June 2008

SeismicWaves

How the National Earthquake Hazards Reduction Program Is Advancing Earthquake Safety

A Hypothetical Disaster Comes to Life

On May 22, 2008, the U.S. Geological Survey (USGS) and the California Geological Survey (CGS) released a 308-page report describing what would happen if a magnitude 7.8 earthquake ruptured the San Andreas Fault in southern California. Halfway around the world, in the Sichuan province of China, millions of people struggled with the consequences of a magnitude 7.9 quake that struck the region on May 12.

The USGS/CGS report and the Sichuan earthquake both brought to public attention—in very different ways—the specter of a powerful earthquake striking densely populated areas. In China, the outcome is tragically real and has included tens of thousands of deaths, hundreds of thousands of injuries, millions of homeless citizens, and billions of dollars of damage.

The likely impact on southern California is revealed in stark detail in the USGS/CGS report. But until another large quake occurs there, as scientists say it inevitably will, these consequences remain hypothetical and to some degree preventable.

The ShakeOut Scenario

Many factors can influence how an earthquake impacts a region, including where, when, and how the quake originates, soil and weather conditions, and levels of urbanization and seismic preparedness. To accurately gauge the effects of a major quake in southern California, the authors of the USGS/CGS report had to make some assumptions about these factors. Their resulting scenario envisions a rupture along the southernmost 200 miles of the San Andreas Fault that produces a magnitude 7.8 earthquake that strikes southern California at 10:00 a.m. on November 13, 2008.

Scientists have identified the southern portion of the San Andreas as the most likely source of a large earthquake in California, and the assumed magnitude of the scenario quake reflects the amount of stress that has accumulated in that part of the fault. November 13 was chosen to coincide with the Great Southern California ShakeOut planned for November 12–16, 2008. This event will include public drills, emergency response exercises, and other earthquake preparedness activities. It is being organized by the Earthquake Country Alliance, a southern California-based public-private partnership, and sponsored by the USGS, the Federal Emergency Management Agency (FEMA), the National Science Foundation, the State of California, and private-sector organizations (see http://www.shakeout.org/).

By describing what will happen without further improvements in seismic mitigation and preparedness, the scenario is intended to encourage such improvements, as is the ShakeOut. Reflecting its hand-in-hand relationship with the ShakeOut, the scenario has been named the ShakeOut Scenario and the USGS/CGS report is entitled *The ShakeOut Scenario*.[1]

To develop the scenario and report, the USGS brought together a multidisciplinary team under the agency's Multi-Hazards Demonstration Project. This group included nearly 200 experts drawn from the USGS, the CGS, the Southern California Earthquake Center, and other organizations in government, academia, and industry. Geologists, seismologists, and computer scientists used the latest research and technology to characterize the hypothetical fault rupture and the ground motions that it would generate.

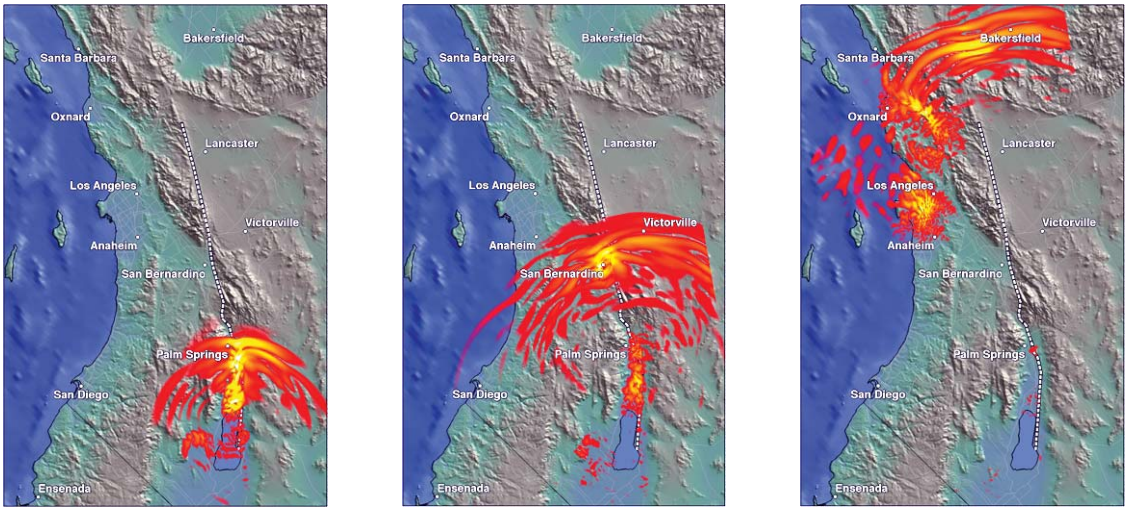
Engineers then examined how these forces would impact buildings and infrastructure. Using HAZUS, FEMA's loss-estimation software, together with expert panels and in-depth studies, the team developed estimates of the types and amounts of damage that would result. This information was used by social scientists and others to estimate casualties, demands on emergency services, and impacts on the regional economy and society. The team also identified activities, such as securing contents and nonstructural elements in buildings, "where relatively small efforts or investments *before* the next earthquake could yield tremendous benefit *after* the earthquake."[2]

Major Quake Effects

If the earthquake described in *The ShakeOut Scenario* actually occurred, it would result in about 1,800 deaths, 50,000 injuries, and economic losses totaling $213 billion. Hundreds of thousands of buildings would be damaged and millions of lives and businesses would be disrupted. The report concludes that, "These numbers are as low as they are because of aggressive retrofitting programs that have increased the

[1] Lucile M. Jones, Richard Bernknopf, Dale Cox et al., 2008, *The ShakeOut Scenario*: USGS Open-File Report 2008-1150 and CGS Preliminary Report 25 (http://pubs.usgs.gov/of/2008/1150/).

[2] Suzanne Perry, Dale Cox, Lucile Jones et al., 2008, *The ShakeOut Earthquake Scenario—A Story That Southern Californians Are Writing*: USGS Circular 1324 and CGS Special Report 207 (http://pubs.usgs.gov/circ/1324/).



In the scenario earthquake, the San Andreas Fault (dashed white line) would rupture from southeast to northwest. These illustrations show the locations of ground motions at 30 seconds, 1 minute, and 2 minutes after the fault starts to rupture. Yellow denotes more violent shaking. Images courtesy of Geoff Ely, University of California San Diego.

seismic resistance of buildings, highways and lifelines, and economic resiliency. These numbers are as large as they are because much more retrofitting could still be done."[3]

Ground shaking would cause about half of the deaths as people are caught in collapsing buildings or struck by falling objects, or as they lose control of vehicles and are involved in traffic accidents. The remaining deaths would result from fires caused by quake damage; an estimated 1,600 fires would ignite in the hours following the quake, some merging to engulf multiple city blocks.

Casualties attributable to building collapses would be limited by the region's strong building codes and by structural mitigation previously completed by government agencies and private owners. Nevertheless, many older, unretrofitted structures built under earlier, less-stringent codes still exist in the area. Ground shaking would irreparably damage about 900 unreinforced-masonry buildings and cause the complete or partial collapse of some 50 low- or mid-rise reinforced-concrete structures and 5 steel high-rise buildings.

The destruction from shaking and fires would interrupt normal activities across southern California. Businesses would be affected not just by the damage to buildings and their contents, but also by impacts on area infrastructure, including highways, railroads, and utilities. These lifelines would be damaged by ground shaking and by surface fault ruptures up to 30 feet wide, rendering them unusable for days, weeks, or longer. Most vulnerable is the water distribution system, which would need to be entirely replaced in the hardest hit areas, severely hampering firefighting. Water might not be restored in these locations for up to 6 months.

Scenario Versus Reality

The next major earthquake to strike southern California will probably differ in many particulars from the one in the ShakeOut Scenario. Its precise location and magnitude—even the fault involved—may be different. However, its overall impact on the region and the nature and magnitude of its effects are likely to be quite comparable to those described in the scenario.

These effects can be reduced through further improvements in seismic mitigation and preparedness, but only if they are implemented before the quake occurs. The ShakeOut Scenario has been created to inspire such activity. How closely this scenario ultimately matches reality will be determined as much by the intervening actions of southern Californians as by the details of the earthquake.

The ShakeOut Scenario is available online at http://pubs.usgs.gov/of/2008/1150/. The USGS and CGS have also published a non-technical, narrative summary of the ShakeOut Scenario, which is available at http://pubs.usgs.gov/circ/1324/.

[3] *The ShakeOut Scenario*, 293.