STATEMENT OF
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BEFORE THE
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
REGARDING
THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

July 29, 2014

Chairman Bucshon, Congressman Lipinski, Members of the Subcommittee, thank you for inviting the U.S. Geological Survey (USGS) to testify at this hearing on the National Earthquake Hazards Reduction Program (NEHRP). The USGS is proud to be a partner in NEHRP, which is led by the National Institute of Standards and Technology (NIST) and includes the Federal Emergency Management Agency (FEMA) and the National Science Foundation (NSF). We greatly appreciate the collective opportunity to provide you a comprehensive update on NEHRP, a highly successful partnership that continues to make valuable contributions to the Nation's resilience to earthquakes.

NEHRP is predicated on the belief that while earthquakes are inevitable, their consequences are not, and there is much that we can do as a Nation to improve public safety and our resilience to earthquakes and related hazards. Within NEHRP each agency performs a distinct and complementary role essential for the overall success of the program. The program is conducted with a high degree of cooperation and collaboration without competition for responsibilities or resources. The heart of this partnership is a broadly shared commitment to translate research results into implementation actions that can reduce earthquake losses. That commitment involves collaboration that goes beyond the four agencies to include other Federal partners, plus State, Tribal and local governments, universities, and the private sector.

USGS NEHRP Activities

Carrying out its role within NEHRP, the USGS strives to deliver the data and information tools that engineering and design professionals, emergency managers, government officials and the public need to prevent earthquake hazards from becoming earthquake disasters. USGS activities supporting NEHRP are implemented through our Earthquake Hazards Program (EHP) and Global Seismographic Network (GSN) Programs. With its partners, the USGS provides rapid and authoritative information on earthquake size, location, shaking intensity, and potential impacts; develops regional and national hazard assessment maps and related products; supports

targeted research to improve our monitoring and assessment capabilities; and builds public awareness of earthquake hazards. In what follows, I discuss the current status of these activities.

Earthquake Monitoring - Delivering Rapid Information for Emergency Response. The USGS provides rapid reports of potentially damaging earthquakes to the White House; the Departments of Defense, Homeland Security (including FEMA), State, Transportation, Energy, Commerce, and the Interior; State, Tribal, and local emergency managers; numerous public and private infrastructure management centers (for example railroads and pipelines); the news media; and the public. Over 430,000 people in the United States and around the world have signed up to receive earthquake notifications via e-mail or text message. The suite of information tools available through the USGS Earthquake Hazards Program website receives tens of millions of hits in the wake of damaging earthquakes.

The USGS Advanced National Seismic System (ANSS) is the technical foundation that allows delivery of these products. The 2000 reauthorization of NEHRP established the ANSS to modernize and expand the Nation's seismic monitoring infrastructure in order to improve the delivery of earthquake information to those who need it most. The ANSS consists of a national backbone network, regional networks operated by State and university partners, the USGS National Earthquake Information Center (NEIC), and ground- and structure-based instruments concentrated in high-hazard urban areas. With funding appropriated by Congress since 2000, the USGS and its partners have installed more than 2,800 new and upgraded stations, out of a total of 7,100 targeted in the ANSS plan for full implementation of the system (USGS Circular 1188). The USGS also initiated 24/7 on-site operations at NEIC in 2006 and supports development of new information tools for enhanced situational awareness such as the ShakeCast, Prompt Assessment of Global Earthquakes for Response (PAGER), and Tweet Earthquake Dispatch (TED) systems (see *earthquake.usgs.gov* for details). These investments have greatly improved the information available for emergency responders, engineering performance studies, and long-term earthquake hazard assessments. A 2005 report by the National Research Council on the costs and benefits of improved seismic monitoring found that the benefits of fully deploying ANSS outweigh the costs many times over.

Substantial improvements in ANSS infrastructure were realized in 2010 and 2011 as a result of economic stimulus funding. The USGS allocated $19 million of the $140 million dollars it received under the American Recovery and Reinvestment Act (ARRA) to the modernization component of ANSS. Outdated equipment at hundreds of legacy seismic stations was replaced with modern digital equipment. Funds were also used to upgrade communications and processing software and to develop critical software components for the system as a whole. ARRA funding was allocated to 13 cooperating State and university partners that performed the station and network upgrades

Assessing the Nation's Earthquake Hazards. Earthquakes are a national challenge, with about 142 million people living in moderate- to high-hazard areas stretched across 42 States. Recent

earthquakes in Colorado, Oklahoma, and Virginia have underscored the national nature of earthquake risk. One of the most important achievements that NEHRP has made is the translation of research into national models of the location and expected severity of earthquake shaking within specified time periods. These models are used to generate maps that are incorporated into the seismic safety elements of building codes and for other purposes. Each major update of the maps is the culmination of a multi-year process to incorporate the best available science, including geologic information about faults, evidence of prehistoric earthquakes, instrumental and historical earthquake catalogs generated by seismic monitoring, and ground deformation measurements.

Earlier this month, the USGS released the latest update of the National Seismic Hazard Maps reflecting the current state of understanding. The release of the updated seismic hazard maps is coordinated with the consequent release of the next generation of model building codes and seismic safety standards, a process that involves close cooperation among the USGS, FEMA, the Building Seismic Safety Council, the American Society of Civil Engineers, the International Code Council, and other organizations. The 2014 maps have now been approved by the NEHRP Recommended Seismic Provisions Update Committee of the Building Seismic Safety Council, a major step towards incorporation into the International Building Code and International Residential Code, which is adopted in almost all States. The maps are also used by insurance companies to set rates for properties, by civil engineers to estimate the stability and landslide potential of hillsides, by the U.S. Environmental Protection Agency to set construction standards that ensure the safety of waste-disposal facilities, and by FEMA to plan the allocation of assistance funds for earthquake education and preparedness. The USGS also works closely with the U.S. Nuclear Regulatory Commission on seismic safety of nuclear power plants, including review of seismic hazard assessments in license applications.

Complementing the national maps, urban seismic hazard maps provide more detailed information on local site conditions for use in engineering and planning. Urban seismic hazard maps have been released for Memphis, Seattle, and Evansville (Indiana), and are near completion for the St. Louis area. Those maps show how forecasted earthquake shaking levels vary, at scales useful for urban planning, earthquake response planning, engineering guidance for major structures, and public education. Such maps require detailed mapping of surficial geology and knowledge of subsurface geology in order to incorporate the local effects into estimates of shaking. Developing these maps would not be possible without significant involvement of local and regional scientists, engineers, emergency managers, and the business community.

Targeted Research**.** USGS assessment and monitoring activities depend on targeted geoscience research. USGS internal research is augmented by external research supported by the USGS through grants to and cooperative agreements with universities, State geological surveys, and geotechnical consultants. Proposals for external work are submitted in response to an annual solicitation that identifies the scientific problems on which the USGS seeks assistance and progress. Each proposal undergoes a rigorous peer-review process. This targeted research is

funded on the basis of merit and provides a bridge from the NSF's investments in fundamental research in order to generate critical advances in understanding that underpin development of the national and urban seismic hazard maps and rapid earthquake response products. Ongoing collaboration with the academic community is one of the great strengths of the USGS with regard to earthquake research. Key examples are the jointly USGS-NSF supported Southern California Earthquake Center (SCEC) and our important partnership with the NSF's EarthScope facility.

Using Earthquake Outreach and Education to Better Prepare. The USGS works to make earthquake hazards understood through education and outreach products developed in concert with NEHRP, university, and local government partners, including the FEMA-supported regional earthquake consortia; the NSF-supported IRIS consortium; and the SCEC university and government consortium. Millions of copies of earthquake preparedness handbooks have been distributed in Alaska, California, Tennessee, Utah, and many other states. As part of an effort to reach non-English-speaking populations, both the southern California and Bay Area versions of *Putting Down Roots in Earthquake Country* have been translated into Spanish, and a shortened version of the Bay Area *Putting Down Roots* has been translated into a number of Asian languages and distributed through Asian-language newspapers. Additional versions of *Putting Down Roots* have been developed for Utah and Idaho, and a version for the Central United States was published for the bicentennial commemoration of the New Madrid sequence of earthquakes that struck the heartland in the winter of 1811-12.

This past October, nearly 25 million people participated in the United States and around the world in the sixth annual Great ShakeOut earthquake drills – a public participation exercise in earthquake awareness and safety. The first ShakeOut, in 2008, was based on a comprehensive, science-based earthquake scenario for the impacts of a major rupture of the southern section of the San Andreas Fault; this formed the basis for the Great Southern California ShakeOut, involving over 5 million people. Through the leadership of SCEC and many others, the ShakeOut approach has been adopted by all 50 U.S. States and several territories as well as several foreign countries, and annual ShakeOuts have led to a number of positive outcomes, including efforts to reduce lifeline vulnerability, retrofit critical structures, improve monitoring systems, and educate residents. More generally, scenarios have proven to be powerful tools for making earthquake hazards real to people ahead of a disaster. The USGS recently entered into a partnership with the City of Los Angeles to use the vulnerabilities identified in the ShakeOut scenario to guide the city's overall resilience efforts.

Post-earthquake coordination and investigations

Following major earthquakes in the United States and abroad, detailed scientific and engineering investigations are carried out in order to improve our knowledge of earthquake processes and impacts in order to hone the nation's earthquake resilience. The 2004 authorization of NEHRP (P.L. 108-360) tasks the USGS with responsibility for coordinating post-earthquake

investigations. The legislation required analysis by NSF and USGS of the causes of the earthquake and the nature of the resulting ground motion, analysis by NSF and NIST of the behavior of structures and lifelines, both damaged and undamaged, and analysis by each NEHRP agency of the effectiveness of the earthquake hazards mitigation programs and actions relating to its area of responsibility, and of how those programs and actions could be strengthened.

The USGS has carried out its post-earthquake coordination responsibility using the guidelines established in USGS Circular 1242, *The Plan to Coordinate NEHRP Post-Earthquake Investigations*, which was developed by the NEHRP agencies and other partners. Since 2010, the USGS has responded to and coordinated the national scientific and technical response for U.S. earthquakes in Arkansas, Colorado, Oklahoma, and Virginia as well as overseas in Chile, Haiti, Japan, Mexico, New Zealand, and Turkey.

The earthquakes that struck Haiti and Chile in 2010 and Japan in 2011 were some of the most devastating in recent history, and the shaking from the Virginia earthquake in 2011 was felt by more people than any previous earthquake in U.S. history. Each of these responses required immediate action by USGS staff, who were diverted from other work, often for weeks or months. Immediate demands included briefings for government officials and responses to the media. The USGS rapidly organized community-wide conference calls to coordinate the scientific and engineering response by Federal, State, university, and other institutional interests. All of the geospatial data collection was coordinated by the USGS. For each of the domestic earthquakes, the USGS deployed either portable seismometers to record aftershocks, or teams of geologists to conduct field studies, or both. For larger foreign earthquakes (Haiti, Chile, Japan, New Zealand), NEHRP agencies sent reconnaissance teams followed by more substantial deployments of USGS/USAID Earthquake Disaster Assistance Teams with portable seismometers and geologic expertise, as well as NSF-supported engineering teams, to determine the causes of building and ground failures.

Opportunities to further reduce earthquake losses in the United States

The Administration's 2015 budget requests $59 million for the USGS' two NEHRP Programs; this is slightly above the FY 2014 level. The proposed budget continues the initiatives that Congress supported in FY 2014: for the further development of an earthquake early warning system, for research on induced seismicity, and for improved ANSS products for situational awareness. The additional funding provided in FY 2014 and FY 2015 allows the USGS to build in these areas, particularly after facing budget reductions due to sequestration in FY 2013.

<u>Earthquake Early Warning: The next advance in public safety</u>

Modern seismic networks can, in favorable circumstances, provide seconds to a minute or more of warning before the onset of strong shaking, enabling Earthquake Early Warning (EEW). Over the past 11 years, the USGS has invested nearly $10 million in both research and development

toward establishing an earthquake early warning capability in California. Funds from the 2009 American Recovery and Reinvestment Act were used in 2010 and 2011 to support the modernization of seismic instrumentation necessary to support the generation of warnings. A test system is operating now; two of the university partners (CalTech and the University of California Berkeley) have been delivering warnings to a small group of test users since January 2011.

The current test system is still in the development phase, however, and considerable additional testing and equipment deployment is required to create a robust and reliable operational warning system. Further work is needed to demonstrate reliability, improve accuracy, establish products for public warning, and expand geographic coverage. The additional funding for EEW that was appropriated by Congress in FY 2014 is being used to complete the R&D phase for the seismic system (an effort that is jointly supported by the Gordon and Betty Moore Foundation) and to improve the operational robustness of the system. The next steps will require expanding coverage throughout California, Oregon, and Washington, integrating global positioning system (GPS) technology into the EEW system, and operating the system continuously on a 24x7 basis.

Induced Seismicity. Potentially damaging earthquakes can be triggered by disposal of waste fluids from oil and gas production operations by injection into deep underground wells. Smaller earthquakes can also be triggered by enhanced geothermal energy production operations and, potentially, by deep geologic carbon sequestration. Although the basic geophysical mechanisms are well known, the specific subsurface conditions that are conducive to triggering are not, and it is not yet possible to make site-specific hazard predictions in advance. Thus, there is a need for more data and research on induced seismicity, to understand how these events may depend on specific operational parameters and geologic conditions and to develop monitoring and mitigation plans for decision-makers attempting to minimize seismic risks.

With the support of Congress and the Administration, the USGS is now working with the Department of Energy and the Environmental Protection Agency to undertake this research and working with industry on case studies that will illuminate the physical factors controlling induced earthquakes. Top-priority efforts are to develop methods to forecast whether or not a particular type of injection operation in a specified geologic setting would be likely to induce or trigger earthquakes, to perform comprehensive studies at two field sites, and to establish procedures to adapt the National Seismic Hazard Maps to take account of the additional hazard due to earthquakes induced in association with wastewater from the production of oil and gas.

NEHRP's Global Reach

The Global Seismographic Network—a program involving the USGS, the National Science Foundation, and the Incorporated Research Institutions for Seismology, IRIS)—provides worldwide coverage for monitoring of earthquake and non-earthquake seismic activity, and supports basic and applied research in Earth science. GSN data are also critical to the NOAA

tsunami warning system (and the tsunami warning systems of other nations) and support research on nuclear explosion detection and treaty verification.

With support from Congress in 2005, and again in 2009 under ARRA, the USGS and NSF have made significant progress maintaining the GSN at a state-of-the-science level, expanding real-time communications throughout the 150-station network and upgrading and standardizing the computers and other components at each station site. Even so, many GSN stations are now more than 20 years old. In 2012, Congress provided additional funding to the Department of Energy (DOE) to replace aging and failed seismic sensors and, under an agreement with DOE, the USGS is currently procuring those new sensors. The USGS and DOE are exploring options to fund installation of the new equipment.

Conclusion

The Department strongly supports reauthorization of NEHRP. It has proven to be a successful partnership that continues to make valuable contributions to the Nation's resilience to earthquakes and other hazards.

Thank you, Chairman Bucshon, for the opportunity to provide the Subcommittee with the USGS views on NEHRP. I would be pleased to answer any questions the Subcommittee may have.

For More Information

The National Earthquake Hazards Reduction Program http://www.nehrp.gov/

Holzer, T.L., and others, 2003, The plan to coordinate NEHRP post-earthquake investigations: U.S. Geological Survey Circular 1242, 27 p. (http://pubs.er.usgs.gov/publication/cir1242)

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