



# Managing Risk in Earthquake Country

## Estimated Losses for a Repeat of the 1906 San Francisco Earthquake and Earthquake Professionals' Action Agenda for Northern California

April 17, 2006

## Overview

This document has been prepared in advance of the 100<sup>th</sup> Anniversary Conference to provide conference leaders and speakers with a concise summary of the study performed to estimate potential losses for a repeat of the 1906 San Francisco Earthquake, as well as the Earthquake Professionals' Agenda of actions that we must undertake to ensure that Northern California can safeguard its extraordinary cultural and economic vitality and rebound quickly following the next major earthquake. All recipients are asked to keep the loss estimates and details of this document confidential until its public release on April 17, 2006. Its contents are as follows:

	<u>Page</u>
Managing Risk in Earthquake Country	1
Estimated Losses for a Repeat of the 1906 San Francisco Earthquake - Summary	2
Earthquake Professionals' Action Agenda for Northern California	5
Appendix: Supporting Documentation for Earthquake Professionals' Action Agenda for Northern California	A-1
Part I. Develop a Culture of Preparedness	A-1
Action 1	A-1
Action 2	A-4
Action 3	A-5
Action 4	A-6
Part II. Invest in Reducing Losses	A-7
Action 5	A-9
Action 6	A-11
Action 7	A-12
Part III. Ensure Resilience in Recovery	A-13
Action 8	A-14
Action 9	A-15
Action 10	A-16

# **Managing Risk in Earthquake Country**

## **100<sup>th</sup> Anniversary Conference Commemorating the 1906 San Francisco Earthquake**

The 1906 Earthquake and Fire have endured as one of the most widely known disasters in the world. Almost 300 miles of the San Andreas Fault ruptured shortly after 5 am on April 18, 1906, affecting portions of 19 counties, from Mendocino in the north to Sacramento in the east and Monterey in the south. The ground shaking and ensuing fires caused more than 3,000 deaths, destroyed over 28,000 buildings, and left homeless about 225,000 of Northern California's one million residents.

### **If a Repeat of the 1906 Earthquake Happened Today**

The Earthquake Engineering Research Institute (EERI), Seismological Society of America (SSA), California Governor's Office of Emergency Services (OES), and U.S. Geological Survey (USGS) commissioned teams of experts to incorporate recent scientific and engineering advances into a new, comprehensive simulation and analysis of potential losses due to a repeat of the 1906 earthquake.

The report, "When the Big One Strikes Again," found that if the 1906 earthquake were to happen today, it would affect many of Northern California's nearly 10 million residents and cost between \$90 and \$120 billion to repair or replace the more than 90,000 damaged buildings and their contents. As many as 10,000 commercial buildings would sustain major structural damage and between 160,000 and 250,000 households would be displaced from damaged residences. Depending upon whether the earthquake occurs during the day or night, building collapses would cause 800 to 3,400 deaths. More than half of these deaths would result from the collapse of old concrete, unreinforced masonry and other vulnerable buildings yet to be strengthened. These dangerous structures comprise less than 5% of the region's building stock; structures built after the mid-1970s are generally much safer.

Subsequent individual fire ignitions would damage an additional 5% to 15% of the region's buildings and cause additional deaths. A conflagration similar in scale to the 1906 fire is possible and could cause an immense loss. Damage to utilities and transportation systems would increase losses by an additional 5% to 15%, and economic disruption from prolonged outages would cost several times this amount. Considering all loss components, the total price tag for a repeat of the 1906 earthquake is likely to exceed \$150 billion.

### **What Still Needs to Be Done**

The earthquake professionals of the 100<sup>th</sup> Anniversary Earthquake Conference have developed an action agenda for the region's residents, businesses, earthquake professionals, and governments to increase safety, reduce losses, and ensure a speedier recovery when the next major earthquake strikes. In summary, the agenda looks specifically at what is needed to develop a culture of preparedness, and calls on all residents, businesses and governments to know their risks and take responsibility for risk management and preparedness. It challenges governments, public agencies, building owners, and the engineering community to target the most dangerous buildings, essential facilities and community-serving infrastructure for strategic investments in mitigation. It calls on governments, insurers and the region's major industries to collaborate to ensure that adequate resources are available for recovery. With these actions and a renewed emphasis on safety, Northern California can safeguard its extraordinary cultural and economic vitality and rebound quickly following the next major earthquake.

# **Summary**

## **Estimated Losses for a Repeat of the 1906 San Francisco Earthquake**

### **Study Methods and References**

The Earthquake Engineering Research Institute (EERI), Seismological Society of America (SSA) and the California Governor's Office of Emergency Services (OES) commissioned a team of earthquake loss experts, led by Charles Kircher and Associates to perform the study summarized in the April 2006 issue of Earthquake Spectra: "When the Big One Strikes Again – Estimated Losses Due to a Repeat of the 1906 San Francisco Earthquake," by Charles A. Kircher et al.

The study relies primarily on the "Earthquake Model" of the Federal Emergency Management Agency's (FEMA) HAZUS technology to estimate earthquake damage and loss to the region's building inventory. Inventory data was supplemented with expert engineering opinion as well as information from recent surveys of some of the region's most vulnerable building, including the: assessor's and neighborhood building survey data from San Francisco's Community Action Plan for Seismic Safety (CAPSS), unreinforced masonry data from the California Seismic Safety Commission, and a tuck-under garage apartment survey in Santa Clara County. Updates to the HAZUS model also include: updates to building and contents replacement values and 'time of day' populations to better reflect the region's conditions; development of new damage and loss functions for retrofitted building types; and modification of economic loss functions to account for the post-disaster "surge" in repair and replacement costs as experienced following the 2004 and 2005 hurricanes in the U.S. Statistics on actual damage and loss caused by the 1989 Loma Prieta Earthquake were used to validate the methodology.

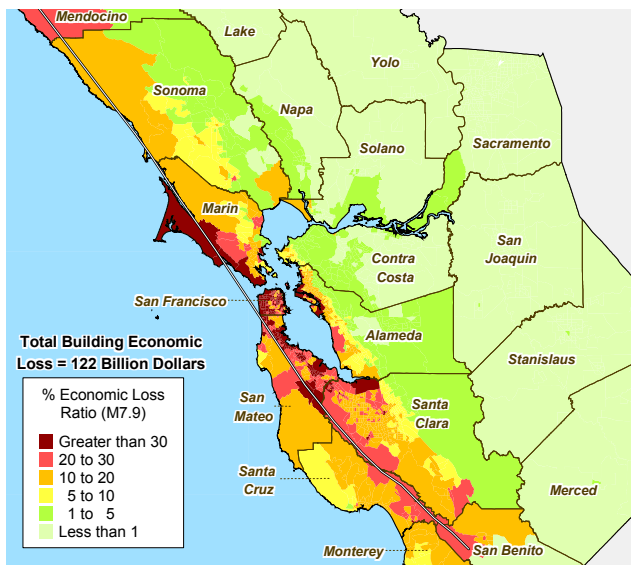
As every earthquake generates a different pattern of ground shaking, two distinctly different ground motion scenarios were used to estimate losses for a repeat of the 1906 earthquake today. The first scenario is based on recent work of the U.S. Geological Survey (USGS) in which the damage and shaking reports for more than 600 sites, compiled after the 1906 earthquake, were re-evaluated, and updated intensities converted into a set of ShakeMaps representing the best available estimate of how the ground shook in 1906. The second scenario assumes that a magnitude Mw7.9 earthquake occurs on the fault segments that ruptured in 1906 and calculates ground motions using a method based on the current seismic provisions of California's building code. This scenario represents the best estimate of how the ground is likely to shake next time and shows a much stronger pattern of shaking in San Francisco and most Bay Area counties than the first scenario.

### **Study Region**

The study covers 19 counties of Northern California (24,000 square miles). This region's risk has increased considerably since 1906 because of substantial increases in both population and property values. In 1906, about 390,000 people lived in San Francisco and less than 1 million lived in the entire 19-county region. Today, the number of San Franciscans has more than doubled and Northern California's population exceeds 10 million. The 19-county region now has more than 3 million buildings with a total value of \$1 trillion (\$1.5 trillion with contents). The majority of the region's property and population is within 25 miles (40 km) of the San Andreas Fault.

### **Building Damage and Losses**

The study estimates that it would cost up to \$120 billion to repair or replace buildings and contents damaged by a repeat of the 1906 earthquake. Of this, San Francisco County would sustain as much as \$34 billion in building-related losses, following by \$28 billion in Santa Clara, \$26 billion in San Mateo, and \$15 billion in Alameda counties. The remaining \$18 billion in building-related losses would be spread across the other 15 counties. For reference, building-related losses totaled about \$80 billion in the 1995 Kobe, Japan earthquake, and only about \$20 billion in the 1994 Northridge Earthquake.



The study estimates that 90,000 to 130,000 buildings across Northern California would sustain extensive or complete structural damage in a repeat of the 1906 earthquake. For reference, more than 140,000 buildings were severely damaged or collapsed in the 1995 Kobe Earthquake, and only about 15,000 buildings were severely damaged in the 1994 Northridge Earthquake.

The study estimates that between 7,000 and 10,000 commercial buildings in Northern California would sustain major structural damage, including about 40% of all commercial buildings in San Francisco and San Mateo counties. Furthermore, between 80,000 and 120,000 residential building in the region would sustain major damage, displacing between 160,000 and 250,000 households or at least 400,000 people.

Depending upon whether the earthquake occurs during the day or night, building collapses would cause between 800 and 3,400 deaths. Building damage from a nighttime earthquake would cause 800 to 1,800 deaths. If the earthquake occurred during the day, human losses would be greater with between 1,600 and 3,400 deaths caused by severe damage to the many vulnerable classes of buildings where we work. For reference, only 60 people died in the Northridge Earthquake (26 of which were building related), and more than 5,000 people died in the 1995 Kobe Earthquake (most of which were building related).

The study shows that more than 50% of the estimated deaths are caused by the collapse of unreinforced masonry buildings, older reinforced concrete buildings, and other vulnerable structures that have not yet been strengthened; yet, these vulnerable structures represent less than 5% of all the buildings in the study region. The most vulnerable building types are one- and two-story wood-frame structures with a minimally reinforced first floor (i.e. soft-story buildings), unreinforced masonry, and older, non-ductile concrete frame structures.

## Fire-related Losses

Several hundred individual fire ignitions are estimated to cause an additional 5% to 15% in building damage as well as additional deaths. This is a region-wide estimate, and some counties, in particular San Francisco which has older buildings and a denser pattern of development, could suffer a greater percentage of fire-related losses. A conflagration similar in scale to the 1906 fire is not likely, but if it did happen it would cause an even greater loss. In 1906, the 3-day conflagration following the earthquake burned over 500 downtown blocks and was responsible for 80% to 90% of all losses.

## **Utility and Infrastructure Losses**

Damage to utilities and transportation systems would increase losses by an additional 5% to 15%. Prolonged utility and transportation outages would cause widespread disruption costing several times this amount. Since the 1989 Loma Prieta Earthquake, many of the region's utility and transportation operators have invested substantially in seismic retrofit or upgrades to their systems. For reference, federal expenditures on transportation and utility repairs following the 1994 Northridge Earthquake exceeded \$4 billion.

Following the 1989 Loma Prieta Earthquake, the California legislature authorized the California Department of Transportation (Caltrans) to lead a multi-year program to evaluate all of the approximately 24,000 publicly-owned roadway bridges in the state and to take actions necessary to prevent their collapse in future earthquakes. Since then, billions of dollars have been invested to retrofit bridges and overpasses across the state. In the Bay Area, most of the major bridges spanning the Bay have been upgraded with the exception of the San Francisco Bay Bridge, which is currently undergoing seismic upgrades and a full replacement of the eastern span. If the 1906 earthquake were to occur today, the Bay Bridge would sustain heavy damage and would be out of service for many weeks. Other bridges spanning the Bay would sustain limited damage to approaches, which would likely affect transportation patterns for days until repairs were completed.

The Bay Area Rapid Transit (BART) is currently undertaking a major seismic retrofit of its entire system, with many projects already underway, including the Transbay Tube retrofits. If a repeat of the 1906 earthquake were to occur today, it would cause extensive damage to the Transbay Tube, forcing its closure for more than two years, and interrupting services for more than 150,000 weekday passenger trips. BART estimates that it would cost \$860 million to repair damage to its system. The subsequent economic disruption caused by a prolonged BART system outage would be several times this amount. Retrofit is being done on some small segments of the Transbay Tube and the latest BART schedule shows completion of the entire Transbay Tube retrofit in April, 2010.

## **Total Losses**

Considering all loss components, the total price tag for a repeat of the 1906 earthquake could reach \$150 billion. This includes both public and private building and contents damage, as well as infrastructure and business interruption losses. It does not include the potentially significant and long-term losses that might be caused by widespread economic disruption, such as potential decreases in property values and property tax revenue, loss of tourism revenues, and other key income generators for the region. For reference, this estimate is similar to the total losses from the 1995 Kobe Earthquake, roughly four times the total losses from the 1994 Northridge Earthquake and about 10 times the total losses from the 1989 Loma Prieta Earthquake (in 2006 dollars).

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## **Earthquake Professionals' Action Agenda for Northern California**

The people, businesses and government agencies in Northern California risk suffering life, structural, and financial losses when major earthquakes strike. Scientists, engineers and emergency management experts gathering for the 100th Anniversary Earthquake Conference call on the region's citizens, businesses, and policymakers to take the following actions to increase safety, reduce losses, and ensure a speedier recovery from the next major earthquake.

### **Develop a Culture of Preparedness**

1. Every household, government agency, and business must know the seismic risks of the buildings they occupy, the transportation systems they use, and the utilities that serve them, as well as the actions they can take to protect themselves.
2. Every household, government agency, and business needs to be prepared to be self-sufficient for at least three days (72 hours) following a disaster.
3. Citizens and governments need to take steps to ensure adequate response care for special needs and vulnerable populations.
4. Government agencies, the region's major industries, and earthquake professionals have to work together to prepare the region to respond to and recover from major earthquakes. This can be done through region-wide, multi-organizational plans, training, exercises and coordination assessments, as well as continuing improvements in our collective understanding of seismic risks.

### **Invest in Reducing Losses**

5. Building owners, governments, and the earth science and engineering professions must target potential collapse-hazard buildings for seismic mitigation, through retrofit, reduced occupancy, or reconstruction.
6. Governments and other relevant agencies must retrofit or replace all facilities essential for emergency response to ensure that they function following earthquakes. These facilities include fire and police stations, emergency communications centers, medical facilities, schools, shelters, and other community-serving facilities.
7. Governments and other relevant agencies must set priorities and retrofit or replace vulnerable response- and community-serving infrastructure, including cellular communications, airports, ports, roads and bridges, transportation, water, dams and levees, sewage and energy supplies, to ensure that functions can be resumed rapidly after earthquakes.

### **Ensure Resiliency in Recovery**

8. Government agencies, the region's major industries, and earthquake professionals have to plan collaboratively for the housing, both short- and long-term, of residents displaced by potential fires, large numbers of uninhabitable buildings, and widespread economic and infrastructure disruption following a major earthquake.
9. Every household, government agency, and business has to assess and plan for financing the likely repair and recovery costs following a major earthquake.

10. Federal, state and local governments, the insurance industry, and the region's major industries have to collaborate to ensure adequate post-event funding to provide economic relief to individuals and communities after a major earthquake, when resources are most scarce yet crucial for recovery and reconstruction.

In conclusion, the earthquake professionals of the 100th Anniversary Earthquake Conference believe that, based on our current understanding of the hazards, local planning, stronger building codes, and ongoing mitigation have substantially reduced the potential loss of life and property that a major Northern California earthquake could cause. Many areas are better prepared than ever before, yet the region is still not sufficiently ready for the next major earthquake. The social and economic consequences could prove to be long-lasting and ruinous to communities. With these actions and a renewed emphasis on safety, Northern California can safeguard its extraordinary cultural and economic vitality and rebound quickly following the next major earthquake.



## **Appendix: Supporting Documentation for Earthquake Professionals' Action Agenda for Northern California**

The earthquake professionals of the 100<sup>th</sup> Anniversary Earthquake Conference have developed an action agenda for the region's residents, businesses, earthquake professionals, and governments to increase safety, reduce losses, and ensure a speedier recovery when the next major earthquake strikes. In summary, the agenda looks specifically at what is needed to develop a culture of preparedness, and calls on all residents, businesses and governments to know their risks and take responsibility for risk management and preparedness. It challenges governments, public agencies, building owners, and the engineering community to target the most dangerous buildings, essential facilities and community-serving infrastructure for strategic investments in mitigation. It calls on governments, insurers and the region's major industries to collaborate to ensure that adequate resources are available for recovery. With these actions and a renewed emphasis on safety, Northern California can safeguard its extraordinary cultural and economic vitality and rebound quickly following the next major earthquake.

The following document encapsulates the details of nominated actions made by the more than 50 experts participating in the action agenda elicitation led by the Northern California chapter of EERI for the 100<sup>th</sup> Anniversary Earthquake Conference. More specifics and justifications for the top ten actions are provided here.

### **Part I. Develop a Culture of Preparedness**

An emphasis on education and preparedness is one of three fundamental underpinnings of this action agenda. This is a region-wide responsibility involving all levels of government, non-governmental agencies, businesses and individuals. All residents and businesses must take responsibility to understand and reduce their risks and make plans to care for themselves and their operations after a disaster. Governments also need to understand their risks, help residents and businesses to access accurate and reliable information about earthquake risk and preparedness, and focus resources on special needs populations, coordinated training and response planning.

**Action 1: Every household, government agency, and business must know the seismic risks of the buildings they occupy, the transportation systems they use, and the utilities that serve them, as well as the actions they can take to protect themselves.**

**1.A. Everyone must take responsibility for living in 'earthquake country' and understand the seismic hazards and vulnerabilities of the places and buildings we occupy, and the roads and utilities we use, as well as the ways we can better prepare and mitigate our risks.**

With the notable exception of the 1989 (Mw6.9) Loma Prieta Earthquake, there have been few moderate or larger earthquakes in Northern California in recent years. The many decades of seismic quiescence after the 1906 earthquake have given a false sense of security to many of region's 10 million residents. Based upon research conducted since the 1989 earthquake, the U.S. Geological Survey (USGS) and other scientists have concluded that there is a 62% probability of at least one magnitude 6.7 or greater quake, capable of causing widespread damage, striking the San Francisco Bay region before 2032. In addition to a 1906-type earthquake, smaller yet powerful earthquakes are possible on any of the region's seven major fault systems. The Hayward fault is of particular concern since it runs through the densely urbanized East Bay corridor and several critical elements of the region's major infrastructure either cross or are within close proximity of that fault.

Northern California has more than 3 million buildings valued at \$1 trillion (\$1.5 trillion with contents). Many of the region's most vulnerable structures have been strengthened or replaced by more seismically resistant construction. Yet, many aging and vulnerable structures, transportation systems and utilities remain. Most were built to older design and code standards which recent earthquakes have shown to be inadequate.

An array of educational resources exists for homeowners, business and commercial building owners, and individuals (Fact Sheets on vulnerable buildings at [www.quake06.org](http://www.quake06.org)). The California Seismic Safety Commission ([www.seismic.ca.gov](http://www.seismic.ca.gov)) has developed both the "Homeowner's Guide to Earthquake Safety" and "Commercial Property Owner's Guide to Earthquake Safety." Each guide includes information on geologic and seismic hazards, explanations of related structural and nonstructural hazards, and recommendations for mitigating earthquake damage. Non-structural mitigation is key for both individual and business safety. One-third of the financial losses and 4 of the deaths in Northridge were caused by building contents. State legislation requires property sellers to disclose potential hazards from earthquakes and any structural deficiencies, of which they have actual knowledge, in a Natural Hazard Disclosure Statement, and to indicate whether any corrective measures have been taken.

City and county building departments, consulting engineers, insurers, lenders, the seismic hazards mapping program of the California Geological Survey (CGS) ([www.consrv.ca.gov](http://www.consrv.ca.gov)), the Association of Bay Area Governments (ABAG) ([www.abag.ca.gov](http://www.abag.ca.gov)), the Governor's Office of Emergency Services (OES) ([www.oes.ca.gov](http://www.oes.ca.gov)) and the USGS ([www.usgs.gov](http://www.usgs.gov)) all provide earthquake hazards, building and mitigation information. City and county emergency services and fire departments, OES, and the American Red Cross ([www.redcross.org](http://www.redcross.org)) can assist with individual preparedness.

### **1.B. Local governments, utility operators, and other public-serving agencies are responsible for gathering credible seismic risk information and making it accessible to the region's residents.**

The public has a right to know about collapse-risk buildings and vulnerable infrastructure so they can make informed decisions about their continued use. All public agencies should survey and make available information on all transportation systems and classes of buildings most susceptible to earthquake damage or collapse.

In 1986, the state enacted legislation requiring local jurisdictions to catalog their unreinforced masonry buildings and develop a retrofit program. In 2002, ABAG surveyed the 109 cities and counties in the 9-county region abutting San Francisco Bay about the status of local earthquake mitigation. In addition to the state-mandated inventory of unreinforced masonry buildings, 40% of responding local governments had conducted an inventory of at least one other type of potentially hazardous private building (i.e. non-ductile concrete frame, tilt-ups, and soft-story one- and two-story residences). In 2004, the Bay Area's overall mitigation rate for unreinforced masonry (demolitions plus retrofits divided by the total number of buildings) was only 49% and considerably lower than the statewide rate of 69% in other areas with active earthquake faults. It is, however, an increase of 3% over the Bay Region's 46% mitigation rate in 2003. Reference: California Seismic Safety Commission, The Right to Know, Disclosure of Seismic Hazards in Buildings, CSSC 92-03.

The cities of Berkeley, Campbell, Fremont, and San Leandro are among those that have conducted inventories of privately-owned multi-family soft-story wood-frame buildings, such as the buildings so heavily damaged in the Marina district of San Francisco in the 1989 Loma Prieta Earthquake. The city of Palo Alto requires the identification of high-occupancy, older concrete buildings and the upgrade of those that are deemed hazardous. Information on the number and locations of vulnerable apartment buildings can be found through each of these cities' building departments.

The State Architect ([www.dsa.dga.ca.gov](http://www.dsa.dga.ca.gov)) has also assessed the seismic vulnerability of California public schools. Over 8,000 school buildings in California are seismically vulnerable and warrant further analysis and potential structural upgrades. The University of California, Berkeley has also embarked on a 20-year program to seismically strengthen all campus facilities at a cost of nearly \$1 billion. While much information has been gathered, public agencies need to enhance efforts to make the information more widely available, promote public awareness and education, and implement policies, standards and incentives that will encourage preparedness and mitigation. While many of the region's public schools have been strengthened or replaced, there are still many dangerous privately-owned school buildings that need mitigation.

#### **1.C. The state's existing unreinforced masonry (URM) placarding law needs to be strengthened.**

The San Simeon Earthquake of December 2003 demonstrated the effectiveness of retrofitting URM buildings. None of the 9 strengthened URMs in downtown Paso Robles suffered major damage while many of the 44 unstrengthened URMs sustained enough damage to require demolition. Two women died in the collapse of an unstrengthened URM. In 1992, state legislation was enacted requiring owners to post placards at entrances to URM buildings. The Seismic Safety Commission recommends that the law be enhanced to impose fines for non-compliance so that there is a better enforcement mechanism. Owners should also be required to post warning signs that clearly describe where occupants can find more information about their building's risk, and recommendations to building occupants for appropriate actions to take when an earthquake occurs. Reference: California Seismic Safety Commission [http://www.seismic.ca.gov/pub/CSSC\\_2004-02\\_FindingsSanSimeonEarthquake.pdf](http://www.seismic.ca.gov/pub/CSSC_2004-02_FindingsSanSimeonEarthquake.pdf)

#### **1.D. Earthquake scientists and engineers must provide efficient, accurate, and reliable risk information, assessment tools and guidance on mitigation and preparedness actions.**

Several of the recent damaging earthquakes - the 1971 Sylmar, the 1983 Coalinga and 1994 Northridge earthquakes - occurred on unknown faults. Scientific investigations must continue to assess the seismic vulnerabilities of all regions of the state. The statewide Seismic Hazard Mapping Program needs to be completed for all potentially high-risk areas of the state. Additional investments in hazard estimation research are also needed to further assess maximum and characteristic magnitude events, as well as recurrence intervals, for the region's major faults, and to refine ground shaking estimates for the region.

Investments in engineering are also needed to refine risk assessment procedures and improve the vocabulary for communicating the risk to the public. The engineering profession also needs to help provide better access to and education for building owners and occupants on expected building damage and performance levels (i.e. life safety versus higher-levels of performance) and what they need to do to protect themselves and reestablish activities quickly after an earthquake.

#### **1.E. Make long-term investments in educating school-age (K-12) children about the threat of earthquakes and what to do about them.**

Most of the region's children are likely to see one or more M7 earthquakes in their lifetimes. Developing a culture of preparedness will take time. We must invest now in educating the next generation of homeowners and business leaders about the region's risks, preparedness and mitigation. Children can also help educate their families on risks and how to prepare.

**Action 2: Every household, government agency, and business needs to be prepared to be self-sufficient for at least three days (72 hours) following a disaster.**

**2.A. All of the region’s residents who are able need to plan to take care of their basic food, water, clothing and bedding needs during the first 3 days after a disaster.**

Over one-third (3 million) of Northern California’s 10 million residents live and work in the three Peninsula counties of San Francisco, San Mateo, and Santa Clara - all within 40 km (25 miles) of the San Andreas Fault. While response services in California have historically performed well, a major urban earthquake will strain local and state resources. The response to Hurricane Katrina illustrates the need for residents to be more self-reliant in a post-disaster situation. Prepare Bay Area is a 3-year initiative led by the American Red Cross Bay Area ([www.preparebayarea.org](http://www.preparebayarea.org)) to help 1 million households develop a disaster response plan, put together an emergency supply kit, and obtain training in CPR, first aid, household mitigation, and other forms of community preparedness.

**2.B. Involve the media, residents and businesses in public information campaigns and regional drills that help develop skills and relationships which will be instrumental after future real disasters.**

We must engage citizens and businesses in disaster preparedness. Public information campaigns and drills need to alert households and businesses to understand the level of disruption likely (i.e. disrupted transportation, electricity/gas, water and communications) and to pre-identify options, including emergency shelter with relatives, friends or family in other communities willing to share homes in case of homelessness. Outreach and education need to emphasize low- or no-cost efforts that can save lives, reduce losses and help people to be more self-reliant. Examples include training in CPR and knowing how and when to shut-off gas and electricity, evacuate structures, and extinguish small fires. Small businesses, in particular, need training in business continuity planning, since about 40% of small businesses never resume operations after disasters. Businesses need tools and approaches for securing potentially hazardous building contents, workplace safety, building risk assessment, and emergency planning. References: [www.disastereducation.org](http://www.disastereducation.org); California Seismic Safety Commission, California Earthquake Loss Reduction Plan, 2002 – 2006, <http://www.seismic.ca.gov/sscomit.htm>

**2.C. Expand the recruitment, training and support for Community Emergency Response Teams (CERTs) throughout the Bay Area in neighborhoods, schools, and workplaces.**

Well-trained occupants in disaster-stricken regions are effective first responders and can leverage professional emergency resources. Earthquake response is uniquely suited to benefit from effective CERTs because of the lack of warning before earthquakes and the all-at-once circumstances that may overwhelm government emergency services. CERTs can provide training and resources for teaching First Aid, light search and rescue, the National Incident Management System, communicating emergency needs to authorities, disaster preparedness, and financial preparedness for the public. Professional CERT training and recruitment resources and personnel already exist in San Francisco, Berkeley, and San Jose. These can be leveraged to help train others in the region. Funding for an expanded regional support network, staff and proper equipment is also needed. References: <http://training.fema.gov/EMIWeb/CERT>; [www.fema.gov/kids/02cert\\_table.pdf](http://www.fema.gov/kids/02cert_table.pdf); <http://www.sanjoseca.gov/emergencyservices/sanjoseprepaired/>; [www.sfgov.org/site/sfnert\\_index.asp](http://www.sfgov.org/site/sfnert_index.asp); <http://www.ci.berkeley.ca.us/fire/oes.html>

**Action 3: Citizens and governments need to take steps to ensure adequate response care for special needs and vulnerable populations.**

**3.A. The region's governments must provide safe, culturally sensitive and appropriate training and support for the region's diverse and special needs population.**

The Loma Prieta Earthquake put the lack of preparedness in responding to special needs communities in front of a worldwide audience, and sixteen years later Hurricane Katrina provided a gruesome reminder that this challenge still remains. In this region, as much as 20% of the population (certainly in the dense urban areas) will need post-disaster care. Collaborating Agencies Responding to Disasters (CARD) (<http://www.preparenow.org/alameda.html>; [www.firstvictims.org](http://www.firstvictims.org)), fire departments, the American Red Cross, and emergency services organization are key resources for this task. CARD was created in Alameda County after the Loma Prieta Earthquake and the Oakland Hills firestorm to provide disaster preparedness/response support to the county's Community Based Organizations (CBOs), and the 'first victims' - members of the community who are seniors, children, disabled, homeless, non-English speakers, low-income or otherwise in need of ongoing support.

**3.B. Region-wide drills need to emphasize special needs populations and provide training to respond to the needs of these individuals. The region's residents and businesses also must be informed of the need to help.**

In the initial aftermath of a disaster, government will be responding to the greatest needs, such as fire suppression and search and rescue. We must engage residents and businesses to prepare themselves, and help others in need. Region-wide drill need to emphasize awareness and basic training for neighbors in need.

**3.C. Recipients of funding from local government must participate in community preparedness training.**

The City of San Leandro, CA requires any agency receiving funding from the City's Community Development Block Grant (CDBG) program to participate in disaster preparedness classes, training, and exercises. These agencies are valued partners in the community's preparedness and are better able to serve and support the preparedness needs of the city's most vulnerable residents. Reference: <http://www.preparenow.org/alameda.html>

**3.D. Strengthen licensing requirements for skilled care facilities to ensure that client care continues post-disaster.**

Access to medical care is an existing, daily problem for many of the region's residents and it will be exacerbated following a catastrophe. As we saw in the Loma Prieta Earthquake and in Hurricane Katrina, medically compromised people require special care beyond what is typically offered in public shelters. In 1997, the Joint Commission on Accreditation of Healthcare Organizations began evaluating health care organizations' disaster recovery plans for computer systems and data protection. Evaluations such as this need to be expanded, and appropriate licensing requirements also established to ensure that all skilled care facilities continue to serve patients after disasters. The public health system and local governments will not be able to accept the additional patient load, if these care facilities are closed.

**Action 4: Government agencies, the region’s major industries, and earthquake professionals have to work together to prepare the region to respond to and recover from major earthquakes. This can be done through region-wide, multi-organizational plans, training, exercises and coordination assessments, as well as continuing improvements in our collective understanding of seismic risks.**

**4.A. All levels of government should exercise together regularly.**

Agencies at many levels of government have responsibilities to ensure readiness, but local governments are the primary lead agency for disaster response. Coordinated exercises require time, resources, and therefore money. Additional capacity in local first responders (i.e. police and fire departments) is needed and appropriate ongoing funding must be provided. Reference: ABAG/MTC Principles for Emergency Response Legislation,

<http://www.abag.ca.gov/jointpolicy/Emergency%20Management%20Legislative%20Principles.pdf>

**4.B. Each level of government must develop all-hazards plans to guide its comprehensive emergency management program in cooperation with other local and regional agencies.**

All-hazard plans should address the need for businesses, neighborhoods, and all citizens (including those with special needs) to ensure their safety and well-being during the immediate response period. They should also: 1) identify hazards and prioritize risks; 2) define mitigation strategies and prioritize investment programs; 3) include an emergency preparedness element to ensure that the agency, as well as its citizens and businesses, are ready to respond to the various hazards; 4) establish standard operating procedures for the response to any hazard; and 5) establish priorities for the recovery of critical infrastructure and services to ensure economic recovery. This comprehensive all-hazards approach is consistent with California General Plan law that requires each local jurisdiction to adopt a safety element as part of its general plan.

Reference: ABAG/MTC Principles for Emergency Response Legislation,

<http://www.abag.ca.gov/jointpolicy/Emergency%20Management%20Legislative%20Principles.pdf>

**4.C. Conduct region-wide drills regularly (every six months to 1 year) and involve public agencies, businesses, households and special needs populations.**

Region-wide drills, conducted regularly and involving all sectors (both private and public), are essential to foster a culture of preparedness in the region. Coordination, collaboration, preparation and planning amongst government, the region’s utilities, major businesses, non-governmental and volunteer organizations, the Red Cross, and others are necessary to focus on the complex and cross-organization issues of a region-wide disaster, including evacuations, responding to major conflagrations, and providing for emergency sheltering needs.

Such drills will require regional leadership from government organizations, such as OES and ABAG, non-governmental organizations, and major industries. Their objectives should address the complex, regional issues requiring cross-organizational solutions and cooperation. They should also have an educational and training component for the general public and special needs populations, teaching universal skills and working with existing community organizations. Existing training resources and efforts need to be used in a more coordinated way and additional resource commitments and cooperation is needed from the region’s utilities, major corporations and volunteer organizations

**4.D. The region’s fire departments need to develop an estimate of the fires expected following a major earthquake, develop plans and capabilities for fire fighting without normal water supply, and exercise these plans with mutual aid jurisdictions.**



Fire following earthquake (FFE) is an obvious severe earthquake hazard in the Bay Area, as demonstrated in 1906, the 1989 Loma Prieta Earthquake, and the 1991 East Bay Hills fire. Estimates have been made of the potential losses due to FFE, demonstrating the continuing risk of peril. Existing fire department planning and drills may need to be redirected and better coordinated for this task. There will likely be needs for new equipment (i.e. additional hoses and pumps) that will require additional funding. Residents also need training and resources to suppress small fires.

#### **4.E. Ensure school and district boards and administrators develop and implement school emergency plans and staff training as required by the current State Education Code.**

School districts and administrators should be involved in regional drills. School compliance with the state's Standardized Emergency Management System (SEMS) is also needed to help improve the region's response coordination. Reference: California Seismic Safety Commission, California Loss Reduction Plan 2002 – 2006, <http://www.seismic.ca.gov/sscom.htm>

#### **4.F. Improve the rapidity and reliability of basic science information concerning the location, size and shaking intensity of earthquakes, and incorporate it to improve early warnings and post-disaster response.**

One of the biggest challenges after an earthquake is to understand quickly the size, source and levels of ground shaking for every earthquake, in order to better define which areas are most seriously impacted, and where damage is likely to be concentrated. After the 1994 Northridge Earthquake, California and the federal government invested in the earthquake monitoring infrastructure in Southern California. Recently, similar efforts have begun in Northern California. The goal is to be able to monitor seismic activity reliably and to quickly report an earthquake's size and location as well as estimate shaking. Investments must continue to improve earthquake monitoring equipment and technology throughout California and harden the communications systems which deliver data so that the measured ground motions can be translated rapidly into maps of ground shaking intensity for use in assessing where damage may have occurred. In addition, the region also needs additional investments in baseline information, such as the maintenance of an up-to-date (in 2 to 5 year intervals) digital database of imagery, to compare with post-disaster data for use in post-disaster building damage and ground failure assessments. References: OES ([www.oes.ca.gov](http://www.oes.ca.gov)), CGS ([www.consrv.ca.gov](http://www.consrv.ca.gov)) and USGS ([www.earthquake.usgs.gov](http://www.earthquake.usgs.gov))

## **Part II. Invest In Reducing Losses**

The second area of focus in this action agenda is more strategic mitigation of the region's most dangerous buildings and critical infrastructure. This is also a region-wide responsibility involving all levels of government, non-governmental agencies, engineering and science professions, businesses and individuals. Five over-arching activities that need to be undertaken to ensure that more strategic investments are being made are:

### **A. Create a 'living risk model' for Northern California which can be used collaboratively by the scientific, technical and policy-making communities to better understand the region's growing risks, evaluate where the biggest risks lie, and promote, prioritize and implement risk reduction efforts.**

The region's risk is ever-changing as vulnerable structures are upgraded or replaced, population continues to grow, and urbanization expands. A living risk model can be an effective tool to help quantify the region's risk in terms of deaths, dollars and downtime. It can be used to evaluate community-wide

earthquake risk (not single buildings) and evaluate the effects of risk management decisions and approaches for handling future losses and recovery. The Northern California Chapter of EERI has initiated work to develop the framework and pilot projects for an accessible, secure data repository and modeling system. Funding and development resources are needed to establish and maintain such a model. Reference: <http://www.quake06.org/lerm.html>

**B. All public agencies in the region must develop consistent and strategic all-hazard mitigation plans.**

The federal Disaster Mitigation Act of 2000 requires public agencies to prepare a Local Hazard Mitigation Plan (LHMP). Dozens of cities, counties, and special districts in the San Francisco Bay Area are using the multi-jurisdictional LHMP coordinated by ABAG. All public agencies in Northern California should develop comprehensive risk reduction strategies and all-hazard mitigation plans that help prioritize the risks. These plans and strategies should demonstrate cost-effectiveness, and also identify resources for mitigation. Local general plan safety elements, building codes, and retrofit programs should also be consistent with the local mitigation strategy and plan, and the LHMP goals should be included in the housing, land use and safety elements of the local agency's general plan. Reference: ABAG/MTC Principles for Emergency Response Legislation, <http://www.abag.ca.gov/jointpolicy/Emergency%20Management%20Legislative%20Principles.pdf>

**C. Secure dedicated funding for mitigation and ensure that the funds are allocated on a priority basis to address the highest risk communities, buildings and infrastructure first.**

In order to accomplish a meaningful level of risk reduction, ongoing funding is needed. The region's public agencies and earthquake professionals must advocate for dedicated mitigation funding through new and existing legislative vehicles (i.e. bond measures, taxes at state, regional and local levels, and tax incentives for building owners). Federal and state financial assistance are critical to seed private funding opportunities. Funds must be allocated on a priority basis to reduce the greatest risks first. Public agencies also need to monitor funded projects to ensure their continued effectiveness. Reference: ABAG/MTC Principles for Emergency Response Legislation, <http://www.abag.ca.gov/jointpolicy/Emergency%20Management%20Legislative%20Principles.pdf>

**D. Strengthen the role of the California Seismic Safety Commission as the policy and technical lead for earthquake risk reduction in the state.**

As it has for 30 years, the Seismic Safety Commission has the technical experts needed to draft recommend policies to the California Legislature. With added support, the Seismic Safety Commission will be able to deepen its examination of risk and disaster consequences, develop substantive recommendations to the Legislature, and also sponsor/support effective action-oriented mitigation initiatives.

**E. Support and co-fund California-based seismic research programs funded by federal agencies or the private sector.**

Research in all areas of earthquake science, engineering, and emergency management needs to be adequately funded so that the cost of mitigation for new and existing structures can be minimized through reduced conservatism and appropriate performance criteria. Reference: CSSC California Loss Reduction Plan, 2002 – 2006, <http://www.seismic.ca.gov/sscm.htm>



**Action 5: Building owners, governments, and the earth science and engineering professions must target potential collapse-hazard buildings for seismic mitigation, through retrofit, reduced occupancy, or reconstruction.**

**5.A. Local governments and the engineering professions are challenged to move beyond identifying dangerous ‘classes of buildings’ and to focus efforts on developing and implementing more cost-effective means of identifying the actual, individual buildings that are most likely to collapse, and to work together with building owners to mitigate collapse hazards.**

The collapse or extensive damage to certain buildings will be the greatest cause of life and economic losses in future earthquakes. Over the past decades, many of the region’s most dangerous buildings have been strengthened or replaced by more earthquake-resistant construction. There are still large numbers of seismically-hazardous buildings, such as unreinforced masonry, older non-ductile reinforced concrete, soft-story wood-frame, and older tilt-up buildings, in the Bay Area. Most are currently in use which puts all the occupants at risk. The 1906 scenario study performed by Charles A. Kircher et al. for the 100<sup>th</sup> Anniversary Conference found that 50% of all the building damage and nearly all the deaths resulting from a repeat of the 1906 earthquake would come from soft-story wood-frame, non-ductile reinforced concrete, and URM buildings which represent less than 4% of the region’s building stock.

Over the past 20 years, effective legislation has led to the reduction of risks posed by unreinforced masonry buildings. As of 2004, nearly half of the 6,718 URM buildings identified in the 10-county Bay Area have been mitigated, through retrofit or demolition. While the majority of unstrengthened URMs are collapse hazards, the safety risks and mitigation solutions for other classes of vulnerable building are not as readily available. For example, many concrete buildings are not likely to collapse and the methods for identifying which ones are at risk can be time-consuming and costly.

Local governments and the engineering profession must collaborate to identify the exceptionally high-risk buildings that are most likely to collapse in a future earthquake, and develop and implement technically sound, economically efficient, and socially acceptable solutions to mitigate them. Recent advances in performance-based engineering procedures and new retrofit techniques show great promise at identifying and correcting safety problems. EERI is sponsoring a major collaborative effort to identify the most dangerous concrete buildings and fix them. The Concrete Coalition unites structural engineers, building officials, public policy interests, building owners and managers in this long-term effort ([www.eeri.org](http://www.eeri.org))

We cannot neglect the facts as we now know them. All of the region’s local governments need to require surveys of all vulnerable building types and identify those that are exceptionally high risk and might collapse, and incorporate seismic retrofit requirements into all-hazard mitigation plans. These exceptionally high risk buildings must be retrofitted or vacated in the shortest possible timeframe to avoid future loss of life.

**5.B. The earthquake professionals are challenged to develop more localized assessments of ground shaking and building response.**

Scientific investigations must continue to complete the statewide Seismic Hazard Mapping Program and also develop more localized estimations of likely ground shaking. Investments in science and engineering are also needed to refine localized procedures for assessing building risk. In particular, state and federal agencies should support focused research to improve procedures that will help identify the exceptionally high-risk buildings within the greater existing building stock. This is especially true for older non-ductile concrete buildings where identification of the truly dangerous, collapse-risk buildings is costly and especially challenging.

**5.C. Adopt and enforce the International Existing Building Code and other key codes regionally, with adequate peer review.**

California has a successful history of seismic safety programs that rely on strict compliance with cost-effective regulations including the 1933 Riley Act that requires building permits for new construction. Seismic risk in existing buildings is not currently regulated in a uniform fashion in California. Existing buildings routinely undergo major alterations and repairs without consideration of overall collapse risk in disasters.

Adopting and enforcing the new International Existing Building Code (IEBC) will continue to allow minor and moderate alterations to existing buildings without significant earthquake safety enhancements. However, it will trigger minimum seismic safety evaluations and retrofits when major repairs and alterations are implemented. The IEBC will regulate seismic retrofits more effectively and in a gradual manner. It will also protect the public's interests more so than current laws. Pioneering governments, such as San Leandro, Berkeley, and the State of Nevada, have already adopted all or part of the IEBC for use in their jurisdictions. FEMA has repeatedly determined that existing state regulations do not comply with federal regulations for the proper repair of buildings damaged in all types of disasters, thus jeopardizing post-disaster eligibility for federal public assistance. Adoption of the IEBC would help to ensure that every local government uses effective post-disaster repair standards and is fully eligible for public assistance from FEMA after disasters. Retrofit priorities and code changes for certain buildings also need to require fire prevention measures that can significantly reduce the number of earthquake-triggered fires. Reference: [www.iccsafe.org](http://www.iccsafe.org) adoption maps therein

**5.D. All levels of government, the engineering profession, and building owners need to collaborate to create effective financial programs to mitigate collapse-risk buildings.**

Recent earthquakes have repeatedly demonstrated the effectiveness of basic seismic retrofits in reducing damage and the cost of repairs after an earthquake, but the high cost of retrofits is one of the biggest impediments. URM retrofit costs about \$40 per square foot, or \$400,000 for an average 10,000 square foot building. Building valuations in Northern California have doubled in recent years, and a greater number of building owners can tap their assets or sell to other owners who may be more able to invest in seismic retrofits. When possible, the costs for managing the risks in collapse-risk buildings should be paid by building owners.

Local, state and federal governments and the earthquake professionals need to collaborate to create effective financial incentives for the private sector to mitigate the most dangerous buildings. Stronger partnerships with the private sector are needed to ensure safer and more disaster resistant commercial and residential buildings, to encourage private investments in these facilities, and to improve the quality of retrofit construction. Economic models, incentives, and real case studies (i.e. improve mortgage terms, reduced insurance rates, and positive tax benefits) are needed which can demonstrate the cost-effectiveness of specific mitigation methods based on increased levels of property, contents, functionality and tax base protection. Many local agencies have encouraged retrofits with permit fee reductions or waivers. Others have developed grant and loan programs financed by redevelopment funds (i.e. cities of Fremont, Berkeley, and Napa), community development block grants (i.e. City of Vallejo), special assessment districts (i.e. City of San Leandro), general obligation (i.e. City and County of San Francisco) and revenue bonds. Resources: Reference: Northern California EERI Quake '06 Campaign, [http://www.quake06.org/quake06/best\\_practices.html](http://www.quake06.org/quake06/best_practices.html); ABAG/MTC Principles for Emergency Response Legislation, <http://www.abag.ca.gov/jointpolicy/Emergency%20Management%20Legislative%20Principles.pdf>; CSSC California Loss Reduction Plan, 2002 – 2006, <http://www.seismic.ca.gov/sscm.htm>

**Action 6: Governments and other relevant agencies must retrofit or replace all facilities essential for emergency response to ensure that they function following earthquakes. These facilities include fire and police stations, emergency communications centers, medical facilities, schools, shelters, and other community-serving facilities.**

The mitigation of vulnerable critical facilities can generate high benefits when compared to costs, potentially saving lives, reducing indirect losses, and shortening recovery after future disasters. If not addressed, the Bay Region faces potentially large indirect life and property losses, particularly conflagrations that could result from dysfunctional or delayed emergency response if based in vulnerable facilities.

**6.A. Governments and relevant agencies need to assess the vulnerabilities of all essential response facilities, prioritize facilities for mitigation, and incorporate mitigation plans into their capital outlay and all-hazard mitigation plans.**

Agencies need to conduct seismic evaluations and assess the costs and prioritize the mitigation of all structural and nonstructural elements of essential response facilities and building contents. Agencies need to identify funding gaps for structural seismic retrofits or replacements of vulnerable structures and advocate for pre-disaster resources. Some financing options include: new tax assessments on property owners, regional or statewide general obligation bonds, redirection of existing capital outlay funds, and federal and state mitigation grants. Agencies also need to monitor and periodically report on mitigation progress.

Many of the region's agencies have already strengthened or replaced many essential facilities. Since 1992, Berkeley voters have approved over \$362 million in local taxes to seismically upgrade and improve fire resistance of public buildings. Major public facilities, schools and fire stations, along with the Civic Center Administrative Building and the Main Library have been reconstructed. The City also has a new emergency operations center, public safety building and has constructed a new multi-jurisdictional fire station. Reference: City of Berkeley, [www.ci.berkeley.ca.us](http://www.ci.berkeley.ca.us). The City and County of San Francisco has strengthened all fire stations and schools for earthquake and fire safety and most city administrative buildings, including the base-isolated City Hall. The City of Oakland is also in the process of seismically upgrading all fire stations and schools, and has upgraded the City Hall and main administrative building.

Following the 1994 Northridge Earthquake, every hospital in California has been required to meet new seismic safety requirements by 2030. Hospitals that are in danger of collapse must be strengthened or vacated by 2008. Medical facilities in the Bay Area are working to replace or retrofit facilities to meet deadlines that, in many cases, have been extended to 2013. At this time, many of the region's hospital facilities remain at risk. Reference: [www.quake06.org/quake06/fact\\_sheets.html](http://www.quake06.org/quake06/fact_sheets.html)

**6.B. State and federal resources are needed to protect and strengthen essential facilities based on priorities in an all-hazards plan.**

Ongoing dedicated funding is needed for risk reduction activities. Federal and state funding sources will be needed to seed local and private investments. These funds should be allocated on a priority basis to reduce the vulnerability of critical facilities and functions. Reference: ABAG/MTC Principles for Emergency Response Legislation, <http://www.abag.ca.gov/jointpolicy/Emergency%20Management%20Legislative%20Principles.pdf>

**Action 7: Governments and other relevant agencies must set priorities and retrofit or replace vulnerable response- and community-serving infrastructure, including cellular communications, airports, ports, roads and bridges, transportation, water, dams and levees, sewage and energy supplies, to ensure that functions can be resumed rapidly after earthquakes.**

It has taken more than 10 years for the Bay Area to fully recover from the 1989 Loma Prieta Earthquake, and some retrofit programs are still underway to seismically upgrade or replace critical elements of the region's infrastructure. At a cost of billions of dollars, Caltrans has rebuilt or retrofit major highway sections and interchanges and most of the bridges crossing the Bay. Only the Bay Bridge, Golden Gate Bridge and the Benicia Bridge are still undergoing seismic strengthening. In November 2004, a \$1 billion regional bond measure was approved by over 66% of voters in 3 Bay Area counties to fund the seismic upgrade of the Bay Area Rapid Transit (BART) metro system. BART is currently undertaking a major seismic retrofit of its entire system, with many projects are already underway. Seismic retrofit of BART's Transbay Tube will take up to 4 years to complete from today. If a repeat of the 1906 earthquake or other major earthquake were to occur today, it would cause extensive damage to the Transbay Tube, forcing its closure for more than two years, and the interruption of services to more than 150,000 weekday passenger trips. Two vulnerable tunnels are BART's Berkeley hills tunnel and one of East Bay Municipal Utility District's (EBMUD) major water supply lines both of which cross the Hayward fault. The Hayward fault crosses Highway 24 west of the Caldecott Tunnel.

Since 1986, Pacific Gas and Electric (PG&E) has been actively mitigating substations and other critical facilities to ensure that the region's power can be restored quickly. During this time, PG&E also completed 88% of a \$2.2 billion upgrade to 2,250 miles of high risk natural gas distribution lines. In 1994, the East Bay Municipal Utility District (EBMUD) began a \$189 million plan to upgrade its entire system to withstand a M7.0 earthquake on the Hayward fault. Work is about 80% complete, and the seismic retrofit of its major supply tunnel that crosses the Hayward Fault near the Caldecott Tunnel will be finished in 2006.

In January 2000, the San Francisco Public Utilities Commission completed a facility reliability study that examined the likely impacts of four scenario earthquakes on the Hetch Hetchy water system. The scenarios included a magnitude 7.9 earthquake on the San Andreas Fault and an earthquake that ruptured the entire Hayward Fault. It described the types and locations of damage to the system and the service interruption implications. In 2002, the Bay Area Economic Forum produced a follow-on report, *Hetch-Hetchy Water and the Bay Area Economy*, estimating that the losses associated with failure of the system would be \$28.7 billion in the San Andreas Fault scenario, and \$17.2 billion in the Hayward Fault scenario. The San Francisco Public Utilities Commission has a \$4.3 billion retrofit program of its system underway, including the Hetch Hetchy reservoir and aqueduct system, and it will be completed in 2014. About 40% of the region's remaining water systems have begun retrofitting.

**7.A. Government and relevant agencies need to assess the vulnerabilities of community-serving infrastructure, set mitigation priorities, develop appropriate contingency plans, and incorporate mitigation plans into their capital outlay and all-hazard mitigation plans.**

Agencies need to complete seismic evaluations, assess the costs, and prioritize the mitigation of public and private utility systems and infrastructure in the region. Basic infrastructure should be robust and redundant to ensure uninterrupted service; or, if uninterrupted service is not possible, contingency plans should be in place to have those systems back in service within 72 hours. Systems need to be put in place to make the repair process as autonomous as possible, so that repair crews can self-dispatch to designated areas and make necessary repairs.

The vulnerability of critical lifelines crossing the seismically vulnerable levee system the Sacramento River Delta also must be mitigated. PG&E has largely eliminated the risk to their pipeline systems crossing the Delta, but a failure of levees would have catastrophic impacts on the water supplies and subsequently on the economies of both Northern and Southern California.

Agencies need to identify funding gaps for seismic retrofits or replacements of vulnerable infrastructure and advocate for pre-disaster resources. Agencies also need to monitor and periodically report on mitigation progress.

#### **7.B. Earthquake engineering and science professionals need to ensure accurate, and reliable seismic hazard and risk information, assessment tools and guidance for infrastructure system mitigation.**

Investments are needed to complete the state's Seismic Hazard Mapping Program and also to further refine our understanding of the locations of faults, liquefaction, shaking, and landslides hazards and their potential effects on lifeline systems.

#### **7.C. State and federal resources are needed to protect and strengthen critical lifeline systems and facilities based on priorities in an all-hazards plan.**

According to the California Infrastructure Coalition (CIC), spending for infrastructure projects in California has decreased over the past decades and only 3% of the state's spending goes toward infrastructure today, despite tremendous growth and aging systems. Many public works systems are nearing, or have exceeded, their life expectancies. Ongoing funding is needed for risk reduction activities; federal and state funding sources are needed to seed other local and private investments. These funds should be allocated on a priority basis to reduce the vulnerability of most critical facilities and functions. Reference: [www.calinfrastructure.org](http://www.calinfrastructure.org); ABAG/MTC Principles for Emergency Response Legislation, <http://www.abag.ca.gov/jointpolicy/Emergency%20Management%20Legislative%20Principles.pdf>

### **Part III. Ensure Resiliency in Recovery**

The third area of focus in this action agenda is to provide resources to fund recovery. Better preparedness and investments in pre-event mitigation will reduce the deaths, injuries, and property damage following a major earthquake. Earthquakes will cause widespread destruction. As Kircher et al.'s study reveals, a repeat of the 1906 earthquake would severely damage more than 100,000 buildings and cost up to \$120 billion to repair or replace these damaged structures and contents. As many as 10,000 commercial buildings in Northern California would sustain major structural damage, and displace over 160,000 households or at least 400,000 people. When the additional losses from infrastructure damage and fires are also considered, the region's total direct economic loss could rise to \$150 billion.

Financing repairs and rebuilding, relocating displaced residents and retaining businesses and communities are just some of the complex challenges that individuals, businesses and governments must face in rebuilding following a catastrophic disaster. Examples abound in New Orleans and many other Gulf Coast communities struggling to rebuild in the aftermath of Hurricane Katrina. Recovery is a region-wide responsibility involving all levels of government, non-governmental agencies, businesses and individuals. Without adequate planning, the long-term social and economic consequences could prove ruinous to some communities.

**Action 8: Government agencies, the region's major industries, and earthquake professionals have to plan collaboratively for the housing, both short- and long-term, of residents displaced by potential fires, large numbers of uninhabitable buildings, and widespread economic and infrastructure disruption following a major earthquake.**

Northern California must be prepared to accommodate large displaced populations on both an interim and longer-term basis.

**8.A. Public agencies, in collaboration with ABAG, OES, the region's major employers, the Red Cross and other response organizations, must establish comprehensive and consistent plans for housing those displaced by future earthquakes.**

Plans for immediate as well as long-term housing must be developed in advance of a major earthquake. According to ABAG, more than one-third of the people left homeless are likely to need short-term public shelter after a major earthquake for several weeks; the other two-thirds will stay in hotels or with friends or relatives in the region. Depending upon the earthquake, over 80,000 households could require short-term shelter. Suitable public facilities for immediate sheltering must be identified. They might include military facilities, publicly-owned parks and recreational facilities, manufactured housing, and other appropriate options. This is especially critical for densely populated areas like San Francisco and Oakland. Agencies must pre-select emergency shelters using criteria that include ease of transport and erection and allow for the gradual return to permanent residences.

Long-term, temporary housing in appropriate locations must be planned. Planning may need to involve areas of Northern California that do not sustain heavy damage in a major earthquake. The planning departments of each city must be involved in this process so that sheltering does not result in permanent blight. Such temporary housing may be needed for up to 5 years, as in Kobe, Japan after the 1995 earthquake.

The region's major employers need to consider how widespread transportation disruption would affect their employees' abilities to commute and may also need to plan for housing staff at their facilities or relocating portions of their business to accommodate displaced residents. Reference: CSSC California Loss Reduction Plan, 2002 – 2006, <http://www.seismic.ca.gov/sscmit.htm>

**8.B. Local agencies must prioritize seismic retrofit of vulnerable housing to prevent catastrophic collapse and loss of housing stock.**

Availability of housing is among the top problems facing the Bay Area today and the problem will only be exacerbated if a significant amount of housing is severely damaged in an earthquake. Residential building owners need help in understanding their risk and in obtaining funds to retrofit soft-story buildings or bolt individual homes to their foundations. Regulations may be needed to require upgrades that reduce potential losses of affordable housing.

Berkeley and San Leandro are two of the region's cities that have seismic retrofit programs for homeowners. Berkeley's program provides economic incentives for homeowners to conduct retrofits with up to 1/3 of the city's 1.5% property tax eligible to be applied toward seismic upgrades; upwards of 65% of single-family homes have been improved through this funding incentive. San Leandro's program provides training and support for simple and cost-effective methods of strengthening wood-frame homes. The city provides workshops for homeowners and contractors, and has standardized retrofit plans and a tool lending library. References: [www.ci.berkeley.ca.us](http://www.ci.berkeley.ca.us); [www.ci.san-leandro.ca.us/cities.html](http://www.ci.san-leandro.ca.us/cities.html)



**Action 9: Every household, government agency, and business has to assess and plan for financing the likely repair and recovery costs following a major earthquake.**

The cost to repair damage from an earthquake will financially threaten many households, public agencies and businesses, regardless of whether they own or rent their building.

**9.A. Each household and business, whether an owner or a tenant, needs to assess the likely cost of repairs and recovery, consider options for financing these costs, and take this information into account in household and business financial planning.**

Just as we plan for future risks like health care, unemployment, disabilities, retirement and credit risk, every household and business, that is able, needs to assess the likely costs to repair their structure and replace damaged contents. There are many simple and cost-effective structural and non-structural mitigation actions that every household and business can take to reduce their losses, including strapping water heaters, strengthening cripple walls and foundations, and anchoring shelving to walls. Costs for repairs and rebuilding can be substantial and need to consider additional living and business interruption expenses until repairs can be completed. For many Gulf Coast residents, this time is likely to be more than a year.

Individuals and businesses typically finance repairs and recovery through a mix of public and private funds. Those with private funds, such as individual savings or insurance, are generally able to access these funds more readily and began repair sooner than those relying heavily or solely upon public funds. Each household and business needs to determine their likely costs and initiate planning to manage this financial risk. Reference: California Earthquake Authority, [www.earthquakeauthority.com](http://www.earthquakeauthority.com);

**9.B. Local governments, the insurance industry, and earthquake professionals are responsible for gathering credible risk assessment and management information and making it accessible to the region's businesses and residents to use in financial planning.**

Public-private partnerships are necessary to better educate and prepare every household and business for dealing with potential damages and a coordinated recovery. Research after the Northridge Earthquake indicates that approximately 40% of small businesses never resume operations after disasters. Small businesses, in particular, need to be educated in business continuity planning. They need tools for seismic hazard mitigation, including a better understanding of earthquake fundamentals, seismic hazards identification, safety information about potentially hazardous building contents and non-structural mitigation, damage and repair cost assessment techniques, and information on public and private financing options. Reference: CSSC California Loss Reduction Plan, 2002 – 2006, <http://www.seismic.ca.gov/ssemit.htm>)

**9.C. Local governments and other public agencies need to complete hazard mitigation plans in compliance with the Disaster Mitigation Act of 2000 so that the region's communities are eligible for post-disaster federal funding.**

The Disaster Mitigation Act of 2000 required states and local governments to have in place pre-event multi-hazard mitigation plans by May 2005. While the main purpose of the Act is to encourage state and local governments to reduce repetitive disaster losses through local planning, risk assessment and mitigation, public agencies must comply with the Act in order to qualify for certain relief funds after a disaster. FEMA is now working with many cities affected by Hurricane Katrina to complete their Local Hazard Mitigation Plan (LHMP) to be eligible for post-disaster funding. The City of Berkeley was the first California city to comply with the requirement, adopting its LHMP in July 2004. ABAG has developed a multi-agency HMP that has been approved by FEMA. Dozens of cities, counties and special

districts are participants in this plan. Those agencies that are not using the ABAG plan must complete their own plan in order to be eligible for future federal post-disaster funding.

**9.D. Local governments, non-profits and other public agencies in the region need to assess the likely damage levels in their community, both to public and private facilities, and plan for the recovery following a major earthquake.**

No local government has sufficient assets for response and recovery. Governments, non-profits and other public agencies often self-insure and rely heavily upon the post-disaster public assistance provided by the federal government through the Stafford Act. State and federal assistance is typically reimbursement-based and usually delayed even under the ‘best’ of circumstances. To help communities rebuild and remain resilient to disasters, each agency must estimate its potential losses and develop a robust, fiscal recovery plan that uses insurance and other post-event funding mechanisms to provide economic relief to individuals and communities at a time when resources are most scarce.

**9.E. The region’s governments and major industries need to help expand the adoption and use of “building occupancy resumption” programs.**

Detailed post-earthquake building safety inspections take time and large portions of the urban core may be cordoned off until the process is complete. This affects the economy’s ability to recover after major earthquakes. A building occupancy resumption program (BORP) allows building owners to pre-certify private post-earthquake inspection of their buildings by qualified engineers. San Francisco established its BORP in 1996 and several other Northern California jurisdictions have since created similar programs. Resources: San Francisco Department of Building Inspection and [www.seaonc.org](http://www.seaonc.org)

**9.F. Engineering and science professionals need to work with building officials to refine the survey processes for determining when buildings are safe to reoccupy after earthquakes so that fewer are actually closed.**

Strong motion records inside buildings can provide an early indication of likely damage that needs only to be validated by a knowledgeable engineer. Investments are needed to expand the region’s strong motion instrumentation and its post-disaster communications reliability and utilization by local governments for damage assessment and reoccupancy determinations.

**Action 10: Federal, state and local governments, the insurance industry, and the region’s major industries have to collaborate to ensure adequate post-event funding to provide economic relief to individuals and communities after a major earthquake, when resources are most scarce yet crucial for recovery and reconstruction.**

Recovery from a major catastrophic earthquake like the 1906 scenario will require a region-wide and collaborative plan that pools public and private resources to put our communities and individual lives back together. In 1906, swift and collaborative action was taken by all levels of government, banks and insurers to begin rebuilding and provide employment for the suddenly homeless and jobless residents. The federal government guaranteed a bond issue for the city equal to 10% of the total damages and deposited federal funds into local banks, effectively making an interest-free loan for rebuilding. Led by the mayor, 40 leading business figures formed a committee to lead planning for reconstruction. Insurers and reinsurers paid out more than \$235 million (equivalent to \$4.9 billion in 2005) for fire and shake-related claims. References: “A shake in insurance history: The 1906 San Francisco Earthquake,” Swiss Re, 2006; [www.swissre.com](http://www.swissre.com); “Blueprints from Cities that Rose from Their Ashes.” NY Times, October 9, 2005.



**10.A. Local, regional and state agencies and the insurance and catastrophe reinsurance industries are challenged to work together to develop alternative products that are actuarially-sound and attractive to residential consumers.**

Private insurance is a major financing source for post-disaster economic recovery in the U.S., and it has been a major source of recovery funding for several recent large-scale disasters - the September 11, 2001 terrorist attacks and the 2004 and 2005 hurricanes. But, for recent U.S. earthquakes – the 1994 Northridge, 2001 Nisqually, and the 2003 San Simeon earthquakes – the proportion of insurance-related funding has been significantly smaller. The adequacy and availability of insurance to offset repair and rebuilding costs, particularly for damaged residential properties, in Northern California is a serious obstacle for future catastrophic earthquake recovery financing.

Following the 1994 Northridge Earthquake, residential losses were nearly half (\$20 billion) of the total direct losses, and private insurance covered an estimated \$10 billion (or 50%) of the total residential loss. But, in 1994, about 30% of California homeowners had earthquake insurance, with levels above 40% in some areas such as Los Angeles. In the epicentral region of San Fernando Valley, an estimated 60% of all homeowners had earthquake insurance in 1994, although far fewer renters and owners of rental housing and condominiums had insurance.

In 1996, the state established the California Earthquake Authority (CEA) – a privately financed, publicly managed organization that offers basic earthquake insurance for California homeowners, condominium owners, mobile homeowners, and renters. Today, the CEA is one of the world’s largest residential earthquake insurance providers with over \$7 billion in financial resources to pay claims from future earthquakes. But the number of residential earthquake insurance policyholders in California has been declining since 1994 in spite of the state’s actions. In 2004, there are only 1.2 million residential earthquake policyholders in California, representing less than 20% of California homeowners; and the policy coverages and typically have a 15% deductible. Policy limitations and the high costs for supplemental coverages are the main reasons cited for the poor penetration rates.

Given the decreasing number of residential earthquake insurance policies, it is quite likely that the proportional public burden for funding residential recovery from future catastrophic earthquakes, especially in the heavily urbanized Northern California region, will be substantially higher than it was in Southern California in 1994. Strategic and collaborative planning between government and insurers is needed to create more affordable and attractive residential insurance products and increase take-up rate among consumers. References: California Earthquake Authority, [www.earthquakeauthority.com](http://www.earthquakeauthority.com); Johnson, LJ, 2005. Strategies for Financing Recovery from Future Catastrophic Earthquakes. ISEE Kobe 2005. Petak, WJ et al., 2000. The Northridge Earthquake, USA and Its Economic and Social Impacts. EuroConference on Global Change and Catastrophe Risk Management, Earthquake Risks in Europe. IIASA: Laxenburg, Austria. Risk Management Solutions (RMS), 2004. The Northridge Earthquake: RMS 10-year Retrospective. RMS: Newark, CA. [www.rms.com](http://www.rms.com).

**10.B. Local and state agencies must collaborate, seeking input from insurers, utilities, and major employers in the region, to plan for a coordinated recovery.**

Following the 1994 Northridge Earthquake, the gap of approximately \$10 billion in residential losses that was not covered by private insurance was filled by a mix of public and private funding sources. Three large public sources of funding were: FEMA’s Individual Assistance grant program (\$1.4 billion), Small Business Administration (SBA) loans to residences and businesses (\$4.1 billion), and Department of Housing and Urban Development (HUD) grants and loans amounting to \$840 million. Private lenders and individual victims assumed the remaining burden for direct damages as well as the many indirect and

hidden costs associated with recovery. The public and private sectors must begin work now to develop a robust, fiscal recovery plan that pools federal and state funding, insurance and other post-event funding mechanisms and focuses on housing and economic recovery strategies that will help the region rebound quickly and safeguard its extraordinary cultural and economic vitality from the next major earthquake. References: Johnson, LJ, 2005. Strategies for Financing Recovery from Future Catastrophic Earthquakes. ISEE Kobe 2005. Petak, WJ et al., 2000. The Northridge Earthquake, USA and Its Economic and Social Impacts. EuroConference on Global Change and Catastrophe Risk Management, Earthquake Risks in Europe. IIASA: Laxenburg, Austria.

**10.C. The science and engineering professions and local governments need to develop and adopt building and lifeline codes for new construction that include regulations and/or incentives for designs that exceed minimum life-safety standards and focus more 'capital preservation', 'immediate occupancy', and 'continued functionality' for structures critical to the local economy.**

We must bring the region to a higher level of seismic performance as soon as possible and help ensure that all structures and lifelines critical to restarting the local economy following a major earthquake are built to standards focused on capital-preservation and continued function. Critical buildings and systems responsible for emergency response, treating the injured, and providing post-earthquake lifelines (such as transportation, water supply, and utilities) must be quickly restored to minimal levels of emergency functions following the next major earthquake. Responsible jurisdictions and professional organizations should develop appropriate regulations and incentives to promote design for higher-than-minimum-life-safety standards for high-occupancy residential and office buildings as well as key industrial facilities, so that we can reoccupy residences and return to jobs as soon as possible. This involves all areas of construction and requires refinements in hazard assessment, target performance levels, design requirements, incentives, construction processes, and post-earthquake repair requirements.

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