk assessments have been funded, and the efforts of the California Geological Survey have been underfunded.

TABLE 14 – SUPPLEMENTARY INFORMATION FOR PLATE 46: Summary Distribution of Slides and Earth Flows in the San Francisco Bay Region

Susceptibility Value on Map	"Official" Full Description (from USGS Open File Report 97-745E, 1997)
Mostly Landslides	**Mostly Landslides** - consists of mapped landslides, intervening areas typically narrower than 1500 feet, and narrow borders around landslides; defined by drawing envelopes around groups of mapped landslides.
Many Landslides	**Many Landslides** - consists of mapped landslides and more extensive intervening areas than in 'Mostly Landslide'; defined by excluding areas free of mapped landslides; outer boundaries are quadrangle and county limits to the areas in which this unit was defined.
Flatland	**Flat Land** - areas of gentle slope at low elevation that have little or no potential for the formation of slumps, translational slides, or earth flow except along stream banks and terrace margins; defined by the distribution of surficial deposits.
Few Landslides	**Few Landslides** - contains few, if any, large mapped landslides, but locally contains scattered small landslides and questionably identified larger landslides; defined in most of the region by excluding groups of mapped landslides but defined directly in areas containing the 'Many Landslides' unit by drawing envelopes around areas free of mapped landslides.
Very Few Landslides	**Very Few Landslides** – (no additional information provided)

The list of mitigation strategies includes several relating to ways in which local governments can increase the speed of completion of hazard maps, particularly GOVT-d-10 and LAND-a-7. The local governments in the Bay Area continue to support efforts by CGS and USGS to collect data and obtain funding for additional studies related to rainfall-induced landslide hazards in the Bay Area. More detailed maps for individual local governments and additional landslide hazard information are available on line at http://quake.abag.ca.gov/landslide.

Past occurrences of Bay Area landslide-related disasters

Flooding and landsliding associated with severe storms have been among the most common disasters in the Bay Area during the period from 1950 to 2009.

Extensive flooding and/or landslides occurred in 1950, 1955, 1957, 1958, 1959,1962, 1963, 1964, 1965, 1966, 1969, 1970, 1973, 1980, 1982, 1983, 1992, 1995, 1996, 1997, 1998, 2005, 2006, and 2008.

See Appendix D and http://quake.abag.ca.gov/mitigation/disaster-history.html for more specific information.

Exposure and vulnerability of the Bay Area to landslide-related disasters

One method of assessing vulnerability is to examine existing land uses in mapped hazard areas.

Existing landslide areas and existing land use –

- Of the 4.39 million acres of land in the Bay Area, **23.1%** are in areas mapped as mostly landslides on the existing landslide map.
- Only **8.3%** of the urban land is in these mostly landslide areas, versus **28.2%** of the non-urban land. Thus, in general, we are avoiding these areas.
- Types of existing urban land uses with the highest percentages in these mostly landslide areas are urban open space (**14.4%**) and residential use (**9.9%**).
- Of the **94,704** acres of urban land in these areas of extensive landslides, **58.1%** is residential use.
- The percentage of urban land located in these mostly landslide areas ranged from a highs of **17.7%** in Marin County, **13.7%** in Sonoma County, and **10.9%** in Contra Costa County to a low of **1%** in San Francisco.

These percentages are based on information in ***Table 15: Existing Landslide Areas and Existing Land Use***. See Plate 46 and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Existing landslide areas and existing infrastructure –

- While **3.9%** of the miles of pipelines and **7.2%** of the miles of roads are in areas mapped as mostly landslides, only **2.1%** of the miles of transit miles and **1.6%** of the rail miles are in these areas. **None** of the MUNI or VTA light rail lines are located in these areas, and only **1.6%** of rail, **7.3%** of ACE, **1.7%** of Amtrak, **4%** of BART, and **1.3%** of Caltrain lines are in these areas.

TABLE 15 – Landslide Hazard and Existing (2005) Land Use

	Total Acres	In Areas of Mostly Landslides	% of Land in Areas of Mostly Landslides
Total	4,387,602	1,011,780	23.1%
Urban	1,139,000	94,704	8.3%
Non-Urban	3,248,602	917,077	28.2%
URBAN ONLY:			
Residential	555,463	54,994	9.9%
Mixed R+C	1,775	7	0.4%
Commercial/ Services	110,502	4,020	3.6%
Mixed C+I	3,344	88	2.6%
Industrial	72,125	2,874	4.0%
Military	30,549	667	2.2%
Infrastructure	205,807	9,046	4.4%
Urban Open	159,435	23,008	14.4%
URBAN ONLY:			
Alameda	180,056	9,462	5.3%
Contra Costa	184,775	20,060	10.9%
Marin	54,146	9,588	17.7%
Napa	35,727	2,063	5.8%
San Francisco	29,273	286	1.0%
San Mateo	104,530	8,752	8.4%
Santa Clara	221,865	9,915	4.5%
Solano	100,720	3,360	3.3%
Sonoma	227,908	31,218	13.7%
	Total Miles	In Areas of Mostly Landslides	% of Miles in Areas of Mostly Landslides
INFRASTRUCTURE:			
Roads	33,021	2,390	7.2%
Transit	433	9	2.1%
Rail	940	15	1.6%
Pipelines	21,851	848	3.9%
	Total Number	In Areas of Mostly Landslides	% in Areas of Mostly Landslides
CRITICAL FACILITIES:			
Health Care	840	7	0.8%
Schools	2,000	37	1.9%
Bridges	4,158	195	4.7%
Water Facilities	2,095	231	11.0%
Wastewater Facilities	338	2	0.6%
Cities & Counties	4,236	117	2.8%

See http://quake.abag.ca.gov/mitigation/pickdbh2.html and http://quake.abag.ca.gov/pickcrit.html for more specific information.

- The exposure of pipelines and roads to landslide hazards is greatest in Marin County, where **15.7%** of the pipelines and **18.3%** of the roads are in these areas of existing landslides.

These percentages are based on information in ***Table 15: Existing Landslide Areas and Existing Land Use***. See Plate 46 and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Existing landslide areas and existing critical facilities –

- Of the **840** critical health care facilities in the Bay Area, only **0.8%** are in areas mapped as mostly landslides on the existing landslide map.
- Of the **2,000** public schools in the Bay Area, only **1.9%** are in areas mapped as mostly landslides on the existing landslide map.
- Of the **6,669** critical facilities owned by cities, counties, and other special districts in the Bay Area, **5.2%** are in areas mapped as mostly landslides on the existing landslide map.

These percentages are based on information in ***Table 15: Existing Landslide Areas and Existing Land Use***. See Plate 46 and http://quake.abag.ca.gov/mitigation/pickcrit.html, for more specific information for individual counties and cities.

Past landslide losses as an indicator of future vulnerability –

Losses from landslides are typically lower than associated flooding. However, in the El Nino storms of early 1998, USGS documented approximately $150 million in losses due to approximately 300 landslides that occurred in the Bay Area and Santa Cruz County[13]. The landslides ranged in size from a 25 m^3 failure of engineered material to a reactivation of the massive (13 million m^3) Mission Peak earthflow complex in Alameda County.

[13] Godt, J.W. , ed., 1999. "Introduction" in ***Maps Showing Locations of Damaging Landslides Caused by El Nino Rainstorms, Winter Season1997-98, San Francisco Bay Region, California***: U.S. Geological Survey Misc. Field Studies Map MF 2325-A-J: Reston, VA. See http://pubs.usgs.gov/mf/1999/mf-2325/.

Wildfire

Wildfire probabilities, location, and extent

Just as weather can result in too much water, the Bay Area's weather can result in too little water. One of the resulting hazards is ***wildfire***. CalFIRE has developed several maps depicting wildfire hazard areas. The two most useful maps are those depicting Wildland Urban Interface (WUI) wildfire threat (***Plate 47***) and wildfire threat from wildland fuels in State Responsibility Areas (***Plate 48***). Additional maps include a map of perimeters of past large fires (300 acre minimum for CDF fires since 1950 and 10 acre minimum for USFS fires since 1878 (***Plate 49***), a map of fire-related risks to ecosystem health as measured by condition class (***Plate 50***), a map of the distribution of wildland-urban-interface housing unit density (***Plate 51***), and a map of post-fire risk of increased surface erosion (***Plate 52***). More detailed maps for individual local governments and additional wildfire hazard information are available on line at http://quake.abag.ca.gov/wildfire.

Using a combination of the map of past wildfires (Plate 49) in combination with the fire threat maps (Plates 47 and 48), a table of the probability of an area burning in the next 130 years could be calculated. Based on an analysis of data on wildfires during the past 130 years, only **0.24%** of the areas mapped as an extreme wildfire threat have burned, **22.8%** of those mapped as very high, and **18.5%** of those mapped as high. In addition, **4.5%** of the areas in wildland-urban-interface fire threat areas have burned.[14] Thus, the probability of the areas mapped as very high hazard on the wildfire threat has ***traditionally*** been much greater than those mapped on the wildland-urban-interface fire threat map. On the other hand, the wildland-urban-interface fire threat map shows more urban areas with a greater potential property value and high fuel loads. In addition, the number of fires, and the size of those fires, has been increasing over time. More specific results of this analysis are shown in ***Table 16***, below.

TABLE 16 – Estimate of Probability of Fire Affecting a Given Area Based on Data from Past 50 Years

Threat Category	Acres Burned from 1878 through 2008	Total Number of Acres Within Threat Classification	Percent of Acres That Burned in Past 130-Year Period
On Wildfire Threat Map			
Moderate	41,651	1,300,662	3.20%
High	218,947	1,183,899	18.49%
Very High	306,264	1,344,664	22.78%
Extreme	5	2,272	0.24%
On Wildland Urban Interface Fire Threat Map			
WUI Acres	37,037	819,317	4.52%

[14] Source – Data from analysis of California Department of Forestry maps at http://www.abag.ca.gov/bayarea/eqmaps/wildfire/. (Also see Table 5.)

TABLE 17 – SUPPLEMENTARY INFORMATION FOR PLATES 47 and 48: Wildland-Urban-Interface (WUI) Fire Threatened Communities and Fire Threat in the San Francisco Bay Region Map

Using a combination of the map of past wildfires (***Plate 49***) in combination with the fire threat maps (***Plates 47 and 48***), a table of the probability of an area burning in the next 50 years can be calculated. The results are shown in the following table and in Table 7 of Appendix C.

Susceptibility Value on Map	Acres Burned in Past 50 Years	Total Number of Acres Within Threat Classification	Percent of Acres That Burned in Past 50-Year Period
ON WUI MAP			
WUI Community at Risk	37,037	819,317	4.52%
ON FIRE THREAT MAP			
Extreme Fire Threat	5	2,272	0.24%
Very High Fire Threat	306,264	1,344,664	22.78%
High Fire Threat	218,947	1,183,899	18.49%
Moderate Fire Threat	41,651	1,300,662	3.20%

TABLE 18 – SUPPLEMENTARY INFORMATION FOR PLATE 51: Fire-Related Risks to Ecosystem Health as Measured by Condition Class

	Low Condition Class 1	**Moderate Condition Class 2**	**High Condition Class 3**
Departure From Natural Regimes	None, minimal	Moderate	High
Vegetation Composition, Structure, Fuels	Similar	Moderately altered	Significantly different
Fire Behavior, Severity, Pattern	Similar	Uncharacteristic	Highly uncharacteristic
Disturbance Agents, Native Species, Hydrologic Functions	Within natural range of variation	Outside historical range of variation	Substantially outside historical range of variation
Increased Smoke Production	Low	Moderate	High

SUPPLEMENTARY INFORMATION FOR PLATE 52: Post-Wildfire Soil Erosion Potential

The State of California Multi-Hazard Mitigation Plan references this map. This State Plan provides the following as explanatory material.

> The effects of fire on soil resources are dependent on the intensity of the fire and are induced by soil heating and by removal of the protective cover of vegetation, litter, and duff. The magnitude of soil heating depends on fuel loading, fuel moisture content, fuel distribution, rate of combustion, soil texture, soil moisture content, and other factors. The movement of heat into the soil depends upon the peak temperature of the fire and how long the heat is present. Because fuels are not evenly distributed around a site, a single fire will cause varying levels of soil heating. The highest soil temperatures occur where fuel consumption is greatest and where the duration of burning is longest. Fires in forested areas often cause high soil temperatures due to heavy fuel accumulation. In contrast, rangelands fires are often shorter in duration and cause less soil heating because of their comparatively light fuel load.
>
> FRAP [Fire and Resource Assessment of the California Department of Forestry] used a modified form of the universal soil loss equation to predict potential soil loss from fire across California. The model characterizes the influence of vegetation and other environmental factors on soil erosion using inputs such as soil and precipitation data, topography, and vegetation cover. The main determining factor in predicting potential soil loss is changes to vegetation cover resulting from fire. These changes approximate the increase in surface erosion from future wildfire burning under both current fuel conditions and severe fire weather.

Past occurrences of Bay Area wildfire-related disasters

Wildfires were common disasters in the Bay Area during the period from 1950 to 2009. Large wildfires occurred in 1961, 1962, 1964, 1965, 1970, 1981, 1985, 1988, 1991, and 2008. The largest urban-wildland fire in the Bay Area, the 1991 fire in the East Bay Hills, resulted in $1.7 billion in losses. In that fire, 3,354 family dwellings and 456 apartments were destroyed, while 25 people were killed and 150 people were injured.

See Appendix D and http://quake.abag.ca.gov/mitigation/disaster-history.html for more specific information.

Exposure and vulnerability of the Bay Area to wildfire-related disasters

Based on an examination of the Wildfire-Urban-Interface fire threat map, it is likely that it is radically overestimating the risk to communities on saturated ground near the Bay such as Foster City and the City of Alameda. In 2005, CalFIRE indicated that the maps would be updated to correct this problem. As of December 2009, this change has still not occurred.

One method of assessing vulnerability is to examine existing land uses in mapped hazard areas.

Wildfire and exposure of existing land use –

- Of the 4.39 million acres of land in the Bay Area, **18.5%** is in Wildland Urban Interface (WUI) wildfire threat areas, while **57.1%** is in the high, very high, or extreme wildfire threat areas in State Responsibility Areas (SRAs).

TABLE 19 – Wildfire Hazard and Existing (2005) Land Use

	Total Acres	Wildland Urban Interface Wildfire Threat	High, Very High, or Extreme Wildfire Threat Areas	% of Land in Wildland Urban Interface Wildfire Threat Area	% of Land in High, Very High, or Extreme Wildfire Threat Area
Total	4,387,602	811,634	2,503,779	18.5%	57.1%
Urban	1,139,000	552,159	234,010	48.5%	20.5%
Non-Urban	3,248,602	259,475	2,269,769	8.0%	69.9%
URBAN ONLY:					
Residential	555,463	323,838	127,576	58.3%	23.0%
Mixed R+C	1,775	888	29	50.0%	1.6%
Commercial/ Services	110,502	44,011	11,040	39.8%	10.0%
Mixed C+I	3,344	993	223	29.7%	6.7%
Industrial	72,125	20,544	8,927	28.5%	12.4%
Military	30,549	7,280	7,374	23.8%	24.1%
Infrastructure	205,807	89,016	21,969	43.3%	10.7%
Urban Open	159,435	65,590	56,867	41.1%	35.7%
URBAN ONLY:					
Alameda	180,056	77,727	21,963	43.2%	12.2%
Contra Costa	184,775	118,828	32,108	64.3%	17.4%
Marin	54,146	40,256	12,469	74.3%	23.0%
Napa	35,727	15,564	11,154	43.6%	31.2%
San Francisco	29,273	13,780	656	47.1%	2.2%
San Mateo	104,530	55,980	17,000	53.6%	16.3%
Santa Clara	221,865	91,768	22,194	41.4%	10.0%
Solano	100,720	33,239	14,283	33.0%	14.2%
Sonoma	227,908	105,017	102,181	46.1%	44.8%
	Total Miles	Wildland Urban Interface Wildfire Threat	High, Very High, or Extreme Wildfire Threat Areas	% of Miles in Wildland Urban Interface Wildfire Threat Area	% of Miles in High, Very High, or Extreme Wildfire Threat Area
INFRASTRUCTURE:					
Roads	33,021	14,798	5,407	44.8%	16.4%
Transit	433	123	24	28.4%	5.5%
Rail	940	264	82	28.1%	8.7%
Pipelines	21,851	11,172	1,301	51.1%	6.0%
	Total Number	Wildland Urban Interface Wildfire Threat	High, Very High, or Extreme Wildfire Threat Areas	% in Wildland Urban Interface Wildfire Threat Area	% in High, Very High, or Extreme Wildfire Threat Area
CRITICAL FACILITIES:					
Health Care	840	322	5	38.3%	0.6%
Schools	2,000	947	58	47.4%	2.9%
Bridges	4,158	1,632	480	39.2%	11.5%
Water Facilities	2,095	1,400	307	66.8%	14.7%
Wastewater Facilities	338	150	5	44.4%	1.5%
Cities & Counties	4,236	1,944	144	45.9%	3.4%

See http://quake.abag.ca.gov/mitigation/pickdbh2.html and http://quake.abag.ca.gov/pickcrit.html for more specific information.

- **48.5%** of the urban land is in the WUI wildfire threat areas, versus **8%** of the non-urban land. On the other hand, **20.5%** of the urban land is in the SRA high, very high, or extreme wildfire threat areas, versus **69.9%** of the non-urban land. This discrepancy is to be expected because the State focuses on non-urban areas.
- Types of existing urban land uses with the highest percentages in WUI wildfire threat areas are residential (**58.3%**), mixed residential-commercial (**50%**), infrastructure use (**43.3%**), and urban open (**41.1%**).
- Of the 552,159 acres of urban land in these WUI wildfire threat areas, **58.6%** is residential use.
- The percentage of urban land located in WUI wildfire threat areas ranged from a high of **74.3%** in Marin County and **64.3%** in Contra Costa County to a low of **33%** in Solano County.

These percentages are based on information in ***Table 19: Wildfire Hazards and Existing Land Use***. See Plates 47 and 48, as well as http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Wildfire and exposure of existing infrastructure –

- While **44.8%** of the region's roads are in WUI wildfire threat areas, only **28.4%** of the transit lines only **28.1%** of the rail are in these areas. (**25.5%** of ACE, **21%** of Amtrak, **38.6%** of BART, **32.5%** of Caltrain, **32.4%** of SF MTA (MUNI), and **19%** of the VTA lines, are in wildland-urban-interface fire threat areas.)
- While **16.4%** of the region's roads are in areas mapped as having high, very high, or extreme wildfire threat, only **5.5%** of the transit lines and **8.7%** of the rail lines are in these areas.
- **12.7%** of ACE, **0.8%** of Amtrak, **3%** of BART, **none** of Caltrain, **none** of SF MTA (MUNI), and **none** of the VTA lines, are in areas of very high or extreme wildfire threat.
- Data on pipelines, though provided, is not particularly relevant because underground pipelines are not particularly vulnerable to damage from wildfires.

These percentages are based on information in ***Table 19: Wildfire Hazards and Existing Land Use***. See Plates 47 and 48, as well as http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Wildfire and exposure of existing critical facilities –

- Of the **840** critical health care facilities in the Bay Area, **38.3%** are in WUI wildfire threat areas, while only **0.6%** are in areas mapped as having high, very high, or extreme wildfire threat.
- Of the **2,000** public schools in the Bay Area, **47.4%** are in WUI wildfire threat areas, while **2.9%** are in areas mapped as having high, very high, or extreme wildfire threat.
- Of the **6,669** critical facilities owned by cities, counties, and other special districts in the Bay Area, **52.4%** are in WUI wildfire threat areas, while **6.8%** are in areas mapped as having high, very high, or extreme wildfire threat.
- These statistics point to the need to ensure that basic fire mitigation measures are undertaken for these exposed facilities.

These percentages are based on information in ***Table 19: Wildfire Hazards and Existing Land Use***. See Plates 47 and 48, as well as http://quake.abag.ca.gov/mitigation/pickcrit.html, for more specific information for individual counties and cities.

Past wildfire losses as an indicator of future vulnerability –

The largest urban-wildland fire in the Bay Area, the 1991 fire in the East Bay Hills, resulted in $1.7 billion in losses. In that fire, 3,354 family dwellings and 456 apartments were destroyed, while 25 people were killed and 150 people were injured. While in the 2005 MJ-LHMP, it was assumed that it was is unlikely that any single fire disaster in the Bay Area would exceed that fire in total losses, that assumption can no longer be made. A combination of increasing property values in wildfire areas, increasing fuel, and climate change all contribute to this change. However, these losses are many times smaller and more localized than that anticipated from a disastrous earthquake.

Drought

Drought probabilities, location, and extent

What would be a ***drought*** in other areas of the country is controlled in the Bay Area through the importation of water and the storage of water in reservoirs. Prolonged periods of drought cause additional drought-related problems, including crop losses and shortages of water for landscaping.

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

There is also no current data on the probability of drought that would be comparable to the USGS effort on earthquakes in the region, or the way 100-year flood maps are created. Such an effort has been promoted by the Western Governors' Association as part of a National Integrated Drought Information System in a 2004 report, ***Creating a Drought Early Warning System for the 21st Century***. In that report, WGA notes, "Droughts are as much a part of the weather and climate extremes as floods, hurricanes and tornadoes. Yet in marked contrast to the myriad federal programs that report, prevent and mitigate the damage of these other extreme events, we passively accept drought's effects as an unavoidable natural hardship. This passive approach to droughts is manifested in our lack of a comprehensive federal drought policy: we respond to droughts through ad hoc, crisis management, rather than through proactive, coordinated strategies designed to mitigate the impacts. To address other natural disasters — floods, hurricanes, tornadoes, etc. — Congress enacted the Stafford Act, which gives clear roles and responsibilities to the various federal agencies and makes the Federal Emergency Management Agency (FEMA) the federal lead." Thus, while long-term drought probabilities are not yet available, annual monitoring has started. See http://www.westgov.org/wga/publicat/nidis.pdf and http://www.drought.unl.edu/dm/monitor.html for more information. The lead federal agency proposed for this effort is the U.S. Department of Agriculture.

The list of mitigation strategies includes several relating to ways in which local governments can help efforts to increase the knowledge of this hazard and/or plan for its impacts, particularly INFR a-13, GOVT c-23, GOVT-d-10, ENVI-a-3, and ENVI-b-1.

Past occurrences of Bay Area drought-related disasters

Major droughts were in 1973, 1976, and 2009. Climate change is likely to increase the number and severity of future droughts. The magnitude of this change is currently unknown.

See Appendix D and http://quake.abag.ca.gov/mitigation/disaster-history.html for more specific information.

Exposure and vulnerability of the Bay Area to drought-related disasters

All of the 4.39 million acres of land in the Bay Area is subject to drought.

The report on ***Hetch-Hetchy Water and the Bay Area Economy*** discussed earlier hints at the importance of water to the region and the potential impacts of drought and population growth. That report notes on page 5 that:

> Based on conditions during the most recent drought period, SFPUC now has determined that the maximum quantity of water it can reliably deliver to its customer base is 239 mgd annually. However, actual demand in 2000-2001 was nearly 260 mgd, and it is generally understood that the SFPUC system is operating in excess of its assured supply capacity and approaching its actual delivery capacity.
>
> Total demand for Hetch Hetchy water is expected to grow to 303 mgd in 2030 and 310 mgd by 2050. Absent a significant expansion of the system, the shortfall relative to assured supply will therefore increase from 21 mgd presently to 64 mgd within 30 years and 71mgd within 50 years.

Most Bay Area water districts develop long-term water supply and management plans, including urban water shortage contingency analyses. ABAG will be working with water districts and others on this issue, as specified in the ABAG Annex, Mitigation Strategy INFR-d-4, ENVI-a-4 and ENVI-a-5.

The ***Executive Summary*** of the ***Integrated Regional Water Management Plan for the San Francisco Bay Area*** states that "the San Francisco Bay Area water, wastewater, flood protection and stormwater management agencies; cities and counties represented by the Association of Bay Area Governments (ABAG); and watershed management interests represented by the California Coastal Conservancy (CCC) and non-governmental environmental organizations signed a Letter of Mutual Understandings (LOMU) to develop an Integrated Regional Water Management Plan (IRWMP) for the San Francisco Bay Area."

According to that BA-IRWMP, "**the Bay Area's existing annual supplies are inadequate to meet projected demands during prolonged drought periods. As the population continues to grow - the gap between available supplies and customer demand will widen in the coming decades unless agencies have the resources to fully implement necessary actions. …** Historically, conservation measures have proven to be effective at controlling Bay Area water use. Overall water use has only increased 1% since 1986 – despite a 23% increase in population.**"**

Finally, the BA-IRWMP notes, "Many sources of supply for the Bay Area are limited in dry years. If the Bay Area experiences another multi-year drought similar to that of the 1987-1992 drought, the following supply reductions are expected for the region:

- 60% reduction in [State Water Project] SWP supplies
- 25% reduction in [Central Valley Project] CVP supplies
- 30% reduction in Tuolumne supplies [source of SF PUC supply]
- 40% reduction in Mokelumne supplies [source of EBMUD water supply]
- 50% +/- reduction in local supplies"

The IRWMP can be accessed at http://bairwmp.org/plan/bay-area-irwmp-document-1.

Dam Failure

Dam failure probabilities, location, and extent

Dams are critical for two reasons: (1) their catastrophic failure can kill many people and destroy homes and other structures downstream from the facility, and (2) the storage capacity is lost and not recovered until the dam is rebuilt (a lengthy process).

Dams built to hold the water in reservoirs can be damaged, due to a huge storm and associated runoff, an earthquake, or a terrorism event. Maps depicting the areas that might be inundated were prepared by the dam owners. These maps have been generalized into a single regional map (***Plate 53***). More detailed maps for individual local governments and additional dam failure hazard information are available on line at http://www.abag.ca.gov/bayarea/eqmaps/damfailure/damfail.html.

No quantitative probability information exists for the Bay Area dam failure hazard, in part because when a dam in known to have a failure potential, the water level is reduced to allow for partial collapse without loss of water as required by the State Division of Safety of Dams and by safety protocols established by dam owners. All Bay Area dams have a lower probability for failure than established as a minimum standard by the Division of Safety of Dams. For example, the SF PUC is currently operating Calaveras Reservoir at less than 30% of capacity to avoid a catastrophic release of water. Thus, the probability of failure resulting in damage is approaching zero.

Past occurrences of Bay Area dam failures

While dams have failed elsewhere, a dam has never failed in the Bay Area.

Exposure and vulnerability of the Bay Area to dam-failure disasters

As with the tsunami evacuation planning maps, the dam failure maps are evacuation planning maps. However, in this case, it may be useful to provide exposure information as one way of evaluating the benefits of having safe dams. Reducing the vulnerability of the region to dam failure continues to be an extremely high priority of the dam owners, as described in Chapter 1-Infrastructure.

Dam failure inundation areas and exposure of existing land use –

- Of the 4.39 million acres of land in the Bay Area, **10.8%** are in areas mapped as dam failure inundation areas.
- **18.1%** of the urban land is in these dam failure inundation areas, versus only **8.2%** of the non-urban land.
- Types of existing urban land uses with the highest percentages in these dam failure inundation areas are mixed commercial-industrial complexes (**31.3%**) and industrial use (**30.1%**).
- Of the 206,593 acres of urban land in these dam failure inundation areas, **38.1%** is residential use.

- The percentage of urban land located in these dam failure inundation areas ranged from a high of approximately **32%** in Alameda and Santa Clara counties to lows of **4.6%** in Marin County and **6.1%** in San Francisco.

These percentages are based on information in ***Table 20: Dam Failure Inundation Areas and Existing Land Use***. See Plate 53 and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Dam failure inundation areas and exposure of existing infrastructure –

- **32.2%** of the miles of rail and **40.4%** of transit lines in the region are in areas mapped as dam failure inundation areas.
- **63.6%** of ACE, **45.4%** of Amtrak, **17.8%** of BART, **51.9%** of Caltrain, **8.1%** of SF MTA (MUNI), and **59.5%** of the VTA lines are in these areas.
- On the other hand, **19.4%** of the roads and **20.8%** of the pipelines are in these areas.

These percentages are based on information in ***Table 20: Dam Failure Inundation Areas and Existing Land Use***. See Plate 53 and http://quake.abag.ca.gov/mitigation/pickdbh2.html for more specific information for individual counties and cities.

Dam failure inundation areas and exposure of existing critical facilities –

- Of the **840** critical health care facilities in the Bay Area, **25.2%** are in areas mapped as dam failure inundation areas.
- Of the **2,000** public schools in the Bay Area, **20.7%** are in areas mapped as dam failure inundation areas.
- Of the **6,669** critical facilities owned by cities, counties, and other special districts in the Bay Area, **23%** are in areas mapped as dam failure inundation areas.

These percentages are based on information in ***Table 20: Dam Failure Inundation Areas and Existing Land Use***. See Plate 53 and http://quake.abag.ca.gov/mitigation/pickcrit.html, for more specific information for individual counties and cities.

These high exposures point to the need to ensure the safety of dams in the region. Existing state and federal laws and requirements should be followed.

Dam owners and operators, under the regulation of the State Division of **Safety of Dams**, routinely inspect their facilities and reevaluate their safety in light of current engineering and seismology. Based on these assessments, EBMUD is retrofitting San Pablo Dam and Reservoir at a cost of $75 million dollars. The San Francisco PUC Calaveras Dam Replacement Project has an estimated total cost of $409 million dollars.

The potential direct property losses from catastrophic failure of these dams are enormous. The 2005 value of the property improvements in the San Pablo Dam inundation area alone is $**1.9 billion.** The 2005 value of the property improvements in the Calaveras Reservoir inundation area is **$15.6 billion.** In one respect, this loss underestimates the potential loss. Since a dam is most likely to fail as a result of ground shaking from a catastrophic earthquake, the combined impact of the two events, as noted in the section on infrastructure interdependencies, will be greater than the individual impact of either disaster on its own. On the other hand, the losses will be minimal when the inundation depth is small (keeping in mind that, due to velocity, losses will

exceed that of a “typical” flood to the same depth). However, due to the age of these maps, no reliable inundation depth information is available and thus this analysis could not be completed in a quantitative manner.

TABLE 20 – Dam Failure Inundation Areas and Existing (2005) Land Use

	Total Acres	In Dam Inundation Area	% of Land in Dam Inundation Area
Total	4,387,602	474,350	10.8%
Urban	1,139,000	206,593	18.1%
Non-Urban	3,248,602	267,757	8.2%
URBAN ONLY:			
Residential	555,463	78,652	14.2%
Mixed R+C	1,775	206	11.6%
Commercial/ Services	110,502	27,842	25.2%
Mixed C+I	3,344	1,046	31.3%
Industrial	72,125	21,726	30.1%
Military	30,549	1,521	5.0%
Infrastructure	205,807	45,177	22.0%
Urban Open	159,435	30,422	19.1%
URBAN ONLY:			
Alameda	180,056	56,653	31.5%
Contra Costa	184,775	18,232	9.9%
Marin	54,146	2,516	4.6%
Napa	35,727	7,549	21.1%
San Francisco	29,273	1,773	6.1%
San Mateo	104,530	9,600	9.2%
Santa Clara	221,865	70,317	31.7%
Solano	100,720	16,840	16.7%
Sonoma	227,908	23,113	10.1%
	Total Miles	In Dam Inundation Area	% of Miles in Dam Inundation Area
INFRASTRUCTURE:			
Roads	33,021	6,422	19.4%
Transit	433	175	40.4%
Rail	940	303	32.2%
Pipelines	21,851	4,556	20.8%
	Total Number	In Dam Inundation Area	% in Dam Inundation Area
CRITICAL FACILITIES:			
Health Care	840	212	25.2%
Schools	2,000	414	20.7%
Bridges	4,158	1,214	29.2%
Water Facilities	2,095	425	20.3%
Wastewater Facilities	338	103	30.5%
Cities & Counties	4,236	1,006	23.7%

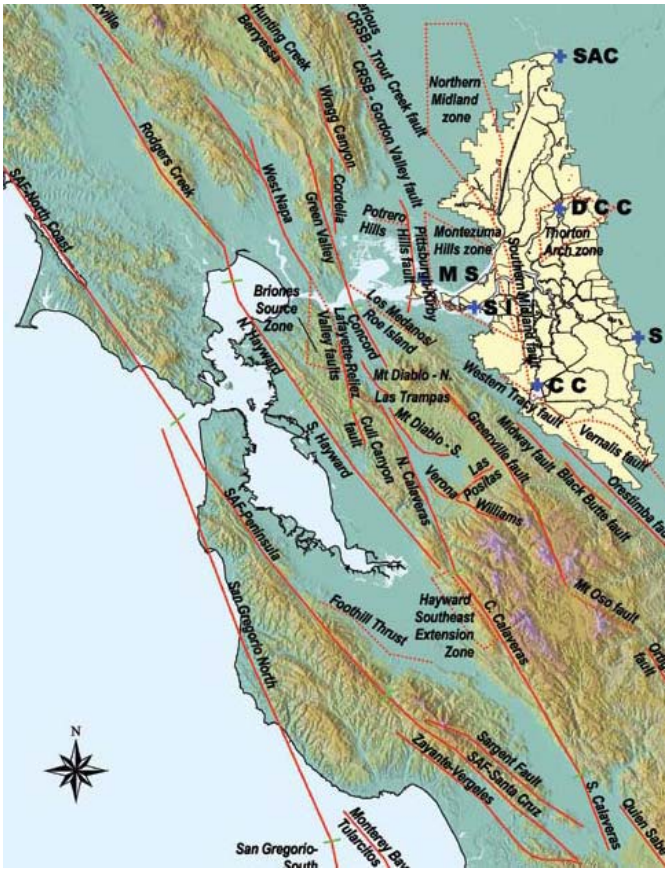
See http://quake.abag.ca.gov/mitigation/pickdbh2.html and http://quake.abag.ca.gov/pickcrit.html for more specific information.

Delta Levee Failure

Delta levee failure probabilities, location, and extent

The probability of levee failure is increasing over time, and is related to sea level rise, climate change impacting the likelihood that rapid snowmelt from a warm late-winter storm would cause flooding, and earthquake probabilities. Some researchers have estimated the likelihood of a multiple levee failure disaster at about 2% per year.

The DRMS performed a time-dependent Probabilistic Seismic Hazard Analysis (PSHA) that identified likely ground motions at six different locations (shown on Figure 1) around the Delta and their likely recurrence rate at selected times over the next 200 years. The study evaluated all faults that could impact the Delta including major Bay Area faults, Delta seismic sources, Coastal Ranges-Sierran Block (CRSB) boundary source zone, Cascadia subduction source zone, and background seismicity (shown on this Figure).



Figure; Faults and Seismic Sources in the Delta Region (DRMS 2008, Figure 6-1)

While Bay Area faults, including San Andreas, Hayward and Calaveras faults, are well characterized, little is known about the local faults in the Delta. The Delta faults have only exhibited a low-level pattern of scattered small earthquakes since 1966, but are still believed to be capable of moderate to strong earthquakes (M>6.0). There is no record of M>5.0 earthquakes on Delta faults, but based on geologic formations likely caused by earthquakes and subsurface seismic data, it is believed that earthquakes on these faults occur every couple thousand years.

Similarly, seismic activity is inferred in the CRSB boundary source zone and it is believed that a magnitude 6.5 earthquake is still possible in this zone.

Much of the land in the Delta Region is below sea level and is protected by approximately 1,115 miles of levees in the Delta and 230 miles of levees in the Suisun Marsh. The majority of these levees started out 3 to 5 feet high and were constructed and maintained by local landowners in the last 130 years to protect farm land from flooding inundation. As a result of land subsidence, sea level rise and increased demand for land in the delta, these levees have been raised and

increased in length over the years. Today most of these levees retain water 365 days a year, and carry additional loads during flood events.

An earthquake is the single biggest risk the Delta Region faces. If an earthquake occurs, levees may fail and as many as 20 or more islands may be flooded instantaneously. This would result in an economic impact of $15 billion or more.

Risk reduction strategies to prevent catastrophic failure were not explored in DRMS Phase 1, but they will be the focus of Phase 2 of the study, due to be completed in 2009.

The Delta has become integral to our economic and environmental sustainability. In 2005, Assembly Bill 1200 required the Department of Water Resources (DWR) to evaluate the potential impact on Delta water supplies from a variety of hazards. Phase 1 of the Delta Risk Management Strategy (DRMS) was completed in 2008 in response to AB 1200 with the objective of determining whether current business-as-usual management and regulatory practices can sustain the Delta Region for the next 100 years.

DRMS focused on evaluating the hazards of subsidence, earthquakes, floods, changes in precipitation, temperature and ocean levels, and a combination of these hazards.

Identifying the Seismic Hazard –

The results of the PSHA indicate that Delta faults contribute most significantly to the hazard at longer return periods, and will produce stronger shaking due to their proximity to the levees. The major Bay Area faults, however, pose a greater risk to the Delta levees. While they are farther away and will produce smaller ground motions at Delta sites, earthquakes occur much more frequently on these faults. The Hayward fault in particular is a great risk to the Delta because it is closer than the San Andreas fault and is capable of producing very large earthquakes. Shaking will be strongest in the western delta and decrease to the east due to increasing distance from the Bay Area faults.

While the ground shaking in the delta will be relatively small from a Hayward fault event, the soils in the western delta are extremely weak and liquefaction will trigger at even low levels of shaking (personal communication, Chuck Real, July 29, 2009). This section of the delta is saturated by water nearly to the surface and is composed of very loose sands down to about 70 feet below ground surface. Because the peat that overlays the sand is extremely light, these sands have never been compressed under the weight of the soils above them. These conditions make the soil extremely susceptible to liquefaction.

The following table depicts the ground motions that are likely to occur at the six study locations in the Delta (Figure 1) at various return periods from all seismic sources.

TABLE 21 – Ground Motions for Return Periods of 100 to 2,500 Years in 2005 from all Seismic Sources (Seismology TM 2007, Table 5)

	Peak Ground Acceleration (g's)			
Delta Site	100 yrs	200 yrs	500 yrs	2,500 yrs
Clifton Court	0.22	0.29	0.40	0.66
Delta Cross Channel	0.15	0.19	0.25	0.37
Montezuma Slough	0.27	0.35	0.47	0.74
Sacramento	0.12	0.15	0.20	0.30
Sherman Is.	0.24	0.31	0.41	0.64
Stockton	0.13	0.17	0.22	0.32

The DRMS study also evaluated the hazard without considering Delta faults and found only a small reduction in potential ground motion over shorter return periods, further illustrating the importance of the Bay Area faults to the hazard in the Delta.

Figure 4 at the end of this document related the seismic vulnerability of individual levees to ground shaking of 0.3g. It does not indicate whether ground motion less than 0.3g is sufficient to cause liquefaction.

Past occurrences of Bay Area Delta levee disasters

While levees of Delta islands fail frequently, these occurrences typically are not on islands within the nine-county San Francisco Bay Area. Even with the Jones Tract levee failure, the island was not within the region. However, this failure almost caused the subsequent loss of both Mokelumne Aqueducts of East Bay MUD. Such occurrences are expected to occur more frequently based on an assessment of the Delta Risk Management Study (DRMS) and other researches. See Appendix D and http://quake.abag.ca.gov/mitigation/disaster-history.html for more specific information on the Jones Tract failure.

Exposure and vulnerability of the Bay Area to Delta levee disasters

The Sacramento-San Joaquin River Delta and Suisun Marsh are vitally important to the Bay Area economy and environment. The region contains highly fertile agricultural land and provides a unique habitat to many estuarine animals. The Delta region contains critical infrastructure including pipelines, highways, and power and communication lines. The Delta is the hub of the California water system, providing water to 25 million people in the State and 3 million acres of farm.

2005 Present Day Seismic Risk –

When an earthquake occurs, all Delta levees may be subject to ground shaking and potential failure simultaneously. If an earthquake is strong enough to cause the failure of one levee, it is

likely that other levees with the same or higher vulnerability will also fail. It only takes the failure of one section of levee to flood an island. Levees to the west are more likely to fail where shaking is stronger than to the east.

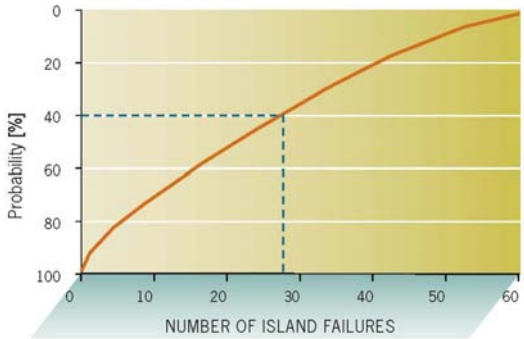


Figure: Probability of exceeding a number of simultaneous islands flooding due to earthquake events over a 25-year period [2005-2030] (DRMS 2008)

The seismicity of the Delta Region is characterized as moderate to high as a result of the active Bay Area faults. The USGS predicts a 62% chance that a magnitude 6.7 or greater earthquake will occur in the Bay Area in the next 30 years.

A simulated 7.2 earthquake on the Hayward fault is estimated to cause a mean number of 50 levee failures. This scenario does not account for the range in possible magnitudes, the various fault segments that could potentially rupture or the possible distances from the epicenter to the Delta. In addition, an earthquake that ruptures to the north or south and moves towards the Delta will be more devastating than an event that ruptures in the middle of the fault and travels north and south, because of the build up of energy in the direction of wave travel. An earthquake on the Hayward fault has other implications for the region because it will also be widely damaging to the Bay Area, reducing our ability to respond to levee damage in the Delta.

2005 Present Day Seismic Consequences –

The consequences of multiple levee failures as the result of an earthquake will be widespread and will impact every sector that relies on the Delta.

Public Health Consequences. The primary public safety concern is potential loss of life on flooded islands as a result of an earthquake. Approximately 10 fatalities can be expected every 100 years on average as a result of an earthquake. Impact on water quality was not specifically analyzed in the DRMS report.

Emergency Response and Levee Repair.
The following table depicts expected time to repair and dewater levee breaches.

Table 22 – Duration and Cost of Repair and Dewatering for Seismic Cases (DRMS 2008, Table 13-9)

No. of Flooded Islands	Estimated range of cost of repair and dewatering ($M)	Estimated range of time to repair and dewater (days)
1	43 – 24	136 – 276
3	204 – 49	270 – 466
10	620 – 1,260	460 – 700
20	1,400 – 2,300	750 – 1,020
30	3,000 – 4,200	1,240 – 1,660

*the range is provided for +/- one standard deviation of the mean

Export Disruption. Repair to damaged levees could take years following a major earthquake. When the levees fail, salt water from the Bay will flow back into the Delta to fill the voids left open by the damaged levees. Drinking water that is normally pumped from the Delta will be too saline for safe consumption and export of fresh water will be disrupted for a period of time until all the levees are repaired and sufficient fresh water can released from upstream to flush out the salt water. If 20 islands were flooded as a result of a major earthquake (~55% probability in the next 25 years), export of fresh water from the Delta could be interrupted for about a year and a half. Contra Costa Water District is particularly as risk because they lack alternative sources of drinking water outside of the Delta.

Economic Consequences. When multiple levees fail in the Delta, the cost will be borne by the entire state. In the DRMS study, the economic consequences are quantified in terms of the economic cost (net costs to the state economy) and economic impacts (value of lost output, lost jobs, lost labor income, lost value income and indirect business taxes). The DRMS study indicates that due to an earthquake economic costs will exceed $20 billion and economic impacts will exceed $12 billion once every 90 years on average. The economic consequences will depend primarily on number of flooded islands, which islands have flooded, and the month in which the initiating event occurs. **ABAG estimates** the 2005 value of property improvements on the Delta islands within Contra Costa County as **$1.4 billion,** and the 2005 value of the property itself as **$1.1 billion** – far less than the potential economic impact of loss of the water supply.

Ecological Consequences. For breach scenarios involving less than 10 breaches, a very small percentage of the total area of the vegetation types in the Delta are impacted. For breach scenarios with 20 breaches, greater losses are incurred for a vegetation types. Large numbers of delta breaches would also have significant impact on terrestrial wildlife because available habitat would be severely reduced.

Increasing Future Risks and Consequences –

As the Delta moves ahead from 2005, several factors will drive changes that will affect the seismic vulnerability of the Delta. These include seismic activity, climate change, subsidence, and population growth and urbanization.

Seismicity. The Bay Area has experienced a period of relatively low seismic activity since the 1906 San Francisco earthquake. As stress continues to build in the earth, we may experience greater seismic activity in the region in the near future. The DRMS study assumes that seismic activity will increase by 10% in 2050, 20% in 2100 and 40% in 2200.

Climate Change. Rising sea levels as a result of global warming produce higher water levels on Delta levees as well as increase internal seepage, both of which will increase the probability that an earthquake will fail the levee. Warmer temperatures will also mean that more winter precipitation falls as rain rather than snow and more runoff will flow into the Delta earlier, adding to the demand on the levees. This study assumed that the levees would be raised to accommodate higher water, but does not assume any strengthening of the levees. Projections estimate that sea-levels will rise between 4 and 16 inches by 2050 and 8 inches and 4.6 feet in 2100.

Subsidence. The ground surface in areas of the Delta-Suisun that have peat soils are expected to continue subsiding if current management practices do not change. Projections for total subsidence are up to 3 feet by 2050, 8 feet by 2100 and 17 feet by 2200, varying across the delta depending on the thickness of the organic layer. These scenarios place additional load on Delta levees as the height of water being held by the levee increases. Seepage through some of the levees will increase due to this additional load, making levees more vulnerable to earthquake loads.

Population Growth and Urbanization. Forecasts indicate that the population of the Delta and Suisun islands will increase by about 160% and the population of the legal Delta will increase 128% between 2000 and 2030 under current policies. This will lead to increased material assets and economic activity in the Delta and Suisun area. In addition the population of the state is expected to increase by 61% between 2005 and 2050, creating more demand for drinking water in the state and greater consequence of levee failures.

Consequences. The risks the delta faces interact with each other, compounding the consequences. Rising sea levels and continuing subsidence will mean that when levees fail, there will be a bigger void that can be filled with water. Additional salinity intrusion into the Delta will require more time and water for flushing. The combination of these two effects will increase the height of water behind levees by about 4 feet by 2050 and 10 feet by 2100.

As demand for drinking water from the Delta and the population and economy of the Delta increases, the consequences of levees failure will continue to increase in the future. In addition, increasing risks in the future mean that levee failures will occur more frequently, result in more levees failures and longer recovery times, further increasing the impact of failure. Economic losses are expected to increase by about 200 percent by 2050 and by about 500 percent by 2100.

The following table demonstrates the increased frequency of levee breaches as a result of seismic events.

Table 23 – Percent Increased Frequency of Seismic Breach Events Under BAU (DRMS 2008, Table 14-17)

Year	Low Risk Scenario	Medium Risk Scenario	High Risk Scenario
2050	28%	35%	49%
2100	68%	93%	140%

Conclusion –

The Delta levees are crucial to our state economy and drinking water system. The levees are extremely vulnerable to seismic risks. This risk is compounded when an earthquake on the Hayward fault fails levees while simultaneously causing significant damage in the Bay Area. Our ability to repair levees depends on our ability to transport goods and workers to the area. This will be difficult if transportation systems are damaged and resources become scarce. The Delta Risk Management Study (DRMS) clearly demonstrates that the levees as they are today are not sufficient to sustain the region for the next 100 years.

Other Concerns Not Addressed Directly as Part of This Plan

Heat

The Bay Area can have days that exceed 100°F. These ***heat*** waves would be more life-threatening if it were not for the common availability of air conditioning. Thus, this hazard is not dealt with directly as part of this Local Hazard Mitigation Plan. However, planning for such emergencies by transportation agencies is dealt with in INFR a-16.

Freezing

The Bay Area, particularly its crops, can be subject to extensive damage due to ***freezes***. Freezing conditions also cause die back of vegetation that can become fuel for the subsequent fire seasons. This issue has been especially problematic for the Bay Area's eucalyptus trees.

Freezing conditions caused emergency conditions in 1970, 1972, 1973, 1990, and 2007.

This hazard is not something that can be easily depicted in map form. The hazard itself can be mitigated, however. Some available strategies are included in Local Hazard Mitigation Plan when dealing with the more general wildfire hazard.

Pandemic Flu

In 2009, the H1N1 flu pandemic has been declared a disaster to facilitate federal funds for local health department activities. While a disaster, mitigation for a pandemic flu is not included in this plan. However, planning for such emergencies by transportation agencies is dealt with in HEAL c-1.

Agricultural Pests

Several of the disasters in the Bay Area in the last few decades are related to insect infestation, particularly as they relate to agricultural production. For example, Contra Costa and San Mateo counties were declared disasters in the 1981 Mediterranean fruit fly infestation, and Santa Clara County was declared disasters in the 1989 Mediterranean fruit fly infestation.

When there is an agricultural emergency, it remains necessary to comply with CEQA. In addition, the State may issue special regulations for local governments. Policies related to agriculture and aquaculture instituted by county offices of the Agricultural Commissioner and county health departments do have a role to play, as identified in the following three strategies, and include ENVI c-1, ENVI c-2, and ENVI c-3.

Summary Overview of Impacts of Natural Hazards on the Bay Area

Earthquake Impacts –

The natural disasters with the largest potential impacts on the Bay Area are earthquakes. Most of the damage is due to ground shaking, with relatively little due to liquefaction and landsliding. For example, in the Loma Prieta earthquake, only 1.6% of the $6 billion in losses could be attributed to liquefaction[15], and an even smaller percentage to landsliding. Surface fault rupture can do significant damage to infrastructure systems, depending on the earthquake. (The fault that caused the Loma Prieta earthquake, for example, did not rupture the surface, so there were no losses associated with fault rupture in that earthquake.)

The extent of the impact of earthquake disasters can best be explained using various earthquake scenario events. For example, in a magnitude 6.9 earthquake on the entire Hayward fault (extending from San Pablo Bay to the border of Alameda and Santa Clara counties), ABAG has estimated over 150,000 uninhabitable housing units and 1,700 road closures. In 2003, the FEMA-developed HAZUS software only estimated 24,000 displaced households, a factor of 6 lower than the ABAG estimates. Part of this discrepancy is due to uncertainty on the impact on wood-frame apartments with parking in the ground floor ("soft-story" apartments). HAZUS estimates the total losses for that earthquake as only $23 billion (versus actual losses of over $40 billion in the Northridge earthquake, a smaller magnitude earthquake with a less vulnerable building stock).

The Bay Area Economic Forum produced a 2002 report on the impact of this earthquake on ***Hetch-Hetchy Water and the Bay Area Economy***[16], estimating that the losses associated with failure of that system alone would be $17.2 billion. Finally, the HAZUS software predicts from 100-700 fatalities in that earthquake scenario, depending on the time of day. These estimates are difficult to evaluate, particularly because they are so tied to the vulnerability of particular systems. For example, fatalities in the BART tube alone could exceed that value if the tube were to rupture catastrophically. Obviously, the current HAZUS estimates are inadequate. Thus, as specified in the ABAG Annex to this plan, ABAG will be working to develop different ways to either refine those estimates or develop alternative ways to express losses and risk. As mentioned earlier, RMS proprietary software used to estimate residential losses produced an estimate of $90 billion given a repeat of the 1868 Hayward earthquake on the southern Hayward fault in 2008, versus an estimate of only $8 billion from the 2003 HAZUS run. This MJ-LHMP estimates that the RMS estimate is much closer to reality. See ABAG Annex mitigation strategy GOVT-e-2. Any remaining gaps in knowledge following that effort will be identified as part of that effort. The goal is for future loss estimates to be city-specific. Interestingly, the work conducted jointly on soft-story housing in Oakland focused not on dollar damage losses, but on issues of habitability and community-level impacts, such as loss of property tax and business tax.

---

[15] Holzer, T.L., ed., 1998. "Introduction" in ***The Loma Prieta, California, Earthquake of October 17, 1989 – Liquefaction.*** U.S. Geological Survey Prof. Paper 1551-B: Reston, VA, pp. B4.

[16] See http://www.bayeconfor.org/pdf/hetchhetchyfinal2.pdf to view the entire report.

Weather-Related Impacts –

Past flooding losses have been significant, but not as large as for earthquakes. For example, the January 1997 floods resulted in $1.8 billion in total damage in California, while the El Nino storms of early 1998 resulted in $550 million in losses in the entire state, including both flooding and landslides impacts. FEMA documents over $98 million in total repetitive losses in the Bay Area that have been paid by their insurance program since its inception, most of which (over $65 million) has occurred in Sonoma County. However, since **6.4%** of the urban land in the Bay Area is within the 100-year flood plain, and climate change may increase the size of spring runoff, future losses could be more significant than in the past. Note that some of the repetitive loss claims have occurred in areas outside of the Q3-mapped 100-year flood plain. Thus, it is clear that other areas are susceptible to flooding, but to a lesser extent.

Losses from landslides are typically lower than associated flooding. However, in the El Nino storms of early 1998, USGS documented approximately $150 million in losses due to approximately 300 landslides that occurred in the Bay Area and Santa Cruz County[17]. The landslides ranged in size from a 25 m^3 failure of engineered material to a reactivation of the massive (13 million m^3) Mission Peak earthflow complex in Alameda County.

The largest urban-wildland fire in the Bay Area, the 1991 fire in the East Bay Hills, resulted in $1.7 billion in losses. In that fire, 3,354 family dwellings and 456 apartments were destroyed, while 25 people were killed and 150 people were injured. While in the 2005 MJ-LHMP, it was assumed that it was is unlikely that any single fire disaster in the Bay Area would exceed that fire in total losses, that assumption can no longer be made. A combination of increasing property values in wildfire areas, increasing fuel, and climate change all contribute to this change. However, these losses are many times smaller and more localized than that anticipated from a disastrous earthquake.

The report on ***Hetch-Hetchy Water and the Bay Area Economy*** discussed earlier hints at the importance of water to the region and the potential impacts of drought and population growth. That report notes on page 5 that:

> Based on conditions during the most recent drought period, SFPUC now has determined that the maximum quantity of water it can reliably deliver to its customer base is 239 mgd annually. However, actual demand in 2000-2001 was nearly 260 mgd, and it is generally understood that the SFPUC system is operating in excess of its assured supply capacity and approaching its actual delivery capacity.
>
> Total demand for Hetch Hetchy water is expected to grow to 303 mgd in 2030 and 310 mgd by 2050. Absent a significant expansion of the system, the shortfall relative to assured supply will therefore increase from 21 mgd presently to 64 mgd within 30 years and 71mgd within 50 years.

M.Cubed conducted an economic assessment of long-term drought on EBMUD's customers. The original study estimates the costs to all EBMUD customers of $186 million with a rationing level of 10% to $1.14 billion with a rationing level of 25% during each year rationing is in

[17] Godt, J.W. , ed., 1999. "Introduction" in ***Maps Showing Locations of Damaging Landslides Caused by El Nino Rainstorms, Winter Season1997-98, San Francisco Bay Region, California***: U.S. Geological Survey Misc. Field Studies Map MF 2325-A-J: Reston, VA. See http://pubs.usgs.gov/mf/1999/mf-2325/.

place.[18] All values are in 2002 dollars. The estimates are contained in the following table. Water shortage costs equal consumer surplus losses for residential, institutional, and irrigation customer classes plus regional value added losses for commercial and industrial customer classes. Regional value added losses equal the sum of losses to labor income, proprietor income, profits and property income, and indirect business taxes.

TABLE 24 – East Bay Municipal Utility District Water Shortage Costs, 2040 Level of Development - (Source: M.Cubed, March 2008, Table 1)

	Water Shortage Cost (in $ millions per year of shortage)		
Rationing Level	**10%**	**15%**	**25%**
Single Family	24.2	47.5	150.7
Multifamily	6.4	12.1	34.2
Commercial	94.5	142.3	786.2
Industrial	57.7	86.8	145.1
Institutional	0.5	0.8	1.7
Irrigation	2.6	5.6	24.6
TOTAL	**186.0**	**295.1**	**1,142.5**

Most Bay Area water districts develop long-term water supply and management plans, including urban water shortage contingency analyses. ABAG will be working with water districts and others on this issue, as specified in the ABAG Annex, Mitigation Strategy INFR-d-4, ENVI-a-4 and ENVI-a-5.

Catastrophic failure of a dam in the region would result in huge losses. While damage losses have not been quantified, the areas subject to dam failure inundation include **18.1%** of the urban land in the Bay Area.

The Delta levees are crucial to our state economy and drinking water system. Delta levee failures have occurred in the past. The Holland and Webb Tracts levee breaks in 1980 impacted Contra Costa, Sacramento, and San Joaquin counties and resulted in $17.4 million in damage. The levees are extremely vulnerable to seismic risks. This risk is compounded when an earthquake on the Hayward fault fails levees while simultaneously causing significant damage in the Bay Area. Our ability to repair levees depends on our ability to transport goods and workers to the area. This will be difficult if transportation systems are damaged and resources become scarce. The Delta Risk Management Study (DRMS) clearly demonstrates that the levees as they are today are not sufficient to sustain the region for the next 100 years.

Lack of understanding of potential impacts of global warming on the region and other hazards leads to further uncertainties in estimating weather-related losses and impacts. Some of these interrelationships are described in Chapter 7 – Environment.

Again, more work is needed in estimating the impacts of weather-related disasters. Thus, as specified in the ABAG Annex to this plan, ABAG will continue to work in developing different

[18] See http://www.ebmud.com/water_&_environment/water_supply/water_supply_management_program/economic_analyses/Cost%20of%20Water%20Shortage.pdf to view full memo.

ways to express losses and risk. Part of this effort is related to coordination with the Bay Area Integrated Water Management Plan effort described in the section on Drought in this Appendix.. See ABAG Annex mitigation strategy GOVT-e-2. Any remaining gaps in knowledge following that effort will be identified as part of that effort. The risk and loss estimates will be city-specific.

How Has Understanding of Hazards and Risks Changed Between 2005 and 2010?

The previous sections focus on describing the most significant natural hazards affecting the San Francisco Bay Area related to earthquakes (faulting, shaking, liquefaction, landslides, and tsunamis) and weather (fire, flooding, landslides, drought, and climate change), as well as dam and levee failure.

Progress –
The most significant change in this analysis in the past five years has been the recognition of significance of the impacts that climate change can potentially have on weather-related hazards. Thus, Chapter 7 – Environment has a section that focuses entirely on this issue of potential climate change impacts and includes mitigation strategies that mitigate climate change itself.

ABAG has also focused on determining hazard exposure of private property and land use changes, which has resulted in newly incorporated Appendices E and F.

The other significant innovative change and improvement in this assessment is the function-by-function integration of risk exposure into the assessment of individual functional systems. This includes, for example, a review of current data and programs related to cripple-wall hazards associated with single-family homes and soft-story issues related to multifamily housing. The assessment goes beyond a simple modeled total of road closures or estimated housing losses to develop mitigation strategies targeted at reducing the ***causes*** of those risks. Each of these assessments is included in the MJ-LHMP Chapters, for this assessment is much more useful than simple hazard exposure calculations, or even data on expected dollar losses, in evaluating the usefulness of various mitigation strategies. The development of these functional assessments was made possible by the series of collaborative efforts among the cities, counties, and special districts of the Bay Area during the past five years. A grant from FEMA through CalEMA, collaboration with ABAG Plan Corporation's Sewer Smart efforts, and specifically allocated funding from MTC has made Chapter 1- Infrastructure much more complete and comprehensive than it would have been without this additional funding targeted and water, wastewater, and transportation systems.

Gaps –
Not all hazards have quantitative probabilistic information. The Bay Area local governments participating in this MJ-LHMP all plan to continue to work together to develop and share risk information. In addition, for example, USGS, the California Geological Survey, CalFIRE, and CalEMA also are working on mapping and risk assessments of some, but not all, of these hazards that will continue to improve these assessments.

ABAG consulted all of the authors of hazard maps used in the 2005 plan and determined if there was a more recent version of those maps or probability information suitable for inclusion in this plan.

- CGS is developing new fault hazard maps that include estimates of fault displacement that should be available within the next five years.
- The USGS and CGS shaking potential map has been updated based on revised earthquake probabilities, but it does not account for differences in soil and rock type. Thus, the earlier shaking potential map continues to be used. Newer maps should be available in five years. (The earthquake probabilities on page C-3 in this plan have been updated, however.)
- The CGS maps of earthquake-induced landslides and liquefaction have not been completed. As noted, we have a mitigation strategy specifically noting our willingness to provide support to CGS in this effort when they approach any of us to obtain parcel-specific studies.
- By the next edition of this plan, CalEMA and CGS should have published tsunami hazard mapping, not just tsunami evacuation maps, that can be used for mitigation planning.
- The CalFIRE wildfire threat maps have been updated, as have the fire perimeter maps. But the WUI fire threat map has not. It continues to show a hazard in the areas next to the Bay with high groundwater that the cities bordering the Bay believe is an overestimation of the threat.
- Flooding Q3 maps have been replaced by D-FIRM maps in all counties except San Mateo, where they have not yet been released by FEMA.
- Landslide hazards assessment continues to be underfunded by USGS. While some promising modeling is on-going, this modeling has not yet resulted in mapping that is more useful to this plan than the maps used in 2005. ABAG grant applications to USGS for funding were denied.
- ABAG did a thorough literature search and was unable to locate any updated information on the probability of drought. As noted earlier, the U.S. Department of Agriculture is beginning to take initiative in this area.

As noted earlier, local governments are suffering in the midst of a recession that has impacted them directly – and that has been made worse by the forced "take away" by the State of California so that the State can balance its budget. Thus, capital improvements budgets have decreased and planning departments have been hit with furloughs and layoffs. Many existing and on-going mitigation efforts have been slowed.

But we have been creative. Through collaborations with the Earthquake Engineering Research Institute Northern California Chapter and the Structural Engineers Association of Northern California, ABAG is continuing to collect valuable information on the locations of vulnerable privately-owned structures through the use of volunteers. The use of volunteers made the collection of a comprehensive review of Oakland's 3,000 multifamily buildings feasible with the assistance of a $100,000 grant from FEMA through CalEMA. The status of those efforts is incorporated into Chapter 3 – Housing and Chapter 4 – Economy. ABAG has a list of unreinforced masonry buildings in the region that appears to be out of date. Unfortunately, local governments did not keep records of specific URM buildings once they had undergone minimal life-safety retrofits. Thus, there remains a large discrepancy between data compiled by the State Seismic Safety Commission and individual cites.

APPENDIX D
Disasters Affecting the San Francisco Bay Area
1950 - 2009

The California Office of Emergency Services has compiled two lists of disasters affecting the State, including the San Francisco Bay Area – one for the period from 1950 – 1999, and a second for more recent disasters. The following list of 69 disasters affecting all or part of the nine-county Bay Area during that 60-year period is extracted from those lists (of over 200 disasters statewide). All but nine of these disasters are caused by natural hazards, for an average of almost one natural disaster affecting all or part of the San Francisco Bay Area every year. Since the adoption of the 2005 LHMP, 12 new disasters have been declared. These disasters included winter storms, drought, fire, a levee break, pandemic flu and several manmade disasters. No earthquake disasters were declared during this period.

County	Floods	Weather/Storm	Drought	Wildfire	Energy Shortage	Earthquake	Agricultural Emergency	Civil Disturbance	Landslide	Water Mngmt & Fish Shortage	Infrastructure related	Oil Spill	Flu	**TOTAL**
Alameda	11	6	3	3	2	1	1	1	0	0	1	1	1	**31**
Contra Costa	12	6	3	0	2	1	1	1	0	0	1	1	1	**29**
Marin	9	7	3	1	2	2	0	0	0	1	0	1	1	**27**
Napa	9	7	3	3	0	1	0	0	0	0	0	0	1	**24**
San Francisco	4	2	1	0	1	1	0	1	0	1	1	1	1	**14**
San Mateo	10	5	3	0	1	1	1	0	1	1	0	1	1	**25**
Santa Clara	9	4	3	2	2	2	2	0	0	0	0	0	1	**25**
Solano	9	6	3	2	0	1	1	0	1	0	0	1	1	**25**
Sonoma	8	9	3	2	1	0	0	0	0	1	0	1	1	**26**
TOTAL	**81**	**52**	**25**	**13**	**11**	**10**	**6**	**3**	**2**	**4**	**3**	**7**	**9**	

November 1950 – Floods

Declared: statewide CA OCD 50-01(11/21/50)
Federal: not declared
Casualties: 9 deaths
Damage: Sacramento River Basin above Delta-$4,983,000; Sacramento-San Joaquin Delta-$4,550,000; San Joaquin River Basin-Consumnes River to Upper San Joaquin River-$11,460,000; Upper San Joaquin River Basin-Kings River to Kern River-$11,190,000; TOTAL-$32,183,000

December 1950 – Floods

Declared: statewide CD 47-DR-CA (12/22/55)
Federal: 12/23/55
Casualties: 74 deaths
Damage: $200 million

May 1957 – Unseasonal and Heavy Rainfall

Declared: State of Emergency—cherry producing areas of Northern California (requested by Department of Agriculture) 5/20/57
Federal: not declared
Casualties: no deaths, 2 injuries
Damage: $6 million in agricultural losses

February 1958 – Storm and Flood Damage

Declared: Northern California (Southern boundaries of Santa Cruz, Santa Clara, Stanislaus, Tuolumne, Alpine Counties to the Oregon border) CDO 58-03 (2/26/58)
Federal: not declared
Damage: not available

April 1958 – Storm and Flood Damage

Declared: statewide (4/2/58)
Federal: 82 (4/4/58)
Casualties: 13 deaths, several injuries
Damage: $20 million, plus $4 million agricultural

September 1959 – Unseasonal and Heavy Rainfall

Declared: Tokay grape producing areas of Northern California (requested by Dept. of Agriculture) (9/19/59)
Federal: not declared
Casualties: 2 deaths
Damage: $100,000

September 1961 – Widespread Fires

Declared: Amador, Butte, El Dorado, Napa, Nevada, Placer, San Diego, Sonoma, Tehama (9/8/61)
Federal: not declared
Damage: public-$243,000; private-$4,183,098; watershed-$1,270,715; TOTAL-$5,696,813

September 1962 - Fires and Explosions

Declared: City of San Leandro (Alameda County) (9/14/62)
Federal: not declared
Casualties: 1 death, 12 injuries
Damage: $500,000

Fall 1962 - Flood and Rainstorms

Declared: Alameda, Butte, Contra Costa, Modoc, Napa, San Mateo, Sierra, Sutter, Yuba (10/17/62), Placer (10/25/62), Trinity (10/30/62), Lassen (11/4/62)
Federal: 138 (10/24/62) amended to include Placer, Trinity, and Lassen Counties
Damage: $4 million+

February 1963 – Abnormally Heavy and Continuous Rainfall

Declared: Northern California (boundaries of San Luis Obispo, Ventura, Los Angeles, and

San Bernardino counties to the Oregon State line) (2/14/64)
Federal: not declared
Damage: not available

February 1963 – Flood and Rainstorms

Declared: Alpine, Nevada, Placer, Plumas, Sierra (2/7/63), Amador, Colusa, El Dorado, Glenn, Lake, Lassen, Tehama, Santa Clara, Santa Cruz, Siskiyou, Yolo, Tulare (2/26/63), Mono, Trinity (2/29/63), Yuba (4/22/63)
Federal: 145 (2/25/63), amended 1/30/63 to include Orange County and Redondo Beach
Damage: not available

September 1964 – Major and Widespread Fires and Excessively High Winds

Declared: Napa (9/22/64), Sonoma (9/23/64), Santa Barbara (9/25/64)
Federal: not declared
Damage: private-$3.5 million; watershed-$13 million; TOTAL-$16.5 million
Note: By special appropriation, Congress approved $860,000 for Santa Barbara County. The USDA, through Forest Service programs, spent $1.044 million for seeding and reestablishing dams in these counties.

September 1964 – Tsunami Caused by March 1964 Earthquake in Alaska

Declared: Marin (9/15/64) (Tax Relief)
Federal: not declared
Damage: not applicable, only costs were for mitigation

Winter '64-'65 – Late Winter Storms

Abnormally heavy and continuous rainfall and windstorm
Declared: OEP 183-DR-CA Del Norte, Humboldt, Shasta, Mendocino (12/22/64), Colusa, Glenn, Lassen, Plumas, Sierra, Siskiyou, Sonoma, Sutter, Tehama, Trinity (12/23/64), Amador, Butte, El Dorado, Modoc, Nevada, Placer, Yuba (12/28/64), Alpine, Lake, Sacramento, Yolo (1/5/65), Marin (1/14/65)
Federal: 12/29/64
Damage: public-$85.327 million; private-$127.822 million; TOTAL-$213.149 million

September 1965 – Major and Widespread Fires

Declared: Marin, Napa, Placer, Solano, Sonoma (9/18/65)
Federal: not declared
Casualties: no deaths
Damage: not available; 113,766 acres and 41 bldgs. Destroyed

9/66 – Riots

Declared: San Francisco (9/27/66)
Federal: not declared
Casualties: no deaths, 42 injuries
Damage: not available

December 1966 – Earthslides

Declared: Redwood City (San Mateo County) (12/16/66)
Federal: not declared
Damage: private-$100,000

August 1968 – Riots and Other Conditions

Declared: City of Richmond (Contra Costa) (8/2/68)
Federal: not declared
Damage: not applicable (worker strike)

Winter '69 – Storms

Storms, flooding
Declared: OEP 253-DR-CA Los Angeles, San Luis Obispo (1/23/69), Fresno, Inyo, Riverside, San Bernardino, Santa Barbara, Tulare, Ventura (1/25/69), Amador, El Dorado, Kern, Kings, Madera, Modoc, Mono, Monterey, Orange, Placer, Sacramento, San Joaquin, Shasta, Solano, Stanislaus, Tuolumne (1/28/69), Mariposa, Merced (1/29/69), Calaveras, San Benito, Sierra (2/8/69), Contra Costa, Humboldt, Mendocino, Sonoma (2/10/69), Plumas, Tehama, Yuba (2/16/69), Butte, Marin, Yolo (3/12/69)
Federal: 1/26/69
Casualties: 47 dead, 161 injured
Damage: public-$185 million; private-$115 million; TOTAL-$300 million

December 1969 – Riots

Declared: City of Berkeley (Alameda County) (2/5/69)
Federal: not declared
Casualties: no deaths, 20 injuries
Damage: not available

Winter '70 – Northern California Flooding

Heavy Winds, Storms, Flooding
Declared: OEP 283-DR-CA Butte, Colusa, Glenn, Lake, Lassen, Marin, Modoc, Plumas, Shasta, Siskiyou, Tehama, Trinity (1/27/70), Sutter, Yuba (2/3/70), Del Norte (2/10/70), Alameda, El Dorado, Mendocino (3/2/70)
Federal: 2/16/70
Damage: public-$19,659,078; private-$7,998,400; TOTAL-$27,657,478

February 10, 1970 – Slide Damage Caused by Heavy Rains and Storms

Declared: City of Oakland (Alameda County) 2/10/70 (Tax Relief)
Federal: not declared
Damage: $11.5 million

Early March 1970 – Freezing Conditions

Declared: Ag. area of Napa (5/1/70), Ag. area of Sonoma (5/19/70), Ag. area of Mendocino (6/8/70), Ag. community of San Joaquin (6/10/70), Ag. community of Lake (7/24/70)

Federal: not declared
Damage: Agricultural loss $19,749,200

April 1970 – Storms And Floods

Declared: Contra Costa (4/10/70) (Tax Relief)
Federal: not declared
Damage: not available

Fall '70 – Statewide Fires

Declared: OEP 295-DR-CA City of Oakland (Alameda County 9/24/70), Los Angeles, Ventura, San Diego (9/28/70), Kern (10/1/70), San Bernardino (10/2/70), Monterey, Riverside (10/20/70), San Bernardino (11/14/70)
Federal: 9/29/70 amended 11/25/70 to include San Bernardino
Casualties: 19 deaths
Damage: public-$52,862,000; watershed-$24,826,000; private-$145,923,000 TOTAL-$223,611,000; 576,508 acres, 722 bldgs. San Bernardino-53,100 acres, 54 bldgs.

Spring '72 – Freeze and Severe Weather Conditions

Declared: Fresno, Kings, Tulare, Merced, Kern, Madera, San Benito, Stanislaus, El Dorado, Tehama, Placer, Nevada, San Joaquin (4/17/72), Colusa (5/22/72), Siskiyou, Modoc (5/22/72), Santa Clara (5/31/72)
Federal: not declared
Damage: crop loss-$111,517,2604/10/72

1973 – Drought Conditions

Declared: Glenn, San Benito, Santa Clara (7/3/73)
Federal: not declared
Damage: agricultural loss-$8 million

January 1973 – Coastal Flooding

Heavy rains, winds, floods, and tidal action
Declared: OEP 364-DR-CA Marin, San Luis Obispo (1/23/73), City of South San Francisco (San Mateo County 1/30/73), Santa Barbara, Solano (2/8/73), Ventura (2/28/73)
Federal: 2/3/73
Damage: public-$5,291,350; private-$12,706,900; TOTAL-$17,998,250

February 1973 – Storms And Floods

Declared: Colusa, Glenn, Napa, Placer, Sutter, Yuba (2/28/73)
Federal: not declared
Damage: public-$1.357 million; private-$507,000; TOTAL-$1.864 million

April 1973 – Storms and Floods

Declared: City of Pacifica—San Mateo (4/11/73) (Tax Relief)
Federal: not declared
Damage: public-$450,000; private-$250,000; TOTAL-$700,000

May 1973 – Eucalyptus Tree Freeze

Declared: Alameda, Contra Costa (4/4/73)
Federal: 5/25/73
Damage: removal of approx. 2 million dead trees—$8-10 million

March 1974 – Gasoline Purchasing Problems

Declared: Alameda, Contra Costa, Los Angeles, Orange, Riverside, San Mateo, Solano (2/28/74), Santa Clara (3/4/74), Ventura (3/10/74)
Federal: not declared
Damage: not applicable

1976 – Drought

Declared: Alpine, Calaveras, Colusa, Fresno, Glenn, Madera, Merced, San Diego, San Joaquin, Solano, Stanislaus, Sutter, Tuolumne (2/9/76), Alameda, Butte, Contra Costa, Kings, Los Angeles, Riverside, San Luis Obispo, Tulare, Yolo (2/13/76), Amador, Monterey, Napa, Nevada, San Benito, San Bernardino, Tehama (2/24/76), San Mateo (3/26/76), Marin (7/6/76)
Federal: not declared
Damage: 1976-$888.5 million; 1977-$1.775 billion; TOTAL-$2.664 billion

1979 – Gasoline Shortage Emergency

Declared: Alameda, Contra Costa, Los Angeles, Marin, Monterey, Orange, Riverside, San Francisco, San Diego, Santa Clara, Santa Cruz, San Mateo, Ventura, San Bernardino (11/13/79), San Bernardino (amending boundaries 9/29/79), Monterey (7/13/79), San Bernardino (7/13/79), Riverside (6/22/79), San Bernardino (6/7/79), Monterey (6/7/79), Riverside, (amending boundaries 5/18/79), Monterey, Riverside (portion) (5/11/79), San Mateo, Santa Cruz (5/9/79), San Bernardino (portion 5/8/79), Alameda, Contra Costa, Los Angeles, Marin, Sonoma, Orange, Santa Clara, Ventura (5/8/79)
Federal: not declared
Damage: not applicable

January 1980 – Delta Levee Break

Rain, high tides, strong winds, and flooding (Holland and Webb Levee breaks)
Declared: FEMA 3078-EM-CA Contra Costa, Sacramento, San Joaquin (1/23/80)
Federal: 1/23/80
Damage: public-$11,158,700; private-$1,479,500; agricultural-$3,887,195; TOTAL-$17,388,013

March 1980 – Storms

Rain, winds, mud slides, and flooding
Declared: Stanislaus, Monterey, Solano, Santa Cruz (3/5/80)
Federal: not declared
Damage: *include figures from 2/82. public-$164,990,642; private-$75,755,500; agricultural-$75,894,675; TOTAL-$316,640,817. These four counties proclaimed in Feb. 1982 but were not included in the Presidential declaration.

Summer '81– Mediterranean Fruit Fly Infestation

Declared: Contra Costa (9/25/81), Los Angeles (8/25/81), San Benito (8/25/81), Stanislaus (8/14/81), Santa Cruz (8/13/81), San Mateo (8/8/81)
Federal: not declared
Damage: $22 million

June 1981 – Atlas Peak Fire

Declared: Napa (6/24/81)
Federal: not declared
Casualties: no deaths
Damage: private-$11 million; watershed-$20 million; TOTAL-$31 million; 23,000 acres burned, 69 structures destroyed

January 1982 – Winter Storms

Heavy winds, rain, flooding, and mud slides
Declared: FEMA 651-DR-CA Alameda, Santa Clara, Solano, San Joaquin (1/9/82), Contra Costa, Humboldt, Marin, San Mateo, Santa Cruz, Sonoma (1/5/82)
Federal: 1/7/82
Casualties: 33 dead, 481 injured
Damage: public-$101.400 million; private-$172.450 million; TOTAL-$273.850 million; 256 homes and 41 businesses destroyed, 6259 homes and 1276 businesses damaged.

October 1982 – Rains Causing Agricultural Losses

Declared: Fresno, Madera, Merced, Monterey, Kern, Tulare, Sacramento, San Joaquin, Solano, Stanislaus, Yolo (10/26/82)
Federal: not declared
Damage: agricultural $345,195,974

December 1982 – High Tides, Strong Winds, and Rains

Declared: Contra Costa, Sacramento, San Joaquin (12/8/82)
Federal: not declared
Damage: public-$5,313,198; private-$1,651,800; TOTAL-$6,964,998

Winter '82-'83 – Winter Storms

Heavy rains, high winds, flooding, levee breaks
Declared: FEMA 682-DR--CA Contra Costa, San Joaquin, Sacramento (12/8/82), Marin, San Mateo, Los Angeles, San Diego (1/27/83), Alameda, Orange, San Benito, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Sonoma, Ventura, Trinity (1/31/83), Colusa, Lake, Mendocino, Monterey, San Luis Obispo, Solano, Yolo (2/7/83), Butte, Glenn, Kern, Kings, San Bernardino, Sutter Tehama, Merced (3/3/83), Del Norte, Fresno, Madera, Napa, Placer, Riverside, Stanislaus, Tulare (3/15/83), Humboldt, Mariposa, Nevada, Yuba (3/21/83)
Federal: 2/9/83

Damage: public-$151,185,870; private-$158,641,170; agricultural-$213,789,992; TOTAL-$523,617,032

December 1983 – Levee Failure, High Winds, High Tides, Floods, Storms, Wind Driven Water

Declared: Contra Costa (12/9/83), Alameda (1/18/84)
Federal: not declared
Damage: public-$7,240,785; private-$2.669 million; agricultural-$1 million; TOTAL-$10,909,785

April 1984 – Morgan Hill Earthquake

Magnitude 6.2
Declared: Santa Clara
Federal: FEMA 4043-EM-CA (4/25//84
Casualties: no deaths, 27 injuries
Damage: public-$365,000; business-$1.7 million; private-$5.2 million; TOTAL-$7.265 million

June 1985 – Statewide Fires

Declared: FEMA 739-DR-CA San Diego (7/1/85), City of Los Angeles (7/3/85), San Luis Obispo (7/8/85), Monterey, Santa Clara, Santa Cruz (7/9/85), Ventura (7/11/85)
Federal: 4/25/84
Casualties: 3 deaths, 470 injured (124 civilians, 346 firefighters)
Damage: public-$34,751,400; private-$30,094,464; TOTAL-$64,845,864; 375,000+ acres, 215 homes destroyed; 131 homes and businesses damaged; 71 miscellaneous structures and vehicles destroyed

Early February 1986 – Storms

Rains, winds, flooding, and mud slides
Declared: FEMA 758-DR-CA Humboldt, Napa, Sonoma (2/18/86), Glenn, Lake, Marin, Modoc, Sacramento, Santa Clara, Santa Cruz, Solano, Yuba (2/19/86), Alpine, Amador, Butte, Calaveras, Colusa, El Dorado, Lassen, Mendocino, Nevada, Placer, Plumas, San Joaquin, Sierra, Sutter, Tehama, Tuolumne, Yolo (2/20/86), Fresno, Madera, San Mateo (2/26/86), Alameda, Contra Costa, Del Norte, Trinity (3/4/86), Mono, San Benito, Shasta (3/12/86)
Federal: 2/18/86
Casualties: 13 deaths, 67 injuries
Damage: public-$157,987,493; private-$249,551,411; TOTAL-$407,538,904; 12,447 homes damaged; 1,382 homes destroyed; 967 businesses damaged; 185 businesses destroyed

September 1988 – Fires (49er, Miller, and Fern)

Declared: FEMA 815-DR-CA Shasta, Solano (9/20/88, beginning 9/17/88), Yuba, Nevada (9/13/88, beginning 9/11/88)
Federal: 9/13/88
Casualties: no deaths

Damage: public-$31,247,534; business-$2,533,100; private-$18,033,800; TOTAL-$31,247,534; 238 homes destroyed, 41 homes damaged; 29 businesses destroyed

August 1989 – Mediterranean Fruit Fly

Declared: Santa Clara (9/6/89)
Federal: not declared
Damage: not applicable—damage was avoided

October 17, 1989 – Loma Prieta Earthquake

Magnitude 7.1
Declared: FEMA 845-DR-CA Alameda, Monterey, San Benito, San Mateo, Santa Clara, Santa Cruz, San Francisco (10/18/89), Contra Costa, Marin, City of Isleton (10/23/89), City of Tracy, Solano (10/30/89)
Federal: 10/18/89
Casualties: 63 deaths, 3,757 injuries (10/18/89)
Damage: Alameda $1,479,104,500, Contra Costa $25 million, Monterey $108 million, San Benito $103.55 million, San Francisco $2 billion, San Mateo $292,941,001, Santa Clara $727.7 million, Santa Cruz $1.526 million, $500 million to $1 billion damage in roads and bridges, $20 million in state government buildings. Total: $5.9 billion; 23,408 homes damaged, 3,530 businesses damaged, 1,018 homes destroyed, 366 businesses destroyed.

Early December 1990 – Freeze

Declared: FEMA 894-DR-CA Santa Cruz (12/28/90), Fresno, Glenn, Imperial, Kern, Mendocino, Monterey, Riverside, San Benito, San Bernardino, San Diego, San Mateo, Santa Barbara, Santa Clara, Solano, Sonoma, Tulare, Ventura (1/11/91), Alameda, Butte, Colusa, Los Angeles, Madera, Marin, Merced, Napa, San Joaquin, San Luis Obispo, Sutter, Yolo, Yuba (1/18/91), Stanislaus, Tehama (2/14/91, beginning 12/19/90)
Federal: 2/11/91
Damage: public buildings-$2,330,353; utilities-$1,614,040; crop damage-$852,385,282; TOTAL-$856,329,675; 500 broken pipes, affecting 5,400 homes

October 1991 – East Bay Hills Fire

Declared: Alameda County, 10/20/91)
Federal: 919 (10/22/91)
Casualties: 25 deaths, 150 injuries
Damage: $1.7 billion; 3,354 family dwellings and 456 apartments destroyed

December 1992 – Late Winter Storms

Snow, rain, and high winds
Declared: FEMA 979-DR-CA Alpine, Los Angels (2/19/93), Humboldt, Napa, Santa Barbara, Culver City and the City of Los Angeles (2/8/93, for event beginning 1/25/93), Contra Costa, Mendocino, Sonoma (1/25/93, for event beginning 1/25/93), Fresno, Imperial, Madera, Monterey, San Bernardino, Sierra, Tehama, Trinity, and Tulare (1/21/93, for event beginning 1/19/93), Modoc, Orange,

Riverside (1/19/93, for event beginning 1/15/93), Lassen, Siskiyou (1/15/93, for event beginning 1/13/93), Plumas (1/13/93, for event beginning 1/12/93), San Diego (1/7/93, for event beginning 1/7/93)

Federal: 1/15/93

Casualties: 20 deaths, 10 injuries

Damage: public property-$32,215, $600 million

January 1995 – Severe Winter Storms

Declared: FEMA 1044-DR-CA Los Angeles, Orange (1/6/95), Humboldt, Lake, Sonoma (1/9/95), Butte, Colusa, Contra Costa, Del Norte, Glenn, Kern, Lassen, Mendocino, Modoc, Monterey, Napa, Placer, Plumas, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Tehama, Ventura, Yolo, Yuba (1/10/95), Alpine, Amador, Nevada, Riverside, Sacramento, San Bernardino, San Mateo, Shasta, Sutter, Trinity (1/11/95), San Diego (1/13/95), Alameda, Marin (1/14/95), Fresno, Kings (1/17/95), El Dorado (2/15/95), Madera, Solano (2/17/95), Siskiyou (3/14/95)

Federal: 1044 (1/13/95)

Casualties: 11 deaths

Damage: public-$299.6 million; individual-$128.4 million; businesses $58.4 million; highways-$158 million; ag-$97 million; TOTAL-$741.4 million; damage to homes: major-1,883; minor-4, 179; destroyed-370.

February 1995 – Late Winter Storms

Declared: FEMA 1046-DR-CA 57 counties (all except Del Norte).

Federal: 1/10/95

Casualties: 17 deaths

Damage: public property-$190.6 million; individual-$122.4 million; business-$46.9 million; highways-$79 million; ag-$651.6 million; TOTAL-approximately $1.1 billion; damage to homes: major-1,322; minor-2,299; destroyed-267

December 1996 to January 1997 – January 1997 Floods

Declared: Alpine, Amador, Butte, Colusa, Del Norte, El Dorado, Glenn, Humboldt, Lake, Lassen, Modoc, Napa, Nevada, Plumas, Sacramento, San Joaquin, Sierra, Siskiyou, Solano, Sonoma, Sutter, Tehama, Trinity, Yuba (1/2/97); Calaveras, Madera, Mono, Monterey, Placer, San Benito, San Luis Obispo, San Mateo, Santa Cruz, Shasta, Stanislaus, Tuolumne, Yolo (1/3/97); Contra Costa, Fresno, Marin, Tulare (1/5/97); Mariposa (1/6/97); Merced, Santa Clara (1/10/97); Alameda, San Francisco (1/19/97); Kings, San Luis Obispo (1/31/97).

Federal: all 48 counties listed above

Casualties: 8 deaths

Damage: $1.8 billion

Add: 300 square miles of land flooded; 23,000 homes, 2,000 businesses damaged or destroyed.

February 2, 1998 – El Nino – DR 1203

Declared: Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, Fresno, Glenn, Humboldt, Kern, Kings, Lake, Los Angeles, Marin, Mendocino, Merced, Monterey, Napa, Orange, Riverside, Sacramento, San Benito, San Bernardino, San Diego, San Francisco, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Siskiyou, Solano, Sonoma, Stanislaus, Sutter, Tehama, Trinity, Tulare, Ventura, Yolo, Yuba.
Federal: All above except Kings and Siskiyou counties
Casualties: 17 deaths
Damage: $550 million

September 3, 2000 – Napa Earthquake – DR 1342

Declared: Napa
Damage: estimated at $15 to $70 million (source: EERI Reconnaissance Report)

June 3, 2004 – San Joaquin Levee Break (Upper Jones Tract) – DR 1529

Declared: (Outside of Bay Area – provided due to indirect impacts to Bay Area)
Damage: estimated at $121 to $125 million (source: San Joaquin Co. Office of Emergency Services)

December 17, 2005 to January 12, 2006 – '05-'06 Winter Storms – DR 1628

Declared: Alameda, Contra Costa, Marin, Napa, San Mateo, Solano, Sonoma
Damage: not available at this time

March 29, 2006 to April 1, 2006 – 2006 Spring Storms – DR 1646

Declared: Alameda, Marin, Napa, San Mateo, Sonoma (in addition to Amador, Calaveras, El Dorado, Lake, Madera, Merced, Nevada, Placer, San Joaquin, Santa Cruz, Stanislaus, and Tuolomne counties outside the Bay Area)
Damage: not available at this time

May 10, 2006 – Roadway Damage from storms

Declared: Alameda, Contra Costa, Marin, Napa, San Mateo, Solano, Sonoma (in addition to Alpine, Amador, Butte, Calaveras, Colusa, Del Norte, El Dorado, Fresno, Humboldt, Kings, Lake, Lassen, Madera, Mendocino, Merced, Monterey, Nevada, Placer, Plumas, Sacramento, San Joaquin, San Luis Obispo, Santa Cruz, Shasta, Sierra, Siskiyou, Stanislaus, Sutter, Trinity, Tulare, Tuolomne, Yolo, and Yuba counties outside the Bay Area)
Damage: not available at this time

June 6, 2006 - Water Management and Fish Shortage

Declared: Marin, San Francisco, San Mateo, Sonoma (in addition to Del Norte, Humboldt, Mendocino, Monterey, Santa Cruz, and Siskiyou counties outside the Bay Area)
Damage: indeterminate

January 12, 2007 – Freeze – DR 1689

Declared: Santa Clara (in addition to El Dorado, Imperial, San Bernadino, San Diego, Riverside, Los Angeles, Fresno, Kern, Kings, Madera, Merced, Monterey, San Luis Obispo, Santa Barbara, Stanislaus, Tulare, Ventura, and Yuba counties outside the Bay Area)
Federal: All above, except Santa Clara and El Dorado counties
Damage: not available at this time

April 29, 2007 – Freeway Collapse

Declared: Alameda, Contra Costa, San Francisco
Damage: $6 million in roadway damage

November 9, 2007 – Oil Spill (COSCO BUSAN)

Declared: Alameda, Contra Costa, Marin, San Francisco, San Mateo, Solano, Sonoma
Damage: 53,000 gallons of oil spilled into San Francisco Bay

January 5, 2008 to January 14, 2008 – 2008 Winter Storms

Declared: San Francisco, City of Oakland (in addition to the City of Grass Valley, and Butte, Colusa, Del Norte, El Dorado, Glenn, Kings, Placer, Sacramento, San Francisco, Sierra, Sutter, Yuba, and Yolo counties outside the Bay Area)
Damage: not available at this time

May 22, 2008 to May 24, 2008 – Fire

Declared: Santa Clara (in addition to Santa Cruz County outside the Bay Area)
Damage: 4,270 acres burned, 31 residences destroyed, 16 injuries reported (source: CalFire)

February 27, 2009 – Drought

Declared: statewide
Damage: $300 million in agricultural revenue loss, potential $3 billion in economic losses over time

April 28, 2009 – Swine Flu

Declared: statewide
Damage: indeterminate

source: FEMA: California State Disaster History and CALEMA: Emergency & Disaster Proclamations and Executive Orders by Date (November 2003-Current)

APPENDIX E
Assessing Vulnerability: An Analysis of Land Use Development Trends and Hazards

This appendix analyzes the current land use patterns in the Bay Area, especially as they relate to the hazard areas as established in this multi-jurisdictional Local Hazard Mitigation Plan. In addition, this section discusses projected development trends in the Bay Area, including the type and location of projected future development, so Bay Area local governments can determine the general vulnerability of current and planned development to natural hazards. For purposes of this analysis, the Bay Area includes the counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma.

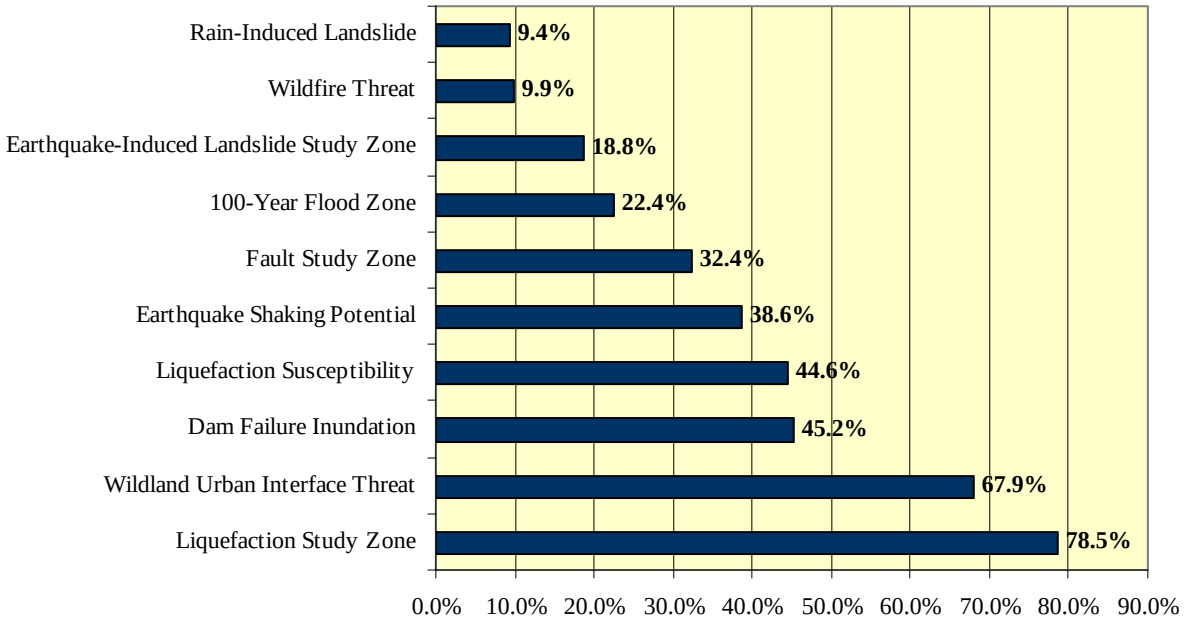
Conclusions and Findings

The San Francisco Bay Area supports a very diverse set of land uses, with the nature of the land use in each county varying considerably from the next. Every county supports some urban population, and almost every county (except San Francisco) has large rural areas, supported by agriculture or ranching. The urban land use patterns also vary considerably among counties, based largely upon the era in which the cities and towns developed, with older areas generally supporting higher urban densities and a larger population.

The region is subject to a number of natural hazards posing a range of risks, and nearly every acre of every land use type is subject to some form of hazard. Based upon acreage alone, the most significant threats in the region are earthquake shaking, wildfires, and to a lesser extent, liquefaction and rainfall-induced landslides. In reality, the first two are the most significant hazards for they have the potential to cause the most damage and loss of life, as landslides and liquefaction are more likely to be localized. The nature of these hazards can vary by the nature of the land use type, as urbanization alters the natural landscape and can affect the potential likeliness of a hazard (usually lessening it by mitigating against the potential hazard). For example, the threat of a wildfire has a strong and complex relationship with urban density. As density intensifies, the risk of fire is increased due to introduced vegetation and structures adding fuel for a wildland fire. Wildfire threat is reduced once urban densities are reached due to the loss of vegetation is lost and changes in building construction.

This appendix focuses on urban land use patterns in high hazard areas because hazards pose a relatively large threat to life and property in an urban area due to the concentration of people and structures. The region has significant amounts of urbanization in high hazard areas. Urbanization has occurred in at least 20% of the total land in seven of the high hazard areas, and in at least 50% in two of the high hazard areas (see Figure 1 and Table 5). While urban development in high hazard areas is unavoidable in many circumstances, these numbers demonstrate that hazards information has not played a significant role in land use decisions. In fact, in several cases urbanization has occurred disproportionately in high hazard areas. For example, the northern part of Santa Clara County, which is highly urbanized, lies in a very large floodplain and is subject not only to flooding but to high liquefaction susceptibility as well. This area is home to San Jose and other cities, has the highest

FIGURE 1 – Percentage of High Hazard Area* that is Urbanized (2005)



*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

population and many of the jobs in the region, and is therefore a major economic backbone to the region and to the State.

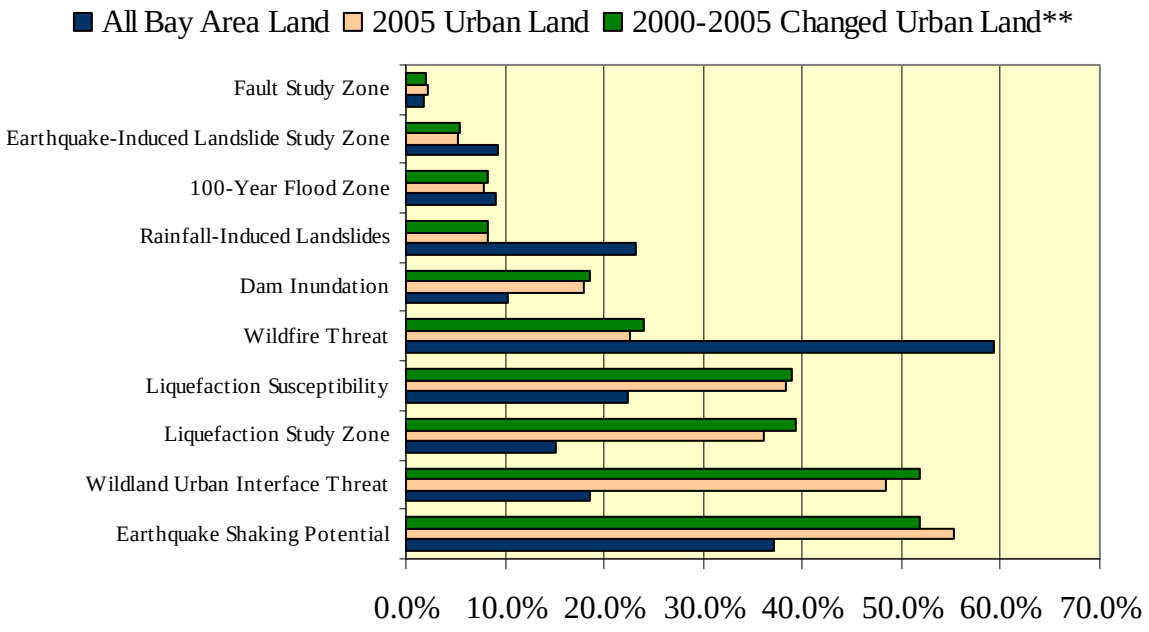
Land use change data for 2000-2005 indicate that hazard information continues to play a very minor role in land use decisions. In addition, land use controls typically remain an insignificant contributor to hazard mitigation efforts. Given the limitations of data, it is not possible to state definitively where development in hazard areas has increased, decreased, or remained the same. It is, however, certain that urbanization in hazard areas is continuing. This trend is a particular concern for those hazards where the percentage of 2000-2005 changed urban land use in the hazard area is greater than the percentage of 2005 urban land in the hazard area (as shown in figure 2). Figure 2 shows that urban development has occurred disproportionately in the high hazard areas for Wildfire (including Wildland-Urban-Interface Threat), Flooding, Liquefaction, and Dam Inundation.

It is important to mention that, while land use regulation has not played a major role in mitigating the effects of hazards, there has been a significant focus on strategies such as building and fire codes, public awareness campaigns, and other approaches to mitigating hazards as outlined in this Local Hazard Mitigation Plan. All of these can significantly reduce the potential effects of any hazard, and occasionally lessen the severity of a disaster. Yet there is no single mitigation strategy that is as foolproof as controlling land use in hazard areas. Simply not developing or limiting development to a certain type within hazard areas reduces the potential effects of a hazard dramatically and possibly eliminates any potential losses. While this is a very strong argument for hazard information to play a much larger role in land use decisions (and land use regulation to play a much larger role in hazard mitigation efforts), this change is unlikely to occur due to the inertia of planning and development decision-making.

While it is impossible to know the extent and location of all new urban development, the trends suggest that there will be increased infill development in urban cores combined with continued development of outlying areas, possibly using a more transit-oriented and mixed-use approach. To the extent that redevelopment increases, this densification will lead to a slower increase in exposure to wildfires and landslides because these are more likely to occur in lower-density areas. In addition, due to lower per capita water use in multifamily areas, this densification will also lead to a slower increase in exposure to drought and water supply shortages. On the other hand, higher densities in existing urban areas will accelerate the exposure to liquefaction, flooding, and earthquake shaking.

There is little indication that hazard information will play any more or less of a role in land use decisions than it currently does today. The ***Seismic Hazards Mapping Act*** of 1990 may provide increased incorporation of liquefaction and earthquake-induced landslide concerns into development decisions as new mapping occurs. Perhaps the most encouraging fact is that there was increased concern among citizens and policy makers following Hurricane Katrina in 2005. How this increased concern will play into development decisions and regulations surrounding hazards has yet to be seen.

FIGURE 2 – Percentage of Land Use in High Hazard Areas* (2000-2005)



* Source: ABAG 2006. See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations.
** Changed Urban Land 2000-2005 includes both new development as well as redevelopment. Source: ABAG 2006.

Information Sources, Definitions, and Hazard Analysis Limitations

One of the core programs of ABAG is to examine past development trends and current development patterns, and to use this information to project future growth patterns in terms of jobs, population, and household growth. Thus, this appendix is based on a variety of ABAG publications, as well as data available internally concerning current land use patterns in designated hazard areas. In addition, outside references have been used to discuss drought concerns. See the reference section at the end of this appendix for a full list of these sources.

High Hazard Areas

High hazard areas are discussed in more detail in the "Land Use Densities in Hazard Areas" section. ***Note that this appendix analyzes only land uses in the high hazard areas, and makes no comment upon the probability of a hazard occurring in a given high hazard area***. The probability of a high hazard area resulting in a disaster varies by hazard. See Appendix C for more information on these probabilities.

- **Fault Rupture Hazard** – There is no map of all active faults in the region that accurately describes their locations. As a substitute, this appendix uses the Alquist-Priolo Fault Rupture Study Zones to determine the threat of fault rupture. High hazard areas for this hazard therefore consist of all acres in this Study Zone. These Zones are much wider than the actual fault traces, and therefore the number of acres in the high hazard areas is overestimated. These maps have not changed for the nine-county Bay Area since the 2005 MJ_LHMP was adopted.
- **Earthquake Shaking Potential** – Earthquake shaking hazard is divided into five categories of increasing shaking potential on the composite USGS Shaking Map (as described in LHMP Appendix C). The two categories of highest potential shaking were used to define the high hazard areas. This map has also not changed since the 2005 MJ-LHMP was adopted.
- **Liquefaction Susceptibility –** Liquefaction is divided into five categories of increasing liquefaction susceptibility on USGS Liquefaction Susceptibility map. This analysis uses the Knudsen and others (2000) version of a map that has been updated after 2005. ***The decision has been made to use the 2000 version of this map because this is the hazard mapping that would have been available for local government use in making land use decisions between 2000 and 2005.*** The three categories of highest liquefaction susceptibility were used to define the high hazard areas. In addition, the California Geological Survey (CGS) has mapped San Francisco and portions of Alameda and Santa Clara counties. The USGS compilation is used for this analysis because it covers the entire Bay Area.
- **Earthquake-Induced Landslides** – These maps were mandated under the ***Seismic Hazards Mapping Act*** of 1990. CGS has completed mapping for a portion of the Bay Area. ***Again, the decision has been made to use the mapping available in 2004 because this is the hazard mapping that would have been available for local government use in making these past land use decisions.*** For these hazard areas, the regional total will consist only of these counties. The hazard area is defined as those areas that are within the study zones (and are therefore subject to the hazard).
- **Tsunamis –** These maps are currently being revised by the CalEMA. CalEMA has stated that the maps are to be used only for evacuation planning, not for this type of analysis. ***Thus, no analysis of hazard mapping impacts on land use has been conducted.*** This omission does ***not*** mean that tsunamis are not a hazard in the region.

- **Flooding –** Areas within the 100-year flood zone (including due to wave action) are in the high hazard area based on FEMA Q3 map. These maps are currently being updated by FEMA to create DFIRM maps that are being used to determine hazard exposure. ***Again, however, the decision has been made to use the Q3 mapping previously available because this is the hazard mapping that would have been available for local government use in making these past land use decisions.***
- **Rainfall-Induced Landslides –** Areas designated "mostly a landslide area" on the USGS Existing Landslide Map are considered to be in the high hazard area for rainfall-induced landslides. These maps have not changed since the 2005 MJ-LHMP was adopted.
- **Wildfire Threat** – Wildfire threat is divided into five categories of increasing wildfire threat as described on the CalFIRE Wildfire Threat Maps. The three categories of highest wildfire threat were used to define the high hazard areas. These areas typically occur further from urban areas that wildland urban interface (WUI) threat areas described below. While there is some overlap in the WUI threat and wildfire threat areas, wildfire is defined on the CalFIRE maps as occurring in non-urban areas outside of city fire department jurisdictions. CalFIRE has completed an update of this mapping since 2005. ***While the new maps are being used for hazard exposure assessment, the decision has been made to use the older mapping because this is the hazard mapping that would have been available for local government use in making these past land use decisions.***
- **Wildland-Urban-Interface Threat** – The high hazard areas are defined as any area within the WUI Threat Zone as described in the WUI Threat maps created by CalFIRE. These hazard areas generally occur on the edge of urban areas. These maps were recently found to somewhat overestimate the amount of land in the threat area. Specifically, land that was urban and bordering the bay was included in the threat region when it should not have been, meaning that the amount of certain land types in this region (medium and high density residential, mixed use lands, all types of employment land uses) is likely to be somewhat high. ***While the new maps are being used for hazard exposure assessment, the decision has been made to use the older mapping because this is the hazard mapping that would have been available for local government use in making these past land use decisions.***
- **Drought –** While drought is a concern for the region, it is not a hazard that can be mapped in the traditional sense. There are no high hazard areas for this hazard, then. This appendix does, however, provide a discussion of the uses of water and potential effects of a drought for varying land uses (see section "Land Use Densities in Hazard Areas").
- **Dam Inundation Maps –** Any area subject to inundation from at least one dam is located in the high hazard area for Dam Inundation. These maps were created under the assumption that a dam would simply disappear, and therefore represent a worst case scenario. In addition, these maps are nearly 40 years old and do not reflect current land conditions that would direct the floodwaters.

Urban Land Use

Urban land use refers to all non-agricultural land uses that involve some development. This includes residential, commercial, infrastructure, industrial, public/institutional, military, and urban open space (including city parks, golf courses, cemeteries and other uses).

Land Use Densities

One section of this of the appendix discusses "land use densities" in hazard areas. These discussions refer to the following land use categories. Data were available to divided residential land uses into a number of categories that directly reflect the density of development. These categories are:

- **Rural Residential (less than 1 unit/acre)** – This development can be characterized by the residential portions of ranches and farms, as well as ranchettes and other large properties.
- **Low-Density Residential (between 1 and 3 units/acre)** – This development is typical of new outer suburbs, as well as more affluent suburbs within older urban areas, where houses and lots tend to be fairly large.
- **Medium-Density Residential (between 3 and 8 units/acre)** – This development is typical of older suburbs and some outer suburbs.
- **High-Density Residential (above 8 units/acre)** – This use encompasses a wide range of development types, including very high-density urban cores, inner suburbs, apartment buildings and condominiums.
- **Mobile Home Parks**
- **Mixed-Use Residential/Commercial Development** – This use includes parcels where retail stores or offices are on the ground floor with residential units above, as well as isolated areas with commercial and residential uses on separate buildings on a single parcel.

Due to a lack of available information, it was not practical to divide employment areas into "employment densities." In addition, it seemed more reflective of the on-the-ground development to discuss the nature of employment development in terms of the land use as opposed to the density of employment. The employment land has therefore been divided into these categories:

- **Commercial Services** – This use includes retail, office, research, hotel, and intensive outdoor areas (such as amusement parks, tennis and swim clubs, and golf clubhouses).
- **Industrial –** This use includes heavy and light industrial, food processing (such as canneries and wineries), scrap metal recycling, and warehousing.
- **Infrastructure** – This use includes airports, marinas, ports, and utility lands and structures for communications, electricity, water supply, and wastewater. It also includes rail lines, park and ride lots, and other public transit associated areas. Roads and highways were excluded due to the large number of acres, which detracted from the quality of meaningful analysis of the other land use types.
- **Public/Institutional** – This use includes government centers, police and fire stations, hospitals, schools and universities, community centers, museums and libraries, religious institutions, jails and professional sports stadiums.
- **Mixed-Use Residential/Commercial Development** – See the definition above. This category is analyzed twice due to the presence of both residential and commercial services. Analyses of all urban land, however, do not double-count this land use type.
- **Mixed-Use Industrial/Commercial Development** – This use includes any parcels where there is a roughly equal mix of industrial and commercial uses. On-site offices of industrial operations are included in the industrial category.

Changed Land Use

The 2005 update of the San Francisco Bay Area Existing Land Use Map allowed for an analysis of land that has changed uses in the last five years from previous uses. This "changed" land use includes new development on formerly undeveloped lands (including urban and agricultural development), as well as areas that have been redeveloped from one urban land use to another. The update also includes detailed information on 2005 Existing Land Use. No equivalent file detailed enough for the purposes of this analysis is available for 2000. Thus, this analysis cannot discuss urbanization rates in comparison to the year 2000. In addition, this appendix can only generalize urbanization rates in hazard areas by comparing 2005 land uses in hazard areas to 2000-2005 changed land uses in hazard areas (as is done in figure 2).

More Information

Tables of existing land use for 2000, 2005, and land use change by hazard, city, and county area available at http://quake.abag.ca.gov/mitigation/pickdbh2.html.

Overview of Land Use Patterns in the Bay Area

General Land Uses in the Region

The San Francisco Bay Area consists of approximately 4.4 million acres of land, of which 26.0% is urbanized, 21.4% is used for agriculture, and the remainder of which is undeveloped rangeland (27.8%), forest land (21.8%), or wetlands (2.4%). The major type of land use varies strongly by county, from completely urbanized San Francisco County to Napa County, which has only a few medium-sized towns and one small city. Figure 3 depicts existing land uses across the region, while Figure 4 shows general land uses by subregions. As can be seen from both Figures 3 and 4, the most rural counties are Napa, Sonoma, and Solano Counties, in which nearly half (41.4%) of the land is used for agriculture. Marin and San Mateo Counties are the next most rural, with a significant amount of built-out urban development along the Bay shore, and large rural and undeveloped areas closer to the coast. In addition, much of Marin County and some of San Mateo County's undeveloped areas are federal or state protected lands that will not experience any new development. Contra Costa, Alameda, and Santa Clara Counties all are highly urbanized along the Bay shore, with varying degrees of development further inland. All three of these counties are experiencing tremendous further urbanization as they have available lands (see the sections "Past Land Use Development Trends 1985-2005" and "Projected Land Use Development Trends 2005-2030"). San Francisco County is by far the most urbanized county in the region, with 97.7% of the land characterized as urban in 2005.

Urban Land Use Types in the Region

TABLE 1 – Percentage of All Urban Land in Each Category by County (2005)

	Residential	Employment Areas (excluding Roads and Highways)	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	Other Urban Land*
9-County Region	58.3%	21.3%	0.2%	0.4%	19.8%
Alameda County	49.7%	26.8%	0.1%	0.9%	22.5%
Contra Costa	54.6%	20.3%	0.0%	0.0%	25.1%
Marin County	72.1%	15.9%	0.0%	0.0%	12.0%
Napa County	65.7%	17.3%	0.1%	0.1%	16.8%
San Francisco County	42.9%	19.7%	4.6%	0.0%	32.8%
San Mateo County	65.2%	21.3%	0.2%	1.9%	11.4%
Santa Clara County	57.1%	26.3%	0.1%	0.3%	16.2%
Solano County	55.0%	19.4%	0.1%	0.0%	25.4%
Sonoma County	64.3%	16.7%	0.1%	0.0%	19.0%

* Other Urban Land is defined as Military Land, Urban Parks, Cemeteries, Vacant Land, and land use for extensive recreation, such as golf courses, campgrounds, and race tracks.

As shown in Table 1, residential development is the majority of urban development in the region, both across and within counties. Table 2 shows that rural residential development (less than 1 unit per acre) is the most common type of residential development in the most rural counties mentioned previously. In the three largely-urbanized counties of Alameda, Contra Costa, and Santa Clara, medium-density residential development (3-8 units per acre) is the most common form of residential development. This type of development is characterized by moderate to large single-family homes in suburban areas. Only San Francisco is characterized by high density development (over 8 units an acre) due to its highly urban nature. In addition, San Francisco is the only county in the region to have a significant amount of mixed use (residential/commercial) development. It is important to note that, while rural residential development takes up a large number of acres (37.9%), the number of housing units is approximately only 15-20% of all housing units in the region (based upon estimates from the ***2005 Existing Land Use Report*** [Perkins and others, 2006] and the ***2000 US Census)***.

The most common form of employment land use across the region is industrial (including light and heavy industrial, warehousing, and food processing), followed very closely by commercial services (retail, office, research centers, hotels and motels) and public/institutional uses. By county, these three uses are typically the most widespread uses, with the most common use being industrial in five counties and commercial in the other four.

TABLE 2 – Percentage of Residential Land in Each Density Category by County (2005)

The most common density category in each county is highlighted.

	Rural Residential (<1 unit/acre)	Low Density (1-3 units/acre)	Medium Density (3-8 units/acre)	High Density Residential (>1 unit/acre)	Mobile Home Parks	Mixed Use Residential/ Commercial
9-County Region	37.9%	12.0%	33.5%	15.4%	1.0%	0.3%
Alameda County	9.6%	11.0%	51.9%	26.1%	1.1%	0.2%
Contra Costa	14.0%	20.1%	43.0%	22.2%	0.7%	0.0%
Marin County	37.2%	27.4%	26.0%	8.8%	0.6%	0.0%
Napa County	50.5%	12.7%	24.1%	8.6%	3.9%	0.2%
San Francisco County	0.0%	0.3%	4.2%	85.7%	0.0%	9.8%
San Mateo County	42.9%	13.6%	25.7%	16.8%	0.7%	0.3%
Santa Clara County	21.7%	11.4%	53.9%	12.4%	0.4%	0.1%
Solano County	53.3%	5.5%	36.3%	3.8%	0.9%	0.2%
Sonoma County	74.1%	6.6%	9.8%	8.1%	1.4%	0.1%

TABLE 3 – Percentage of Employment Land of Each Type Category by County (2005)

The most common land use category in each county is highlighted.

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial
9-County Region	30.4%	34.6%	9.8%	22.8%	0.9%	1.6%
Alameda County	28.6%	35.8%	11.9%	20.2%	0.4%	3.1%
Contra Costa	23.6%	40.8%	10.7%	25.0%	0.0%	0.0%
Marin County	78.2%	8.7%	6.6%	6.4%	0.0%	0.0%
Napa County	13.8%	56.3%	20.6%	7.8%	0.7%	0.8%
San Francisco County	35.3%	18.9%	0.9%	25.8%	19.0%	0.1%
San Mateo County	27.1%	17.4%	22.4%	24.3%	0.9%	8.0%
Santa Clara County	36.1%	28.9%	5.6%	28.0%	0.3%	1.0%
Solano County	28.5%	35.8%	9.5%	25.6%	0.5%	0.0%
Sonoma County	25.3%	48.5%	6.0%	19.8%	0.5%	0.0%

Urban Land Use Development Patterns in the Region

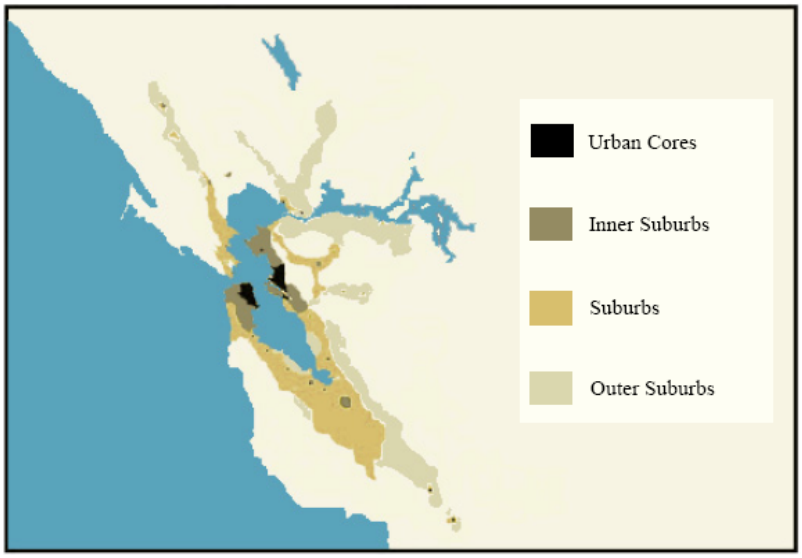
The urban Bay Area has been broadly classified according to the time period of development into:

- **Inner Cities** or **Urban Cores** (areas largely built out by 1900);
- **Inner Suburbs** (areas which developed between 1900 and 1940);
- **Suburbs** (areas which developed between 1940 and 1980); and
- **Outer Suburbs** (areas which developed after 1980).

This classification is based upon ***Geography and Urban Evolution of the San Francisco Bay Area*** (Vance, 1964), which discusses the process of growth and change in the Bay Area, and interpretations of the urban growth that has occurred since 1964.

Figure 5 depicts these different zones in broad terms. It should be noted that within the suburb and outer suburb zones, there may or may not be small urban pockets that were developed before World War II; however, because of the broadness of this diagram, they are not shown.

FIGURE 5 – Spatial-Temporal Development Diagram of the San Francisco Bay Area



Inner Cities and Urban Cores

The Bay Area's inner cities constitute the historic core of the region and include the urban centers of Oakland and San Francisco. These cities, typically built out by 1900, are characterized by streets arranged in grids. These areas also generally have the largest populations in the Bay Area (with the exception of San Jose), and contain medium to high-density residential and high density employment centers in the city centers. Nearly all of San Francisco's residential land, for example, occurs at a density of greater than eight units per acre. These areas are also often characterized by a large amount of mixed-use development when compared to more recently developed areas.

Inner Suburbs

The Bay Area's inner suburbs include those suburbs that developed after the turn of the century and before World War II. These areas typically developed around the streetcar and railroad systems, which were the main transportation networks for the Bay Area during this time period. Included within these zones are the residential areas surrounding the inner city as well as those communities that developed as the railroad system expanded beyond core areas during the teens and twenties. Generally, the urban form of these areas continues to follow a grid pattern. Typically they consist of residential areas with commercial development along arterial streets. Areas characterized by inner suburbs include the region just south of San Francisco, as well as parts of the East Bay north of Oakland such as the cities of Richmond, Berkeley, and Alameda, as well as parts of San Jose.

Suburbs

This classification refers to the large portions of the Bay Area that developed after World War II and before 1980. Referred to by Vance (1964) as "non-centric industrial and housing areas", most of the urban Bay Area falls within these areas. According to the 2000 Census, 76% of the Bay Area housing stock has been built since 1950, with 68% of those homes built between 1950 and 1980 (52% of all homes that were built after 1950). While suburbs include large and varied portions of the Bay Area, these areas developed around a newly expanding automobile transportation system. These areas are characterized by the prevalence of wide commercial arterials connecting pockets of single-family dwellings. Areas that fall into this category include the majority of the South Bay and Peninsula, as well as areas in the East Bay south of Oakland, along the I-680 corridor, and much of eastern Marin County.

Outer Suburbs

Outer suburbs are those areas with new residential use that have been subdivided in the last 10 or 15 years. These are primarily located around some of the smaller old railroad communities in the outlying portions of the greater Bay Area. Typically these areas are characterized by residential development in the form of single-family dwelling subdivisions and large retail service developments with high square-footage ("big box") stores. These areas continue the pattern of development along highway corridors, including Interstate 80 in the North Bay, Highways 4 and 580 in the East Bay, and Highway 101 in the South and North Bay areas. Cities typical of this type of development include Dublin and Livermore in Alameda County, Petaluma in Sonoma County, and Antioch in Contra Costa County.

Past Land Use Development Trends (1985-2005)

Two major trends appear when analyzing land use changes in the Bay Area in recent years. The first trend is that of continued outward expansion of suburbs and the conversion of agricultural and grazing land into suburban developments. This is a typical pattern seen across the country, and, in the Bay Area, this has significant implications for the potential impacts of hazards. This is because this pattern of development is increasingly occurring in low-lying agricultural areas and areas exposed to high wildfire threat or liquefaction susceptibility. The second trend is that of the redevelopment of urbanized areas, especially in formerly industrial areas. This trend has become increasingly common in the past ten to fifteen years. These trends exist through all four

Spatial-Temporal Development Zones in the Bay Area and, as will be demonstrated, the predicted growth can be largely interpreted by these two development trends.

Figure 6 shows the areas in the region that have changed land use in the last five years. These areas are discussed in more detail below. It can be seen, however, that, with one significant exception, the major land use changes have been the development (or redevelopment) into residential and employment areas. The significant exception to this is in Sonoma and Napa counties, where large areas have been converted to vineyards and wineries.

Inner Cities and Urban Cores

Land use change within the urban core areas of the Bay Area during the last twenty years has consisted largely of the redevelopment of large industrial areas, former military areas, or small-scale individual lots of a variety of prior land uses.

Alameda County's urban cores recently experienced significant amounts of redevelopment of these large industrial areas. For example, areas such as Emeryville and West Oakland saw part of the former industrial area along or near the Bay shore converted to large-scale developments such as the Emery Bay outdoor mall (which is currently in the process of adding residential units). In addition, many "smart growth" high-density mixed-use developments have been built adjacent to public transit stations. Examples of these developments include the Mandela Gateway Hope VI project by the West Oakland BART Station and the Fruitvale Station by the Fruitvale BART Station in Oakland.

In San Francisco, the Rincon and Mission Bay Areas have also seen significant redevelopment in the past decade. In the Rincon District, formerly industrial areas have been redeveloped into commercial and residential towers, expanding San Francisco's downtown south. In the Mission Bay District, the extension of the University of California San Francisco campus, complete with supporting residential and commercial services, has revitalized another formerly industrial area.

Military land has also served as another major source of land for redevelopment, as many bases in the region have been closed and ceded from military control in the past 15 years. For example, construction has just begun in parts of the former Hunter's Point Shipyard in San Francisco, which unofficially closed in the mid 1970's but has since been mired in costly cleanup of pollutants, being designated a Superfund site in the 1980's. Also, the Presidio in San Francisco was transferred from the military to the National Park Service in the mid 1990's and has since both been used as parkland and as office and retail space for a variety of industries. The latest development on the Presidio, the Letterman Digital Arts Center, is a 23-acre redevelopment of the former Letterman Medical Center which now houses Lucasfilm's operations. In addition, the Oakland Army Base was transferred from the military to the Oakland Redevelopment Agency in the early 2000s and is currently under redevelopment planning.

With these types of exceptions, land use changes tended to be limited to specific lots and specific buildings.

Inner Suburbs

The inner suburb areas have experienced very modest changes in the past twenty years, maintaining essentially the same form and land uses that were originally established in these

areas. Some changes have occurred, however, and these areas are experiencing some redevelopment where land is available. For example, the Richmond Marina saw new residential and commercial-service development in the last twenty years.

Like the urban cores, the inner suburbs have recently had land freed up from military base closures. Specifically, the Alameda Naval Air Station in Alameda County and Treasure Island in San Francisco County are currently in the planning processes for redevelopment. Currently the Final Alameda Point Reuse Plan has been approved, and calls for the redevelopment of the 700 acres base into a variety of uses. These uses include significant mixed-use development in a walkable civic center, various densities of residential development, urban parks and open space, protected wetlands, a golf course, and a sports complex. Preliminary Treasure Island redevelopment proposals suggest a similar redevelopment pattern, with the possibility of agriculture on the island as well.

Suburbs

Although these areas experienced changes in land use during the 1985-2005 period in the form of infill development, the scale of these infill projects tends to be large and focused around wide commercial arterials. The construction of apartments and condominiums as well as the infill of large-scale service, retail and office developments has been fairly typical of the development in many suburbs. Overall, the suburban areas of the region experienced the greatest diversity in land use change of any of the four Development Zones.

Regions of the Bay Area, such as the I-880 Corridor in San Jose, I-680 corridor in Alameda and Contra Costa counties and the Highway 85 corridor in Santa Clara County, have continued to experience modest but diverse land use changes. In both these instances, development occurred in the form of residential development, as well as growth of commercial and light industrial uses. For example, during the past twenty years, Blackhawk in Contra Costa County grew from a few hundred residential units to thousands of residential units. Modest growth resulting in land use changes also occurred in some areas along San Pablo Bay in the North Bay. In the Highway 85 corridor, some land that was classified as “Marsh” or “Sparsely Vegetated” now is utilized mostly by “Light Industry.” A notable exception is an area east of Fremont that was once used as golf course. It is now one of the few areas surrounding the bay which is, for the most part, being allowed to revert to “Marsh.”

Outer Suburbs

The expansion of the outer suburbs was the major type of land use change in the region from 1985-2005. This type of development generally turned non-urban land uses, such as rangeland, forestland, and agricultural land, into the low-density pattern of land use mentioned previously. This development has occurred mainly in four counties: Alameda (Livermore, Pleasanton, Dublin), Santa Clara (Morgan Hill, Gilroy, San Jose), Contra Costa (Antioch, Brentwood, Oakley, Pittsburg), and Solano (Fairfield, Vacaville, Rio Vista). These counties are similar in that they all have significant amounts of undeveloped land which have provided room for this type of low-density development to occur.

A significant exception to this type of development occurred in Sonoma and Napa counties, which, due to the success and growth of the wine industry, have taken large steps to promote new winery and vineyard development. Strict urban growth policies restricting growth outside

of city boundaries and promoting wine industry expansion and development have resulted in the development of thousands of acres of new vineyards in the last five years.

Land Use in Hazard Areas (2005)

General Land Uses in Hazard Areas

The first step in making an analysis of land use in hazard areas is to establish the base case for all other statistics to be compared against. For the purposes of this appendix, the base case is to analyze how much land in each county is in the high hazard area for a particular hazard. This analysis uses the newly completed 2005 existing land use information to more accurately reflect current development in hazard areas.

Table 4 gives the percentage of all land in each high hazard area by county and across the entire region. According to these percentages, the hazards that are most prevalent are wildfire threat (59.3%) and earthquake shaking (37.1%), followed by rainfall-induced landslides (23.1%) and liquefaction susceptibility (22.3%). By comparing individual counties to the region as a whole, one can begin to determine which threats are most significant to a particular county. For example, 79.5% of Marin County's land is in a high wildfire threat area, far above the region's total of 59.3%. Similarly, San Francisco and San Mateo counties are particularly susceptible to earthquake shaking, with 78.3% and 83.4% of the land in the high hazard area respectively.

The first analysis that can be undertaken is to better understand the nature of development in the high hazard areas. Specifically, it is important to understand how much of the high hazard land is urban, as this suggests the risk to people and property due to a given hazard. Table 5 shows the percentage of the high hazard land within counties and across the region that is urbanized.

This statistic can be used with Table 4 to understand the nature of the risk imposed by a hazard in a given county. For instance, although Sonoma and Napa County both have similar amounts of land in high liquefaction susceptibility areas, Sonoma County has developed upon 41.4% of these lands, while Napa County has developed only 15.9% of these lands. Liquefaction, therefore, is significantly more of a risk in Sonoma County than Napa County, despite similar amounts of land in the high hazard areas.

Table 5 by itself also demonstrates that there is a significant amount of development in nearly all high hazard areas. Across the region, over 20% of the high hazard area has been developed for seven of the ten hazards discussed in this appendix, and over 50% of the high hazard land has been developed for two of those hazards. Most importantly, the amount of urban land in the high hazard areas tends to reflect the degree of urbanization in the county, with percentages lowest in the rural counties and highest in the most urban counties. What this suggests is that, with some exceptions, urban development in the region probably traditionally occurred without a strong regard for hazard concerns. If the alternative were true (hazard concerns have strongly affected the pattern of urban development), then one would expect to see levels of urbanization in hazard areas less correlated with levels of urbanization and more reflective of land use policies restricting development in hazard areas.

This conclusion is complicated by the fact that land use controls occur at the local, not the county, level and that urbanization would be reflected in the data somewhat regardless of land use policies.

TABLE 4 – Percentage of All (Urban and Non Urban) Land in High Hazard Areas* by County (2005)

	Fault Study Zone	Earthquake Shaking Potential	Liquefaction Susceptibility	Liquefaction Study Zone*	Earthquake-Induced Landslide Study Zone*	100-Year Flood Zone	Rainfall-Induced Landslide Areas	Wildfire Threat	Wildland-Urban-Interface Threat Areas*	Dam Failure Inundation
9-County Region	1.8%	37.1%	22.3%	15.1%	9.2%	9.1%	23.1%	59.3%	18.5%	10.3%
Alameda County	3.2%	51.3%	27.7%	20.2%	6.9%	8.1%	26.8%	57.2%	19.6%	18.7%
Contra Costa County	1.1%	28.6%	29.1%	N/A	N/A	13.8%	21.7%	48.2%	33.6%	7.0%
Marin County	1.8%	56.8%	14.8%	N/A	N/A	6.3%	35.0%	79.5%	17.9%	1.8%
Napa County	0.3%	2.5%	10.1%	N/A	N/A	6.1%	18.6%	77.8%	10.5%	5.6%
San Francisco County	0.0%	78.3%	48.9%	20.2%	3.4%	0.0%	1.0%	2.3%	46.8%	5.9%
San Mateo County	3.7%	83.4%	17.2%	N/A	N/A	3.6%	23.0%	49.3%	24.7%	3.7%
Santa Clara County	2.6%	46.8%	20.9%	12.0%	10.6%	6.6%	29.7%	66.1%	16.0%	12.0%
Solano County	0.7%	13.2%	49.2%	N/A	N/A	30.4%	4.8%	18.9%	9.4%	25.7%
Sonoma County	1.8%	34.5%	12.8%	N/A	N/A	2.8%	24.9%	70.1%	19.2%	5.3%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

The conclusion remain intuitive, however, given that many cities have not adopted regulations regarding many of these hazards, as well as the fact that many of these areas were built previous to State of California regulations regarding development and hazards. The analysis of change in hazard areas will discuss if and how this has changed in recent years (see the section "Changes in Land Use Development in Hazard Areas 2000-2005").

Land Use "Densities" in Hazard Areas

It is important to note a few pieces of information before further examining land use in hazard areas. First, in analyzing the density of development occurring in a given hazard zone, it should not be surprising that the most common density is largely a function of the type of development that is common in the county of concern (see Tables 2 and 3). For example, since the majority of residential development in the Bay Area is either rural or medium density, one should expect to see these types of development occurring most frequently in hazard areas. This expectation is borne out in the available data, as demonstrated in Table 6.

TABLE 5 – Percentage of High Hazard Land* that is Urban by County (2005)

	Fault Study Zone	Earthquake Shaking Potential	Liquefaction Susceptibility	Liquefaction Study Zone*	Earthquake-Induced Landslide Study Zone*	100-Year Flood Zone	Rainfall-Induced Landslide Areas	Wildfire Threat	Wildland-Urban-Interface Threat Areas *	Dam Failure Inundation
9-County Region	32.4%	38.6%	44.6%	78.5%	18.8%	22.4%	9.4%	9.9%	67.9%	45.2%
Alameda County	52.3%	59.5%	68.8%	73.5%	34.7%	31.9%	7.5%	10.0%	83.8%	64.2%
Contra Costa County	68.5%	60.9%	44.1%	N/A	N/A	22.5%	20.2%	17.1%	77.2%	57.3%
Marin County	12.7%	12.1%	38.0%	N/A	N/A	31.3%	8.4%	6.5%	68.5%	43.2%
Napa County	28.7%	9.3%	15.9%	N/A	N/A	12.9%	2.4%	3.5%	31.2%	21.6%
San Francisco County	0.0%	98.8%	97.2%	97.5%	94.3%	0.0%	99.0%	87.4%	97.7%	99.7%
San Mateo County	44.1%	39.2%	68.8%	N/A	N/A	48.1%	13.3%	11.7%	78.8%	89.5%
Santa Clara County	19.9%	44.7%	72.3%	82.1%	11.9%	47.0%	4.1%	5.0%	70.3%	71.6%
Solano County	28.9%	9.3%	14.8%	N/A	N/A	9.0%	13.4%	19.0%	67.3%	12.6%
Sonoma County	20.6%	25.5%	41.4%	N/A	N/A	31.6%	12.5%	14.3%	54.5%	41.3%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Second, because of this trend above, one must be careful when making generalizations about the susceptibility of a type of development to a particular hazard based upon the type of development
in the hazard area. A good example of this concerns San Francisco County, in which the residential development is almost exclusively high density. Almost all land in any hazard zone in San Francisco is therefore high density, and this says nothing of the susceptibility of high density housing to a particular disaster. Some generalizations can be drawn from the data, however, concerning the susceptibility of a particular *residential* density to some of the hazards. For others, however, no obvious trends appear. The trends that can be drawn from the data in Table 7 are listed below:

- **Liquefaction Susceptibility** increases with increasing density, as higher density residential developments are more likely to be built either on landfill or in floodplains than rural homes.
- **Tsunamis Threat** can be assumed to be related only to the proximity to the shoreline, not to the type of development, despite the lack of data to directly demonstrate this fact.
- **Rainfall-Induced Landslide Areas** decrease with increasing density, as more developed areas will have more measures in place to prevent landslides than rural areas, as well as more impervious surfaces and storm sewers.

- **Wildfire (including Wildland Urban Interface) Threat** - As density intensifies, the risk of fire is increased due to introduced vegetation and structures adding fuel for a wildland fire. Wildfire threat is reduced once urban densities are reached due to the loss of vegetation and changes in building construction.
- **Mobile Home Park Land** tends to be more subject to flooding, liquefaction and dam failure inundation than other densities, likely due to the fact that mobile park homes are often situated in areas where permanent development is unsafe or undesirable.

Finally, two types of tables have been prepared for each major category of use (residential density and employment use). The first table is intended to answer the question "How much of this hazard area is a particular density or use?" It therefore gives percentages that relate to the total land in that particular hazard area. The second table answers the question "How much of a particular density or use is in the hazard area?" The percentages therefore relate to the amount of land in that particular density or use category.

TABLE 6 – Percentage of All Residential Land in High Hazard Areas* by Density (2005)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the residential development in this high hazard area is this density."

	Rural Residential (<1 unit/acre or 1-5 acres/unit)	Low-Density Residential (1-3 units/acre)	Medium-Density Residential (3-8 units/acre)	High-Density Residential (>8 units/acre)	Mobile Home Park Land	Mixed Use Residential/ Commercial	All Residential Development
Fault Study Zone	40.2%	12.9%	33.0%	12.8%	0.9%	0.2%	100.0%
Earthquake Shaking Potential	27.3%	12.7%	37.7%	20.9%	1.0%	0.4%	100.0%
Liquefaction Susceptibility	19.5%	9.9%	46.2%	22.3%	1.6%	0.5%	100.0%
Liquefaction Study Zone*	5.3%	3.7%	58.2%	30.4%	1.8%	0.5%	100.0%
Earthquake-Induced Landslide Study Zone*	10.1%	10.1%	67.6%	11.6%	0.1%	0.4%	100.0%
100-Year Flood Zone	32.0%	11.5%	39.6%	14.0%	2.6%	0.3%	100.0%
Rainfall-Induced Landslide Areas	63.6%	13.5%	14.4%	8.2%	0.3%	0.0%	100.0%
Wildfire Threat	73.0%	9.4%	10.2%	6.9%	0.4%	0.0%	100.0%
Wildland-Urban-Interface Threat Areas*	37.8%	15.5%	32.0%	13.5%	0.9%	0.3%	100.0%
Dam Failure Inundation	21.3%	8.2%	47.1%	21.8%	1.3%	0.3%	100.0%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Fault Study Zones

Fault rupture represents a minor hazard across the region, with only 1.8% of all the land in the region in the Fault Study Zones (which, as stated previously, is an overestimate of the actual land in danger of surface ruptures). Areas subject to surface rupture are strictly regulated by the Alquist-Priolo Earthquake Fault Zoning Act of 1972 (see the section "Projections of Future Land Uses in Hazard Areas"), which means that no residential structures and essentially no other structures can be built astride active faults subject to surface rupture. It should therefore be expected that there has been no new development or redevelopment on the faults themselves, and very little change in the Fault Study Zones.

TABLE 7 – Percentage of Each Residential Density in High Hazard Areas* by Hazard (2005)

The density with the largest percentage of land in the high hazard area is highlighted.
This table should be read as "Across the region, x% of the residential development of this density is in the high hazard area for this hazard."

	Rural Residential (<1 unit/acre or 1-5 acres/unit)	Low-Density Residential (1-3 units/acre)	Medium-Density Residential (3-8 units/acre)	High-Density Residential (>8 units/acre)	Mobile Home Park Land	Mixed Use Residential/ Commercial	All Densities
Fault Study Zone	2.4%	2.4%	2.2%	1.9%	2.1%	1.7%	2.3%
Earthquake Shaking Potential	37.9%	55.5%	59.3%	71.2%	53.0%	72.0%	52.5%
Liquefaction Susceptibility	16.3%	26.2%	43.8%	45.8%	51.5%	46.4%	31.7%
Liquefaction Study Zone *	9.3%	9.5%	31.8%	38.3%	73.1%	20.7%	27.5%
Earthquake-Induced Landslide Study Zone *	2.8%	4.1%	5.8%	2.3%	0.5%	2.7%	4.3%
100-Year Flood Zone	3.7%	4.2%	5.2%	4.0%	11.8%	4.3%	4.4%
Rainfall-Induced Landslide Areas	16.6%	11.2%	4.2%	5.2%	2.9%	0.4%	9.9%
Wildfire Threat	47.9%	19.5%	7.6%	11.1%	10.8%	2.8%	24.8%
Wildland-Urban-Interface Threat Areas *	58.2%	75.6%	55.6%	51.1%	52.2%	50.1%	58.2%
Dam Failure Inundation	7.8%	9.4%	19.5%	19.6%	19.1%	11.4%	13.8%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Existing Land Use (2005)

- Among existing residential densities, rural residential is the most prevalent in the Fault Study Zones, representing 40.2% of all the residential land in the Study Zones.
- Overall, 2.3% of residential land is present in the Fault Study Zones.
- Counties of note include San Mateo, in which 5.5% of all residential land is in the Study Zone, with 16.4% of all of the mobile home park land, and 9.4% of all rural residential in the county in Fault Study Zones. In addition, 12.8% of Alameda County's mixed-use development is in Fault Study Zones.
- No fault traces in San Francisco have been designated as active by the State Geologist meaning that no land is in these study zones in that county, despite its high shaking potential.
- In terms of existing employment land use types, the most prevalent use in the Fault Study Zones is industrial (32.7%), followed closely by commercial services (31.0%).
- Overall, 1.8% of the employment land is in the Study Zones, led by public/institutional land, 3.0c% of which is in the study zone.
- The only county of note is Napa County, in which 10.5% of the infrastructure is in the Fault Study Zones.

TABLE 8 – Percentage of All Employment Land in High Hazard Areas* by Type (2005)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the employment-oriented development in this high hazard area is this type."

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	All Employment-Oriented Development
Fault Study Zone	18.8%	31.5%	10.9%	37.3%	0.8%	0.7%	100.0%
Earthquake Shaking Potential	31.0%	32.7%	10.1%	23.0%	1.0%	2.2%	100.0%
Liquefaction Susceptibility	33.4%	35.8%	10.7%	17.8%	0.6%	1.7%	100.0%
Liquefaction Study Zone*	29.9%	42.6%	11.6%	12.7%	0.5%	2.6%	100.0%
Earthquake-Induced Landslide Study Zone *	23.5%	18.2%	2.3%	54.8%	1.2%	0.0%	100.0%
100-Year Flood Zone	31.8%	44.4%	12.9%	8.0%	0.3%	2.7%	100.0%
Rainfall-Induced Landslide Areas	29.8%	39.7%	3.4%	25.7%	0.1%	1.2%	100.0%
Wildfire Threat	32.3%	20.1%	10.2%	35.8%	0.3%	1.4%	100.0%
Wildland-Urban-Interface Threat Areas *	31.1%	28.9%	7.3%	30.1%	1.2%	1.4%	100.0%
Dam Failure Inundation	33.7%	39.6%	6.7%	17.6%	0.4%	2.0%	100.0%

* See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Changed Land Use (2000-2005)

- 2.1% of changed residential and 1.0% of the changed employment land occurred in Fault Study Zones.

While it is uncertain where in the Study Zones these changes are taking place, it must be assumed that State law is being properly enforced and no new structures have been built in the past five years astride active faults. The percentage of new development in the Study Zones generally reflects this, with one exception. This is in San Mateo County, where 13.6% of new rural residential and 58.8% of new or redeveloped Mobile Home Park Land is in the Fault Study Zones! This discrepancy is probably accounted for by the fact that both of these things can occur without actual construction of a dwelling on an active fault, and that construction of a single home is also exempt from the act. Mobile home parks do not consist of permanent structures and, since the majority of a rural residential parcel is not built upon, there likely are no homes built on any active faults.

TABLE 9 -Percentage of Each Employment Type in High Hazard Areas* by Hazard (2005)

The land use with the largest percentage of land in the high hazard area is highlighted.
This table should be read as "Across the region, x% of the development of this type is in the high hazard area for this hazard."

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	All Types
Fault Study Zone	1.1%	1.7%	2.0%	3.0%	1.7%	0.8%	1.8%
Earthquake Shaking Potential	65.1%	60.1%	65.7%	64.3%	72.0%	88.6%	63.7%
Liquefaction Susceptibility	59.5%	55.8%	58.9%	42.1%	35.8%	58.7%	54.0%
Liquefaction Study Zone*	49.1%	73.0%	77.1%	27.9%	20.7%	75.0%	53.8%
Earthquake-Induced Landslide Study Zone*	2.3%	1.9%	0.9%	7.2%	2.7%	0.1%	3.2%
100-Year Flood Zone	13.8%	16.9%	17.3%	4.6%	4.3%	22.1%	13.2%
Rainfall-Induced Landslide Areas	3.4%	4.0%	1.2%	3.9%	0.5%	2.6%	3.5%
Wildfire Threat	9.2%	5.0%	9.0%	13.6%	2.8%	7.4%	8.7%
Wildland-Urban-Interface Threat Areas*	35.1%	28.6%	25.4%	45.3%	50.1%	29.9%	34.3%
Dam Failure Inundation	28.3%	29.1%	17.4%	19.7%	11.4%	31.3%	25.5%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Earthquake Shaking Potential

The most significant hazard to the majority of residential land in the Bay Area is earthquakes and the damage that would result from shaking. The high hazard area is pervasive throughout almost all of the Bay Area, as there are a number of active faults in the region. The highest potential for shaking occurs near fault lines which run through or adjacent to most counties, but especially San Francisco, San Mateo, western Alameda, western Contra Costa, Sonoma, and western Marin counties. Shaking Potential is relatively low in Napa and Solano counties, as well as in eastern Contra Costa County. Across the region 37.1%, of the region's land is in a high hazard area for shaking potential, second only to wildfire threat. Shaking potential poses a much more significant threat than wildfires because it acts over a much larger area for any given event, and is much higher in highly urbanized areas than wildfire, representing a higher risk of life and property. This earthquake threat will be exacerbated by the added threat of earthquake-induced wildfires.

TABLE 10 – Percentage of All Residential Land in High Hazard Areas* by Density (2000-2005 Change)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the new or redeveloped residential development in this high hazard area is this density."

	Rural Residential (<1 unit/acre or 1-5 acres/unit)	Low-Density Residential (1-3 units/acre)	Medium-Density Residential (3-8 units/acre)	High-Density Residential (>8 units/acre)	Mobile Home Park Land	Mixed Use Residential/ Commercial	All Residential Development
Fault Study Zone	30.2%	16.5%	23.9%	22.8%	6.6%	0.1%	100.0%
Earthquake Shaking Potential	24.0%	13.8%	17.6%	41.6%	2.3%	0.6%	100.0%
Liquefaction Susceptibility	18.5%	10.0%	28.8%	39.7%	2.2%	0.7%	100.0%
Liquefaction Study Zone*	9.8%	8.0%	14.8%	62.2%	4.8%	0.4%	100.0%
Earthquake-Induced Landslide Study Zone*	47.5%	28.4%	16.2%	7.9%	0.0%	0.0%	100.0%
100-Year Flood Zone	26.5%	11.4%	21.7%	38.4%	1.8%	0.1%	100.0%
Rainfall-Induced Landslide Areas	37.2%	14.2%	10.5%	35.1%	3.0%	0.0%	100.0%
Wildfire Threat	29.9%	16.0%	24.0%	29.0%	0.8%	0.3%	100.0%
Wildland-Urban-Interface Threat Areas*	41.0%	11.4%	15.4%	29.9%	2.2%	0.0%	100.0%
Dam Failure Inundation	21.0%	9.6%	25.6%	40.1%	3.5%	0.2%	100.0%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Existing Land Use (2005)

- Of all residential densities, medium density residential is the most prevalent in the high hazard area for shaking potential (37.7%), a fact which reflects that this is the most common type of residential development in the more urbanized counties (mentioned above).
- 52.5% of all residential land in the region is in the high hazard area for shaking.
- High-density residential and mixed-use developments are most represented, with 71.2% and 72.0% of the land in those densities in the high hazard area respectively. Again, this is reflective of the fact that the high hazard area for shaking potential occurs largely in the older urbanized, higher density areas of the region such as Oakland, San Francisco, and San Mateo County.
- While the percentages are high across all densities (generally 20-50% in all counties except Napa), San Mateo County has a staggering 90.9% of its residential land in the high hazard area! This is followed by San Francisco and Alameda counties, with 80.1% and 79.9% of all residential land in the high hazard areas respectively.

TABLE 11 – Percentage of Each Residential Density in High Hazard Areas* by Hazard (2000-2005 Change)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the new or redeveloped residential development of this density is in the high hazard area for this hazard."

	Rural Residential (<1 unit/acre or 1-5 acres/unit)	Low-Density Residential (1-3 units/acre)	Medium-Density Residential (3-8 units/acre)	High-Density Residential (>8 units/acre)	Mobile Home Park Land	Mixed Use Residential/ Commercial	All Densities
Fault Study Zone	2.3%	2.7%	2.1%	1.4%	8.2%	0.8%	2.1%
Earthquake Shaking Potential	38.4%	47.3%	33.2%	54.6%	60.8%	72.4%	44.3%
Liquefaction Susceptibility	19.9%	23.1%	36.4%	35.0%	38.3%	58.3%	29.7%
Liquefaction Study Zone*	11.3%	12.9%	17.6%	43.4%	36.1%	10.2%	25.5%
Earthquake-Induced Landslide Study Zone*	16.6%	13.9%	5.8%	1.7%	0.0%	0.0%	7.7%
100-Year Flood Zone	5.0%	4.6%	4.8%	5.9%	5.7%	1.6%	5.2%
Rainfall-Induced Landslide Areas	16.3%	13.3%	5.4%	12.6%	21.6%	0.0%	12.1%
Wildfire Threat	41.6%	24.9%	18.4%	24.9%	36.6%	0.0%	28.1%
Wildland-Urban-Interface Threat Areas*	69.5%	79.9%	65.5%	55.3%	30.8%	47.2%	64.4%
Dam Failure Inundation	9.8%	9.6%	14.1%	15.4%	27.3%	6.3%	12.9%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

TABLE 12 – Percentage of All Employment Land in High Hazard Areas* by Type (2000-2005 Change)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the new or redeveloped employment-oriented development in this high hazard area is this type."

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	All Types
Fault Study Zone	38.0%	39.3%	0.0%	22.2%	0.4%	0.0%	100.0%
Earthquake Shaking Potential	47.6%	43.1%	0.2%	8.0%	0.6%	0.4%	100.0%
Liquefaction Susceptibility	51.0%	40.0%	0.3%	7.8%	0.6%	0.4%	100.0%
Liquefaction Study Zone*	48.3%	47.7%	0.4%	2.9%	0.1%	0.6%	100.0%
Earthquake-Induced Landslide Study Zone*	80.2%	3.1%	0.0%	16.8%	0.0%	0.0%	100.0%
100-Year Flood Zone	50.1%	44.8%	0.3%	4.6%	0.1%	0.0%	100.0%
Rainfall-Induced Landslide Areas	30.0%	63.1%	0.0%	6.9%	0.0%	0.0%	100.0%
Wildfire Threat	35.3%	53.3%	0.0%	11.4%	0.0%	0.0%	100.0%
Wildland-Urban-Interface Threat Areas*	47.9%	37.8%	0.1%	13.3%	0.7%	0.3%	100.0%
Dam Failure Inundation	47.1%	47.3%	0.1%	5.3%	0.1%	0.0%	100.0%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Changed Land Use (2005)

- 44.3% of all changed residential and 64.1% of all changed employment lands were in the high hazard area for shaking.
- Mixed-use (residential/commercial) development had the most change in the high hazard zone, at 72.4%.

Among counties, changed high-density residential had a particularly large percentage of development in the hazard areas, including 92.9% in Alameda, 88.2% in San Mateo, and 85.8% in Santa Clara counties.

Earthquake-Induced Landslide Study Zones

Similar to the Fault Study Zone situation, the areas of high hazard from earthquake-induced landslides are represented here by their presence in the CGS Landslide Study Zones. This again means that the number of acres at risk is overrepresented in this analysis, and serves only as a proxy for development in the actual high hazard areas. In addition, the Study Zone Mapping is still in progress and maps have been created for Alameda, San Francisco, and Santa Clara

TABLE 13 – Percentage of Each Commercial Type in High Hazard Areas* by Hazard (2000-2005 Change)

The land use with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the new or redeveloped land of this type is in the high hazard area for this hazard."

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	All Types
Fault Study Zone	0.8%	0.9%	0.0%	2.2%	0.8%	0.0%	1.0%
Earthquake Shaking Potential	66.3%	64.6%	70.2%	51.6%	72.4%	66.0%	64.1%
Liquefaction Susceptibility	61.7%	52.1%	74.5%	43.5%	58.3%	53.2%	55.7%
Liquefaction Study Zone*	55.1%	68.8%	92.6%	21.4%	10.2%	71.4%	57.8%
Earthquake-Induced Landslide Study Zone*	1.8%	0.1%	0.0%	2.5%	0.0%	0.0%	1.1%
100-Year Flood Zone	14.6%	14.0%	23.4%	6.2%	1.6%	1.1%	13.4%
Rainfall-Induced Landslide Areas	2.2%	4.9%	0.0%	2.3%	0.0%	0.0%	3.3%
Wildfire Threat	8.9%	14.5%	0.0%	13.3%	0.0%	1.1%	11.6%
Wildland-Urban-Interface Threat Areas*	37.8%	32.1%	10.6%	48.5%	47.2%	25.5%	36.4%
Dam Failure Inundation	31.0%	33.6%	10.6%	16.2%	6.3%	3.2%	30.3%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

counties only. The numbers presented here only represent these parts of the region. It is therefore very difficult to draw any conclusion as to the potential seriousness of this hazard at the current time.

Existing Land Use (2005)

- In the available areas, 9.2% of all land is located within the Study Zones.
- Of all existing residential development in these areas, 4.3% is in the Study Zones, the majority of which (67.6%) is medium-density residential, reflecting the most common form of residential development in the available areas.
- Alameda County has the most residential land in the Study Zone at 6.9%.
- Of all available existing employment areas, only 3.2% is in the Study Zones, a disproportionate amount of which (54.8%) is public or institutional. This trend is especially true in Alameda County, where 93.6% of the land in the Study Zone is public or institutional.

Changed Land Use (2000-2005)

- Examining recent land use changes paints roughly the same picture.
- Across all three counties, 7.7% of the changed residential land and 1.1% of the changed employment areas are in the Study Zones.
- Residential percentages are comparably high, especially in Santa Clara County, where 10.7% of the change residential land is in the Study Zone.
- In San Francisco, no redeveloped land in the last five years was in the Study Zone.

Liquefaction Susceptibility

Liquefaction susceptibility is one of the more significant hazards in the region, for a number of reasons. First, the higher susceptibility categories represent 22.3% of the region's land. Second, there is a high degree of urbanization that has occurred in these areas (44.6%), especially in the areas along the Bay shore in nearly every county (but especially in San Francisco, Alameda, Contra Costa, and Santa Clara counties) in the region. Third, the liquefaction poses a threat to the infrastructure of pipes and roads that comes with urbanization (28.1% of the 2004 existing infrastructure miles is located in the high hazard area for liquefaction).

Additionally, the threat of liquefaction is important in the low-lying agricultural lands in the San Francisco Bay-Delta, which includes eastern Contra Costa and Solano Counties. These areas are protected by levees which are susceptible to breach due to liquefaction of the soils underneath the levees, with a significant potential to flood agricultural, and, increasingly, suburban land. These levee failures might also impact water supply by disrupting the water delivery system.

Existing Land Use (2005)

- Across the region, 31.7% of all residential land is in the high hazard area, with medium-density residential comprising the majority (46.2%) of the hazard area.
- High-density and rural residential are also highly present in the hazard area, reflecting the fact that the high hazard area lies largely in older areas along the bay and in the delta areas of Solano and Contra Costa Counties.
- Alameda (46.4%), San Francisco (42.2%), and Santa Clara counties (48.4%) have very high levels of residential land in the high hazard areas.
- In Santa Clara County, four of the six residential densities have over 50% of the land in the high hazard area.
- Among all employment areas, the numbers are generally higher than for residential, with 54.0% of all employment types in the high hazard area.
- Santa Clara County especially has a significant amount of land in the high hazard area (71.6%).
- Among employment land uses, industrial is generally the most prevalent in the high hazard areas, which reflects the large amount of industrial development along the Bay shore in most counties in the region.

Changed Land Use (2000-2005)

- Recent changes in land use show similar statistics, suggesting that development and redevelopment in liquefaction high hazard areas is continuing at roughly the same pace as it traditionally has occurred.

- Across residential densities, high density is most prevalent (39.7%) for all of the changed land in the hazard area, followed by medium density (28.8%).
- San Francisco has redeveloped the most residential land in the high hazard area (51.3%), followed again by Alameda and Santa Clara Counties.
- Again, the numbers were generally higher for employment areas than for residential areas, with 55.7% of the changed employment areas in the high hazard area.
- Commercial services and industrial were the most prevalent changed employment areas in the high hazard area, representing 51.0% and 40.0% of this land in the high hazard area.
- Marin, San Francisco, and Santa Clara counties have the highest percentages of changed employment land, with more than 70% of this in the high hazard area for each county.

100-Year Flood Zones

Areas susceptible to flooding are geographically similar to the areas that are susceptible to liquefaction, so there is a significant overlap in development in these two hazard areas. Specifically, approximately half of the land that is in the high hazard area for liquefaction is in the 100-year flood zone ("flood zone"). The areas most subject to flooding in the region are along the southern part of San Francisco Bay (southwestern Alameda County, northern Santa Clara County), the northern parts of San Pablo and Suisun Bay (southern Napa and Solano Counties), and the delta region (northeastern Contra Costa and eastern Solano Counties).

Existing Land Use (2005)

- Across existing residential densities, 4.4% of the land is in the 100-year flood zone, with medium-density residential (39.6%) and rural residential (32.0%) making up the bulk of the residential in the flood zone.
- A disproportionate amount of the mobile home park land (11.8%) is located in the flood zone, likely for reasons mentioned previously (this is true across nearly every county as well).
- By county, the amount of residential development in the 100-year flood zone varies from 0% (San Francisco) to approximately 7% (Napa, Santa Clara, and Solano counties).
- Mixed-use development (residential/commercial) is also slightly disproportionately located in 100-year flood zone, especially in Santa Clara County, where 32.0% of the county's mixed use development is located in the flood zone.
- Similar to the liquefaction susceptibility areas, employment land use types generally have higher percentages of land in the flood zone than do residential densities, with 13.4% of all types in the flood zone.
- Among the counties, industrial generally has the highest percentage of land in the Flood Zone. Commercial and infrastructure have slightly less land in the flood zone, and, in some cases, have more land in the flood zone than industrial.
- Marin County has the most employment development in the flood zone (29.7%) of all counties, with 74.1% of that development being commercial services.

Changed Land Use (2000-2005)

- The changed land use numbers suggest that development in the 100-year flood zone has certainly continued, and likely increased fairly significantly in the last five years.

- The amount of changed residential land in the flood zone is 5.2%, which is higher than the existing 2005 statistic (which means that the 2000 statistic was actually much lower than 4.4%).
- Employment land uses as a whole have not particularly increased in the flood zone, though development has continued there, with 13.4% of the changed employment development in the flood zone.
- Marin, Contra Costa, and Santa Clara counties experienced the largest amount of changed residential land use in the flood zone at 7-8%.
- No one residential density had more changes in the flood zone across counties, with all densities except mixed use at roughly 5-6%.
- In terms of employment land, Marin County again had the highest amount of change in the flood zone at 59.7% of all changed employment land (although this was only 37 acres total).
- Across counties, commercial services (14.6%) and industrial (14.0%) were most developed in the flood zone. It must be noted that, while a higher percentage of changed infrastructure (23.4%) was in the flood zone, this amounted to only 11 changed acres (as opposed to roughly 1500 changed acres each for industrial and commercial services).

Rainfall-Induced Landslide Areas

While landslides are prevalent throughout the region (23.1% of the region is in a high hazard0 area for landslides), they pose a relatively small danger (when compared to earthquakes or liquefaction) for at least three reasons. First, they are highly localized in nature, and any one landslide is unlikely to cause damage to more than a few structures, unless there are very severe landslides caused by particularly heavy rains. Second, only a very small portion (9.4%) of the high hazard area for landslides has been urbanized as of 2005. Third, most of the urbanized areas in the high hazard area are rural, posing an overall small risk to homes and businesses. However, understanding land use in landslide areas is important because land use controls (such as prohibiting development on unstable soils or steep slopes) are the most effective and cheapest way to prevent loss of life and property due to landslides.

Existing Land Use (2005)

- Across the region, 9.9% of the residential development is in the high hazard area, of which 63.6% of the land is rural residential.
- With some exceptions the amount of land in the high hazard area generally decreases with increasing residential density, both across and within counties.
- The counties with the largest amount of residential land in the high hazard area are Marin (21.2%) and Sonoma (14.4%), followed by Contra Costa and San Mateo (with roughly 12% each).
- Employment land uses have lower percentages of land in the high hazard area than residential uses across all counties, with only 3.5% of all employment land in the high hazard area in the region.
- Across the region, industrial is most prevalent in the high hazard area (39.7% of high hazard land) followed by commercial services (39.8%) and public or institutional (25.7%).

Changed Land Use (2000-2005)

- Development is still occurring in areas subject to landslides across the region, as 12.1% of the changed residential land use and 3.3% of the changed employment land was in the high hazard area.

- Significantly more changed development in the high hazard area was residential than employment-oriented (4200 acres of changed residential versus 780 acres of changed employment land).
- Marin, Sonoma and Contra Costa had the most residential changed land in high hazard areas in the region, and Sonoma had the most changed employment land in the region.

Wildfire

In this appendix, threat due to fire is measured using two separate hazard maps, WUI threat and wildfire threat. The California Department of Forestry (CDF) separates has created these two maps based upon the nature of response to the fire; local jurisdictions respond to fires in WUI threat areas, while CDF responds to those in the wildfire threat areas. In addition, as noted in Appendix C, there is a difference in probability of a fire occurring in the different threat areas; fires are statistically more likely to occur in wildfire threat areas than WUI threat areas (based upon past acreage burned in each area).

This separation of fire hazards into two hazard areas is essentially artificial, and this separation affects the way the data show the relationship between fires and land uses. Specifically, wildfire threat clearly is highest in rural densities and lowers with increasing density, while WUI threat peaks at low densities and then decreases as vegetation is lost due to urbanization. Examining either one of these two maps by itself therefore gives a somewhat misleading picture of the true nature of fire as it relates to urban densities. As density intensifies, the risk of fire is increased due to introduced vegetation and structures adding fuel for a wildland fire. Wildfire threat is reduced once urban densities are reached due to the loss of vegetation is lost and changes in building construction.

Wildfire Threat

Of all hazards, the threat of wildfires is likely the most causally linked to the density of development in an area, with an inverse relationship existing between density and wildfire threat. This can be seen in the general county land uses, where the counties with the smallest amounts of urban land generally have the highest potential for wildfires. For example, in San Francisco County, the only lands subject to wildfire threat are in the large park areas such as Golden Gate Park and the Presidio, not in highly urbanized areas. It can also be seen in the existing residential densities, where the amount of land in the wildfire threat areas generally dramatically decreases between the two lower densities and the two higher densities. The causal link is fairly simple in that highly urbanized areas lack the fuel load in terms of vegetation (especially dry dead vegetation and tinder) when compared to rural areas. Wildfires therefore pose a significantly higher threat to the development in rural areas than to the development in urban areas.

Existing Land Use (2005)

- Across all counties, 24.8% of all residential land is in a high wildfire threat area, with rural residential comprising 73.0% of that area. Nearly half (47.9%) of the rural residential land in the region is in a high wildfire threat area.
- Rural Sonoma County (74.1% rural residential) alone comprises 46.3% of all of the residential acres in the region in the high wildfire threat area.

- Counties in which the majority of residential land is rural (San Mateo, Marin, Solano, Sonoma, Napa) have roughly 20%-50% of the residential land in high wildfire threat areas. The other counties (in which rural is not the most common form of residential development) have 0%-16% of the residential land in the threat areas.
- While the figures are smaller for existing employment lands, similar comparisons can be drawn across counties, as less urbanized counties have higher percentages of land in the high hazard areas.
- Among employment land types, commercial, industrial, and public or institutional lands tend to share the highest percentages in the wildfire threat areas, the top one varying by county.
- Overall, 8.7% of existing employment lands was in the high wildfire threat areas.

Changed Land Use (2000-2005)

- As for many other hazards, changed land use patterns are very similar to existing land use patterns for both residential and employment densities. 28.1% of changed residential lands and 11.6% of changed employment lands are in the high hazard area.
- North Bay counties (Sonoma, Marin, and Napa) have the highest amount of changed residential lands in wildfire threat areas (44.2%, 39.0%, and 33.9% respectively).
- Going against two generalizations, Contra Costa (a fairly urbanized county) has also had 31.2% of the changed residential development in the county in high wildfire threat areas, the majority of which (48.1%) is high-density residential.
- Due mostly to the above fact, changed high-density residential represents approximately 30% of all changed residential development in the high wildfire threat areas (second only to rural residential).
- 50.1% of the changed employment land in Napa County (including 69.1% of commercial services land) and 32.4% of the changed employment land in Sonoma County was in the high wildfire threat area. The actual effect is much bigger in Sonoma County, as there were roughly 1,500 acres of changed employment in threat areas in that county, versus 350 acres in Napa County.

Wildland-Urban-Interface Threat Areas

The amount of development in the WUI threat areas is very high when compared to most other hazards, reflecting the large threat that wildfire poses to the much of region's residential development.

Existing Land Use (2005)

- 58.2% of the region's residential development is in WUI threat areas, including 58.2% of the rural residential and 75.6% of the low-density residential development.
- Contra Costa and Marin counties, in particular, had very high levels of residential development in the WUI threat areas, with approximately 78% of all densities in the threat areas.
- In Contra Costa County, 91.6% of all low-density residential development (15,585 acres) is in the WUI threat areas.
- Values for existing employment lands were much lower than residential lands, with 34.3% of the employment lands in the WUI threat areas.
- Marin (59.2%), Contra Costa (48.0%), and San Mateo counties (46.6%) had the most employment lands in WUI threat areas.

Changed Land Use (2000-2005)

- Residential development continued at a dramatic rate in the WUI threat areas, with 64.4% of the changed residential land and 36.4% of the changed employment land in the WUI threat areas.
- Across the region, 79.9% of the changed low-density residential was in a WUI threat area.
- Across all counties, no one changed residential density had consistently higher percentages of development in threat areas than others. Very generally, however, the two lower densities (rural and low-density) tend to have larger proportions of land in the threat areas than the higher densities.
- Again, Contra Costa, San Mateo and Marin counties had the largest percentage of changed development in the WUI threat areas.

Dam Inundation Areas

Dam failure presents a relatively small but potentially very significant threat to the region. While only 10.3% of the region's land is in a dam inundation area, nearly half of this land (45.2%) is urbanized. This percentage includes 99.7% of San Francisco, 89.5% of San Mateo, 71.6% of Santa Clara, and 64.2% of Alameda counties. In fact only two counties have less than 25% of the land in the dam inundation areas urbanized (Napa and Solano). Dam failures therefore present a very high potential risk for loss of life and property (For exposure estimates, see Appendix F).

Existing Land Use (2005)

- Across all counties 13.8% of the existing residential land and 25.5% of the existing employment land is located in dam inundation areas.
- Within the dam inundation areas of most counties, the representation of residential densities is consistent with the representation of the densities in the rest of the county. The exceptions are San Mateo, Napa, and Marin counties, which all three have medium-density residential as the most common form of residential development in the dam inundation areas.
- Across counties, medium-density residential is the most common form of residential development in the dam inundation areas, representing 47.1% of all residential land in the dam inundation areas.
- Prevalence of land in the dam inundation areas increases with increasing residential density across nearly every county. The only exception is Solano County, where the large majority of land in the dam inundation areas is agricultural (and thus the associated land is low density and rural).
- Among employment land types, commercial, industrial, and public or institutional lands tend to share the highest percentages in the dam inundation areas, the top one varying by county.
- Santa Clara (43.1%) and Alameda (36.6%) counties have the most employment land in the dam inundation areas, including 64.4% of Santa Clara's infrastructure and 48.7% of Alameda's industrial.

Changed Land Use (2000-2005)

- Across all counties, 13.0% of the changed residential land and 30.3% of the changed employment land is located in the dam inundation areas, similar numbers to 2005 existing numbers.

- For the region, high-density residential is the most common form of changed residential land use in dam inundation areas, at 40.1%. Within counties, the most common density varies considerably from one county to the next.
- Santa Clara (25.5%) and Alameda (30.8%) counties have the most changed residential land in the dam inundation areas, including approximately 37% of Alameda's medium and high-density residential.
- For the region, commercial services and industrial comprise nearly all of the changed employment land uses in dam inundation areas, at 47.3% and 47.1% respectively. This is true for each county as well.
- Santa Clara (51.7%) and Alameda (42.4%) counties have the most changed employment land in the dam inundation areas, including 62.7% of Santa Clara's industrial.

Drought

Drought is a fairly unique type of hazard in that it deals with the supply of a physical resource that can be directly manipulated, moved, and stored. The impacts of a drought therefore, unlike most of the other hazards, can be prevented (or at least drastically mitigated), given adequate planning before a drought year. It therefore is less practical to discuss drought in terms of geographically delineated "drought hazard areas" than it is to discuss how different residential densities use water, and thus how they can be differently affected by drought.

Residential water use statistics are reported by the 90 local or regional water districts in the Bay Area to the California Department of Water Resources (DWR). DWR breaks up residential water use into statistics by customer class, which is a measure generally reflects the density of development. Specifically, DWR breaks up residential customer classes into Single-Family Residential, which includes rural, low and medium-density development, and Multifamily Residential, which includes medium- to high-density development. Residential water use is further broken up into two categories of use: indoor and outdoor. Indoor uses include dishwashing and laundry, showers, and other household uses of water. Outdoor uses, which focus on maintenance of landscaping and gardens, are generally more water intensive than indoor uses. For example, in 2000, outdoor residential use of water comprised 52% of all residential water use, and 33% of all urban water use. Figure 7 demonstrates both the break up of customer class as well as amount of water consumed in 2000 for each customer class in the Bay Area.

Thus, residential densities with more landscaping will have a much higher outdoor water use, and a corresponding higher total water use, than residential densities with little or no landscaping. Since lower densities generally have higher levels of landscaping than higher densities, it can be generalized that, as residential density decreases, water use increases. This generalization is borne out in available data, as demonstrated in Table 14 below. Notice how, while indoor water use is comparable between densities (and is in fact lower for Single Family Residential), outdoor water use is significantly higher for lower-density developments, making overall water use higher at lower densities. This is accentuated by the fact that most higher-density development in the region occurs in areas that are generally cooler, such as San Francisco, San Mateo, western Alameda, and western Contra Costa counties, compared with lower-density areas in the drier regions in the North and South Bay, as well as the eastern parts of Alameda and Contra Costa counties.

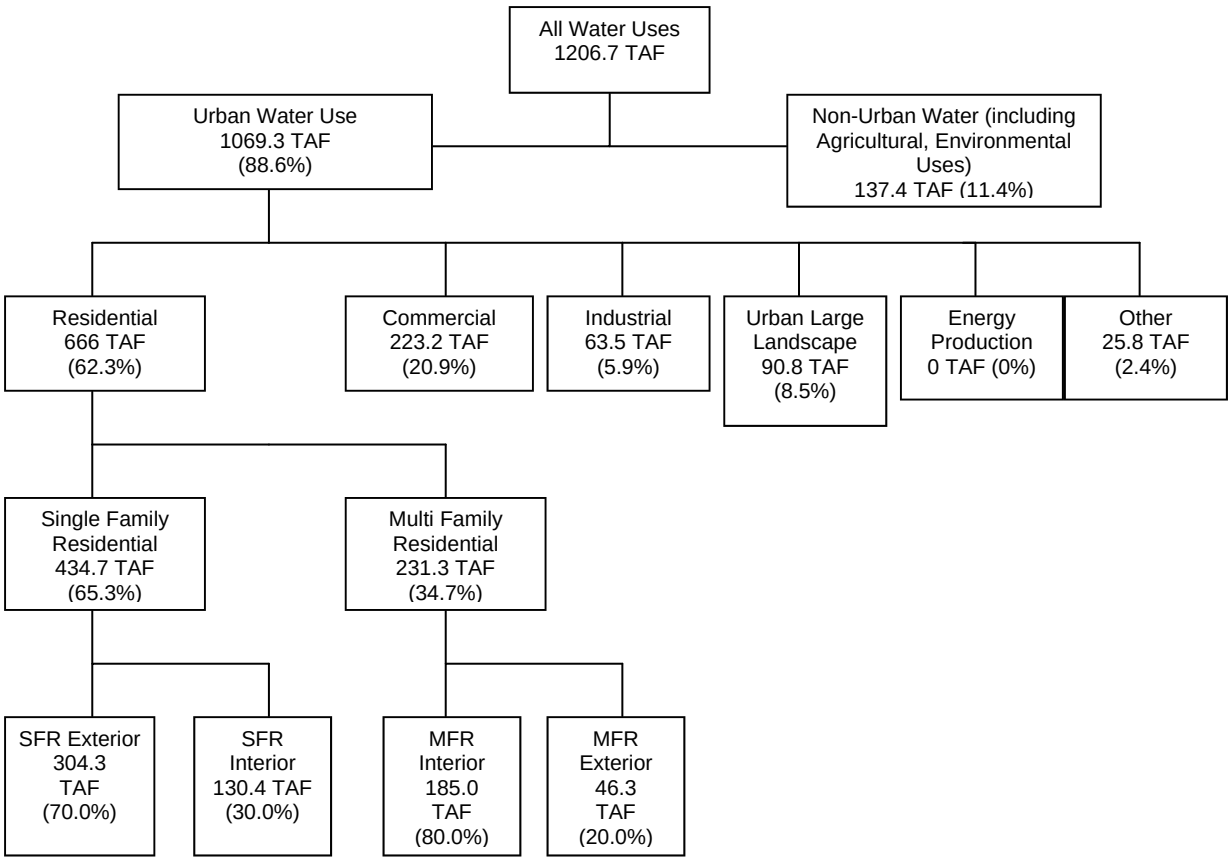


FIGURE 7 – Bay Area Water Use in 2000 by Customer Class (DWR in print)
Percentages indicate percentage of parent category, not of total water use.

How different residential areas will be affected by drought is a complex mixture of how much water is normally used in that area (which is, in part, a function of the density of that area), the policies of the water agency for that area, and the intensity and duration of the drought. The Urban Water Management Planning Act, passed by the State in 1983, requires all water districts with at least 3,000 customers to create an Urban Water Management Plan in order to obtain state drought mitigation funding. Generally, as part of this plan, water districts create a Water Shortage Contingency Plan to discuss what conservation, pricing, and regulatory measures will take effect during water shortages of varying intensities and durations. Thus, when drought occurs for a particular water district, the effects are spread out over the service area according to the contingency plan of that district, rather than felt in a particular "hazard area." In addition, every water district has different general policies on water use and water recycling, and this affects how much water its customers consume. In general, outdoor uses are less essential to normal household function than indoor uses, and thus are more likely to be cut back first during a drought. Indoor water conservation measures would take place only when outdoor conservation and pricing measures do not alleviate the drought.

Table 14 – Bay Area Residential Water Use (1998, 2000, and 2001)
Units are Thousand Acre Feet

	Single Family Residential-Exterior	Percent of Total Residential Water Use	Single Family Residential-Interior	Percent of Total Residential Water Use	All Single Family Residential Percentage of Total Residential Water Use	Multiple Family Residential-Exterior	Percent of Total Residential Water Use	Multiple Family Residential-Interior	Percent of Total Residential Water Use	All Multiple Family Residential Percentage of Total Residential Water Use
1998	280.0	45.5%	120.3	19.6%	65.1%	42.8	7.0%	171.3	27.9%	34.9%
2000	304.3	45.7%	130.4	19.6%	65.3%	46.3	7.0%	185.0	27.7%	34.7%
2001	317.0	45.6%	135.9	19.6%	65.2%	48.4	7.0%	193.5	27.8%	34.8%

(Source: DWR, 2005)

Projected Land Use Development Trends (2005-2030)

This county-by-county analysis uses projected job growth a proxy for commercial development and projected household growth as a proxy for residential development.

An analysis of projected growth trends indicates that three counties will likely dominate the urban development in the next 25 years. The first is Santa Clara, which is the most populated county in the region and is expected to continue to grow the fastest (in numbers of households). The next fastest counties are Alameda and Contra Costa counties, which are also the second and third most populous counties respectively. These two counties are expected to experience the largest job growth between now and 2030, followed by Santa Clara County. The dominance by these three counties can be explained by recalling the two main development patterns explained in the previous section. Namely, these three counties are experiencing both patterns of development, in that previously developed areas urban areas are redeveloping and outlying areas composed of agricultural and rural land are developing into residential suburbs. These counties are experiencing both patterns of growth because they have both the available land for outward expansion as well as because some local governments are making efforts to promote redevelopment of existing urban areas. The remaining counties do not have the available land or have taken steps to declare much of the unincorporated land off-limits to development. These counties are therefore projected to experience less growth in the next ten years than the three mentioned above.

Alameda County

Alameda County is expected to experience a tremendous amount of growth, largely due to the redevelopment of Oakland and other cities in northern Alameda County, which began within the past decade and is projected to continue picking up pace. This development has been almost exclusively residential and commercial, as cities pursue urban revitalization project that are either high-density residential, commercial, or mixed-use developments. Oakland alone is

expected to add more than 40,000 new households by 2030. In addition, suburban cities in the Tri-Valley area (Pleasanton, Dublin, and Livermore) and southern Alameda County (Fremont, Newark, Union City) will likely continue outward single-use residential and commercial expansion. Overall, over 134,860 new households and 341,370 new jobs are expected to be added in Alameda County.

Contra Costa County

Between now and 2030, Contra Costa County is expected to add approximately 88,350 new households, with major development continuing to occur in outlying cities such as San Ramon, Brentwood, and Concord and Antioch at first. In fact, 47% of the county's growth in the next ten years is expected to occur in the outlying eastern cities of the county, combining low and medium density single-use suburban development, and some low-density mixed use development. Growth will likely slow somewhat in these areas after 2015. In addition, there will likely be some urban redevelopment occurring in the western county cities of Richmond and Hercules as vacant and industrial land is reused. Jobs growth and commercial development is projected to be about half that of Alameda County, with almost 170,860 new jobs to be added by 2030. This growth is expected to occur largely in the cities of Hercules, Pittsburgh, and Antioch (which are all located along the major east-west transportation corridor of Highway 4), and Concord and San Ramon (located along the major north-south I-680 corridor). Despite the development of new land into suburban neighborhoods, the county is expected to retain two-thirds of its agricultural and rural open space by 2030.

Marin County

Marin County is one of the least populated counties in the region largely due to the lack of developable land in the county. The small population is due to the county's mountainous terrain, the presence of a significant amount of parkland that is federally or State owned, and smart growth policies in the county that have preserved a large portion of the remaining agricultural lands. In addition, the aging and affluent nature of the county's residents means that there will likely be little increase in the population; few children are born that can replace the aging population and the area is generally too expensive for newcomers with families to move there. The development that will likely occur in the county is expected to occur largely in the City of Novato, Marin's largest city, which is expected to add over 15,000 new jobs and approximately 4,000 new households by 2030, the majority of which will likely be low density single family homes. Overall, Marin County is projected to add approximately 13,000 new households and 38,000 new jobs.

Napa County

Napa County's land use patterns center on the wine industry and the profits that it creates, from both the production of grapes and wine and the resulting tourism that it attracts. Napa is the least populous county in the region and has only five incorporated areas, of which the City of Napa is the largest. It is therefore expected that there will be little growth, especially in the unincorporated areas, where growth should slow due to the county's growth policies that discourage development in favor of agriculture. The significant majority of growth is expected to occur in the two largest cities, Napa and American Canyon, which are forecasted to add roughly 7,000 of the county's new 8,200 households by 2030. The majority of the 19,800 jobs added will likely be related to the wine and tourist industries or to providing services for

residents, and development should reflect this by remaining near cities or by agricultural and winery development in the outlying areas of the county.

San Francisco County

The City and County of San Francisco is unique in the region in that it has no undeveloped land available for expansion, and all of the County's development must therefore come in the form of redevelopment and revitalization of former industrial and military areas. San Francisco's development is one of the densest in the United States, and new development will likely continue to reflect this pattern. For example, the South of Market area (SOMA) is already experiencing very high-density residential and commercial development as new high rises are constructed, a pattern which is likely to continue. Other areas to be redeveloped include the Mission Bay and Bayview/Hunter's Point areas, which are receiving light rail and transit-oriented style development. Overall, San Francisco is expected to add 59,500 new households and 253,000 new jobs by 2030, maintaining its status as the region's cultural and economic center.

San Mateo County

San Mateo County's location between the employment centers of San Francisco and the Silicon Valley has allowed it to develop in such a way that its residents now supply a large portion of the neighboring counties' workforces. San Mateo is therefore a county of 20 small to medium-sized cities that are largely of an older, medium-density suburban residential character. Its economy is linked to both San Francisco and Santa Clara counties, and has seen a drop off in the number of jobs as the economy slowed in 2000. Job growth and commercial development is expected to continue slowly through 2015, after which it will likely increase pace. Residential development will also likely be slow, with the county adding only 36,000 new households by 2030, distributed over the whole north-south axis of the county.

Santa Clara County

The Bay Area's most populous county, despite the setbacks of the early 2000's, is forecasted to continue to expand fairly rapidly (proportionally), led by the region's most populous city, San Jose. As stated before, this trend is due to the large amount of developable land on the outskirts of the county, as well as the fact that many local governments are focusing on urban redevelopment, especially as it is linked to transit. San Jose in particular is expected to add nearly 95,000 of the county's 167,000 new households, much of it along transit-oriented developments along new and planned extensions of light rail, Caltrain and BART extension. San Jose is projected to also add 220,000 of the County's new 437,000 jobs. Other regions expected to experience growth will be Mountain View in northern Santa Clara County, which is projected to add 22,000 new jobs, and the cities of Santa Clara and Sunnyvale which are expected to collectively add approximately 22,000 new households by 2030. The cities of Gilroy and Morgan Hill in southern Santa Clara County will likely also expand rapidly given their current small size.

Solano County

Solano County is expected to experience the highest percentage of growth in coming years of all regions, with the population growing by more than one-third by 2030. This growth will likely take place almost exclusively in the seven incorporated areas in the county, due to the Orderly Growth Initiative passed in 1994, which restricts development on agricultural lands. The

development in the county is projected to take place largely in the three centers of Solano County, the cities of Vacaville, Vallejo, and Fairfield. Fairfield alone is expected to add 37,000 of the county's 52,000 new households by 2030. This development is likely to be very low-density residential, continuing current patterns, especially in the more northerly cities of Fairfield and Vacaville.

Sonoma County

Sonoma County, a largely rural county with the exception of a few medium sized-cities, is projected to experience strong proportional growth, largely due to its diversified economy and large amount of developable land. The growth will likely occur mainly in the largest cities, especially Santa Rosa, the largest city in the county, which is expected to add 53,000 new jobs and 14,000 new households by 2015. The character of this development is likely to continue on the current path of very low-density development on the outskirts of the cities. Overall, Sonoma County is expected to add 31,000 new households and 104,000 new jobs by 2030.

Projections of Future Land Uses in Hazard Areas

There are strong pressures to build in areas of natural hazards. ABAG's **Projections 2005** forecasts for the region to grow from a population of 7,091,700 in 2005 to 8,747,100 in 2030. At the same time, these people, who live in 2,582,980 households in 2005, are projected to live in 3,182,220 households in 2030. Finally, while the Bay Area employed 3,516,960 in 2005, it is expected to employ 5,120,600 people in 2030.

This growth continues to place increasing pressure on the region to expand urban development, both by increasing the density of areas of existing urban and inner suburban housing, and by the conversion of agricultural and grazing lands to suburban development.

Yet at the same time there are strong pressures not to build in hazardous areas. Over the past few decades, a desire to build more disaster-resistant communities and create more environmentally-sensitive growth has led to a series of state laws and local regulations. These restrictions on development are intended to promote one of the eight major objectives of this Local Hazard Mitigation Plan:

> ***Land use change needs to be accompanied by a respect for hazardous areas and facilities, as well as recognize the interconnected nature of the Bay Area.***

Because these conflicting pressures concerning development in hazard area have been in existence for several years, it is probable that the development trends and future land use densities in these areas of the last five years will continue for the foreseeable future. This trend, however, will be affected by more stringent mitigation measures and a continual replacement of older structures and development with new, better engineered, but denser, development.

While it is impossible to know the extent and location of all new urban development, the trends suggest that there will be increased infill development in urban cores combined with continued development of outlying areas, possibly using a more transit-oriented and mixed-use approach. To the extent that redevelopment increases, this densification will lead to a slower increase in exposure to wildfires and landslides because these are more likely to occur in lower-density areas. In addition,

due to lower per capita water use in multifamily areas, this densification will also lead to a slower increase in exposure to drought and water supply shortages. On the other hand, higher densities in existing urban areas will accelerate the exposure to liquefaction, flooding, and earthquake shaking.

It is important to mention that, while land use regulation has not played a major role in mitigating the effects of hazards, there has been a significant focus on strategies such as building and fire codes, public awareness campaigns, and other approaches to mitigating hazards as outlined in this Local Hazard Mitigation Plan. All of these can significantly reduce the potential effects of any hazard, and occasionally lessen the severity of a disaster. Yet there is no single mitigation strategy that is as foolproof as controlling land use in hazard areas. Simply not developing or limiting development to a certain type within hazard areas reduces the potential effects of a hazard dramatically and possibly eliminates any potential losses. While this is a very strong argument for hazard information to play a much larger role in land use decisions (and land use regulation to play a much larger role in hazard mitigation efforts), this change is unlikely to occur due to the inertia of planning and development decision-making.

There is little indication that hazard information will play any more or less of a role in land use decisions than it currently does today. The ***Seismic Hazards Mapping Act*** of 1990 may provide increased incorporation of liquefaction and earthquake-induced landslide concerns into development decisions as new mapping occurs. Perhaps the most encouraging fact is that there is increased concern among citizens and policy makers following Hurricane Katrina in 2005. How this increased concern will play into development decisions and regulations surrounding hazards has yet to be seen. Interestingly, the California Legislative Analyst recently issued a statement that discusses reducing risks trough land use decisions, which may signal an increased awareness on these issues at the state level (California Legislative Analyst, 2006).

Two State laws related to land use and disaster mitigation were enacted in the early 1970s and a third one was enacted in 1990. Additional local regulations typically have been instituted more recently. Some have been implemented as a result of adopting annexes to the Bay Area multi-jurisdictional Local Hazard Mitigation Plan. For a comprehensive picture of the priorities being established for the identified strategies, see **http://quake.abag.ca.gov/mitigation/strategy.html.**

The following sections catalog some of the State laws and local regulations controlling development in hazard areas that could potentially affect future land use densities in hazard areas. These laws take varying approaches to mitigating the effects of hazards. At their most efficient, these controls can eliminate a hazard, particularly hazards associated with new construction. On the other hand, most regulations are merely requirements to mitigate a hazard through engineering, not avoidance of the land where the hazard is located. Finally, for two of the hazards (dam failure and tsunamis) the strategy is to expedite evacuations, not mitigation.

State Laws Applying to Multiple Hazards

Every city and county is required to prepare a General Plan. Over the years, required elements have been specified, including the Safety and Seismic Safety elements (now consolidated into a single Safety Element), which has been required since 1971. The General Plan contains seven required elements outlining local policies guiding future development in the jurisdiction. Local zoning for future development is required to be consistent with the policies identified in this

General Plan (except for in charter cities). All California cities and counties have a Safety Element, either as a separate document or integrated into their General Plan. As part of that plan, jurisdictions must identify and map natural hazards.

Most of the local governments are implementing the mitigation strategies of their annexes to this multi-jurisdictional plan by adopting them as an implementation appendix to their Safety Elements. This re-examination of the Safety Element will be useful, for many of these elements are several years old and out of date. See http://ceres.ca.gov/planning/genplan/gpg.pdf for the California ***General Plan Guidelines*** published by the California Office of Planning and Research (OPR).

Local Regulations Applying to Multiple Hazards

Smart Growth programs are intended to revitalize urban areas and promote sustainability **as an alternative to developing in outlying and hazard-prone areas**. ABAG and the other regional agencies in the region, including the Metropolitan Transportation Commission (MTC) and the Bay Area Air Quality Management District have adopted polices to promote Smart Growth. In addition, boards of supervisors of all nine Bay Area counties and city councils of 66 of the regions cities have taken action in support of the objectives of the Bay Area Alliance for Sustainable Communities, is a multi-stakeholder coalition established in 1997 to develop and implement an action plan that will lead to a more sustainable region. Ways to meld Smart Growth and sustainability concepts with hazard mitigation include –

1) Prioritizing retrofit of infrastructure that serves urban areas over constructing new infrastructure to serve outlying areas.
2) Working to retrofit homes in older areas to provide safe housing close to job centers.
3) Working to retrofit older downtown areas to protect architectural diversity and promote disaster-resistance.
4) Protecting areas susceptible to extreme hazards as open space.
5) Providing new buffers and preserving existing buffers between urban development and existing users of large amounts of hazardous materials, such as major industry, due to the potential for catastrophic releases in a major earthquake, flood, or terrorism disaster.

Hillside development can be problematic due to the potential hazards of wildfire and landsliding. The pressure to convert hillside areas to urban uses is great, however, in inner suburban communities that have no remaining non-urban land, as well as in communities actively preserving agricultural land (particularly in the North Bay where vineyards are prevalent). Tools to mitigate risks available to local governments are –

1) Establishing a buffer zone between residential properties and landslide or wildfire hazard areas.
2) Discouraging, adding additional mitigation strategies for, or preventing construction on slopes greater than a set percentage, such as 15%, due to landslide or wildfire hazard concerns.

State Laws Applying to Earthquakes

The ***Seismic Hazards Mapping Act*** of 1990 requires the preparation of site-specific geotechnical reports for development proposals in areas identified as Zones of Required Investigation for ***earthquake-induced landslides or liquefaction*** as designated by the State Geologist. Cities and Counties are also required to incorporate the Official Seismic Hazard Zone Maps into their Safety Elements. Lastly, the Seismic Hazards Mapping Act, as well as the Natural Hazard Disclosure Statement, requires sellers of real property to disclose to buyers if property is within a Zone of Required Investigation. Due to funding, Seismic Hazard Zone maps have only been completed in selected portions of the Bay Area. As maps become available, affected cities and counties are required to enforce the preparation of these reports and condition project approval on the incorporation of necessary mitigation measures related to site remediation, structure and foundation design, and/or avoidance. This Act must be implemented by cities and counties in the region with hazards mapped by CGS. In 2005, this included San Francisco and parts of Alameda, Contra Costa, San Mateo, and Santa Clara counties, as well as 43 cities.

Since the Act has only been in place for less than 15 years, and most Bay Area maps are recent, the impact of this legislation has not been as great as the Alquist-Priolo Fault Study Zones Act. In addition, the focus on the Act is on new development, not existing development, and on mitigation, rather than avoidance of the identified seismic (liquefaction or earthquake-induced landslide) hazards.

The ***Alquist-Priolo Earthquake Fault Zoning Act*** of 1972 was passed by the legislature as a result of the San Fernando earthquake in southern California. This Act is intended to deal with the specific hazard of active faults that extend to the earth's surface, creating a ***surface rupture hazard***. The Act requires that the State Geologist (the head of the California Geological Survey – CGS) designate zones approximately ¼-mile wide along known active faults. Within these zones, site-specific geologic reports must be prepared for development proposals (except for housing developments of less than four units or not involving structures intended for human occupancy). Typically, at a minimum, structures intended for human occupancy cannot be placed within 50 feet of an active fault trace. Finally, the Act requires disclosure to potential buyers in these zones.

The Act's ability to eliminate the surface fault rupture hazards in the region for future development is limited because it specifically exempts:

- existing development;
- new developments containing less than four single family homes; and
- structures not intended for human occupancy (including pipelines, power substations, and pumping plants).

Local governments need to ensure that these facilities, many of which are actually constructed by local governments, have adequate mitigation to increase safety.

Local Regulations Applying to Earthquakes

First, Section 2624 of the Fault Zoning Act specifically states that local governments have the authority to recognize that some faults may be a hazard for surface rupture even though they do not meet the strict criteria imposed by the Fault Zoning Act. For example, zones have been

identified by Santa Clara County and by the City of Saratoga for the Monte Vista-Shannon fault system.

Second, recognizing that CGS has not completed earthquake-induced landslide and liquefaction mapping for significant portions of the Bay Area, local governments can require geologic reports in areas mapped by others as having significant liquefaction or landslide hazards.

Third, CGS's efforts to complete the earthquake-induced landslide and liquefaction mapping will be easier if cities and counties cooperate by providing access to their records and by expediting permitting for new research conducted in their jurisdiction.

Finally, local governments review the geologic and engineering reports prepared by developers to implement the Fault Zoning Act and the Seismic Hazards Mapping Act. Local governments are required to ensure that reviews are conducted by appropriately trained and credentialed personnel, whether they use their own staff or outside consultants.

Local Regulations Applying to Wildland and Structural Fires

Local government regulations mitigating fire hazards include –

1) Reviewing development proposals to ensure that they incorporate required and appropriate fire-mitigation measures, including adequate provisions for occupant evacuation and access by emergency response personnel and equipment.
2) Developing a clear legislative and regulatory framework at both the state and local levels to manage the wildland-urban-interface consistent with ***Fire Wise*** and sustainable community principles.

Local Regulations Applying to Flooding

Local government regulations mitigating flooding hazards include –

1) Establishing and enforce requirements for new development so that site-specific designs and source-control techniques are used to manage peak stormwater runoff flows and impacts from increased runoff volumes.
2) Incorporating FEMA guidelines, regulatory standards (such as ASCE 24), and other suggested activities into local government plans and procedures for managing flood hazards.
3) Providing an institutional mechanism to ensure that development proposals adjacent to floodways and in floodplains are referred to flood control districts and wastewater agencies for review and comment (consistent with the NPDES program).
4) Establishing and enforce regulations concerning new construction (and major improvements to existing structures) within flood zones in order to be in compliance with federal requirements and, thus, be a participant in the Community Rating System of the ***National Flood Insurance Program.***

Local Regulations Applying to Landslides and Erosion

Local government regulations mitigating rainfall-induced landslide hazards and erosion include:

1) Establishing and enforcing provisions (under subdivision ordinances or other means) that geotechnical and soil-hazard investigations be conducted and filed to prevent grading from

creating unstable slopes, and that any necessary corrective actions be taken prior to development approval.
2) Requiring that local government reviews of these investigations are conducted by appropriately trained and credentialed personnel.
3) Establishing and enforcing grading, erosion, and sedimentation ordinances by requiring, under certain conditions, grading permits and plans to control erosion and sedimentation prior to development approval.
4) Establishing and enforcing provisions under the creek protection, storm water management, and discharge control ordinances designed to control erosion and sedimentation.
5) Establishing requirements in zoning ordinances to address hillside development constraints, especially in areas of existing landslides.

References

California Department of Water Resources, Urban Water Management Planning Program. 2005. ***California Water Plan Update 2005*** v. 3: DWR Bulletin 160-05: Sacramento, CA. Available at http://www.waterplan.water.ca.gov/cwpu2005/.

California Legislative Analyst. 2006. "A Perspective on Emergencies and Disasters in California" pp. 145-174 in ***Analysis of the 2006-07 Budget Bill:*** Sacramento, CA. Available at http://www.lao.ca.gov/analysis_2006/2006_pandi/Pandi_06.pdf.

Fassinger, P.W., Kirking, B., Perry, P.R., Wong, W., and Yang, C.M., 2004. ***Projections 2005 – Forecasts for the San Francisco Bay Area to the Year 2030***: Association of Bay Area Governments, Oakland, CA, 292 pp.

Perkins, J.B., Chuaqui, B., and Smith, K., 2002. ***Existing Land Use in 2000: Data for Bay Area Counties***: Association of Bay Area Governments, Oakland, CA, 42 pp.

Perkins, J.B., Chuaqui, B., and Strunin, J., 2006. ***Existing Land Use in 2005: Data for Bay Area Counties***: Association of Bay Area Governments, Oakland, CA, 42 pp.

Perkins, J.B., Kirking, B., Smith, K., and Smith, M., 2005. ***Taming Natural Disasters: Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area***: Association of Bay Area Governments, Oakland, CA, 90 pages.

U.S. Bureau of the Census. 2000. ***2000 Census Table: Total Housing Units.*** Washington, D.C.: United States Census Bureau.

APPENDIX F
Assessing Vulnerability: Private Building and Value Exposure Estimates

This appendix discusses the number of buildings and dollars exposed to the hazards listed in the Local Hazard Mitigation Plan. For this appendix, ABAG created estimates of the number of buildings and the real value of property based upon 2005 County Tax Assessor's information. Since no other attempt to value the real property in the Bay Area has used this method, a thorough methodology is included in this appendix.

The numbers in this appendix are an estimate of the 2005 market value of private improvements. ABAG created these values ***only*** to provide estimates of property at risk in hazard areas. ***They do not represent scenarios of loss due to hazards, nor do they represent the replacement value (cost of repairing or replacing a structure) that would be damaged or destroyed during a hazard event. In addition, they do not include public and other nontaxable improvements, as assessors do not assess the value of these properties. Finally, they should not be used, by themselves, to compare the relative risk of earthquakes versus fire versus flooding in the Bay Area for they do not contain information on probability of occurrence for the various hazards, or the damage level associated with a particular use or building type given a level of hazard.***

Almost all of the assumptions made in this analysis tend to underestimate the number and value of buildings in the Bay Area. The single exception is the decision made to use 2005 market value of property, rather than escalating it for a period, and then deflating it due to the 2008-2009 recession. However, every indication is that the cost of labor for contractors has not dropped. Thus, it is likely that the number of private buildings and actual market value of private improvements in the region is much higher than the values provided in this Appendix. .

The final section of this appendix discusses the uses and limitations of these estimates when creating loss estimates for specific hazards based upon the probability of various hazards resulting in damage, as well as the percent loss expected to occur to selected building types in various categories of hazard.

Definitions of "High" Hazard Areas

Note that this appendix analyzes only buildings and their values in the high hazard areas, and makes no comment upon the probability of a hazard occurring in a given high hazard area. The probability of a high hazard area resulting in a disaster varies by hazard. See Appendix C for more information on these probabilities.

- **Fault Rupture Hazard** – There is no map of all active faults in the region that accurately describes their locations. As a substitute, this appendix uses the Alquist-Priolo Fault Rupture Study Zones to determine the threat of fault rupture. High hazard areas for this hazard therefore consist of the area in this Study Zone. These Zones are much wider than the actual fault traces, and therefore the number of buildings and their values in the high hazard areas is overestimated.

- **Earthquake Shaking Potential** – Earthquake shaking hazard is divided into five categories of increasing shaking potential on the composite USGS Shaking Map (as described in Appendix C). The two categories of highest potential shaking are used to define the high hazard areas: peak accelerations of greater than 60% g with a 10% chance of being exceeded in the next 50 years.
- **Liquefaction Susceptibility –** Liquefaction is divided into five categories of increasing liquefaction susceptibility on the USGS Liquefaction Susceptibility Map (Witter and others, 2006). This map is similar to, and an update of, the Knudsen and others map (2000). The three categories of highest liquefaction susceptibility (very high, high, and moderate) are used to define the high hazard areas. In addition, the California Geological Survey (CGS) has mapped San Francisco and portions of Alameda, San Mateo, and Santa Clara counties. The USGS compilation is used for the analysis in this Appendix because it covers the entire Bay Area.
- **Earthquake-Induced Landslides** – These maps were mandated under the ***Seismic Hazards Mapping Act*** of 1990. Currently, CGS has mapped San Francisco and portions of Alameda, San Mateo, and Santa Clara counties. Therefore, for these hazard areas, the regional total will consist only of these four counties. The hazard area is defined as those areas that are within the study zones (and are therefore subject to the hazard).
- **Tsunamis –** These maps are currently being prepared and revised by the CalEMA. Maps have been delivered to the counties, but, as of mid-October 2009, ABAG did not have access to these maps. In addition, CalEMA has stated that the maps are to be used only for evacuation planning, not for this type of analysis. This omission does ***not*** mean that tsunamis are not a hazard in the region.
- **Flooding –** Areas within the 100-year flood zone (including due to wave action) are in the high hazard area based on FEMA mapping. Such maps are not available for San Francisco. ABAG has used the D-FIRM maps for seven of the counties. However, because the maps were not available, in mid-October 2009, the Q3 map was used in San Mateo County. These maps are not expected to be released until September 2010.
- **Rainfall-Induced Landslides –** Areas designated "mostly a landslide area" on the USGS Existing Landslide Map are considered to be in the high hazard area for rainfall-induced landslides. This assessment is consistent with the 2004-2005 analysis.
- **Wildfire Threat** – Wildfire threat is divided into five categories of increasing wildfire threat as described on the California Department of Forestry (CDF) Wildfire Threat Maps. The three categories of highest wildfire threat were used to define the high hazard areas. These areas typically occur further from urban areas that wildland urban interface (WUI) threat areas described below. While there is some overlap in the WUI threat and wildfire threat areas, wildfire is defined on the CDF maps as occurring in non-urban areas outside of city fire department jurisdictions. The most recent version of this map has been used.
- **Wildland-Urban-Interface Threat** – The high hazard areas are defined as any area within the WUI Threat Zone as described in the WUI Threat maps created by the California Department of Forestry. These hazard areas generally occur on the edge of urban areas. These maps were recently found to somewhat overestimate the amount of land in the threat area. Specifically, land that was urban and bordering the bay was included in the threat region when it should not have been, meaning that the amount of certain land types in this region (medium and high density residential, mixed use lands, all types of employment land

- **Drought –** While drought is a concern for the region, it is not a hazard that can be mapped in the traditional sense. There are no high hazard areas for this hazard, then. This appendix does, however, provide a discussion of the uses of water and potential effects of a drought for varying land uses (see section "Land Use Densities in Hazard Areas").
- **Dam Inundation Maps –** Any area subject to inundation from at least one dam is located in the high hazard area for Dam Inundation. These maps were created under the assumption that a dam would simply disappear, and therefore represent a worst case scenario. In addition, most of these maps are nearly 40 years old and do not reflect current land conditions that would direct the floodwaters.
- **Delta Levee Failure –** Failure of one or more Delta levees will have impacts far beyond the value of property inundated. Thus, the decision was made to not produce property numbers and values for these islands.

Exposed Value of Private Buildings

According to these ABAG estimates, the total market value of private improvements in the Bay Area was $1.064 trillion in 2005, 78.7% ($837.4 billion) of which was residential property, 13.4% ($142.3 billion) of which was commercial, and 7.9% ($84.2 billion) of which was industrial/other. This estimate includes only taxable properties that the assessor has assessed a value for, and does not include properties that are public or exempt from taxation. ***Table 1*** shows the value of these properties in each high hazard area for each county and across the region. The majority of value in the region is in Santa Clara, Alameda, and Contra Costa counties, which contain 57.0% of the region's value of improvements (that is, buildings).

Due to the 2008-2009 economic recession, which has been precipitated by a downturn in the housing market, there is no reasonable way to revise the 2005 values. The values escalated exponentially during the 2005-2007 period, and then crashed in the 2008-2009 period. Sales of properties have been reduced, with lower-value properties being sold, while many higher value properties are not going on the market. Thus, taking an average of the sales price of properties is not valid. In addition, while property values have dropped in the past two years, the costs of retrofit and repair have not changed. The decision has been made to continue to use the 2005 values in this plan, understanding that these numbers will need to be updated for the 2015 version of this MJ-LHMP.

Examining the exposure by type of development (***Table 2***) reveals that residential properties make up the bulk of the exposed value in the region for every hazard. One can determine if properties are disproportionately exposed to hazards by comparing the percentage of value in each high hazard area to the overall percentage of value in the region. For example, if the percentage of exposed residential value for a particular hazard is higher than 78.7%, the value for all land, residential properties are disproportionately exposed to that hazard. Using this technique, one can determine that residential properties are disproportionately exposed to fault rupture, rainfall-induced landslides, and both wildfire and WUI fire threat. Commercial properties are disproportionately exposed to shaking, liquefaction, and flooding. All other properties are disproportionately exposed to fault rupture, liquefaction, rainfall induced landslides, wildfire threat, dam failure, and, especially, flooding.

TABLE 2 – Percentage of Estimated Value of Properties in High Hazard Areas* by Type

This table should be read as "Across the region, this percentage of the value in this high hazard area is this type of development."

	All Land	Fault Study Zone	Shaking Potential	Liquefaction Susceptibility	Liquefaction Study Zone	Earthquake-Induced Landslide Study Zone
Total Value	100.0%	100.0%	100.0%	100.0%	N/A	N/A
Residential	78.7%	83.6%	77.3%	73.4%	N/A	N/A
Commercial	13.4%	5.4%	15.2%	18.5%	N/A	N/A
Industrial/Other	7.9%	10.9%	7.4%	8.1%	N/A	N/A
	All Land	**100-Year FEMA Flood Zone**	**Rainfall-Induced Landslides**	**Wildfire Threat Area**	**WUI Threat Area**	**Dam Failure Inundation Area**
Total Value	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Residential	78.7%	57.0%	86.8%	81.4%	84.5%	70.4%
Commercial	13.4%	19.7%	8.4%	13.1%	5.7%	12.0%
Industrial/Other	7.9%	34.7%	9.7%	16.0%	6.7%	17.1%

*See Local Hazard Mitigation Plan Appendix F, pages 1-3, for definitions of high hazard areas and data limitations. **Note** – Regional data for liquefaction study zones and earthquake-induced landslide study zones are not available because the mapping is not complete.
Source: ABAG 2009.

Table 3 shows the percentage of value in each county that is exposed to the high hazard areas. By comparing hazards across the region (or by county), one can begin to understand the potential economic impacts of a hazard event. In this manner, it is clear that the highest exposure of vale to a hazard is in the high hazard areas for shaking potential, WUI threat, and liquefaction. 68.6% ($729.9 billion) of the value in the region is in the high hazard area for shaking, while 52.0% ($553.3 billion) is in a WUI threat area, and 48.4% ($511.1 billion) is in a high liquefaction susceptibility area. One would expect these three high hazard areas to contain the most value in the region, given that these same three high hazard areas contain the highest acreages of urban land in the region (see Appendix E, Figure 2). Of the other hazards, only dam inundation areas contain a significant portion of the value in the region (20.0%).

Table 3 also demonstrates some particular points of note. First, when compared to residential properties, nonresidential (especially commercial) properties generally have a higher percentage of value in high liquefaction susceptibility areas, both across the region and within most counties. This is consistent with the fact that much of the large industrial other non-residential areas are on bay fill right on the Bay shore. For that same reason, non-residential properties have a higher percentage of the value in the 100-year flood zones than do residential properties (although this varies by county). Also, nonresidential properties also have a much higher percentage of value exposed to dam inundation hazards than residential properties. Finally, residential properties have a much higher percentage of value exposed to fire hazards (wildfire and WUI threat) than do nonresidential properties for nearly every county and across the region.

Exposed Number of Private Buildings

According to the estimates (based on one building per assessors parcel), the total number of private buildings in the Bay Area is 1.78 million, 93.2% (1.66 million buildings) of which are residential buildings, 3.8% (68,098 buildings) of which are commercial buildings, and 3.0% (53,689 buildings) of which are industrial/other buildings. ***Table 4*** shows the number of buildings in each high hazard area (see pages 1-3 for definitions of high hazard areas) for each county and across the region. As with the value, the majority of buildings in the region are in Santa Clara, Alameda, and Contra Costa counties, which contain 59.1% of the region's buildings.

Examining the exposure by type of development (***Table 5***) reveals that residential properties make up the bulk of the exposed buildings in the region for every hazard, and make up over 90% of all exposed buildings for every hazard except flooding and wildfire hazards. By making the same comparison in ***Table 5*** that was made for ***Table 2,*** one can again compare the percentage of buildings in each high hazard area to the overall percentage of buildings in the region to determine if a type of building is disproportionately exposed to a hazard. In this manner, one can see that residential buildings are disproportionately exposed to fault rupture, and WUI threat. Commercial properties are disproportionately exposed to shaking, liquefaction (both liquefaction hazards), flooding, and dam inundation. All other properties are disproportionately exposed to liquefaction (both liquefaction hazards), both landslide hazards, and dam failure, but especially flooding and wildfire threat.

TABLE 5 – Percentage of Estimated Number of Private Buildings in High Hazard Areas* by Type

This table should be read as "Across the region, this percentage of the buildings in this high hazard area is this type of development."

	All Land	Fault Study Zone	Shaking Potential	Liquefaction Susceptibility	Liquefaction Study Zone	Earthquake-Induced Landslide Study Zone
Total Value	100.0%	100.0%	100.0%	100.0%	N/A	N/A
Residential	93.2%	95.0%	93.0%	91.8%	N/A	N/A
Commercial	3.8%	2.7%	4.2%	4.9%	N/A	N/A
Industrial	3.0%	2.3%	2.8%	3.3%	N/A	N/A
	All Land	**100-Year FEMA Flood Zone**	**Rainfall-Induced Landslides**	**Wildfire Threat Area**	**WUI Threat Area**	**Dam Failure Inundation Area**
Total Value	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Residential	93.2%	84.7%	92.6%	87.7%	94.9%	92.0%
Commercial	3.8%	6.9%	1.1%	1.4%	2.9%	4.4%
Industrial	3.0%	8.4%	6.3%	10.9%	2.2%	3.6%

* See Local Hazard Mitigation Plan Appendix F, pages 1-3, for definitions of high hazard areas and data limitations. **Note** – Regional data for liquefaction study zones and earthquake-induced landslide study zones are not available because the mapping is not complete.
Source: ABAG 2009.

Table 6 shows the percentage of buildings in each county that is exposed to the high hazard areas. The highest building exposure is in the high hazard areas for shaking potential, WUI threat, and liquefaction. Almost two thirds of the buildings (66.4% or 1.18 million properties) in the region are in the high hazard area for shaking, while 50.8% (906,355 buildings) are in a WUI threat area, and 48.0% (856,893 buildings) is in a high liquefaction susceptibility area. As with estimated value, these are again the same three high hazard areas that contain the highest acreages of urban land in the region (see LHMP Appendix E, Figure 2). Of the other hazards, only dam inundation areas contain a significant portion of the value in the region (19.2%). These results are highly consistent with the exposed values in hazard areas, with the percentages of buildings in the high hazard areas within a few percentage points of the percentage of exposed value.

No estimate of the *total* number of public and institutional buildings exists for the Bay Area. Exposure of many public and institutional critical facilities to hazards is described in Appendix C.

Definitions, Methodologies, and Information Sources

Definitions

For definitions of high hazard areas, pages 1-3.

The analysis in this section is based on three basic breakdowns of privately-owned property. *Other properties, such as schools, hospitals, municipal buildings, and institutional properties, are analyzed as critical facilities in Appendix C. While a limited number of local governments provided ABAG staff with the insured values of these structures, the data are insufficient to make a consistent estimate of the value of these structures.* The three categories of property analyzed are:

- **Residential and Mixed-Use** – including homes, condominiums, apartments, and mixed-use buildings with commercial on the ground floor.
- **Commercial and Recreational** – including retail, office, recreational, motels/hotels, research and development, and properties with mixed commercial and light industrial buildings.
- **Industrial and Other** – including light and heavy industrial, recycling, warehousing, communications, food processing, and other non-commercial and non-residential uses.

The categories of land use for the properties were obtained from the 2005 Existing Land Use Map (Perkins and others, 2005) and assessor's land use information for the parcel.

Exposure Estimates Methodology and Information Sources

Creating the Parcel Layers

Estimates of market value of private buildings were based upon County Tax Assessors' information, collected on a parcel level for every parcel in the region. For the majority of counties, this information came with parcel maps for the county, allowing for the use of Geographic Information Systems (GIS) technology to assign spatial qualities to the attributes. There were three counties, however, in which GIS parcel layers (data tables with spatial information) were unavailable for the complete county. The exposure estimates are summarized by land use type based upon the 2005 Existing Land Use Map (see Appendix E), which was used to assign standardized land uses to each of the parcels. Parcel data tables (with no spatial information) were available for all nine counties in the region.

For the three counties without assessors' parcel layers, different methods were used to assemble the parcel layers.

- In Santa Clara County, a complete GIS parcel layer was created with parcel layers obtained from a number of cities in the county (San Jose, Milpitas, Santa Clara, Palo Alto, and Cupertino). In areas where there were still no parcels, a 2003 GIS parcel layer was obtained from the Santa Clara Valley Transit Authority and was used to fill in missing areas in the GIS parcel layer.
- In Alameda County, GIS parcel layers were collected for every city except the cities of Alameda and Albany. There were no other parcel layers available for the county, and so the parcel layer remained incomplete for Alameda County (approximately 93% complete).
- In Solano County, GIS parcel layers were collected from the three largest cities in the county (Vacaville, Fairfield, and Vallejo). There were no other parcel layers available for the county, and so the parcel layer remained incomplete for Solano County (approximately 50% complete). The available parcel layers, however, do capture roughly two-thirds of the urban area (and thus most of the improvement value) in that county.

Since the resulting parcel layer was incomplete for Alameda and Solano Counties, two additional steps were taken to increase the accuracy of the following estimates for these two counties.

1. Parcel records were geocoded (assigned spatial data based upon addresses) to create a point layer for all parcels that were not included in the available parcel layers for the county.
2. These geocoded points were added to the point parcel layer for that county to create a more accurate estimate of the number and value of the buildings in the hazard areas.

This does not mean that the combined tables are a complete list of all parcels in these counties for two reasons. First, geocoding is often inaccurate with some of the parcels due to bad address or zip code information. In addition, many parcels cannot be geocoded because there are no addresses for the parcel or the reference street layer does not have a street present on it.

- In Alameda County, all parcels in the cities of Alameda and Albany were geocoded to create a point layer for these cities. Using this method, 84% of the parcel records in Alameda and Albany were successfully included.
- In Solano County, a similar procedure was used. However, in this county, only 57% of the parcel records outside of the cities of Vacaville, Fairfield, and Vallejo were successfully included.

Thus, for both of these counties, not all parcels were assigned spatial data, resulting in the estimates of the number of buildings and value of improvements being low when compared to the actual number of buildings and value of improvements. This underestimate is more severe in Solano County than Alameda County). In effect, the geocoding effort lessened, but did not remove, the underestimation of parcels and value.

In order to determine whether a parcel was in a hazard area, the point at the geographical center ("centroid") of the parcel was determined in GIS and "joined" (spatially linked) to the hazard area layers used in this LHMP. When geocoding was required, the point used for "joining" with the hazard layer is the location of the address, which is in the center of the street in front of the parcel.

Total Number of Buildings Exposed

While the number of buildings is occasionally included in assessor's parcel information, this information is very incomplete and may also be inaccurate, as identifying the number of buildings is not the focus of the assessor's work. Instead, for all parcels where a positive assessed improvement value indicated that a building was present on the parcel, it was assumed that there was one building per parcel. While this assumption is accurate for most single family homes (which comprise the majority of Bay Area development), it is also introduces several sources of error. First, all apartment, condominium, office, and industrial complexes that are considered to be one parcel by the assessor may actually be composed of several buildings. In addition, many single-family parcels consist of in-law units or detached garages, which are also separate buildings. Finally, many condominiums, although they are in one building, are considered to be separate parcels. The first two inaccuracies suggest that the assumption of one building per parcel will underestimate the number of buildings exposed to a hazard, and the last suggests that the assumption will overestimate the number of buildings exposed to a hazard. Overall, the first two inaccuracies are much more common, meaning that the number of buildings exposed to a hazard is likely to be higher than the statistics presented here.

To determine the number of parcels (and estimated buildings) in a hazard area, the centroid for each parcel was joined to the hazard layer. Parcels were counted for each hazard category for each county.

Total Value of Improvements Exposed

Exposure estimates were created using the assessed value of improvements for every parcel. In California, however, the assessed value of a property is rarely equal to the real market value of the property. Proposition 13, passed in 1978, limits the amount of value that the assessor can claim real property to be worth. Specifically, after a property is sold, the assessor can only raise the assessed value of the property at a maximum of 2% per year, even if the market inflates the value significantly more than 2%. Once the property is sold again, the assessor can use that sales price as the new assessed value. Thus the assessed value is equal to the real market value only in the year when the property is sold. The longer it has been since the property was sold, the larger discrepancy that will exist between the assessed value and the real market value of the property (with the assessed value generally much lower than the market value). While this is a significant problem for all properties, it is likely an even larger problem for nonresidential properties, which have very low turnover when compared with residential properties.

ABAG's estimates adjusted for the above situation by estimating the real market value based upon the assessed value of the property, the last sales price, and the last sales date, as well as the land use for the property (as obtained from the 2005 Existing Land Use Map and assessor's land use information for the parcel). The assessed values were obtained directly from the County Assessor for four counties – Contra Costa, Marin, San Francisco, and San Mateo. For the remaining five counties, the data were purchased from First American Real Estate Solutions (Metroscan). Sales information was not always available, and the adjustment process accounted for this fact.

Estimating the Real Value

1. If a property had no sales information or was sold before 1976 (the effective date of Proposition 13), the assessed value of improvements was assumed to be the correct market value in 1976. This assumption was made because properties with no sales information were likely sold before the quality of information was at current standards (and thus before 1976). This assumption may have had the effect of over-inflating values for properties with no sales date information if they were sold after 1976. The assessed value was inflated by an index based upon its land use category (see below) to 2005 current market value.
2. If a property had all sales information and was sold after 1976, the sales price was adjusted by the ratio of improvements to land value to obtain the market value of the improvements for the year of the sale. This value was then inflated by an index based upon the parcel land use category (see below) to 2005 current market value. If there was no ratio of improvements for the parcel, the median ratio of improvements to land value for the land use category in that county was used to estimate the improvement value for the year of the sale (which was then inflated by the index).

Inflation Indices

The first land use category included all residential properties: single-family homes, multi-family homes, apartment buildings, mixed-use (residential/commercial) buildings, mobile parks, and group quarters. The index for residential properties was created using the average single-family home sales price from 1989-2005 by county, and a single-family home market trend index for 1976-1989 by subregion (1-4 counties). These data were provided by the Real Estate Research Council of Northern California in the Northern California Real Estate Reports (1990, 1996, 2005).

The second category was for all other properties, including commercial, industrial, and any other type of property that had an improvement value for the parcel. This index was created from the Consumer Price Index (CPI) for the entire region. This index generally inflated the assessed value at a considerably smaller rate than the single-family home index, reflecting the rapidly inflating housing market in the Bay Area.

Trial estimates included a separate index for multi-family housing, using the rental CPI for the entire Bay Area from 1982-2005, and the Housing CPI for 1976-1982. This index was later not used largely because, in the Bay Area, the rental market is not as profitable as the real estate investment market. This trend means that the rental CPI for the region was likely to underestimate the value of the properties. Thus, investors in rental housing are treating this investment as a housing investment with expectations of future gains in line with the overall regional real estate market, rather than as income properties with a market value based on rental income. A single-family market index was more reflective of that fact.

Almost all of the assumptions made in this analysis underestimated the value of buildings in the Bay Area. The CPI inflator for non-residential properties is also probably low because real estate has traditionally gone up in value faster than the other commodities in that index. It is likely that the actual market value of private improvements in the region is much higher.

Applications and Limitations of the Estimates of Market Value and Comparisons to Other Loss Exposure Estimates

The above numbers are only an estimate of the 2005 market value of private improvements. ABAG created these values only to provide estimates of property at risk in hazard areas. They do not represent scenarios of loss due to hazards, nor do they represent the replacement value (cost of repairing or replacing a structure) that would be damaged or destroyed during a hazard event. In addition, they do not represent public and other nontaxable improvements, as assessors do not assess the value of these properties.

At least three studies have estimated the value of improvements in the Bay Area in order to develop loss estimates for hazard events: (1) FEMA's HAZUS model, (2) independent work by Risk Management Solutions (RMS), (3) Kircher and others (2006) in the estimate of losses due to a repeat of the 1906 earthquake. The first two estimates calculate the engineered replacement value based on an estimated square footage of building stock (based on census data of population) multiplied by an average cost per square foot for various types of construction (from Means). Kircher and others modified the HAZUS values based on an "average" ratio between the RMS and HAZUS default values. ***Table 7*** compares these replacement values from HAZUS, Kircher and others, and RMS, with the market value estimates used in this analysis. The values in this appendix are generally significantly higher than the other estimates.

When losses occur, replacement value is a better estimator of actual losses than fair market value. If these market values were converted to replacement values, they would increase for at least two reasons. First, replacement value assumes replacing structures, which typically costs more than the fair market value of the old structure. Second, even in a localized emergency, there are market factors that increase the price of materials and labor further as they are in short supply relative to the demand. Kircher and others estimated that, in a 1906 event, this would inflate losses by approximately 30%. Thus, to convert the numbers in this appendix for use in loss estimates would require that two multipliers be used – the first to convert market value to replacement value in a non-disaster climate, and a second to convert non-disaster replacement value to disaster replacement value. These two multipliers could easily increase the loss exposures by 50%.

Loss Estimates – The Next Step

One of the most useful ways to examine Bay Area risk is to estimate the total losses that might be expected from a variety of hazards over a given period, such as 100 years, or to change those losses to an average annual exposure. The principal use for such estimates by a local government in the Bay Area is likely to be to determine the costs of ***not*** mitigating a hazard to compare against the costs and benefits of hazard mitigation.

To obtain these loss estimates, one needs the probability of the event occurring. For example, in a 100-year, one could assume that one flood would completely inundate the 100-year floodplain or that the wildfires of the last 50 years would occur twice. During the same interval, various earthquake scenarios would have a fixed probability of occurring.

One also needs the probability of the event resulting in damage to a particular location. In this case, those hazards that have various levels of severity (such as wildfire threat, earthquake shaking and liquefaction) will have various probabilities of damage based on whether the hazard is very high, high, or moderate.

TABLE 7 – Comparison of ABAG Market Value of Private Improvements to Other Sources of Replacement Value for Use in Loss Estimates (in Millions of Dollars)

Residential Properties	Assessed Improvement Value	HAZUS	Kircher and others	RMS	ABAG Estimated Market Value
Alameda	62,038	100,936	111,030	112,203	153,329
Contra Costa	49,243	74,902	82,392	74,759	124,098
Marin	17,425	24,338	26,772	25,961	39,450
Napa	5,568	9,126	10,039	10,166	14,502
San Francisco	21,446	56,633	62,296	72,001	71,802
San Mateo	40,728	57,814	63,595	64,316	116,238
Santa Clara	71,099	123,200	135,520	153,773	193,968
Solano	12,680	25,519	28,071	23,606	47,601
Sonoma	22,129	35,203	38,723	31,243	76,472
Total	302,356	507,671	558,438	568,028	837,460

Employment Properties	Assessed Improvement Value	HAZUS	Kircher and others	RMS	ABAG Estimated Market Value
Alameda	19,843	26,169	52,338	45,735	34,443
Contra Costa	19,357	10,207	20,414	19,687	47,771
Marin	3,197	4,639	9,278	8,217	8,588
Napa	1,105	2,270	4,540	3,641	6,879
San Francisco	20,898	18,941	37,882	40,334	26,392
San Mateo	10,665	10,353	20,706	21,410	29,699
Santa Clara	27,073	23,896	47,792	54,865	53,167
Solano	1,904	3,375	6,750	5,793	6,563
Sonoma	4,660	6,067	12,134	9,426	13,080
Total	108,702	105,917	211,834	209,108	226,582

All Properties	Assessed Improvement Value	HAZUS	Kircher and others	RMS	ABAG Estimated Market Value
Alameda	85,398	123,271	155,700	157,938	187,772
Contra Costa	73,607	85,109	102,807	94,446	171,869
Marin	22,211	28,977	36,050	34,178	48,038
Napa	10,077	11,396	14,579	13,807	21,381
San Francisco	44,290	75,574	100,179	112,335	98,194
San Mateo	53,679	68,167	84,301	85,726	145,937
Santa Clara	104,329	147,096	183,312	208,638	247,135
Solano	16,124	28,894	34,820	29,399	54,164
Sonoma	28,675	41,270	50,858	40,669	89,552
Total	438,390	609,754	762,606	777,136	1,064,042

Finally, one needs an estimate of the damage to property that might occur should an event happen. For example, if an area is burned in a wildfire, it is reasonable to assume that the entire building and its contents are 100% destroyed. On the other hand, if a building is flooded, it is damaged but not destroyed. In the most complex case, if a building is shaking in an earthquake, it may be undamaged or completely destroyed or anything in between based on the type and quality of building construction.

Published loss estimates are becoming increasingly sophisticated as the information on probability and damage becomes increasingly well understood based on statistics and other information from past disasters. However, the estimates are typically published for the State, a region, or a county, not for a particular city or neighborhood. The reason for the reluctance of modelers to publish more generic loss estimates is that the data become increasingly unreliable at more local levels. The data on building numbers and values included in this report should greatly improve future estimates.

ABAG could use existing software and modeling to produce loss estimates for the various hazards in the region. Even the data produced for this appendix would improve existing loss estimates. For example, the losses estimated by Kircher and others might be assumed to be low by approximately one-third based on the information in ***Table 7***, above. However, other information, such as the precise location and number of soft-story multifamily residential buildings and retrofitted and unretrofitted unreinforced masonry buildings is equally important.

The recommendation of this appendix is that future Bay Area loss estimates be conducted on a parcel-by-parcel basis and aggregated to census tracts and cities. To accomplish this goal, ABAG will seek funding to collect and improve building inventory information and use it to prepare loss estimates for use by cities, counties, and special districts for benefit-cost-analysis of hazard mitigation programs. The focus of these efforts will be on buildings that are statistically more vulnerable in earthquakes (both unretrofitted and retrofitted to a minimal standard): unreinforced masonry buildings, soft-story multifamily residential buildings, tilt-up concrete buildings, and non-ductile concrete frame buildings.

References

Kircher, Charles A., Seligson, Hope A., Bouabid, Jawhar, and Morrow, Guy C., 2006. "When the *Big One* Strikes Again—Estimated Losses due to a Repeat of the 1906 San Francisco Earthquake" in ***Earthquake Spectra,*** v. 22, issue S2, pp. S297-S339.

Perkins, Jeanne B., Chuaqui, Ben, and Strunin, Jonathan, 2006. ***Existing Land Use in 2005: Data for Bay Area Counties***: Association of Bay Area Governments, Oakland, CA, 42 pp.

Perkins, Jeanne B., Kirking, Brian, Smith, Kearey, and Smith, Michael, 2005. ***Taming Natural Disasters: Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area***: Association of Bay Area Governments, Oakland, CA, 90 pages.

USGS Working Group on Earthquake Probabilities, 2003. ***Earthquake Probabilities in the San Francisco Bay Region*** **-** USGS Open-File Report 03-214, Table 6-16. Ch. 6, pg. 24, at http://geopubs.wr.usgs.gov/open-file/of03-214/.

APPENDIX G
Summary List of Mitigation Strategies with Regional Priorities and Hazards Mitigated

The following table compares the strategies from the 2005 plan with the strategies in the current 2010 plan. The first column shows the strategy number in 2005. The second column shows the strategy number from 2010. Strategy numbers changed when strategies were added or deleted from the list. New strategies are indicated by the word "new". Deleted strategies are listed at the end of each section with their 2005 strategy number. The mitigation strategy shows added or changed wording in red. Significantly reworded strategies are indicated, as well as any significant wording deleted from the strategy. The original wording of the strategies can be viewed on the web at http://quake.abag.ca.gov/mitigation/stratlist-2005.html. The Applicable Hazards column lists which hazards each strategy is meant to mitigate. The following list the abbreviations used for each hazard. Many mitigation strategies apply to multiple hazards.

EQ	Earthquake
LS	Landslide
WF	Wildfire
FL	Flood
SEC	Security
DF	Dam Failure
LF	Levee Failure
TS	Tsunami
DR	Drought
Ag	Agriculture
Flu	Pandemic Flu

The last column indicated whether each mitigation strategy applies to existing or new construction, both, or whether the strategy does not implicitly deal with construction or development. **Appendix A** documents the process of updating the strategies and coming to consensus on the regional priorities.

Infrastructure Mitigation Strategies

2009-2010 Strategy Number	2005 Original Strategy Number	Specific Mitigation Strategy	Applicable Hazards	Regional Priority	New vs. Existing Construction
INFR - a - Multi-Hazard **(owned by the infrastructure provider filling out this form, including a city, county, or special district)**					
a-1	a-1	Assess the vulnerability of critical facilities **owned** by **infrastructure** operators subject to damage in natural disasters or security threats, including **fuel tanks and** facilities owned outside of the Bay Area that can impact service delivery within the region. **Note** - **Infrastructure** agencies, departments, and districts are those that operate transportation and utility facilities and networks.	EQ LS WF FL SEC	Existing program, underfunded	Ex.

a-2	a-2	**If a dam owner,** comply with State of California and federal requirements to assess the vulnerability of dams to damage from earthquakes, seiches, landslides, liquefaction, or security threats.	EQ LS WF FL SEC DF	Existing program	n/a
a-3	a-3	Encourage the cooperation of utility system providers and cities, counties, and special districts, **and PG&E** to develop strong and effective mitigation strategies for infrastructure systems and facilities.	EQ LS WF FL DR SEC	Existing program	Both
a-4	a-4	Retrofit or replace critical lifeline **infrastructure** facilities and/or their backup facilities that are shown to be vulnerable to damage in natural disasters.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-5	a-5	Support and encourage efforts of ***other*** (lifeline **infrastructure**) agencies as they plan for and arrange financing for seismic retrofits and other disaster mitigation strategies. (For example, a city might pass a resolution in support of a transit agency's retrofit program.)	EQ LS WF FL DR SEC	Existing program	Ex.
a-6	a-6	Develop a plan for speeding the repair and functional restoration of **water and wastewater** systems through stockpiling of shoring materials, temporary pumps, surface pipelines, portable hydrants, and other supplies, such as those available through the Water **/Wastewater** Agency Response Network (WARN). **Communicate that plan to local governments and critical facility operators.**	EQ LS WF FL DR SEC	Existing program	Ex.
a-7	a-7	Engage in, support, and/or encourage research by others **(such as USGS, universities, or Pacific Earthquake Engineering Research Center-PEER)** on measures to further strengthen transportation, water, sewer, and power systems so that they are less vulnerable to damage in disasters.	EQ LS WF FL DR SEC	Existing program	Ex.
a-8	a-8	Pre-position emergency power generation capacity (or have rental/lease agreements for these generators) in critical buildings of cities, counties, and special districts to maintain continuity of government and services.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-9	a-9	(REWORDED) **Ensure that critical intersection traffic lights function following loss of power by installing battery back-ups, emergency generators, or lights powered by alternative energy sources such as solar. Proper functioning of these lights is essential for rapid evacuation, such as with hazmat releases resulting from natural disasters.**	EQ LS WF FL SEC	Existing program, underfunded	Both
a-10	a-10	Develop unused or new pedestrian rights-of-way as walkways to serve as additional evacuation routes (such as fire roads in park lands).	EQ LS WF FL	Existing program, underfunded	Both

			SEC		
a-11	a-11	Minimize the likelihood that power interruptions **will adversely impact lifeline utility systems or critical facilities by ensuring that they have adequate back-up power.**	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-12	a-12	Encourage replacing above ground electric and phone wires and other structures with underground facilities, and use the planning-approval process to ensure that all new phone and electrical utility lines are installed underground.	EQ LS WF FL SEC	Existing program, underfunded	Both
a-13	a-13	**If you own a dam,** coordinate with the State Division of Safety of Dams to ensure an adequate timeline for the maintenance and inspection of dams, as required of dam owners by State law, **and communicate this information to local governments and the public.**	EQ LS WF FL SEC DF	Existing program	n/a
a-14	a-14	Encourage communication between State **Emergency Management Agency (CalEMA)**, FEMA, and utilities related to emergencies occurring outside of the Bay Area that can affect service delivery in the region.	EQ LS WF FL DR SEC	Existing program	n/a
a-15	a-15	Ensure that transit operators, private ambulance companies, cities, and/or counties have mechanisms in place for medical transport during and after disasters that take into consideration the potential for reduced capabilities of roads following these same disasters.	EQ LS WF FL SEC	Existing program	Ex.
a-16	new	**Recognize that heat emergencies produce the need for non-medical transport of people to cooling centers by ensuring that (1) transit operators have plans for non-medical transport of people during and after such emergencies including the use of paratransit and (2) cities, counties, and transit agencies have developed ways to communicate the plan to the public.**	Heat	Existing program, underfunded	Ex.
a-17	a-16	Effectively utilize the **Regional** Transportation Management Center (TMC) **in Oakland**, the staffing of which is provided by Caltrans, the CHP and MTC. The TMC is designed to maximize safety and efficiency throughout the highway system. It includes the Emergency Resource Center (ERC) which was created specifically for primary planning and procedural disaster management. **RESPONSIBLE AGENCY: MTC only.**	EQ LS WF FL SEC	Existing program	n/a
a-18	new	**Develop (with the participation of paratransit providers, emergency responders, and public health professionals) plans and procedures for paratransit system response and recovery from disasters.**	EQ LS WF FL Heat SEC	Existing program, underfunded	Ex.

a-19	new	**Coordinate with other critical infrastructure facilities to establish plans for delivery of water and wastewater treatment chemicals.**	EQ LS WF FL SEC	Existing program	Ex.
a-20	new	**Establish plans for delivery of fuel to critical infrastructure providers.**	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-21	new	**As an infrastructure operator, designate a back-up Emergency Operations Center with redundant communications systems.**	EQ LS WF FL SEC	Existing program, underfunded	n/a
a-22	new	**Monitor scientific studies of the Sacramento-San Joaquin Delta and policy decisions related to the long-term disaster resistance of that Delta system to ensure that decisions are made based on comprehensive analysis and in a scientifically-defensible manner. Levee failure due to earthquakes, flooding, and climate change (including sea level rise and more frequent and more severe flooding) are all of concern. The long-term health of the Delta area is critical to the Bay Area's water supply, is essential for the San Francisco Bay and estuary's environmental health, provides recreation opportunities for Bay Area residents, and provides the long-term sustainability of Delta communities. While only part of the Delta is within the nine Bay Area counties covered by this multi-jurisdictional LHMP, the Delta is tied to the infrastructure, water supply, and economy of the Bay Area.**	EQ FL LF	Existing program, underfunded	Both
INFR - b - Earthquakes					
b-1	b-1	Expedite the funding and retrofit of seismically-deficient city- and county-owned bridges and road structures by working with Caltrans and other appropriate governmental agencies.	EQ	Existing program, underfunded	Ex.
b-2	b-2	Establish a higher priority for funding seismic retrofit of existing transportation and infrastructure systems (such as BART) than for expansion of those systems.	EQ	Existing program, underfunded	Both
b-3	b-3	Include "areas subject to high ground shaking, earthquake-induced ground failure, and surface fault rupture" in the list of criteria used for determining a replacement schedule for pipelines (along with importance, age, type of construction material, size, condition, and maintenance or repair history).	EQ	Existing program	Both
b-4	b-4	Install specially-engineered pipelines in areas subject to faulting, liquefaction, earthquake-induced landsliding, or other earthquake hazard.	EQ	Existing program, underfunded	Both
b-5	b-5	Replace or retrofit water-retention structures that are determined to be structurally deficient, **including levees, dams, reservoirs and tanks.**	EQ DF LF	Existing program, underfunded	Ex.

b-6	b-6	Install portable facilities (such as hoses, pumps, emergency generators, or other equipment) to allow pipelines to bypass failure zones such as fault rupture areas, areas of liquefaction, and other ground failure areas (using a priority scheme if funds are not available for installation at all needed locations).	EQ	Existing program, underfunded	Ex.
b-7	b-7	Install earthquake-resistant connections when pipes enter and exit bridges **and work with bridge owners to encourage retrofit of these structures.**	EQ	Existing program, underfunded	Both
b-8	b-8	Comply with all applicable building and fire codes, as well as other regulations (such as state requirements for fault, landslide, and liquefaction investigations in particular mapped areas) when constructing or significantly remodeling infrastructure facilities.	EQ	Existing program	Both
b-9	b-9	Clarify to workers in critical facilities and emergency personnel, as well as to elected officials and the public, the extent to which the facilities are expected to perform only at a life safety level (allowing for the safe evacuation of personnel) or are expected to remain functional following an earthquake.	EQ	Existing program	Ex.
b-10	b-10	**Develop** a water-**based** transportation "system" across the Bay for use in the event of major earthquakes. Implementation of such a system could prove extremely useful in the event of structural failure of either the road-bridge systems or BART and might serve as an adjunct to existing transportation system elements in the movement of large numbers of people and/or goods.	EQ	Existing program	Both
INFR - c - Wildfire					
c-1	c-1	Ensure a reliable source of water for fire suppression (meeting acceptable standards for minimum volume and duration of flow) for existing and new development.	WF	Existing program, underfunded	Both
c-2	c-2	Develop a coordinated approach between fire jurisdictions and water supply agencies to identify needed improvements to the water distribution system, initially focusing on areas of highest wildfire hazard **(including wildfire threat areas and in wildland-urban-interface areas).**	WF	Existing program, underfunded	Ex.
c-3	c-3	Develop a defensible space vegetation program that includes the clearing or thinning of (a) non-fire resistive vegetation within 30 feet of access and evacuation roads and routes to critical facilities, or (b) all non-native species (such as eucalyptus and pine, but not necessarily oaks) within 30 feet of access and evacuation roads and routes to critical facilities.	WF	Existing program, underfunded	Ex.
c-4	c-4	**For new development,** ensure all dead-end segments of public roads in high hazard areas have at least a "T" intersection turn-around sufficient for typical wildland fire equipment.	WF	Existing program	New
c-5	c-5	**For new development,** enforce minimum road width of 20 feet with an additional 10-foot clearance on each shoulder on all driveways and road segments greater than 50 feet in length in wildfire hazard areas.	WF	Existing program	New

c-6	c-6	Require that development in high fire hazard areas provide adequate access roads (with width and vertical clearance that meet the minimum standards of the *Fire Code* or relevant local ordinance), onsite fire protection systems, evacuation signage, and fire breaks.	WF	Existing program	New
c-7	c-7	Ensure adequate fire equipment road or fire road access to developed and open space areas.	WF	Existing program	Both
c-8	c-8	Maintain fire roads and/or public right-of-way roads and keep them passable at all times.	WF	Existing program, underfunded	Ex.
INFR - d - Flooding					
d-1	d-1	Conduct a watershed analysis of runoff and drainage systems to predict areas of insufficient capacity in the storm drain and natural creek system.	FL	Existing program, underfunded	Both
d-2	d-2	Develop procedures for performing a watershed analysis to **examine** the impact of development on flooding potential downstream, including communities outside of the jurisdiction of proposed projects.	FL	Existing program, underfunded	New
d-3	d-3	Conduct a watershed analysis at least once every **ten** years **unless there is a major development in the watershed or a major change in the Land Use Element of the General Plan of the cities or counties within the watershed.**	FL	Existing program, underfunded	Both
d-4	d-4	Assist, support, and/or encourage the U.S. Army Corp of Engineers, various Flood Control and Water Conservation Districts, and other responsible agencies to locate and maintain funding for the development of flood control projects that have high cost-benefit ratios (such as through the writing of letters of support and/or passing resolutions in support of these efforts).	FL	Existing program	Both
d-5	d-5	Pursue funding for the design and construction of storm drainage projects to protect vulnerable properties, including property acquisitions, upstream storage such as detention basins, and channel widening with the associated right-of-way acquisitions, relocations, and environmental mitigations.	FL	Existing program, underfunded	Both
d-6	d-6	Continue to repair and make structural improvements to storm drains, pipelines, and/or channels to enable them to perform to their design capacity in handling water flows as part of regular maintenance activities. **(This strategy has the secondary benefit of addressing fuel, chemical, and cleaning product issues.)**	FL	Existing program, underfunded	Ex.
d-7	d-7	Continue maintenance efforts to keep storm drains and creeks free of obstructions, while retaining vegetation in the channel (as appropriate) to allow for the free flow of water.	FL	Existing program, underfunded	Ex.
d-8	d-8	Enforce provisions under creek protection, stormwater management, and discharge control ordinances designed to keep watercourses free of obstructions and to protect drainage facilities to **conform** with the Regional Water Quality Control Board's Best Management Practices.	FL	Existing program, underfunded	Ex.

d-9	d-9	Develop an approach and locations for various watercourse bank protection strategies, including for example, (1) an assessment of banks to inventory areas that appear prone to failure, (2) bank stabilization, including installation of rip rap, **or whatever regulatory agencies allow** (3) stream bed depth management using dredging, and (4) removal of out-of-date coffer dams in rivers and tributary streams.	FL	Existing program, underfunded	Ex.
d-10	d-10	Use **reservoir** sediment **or reed** removal as one way to increase storage for both flood control and water supply.	FL	Existing program, underfunded	Ex.
d-11	d-11	**Identify** critical **locally-owned** bridges affected by flooding and either **elevate them** to increase stream flow and maintain critical **ingress** and egress routes **or modify the channel to achieve equivalent objectives.**	FL	Existing program, underfunded	Ex.
d-12	d-12	Provide **or support the** mechanism to expedite the repair or replacement of levees that are vulnerable to collapse from earthquake-induced shaking or liquefaction, rodents, and other concerns, particularly those protecting critical infrastructure.	FL LF	Existing program, underfunded	Ex.
d-13	d-13	Ensure that utility systems in new developments are constructed in ways that reduce or eliminate flood damage.	FL	Existing program	New
d-14	d-14	Determine whether or not wastewater treatment plants are protected from floods, and if not, investigate the use of flood-control berms to not only protect from stream or river flooding, but also **increase** plant security.	FL	Existing program, underfunded	Ex.
d-15	d-15	Work cooperatively with water agencies, flood control districts, Caltrans, and local transportation agencies to determine appropriate performance criteria for watershed analysis.	FL	Existing program, underfunded	Both
d-16	d-16	Work for better cooperation among the patchwork of agencies managing flood control issues.	FL	Existing program	Both
d-17	d-17	**Improve monitoring of** creek and watercourse flows to predict potential for flooding downstream **by working cooperatively with land owners and the cities and counties in the watershed.**	FL	Existing program, underfunded	Both
d-18	new	**Using criteria developed by EPA for asset management, inventory existing assets, the condition of those assets, and improvements needed to protect and maintain those assets. Capture this information in a Geographic Information System (GIS) and use it to select locations for creek monitoring gauges.**	FL	Existing program, underfunded	Ex.
INFR - e - Landslides					
e-1	e-1	Include “areas subject to ground failure” in the list of criteria used for determining a replacement schedule (along with importance, age, type of construction material, size, condition, and maintenance or repair history) for pipelines.	LS	Existing program	Ex.

e-2	e-2	Establish requirements in zoning ordinances to address hillside development constraints in areas of steep slopes that are likely to lead to excessive road maintenance or where roads will be difficult to maintain during winter storms due to landsliding.	LS	Existing program	New
INFR - f - Building Reoccupancy					
f-1	f-1	Ensure that critical buildings owned or leased by special districts or private utility companies participate in a program similar to San Francisco's Building Occupancy Resumption Program (BORP). The BORP program permits owners of buildings to hire qualified **engineers** to create facility-specific post-disaster inspection plans and allows these engineers to become automatically deputized as City/County inspectors for these buildings in the event of an earthquake or other disaster. This program allows rapid reoccupancy of the buildings. **Note** - A qualified **(deleted structural)** engineer is a California licensed **engineer** with relevant experience.	EQ LS WF FL SEC	Existing program	Ex.
INFR - g - Public Education					
g-1	g-1	Provide materials to the public related to planning for power outages.	EQ LS WF FL SEC	Existing program	Ex.
g-2	g-2	Provide materials to the public related to family and personal planning for delays due to traffic or road closures, **or due to transit system disruption caused by disasters.**	EQ LS WF FL SEC	Existing program	Ex.
g-3	g-3	Provide materials to the public related to coping with reductions in water supply or contamination of that supply **BEYOND regulatory notification requirements.**	EQ LS WF FL DR SEC	Existing program	Ex.
g-4	g-4	Provide materials to the public related to coping with disrupted storm drains, sewage lines, and wastewater treatment **(such as materials developed by ABAG's Sewer Smart Program).**	EQ LS WF FL DR SEC	Existing program	Ex.
g-5	g-5	Facilitate and/or coordinate the distribution of **emergency preparedness or mitigation** materials that are prepared by others, such as by **making the use of the internet or other electronic means,** or placing materials on community access channels or in city or utility newsletters, as appropriate.	EQ LS WF FL DR SEC	Existing program	Ex.
g-6	**new**	Sponsor the formation **and training** of Community Emergency Response Teams (CERT) **for the employees of your agency.** [Note – these programs go by a variety of names in various cities and areas.]	EQ LS WF FL DR	Existing program	n/a

			SEC		

g-7	**new**	Develop and distribute culturally appropriate materials related to disaster mitigation and preparedness, such as those on the http://www.preparenow.org website **related to infrastructure issues.**	EQ LS WF FL DR SEC	Existing program	Ex.

Health Mitigation Strategies

2009-2010 Strategy Number	2005 Original Strategy Number	Specific Mitigation Strategy	Applicable Hazards	Regional Priority	New vs. Existing Construction
HEAL - a - Hospitals and Other Critical Health Care Facilities **(including those facilities licensed by OSHPD, as well as water agencies, public & private hospitals as noted). To be filled out by cities, counties, and county health departments.**					
a-1	a-1	**Work to ensure that cities, counties,** county health departments, and hospital operators **coordinate with each other (and that hospitals cooperate with the California Office of Statewide Health Planning and Development - OSHPD) to comply with current state law** that mandates that critical facilities are structurally sound and have nonstructural systems designed to remain functional following disasters **by 2013. In particular, this coordination should include understanding any problems with obtaining needed funding.** **RESPONSIBLE AGENCIES: Cities, counties, county health departments, and hospitals**	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-2	a-2	Encourage hospitals in your community to work with OSHPD to formalize arrangements with structural engineers to report to the hospital, assess damage, and determine if the buildings can be reoccupied. The program should be similar to San Francisco's Building Occupancy Resumption Program (BORP) that permits owners of buildings to hire qualified structural engineers to create building-specific post-disaster inspection plans and allows these engineers to become automatically deputized as inspectors for these buildings in the event of an earthquake or other disaster. OSHPD, rather than city/county building departments, has the authority and responsibility for the structural integrity of hospital structures. **RESPONSIBLE AGENCIES: Cities, counties, county health departments, and hospitals**	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-3	a-3	Ensure health care facilities are adequately prepared to care for victims with respiratory problems related to smoke and/or particulate matter inhalation. **RESPONSIBLE AGENCIES: Cities, counties, county health departments, and hospitals**	EQ WF SEC	Existing program	Both

a-4	a-4	Ensure these health care facilities have the capacity to shut off outside air and be self-contained. **RESPONSIBLE AGENCIES: Cities, counties, county health departments, and hospitals**	EQ WF SEC	Existing program	Both
a-5	a-5	Ensure that hospitals and other major health care facilities have auxiliary water and power sources. **RESPONSIBLE AGENCIES: Cities, counties, county health departments, water suppliers, and hospitals**	EQ LS WF FL SEC	Existing program, underfunded	Both
a-6	a-6	Work to ensure that county health departments work with health care facilities to institute isolation capacity should a need for them arise following a communicable disease epidemic. **Isolation capacity varies from a section of the hospital for most communicable diseases to the entire hospital for a major pandemic flu.** **RESPONSIBLE AGENCIES: Cities, counties, county health departments, and hospitals**	EQ WF FL SEC	Existing program, underfunded	Both
a-7	a-7	Develop printed materials, utilize existing materials (such as developed by FEMA, the American Red Cross, **and others, including non-profit organizations**), conduct workshops, and/or provide outreach encouraging employees of these critical health care facilities to have family disaster plans and conduct mitigation activities in their own homes. **RESPONSIBLE AGENCIES: Cities, counties, county health departments, and hospitals**	EQ LS WF FL SEC	Existing program	n/a
HEAL - b - Ancillary Health-Related Facilities (including medical offices, pharmacies, free-standing or specialty clinics, etc.)					
b-1	b-1	Identify these ancillary facilities in your community. **These facilities are not regulated by OSHPD in the same way as hospitals.** **RESPONSIBLE AGENCIES: Cities, counties, and county health departments**	EQ LS WF FL SEC	High	Ex.
b-2	b-2	Encourage these facility operators to develop disaster mitigation plans. **RESPONSIBLE AGENCIES: Cities, counties, and county health departments**	EQ LS WF FL SEC	High	Ex.
b-3	b-3	Encourage these facility operators to create, maintain, and/or continue partnerships with local governments to develop response and **business continuity** plans **for** recovery. **RESPONSIBLE AGENCIES: Cities, counties, and county health departments**	EQ LS WF FL SEC	High	Ex.
HEAL - c - Interface with National and State Health Care Initiatives **and Hazardous Materials Response Teams**					
c-1	c-1	Designate locations for the distribution of antibiotics to large numbers of people should the need arise, as required to be included in each county's Strategic National Stockpile Plan. **RESPONSIBLE AGENCIES: County Health Departments**	FLU SEC	Existing program	Ex.

c-2	c-2	Ensure that you know the Metropolitan Medical Response System (MMRS) cities in your area. Fremont, Oakland, **San Francisco, and San Jose (plus Sacramento and Stockton)** are the MMRS cities **in or near the Bay Area.** MMRS cities are provided with additional federal funds for organizing, equipping, and training groups of local fire, rescue, medical, and other emergency management personnel **to respond to a mass casualty event. (The coordination among public health, medical, emergency management, coroner, EMS, fire, and law enforcement is a model for all cities and counties.)** **RESPONSIBLE AGENCIES: Cities, counties, county health departments, and hospitals**	EQ LS WF FL SEC	Existing program	n/a
c-3	c-3	Know **that** National Disaster Medical System (NDMS) uniformed or non-uniformed personnel are within one-to-four hours of your community. These federal resources include veterinary, mortuary, and medical personnel. **Teams in or near the Bay Area are headquartered in the cities of Santa Clara and Sacramento.** **RESPONSIBLE AGENCIES: Cities, counties, county health departments, and hospitals**	EQ LS WF FL SEC	Existing program	Ex.
c-4	c-4	**Plan for hazmat related-issues due to a natural or technological disaster. Hazmat teams should** utilize the State of California Department of Health Services laboratory in Richmond for confirmation of biological agents and Lawrence Livermore National Laboratory or Sandia (both in Livermore) for confirmation of radiological agents. **RESPONSIBLE AGENCIES: Cities, counties, county health departments, and hospitals.**	EQ WF FL SEC	Existing program	Ex.
c-5	d-1	Create discussion forums for food and health personnel (including, for example, medical professionals, veterinarians, and plant pathologists) to develop safety, security, and response strategies for food supply contamination **(at the source, in processing facilities, in distribution centers, and in grocery stores).** **RESPONSIBLE AGENCIES: County environmental health departments**	FL SEC	Existing program	Both
c-6	new	**Ensure mental health continuity of operations and disaster planning is coordinated among county departments, (including Public Health and Emergency Services), private sector mental health organizations, professional associations, and national and community-based non-profit agencies involved in supporting community mental health programs. First, such planning should ensure that the capability exists to provide both immediate on-site mental health support at facilities such as evacuation centers, emergency shelters, and local assistance centers, as well as to coordinate on-going mental health support during the long-term recovery process. Second, this planning should ensure that mental health providers, in collaboration with the county agencies responsible for providing public information, are prepared to provide consistent post-disaster stress and other mental health guidance to the public impacted by the**	EQ LS WF FL SEC	Existing program, underfunded	Ex.

		disaster.			
deleted	d-2	(duplicate information to c-2)			
deleted	d-3	(duplicate information to c-3)			
deleted	d-4	(duplicate information to c-4)			

Housing Mitigation Strategies

2009-2010 Strategy Number	**2005 Original Strategy Number**	**Specific Mitigation Strategy**	**Applicable Hazards**	**Regional Priority**	**New vs. Existing Construction**
HSNG - a - Multi-Hazard					
a-1	a-1	Assist in ensuring adequate hazard disclosure by working with real estate agents to improve enforcement of real estate disclosure requirements **for residential properties** with regard to seven official natural hazard zones: **1) Special Flood Hazard Areas (designated by FEMA), 2) Areas of Potential Flooding from dam failure inundation, 3) Very High Fire Hazard Severity Zones, 4) Wildland Fire Zones, 5) Earthquake Fault Zones (designated under the Alquist-Priolo Earthquake Fault Zoning Act), and the 6) Liquefaction and Landslide Hazard Zones (designated under the Seismic Hazard Mapping Act).**	EQ LS WF FL SEC DF	Existing program	Ex.

a-2	a-2	Create incentives for **private** owners of historic or architecturally significant residential buildings to undertake mitigation to levels that will minimize the likelihood that these buildings will need to be demolished after a disaster, particularly if those alterations conform to the federal Secretary of the Interior's *Guidelines for Rehabilitation.*	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-3	NEW Was GOVT b-4	Develop a plan for short-term sheltering of residents **of your community in conjunction with the American Red Cross.**	EQ LS WF FL SEC	Existing program	Ex.
a-4	NEW Was GOVT b-4	**Develop a plan for interim housing for those displaced by working with the Regional Catastrophic Planning Grant Program (CPGP) that funded this effort in 2009. (Estimated completion is 2011.)**	EQ LS WF FL SEC	Under Study	Ex.

HSNG - b - Single-Family Homes Vulnerable to Earthquakes					
b-1	b-1	Utilize or recommend adoption of a retrofit standard that includes standard plan sets and construction details for voluntary bolting of homes to their foundations and bracing of outside walls of crawl spaces ("cripple" walls), such as **Plan Set A** developed by a committee representing the East Bay-Peninsula-Monterey Chapters of the International Code Council (ICC), California Building Officials (CALBO), the Structural Engineers Association of Northern California (SEAONC), the Northern California Chapter of the Earthquake Engineering Research Institute (EERI-NC), and ABAG's Earthquake Program.	EQ	Existing program, underfunded	Ex.
b-2	b-2	Require engineered plan sets for **seismic** retrofitting of heavy two-story homes with living areas over garages, as well as for split level homes **(that is, homes not covered by Plan Set A)**, until standard plan sets and construction details become available.	EQ	Existing program	Ex.
b-3	b-3	Require engineered plan sets for **seismic** retrofitting of homes on steep hillsides **(because these homes are not covered by Plan Set A)**.	EQ	Existing program	Ex.
b-4	b-4	Encourage local government building inspectors to take classes on a periodic basis (such as the FEMA-developed training classes offered by ABAG) on retrofitting of single-family homes, **including application of Plan Set A.**	EQ	Existing program	Ex.
b-5	b-5	Encourage private retrofit contractors and home inspectors doing work in your area to take retrofit classes on a periodic basis (such as the FEMA-developed training classes offered by ABAG **or additional classes that might be offered by the CALBO Training Institute**) on retrofitting of single-family homes.	EQ	Existing program	Ex.
b-6	b-6	Conduct demonstration projects on common existing housing types demonstrating structural and nonstructural mitigation techniques as community models for earthquake mitigation.	EQ	Moderate	Ex.
b-7	b-7	Provide retrofit classes or workshops for homeowners in your community**, or help promote utilization of subregional workshops in the South Bay, East Bay, Peninsula, and North Bay as such workshops become available through outreach using existing community education programs.**	EQ	Existing program, underfunded	Ex.
b-8	b-8	Establish tool-lending libraries with common tools needed for retrofitting for use by homeowners with appropriate training.	EQ	Moderate	Ex.
b-9	b-9	**(reworded) Provide financial incentives to owners of single-family homes to retrofit if those retrofits comply with Plan Set A or IEBC 2006 in addition to that provided by existing State law that makes such retrofits exempt from increases in property taxes.**	EQ	Existing program, underfunded	Ex.

HSNG - c - Soft-Story Multifamily Residential Structures Vulnerable to Earthquakes					
c-1	c-1	Require engineered plan sets for voluntary or mandatory soft-story **seismic** retrofits **by private owners** until a standard plan set and construction details become available.	EQ	Existing program	Ex.
c-2	c-2	Adopt the 2009 **(changed date)** International Existing Building Code or the latest applicable standard for the design of voluntary or mandatory soft-story building retrofits **for use in city/county building department regulations. In addition, allow use of changes to that standard recommended by SEAOC for the 2012 IEBC.**	EQ	Existing program	Ex.
c-3	c-3	Work to educate building owners, local government staff, engineers, and contractors on **privately-owned** soft-story retrofit procedures and incentives using materials such as those developed by ABAG and the City of San Jose (see **http://quake.abag.ca.gov/eqhouse.html**.)	EQ	Moderate	Ex.
c-4	c-4	Conduct an inventory of **privately-owned** existing or suspected soft-story residential structures **as a first step in establishing voluntary or mandatory programs for retrofitting these buildings.**	EQ	Existing program, underfunded	Ex.
c-5	c-5	Use the soft-story inventory to require **private** owners to inform all existing tenants (and **prospective** tenants prior to signing a lease agreement) that they **may** live in this type of building.	EQ	High	Ex.
c-6	c-6	Use the soft-story inventory to require **private** owners to inform all existing **and prospective** tenants that they **may** need to be prepared to live elsewhere following an earthquake if the building has not been retrofitted.	EQ	Moderate	Ex.
c-7	c-7	Investigate and adopt appropriate financial, procedural, and land use incentives (such as parking waivers) for **private** owners of soft-story buildings to facilitate retrofit such as those **described** by ABAG (see ***http://quake.abag.ca.gov/fixit***).	EQ	High	Ex.
c-8	c-8	(reworded) Explore development of State regulations or legislation to require or encourage **private** owners of soft-story structures to strengthen them.	EQ	Moderate	Ex.
c-9	c-9	Provide technical assistance in seismically strengthening **privately-owned** soft-story structures.	EQ	Under Study	Ex.
HSNG - d - Unreinforced Masonry Housing Stock					
d-1	d-1	Continue to actively implement existing State law that requires cities and counties to maintain lists of the addresses of unreinforced masonry buildings and inform **private** property owners that they own this type of hazardous structure.	EQ	Existing program	Ex.

d-2	d-2	Accelerate retrofitting of **privately-owned** unreinforced masonry structures that have not been retrofitted, for example, by (a) actively working with owners to obtain structural analyses of their buildings, (b) helping owners obtain retrofit funding, (c) adopting a mandatory versus voluntary, retrofit program, and/or (d) applying penalties to owners who show inadequate efforts to upgrade these buildings.	EQ	Existing program, underfunded	Ex.
d-3	d-3	Require **private** owners to inform all existing **tenants (and prospective** tenants prior to signing a lease agreement) that they live in **an unreinforced masonry** building and the standard to which it may have been retrofitted.	EQ	Existing program, underfunded	Ex.
d-4	d-4	As required by State law**,** require **private** owners to inform all existing tenants that they may need to be prepared to live elsewhere following an earthquake even if the building has been retrofitted, **because** it has probably been retrofitted to a life-safety standard, not to a standard that will allow occupancy following major earthquakes.	EQ	Existing program	Ex.
HSNG - e - Other Privately-Owned Structurally Vulnerable Residential Buildings and Earthquakes					
e-1	e-1	Identify and work toward tying down mobile homes used as year-round permanent residences using an appropriate cost-sharing basis (for example, 75% grant, 25% owner).	EQ	Existing program, underfunded	Ex.
e-2	e-2	Inventory non-ductile concrete, tilt-up concrete **(such as converted lofts)**, and other privately-owned potentially structurally **vulnerable** residential buildings.	EQ	Existing program, underfunded	Ex.
e-3	e-3	Adopt the **2009** International Existing Building Code or the latest applicable standard for the design of voluntary or mandatory retrofit of **privately-owned** seismically vulnerable buildings.	EQ	Existing program	Ex.
e-4	e-4	Adopt one or more of the following strategies as incentives to encourage retrofitting of privately-owned **seismically vulnerable** residential buildings: (a) waivers or reductions of permit fees, (b) below-market loans, (c) local tax breaks, (d) grants to cover the cost of retrofitting or of a structural analysis, (e) land use **(such as parking requirement waivers)** and procedural incentives, or (f) technical assistance.	EQ	Existing program, underfunded	Ex.
HSNG - f - New Construction and Earthquakes					
f-1	f-1	Continue to require that all new housing be constructed in compliance with **(deleted "structural")** requirements of the most recently adopted version of the *California Building Code*.	EQ	Existing program	New
f-2	f-2	Conduct appropriate employee training and support continued education to ensure enforcement of building codes and construction standards, as well as identification of typical design inadequacies of housing and recommended improvements.	EQ	Existing program	Both

HSNG - g - Wildfire and Structural Fires					
g-1	g-1	Increase efforts to reduce hazards in existing **private** development in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat through improving engineering design and vegetation management for mitigation, appropriate code enforcement, and public education on defensible space mitigation strategies.	WF	Existing program	Ex.
g-2	g-2	Tie public education on defensible space and a comprehensive defensible space ordinance to a field program of enforcement.	WF	Existing program	Both
g-3	g-3	Require that new homes in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat be constructed of fire-resistant building materials (including roofing and exterior walls) and incorporate fire-resistant design features (such as minimal use of eaves, internal corners, and open first floors) to increase structural survivability and reduce ignitability. **Note** - See Structural Fire Prevention Field Guide for Mitigation of Wildfires at http://osfm.fire.ca.gov/structural.html.	WF	Existing program	New
g-4	g-4	Create or identify "model" **properties showing defensible space and structural survivability** in neighborhoods that are wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat.	WF	Moderate	Both
g-5	g-5	Consider fire safety, evacuation, and emergency vehicle access when reviewing proposals to add secondary units or additional residential units in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat.	WF	Existing program	Ex.
g-6	g-6	Adopt and amend as needed updated versions of the *California Building and Fire Codes* so that optimal fire-protection standards are used in construction and renovation projects **of private buildings.**	WF	Existing program	Both
g-7	g-7	Create a mechanism to enforce provisions of the *California Building and Fire Codes* and other local codes that require the installation of smoke detectors and fire-extinguishing systems **on existing residential buildings** by making installation a condition of (a) finalizing a permit for any work valued at over a fixed amount and/or (b) on any building over 75 feet in height, and/or (b) as a condition for the transfer of property.	WF	Existing program	Ex.
g-8	g-8	Work to ensure a reliable source of water for fire suppression in rural-residential areas through the cooperative efforts of water districts, fire districts, and residents.	WF	Existing program, underfunded	Both

g-9	g-9	Expand vegetation management programs in wildland-urban- interface fire-threatened communities or in areas exposed to high-to-extreme fire threat to more effectively manage the fuel load through roadside collection and chipping, mechanical fuel reduction equipment, selected harvesting, use of goats or other organic methods of fuel reduction, and selected use of controlled burning.	WF	Existing program, underfunded	Both
g-10	g-11	Establish **special funding mechanisms** (such as Fire Hazard Abatement Districts **or regional bond funding**) to fund reduction in fire risk of existing properties through vegetation management that includes reduction of fuel loads, use of defensible space, and fuel breaks.	WF	Existing program, underfunded	Both
g-11	g-12	Work with residents in rural-residential areas to ensure adequate **plans are developed for appropriate** access and evacuation in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat. **For example, in some areas, additional roads can be created, and in other areas, the communities will need to focus on early warning and evacuation because additional roads are not feasible.**	WF	Existing program, underfunded	Both
g-12	g-13	Require fire sprinklers in new homes located more than 1.5 miles or a 5-minute response time from a fire station or in an identified high hazard wildland-urban-interface wildfire area.	WF	Existing program	New
g-13	g-14	Require fire sprinklers in all new or substantially remodeled multifamily housing, regardless of distance from a fire station.	WF	Existing program	Both
g-14	g-15	Require sprinklers in all mixed use development to protect residential uses from fires started in non-residential areas.	WF	Existing program	New
g-15	g-16	Compile a list of **privately-owned** high-rise and high-occupancy buildings which are deemed, due to their age or construction materials, to be particularly susceptible to fire hazards, and determine an expeditious timeline for the fire-safety inspection of all such structures.	WF	Existing program	Ex.
g-16	g-17	Conduct periodic fire-safety inspections of all multi-family buildings, as required by State law.	WF	Existing program	Ex.
g-17	g-18	Ensure that **city/county-initiated** fire-preventive vegetation-management techniques and practices for creek sides and high-slope areas do not contribute to the landslide and erosion hazard. **For example, vegetation in these sensitive areas could be thinned, rather than removed, or replanted with less flammable materials. When thinning, the non-native species should be removed first. Other options would be to use structural mitigation, rather than vegetation management in the most sensitive areas.**	WF LS	Existing program, underfunded	Both
g-18	g-19	Create a mechanism to require the bracing of water heaters and flexible couplings on gas appliances, and/or (as specified under "**b.** Single-family homes vulnerable to earthquakes" above) the bolting of homes to their foundations and strengthening of cripple walls to reduce fire ignitions due to earthquakes.	EQ WF	Existing program	Ex.

g-19	g-20	Work with the State Fire Marshall, the California Seismic Safety **Commission, Pacific Earthquake Engineering Research Center** (PEER), and other experts to identify and manage gas-related fire risks of soft-story residential or mixed use buildings that are prone to collapse and occupant entrapment consistent with the natural gas safety recommendations of Seismic Safety Commission Report SSC-02-03. **Note** - See http://www.seismic.ca.gov/pub/CSSC_2002-03_Natural%20Gas%20Safety.pdf. **Also note** - any values that are installed may need to have both excess flow and seismic triggers ("hybrid" valves).	EQ WF	Moderate	Ex.
g-20	new	**Work with insurance companies to create a public/private partnership to give a discount on fire insurance premiums to "Forester Certified" *Fire Wise* landscaping and fire-resistant building materials on private property.**	WF	Existing program, underfunded	Ex.
HSNG - h - Flooding					
h-1	h-1	To reduce flood risk, thereby reducing the cost of flood insurance to **private** property owners, work to qualify for the highest-feasible rating under the Community Rating System of the National Flood Insurance Program.	FL	Existing program	Both
h-2	h-2	Balance the housing needs of residents against the risk from potential flood-related hazards.	FL	Existing program	New
h-3	h-3	Ensure that new **private** development pays its fair share of improvements to the storm drainage system necessary to accommodate increased flows from the development, ***or*** does not increase runoff by draining water to pervious areas or detention facilities.	FL	Existing program	New
h-4	h-4	Provide sandbags and plastic sheeting to residents in anticipation of rainstorms, and deliver those materials to **vulnerable populations** upon request.	FL	Existing program	Ex.
h-5	h-5	Provide public information on locations for obtaining sandbags and/or deliver those sandbags to those various locations throughout a city and/or county prior to and/or during the rainy season.	FL	Existing program	Ex.
h-6	h-6	Apply floodplain management regulations for **private** development in the floodplain and floodway.	FL	Existing program	New
h-7	h-7	Ensure that new subdivisions are designed to reduce or eliminate flood damage by requiring lots and rights-of-way **be** laid out for the provision of approved sewer and drainage facilities, providing on-site detention facilities whenever practicable.	FL	Existing program	New
h-8	h-8	Encourage home and apartment owners to participate in home elevation programs **within flood hazard areas.**	FL	Existing program	Ex.
h-9	h-9	As funding opportunities become available, encourage home and apartment owners to participate in acquisition and relocation programs for areas within floodways.	FL	Moderate	Ex.

h-10	h-10	Encourage owners of properties in a floodplain to consider purchasing flood insurance. For example, point out that most homeowners' insurance policies do not cover a property for flood damage.	FL	Existing program	Ex.

HSNG - i - Landslides and Erosion					
i-1	i-1	Increase efforts to reduce landslides and erosion in existing and future development by improving appropriate code enforcement and use of applicable standards **for private property**, such as those appearing in the *California Building Code*, California Geological Survey *Special Report 117 – Guidelines for Evaluating and Mitigating Seismic Hazards in California, American Society of Civil Engineers (ASCE) report Recommended Procedures for Implementation of DMG Special Publication 117: Guidelines for Analyzing and Mitigating Landslide Hazards in California, and the California Board for Geologists and Geophysicists Guidelines for Engineering Geologic Reports.* Such standards should cover excavation, fill placement, cut-fill transitions, slope stability, drainage and erosion control, slope setbacks, expansive soils, collapsible soils, environmental issues, geological and geotechnical investigations, grading plans and specifications, protection of adjacent properties, and review and permit issuance.	LS	Existing program	Both
i-2	i-2	Increase efforts to reduce landslides and erosion in existing and future **private** development through continuing education of design professionals on mitigation strategies.	LS	Existing program, underfunded	Both
HSNG - j - Building Reoccupancy					
j-1	j-1 same as econ i-5	Develop and enforce a **repair and reconstruction** ordinance to ensure that **damaged** buildings are repaired in an appropriate and timely manner and retrofitted concurrently. **This repair and reconstruction ordinance should apply to all public and private buildings, and also apply to repair of all damage, regardless of cause. See http://quake.abag.ca.gov/recovery/info-repair-ord.html.**	EQ LS WF FL SEC	Existing program	Ex.
j-2	new same as econ i-6	Establish preservation-sensitive measures for the repair and reoccupancy of historically significant **privately-owned** structures, including requirements for temporary shoring or stabilization where needed, arrangements for consulting with preservationists, and expedited permit procedures for suitable repair or rebuilding of historically or architecturally valuable structures.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
HSNG - k - Public Education					
k-1	k-1	Provide information to residents of your community on the availability of interactive hazard maps showing your community on ABAG's web site.	EQ LS WF FL SEC	Existing program	Both
k-2	k-2	Develop printed materials, utilize existing materials (such as developed by FEMA and the American Red Cross), conduct workshops, and/or provide outreach encouraging residents to have family disaster plans that include drop-cover-hold earthquake drills, fire and storm evacuation procedures, and shelter-in-place emergency guidelines.	EQ LS WF FL SEC	Existing program, underfunded	n/a

k-3	k-3	Inform residents of comprehensive mitigation activities, including elevation of appliances above expected flood levels, use of fire-resistant roofing and defensible space in high wildfire threat and wildfire-urban-interface areas, structural retrofitting techniques for older homes, and use of intelligent grading practices through workshops, publications, and media announcements and events.	EQ LS WF FL SEC	Existing program, underfunded	Both
k-4	k-4	Develop a public education campaign on the cost, risk, and benefits of earthquake, flood, and other hazard insurance **as compared to mitigation.**	EQ LS FL SEC	Existing program, underfunded	Both
k-5	k-5	Use disaster anniversaries, such as April (the 1906 earthquake), September (9/11), and October (Loma Prieta earthquake and Oakland Hills fire), to remind the public **of** safety and security mitigation activities.	EQ LS WF FL SEC	Existing program	Both
k-6	k-6	Sponsor the formation and training of Community Emergency Response Teams (CERT) **for residents in your community.** [Note – these programs go by a variety of names in various cities and areas.]	EQ LS WF FL SEC	Existing program, underfunded	n/a
k-7	k-7	Include flood fighting technique session based on California Department of Water Resources training to the list of available public training classes offered by CERT.	FL	Existing program, underfunded	n/a
k-8	k-8	Institute the neighborhood watch block captain and team programs outlined in the Citizen Corps program guide.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
k-9	k-9	Assist residents in the development of defensible space through the use of, for example, “tool libraries” for weed abatement tools, roadside collection and/or chipping services (for brush, weeds, and tree branches) in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat.	WF	Existing program, underfunded	Ex.
k-10	k-10	Train homeowners to locate and shut off gas valves if they smell or hear gas leaking.	EQ LS WF FL SEC	Existing program	Ex.
k-11	k-12	Develop a program to provide at-cost NOAA weather radios to residents of flood hazard areas **that request them, with priority to neighborhood watch captains and others trained in their use.**	FL	Moderate	n/a
k-12	k-13	Make use of the materials on the ABAG web site at http://quake.abag.ca.gov/fixit and other web sites to increase residential mitigation activities related to earthquakes. (ABAG plans to continue to improve the quality of those materials over time.)	EQ	Existing program	Ex.
k-13	k-14	Develop a “Maintain-a-Drain” campaign, similar to that of the City of Oakland, encouraging **private** businesses and residents to keep storm drains in their neighborhood free	FL	Existing program	Ex.

		of debris.			
k-14	k-15	Encourage the formation of a community- and neighborhood-based approach to wildfire education and action through local Fire Safe Councils and the *Fire Wise Program*. **This effort is important because grant funds are currently available to offset costs of specific council-supported projects.**	WF	Existing program, underfunded	Ex.
k-15	k-16	Inform shoreline-property owners of the possible long-term economic threat posed by rising sea levels.	FL	Under Study	Ex.
k-16	k-17	Distribute appropriate materials related to disaster mitigation and preparedness **to residents. Appropriate materials are (1) culturally appropriate and (2) suitable for special needs populations. For example, such materials are available on the** http://www.preparenow.org website **and from non-governmental organizations that work with these communities on an on-going basis.**	EQ LS WF FL SEC	Existing program	Ex.
deleted	g-10	DELETED - REPLACED BY DISCUSSION OF REVERSE 911 in GOVT c-14.			
deleted	k-11				

Economy Mitigation Strategies

2009-2010 Strategy Number	2005 Original Strategy Number	Specific Mitigation Strategy	Applicable Hazards	Regional Priority	New vs. Existing Construction
ECON - a - Multi-Hazard					
a-1	a-1	Assist in ensuring adequate hazard disclosure by working with real estate agents to improve enforcement of real estate disclosure requirements **for commercial and industrial properties** with regard to seven official natural hazard zones: **1) Special Flood Hazard Areas (designated by FEMA), 2) Areas of Potential Flooding from dam failure inundation, 3) Very High Fire Hazard Severity Zones, 4) Wildland Fire Zones, 5) Earthquake Fault Zones (designated under the Alquist-Priolo Earthquake Fault Zoning Act), and the 6) Liquefaction and Landslide Hazard Zones (designated under the Seismic Hazard Mapping Act).**	EQ LS WF FL SEC DF	Existing program	Ex.

a-2	a-2	Create incentives for **private** owners of historic or architecturally significant **commercial and industrial** buildings to undertake mitigation to levels that will minimize the likelihood that these buildings will need to be demolished after a disaster, particularly if those alterations conform to the federal Secretary of the Interior's *Guidelines for Rehabilitation.*	EQ LS WF FL SEC	Existing program, underfunded	Ex.
ECON - b - Soft-Story Commercial Buildings Vulnerable to Earthquakes					
b-1	b-1	Require engineered plan sets for voluntary or mandatory soft-story **seismic** retrofits **by private owners** until a standard plan set and construction details become available.	EQ	Existing program	Ex.
b-2	b-2	Adopt the 2009 **(changed date)** International Existing Building Code or the latest applicable standard for the design of voluntary or mandatory soft-story building retrofits **for use in city/county building department regulations. In addition, allow use of changes to that standard recommended by SEAOC for the 2012 IEBC.**	EQ	Existing program	Ex.
b-3	b-3	Work to educate building owners, local government staff, engineers, and contractors on **privately-owned** soft-story retrofit procedures and incentives using materials such as those developed by ABAG and the City of San Jose (see **http://quake.abag.ca.gov/eqhouse.html**.)	EQ	Moderate	Ex.
b-4	b-4	Conduct an inventory of **privately-owned** existing or suspected soft-story commercial or industrial structures **as a first step in establishing voluntary or mandatory programs for retrofitting these buildings.**	EQ	High	Ex.
b-5	b-5	Use the soft-story inventory to require **private** owners to inform all existing tenants (and **prospective** tenants prior to signing a lease agreement) that they **may** work in this type of building.	EQ	High	Ex.
b-6	b-6	Use the soft-story inventory to require **private** owners to inform all existing **and prospective** tenants that they **may** need to be prepared to work elsewhere following an earthquake if the building has not been retrofitted.	EQ	Moderate	Ex.
b-7	b-7	Investigate and adopt appropriate financial, procedural, and land use incentives (such as parking waivers) for **private** owners of soft-story buildings to facilitate retrofit such as those **described** by ABAG (see ***http://quake.abag.ca.gov/fixit***).	EQ	High	Ex.
b-8	b-8	(reworded) Explore development of State regulations or legislation to require or encourage **private** owners of soft-story structures to strengthen them.	EQ	Moderate	Ex.
b-9	b-9	Provide technical assistance in seismically strengthening **privately-owned** soft-story structures.	EQ	Under Study	Ex.
ECON - c - Unreinforced Masonry Buildings in Older Downtown Areas					
c-1	c-1	Continue to actively implement existing State law that requires cities and counties to maintain lists of the addresses of unreinforced masonry buildings and inform **private** property owners that they own this type of hazardous structure.	EQ	Existing program	Ex.

c-2	c-2	Accelerate retrofitting of **privately-owned** unreinforced masonry structures that have not been retrofitted, for example, by (a) actively working with owners to obtain structural analyses of their buildings, (b) helping owners obtain retrofit funding, (c) adopting a mandatory (**rather than** voluntary) retrofit program, and/or (d) applying penalties to owners who show inadequate efforts to upgrade these buildings.	EQ	Existing program, underfunded	Ex.
c-3	c-3	Require **private** owners to inform all existing **tenants (and prospective** tenants prior to signing a lease agreement) that they work in **an unreinforced masonry** building and the standard to which it may have been retrofitted.	EQ	Existing program, underfunded	Ex.
c-4	c-4	As required by State law**,** require **private** owners to inform all existing tenants that they may need to be prepared to work elsewhere following an earthquake even if the building has been retrofitted, **because** it has probably been retrofitted to a life-safety standard, not to a standard that will allow occupancy following major earthquakes.	EQ	Existing program	Ex.
ECON - d - Privately-Owned Structurally **Vulnerable** Buildings					
d-1	d-1	Inventory non-ductile concrete, tilt-up concrete, and other privately-owned structurally **vulnerable** buildings.	EQ	Existing program, underfunded	Ex.
d-2	d-2	Adopt the **2009** International Existing Building Code or the latest applicable standard for the design of voluntary or mandatory retrofit of **privately-owned** seismically vulnerable buildings.	EQ	Existing program	Ex.
d-3	d-3	Adopt one or more of the following strategies as incentives to encourage retrofitting of privately-owned **seismically vulnerable** commercial and industrial buildings: (a) waivers or reductions of permit fees, (b) below-market loans, (c) local tax breaks, (d) grants to cover the cost of retrofitting or of a structural analysis, (e) land use **(such as parking requirement waivers)** and procedural incentives, or (f) technical assistance.	EQ	Existing program, underfunded	Ex.
ECON - e - Wildfire and Structural Fires					
e-1	e-1	Increase efforts to reduce hazards in existing **private** development in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat through improving engineering design and vegetation management for mitigation, appropriate code enforcement, and public education on defensible space mitigation strategies.	WF	Existing program	Ex.
e-2	new	**Tie public education on defensible space and a comprehensive defensible space ordinance to a field program of enforcement.**	WF	Existing program	Both
e-3	e-2	Require that new **privately-owned** business and office buildings in high fire hazard areas be constructed of fire-resistant building materials and incorporate fire-resistant design features (such as minimal use of eaves, internal corners, and open first floors) to increase structural survivability and reduce ignitability.	WF	Existing program	New

e-4	e-3	Adopt and amend as needed updated versions of the *California Building and Fire Codes* so that optimal fire-protection standards are used in construction and renovation projects **of private buildings.**	WF	Existing program	Both
e-5	e-4	Create a mechanism to enforce provisions of the *California Building and Fire Codes* and other local codes that require the installation of smoke detectors and fire-extinguishing systems **on existing privately-owned buildings** by making installation a condition of (a) finalizing a permit for any work valued at over a fixed amount and/or (b) on any building over 75 feet in height, and/or (b) as a condition for the transfer of property.	WF	Existing program	Ex.
e-6	e-5	(reworded to more closely match the HSNG strategy) Expand vegetation management programs in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat to more effectively manage the fuel load through roadside collection and chipping, mechanical fuel reduction equipment, selected harvesting, use of goats or other organic methods of fuel reduction, and selected use of controlled burning.	WF	Existing program, underfunded	Ex.
e-7	e-6	Establish **special funding mechanisms (such as** Fire Hazard Abatement Districts **or regional bond funding**) to fund reduction in fire risk of existing properties through vegetation management that includes reduction of fuel loads, use of defensible space, and fuel breaks.	WF	Existing program, underfunded	Both
e-8	e-7	Establish **special funding mechanisms (such as** Fire Hazard Abatement Districts **or regional bond funding**) to fund fire-safety inspections of private properties, roving firefighter patrols on high fire-hazard days, and public education efforts.	WF	Existing program, underfunded	Both
e-9	e-8	Compile a list of **privately-owned** high-rise and high-occupancy buildings that are deemed, due to their age or construction materials, to be particularly susceptible to fire hazards, and determine an expeditious timeline for the fire-safety inspection of all such structures.	WF	Existing program	Ex.
e-10	e-9	Conduct periodic fire-safety inspections of all **privately-owned** commercial and **industrial** buildings.	WF	Existing program	Ex.
e-11	e-10	Work with the State Fire Marshall, the California Seismic Safety **Commission, Pacific Earthquake Engineering Research Center** (PEER), and other experts to identify and manage gas-related fire risks of **privately-owned** soft-story mixed use buildings that are prone to collapse and occupant entrapment consistent with the natural gas safety recommendations of Seismic Safety Commission Report SSC-02-03. **Note** - See http://www.seismic.ca.gov/pub/CSSC_2002-03_Natural%20Gas%20Safety.pdf. **Also note** - any valves that are installed may need to have both excess flow and seismic triggers ("hybrid" valves).	EQ WF	Moderate	Ex.
e-12	e-11	Ensure that **city/county-initiated** fire-preventive vegetation-management techniques and practices for creek sides and high-slope areas do not contribute to the landslide and erosion hazard.	WF	Existing program	Both

e-13	e-12	Work with insurance companies to create a public/private partnership to give a discount on fire insurance premiums to "Forester Certified" *Fire Wise* landscaping and fire-resistant building materials **on private property.**	WF	Existing program, underfunded	Ex.
ECON - f – Flooding					
f-1	f-1	To reduce flood risk, thereby reducing the cost of flood insurance to **private** property owners, work to qualify for the highest-feasible rating under the Community Rating System of the National Flood Insurance Program.	FL	Existing program	Ex.
f-2	f-2	Balance the needs for **private** commercial and industrial development against the risk from potential flood-related hazards.	FL	Existing program	New
f-3	f-3	Ensure that new **private** development pays its fair share of improvements to the storm drainage system necessary to accommodate increased flows from the development, ***or*** does not increase runoff by draining water to pervious areas or detention facilities.	FL	Existing program	New
f-4	f-4	Provide sandbags and plastic sheeting to **private** businesses in anticipation of rainstorms, and deliver those materials to **vulnerable populations** upon request.	FL	Existing program	Ex.
f-5	f-5	Provide information **to private business** on locations for obtaining sandbags and deliver those sandbags to those various locations throughout a city and/or county.	FL	Existing program	Ex.
f-6	f-6	Apply floodplain management regulations for **private** development in the floodplain and floodway.	FL	Existing program	New
f-7	f-7	Encourage **private** business owners to participate in building elevation programs **within flood hazard areas.**	FL	Existing program	Ex.
f-8	f-8	As funding becomes available, encourage **private** business owners to participate in acquisition and relocation programs for areas within floodways.	FL	Moderate	Ex.
f-9	f-9	Require an annual inspection of approved flood-proofed **privately-owned** buildings to ensure that (a) all flood-proofing components will operate properly under flood conditions and (b) all responsible personnel are aware of their duties and responsibilities as described in their building's *Flood Emergency Operation Plan* and *Inspection & Maintenance Plan*.	FL	Existing program	Ex.

ECON - g - Landslides and Erosion					
g-1	g-1	Increase efforts to reduce landslides and erosion in existing and future development by improving appropriate code enforcement and use of applicable standards **for private property**, such as those appearing in the *California Building Code*, California Geological Survey *Special Report 117 – Guidelines for Evaluating and Mitigating Seismic Hazards in California,* American Society of Civil Engineers (ASCE) report *Recommended Procedures for Implementation of DMG Special Publication 117: Guidelines for Analyzing and Mitigating Landslide Hazards in California,* and the California Board for Geologists and Geophysicists *Guidelines for Engineering Geologic Reports.* Such standards should cover excavation, fill placement, cut-fill transitions, slope stability, drainage and erosion control, slope setbacks, expansive soils, collapsible soils, environmental issues, geological and geotechnical investigations, grading plans and specifications, protection of adjacent properties, and review and permit issuance.	LS	Existing program	Both
g-2	g-2	Increase efforts to reduce landslides and erosion in existing and future **private** development through continuing education of design professionals on mitigation strategies.	LS	Existing program, underfunded	Both
ECON - h - **New** Construction **and Earthquakes**					
h-1	h-1	Continue to require that all new **privately-owned** commercial and industrial buildings be constructed in compliance with **(deleted "structural")** requirements of the most recently adopted version of the *California Building Code*.	EQ	Existing program	New
h-2	h-2	Conduct appropriate employee training and support continued education to ensure enforcement of construction standards **for private development.**	EQ	Existing program	New
h-3	h-3	**Work with private building owners to help them** recognize that many strategies that increase earthquake resistance also decrease damage in an explosion. In addition, recognize that ventilation systems can be designed to contain airborne biological agents.	EQ SEC	Existing program, underfunded	Ex.
ECON - i - Building Reoccupancy					
i-1	i-1	Institute a program **to encourage owners of private buildings to participate in a program** similar to San Francisco's Building Occupancy Resumption Program (BORP). This program permits owners of private buildings to hire qualified structural engineers to create building-specific post-disaster inspection plans and allows these engineers to become automatically deputized as City/County inspectors for these buildings in the event of an earthquake or other disaster.	EQ LS WF FL SEC	Existing program, underfunded	Ex.

i-2	i-2	Actively notify **private** owners of historic or architecturally significant buildings of the availability of the local BORP-type program and encourage them to participate to ensure that appropriately qualified structural engineers are inspecting their buildings, thus reducing the likelihood that the buildings will be inappropriately evaluated following a disaster.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
i-3	i-3	Actively notify owners of ***educational facility*** buildings of the availability of the local BORP-type program and encourage them to participate to ensure that appropriately qualified structural engineers are inspecting their buildings, thus reducing the likelihood that the buildings will be inappropriately evaluated following a disaster.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
i-4	i-4	Allow **private building** owners to participate in a BORP-type program as described above, but not actively encourage them to do so.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
i-5	i-5	Develop and enforce a **repair and reconstruction** ordinance to ensure that damaged buildings are repaired in an appropriate and timely manner and retrofitted concurrently**. This repair and reconstruction ordinance should apply to all public and private buildings, and also apply to repair of all damage, regardless of cause. See http://quake.abag.ca.gov/recovery/info-repair-ord.html.**	EQ LS WF FL SEC	Existing program	Ex.
i-6	i-6	Establish preservation-sensitive measures for the repair and reoccupancy of historically significant **privately-owned** structures, including requirements for temporary shoring or stabilization where needed, arrangements for consulting with preservationists and expedited permit procedures for suitable repair or rebuilding of historically or architecturally valuable structures.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
ECON - j - Public Education					
j-1	j-1	Provide information to **private** business owners and **their** employees on the availability of interactive hazard maps on ABAG's web site.	EQ LS WF FL SEC	Existing program	Ex.
j-2	j-2	Develop printed materials, utilize existing materials (such as developed by FEMA and the American Red Cross), conduct workshops, and/or provide outreach encouraging **private** businesses' employees to have family disaster plans that include drop-cover-hold earthquake drills, fire and storm evacuation procedures, and shelter-in-place emergency guidelines.	EQ LS WF FL SEC	Existing program, underfunded	n/a
j-3	j-3	Develop **and** print materials, conduct workshops, and provide outreach to Bay Area **private** businesses focusing on business continuity planning.	EQ LS WF FL SEC	Existing program, underfunded	Ex.

j-4	j-4	Inform Bay Area **private** business owners of mitigation activities, including elevation of appliances above expected flood levels, use of fire-resistant roofing and defensible space in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat, structural retrofitting techniques for older buildings, and use of intelligent grading practices through workshops, publications, and media announcements and events.	WF FL	Existing program, underfunded	Ex.
j-5	j-5	Sponsor the formation and training of Community Emergency Response Teams (CERT) training **for other than your own employees** through partnerships with local **private** businesses. [Note – these programs go by a variety of names in various cities and areas.]	EQ LS WF FL SEC	Existing program, underfunded	n/a
j-6	j-6	Assist **private** businesses in the development of defensible space through the use of, for example, "tool libraries" for weed abatement tools, roadside collection and/or chipping services (for brush, weeds, and tree branches) in wildland-urban-interface fire-threatened communities or in areas exposed to high-to-extreme fire threat.	WF	Existing program, underfunded	Ex.
j-7	j-7	Make use of the materials developed by others (such as found on ABAG's web site at ***http://quake.abag.ca.gov/business***) to increase mitigation activities related to earthquakes **by groups other than your own agency.** ABAG plans to continue to improve the quality of those materials over time.	EQ	Existing program	Ex.
j-8	j-8	Develop a "Maintain-a-Drain" campaign, similar to that of the City of Oakland, encouraging **private** businesses and residents to keep storm drains in their neighborhood free of debris.	FL	Existing program	Ex.
j-9	j-9	Encourage the formation of a community- and neighborhood-based approach to wildfire education and action through local Fire Safe Councils and the *Fire Wise Program*. **This effort is important because grant funds are currently available to offset costs of specific council-supported projects.**	WF	Existing program, underfunded	Ex.
j-10	j-10	Encourage **private** businesses and laboratories handling hazardous materials or pathogens increase security to a level high enough to create a deterrent to crime and terrorism, including active implementation of "cradle-to-grave" tracking systems.	SEC EQ	Existing program, underfunded	Ex.
j-11	j-11	Encourage joint meetings of security and operations personnel at major **private** employers to develop innovative ways for these personnel to work together to increase safety and security.	SEC EQ	Existing program, underfunded	Ex.
j-12	j-12	Inform **private** shoreline-property owners of the possible long-term economic threat posed by rising sea levels.	FL	Under Study	Ex.

j-13	j-13	Distribute appropriate materials related to disaster mitigation and preparedness **to private business owners. Appropriate materials are (1) culturally appropriate and (2) suitable for special needs populations. For example, such materials are available on the** http://www.preparenow.org website **and from non-governmental organizations that work with these communities on an on-going basis.**	EQ LS WF FL SEC	Existing program	Ex.

Government Strategies

2009-2010 Strategy Number	2005 Original Strategy Number	Specific Mitigation Strategy	Applicable Hazards	Regional Priority	New vs. Existing Construction
GOVT - a - Focus on Critical Facilities **(...Owned by the Local Government Filling Out This Form)**					
a-1	a-1	Assess the vulnerability of critical facilities (such as city halls, fire stations, **operations and communications headquarters,** community service centers, seaports, and airports) to damage in **natural disasters** and make recommendations for appropriate mitigation.	EQ LS WF FL	Existing program, underfunded	Ex.
a-2	a-2	Retrofit or replace critical facilities that are shown to be vulnerable to damage in natural disasters.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-3	a-3	Clarify to workers in critical facilities and emergency personnel, as well as to elected officials and the public, the extent to which the facilities are expected to perform only at a life safety level (allowing for the safe evacuation of personnel) or are expected to remain functional following an earthquake.	EQ	Existing program	Ex.
a-4	a-4	Conduct comprehensive programs to identify and mitigate problems with facility contents, architectural components, and equipment that will prevent critical buildings from being functional after major natural disasters. **Such contents and equipment includes computers and servers, phones, files, and other tools used by staff to conduct daily business.**	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-5	a-5	Encourage joint meetings of security and operations personnel at critical facilities to develop innovative ways for these personnel to work together to increase safety and security.	EQ LS WF FL SEC	Existing program	Ex.

a-6	a-6	**When** installing micro and/or surveillance cameras around critical public assets tied to web-based software, and develop a surveillance protocol to monitor these cameras, investigate the possibility of using the cameras for the secondary purpose of post-disaster damage assessment.	EQ LS WF FL SEC	Moderate	Ex.
a-7	a-7	Identify and undertake cost-effective retrofit measures **related to security** on critical facilities (such as moving and redesigning air intake vents and installing blast-resistant features) when these buildings undergo major renovations **related to other natural hazards.**	EQ LS WF FL SEC	Moderate	Ex.
a-8	a-8	Coordinate with the State Division of Safety of Dams to ensure that cities and counties are aware of the timeline for the maintenance and inspection of dams whose failure would impact their jurisdiction.	EQ LS WF FL SEC DF	Existing program, underfunded	n/a
a-9	a-9	As a secondary focus, assess the vulnerability of non-critical facilities to damage in natural disasters based on occupancy and structural type, make recommendations on priorities for structural improvements or occupancy reductions, and identify potential funding mechanisms.	EQ LS WF FL SEC	Moderate	Ex.
a-10	a-10	Ensure that **new** government-owned facilities **comply with and** are subject to the same or more stringent regulations as imposed on privately-owned development.	EQ LS WF FL SEC	Existing program	New
a-11	a-11	Comply with all applicable building and fire codes, as well as other regulations (such as state requirements for fault, landslide, and liquefaction investigations in particular mapped areas) when constructing or significantly remodeling government-owned facilities.	EQ LS WF FL SEC	Existing program	Both
a-12	a-12	Prior to acquisition of property to be used as a critical facility, conduct a study to ensure the absence of significant **structural** hazards **and hazards associated with the building site.**	EQ LS WF FL SEC	Existing program	Both
a-13	new	**Ensure that any regulations imposed on private-owned businesses related to repair and reconstruction (see "Economy Section") are enforced and imposed on local government's own buildings and structures.**	EQ LS WF FL SEC	Existing program	Both
GOVT - b - Maintain and Enhance Local Government's Emergency Recovery Planning					
b-1	b-1	Establish a framework and process for pre-event planning for post-event recovery that specifies roles, priorities, and responsibilities of various departments within the local government organization, and that outlines a structure and process for policy-making involving elected officials and appointed advisory committees.	EQ LS WF FL SEC	Existing program	n/a

b-2	b-2	Prepare a basic Recovery Plan that outlines the major issues and tasks that are likely to be the key elements of community recovery, as well as integrate this planning into response planning **(such as with continuity of operations plans).**	EQ LS WF FL SEC	Existing program, underfunded	n/a
b-3	b-3	Establish a goal for the resumption of local government services that may vary from function to function.	EQ LS WF FL SEC	Existing program	n/a
b-4	b-25	Develop a **continuity of operations** plan that includes back-up storage of vital records, such as **plans and back-up procedures to pay employees and vendors if normal finance department operations are disrupted, as well as other essential electronic files.**	EQ LS WF FL SEC	Existing program, underfunded	n/a
b-5	new	**Plan for the emergency relocation of government-owned facilities critical to recovery, as well as any facilities with known structural deficiencies or in hazardous areas.**	EQ LS WF FL SEC	Existing program, underfunded	n/a
GOVT - c - Maintain and Enhance Local Government's Emergency Response Capacity					
c-1	new (old b-4 moved to HSNG a-3)	Develop a plan for short-term and intermediate-term sheltering of **your employees.**	EQ LS WF FL SEC	Existing program	Ex.
c-2	new	**Encourage your employees to have a family disaster plan.**	EQ LS WF FL SEC	Existing program	n/a
c-3	new	**Offer CERT/NERT-type training to your employees.**	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-4	b-5 (a)	Periodically assess the need for new or relocated fire or police stations and other emergency facilities.	EQ LS WF FL SEC	Existing program	Both
c-5	b-5 (b)	Periodically assess the need for changes in staffing levels, **as well as for** additional or updated supplies, equipment, technologies, and in-service training classes.	EQ LS WF FL SEC	Existing program	n/a
c-6	b-6	Ensure that **fire, police, and other emergency** personnel have adequate radios, breathing apparatuses, protective gear, and other equipment to respond to a major disaster.	EQ LS WF FL SEC	Existing program, underfunded	n/a

c-7	b-7	**Participate in** developing and maintaining a system of interoperable communications for first responders from cities, counties, special districts, state, and federal agencies.	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-8	b-8	Harden emergency response communications, including, for example, building redundant capacity into public safety alerting and/or answering points, replacing or hardening microwave and simulcast systems, adding digital encryption for programmable radios, and ensuring a plug-and-play capability for amateur radio.	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-9	b-9	Purchase command vehicles for use as mobile command/EOC vehicles if current vehicles are unsuitable or inadequate.	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-10	b-10	Maintain the local government's emergency operations center in a fully functional state of readiness.	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-11	b-11	Expand or participate in expanding traditional disaster exercises involving city and county emergency personnel to include airport and port personnel, transit and infrastructure providers, hospitals, schools, park districts, and major employers.	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-12	b-12	Maintain and update as necessary the local government's Standardized Emergency Management System (SEMS) Plan **and the National Incident Management System (NIMS) Plan, and submit an appropriate NIMSCAST report.**	EQ LS WF FL SEC	Existing program	n/a
c-13	b-13	Continue to participate not only in general mutual-aid agreements, but also in agreements with adjoining jurisdictions for cooperative response to fires, floods, earthquakes, and other disasters.	EQ LS WF FL SEC	Existing program	n/a
c-14	b-14 & b-22	Install alert and warning systems for **rapid evacuation or shelter-in-place. Such systems include** outdoor sirens **and/or reverse-911 calling systems.**	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-15	b-15	Conduct periodic tests of the alerting and warning system. **(deleted some wording)**	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-16	b-16	Regulate and enforce the location and design of street-address numbers on buildings and minimize the naming of short streets (that are actually driveways) to single homes.	EQ LS WF FL SEC	Existing program	Both

c-17	b-17	Monitor weather during times of high fire risk using, for example, weather stations tied into police and fire dispatch centers.	WF	Existing program	n/a
c-18	b-18	Establish regional protocols on how to respond to the NOAA Monterey weather forecasts, such as the identifying types of closures, limits on work that could cause ignitions, and prepositioning of suppression forces. A multi-agency coordination of response also helps provide unified messages to the public about how they should respond to these periods of increased fire danger. **Response should also be modified based on knowledge of local micro-climates. Local agencies with less risk then may be available for mutual aid.**	WF	Existing program	n/a
c-19	b-19	Increase local patrolling during periods of high fire weather.	WF	Existing program, underfunded	n/a
c-20	b-20	Create and maintain an automated system of rain and flood gauges that is web enabled and publicly-accessible. **Work toward creating a coordinated regional system.**	FL LS	Existing program, underfunded	n/a
c-21	b-21	Place remote sensors in strategic locations for early warning of hazmat releases or use of weapons of mass destruction, **understanding that the appropriate early warning strategy depends on the type of problem.**	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-22	b-23	Review and update, as necessary, procedures pursuant to the *State Dam Safety Act* for the emergency evacuation of areas located below major water-storage facilities.	EQ LS FL SEC DF	Existing program	Ex.
c-23	a-8	Improve coordination among cities, counties, and dam owners so that cities and counties can better plan for evacuation of areas that could be inundated if a dam failed, impacting their jurisdiction.	EQ LS FL DF SEC	Existing program	Ex.
c-24	b-24	Develop procedures for the emergency evacuation of areas identified on tsunami evacuation maps as these maps become available.	EQ TS	Existing program	Ex.
c-25	**new**	**Support and encourage planning and identification of facilities for the coordination of distribution of water, food, blankets, and other supplies, coordinating this effort with the American Red Cross.**	EQ LS WF FL SEC	Existing program, underfunded	n/a
GOVT - d - Participate in National, State, Multi-Jurisdictional and Professional Society Efforts to Identify and Mitigate Hazards					
d-1	c-1	Promote information sharing among overlapping and neighboring local governments, including cities, counties, and special districts, as well as utilities.	EQ LS WF FL SEC	Existing program	n/a

d-2	c-2	Recognize that emergency services is more than the coordination of police and fire response**;** it also includes planning activities with providers of water, food, energy, transportation, financial, information, and public health services.	EQ LS WF FL SEC	Existing program	n/a
d-3	c-3	Recognize that a multi-agency approach is needed to mitigate flooding by having flood control districts, cities, counties, and utilities meet at least annually to jointly discuss their capital improvement programs for most effectively reducing the threat of flooding. **Work toward making this process more formal to insure that flooding is considered at existing joint-agency meetings.**	FL	Existing program, underfunded	n/a
d-4	c-4	As new flood-control projects are completed, request that FEMA revise its flood-insurance rate maps and digital Geographic Information System **(GIS)** data to reflect flood risks as accurately as possible.	FL	Existing program	Both
d-5	c-5	Participate in FEMA's National Flood Insurance Program.	FL	Existing program	n/a
d-6	c-6	Participate in multi-agency efforts to mitigate fire threat, such as the Hills Emergency Forum (in the **E**ast Bay), various *FireSafe* Council programs, and city-utility task forces. **Such participation increases a jurisdiction's competitiveness in obtaining grants.**	WF	Existing program, underfunded	Both
d-7	c-7	Work with major employers and agencies that handle hazardous materials to coordinate mitigation efforts for the possible release of these materials due to a natural disaster such as an earthquake, flood, fire, or landslide.	EQ LS WF FL SEC	Existing program	Both
d-8	c-8	Encourage staff to participate in efforts by professional organizations to mitigate earthquake and landslide disaster losses, such as the efforts of the Northern California Chapter of the Earthquake Engineering Research Institute, the East Bay-Peninsula Chapter of the International Code Council, the Structural Engineers Association of Northern California, and the American Society of Grading Officials.	EQ LS	Existing program	Both
d-9	c-9	Conduct and/or promote attendance at local or regional hazard conferences and workshops for elected officials **and staff** to educate **them** on the critical need for programs in mitigating earthquake, wildfire, flood, and landslide hazards.	EQ LS WF FL SEC	Existing program, underfunded	Both
d-10	c-10	Cooperate with researchers working on government-funded projects to refine information on hazards, for example, by expediting the permit and approval process for installation of seismic arrays, gravity survey instruments, borehole drilling, fault trenching, landslide mapping, flood modeling, and/or damage data collection.	EQ LS WF FL SEC	Existing program	Both

GOVT - d - Take a Lead in Loss and Risk Assessment Activities					
e-1	e-1	Work with the cities, counties, and special districts in the Bay Area to encourage them to adopt a Local Hazard Mitigation Plan and to assist them in integrating it into their overall planning process. **RESPONSIBILITY: ABAG only; all others are "not applicable."**	EQ LS WF FL DR TS SEC Flu Ag Heat	Existing program, underfunded	Both
e-2	e-2	Improve the risk assessment and loss estimation work in the ***Taming Natural Disasters*** report and multi-jurisdictional plan related to natural disasters. **RESPONSIBILITY: ABAG only; all others are "not applicable."**	EQ LS WF FL DR TS Flu Ag Heat	Existing program, underfunded	Both

Education Strategies

2009-2010 Strategy Number	2005 Original Strategy Number	Specific Mitigation Strategy	Applicable Hazards	Regional Priority	New vs. Existing Construction
EDUC - a - Focus on Critical Facilities **(...Owned by School Districts)**					
a-1	a-1	Assess the vulnerability of critical **public** education facilities to damage in natural disasters and make recommendations for appropriate mitigation.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-2	a-2	Retrofit or replace critical **public** education facilities that are shown to be vulnerable to damage in natural disasters.	EQ LS WF FL SEC	Existing program, underfunded	Ex.
a-3	a-3	Conduct comprehensive programs to identify and mitigate problems with facility contents, architectural components, and equipment that will prevent critical **public education** buildings from being functional after major disasters.	EQ LS WF FL SEC	Existing program, underfunded	Ex.

a-4	a-4	As a secondary focus, assess the vulnerability of non-critical educational facilities **(that is, those that do not house students)** to damage in natural disasters based on occupancy and structural type, make recommendations on priorities for structural improvements or occupancy reductions, and identify potential funding mechanisms.	EQ LS WF FL SEC	Moderate	Ex.
a-5	new	Assess the vulnerability of critical private education, pre-school, and day care facilities to damage in natural disasters and make recommendations for appropriate mitigation.	EQ LS WF FL SEC	Moderate	Ex.
a-6	a-5	(Major Rewording) **Work with CalEMA and the Division of the State Architect to ensure that there will be an adequate group of Safety Assessment Program (SAP) inspectors trained and deployed by CalEMA to schools for post-disaster inspection. In addition, if a school district is uncomfortable with delays in inspection due to too few SAP inspectors available in catastrophic disasters, formalized arrangements can also be created with those inspectors certified by the Division of the State Architect as construction inspectors to report to the district, assess damage, and determine if the buildings can be reoccupied.**	EQ LS WF FL SEC	Existing program, underfunded	Ex.
EDUC - b - Use of Educational Facilities as Emergency Shelters					
b-1	b-1	Work cooperatively with the American Red Cross, **cities, counties, and non-profits** to set up memoranda of understanding for use of education facilities as emergency shelters following disasters.	EQ LS WF FL SEC	Existing program	Ex.
b-2	b-2	Work cooperatively to ensure that school district personnel and relevant staff understand and are trained that being designated by the American Red Cross or others as a potential emergency shelter does NOT mean that the school has had a hazard or structural evaluation to ensure that it can be used as a shelter following any specific disaster.	EQ LS WF FL SEC	Existing program	n/a
b-3	b-3	Work cooperatively to ensure that school district personnel understand and are trained that they are designated as disaster service workers and must remain at the school until released.	EQ LS WF FL SEC	Existing program	n/a
EDUC - c - Actions Related to Disaster Preparedness and Recovery Planning					
c-1	new	Encourage employees of schools to have family disaster plans and conduct mitigation activities in their own homes.	EQ LS WF FL SEC	Existing program	n/a

c-2	c-2	Develop plans, in conjunction with fire jurisdictions, for evacuation or sheltering in place of school children during periods of high fire danger, thereby recognizing that overloading of streets near schools by parents attempting to pick up their children during these periods can restrict access by fire personnel and equipment.	EQ LS WF FL SEC	Existing program	Ex.
c-3	c-3	Offer the 20-hour basic CERT training to teachers and after-school personnel.	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-4	c-4	Offer the 20-hour basic **Student Emergency Response Training (SERT, rather than** CERT) training to middle school and/or high school students as a part of the basic science or civics curriculum, as an after school club, or as a way to earn public service hours.	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-5	c-5	Offer the 20-hour basic CERT training course through the Adult School system and/or through the Community College system **(either using instructors with teaching credentials or by making facilities available for classes not run by school personnel themselves).**	EQ LS WF FL SEC	Existing program, underfunded	n/a
c-6	c-6	Develop and maintain the capacity for schools to take care of the students for the first 48 hours after a disaster, and notify parents that this capacity exists.	EQ LS WF FL SEC	Existing program	n/a
c-7	new	**Develop a continuity of operations and disaster recovery plan using models such as that developed by the University of California Berkeley. (The American Red Cross has a role in promoting this activity, as well, in schools that they plan to use as shelters.)**	EQ LS WF FL SEC	High	n/a
EDUC - d- Actions Related to Schools as Conduits for Information to Families About Emergencies					
d-1	c-1	Utilize the unique ability of schools to reach families through educational materials on hazards, mitigation, and preparedness, particularly after disasters and at the beginning of the school year. These efforts will not only make the entire community more disaster-resistant, but speed the return of schools from use as shelters to use as teaching facilities, **particularly if coordinated with cities, counties, the American Red Cross and others.**	EQ LS WF FL SEC	Very High	n/a
d-2	c-7	Develop and distribute culturally appropriate materials related to disaster mitigation and preparedness, such as those on the http://www.preparenow.org website.	EQ LS WF FL SEC	Existing program	n/a

Environment Strategies

2009-2010 Strategy Number	2005 Original Strategy Number	Specific Mitigation Strategy	Applicable Hazards	Regional Priority	New vs. Existing Construction
ENVI - a - Environmental Sustainability and Pollution Reduction					
a-1	a-1	Continue to enforce State-mandated requirements, such as the *California Environmental Quality Act*, to ensure that mitigation activities for hazards, such as seismic retrofits and vegetation clearance programs for fire threat, are conducted in a way that reduces environmental degradation such as air quality impacts, noise during construction, and loss of sensitive habitats and species, while respecting the community value of historic preservation.	EQ LS WF FL DR SEC	Existing program	Ex.
a-2	a-2	Encourage regulatory agencies to work collaboratively with safety professionals to develop creative mitigation strategies that effectively balance environmental and safety needs, particularly to meet critical wildfire, flood, and earthquake safety levels.	EQ WF FL SEC	Existing program	Both
a-3	a-3	Continue to enforce and/or comply with State-mandated requirements, such as the *California Environmental Quality Act* and environmental regulations to ensure that urban development is conducted in a way to minimize air pollution. For example, air pollution levels can lead to global warming, and then to drought, increased vegetation susceptibility to disease (such as pine bark beetle infestations), and associated increased fire hazard.	LS WF FL DR SEC	Existing program	New
a-4	a-4	Develop and implement a comprehensive program for watershed **management** optimizing **ecosystem** health with water yield to balance water supply, flooding, fire, and erosion concerns.	LS WF FL DR SEC	Under study	Both
a-5	a-5	Balance the need for the smooth flow of storm waters versus the need to maintain wildlife habitat by developing and implementing a comprehensive Streambed Vegetation Management Plan that ensures the efficacy of flood control efforts, **mitigates wildfires** and maintains the viability of living rivers.	LS WF FL DR	Existing program	Both
a-6	a-8	Comply with applicable performance standards of any *National Pollutant Discharge Elimination System* municipal stormwater permit that seeks to manage increases in stormwater run-off flows from new development and redevelopment construction projects.	FL	Existing program	Both
a-7	a-9	Enforce and/or comply with the grading, erosion, and sedimentation requirements by prohibiting the discharge of concentrated stormwater flows by other than approved methods that seek to minimize associated pollution.	LS FL	Existing program	Both

a-8	a-10	Explore ways to require that hazardous materials stored in the flood zone be elevated or otherwise protected from flood waters.	FL	Existing program	Both
a-9	a-11	Enforce and/or comply with the hazardous materials requirements of the State of California Certified Unified Program Agency (CUPA).	EQ LS WF FL SEC	Existing program	Both
a-10	a-12	Provide information on hazardous waste disposal and/or drop off locations.	EQ LS WF FL SEC	Existing program	n/a
a-11	new	**When remodeling existing government and infrastructure buildings and facilities, remove asbestos to speed up clean up of buildings so that they can be reoccupied more quickly.**	EQ LS WF FL SEC	Under study	Ex.
a-12	a-13	Develop and implement a program to control invasive and exotic species that contribute to fire and flooding hazards (such as eucalyptus, cattails, and cordgrass). **This program could include vegetation removal, thinning, or replacement in hazard areas where there is a direct threat to structures.**	WF FL	Existing program, underfunded	n/a
a-13	a-14	Enforce provisions under creek protection, stormwater management, and discharge control ordinances designed to keep watercourses free of obstructions and to protect drainage facilities to conform with the Regional Water Quality Control Board's Best Management Practices.	FL	Existing program, underfunded	n/a
ENVI - b - Climate Change					
b-1	a-6 + a-7	**Stay informed of scientific information compiled by regional and state sources on the subject of rising sea levels and global warming, especially on additional actions that local governments can take to mitigate this hazard including special design and engineering of government-owned facilities in low-lying areas, such as wastewater treatment plants, ports, and airports.**	LS WF FL DR	Existing program	Both
b-2	new	**Inventory global warming emissions in your own local government's operations and in the community, set reduction targets and create an action plan.**	LS WF FL DR	Existing program, underfunded	n/a
b-3	new	**Adopt and enforce land-use policies that reduce sprawl, preserve open space, and create compact, walkable urban communities.**	LS WF FL DR	Existing program, underfunded	Both
b-4	new	**Promote transportation options such as bicycle trails, commute trip reduction programs, incentives for car pooling and public transit.**	LS WF FL DR	Existing program, underfunded	n/a

b-5	new	**Increase the use of clean, alternative energy by, for example, investing in "green tags", advocating for the development of renewable energy resources, recovering landfill methane for energy production, and supporting the use of waste to energy technology.**	LS WF FL DR	Existing program, underfunded	n/a
b-6	new	**Make energy efficiency a priority through building code improvements, retrofitting city facilities with energy efficient lighting and urging employees to conserve energy and save money.**	LS WF FL DR	Existing program, underfunded	Both
b-7	new	**Purchase only Energy Star equipment and appliances for local government use.**	LS WF FL DR	Existing program, underfunded	Both
b-8	new	**Practice and promote sustainable building practices using the U.S. Green Building Council's LEED program or a similar system.**	LS WF FL DR	Existing program, underfunded	Both
b-9	new	**Increase the average fuel efficiency of municipal fleet vehicles; reduce the number of vehicles; launch an employee education program including anti-idling messages; convert diesel vehicles to bio-diesel.**	LS WF FL DR	Existing program, underfunded	n/a
b-10	new	**Evaluate opportunities to increase pump efficiency in water and wastewater systems; recover wastewater treatment methane for energy production.**	LS WF FL DR	Existing program, underfunded	n/a
b-11	new	**Increase recycling rates in local government operations and in the community.**	LS WF FL DR	Existing program, underfunded	n/a
b-12	new	**Maintain healthy urban forests; promote tree planting to increase shading and to absorb CO2.**	LS WF FL DR	Existing program, underfunded	n/a
b-13	new	**Help educate the public, schools, other jurisdictions, professional associations, business and industry about reducing global warming pollution.**	LS WF FL DR	Existing program, underfunded	n/a
ENVI - c - Agricultural and Aquaculture Resilience					
c-1	b-1	Maintain a variety of crops in rural areas of the region to increase agricultural diversity and crop resiliency. **RESPONSIBLE AGENCIES: County Offices of the Agricultural Commissioner.**	Ag DR SEC	Moderate	n/a
c-2	b-2	Promote and maintain the public-private partnerships dedicated to preventing the introduction of agricultural pests into regionally-significant crops, such as the glassy-winged sharpshooter into vineyards. **RESPONSIBLE AGENCIES: County Offices of the Agricultural Commissioner.**	Ag DR SEC	Existing program	n/a

c-3	b-4	Encourage livestock operators to develop an early-warning system to detect animals with communicable diseases (due to natural causes or bioterrorism). **RESPONSIBLE AGENCIES: County Health Department and Office of the County Agricultural Commissioner.**	Ag Flu SEC	Existing program	n/a
deleted	b-3	(deleted since not a disaster-related strategy)			

Land Use Strategies

2009-2010 Strategy Number	2005 Original Strategy Number	Specific Mitigation Strategy	Applicable Hazards	Regional Priority	New vs. Existing Construction
LAND - a - Earthquake Hazard Studies for New **Private** Developments					
a-1	a-1	Enforce and/or comply with the State-mandated requirement that site-specific geologic reports be prepared for development proposals within Alquist-Priolo Earthquake Fault Zones, and restrict the placement of structures for human occupancy. (This Act is intended to deal with the ***specific*** hazard of active faults that extend to the earth's surface, creating a surface rupture hazard.)	EQ	Existing program	New
a-2	a-2	Require preparation of site-specific geologic or geotechnical reports for development and redevelopment proposals in areas subject to earthquake-induced landslides or liquefaction as mandated by the State Seismic Hazard Mapping Act in selected portions of the Bay Area where these maps have been completed, and condition project approval on the incorporation of necessary mitigation measures related to site remediation, structure and foundation design, and/or avoidance.	EQ	Existing program	Both
a-3	a-3	Recognizing that some faults may be a hazard for surface rupture, even though they do not meet the strict criteria imposed by the Alquist-Priolo Earthquake Fault Zoning Act, identify and require geologic reports in areas adjacent to locally-significant faults.	EQ	Existing program	New
a-4	new	**Ensure that development proposed near faults with a history of complex surface rupture (multiple traces, warping, thrusting, etc.) has larger setbacks than the minimum fifty feet.**	EQ	Under study	New
a-5	new	**Consider imposing requirements similar to the Alquist-Priolo Earthquake Fault Zoning Act for structures without human occupancy if these buildings are still essential for the economic recovery of the community or region.**	EQ	Under study	New

a-6	a-4	Recognizing that the California Geological Survey has not completed earthquake-induced landslide and liquefaction mapping for much of the Bay Area, identify and require geologic reports in areas mapped by others as having significant liquefaction or landslide hazards.	EQ	Existing program	New
a-7	a-5	Support and/or facilitate efforts by the California Geological Survey to complete the earthquake-induced landslide and liquefaction mapping for the Bay Area.	EQ	Existing program	n/a
a-8	a-6	Require that local government reviews of geologic and engineering studies are conducted by appropriately trained and credentialed personnel.	EQ	Existing program	n/a
LAND - b - Wildland and Structural Fires					
b-1	b-1	Review **new** development proposals to ensure that they incorporate required and appropriate fire-mitigation measures, including adequate provisions for occupant evacuation and access by emergency response personnel and equipment.	WF	Existing program	New
b-2	b-2	Develop a clear legislative and regulatory framework at both the state and local levels to manage the wildland-urban-interface consistent with *Fire Wise* and sustainable community principles.	WF	Existing program	Both
LAND - c - Flooding					
c-1	c-1	Establish and enforce requirements for new development so that site-specific designs and source-control techniques are used to manage peak stormwater runoff flows and impacts from increased runoff volumes.	FL	Existing program	New
c-2	c-2	Incorporate FEMA guidelines and suggested activities into local government plans and procedures for managing flood hazards.	FL	Existing program	n/a
c-3	c-3	Provide an institutional mechanism to ensure that development proposals adjacent to floodways and in floodplains are referred to flood control districts and wastewater agencies for review and comment (consistent with the NPDES program).	FL	Existing program	New
c-4	c-4	Establish and enforce regulations concerning new construction (and major improvements to existing structures) within flood zones in order to be in compliance with federal requirements and, thus, be a participant in the Community Rating System of the *National Flood Insurance Program*.	FL	Existing program	New
c-5	new	**Encourage new development near floodways to incorporate a buffer zone or setback from that floodway to allow for changes in stormwater flows in the watershed over time.**	FL	High	New
c-6	new	**For purposes of creating an improved hazard mitigation plan for the region as a whole, ABAG, and Bay Area cities and counties, jointly request geographically defined repetitive flooding loss data from FEMA for their own jurisdictions.**	FL	High	Ex.

LAND - d - Landslides and Erosion					
d-1	d-1	Establish and enforce provisions (under subdivision ordinances or other means) that geotechnical and soil-hazard investigations be conducted and filed to prevent grading from creating unstable slopes, and that any necessary corrective actions be taken prior to development approval.	LS	Existing program	New
d-2	d-2	Require that local government reviews of these investigations are conducted by appropriately trained and credentialed personnel.	LS	Existing program	New
d-3	d-3	Establish and enforce grading, erosion, and sedimentation ordinances by requiring, under certain conditions, grading permits and plans to control erosion and sedimentation prior to development approval.	LS	Existing program	New
d-4	d-4	Establish and enforce provisions under the creek protection, storm water management, and discharge control ordinances designed to control erosion and sedimentation.	LS	Existing program	Both
d-5	d-5	Establish requirements in zoning ordinances to address hillside development constraints, especially in areas of existing landslides.	LS	Existing program	New
LAND - e - Hillside - Multi-Hazard					
e-1	e-1	For new development, require a buffer zone between residential properties and landslide or wildfire hazard areas.	LS WF	Existing program	New
e-2	e-2	Discourage, add additional mitigation strategies, or prevent **new** construction **or major remodels** on slopes greater than a set percentage, such as 15%, due to landslide or wildfire hazard concerns.	LS WF	Existing program	Both
LAND - f - Smart Growth to Revitalize Urban Areas and Promote Sustainability					
f-1	f-1	Prioritize retrofit of infrastructure that serves urban areas **(or urban services areas)** over constructing new infrastructure to serve outlying areas.	EQ LS WF FL DR SEC	Existing program	New
f-2	f-2	Work to retrofit homes in older **urban neighborhoods** to provide safe housing close to job centers.	EQ LS WF FL DR SEC	Existing program, underfunded	Ex.
f-3	f-3	Work to retrofit older downtown areas **and redevelopment districts** to protect architectural diversity and promote disaster-resistance.	EQ LS WF FL SEC	Existing program, underfunded	Ex.

f-4	f-4	Work with non-profits and through other mechanisms to protect as open space **those** areas susceptible to extreme hazards **(such as through land acquisition, zoning, and designation as priority conservation areas).**	EQ LS WF FL SEC	Existing program, underfunded	New
f-5	f-5	Strive to preserve existing buffers between development and existing users of large amounts of hazardous materials, such as major industry, due to the potential for catastrophic releases **or fires** due to an earthquake, **accident,** or terrorism. (Flooding might also result in release or spread of these materials; however, it is unlikely.) **In areas where buffers do not exist or cannot be created, provide alternative mitigation.**	EQ LS WF FL SEC	Existing program	New
LAND - g - Hazard Abatement Districts					
g-1	new	**Use hazard abatement districts as a funding mechanism to ensure that mitigation strategies are implemented and enforced over time.**	EQ LS WF FL	Under study	Both

APPENDIX H
Record of Plan Participation

This appendix serves as documentation of the planning process. For a narrative description of the planning process, see **Appendix A**.

Local governments and special districts gathered at a series of 5 sub-regional workshops, plus two transit and water specific workshops, to review the mitigation strategies from the 2005 plan and come to a consensus on the priorities for each of the strategies. At each workshop, the participants chose the regional priority that they thought to be most appropriate. The priorities from each workshop were documented by ABAG and could be viewed by participants of the future sub regional workshops to help with their priority decision. Consensus was achieved for the majority of the strategies in the sub regional workshops.

Following these workshops, issue specific workshops were held on fire, flooding, infrastructure, and housing and economy. These workshops were attended by a variety of cities, counties, private groups and special districts particularly interested in these issues. At these workshops, participants reviewed strategies for which priority consensus was not met in the previous series of workshops. In many cases, consensus could be reached by modifying the wording of the strategy.

The draft strategies and regional priorities developed in the previous workshops were reviewed by ABAG's Regional Planning Committee (RPC) and recommended for adoption by ABAG's Executive Board. Comments received by RPC were incorporated into the strategies and the Draft final list of strategies and priorities were approved by ABAG's Executive Board on September 17, 2009.

ABAG developed chapters for the update of the plan which helped organize the strategies and put them into context. These chapters were reviewed by participating jurisdictions at a series of workshops held by ABAG. Some individual jurisdictions also submitted comments on the chapters and appendices via email or verbally to ABAG staff. Comments were incorporated by ABAG and the chapters were presented to RPC on October 7, 2009 for comments and review.

The following tables indicate the local governments participating in the plan development process as of December 2009 and the number of times they have participated in the planning activities described above. Records of the precise meetings attended by individuals are available on request at ABAG. Contact information for local government participants is listed in **Appendix I**.

APPENDIX I
Participating Jurisdictions Contact List

The following pages contain contact information for the participating jurisdictions on this update of the LHMP. This list does not contain contact information for the entire planning team. Rosters for the committees on the planning team and more information about all the participants of the planning team can be found in **Appendix A**.

Fname	Lname	Title	Jurisdiction/Agency	Phone	E-mail	County
Elizabeth	McElligott	Assistant Deputy Director	Alameda County Community Development Agency	510.670.6120	elizabeth.mcelligott@acgov.org	Alameda
Sandi	Rivera	Assistant Planning Director	Alameda County Community Development Agency	510.670.6120	sandra.rivera@acgov.org	Alameda
Marla	Blagg		Alameda County Fire Department	510.618.3468	Marla.blagg@acgov.org	Alameda
Michael	Cadrecha	Architect	Alameda County GSA	510.208.9589	michael.cadrecha@acgov.org	Alameda
John	Kitching	Deputy Director	Alameda County GSA	510.208.9533	john.kitching@acgov.org	Alameda
Sandra	Williams	Emergency Manager	Alameda County Medical Center	510.773.6824	swilliams@acmedctr.org	Alameda
Steve	Dennis	Emergency Services Supervisor	Alameda County Water District	510.668.6530	Steve.Dennis@acwd.com	Alameda
Patricia	Dustman	Program and Planning Engineering Supervisor	Alameda County Water District	510.770.1793	patricia.dustman@acwd.com	Alameda
Ricci	Zombeck	Division Chief	Alameda Fire Dept.	510.337.2131	rzombeck@ci.alameda.ca.us	Alameda
Gloria	Williams	Emergency Preparedness Coordinator	Alameda Hopsital	510.814.4608	gwilliams@alamedahospital.org	Alameda
Jeff	Bond	Planning	Albany	510.528.5769	jbond@albanyca.org	Alameda
Brian	Crudo	Fire Marshal	Albany	510.528.5775	bcrudo@albanyca.org	Alameda
Khin	Chin	Associate Management Analyst	Berkeley Fire Dept.	510.981.5506	kchin@cityofberkeley.info	Alameda
Gil	Dong	Deputy Fire Chief	Berkeley Fire Dept.	510.981.5506	gdong@cityofberkeley.info	Alameda
Michael	Miller	Director, MOT	Castro Valley Unified School District	510.537.3000x1363	mmiller@cv.k12.ca.us	Alameda
Genevieve	Pastor	Emergency Preparedness Manager	City of Livermore (Livermore-Pleasanton Fire Dept.)	925.454.2317	gpastor-cohen@lpfire.org	Alameda
Roger	Bradley	Administrative Analyst/Emerg.Serv.Coord.	Dublin	925.833.6650	roger.bradley@ci.dublin.ca.us	Alameda
Stephen	Cutright	Fire Chief/Emergency Services Director	Emeryville	510.596.3750	scutright@emeryville.org	Alameda
Maya	Williams	City Manager's Office	Fremont	510.494.4778	mwilliams@fremont.gov	Alameda
Arlynne	Camire	Associate Planner, Dept of Planning & Development	Hayward	510.583.4206	arlynne.camire@hayward-ca.gov	Alameda
Thor	Poulsen	Public Education Officer, Emergency Services	Hayward	510.583.4948	thor.poulsen@hayward-ca.gov	Alameda
Cheryl	Miller	Staff Support	Hills Emergency Forum	510.893.9888	cmiller@amphiondesign.com	Alameda
Frank	Ramos	Manager Emergency Preparedness	Las Positas-Chabot Community College District	925.485.5512	framos@clpccd.org	Alameda
Jeff	Flynn		LAVTA (Wheels)	925.455.7560	jflynn@lavta.org	Alameda
Ed	Foust	Risk Manager	Livermore	925.960.4410	ewfoust@ci.livermore.ca.us	Alameda
Stephan	Kiefer	Building Official	Livermore	925.960.4410	sakiefer@ci.livermore.ca.us	Alameda
Ava	Garavatti	Lieutenant	Livermore Police Dept.	925.371.4832	agaravatti@ci.livermore.ca.us	Alameda
Ray	Collier	Building Official	Newark	510.790.7217	ray.collier@newark.org	Alameda
Devan	Reiff	Planner	Oakland	510.238.3550	dreiff@oaklandnet.com	Alameda
Coleen	Bell	Fire Dept. Emergency Services	Oakland OES / Fire Dept	510.238.7044	CABell@oaklandnet.com	Alameda
Gloria	Beltran	Disaster Coordinator	Oakland USD	510.879.8200	gloria.beltran@ousd.k12.ca.us	Alameda
Steve	Osawa	Chief of Campus Police	Ohlone Community College District	510.659.6111	sosawa@ohlone.edu	Alameda
John	Speakman	Fire Chief	Piedmont	510.420.3038	jspeakman@piedmont.com	Alameda
Dave	Swan	Fire Dept.	Piedmont	510.420.3030	dswan@piedmont.com	Alameda
Dennis	Corbett	Senior Plan Checker	Pleasanton	925.931.5304	dcorbett@ci.pleasanton.ca.us	Alameda
George	Thomas	Chief Building and Safety Official	Pleasanton	925.931.5300	gthomas@ci.pleasanton.ca.us	Alameda
Kathleen	Ornelas	Community Relations Representative	San Leandro	510.577.3363	KOrnelas@ci.san-leandro.ca.us	Alameda
Joan	Malloy	Economic and Community Development Director	Union City	510.675.5319	jmalloy@unioncity.org	Alameda
Tom	Hughes		Zone 7 Water Agency	925.447.6703	thughes@zone7water.com	Alameda
Jeff	Jones	Emergency and Safety Supervisor	Zone 7 Water Agency	925.454.5000	jjones@zone7water.com	Alameda
Sara	Whatley	Safety Technician I	Zone 7 Water Agency	925.454.5000	swhatley@zone7water.com	Alameda
Curt	Strommen	Safety Officer	Dublin-San Ramon Services District	925.875.2333	strommen@dsrsd.com	Alameda
Bill	Cain	Project Manager- Seismic and Mititgation Planning	East Bay Municipal Utility District	510.287.1198	bcain@ebmud.com	Alameda/CC
Ed	Sullivan	Security & Emergency Preparedness Specialist	East Bay Municipal Utility District	510.287.7032	esulliva@ebmud.com	Alameda/CC
Jeff	Rasmussen		East Bay Regional Park District	510.544.2204	jrasmussen@ebparks.org	Alameda/CC
Bill	Morris	Safety Administrator	AC Transit	510.891.4807	wmorris@actransit.org	Alameda-CC
Traci	Johnson	Seismic Engineering Manager	BART	510.287.4981	tjohnso@bart.gov	Alameda-CC-SF
Marguerite	Lawry	Director, Vice President and Secretary	Bethel Island Municipal Improvement Dist.	925.687.3254	lawry@prodigy.net	Contra Costa
Ben	Tolero	Field Operations Division	Brentood Police Dept.	925.809.7713	btolero@ci.brentwood.ca.us	Contra Costa
Tim	Herbert	Police Dept.	Brentwood	925.809.7737	therbert@ci.brentwood.ca.us	Contra Costa
Eric	Brennan	Water Operations Manager	Brentwood Public Works Department	925.516.6000	ebrennan@ci.brentwood.ca.us	Contra Costa
Kelly	Warren	Safety/Special Projects Coordinator	Brentwood Public Works Department	925.516.6000	kwarren@ci.brentwood.ca.us	Contra Costa
Tony	Craig		CCCTA	925.676.1976	craig@cccta.org	Contra Costa

Fname	Lname	Title	Jurisdiction/Agency	Phone	E-mail	County
Elizabeth	McElligott	Assistant Deputy Director	Alameda County Community Development Agency	510.670.6120	elizabeth.mcelligott@acgov.org	Alameda
Sandi	Rivera	Assistant Planning Director	Alameda County Community Development Agency	510.670.6120	sandra.rivera@acgov.org	Alameda
Marla	Blagg		Alameda County Fire Department	510.618.3468	Marla.blagg@acgov.org	Alameda
Chad	Angrisani	Engineering	Clayton	925.672.9700	chada@permcoengineering.com	Contra Costa
Kristy	Madrid	PW/Engineering Services	Concord	925.671.3257	kmadrid@ci.concord.ca.us	Contra Costa
Emily	Corwin		Contra Costa Water District	925.688.8310	ecorwin@ccwater.com	Contra Costa
Jeff	Quimby		Contra Costa Water District	925.688.8310	jquimby@ccwater.com	Contra Costa
Ann	Hutcheson	Director of Administrative Services	Eastern Contra Costa Transit Authority (Tri Delta Transi	925.754.6622	annh@eccta.org	Contra Costa
Michael	Bond		El Cerrito Fire Dept.	510.215.4450	mbond@ci.el-cerrito.ca.us	Contra Costa
Jose	Pacheco		Hercules	510.799.8200	jpacheco@ci.hercules.ca.us	Contra Costa
Ann	Merideth	Community Development Director	Lafayette	925.299.3218	AMerideth@ci.lafayette.ca.us	Contra Costa
Tim	Tucker	City Engineer	Martinez	925.372.3562	ttucker@cityofmartinez.org	Contra Costa
Jill	Mecurio	Public Works Director/Town Engineer	Moraga	925.631.6844	jmercurio@moraga.ca.us	Contra Costa
Courtney	Mizutani		Moraga	925.631.6844	cmizutani@sbcglobal.net	Contra Costa
Bill	French	Fire Chief	Moraga-Orinda Fire Dept.	925.258.4599	WFrench@cityoforinda.org	Contra Costa
Chris	Thorsen	Chief of Police	Oakley	925.625.8820	thorsen@ci.oakley.ca.us	Contra Costa
Aaron	Baker	Chief of Police	Pittsburg	925.766.8672	MBarbanica@ci.pittsburg.ca.us	Contra Costa
Lori	Reese-Brown	Principal Planner	Richmond Planning Dept.	510.620.6869	Lori_Reese-Brown@ci.richmond.ca.us	Contra Costa
Ronalyn	Nonato	Engineering Tech	San Pablo	510.215.3205	ronalynn@ci.san-pablo.ca.us	Contra Costa
Ray	Riordan	Emergency Preparedness Program Mgr.	San Ramon	925.973.3304	rriordan@sanramon.ca.gov	Contra Costa
Lee	Braun	Building Official	Belvedere	415.435.8916	buildingofficial@cityofbelvedere.org	Marin
Jennifer	Blackman	General Manager	Bolinas Community Public Utilities District	415.868.1224	jblackman@bcpud.org	Marin
Roger	Sprehn	Director of Emergency Services	Corte Madera Fire Dept.	415.927.5197	rsprehn@ci.corte-madera.ca.us	Marin
Kathleen	Wilkie	Public Works Director	Fairfax	415.453.0291	kwilkie@townoffairfax.org	Marin
Thomasin	Grim	Grant Program Coordinator	Marin Municipal Water District	415.945.1542	tgrim@marinwater.org	Marin
Nancy	Andrews		Novato	415.897.4367	nandrews@ci.novato.ca.us	Marin
Jim	Reis	Police Chief	Ross	415.453.1453x101	jreis@townofross.org	Marin
Ross	Mayfield		Ross School District	707.462.4645	ross@saber.net	Marin
Jim	Providenza	Commander, Police Department	San Anselmo	415.258.4610	jprovidenza@sananselmopd.org	Marin
Steven	Hancock	Office of Emergency Services	San Rafael	415.485.3111	steven.hancock@cityofsanrafael.org	Marin
Scott	Phillips	Assistant Planner	Tiburon	415.435.7385	sphillips@ci.tiburon.ca.us	Marin
Dan	Hall		Napa	707.257.9586	dhall@cityofnapa.org	Napa
John	Rodgers	Emergency Planner Coordinator	San Francisco Public Utilities Commission	415.554.2458	jrodgers@sfwater.org	San Francisco
Keith	Stahnke	Operations Manager	SF WETA	415.291.3377	Stahnke@watertransit.org	San Francisco
Tom	Kennedy		SFMTA	415.554.6869	thomas.kennedy@sfmta.com	San Francisco
David	Lynch		GGBHTD	415.923.2231	dlynch@goldengate.org	San Francisco/Marin
Mike	Guerra	Lieutenant	Atherton Police Department	650.752.0506	guerra@ci.atherton.ca.us	San Mateo
Kristin	Nichols	Sergeant	Atherton Police Department	650.688.6500	knichols@ci.atherton.ca.us	San Mateo
Patrick	Halleran	Emergency Management Coordinator	Belmont	650.595.7408	path@belmont.gov	San Mateo
Christy	Adonis	Disaster Preparedness Officer	Belmont-San Carlos Fire Dept.	650.802.4254	christya@bscfd.org	San Mateo
John	Swiecki	Principal Planner	Brisbane	415.508.2120	jswiecki@ci.brisbane.ca.us	San Mateo
Joe	Cyr	Chief Building Official	Burlingame	650.558.7270	jcyr@burlingame.org	San Mateo
Gordon	Gottsche	Public Works	Burlingame	650.558.7230	ggottsche@burlingame.org	San Mateo
Robert	Mallick	Superindendent, Public Woks	Burlingame	650.558.7673	rmallick@burlingame.org	San Mateo
Jim	Nantell	City Manager	Burlingame	650.286.3350	jnantell@burlingame.org	San Mateo
John	Parkin	Emergency Services	Central County Fire	650.558.7600	jparkin@centralcountyfd.org	San Mateo
Andrea	Ouse	Deputy City Planner	Colma	650.985.2590	andrea.ouse@lsa-assoc.com	San Mateo
Matt	Lucent	Comm. Emerg. Planning/Disaster Prep.Coord.	Daly City (North County Fire Authority)	650.991.8139	mlucett@dalycity.org	San Mateo
Frank	Rainone	Building Official	East Palo Alto	650.444.0154	frainone@cityofepa.org	San Mateo
John	Chalmers	Captain	East Palo Alto Police Dept.	650.853.3154	jchalmers@cityofepa.org	San Mateo
Ronald	Davis	Chief of Police	East Palo Alto Police Dept.	650.863.3125	rdavis@cityofepa.org	San Mateo
Tom	Reaves	Fire Chief, Fire Department	Foster City	650.286.3350	treaves@fostercity.org	San Mateo
Michael	Dolder	Interim City Manager	Half Moon Bay	650.726.8272	mdolder@ci.half-moon-bay.ca.us	San Mateo

Fname	Lname	Title	Jurisdiction/Agency	Phone	E-mail	County
Elizabeth	McElligott	Assistant Deputy Director	Alameda County Community Development Agency	510.670.6120	elizabeth.mcelligott@acgov.org	Alameda
Sandi	Rivera	Assistant Planning Director	Alameda County Community Development Agency	510.670.6120	sandra.rivera@acgov.org	Alameda
Marla	Blagg		Alameda County Fire Department	510.618.3468	Marla.blagg@acgov.org	Alameda
John	Mullins	Building Official	Hillsborough	650.375.7487	jmullins@hillsborough.net	San Mateo
Craig	West	Supervisor	Hillsborough	650.375.7515	cwest@hillsborough.net	San Mateo
Bill	Reilly	Emergency Services Coordinator	Hillsborough	650.558.7601	breilly@centralcountyfd.org	San Mateo
Dave	Ballestrasse	Asst. Water Superintendent	Hillsborough Water Department	650.375.7517	Dballestrasse@hillsborough.net	San Mateo
Ed	Cooney	Analyst	Hillsborough Water Department	650.579.3355	ECooney@hillsborough.net	San Mateo
John	Schultz	Director-Maintenance, Operations, Health&Safety, Trans	Jefferson Union High School District	650.550.7900	JSchultz@juhsd.net	San Mateo
Bruce	Goitia	Police Chief	Menlo Park	650.330.6322	bagoitia@menlopark.org	San Mateo
Dani	O'Connor	Police Dept.	Menlo Park	650.330.6610	DO'Connor@menlopark.org	San Mateo
Michael	Anderson		Mid Peninsula Water District	650.591.8941	michaela@midpeninsulawater.org	San Mateo
Brent	Chester		Mid Peninsula Water District	650.591.8941	brentc@midpeninsulawater.org	San Mateo
Lanty	Molloy	Captain	Milbrae Fire Dept	650.259.2400	lmolloy@ci.millbrae.ca.us	San Mateo
Rick	Ortega	Division Chief	Milbrae Fire Dept	650.259.2400	ROrtega@ci.millbrae.ca.us	San Mateo
Jessica	Adams-Weber	SRT Consultants	Montara Water and Sanitary District	415.776.5800x303	jessica@srtconsultants.com	San Mateo
Erin	McGranahan	Associate City Planner	Monte Sereno	408.354.7635	erin@montesereno.org	San Mateo
Kevin	O'Connell	General Manager	North Coast County Water District	650.355.3462	koconnell@nccwd.com	San Mateo
Richard	Johnson	Deputy Fire Chief - Support Services Bureau	North County Fire Authority	650.746.8371	rjohnson@dalycity.org	San Mateo
Elizabeth	Claycomb	Planner	Pacifica	650.738.7342	claycombe@ci.pacifica.ca.us	San Mateo
Jessie	Deguzman	Engineer	Pacifica	650.738.3767	deguzmanj@ci.pacifica.ca.us	San Mateo
Jason	Lo	Code Enforcement Officer	Pacifica	650.738.7343	loj@ci.pacifica.ca.us	San Mateo
Fernando	Realyvasquez	Captain, Emergency Coordinator	Pacifica Police Dept.	650.738.7314	realyvasquezf@pacificapolice.org	San Mateo
Janet	McDougall	Assistant Town Manager	Portola Valley	650.851.1700x281	JMcDougall@portolavalley.net	San Mateo
Jill	Ekas	Planning Manager	Redwood City	650.780.7298	gbonte@redwoodcity.org	San Mateo
Joel	Slavit	Grants Manager	Samtrans	650.508.6476	slavitj@samtrans.com	San Mateo
Dennis	Haag	Fire Chief	San Bruno	650.616.7096	dhaag@sanbruno.ca.gov	San Mateo
Michael	Leong	Fire Marshal	San Mateo	650.522.7900	mleong@cityofsanmateo.org	San Mateo
Charles	Clark	Building Inspector Manager	San Mateo County	650.599.1593	CEClark@co.sanmateo.ca.us	San Mateo
Steve	Monowitz	Long Range Planning Manager	San Mateo County Planning and Building Dept.	650.363.1855	smonowitz@co.sanmateo.ca.us	San Mateo
Jessica	Adams-Weber	SRT Consultants	Sewer Authority - Mid-Coastline	415.776.5800	jessica@srtconsultants.com	San Mateo
Tanya	Yurovsky	SRT Consultants	Sewer Authority - Mid-Coastline	415.776.5800	tanya@srtconsultants.com	San Mateo
Chris	Campagna	Battalion Chief, Fire Department	South San Francisco	650.875.6961	Chris.Campagna@ssf.net	San Mateo
Eunejune	Kim	Deputy Town Engineer	Woodside	650.851.6790	EKim@woodsidetown.org	San Mateo
Len	Materman	Executive Director	San Francisquito Creek JPA	650.561.4580	len@sfcjpa.org	San Mateo/SC
Jim	Simunovich	Manager of Operations	Cal Water	408.367.8242	jsimunovich@calwater.com	Santa Clara
Dan	Campbell	Emergency Services Coordinator	Campbell (Santa Clara County Fire Dept.)	408.656.9047	dcampbell@cityofcampbell.com	Santa Clara
Greg	Casteel	Building Official	Cupertino	408.777.3206	gregc@cupertino.org	Santa Clara
Marsha	Hovey	Emergency Services Coordinator	Cupertino OES	408.777.3335	MarshaH@cupertino.org	Santa Clara
Erik	Walukiewicz	Coordinator of Safety Operations Services	Fremont Union High School District	408.522.2256		Santa Clara
Kristi	Abrams	Senior Civil Engineer	Gilroy	408.846.0208	kabrams@ci.gilroy.ca.us	Santa Clara
Roy	Shackel	Fire Captain	Gilroy Fire Dept./OES	408.846.0208	rshackel@ci.gilroy.ca.us	Santa Clara
Matt	Hartley	Police Dept.	Los Altos	650.947.2801	MHartley@losaltosca.gov	Santa Clara
Steve	Garcia	Public Safety Officer	Los Altos Hills	650.941.7222x242	sgarcia@losaltoshills.ca.gov	Santa Clara
Anthony	Ghiossi	Building Official	Los Gatos	408.354.6815	AGhiossi@losgatosca.gov	Santa Clara
Wendie	Rooney	Director, Community Development	Los Gatos	408.354.6874	wrooney@losgatosca.gov	Santa Clara
Patty	Joki	Fire Marshal	Milpitas	408.586.3370	pjoki@ci.milpitas.ca.gov	Santa Clara
Kathleen	Phalen	Civil Engineer - Utility Section	Milpitas	408.586.3345	kphalen@ci.milpitas.ca.gov	Santa Clara
Howard	Salamanca	Associate Civil Engineer - Utility Section	Milpitas	408.586.3348	hsalamanca@ci.milpitas.ca.gov	Santa Clara
Sean	Simonson	Emergency Services Coordinator	Milpitas	408.586.3051	ssimonson@ci.milpitas.ca.gov	Santa Clara
B	Loventhal	City Manager	Monte Sereno	408.354.7635	bloventhal@montesereno.org	Santa Clara
Jennifer	Ponce	OES Coordinator	Morgan Hill	408.776.7310	Jennifer.Ponce@morganhill.ca.gov	Santa Clara
Karl	Gettrost	Inspector	Mountain View Building Dept.	650.903.6300	karl.gettrost@mountainview.gov	Santa Clara

Fname	Lname	Title	Jurisdiction/Agency	Phone	E-mail	County
Elizabeth	McElligott	Assistant Deputy Director	Alameda County Community Development Agency	510.670.6120	elizabeth.mcelligott@acgov.org	Alameda
Sandi	Rivera	Assistant Planning Director	Alameda County Community Development Agency	510.670.6120	sandra.rivera@acgov.org	Alameda
Marla	Blagg		Alameda County Fire Department	510.618.3468	Marla.blagg@acgov.org	Alameda
Lynn	Brown	OES Coordinator	Mountain View Fire Dept.	650.903.6825	lynn.brown@ci.mtnview.ca.us	Santa Clara
Gregg	Hosfeldt	Assistant Public Works Director	Mountain View Water Department	650.903.6205	gregg.hosfeldt@mountainview.gov	Santa Clara
Will	Medina	Water Supervisor	Mountain View Water Department	650.903.6208	will.medina@mountainview.gov	Santa Clara
Larry I.	Perlin	Chief Building Official	Palo Alto	650.329.2550	larry.perlin@cityofpaloalto.org	Santa Clara
Barbara	Cimino	Disaster Coordinator	Palo Alto Fire Dept. OES	650.617.3164	barbara.cimino@cityofpaloalto.org	Santa Clara
Joubin	Pakpour	District Engineer	Purissima Hills Water District	925.224.7717	JPakpour@pcgengr.com	Santa Clara
Gary	Ushiro	Senior Engineer	Purissima Hills Water District	925.224.7717	gushiro@pcgengr.com	Santa Clara
Patrick	Walter	General Manager	Purissima Hills Water District	650.948.1217	pwalter@purissimawater.org	Santa Clara
Joseph	Carrillo	OES Director	San Jose	408.277.8350	joseph.carrillo@sanjoseca.gov	Santa Clara
Scarlett	Lam	Administrative Officer	San Jose	408.535.3500	scarlett@cal.berkeley.edu	Santa Clara
James	Wyatt	Battalion Chief	San Jose	408.277.4251	jim.wyatt@sanjoseca.gov	Santa Clara
Jim	Wollbrinck	Security & Emergency Preparedness Specialist	San Jose Water Company	408.279.7408	jim_wollbrinck@sjwater.com	Santa Clara
Gene	Sawyer	Deputy Fire Chief	Santa Clara	408.615.4953	gsawyer@ci.santa-clara.ca.us	Santa Clara
Jim	Yoke	Emergency Services Coordinator	Santa Clara Co. Fire Dept. (Los Gatos, Saratoga, Monte	408.887.7818	sccfd_esc@yahoo.com	Santa Clara
Miguel	Grey	Program Manager	Santa Clara County OES	408.808.7804	Miguel.Grey@oes.sccgov.org	Santa Clara
Harry	Reinstein	Senior Emergency Planning Coordinator	Santa Clara County OES	408.299.5105	harry.reinstein@oes.sccgov.org	Santa Clara
Marcella	Rensi		Santa Clara Valley Transportation Authority	408.321.5717	marcella.rensi@vta.org	Santa Clara
Martin	Gamez	Unit Manager, Office of Emergency Services	Santa Clara Valley Water District	408.265.2607	mgamez@valleywater.org	Santa Clara
Michael	Hamer	Senior Manager, Emergency Services and Community F	Santa Clara Valley Water District	408.265.2607	mhamer@valleywater.org	Santa Clara
Juan	Ledesma	Senior Analyst	Santa Clara Valley Water District	408.265.2607x3172	jledesma@valleywater.org	Santa Clara
Barbara	Powell	Assistant City Manager	Saratoga	408.868.1215	bpowell@saratoga.ca.us	Santa Clara
Roy	Nelson	General Manager	Silver Creek Valley Country Club (Geological Hazard Ab	408.353.4303	GenMgr@SCVCC-GHAD.org	Santa Clara
Cherel	Sampson	Emergency Planner, OES	Sunnyvale	408.730.7198	csampson@ci.sunnyvale.ca.us	Santa Clara
Tonya	Gilmore		Benicia	707.746.4334	tgilmore@ci.benicia.ca.us	Solano
Tim	Winfield	Fire Department	Benicia Fire Dept.	707.746.4275	twinfield@ci.benicia.ca.us	Solano
Gina	Eleccion	Management Analyst	Benicia, Community Development	707.746.4278	geleccion@ci.benicia.ca.us	Solano
Scott	Rovanpera	Water Treatment Plant Superintendent	City of Benicia Water Department	707.746.4394	srovanpera@ci.benicia.ca.us	Solano
Carrie	Wenslawski	Management Analyst II	City of Benicia Water Department	707.746.4236	cwenslawski@ci.benicia.ca.us	Solano
Mike	Arnold	Captain	Coredlia Fire Protection District	707.864.0468	fog5110@sbcglobal.net	Solano
Jay	Huyssoon	Fire Chief	Coredlia Fire Protection District	707.864.0468	jhuyssoon@sbcglobal.net	Solano
Ed	Tubbs	Assistant Chief	Dixon Fire Dept.	707.678.7060	etubbs@ci.dixon.ca.us	Solano
Brian	Miller	Associate Planner, Dept of Planning & Development	Fairfield	707.428.7446	BKMILLER@ci.fairfield.ca.us	Solano
Tom	Myers	Interim Fire Chief	Rio Vista Fire Dept, Delta Fire District	707.374.2233	tmyers@ci.rio-vista.ca.us	Solano
Cliff	Covey	Hssf. Director	Solano County Department of Resource Management	707.784.6765	CCovey@SolanoCounty.com	Solano
Matthew	Geisert	Hazardous Materials Supervisor	Solano County Department of Resource Management	707.784.3314	MGeisert@solanocounty.com	Solano
Fred	Hofstetter	E.S. Tech	Solano County Sheriff's OES	707.784.1651	fmhofstetter@solanocounty.com	Solano
David	Okita	General Manager	Solano County Water Agency	707.455.1103	dokita@scwa2.com	Solano
Frank	Morris		Solano Irrigation District	707.455.4026	fmorris@sidwater.org	Solano
Gary	Cullen	Dep. Director of PW-Maintenance	Vacaville	707.469.6503	GCullen@cityofvacaville.com	Solano
Frank	Drayton	Operations Chief	Vacaville Fire Department	707.249.1723	fdrayton@cityofvacaville.com	Solano
MJ	Lanni		Vallejo	707.648.4527	mjlanni@ci.vallejo.ca.us	Solano
Lee Ann	Lantrip		Vallejo	707.648.4528	LLantrip@ci.vallejo.ca.us	Solano
Bill	Tweedy	Fire Department Information Officer	Vallejo	707.333.8433	wtweedy@ci.vallejo.ca.us	Solano
Gezel	Simmons	Safety and Risk Management Technician	Vallejo Sanitation and Flood Control District	707.644.8949x208	gsimmons@vsfcd.com	Solano
Zoeanne	Tafolla	Director of Safety and Risk Management	Vallejo Sanitation and Flood Control District	707.644.8949x281	ztafolla@vsfcd.com	Solano
Janine	Wooley		Vallejo Transportation	707.553.7224	jwooley@ci.vallejo.ca.us	Solano
Mike	Lehman		Vallejo Water Department	707.648.4307	mikelehman@ci.vallejo.ca.us	Solano
Paul	Wade	City Engineer	Cloverdale	707.894.1722	PWade@ci.cloverdale.ca.us	Sonoma
Robert	Stewart	Police Chief	Cotati	707.792.4611	rstewart@ci.cotati.ca.us	Sonoma
Damien	O'Bid	City Engineer, Public Works	Cotati Water Department	707.665.3620	DObid@ci.cotati.ca.us	Sonoma

Fname	Lname	Title	Jurisdiction/Agency	Phone	E-mail	County
Elizabeth	McElligott	Assistant Deputy Director	Alameda County Community Development Agency	510.670.6120	elizabeth.mcelligott@acgov.org	Alameda
Sandi	Rivera	Assistant Planning Director	Alameda County Community Development Agency	510.670.6120	sandra.rivera@acgov.org	Alameda
Marla	Blagg		Alameda County Fire Department	510.618.3468	Marla.blagg@acgov.org	Alameda
Randy	Collins	Fire Department	Healdsburg	707.431.3360	rcollins@ci.healdsburg.ca.us	Sonoma
Nancy	Woods	Consultant	Petaluma	916.383.5085	transtec.consulting@gmail.com	Sonoma
Marilyn	Ponton	Planner	Rohnert Park	707.588.2231	rbendorff@rpcity.org	Sonoma
Rick	Moshier	Director of Public Works	Santa Rosa	707.543.4200	rmoshier@srcity.org	Sonoma
Steve	Allen	Supervising Engineer - Utilities	Santa Rosa Water Department	707.543.4527	sallen@srcity.org	Sonoma
David	Guhin	Deputy Director- Utilities	Santa Rosa Water Department	707.543.4299	dguhin@srcity.org	Sonoma
John	Zanzi	Chief	Sebastopol Fire Dept.	707.823.8061	jzanzi@sonic.net	Sonoma
Linda	Kelly	City Manager	Sonoma	707.933.2215	lkelly@sonomacity.org	Sonoma
Deborah	Rogers	Management Analyst	Sonoma	707-933.2218	debrar@sonomacity.org	Sonoma
DeWayne	Starnes	Chief Building Official	Sonoma County	707.565.1900	VSTARNES@sonoma-county.org	Sonoma
Bob	Smylie	Deputy Emergency Services Coordinator	Sonoma County Dept. Emergency Services	707.565.1152	rsmylie@sonoma-county.org	Sonoma
Pauletta	Cangson	Associate Planner/Code Enforcement	Windsor	707.838.5335	pcangson@Townofwindsor.com	Sonoma
Peter	Chamberlin	Building and Planning Director	Windsor	707.838.5335	pchamberlin@townofwindsor.com	Sonoma
Danielle	Hutchings	Earthquake and Hazards Specialist	Association of Bay Area Governments (ABAG)	510.464.7951	danielleh@abag.ca.gov	whole region
Jeanne	Perkins	Consultant to Earthquake and Hazards Program	Association of Bay Area Governments (ABAG)	510.464.7934	jeannep@abag.ca.gov	whole region
Sara	Polgar	Planner	Bay Conservation and Development Commission (BCD	415.352.3600	sarap@bcdc.ca.gov	whole region
Nancy	Okasaki	Transportation Planner	Metropolitan Transportation Commission (MTC)	510.817.5759	nokasaki@mtc.ca.gov	whole region