Testimony of
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Committee on Natural Resources
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United States Geological Survey's Earthquake Hazards Program
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Chairman Costa and Subcommittee Members, I am Lloyd S. Cluff of Pacific Gas and Electric Company in San Francisco. Thank you for the invitation and opportunity to present testimony to this distinguished Subcommittee. I have been involved with earthquake science and earthquake engineering activities for the past 48 years in an effort to better understand earthquake hazards and their effects, and to work with the earthquake science and engineering community to develop mitigation measures to minimize damage during future earthquakes. I have first-hand knowledge of the value and accomplishments that are needed toward the reduction of earthquake risks, as well as the overall value of the U. S. Geological Survey's Earthquake Hazards Program toward improving the earthquake safety of our nation.

Working with the U. S. Geological Survey

For my testimony today, I will speak from various viewpoints; first, from the perspective of the past chairman of the congressionally mandated Scientific Earthquake Studies Advisory Committee (SESAC). The SESAC was appointed by the Secretary of the Interior to advise on activities of the U.S. Geological Survey for the National Earthquake Hazards Reduction Program (NEHRP). As chairman of SESAC, I was responsible for working with the committee to write annual reports to Congress (2003, 2004, 2005, and 2006). My testimony includes a limited amount of data and recommendations form those reports.

And second, I will speak from the perspective of a user of products and services developed by the U. S. Geological Survey's Earthquake Hazards Program. I am Director of the Earthquake Risk Management Program for Pacific Gas and Electric Company (PG&E) in San Francisco, one of the nation's largest-investor owned gas and electric utilities. We work in collaboration with the USGS to extract from their research the valuable information of value to PG&E's activities in preparation for major earthquakes. PG&E has taken measures to mitigate and minimize the impact of major earthquakes, as well as to improve the ability of the utility to restore power to PG&E's customers. Our coordination with the USGS and the use of the USGS products and services from their Earthquake Hazards Research Program is invaluable toward PG&E's earthquake hazard mitigation and risk reduction efforts.

During the more than three decades since the National Earthquake Hazards Reduction Program was established, the USGS Earthquake Hazards Program has provided insightful scientific leadership toward understanding earthquake hazards and by working with engineering groups they have the potential to reduce earthquake risks. This leadership has resulted in major advances in identifying and characterizing active faults (earthquake sources) and understanding the destructive effects of earthquakes that will eventually be released by slip on these faults. Twenty-five years ago, there was hope that short-term earthquake predictions would have been realized by now. Although that capability has not been realized, reliable estimations of the locations of future major earthquakes, their size, their likelihood of occurrence, and the character and extent of their effects are now possible.

Additionally, a wealth of information has been developed to enhance our knowledge of the vulnerabilities of the built environment to earthquakes. We now better understand the factors that influence good as well as poor earthquake performance of utilities and transportation systems, as well as specific types of structures and buildings. This improved knowledge has resulted in useful tools that, if applied, have the potential to bring unacceptable risks under control to protect the public and minimize catastrophic consequences.

However, the risk is growing faster than our ability to provide effective mitigation. In spite of the increased knowledge and the good work that has been done, particularly in regions of high seismic exposure, earthquake risk continues to grow nationwide. This is largely due to (1) uncontrolled growth in earthquake-prone areas, (2) the lack of effective land-use planning in the hazardous areas, (3) the lack of implementation and enforcement of appropriate building standards, and (4) the high cost of strengthening the existing built environment. This trend has positioned the nation in an unacceptable situation, one that will eventually result in catastrophic losses. Studies such as the 1999, National Research Council publication, *The Impacts of Natural Disasters: A Framework For Loss Estimation*, show the per-event costs could reach thousands to tens of thousands dead, hundreds of thousands injured and homeless, and direct and indirect economic losses that could exceed $200 billion for a single event. This trend will not be reversed until the earthquake-prone communities in all 39 vulnerable states understand the threat and take action to mitigate unacceptable risks.

Pacific Gas and Electric Company's (PG&E) Earthquake Risk Management Program--In addition to its concern for employee and customer safety during earthquakes, Pacific Gas and Electric Company has a strong economic interest in "keeping the lights on for all of our customers." PG&E has vast resources in dams and power plants, transmission and distribution systems, and administrative buildings. Although protecting these resources from earthquake damage is important, more important is the functionality of these facilities following destructive earthquakes. The ability to continue to provide, or quickly restore utility service to customers, will assist emergency response efforts and reduce recovery time for the community, as well as assure a continuing income stream to northern California businesses during a particularly

challenging time. Functionality also affects the communities PG&E serves, as businesses having gas and electricity can recover quickly, lessening the overall economic impact to the community and the nation.

PG&E has been able to leverage their efforts to improve earthquake safety and reliability of their gas and electric systems through the development of user-driven, public/private research partnerships, co-funded in part by state and national agencies. Three examples are presented below.

PG&E/U.S. Geological Survey CRADA --The 1989 Loma Prieta earthquake provided an opportunity and motivation for PG&E to focus on better understanding the nature and character of earthquake hazards in Central and Northern California, PG&E's service territory. After extensive discussions with the USGS Menlo Park office in 1992, PG&E entered into a non-financial Cooperative Research and Development Agreement (CRADA) with the USGS. We agreed to cooperate on research on earthquake hazards throughout the greater San Francisco Bay Area. Based on the success of this effort, in 1996, the agreement was modified into a financial CRADA. Over the next few years PG&E has provided $5.4 million in funding for projects with USGS scientists and other collaborating earthquake hazard groups that would focus on PG&E's needs for system safety and reliability improvements, throughout our service territory. Generally, the projects include studies to better understand the location and characteristics of specific active faults, the effects of strong ground shaking, local site effects known to influence the degree of damage at particular locations, and the nature of ground failure mechanisms (landslides and liquefaction). Many projects have been completed, and the results are being used to help reduce earthquake risks not only to PG&E facilities, but also to PG&E's industrial customers, private homeowners, and the public at large. In addition, we are working with earthquake engineering groups to reduce the risk.

Pacific Earthquake Engineering Research Center (PEER)--The research results from the PG&E/USGS cooperative program feeds directly into another user-driven, applied research, public/private partnership that PG&E played a major role in establishing, the Pacific Earthquake Engineering Research Center (PEER) Lifelines Research Program. Program partners include PG&E, Caltrans, and the California Energy Commission (CEC), under the auspices of the Pacific Earthquake Engineering Research Center (PEER), at the University of California at Berkeley.

In 1996, PG&E and the University of California entered into an agreement to focus applied research efforts toward improving the earthquake performance (safety and reliability) of gas and electric systems in California. The concept of the users driving the research agenda, in collaboration with the best earthquake researchers available, was the focus of this initial partnership. PG&E engineers are intimately involved in selecting research topics, as well as guiding the research so that research results will be in a form that can be used in improving operations. This collaboration provides a mechanism for research results to be immediately implemented to improve PG&E's system seismic safety and performance during earthquakes.

Misplaced Complacency --Many public policy makers know that earthquakes are infrequent and assume they can be safely ignored in favor of more pressing issues; but they can be assured that when a catastrophic earthquake occurs on their watch, the truth will be revealed. Public perception, it could be said, might be that the United States is not that vulnerable to earthquakes, because the number of lives lost has been exceptionally low compared with that in other countries. The fact is it has been a matter of luck that earthquake deaths have not been higher in the United States. Thirty-nine states have an earthquake threat, and it is just a matter of time before disaster strikes. We cannot afford to rely on good fortune to minimize earthquake loss of life. Let's look at a few examples.

1971 San Fernando, California Magnitude 6.7 Earthquake --The San Fernando earthquake was a direct hit beneath the San Fernando Valley, a few miles north of downtown Los Angeles. The earthquake occurred at 6:00 A.M., when most people were safe at home. The Lower San Fernando Dam was severely damaged and would have experienced massive failure, except the reservoir had been drawn down for maintenance a few days before the earthquake. We were lucky that the duration of the shaking was short. Had the earthquake lasted a few more seconds, the dam would have massively failed, releasing the water in the reservoir onto the 80,000 people living directly downstream. The first floor of the outpatient facility at the new Olive View Hospital massively collapsed, but it was unoccupied because of the early morning hour of the earthquake; later in the day, the facility would have had hundreds of patients.

1989 Loma Prieta, California Magnitude 7.0 Earthquake--In spite of the fact that a major earthquake struck the San Francisco Bay Area on October 17, 1989, losses were minimal; there were only 63 deaths. We take credit for the fact that we had an aggressive program of seismic safety improvements throughout the Bay Area, and that helped limit the losses. However, we were lucky. The center of the energy release along the San Andreas fault was in the Santa Cruz Mountains, 30 to 60 miles from the major cities. Had the earthquake been closer, damage, particularly to the older building stock that had not been seismically upgraded, would have been disastrous. It occurred at 5:04 P.M., commute time, the worst time of day for an earthquake according to earthquake scenarios, and because the streets are filled with people and the freeways are jammed with traffic. An upper section of the Bay Bridge dropped onto the lower deck, and the Cyprus double-decker freeway in Oakland massively collapsed. These two structural failures could have been the source of hundreds of deaths. But we were lucky. The World Series Earthquake, as it has been called, occurred at the beginning of the third game of the World Series between the two Bay Area teams, the San Francisco Giants and the Oakland Athletics. The freeways and bridges were eerily empty while people were inside, watching the game. It was also fortunate that, because of the game, we had media coverage of the earthquake that lasted more than two weeks, helping to raise awareness of the earthquake threat.

1994 Northridge, California Magnitude 6.7 Earthquake--The Northridge earthquake also occurred during the early morning hours, 4:31 A.M., on Martin Luther King Day. Had the earthquake occurred only a few hours later on the national holiday, the near-

massive collapse of the Bullocks Department Store in Northridge would have resulted in more deaths in that one building than all the deaths (57) in the entire region affected by the earthquake. Thousands of commercial buildings were badly damaged and many collapsed, and many freeway bridges collapsed, but they were all virtually empty at the time of the earthquake because of the early morning time of the earthquake.

2001 Nisqually, Washington Magnitude 6.8 Earthquake--The February 28, 2001 earthquake that struck the Nisqually district of Seattle, Washington resulted in only minor casualties and localized damage. The lack of significant damage and casualties were due to two important factors: the focal depth of the earthquake of was two to three times deeper (55 km) than most damaging earthquakes in California, and for the past few decades the Seattle region has adopted an aggressive seismic safety improvement program, particularly with support from FEMA's Project Impact during the 1990s. However, just prior to the earthquake, due to Mardi gras-related riots in Pioneer Square and the SoHo District, the police had barricaded the area to public access. We were lucky because in this old part of the city, unreinforced masonry walls fell into the streets when the earthquake struck, and would have resulted in many casualties had people been allowed normal access.

2002 Denali Fault, Alaska Magnitude 7.9 Earthquake--The second largest earthquake ever to strike the United States, the magnitude 7.9 earthquake on November 3, 2002 on the Denali fault, was a media non-event. This was partly because the earthquake struck a very remote region of Alaska. We were lucky this large earthquake was released on a fault in Alaska, rather than along one of the many faults close to major population centers in California. A similar earthquake along any of the faults associated with the San Andreas fault would have resulted in thousands of deaths and direct and indirect economic losses that could have easily exceeded $200 billion.

But it was also a media non-event because the only significant structure situated in the path of this potentially devastating earthquake did not fail. It was ***not*** a matter of luck that the Trans-Alaska Pipeline performed so well. It was because of the exceptional scientific assessment of the earthquake hazards and the innovative engineering design that prevented a catastrophic oil spill. The Denali fault experienced 18 feet of horizontal and 2.5 feet of vertical displacement at the pipeline crossing of the fault. Thirty two years ago, I organized and directed a state-of-the-art scientific team to complete seismic hazard evaluations and develop with earthquake engineers the design criteria of the pipeline to accommodate surface fault displacement. We worked with an innovative pipeline engineering design team, under the direction of professors Newmark and Hall, and the result was that when the maximum design earthquake (fault displacement) occurred directly beneath the pipeline, not a drop of oil was spilled because the pipeline was well prepared to accommodate the fault displacement and related earthquake effects.

Seventeen percent of U.S. crude oil flows through the Trans-Alaska Pipeline. The State of Alaska depends on the pipeline for eighty percent of its revenue. If damaged, the pipeline could have been disabled for many months, causing oil and gas prices to soar. It

is possible that if the pipeline had broken, the resulting environmental disaster would have significantly delayed the pipeline's restoration.

Earthquake programs and hazard-reduction priorities are too important to risk being lost among competing demands and priorities. In California, important earthquake programs were but a small portion of the overall responsibilities of departments responsible for emergency response, geologic hazards, and structural engineering. The State responded by establishing a Seismic Safety Commission as an independent and single-minded body charged with making certain that earthquake safety is never overlooked. At the present time the Commission is threatened by bureaucratic elimination.

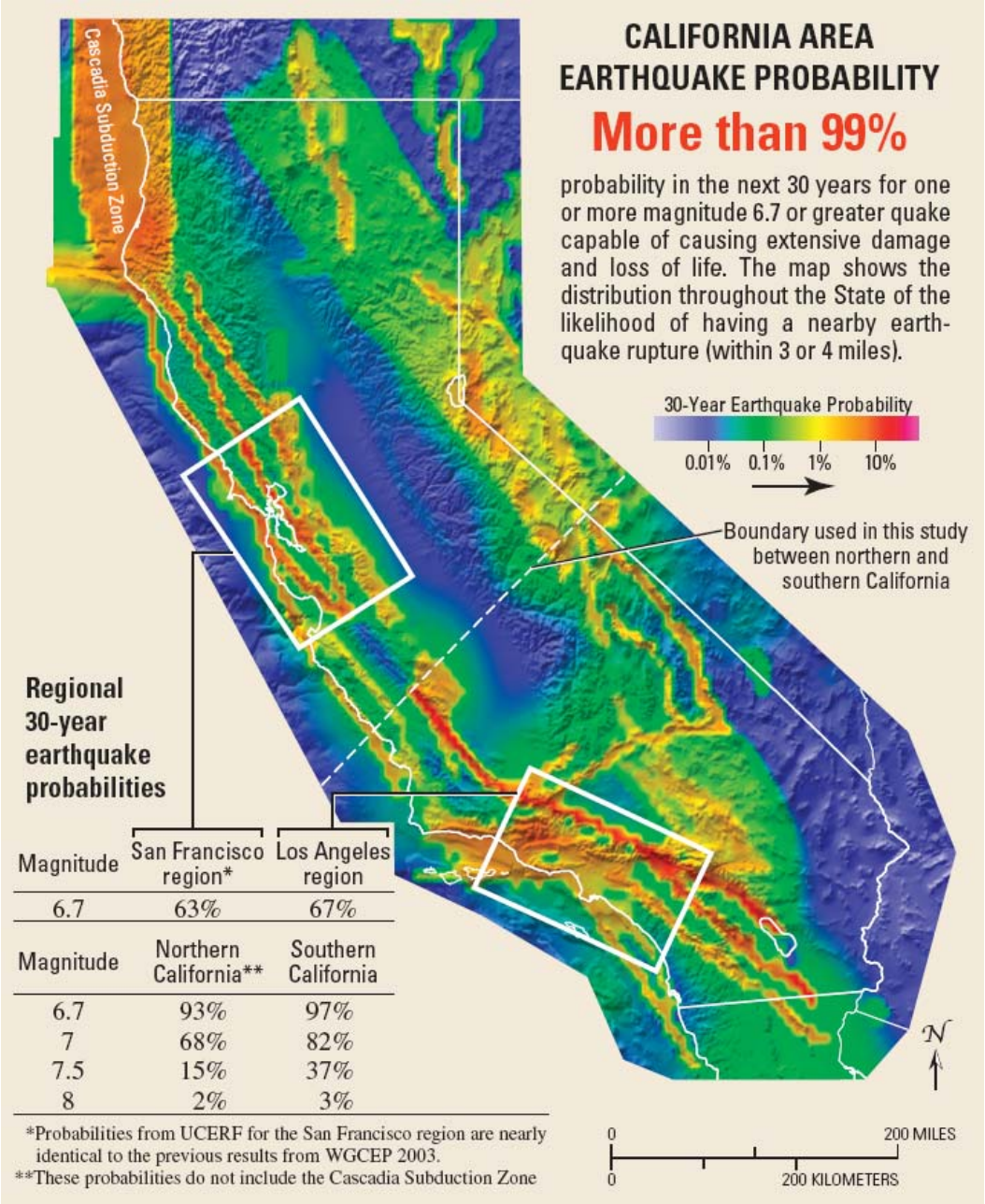
SESAC Recommendations:
All of the SESAC reports have strongly recommended full funding of the ANSS at the authorized funding level as follows:

The SESAC continues to strongly recommend to the Director of the USGS that full funding of the ANSS at the level authorized in the current NEHRP legislation be appropriated. The USGS must make a commitment to work through the Department of the Interior and the Office of Management and Budget to ensure this objective is met. Full deployment of the ANSS offers the potential to substantially reduce earthquake losses and their consequences by providing critical information for land-use planning, building design, insurance, warnings, and emergency preparedness and response. A 2005 report by the National Research Council reiterates that the potential benefits far exceed the costs.

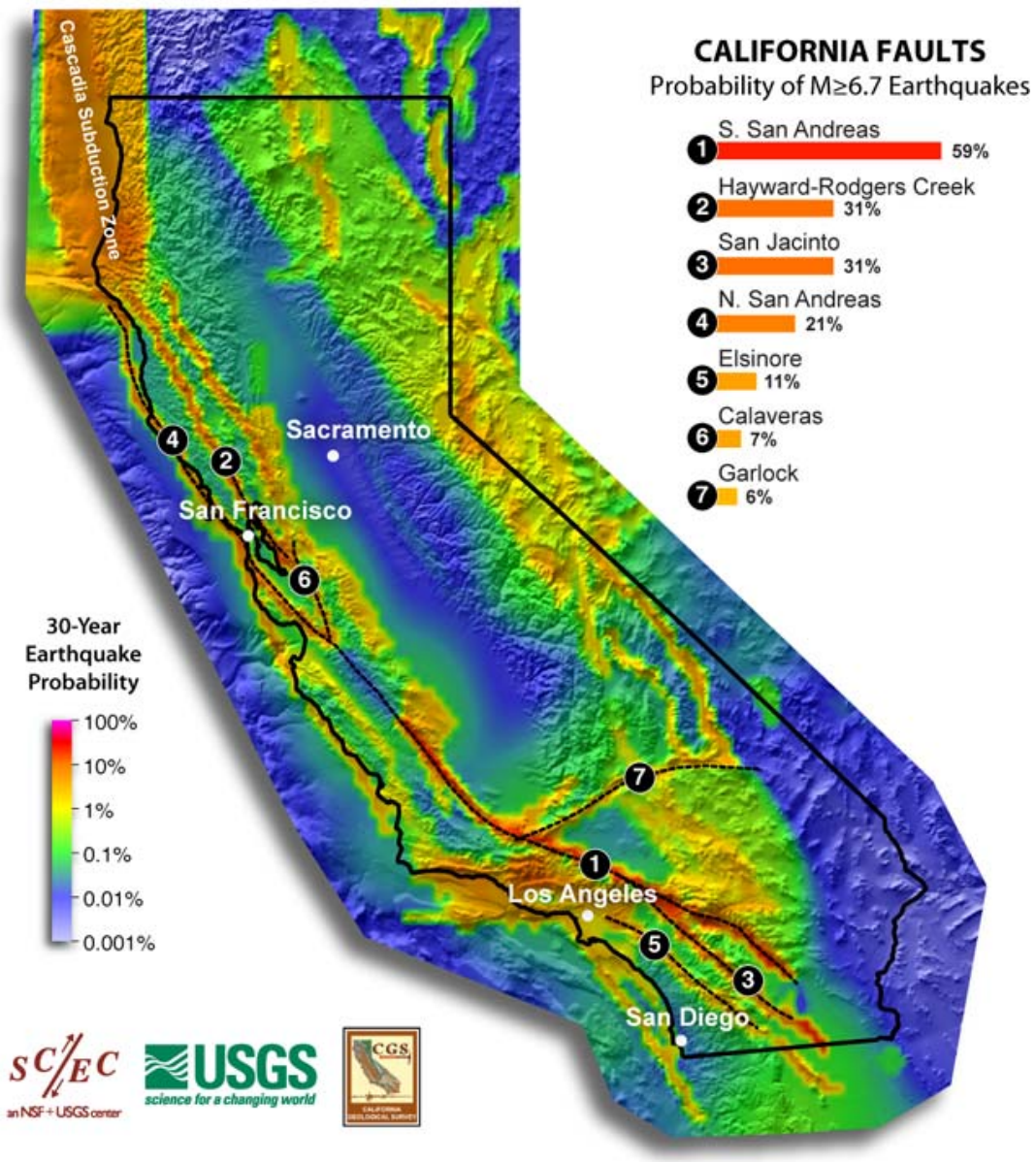
2005 SESAC Recommendation

The SESAC strongly encourages the USGS, the Secretary of the Interior, the Office of Management and Budget, and Congress to move forward vigorously with the Natural Hazards Initiative in the USGS fiscal year 2007 budget. Recent events have spotlighted natural hazards, and the Committee believes the USGS, through its Natural Hazards Initiative, has a major growth opportunity to take the leadership in creating a disaster-resistant country. We recommend the USGS undertake a complete analysis of the consequences of catastrophic earthquakes in the San Francisco Bay Area and in Southern California and integrate the complete picture, from rupture on the fault, wave propagation into buildings and other structures, the response of all levels of our infrastructure, the emergency response, and continuing to the full recovery of our society. The purpose of this exercise would be to identify where and when the breaking points for an extreme earthquake disaster in California will be. The lessons learned in this demonstration project would be applicable to all national extreme disasters.

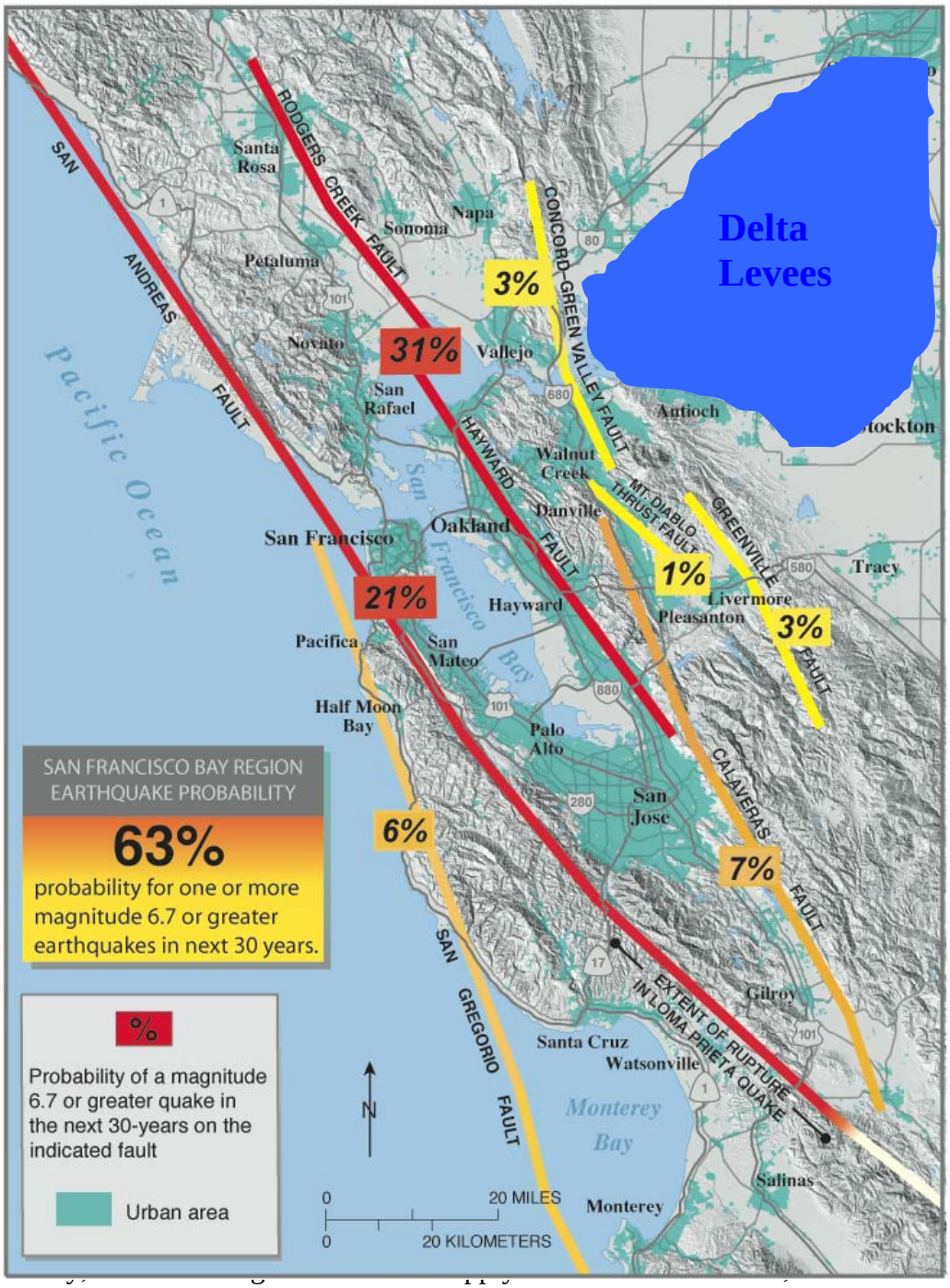
Forecasting Future California Earthquakes
On April 14 the USGS, in collaboration with the Southern California Earthquake Center, the California Geological Survey, the California Earthquake Authority, and various earthquake scientists from universities, released statewide earthquake fault rupture forecasts. The following maps illustrate the locations where severely damaging earthquakes have a high likelihood of occurring.



SCEC/USGS Project on California Earthquake Probability



San Francisco Bay Region Earthquake Probabilities



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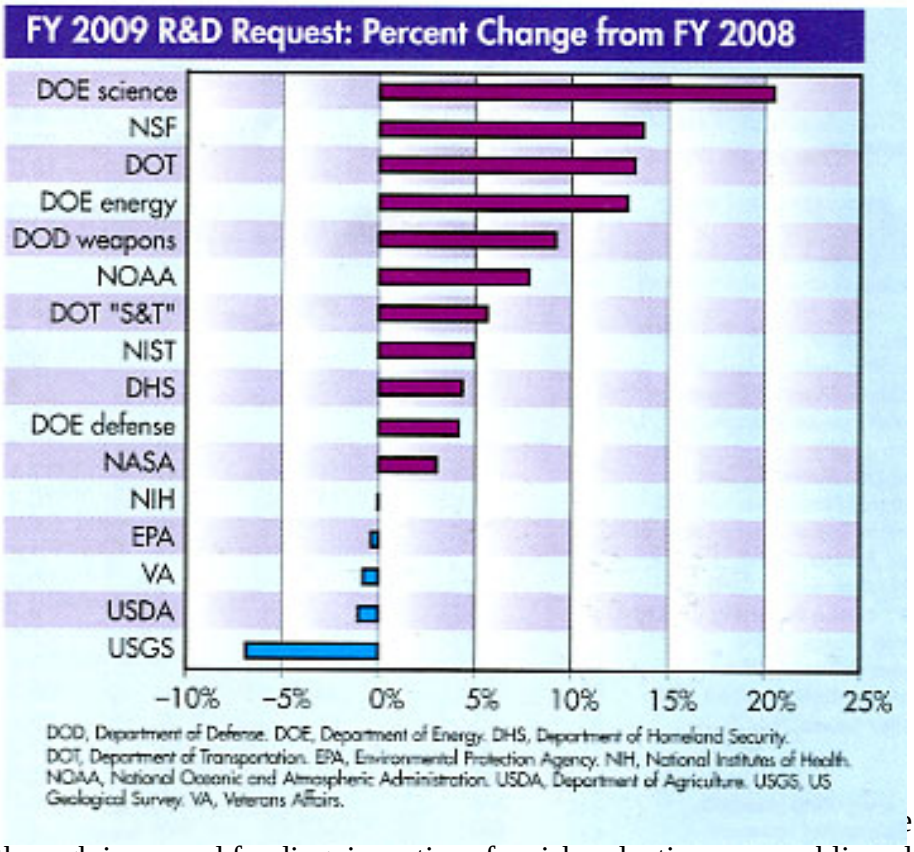
Conclusion--Unless seismic safety is afforded a priority that is now lacking throughout most of the 39 states that have significant earthquake exposure, the United States will experience unacceptable yet avoidable deaths and economic losses from future earthquakes. We have been lucky; we cannot afford to base our earthquake public policy on dumb luck.

The FY 2009 R&D Request illustrated below showing substantial increases in the science budgets of almost all agencies, with the the exception of the USGS budget decrease. This has been a continuing problem during the past several years and must be considered unacceptable by this subcommittee. I urge you to work with other Congressional groups to correct this unacceptable situation. The Earthquake Hazards Program is essential to earthquake safety of our nation.



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implementation through increased funding, incentives for risk reduction, new public policy, and inspired leadership.

As pointed out in the recent Earthquake Engineering Research Institute report, *Securing Society Against Catastrophic Earthquake Losses* (Earthquake *Engineering Research Institute, Oakland, California, 2003), at current funding levels, it will likely take 100-plus years to secure the nation against unacceptable earthquake risks. Based on EERI's research and outreach plan, implementing an expanded program that has three times the funding and includes full appropriations for ANSS and NEES, will provide the needed earthquake risk reduction results in the next 20 to 30 years. The next major earthquake will demonstrate that 100 years is much too long to wait.*

Thank you for the opportunity to address the subcommittee.