



**Annual Report
of the
National Earthquake Hazards Reduction
Program
for Fiscal Year 2013**

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FEMA

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USGS
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This report about the National Earthquake Hazards Reduction Program (NEHRP) during fiscal year (FY) 2013 is submitted to Congress by the Interagency Coordinating Committee (ICC) of NEHRP, as required by the Earthquake Hazards Reduction Program Reauthorization Act of 2004 (42 U.S.C. 7701 *et seq.*, as amended by Public Law 108–360).

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Executive Summary

This is the annual report of the National Earthquake Hazards Reduction Program (NEHRP) for fiscal year (FY) 2013,¹ presented by the NEHRP Interagency Coordinating Committee (ICC). This report, required by Public Law 108–360, describes the FY 2013 activities of the NEHRP agencies, and their progress toward reducing the impacts of future earthquakes in the United States. The report also lists actual program budgets for FY 2014 and budgets for FY 2015 proposed by the Administration.

The four Federal agencies participating in NEHRP are the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), and the U.S. Geological Survey (USGS). NIST serves as the NEHRP lead agency and the Director of NIST chairs the ICC. Within NEHRP, the participating agencies have distinct roles and responsibilities that are mutually dependent and supportive.

The NEHRP ICC is composed of the Administrator of FEMA, the Directors of NIST, NSF, and USGS, and the Directors of the White House Office of Science and Technology Policy and Office of Management and Budget.

Worldwide, the FY 2013 was relatively quiet for earthquakes: several significant, damaging earthquakes caused only about a thousand deaths, as compared to the tens or hundreds of thousands of deaths in some recent years. Within the United States, only minor damage was reported from earthquakes in Oklahoma and California. However, the Nation continues to face high seismic risk in many of its cities, States, and Territories. A primary role of NEHRP is to provide leadership and resources for developing new, cost-effective measures to reduce the damage and disruption that earthquakes cause, and to advocate for their implementation. Some of the significant NEHRP activities of FY 2013 are outlined briefly below.

During FY 2013, NSF supported researchers at the University of Washington to conduct the "M9" project through its Hazards Science, Engineering, and Education for Sustainability (SEES) program that involves multiple Directorates and Offices. This project is addressing challenges in reducing risks associated with major earthquakes along the Cascadia subduction zone of the Pacific Northwest. The project assembles experts in earthquake hazard, warning and adaptive planning, and societal responses in a multidisciplinary effort to develop advanced probabilistic estimates of the hazards posed by major Cascadia earthquakes and subsequent landslides, liquefaction, tsunamis, and other secondary effects. The models will

¹ This report covers FY 2013 as defined by the Federal Government, a period that began on October 1, 2012, and ended on September 30, 2013.

be integrated into planning to improve community resilience, and will support the development of a prototype earthquake early warning (EEW) system in the western United States. Paralleling this effort, the USGS and its partners began testing a limited-capability EEW system in California, building upon prior investments in the Advanced National Seismic System (ANSS).

USGS continued to place significant research emphasis on understanding earthquakes caused by human activity – “induced seismicity.” The USGS has documented a significant increase in seismicity in the Central U.S.; much of it is likely associated with wastewater disposal from stimulated gas and oil production (secondary recovery). USGS and its partners have linked such wastewater disposal to moderate-size earthquakes in southern Colorado, Arkansas, Oklahoma, Texas, and Ohio. In FY 2013, USGS published a comprehensive review paper on the fluid injection triggering of earthquakes. In a related activity, the USGS began monitoring at a new, deep well carbon sequestration plant near Decatur, Illinois, in collaboration with the plant operator, the state of Illinois, and the Department of Energy.

The USGS and its partners completed a major update to earthquake probabilities in California, called the Uniform California Earthquake Rupture Forecast-3 (UCERF3). UCERF3 will be used in building codes, setting earthquake insurance rates, and other risk-mitigation efforts. USGS also completed a review and revision of the National Seismic Hazard Maps that are the basis for ground shaking levels used in building codes nationwide.

NSF supported researchers from the University of Texas at Austin and Brigham Young University, in collaboration with New Zealand researchers, to investigate cost-effective shallow ground improvement methods for mitigating damage to residential structures caused by soil liquefaction. The findings of this work are already being used in Christchurch, New Zealand, to remediate sites affected by earthquake shaking in calendar years 2010 and 2011. Complementing this work, NIST supported research that led to a comprehensive report on soil-structure interaction (the collective response to earthquake shaking of a structure, its foundation, and the soil underlying and surrounding the foundation). The report advances the state of knowledge about soil-structure interaction, and presents specific techniques that practicing engineers can use to model this interaction.

NIST also supported research to develop a report that provides a *Tentative Framework for Development of Advanced Seismic Design Criteria for New Buildings*. This work presents a conceptual framework to reformulate the seismic design parameters used in building codes so that they more reliably achieve uniform risk objectives in design. It is expected that this new framework will provide guidance for future research supported by NIST and NSF, and for FEMA efforts to promote the adoption and implementation of seismic safety elements in building codes.

FEMA refined and tested “Rapid Observation of Vulnerability and Estimation of Risk (ROVER),” a software system for mobile devices that automates two *de facto* international standards for building safety screening procedures. FEMA also conducted a variety of activities to support practical implementation of risk reduction measures, including revised procedures for developing and distributing relevant publications. More than 200,000 FEMA Building Science Branch publications were distributed to users of FEMA products nationwide. FEMA also developed training materials and provided training for approximately 5,000 constituents.

FEMA, NSF, and USGS again supported *ShakeOut* exercises, the world’s largest earthquake preparedness drill for schools, organizations, and homes. Almost 19 million people participated in *ShakeOut* activities worldwide, including participants from 42 States and U.S. Territories. New *ShakeOut* exercises were conducted in the Northeastern U.S., the Rocky Mountain region, American Samoa, and Hawaii.

Section 1

Introduction

The National Earthquake Hazards Reduction Program (NEHRP) is a multiagency program established by Congress “to reduce the risks of life and property from future earthquakes in the United States.”² The four Federal agencies participating in NEHRP are the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), and the U.S. Geological Survey (USGS). NIST serves as the lead agency for NEHRP.

NEHRP was initially authorized by Congress in 1978. Since then, Congress has periodically reauthorized the program, generally at two to five-year intervals. The latest reauthorization of NEHRP (Public Law 108–360, the Earthquake Hazards Reduction Program Reauthorization Act of 2004) authorized funding for the four participating agencies through fiscal year (FY) 2009. Pending the passage of new reauthorizing legislation, the NEHRP agencies continue to perform their duties as outlined in Public Law 108–360, within budget allocations that are less than the authorized funding levels for FY 2009.

Public Law 108–360 requires that the NEHRP Interagency Coordinating Committee (ICC), through which senior agency officials direct the program, submit an annual report to Congress on NEHRP budgets and activities. The ICC submits this annual report, covering FY 2013, pursuant to that requirement.

Previous NEHRP annual reports provide details on the organizational structure of NEHRP and agency roles and responsibilities. That information is available at www.nehrp.gov. This NEHRP annual report for FY 2013 provides information on NEHRP budgets, highlights of statutory program activities, State activities promoting implementation of research results, and related non-NEHRP activities that support NEHRP goals. This report and prior NEHRP annual reports are available at www.nehrp.gov/about/reports.htm.

The year 2013 was relatively quiet worldwide for significant, damaging earthquakes (see Section 5). Within the United States, only minor damage was reported from earthquakes in Oklahoma and California. However, the Nation continues to face high seismic risk in many of its cities, States, and Territories. About 142 million Americans in 42 States live in urban areas with moderate to high earthquake risk.³ A primary role of NEHRP is to provide stable

² The Earthquake Hazards Reduction Act of 1977 (Public Law 95-124, 42 U.S.C. 7701 *et seq.*), as amended by Public Laws 101-614, 105-47, 106-503, and 108-360.

³ Statement of Dr. David Applegate before the House Committee on Science, Space, and Technology, Subcommittee on Research and Technology regarding the National Earthquake Hazards Reduction Program, July 29, 2014.

and innovative leadership and adequate resources for the development of new, cost-effective measures to reduce the damage that earthquakes cause and to promote their implementation. Future earthquakes in the United States are inevitable. Thus the continued efforts of NEHRP are essential for the Nation to prepare for their eventual occurrence, to survive them safely, and to reduce their impacts on life, property, and economic and social systems. This work is needed to support the Nation's becoming an earthquake-resilient nation.

Section 2 Program Budgets

Public Law 108–360 requires that NEHRP annual reports include, for each agency participating in the program and for each program activity defined in the legislation, the budget for the current fiscal year (*i.e.*, the year following that covered in the report) and the proposed program budget for the next fiscal year. *The Strategic Plan for the National Earthquake Hazards Reduction Program, Fiscal Years 2009–2013*, published in October 2008 (www.nehrp.gov/pdf/strategic_plan_2008.pdf), defined three major goals for NEHRP that encompass all but one of the program activities defined in Public Law 108–360. The remaining activity, which concerns the development, operation, and maintenance of NEHRP facilities, was incorporated directly into the strategic plan. Table 2.1 shows the relationships between the congressionally defined program activities and the goals and activities that are included in the strategic plan.

TABLE 2.1—RELATIONSHIPS OF NEHRP STRATEGIC GOALS TO STATUTORY PROGRAM ACTIVITIES

NEHRP Strategic Goals	Statutory Program Activities*
Goal A: Improve understanding of earthquake processes and impacts.	Improve the understanding of earthquakes and their effects on communities, buildings, structures, and lifelines, through interdisciplinary research that involves engineering, natural sciences, and social, economic, and decision sciences.
Goal B: Develop cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society at large.	Develop effective measures for earthquake hazards reduction.
Goal C: Improve the earthquake resilience of communities nationwide.	Promote the adoption of earthquake hazards reduction measures by Federal, State, and local governments, and others.
Develop, operate, and maintain NEHRP facilities.	Develop, operate, and maintain ANSS, NEES, and the GSN.

* As defined by Congress in Public Law 108–360.

During FY 2013, NEHRP activities were impacted by reductions in spending authority imposed by sequestration of Federal funds. The USGS has a specific appropriation line item covering NEHRP activities. Sequestration led directly to a reduction of \$3.4 million in FY 2013, compared to FY 2012, for USGS NEHRP work. Other NEHRP agencies (FEMA, NIST, and NSF) provide allocations for NEHRP work from their total spending authorities, rather than having specific NEHRP line items. They addressed sequestration reductions during their internal considerations of budget allocations for NEHRP activities.

Program budgets for FY 2014 are presented in Table 2.2, which shows the funding that each participating agency is directing to accomplish the goals and objectives specified in the strategic plan. Table 2.3 identifies the agency funding requested or anticipated for NEHRP in FY 2015. Funding for the development, operation, and maintenance of NEHRP facilities supports the Advanced National Seismic System (ANSS) and the Global Seismographic Network (GSN). Funding for the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), previously reported as a NEHRP facility, is now included in the NSF budget under Goal A.

2.1 NEHRP Enacted FY 2014 Budgets by Strategic Goal

Table 2.2 lists the FY 2014 NEHRP budgets, by strategic goal, for the NEHRP agencies: Federal Emergency Management Agency (FEMA), National Institute of Standards and Technology (NIST), National Science Foundation (NSF), and U.S. Geological Survey (USGS).

TABLE 2.2—NEHRP AGENCY BUDGETS FOR FY 2014

Strategic Goal	FY 2014 Funds Allocated to Goal (\$M) ¹				
	FEMA ²	NIST ³	NSF ⁴	USGS ⁵	Total
Goal A: Improve understanding of earthquake processes and impacts.	0.1	0.3	47.5	11.2	59.1
Goal B: Develop cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society at large.	3.8	2.7		18.9	25.4
Goal C: Improve the earthquake resilience of communities nationwide.	3.9	0.9		15.4	20.2
Develop, operate, and maintain NEHRP facilities:					
ANSS—USGS				8.3	8.3
GSN—NSF and USGS			3.5	4.9	8.4
Total:	7.8	3.9	51.0	58.7	121.4

Notes on Table 2.2:

¹ Budgets are rounded to the nearest \$0.1 million.

² The FEMA FY 2014 budget is an allocation from the U.S. Department of Homeland Security (DHS) appropriation that covers NEHRP activities but excludes employee salaries and expenses (S&E).

³ The NIST FY 2014 budget is an allocation from the NIST appropriation that covers all NEHRP-related activities, including the NEHRP Lead Agency role and Earthquake Risk Reduction R&D activities.

⁴ The NSF FY 2014 budget is an allocation from the NSF appropriation that covers NEHRP activities but excludes Agency Operations and Award Management (AOAM). The NSF budget includes support for the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES).

⁵ The USGS FY 2014 budget is a line item in the USGS appropriation that covers NEHRP activities. The amount reported for ANSS in the table is the information technology cost (only).

2.2 NEHRP FY 2015 Budget Requests by Strategic Goal

Table 2.3 lists the FY 2015 NEHRP planning budgets for each agency by strategic goal. These figures are based on agency submissions included in the President’s FY 2015 budget request to Congress.

TABLE 2.3—NEHRP AGENCY BUDGET REQUESTS FOR FY 2015

Strategic Goal	FY 2015 Funds Requested or Anticipated for NEHRP Goals (\$M) ¹				
	FEMA ²	NIST ³	NSF ⁴	USGS ⁵	Total
Goal A: Improve understanding of earthquake processes and impacts.	0.1	0.3	48.7	11.3	60.4
Goal B: Develop cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society at large.	3.8	3.0		19.0	25.8
Goal C: Improve the earthquake resilience of communities nationwide.	3.9	0.6		15.5	20.0
Develop, operate, and maintain NEHRP facilities:					
ANSS—USGS				8.3	8.3
GSN—NSF and USGS			3.5	4.9	8.4
Total:	7.8	3.9	52.2	59.0	122.9

Notes on Table 2.3:

¹ Budgets are rounded to the nearest \$0.1 million.

² The FEMA FY 2015 budget is a planned allocation from the U.S. Department of Homeland Security (DHS) appropriation that covers NEHRP activities but excludes employee salaries and expenses (S&E).

³ The NIST FY 2015 budget is a planned allocation from the NIST appropriation that covers all NEHRP-related activities, including the NEHRP Lead Agency role and Earthquake Risk Reduction R&D activities.

⁴ The NSF FY 2015 budget is a planned allocation from the NSF appropriation that covers NEHRP activities but excludes Agency Operations and Award Management (AOAM). The NSF budget includes support for the earthquake engineering research infrastructure and activities that will form the successor to the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) infrastructure as part of the Natural Hazards Engineering Research Infrastructure to be supported in FY 2015.

⁵ The USGS FY 2015 budget is a line item in the USGS appropriation that covers NEHRP activities. The amount reported for ANSS in the table is the information technology cost (only).

Section 3

Statutory Program Highlights

This section briefly summarizes major activity highlights and accomplishments of the NEHRP during FY 2013. The organization of this chapter follows that of the NEHRP strategic plan. The strategic plan defines NEHRP in terms of broad strategic goals and more specific objectives and related strategic priorities. The goals are directly linked to the NEHRP activities defined in Public Law 108–360, Section 103(2). By following the structure of the strategic plan, this report allows the reader to directly assess how accomplishments are furthering progress toward the program’s stated goals and objectives. Accomplishments are not categorized by NEHRP agency but, rather, are cast in terms of collective progress toward NEHRP goals.

3.1 Goal A: Improve Understanding of Earthquake Processes and Impacts

Understanding how and why earthquakes occur and what happens to our communities when they do is an essential step in building the knowledge required to reduce the consequences of future earthquakes. For this reason, NEHRP supports basic research related to earthquakes in geoscience, engineering, and social science. The research supported and undertaken under Goal A provides a strong foundation for the development and implementation of practical earthquake risk-reduction measures pursued under the other strategic goals.

Strategic Goal A is directly related to the congressionally-defined NEHRP program activity, “Improve the understanding of earthquakes and their effects on communities, buildings, structures, and lifelines through interdisciplinary research that involves engineering, natural sciences, and social, economic, and decisions sciences.”⁴ Strategic Goal A activities include advancing understanding of earthquake phenomena and generation processes, earthquake effects on the built environment, and the social, behavioral, and economic factors linked to implementing risk reduction and mitigation strategies in both the public and private sectors. Strategic Goal A also covers efforts to improve post-earthquake information acquisition and management.

In 2013, the NEHRP agencies supported a variety of work to improve the fundamental understanding of earthquakes and their impacts. Representative accomplishments and activities under this goal are presented below.

⁴ See footnote 2.

Induced seismicity

Significant research emphasis was placed on understanding induced seismicity—earthquakes caused by the actions of man. Beginning in FY 2008, the USGS has documented a significant increase in seismicity in the Central U.S.; much of it is likely associated with wastewater disposal from stimulated gas and oil production (secondary recovery). For example, hydraulic fracture well treatments may generate large volumes of wastewater that are inappropriate for surface disposal. A commonly used disposal practice involves pumping waste fluids into deep wells at high pressures. USGS and its partners have linked this type of wastewater disposal to moderate-size earthquakes in southern Colorado, Arkansas, Oklahoma, Texas, and Ohio. In FY 2013, the USGS published a comprehensive review paper⁵ on the fluid injection triggering of earthquakes, and also began monitoring at a new deep well carbon sequestration plant in Decatur, Illinois, in cooperation with the plant operator, the state of Illinois, and the Department of Energy.

Safer steel frame buildings

An NSF-supported research project, led by the University of Washington, in combination with other test data, has been used to develop a new design procedure that makes concentrically braced frames easier to construct and safer in earthquakes. Although these braced frames are commonly used in U.S. construction, there are almost no tests of such systems. In addition, current designs of braced frames are complicated and sometimes difficult to construct. This project completed a comprehensive series of experiments and nonlinear analyses on more than 40 large-scale braced frame systems. Tests were performed at the University of Washington, University of Minnesota, University of California at Berkeley, and the National Center for Research in Earthquake Engineering in Taiwan. The frames were designed and built with a wide range of design parameters, and were then tested through their entire range of system performance up to and including ultimate system failure. Nonlinear analyses were performed on all specimens to enhance the understanding obtained from the experiments and to extend the knowledge to a broader range of braced frame systems. This research has resulted in the development of new and improved seismic design procedures for concentrically braced frames. This will reduce the material required for building such structures while significantly improving their seismic performance and inelastic deformation capacity.

Earthquake safety in the Pacific Northwest

In FY 2013, an NSF-supported research project at the University of Washington began the "M9" project that is addressing challenges in reducing risks associated with major earthquakes along the Cascadia subduction zone of the Pacific Northwest. This project is supported through the Hazards Science, Engineering, and Education for Sustainability (SEES) program that engages multiple Directorates and Offices at NSF. Historically, the

⁵ Ellsworth, William L. "Injection-Induced Earthquakes," *Science*, Vol 341, pp 1225942, July 12 2013.

Cascadia subduction zone has experienced earthquakes comparable to the 2011 Tohoku, Japan, earthquake. This project assembles experts in earthquake hazard, warning, and adaptive planning, and societal responses in a multidisciplinary effort to develop advanced probabilistic estimates of the hazards posed by major Cascadia earthquakes and subsequent landslides, liquefaction, tsunami, and other secondary effects. Models developed through Hazards SEES will later be integrated into planning to improve community resilience. The project also builds on ongoing work to develop a prototype earthquake early warning system (EEW) in the western United States (see later discussion under Goal C, Section 3.3).

3.2 Goal B: Develop Cost-Effective Measures to Reduce Earthquake Impacts on Individuals, the Built Environment, and Society at Large

NEHRP activities under Goal B are designed to develop practical and cost-effective methods and measures for earthquake risk assessment and mitigation that build upon the research results obtained under Goal A. Goal B is directly linked to the congressionally-defined NEHRP program activity, “Develop effective measures for earthquake hazards reduction.”⁶ Goal B includes activities by the NEHRP agencies to assess earthquake hazards for research and practical application, and to develop tools for advanced loss estimation and risk assessment, improved seismic performance of buildings and other structures, and improved seismic performance of critical infrastructure. Selected accomplishments of the NEHRP agencies that relate to developing resources to assess and reduce risk are presented below.

National hazard assessment revision

USGS completed review and revision of the National Seismic Hazard Maps. This represents a significant effort that is conducted on a six-year cycle. These maps, which are the basis for building codes nationwide, will be submitted to the Building Seismic Safety Council (BSSC) for consideration in FEMA-supported efforts to provide the next generation of recommended seismic design provisions in U.S. model building codes.

California hazard assessment

Because California has special hazard assessment needs for insurance and other purposes, a separate, detailed study is performed for that state. In FY 2013, the USGS and its partners completed a major update to earthquake probabilities in California, called the *Uniform California Earthquake Rupture Forecast-3* (UCERF3). This new forecast model for California provides significant improvement by acknowledging a wider range of possible earthquakes, including ruptures that can jump or migrate from one fault to another. UCERF3 also embodies several other innovations, including a more thorough use of global positioning system (GPS) data in determining earthquake occurrence rates. UCERF3 will be used in building codes, in setting earthquake insurance rates, and in other risk mitigation efforts.

⁶ See footnote 2.

The results of UCERF3 are compatible with and were incorporated in the national assessment cited above.

Soil failure during earthquakes

NSF-supported research conducted by the University of Texas at Austin and Brigham Young University, in collaboration with researchers from New Zealand, identified cost-effective shallow ground improvement methods for mitigating damage to residential structures caused by soil liquefaction (*i.e.*, when soils lose strength and turn into viscous fluids during earthquakes). This research tested several different potential methods to limit soil liquefaction in locations with differing ground conditions. The findings of this work are already being used in Christchurch, New Zealand to remediate land at many sites affected by earthquake shaking in calendar years 2010 and 2011 and to construct new homes and larger structures in areas of potential earthquake damage.

Soil-structure interaction

NIST supported the NEHRP Consultants Joint Venture (NCJV), a partnership of the Applied Technology Council (ATC) and the Consortium of Universities for Research in Earthquake Engineering (CUREE), which completed a number of reports evaluating significant issues that affect earthquake-resistant design of structures. One such report was *Soil-Structure Interaction for Building Structures* (NIST GCR 12-917-21). Soil-structure interaction (SSI) analysis evaluates the collective response to earthquake shaking of three linked systems: a structure, its foundation, and the soil underlying and surrounding the foundation. Practicing engineers often have a poor understanding of SSI issues, and technical literature and building codes and standards have been confusing or provide limited guidance. This report advances the state of knowledge about SSI, and presents specific SSI modeling techniques for practicing engineers.

Advanced earthquake-resistant building design criteria

Again supported by NIST, NCJV completed another report, *Tentative Framework for Development of Advanced Seismic Design Criteria for New Buildings* (NIST GCR 12-917-20). Previous work has indicated that the current formulation of seismic design parameters used in building codes do not fully address the potential variation in collapse performance of buildings due to differences in building intrinsic vibrational response, inelastic response capacity, and seismic design loading. This report presents a conceptual framework to reformulate these seismic design parameters so that they more reliably achieve uniform risk objectives in design. The framework can serve to guide future research supported by NIST and NSF, as well as FEMA-supported implementation activities.

Rapid screening of buildings for earthquake safety

FEMA refined its *Rapid Observation of Vulnerability and Estimation of Risk* (ROVER) analysis package, free software for mobile devices that automates two *de facto* international standards for building safety screening procedures. This software was successfully tested in trial

projects in Salt Lake City by the Utah Seismic Safety Commission and the Structural Engineers Association of Utah, and in Los Angeles by the Los Angeles Unified School District.

3.3 Goal C: Improve the Earthquake Resilience of Communities Nationwide

Through activities supported under Goal C, NEHRP agencies work to apply research results developed under Goal A and risk-reduction methodologies developed under Goal B to practical measures that will increase public safety and reduce losses in future earthquakes. Work under this goal includes the monitoring and reporting of seismic activity worldwide. Goal C is directly related to the congressionally-defined NEHRP program activity, “Promote the adoption of earthquake hazards reduction measures by Federal, State, and local governments, national standards and model code organizations, architects and engineers, building owners, and others with a role in planning and constructing buildings, structures, and lifelines.”⁷

Goal C includes numerous NEHRP-wide activities to improve the accuracy, timeliness, and content of earthquake information products; to develop comprehensive earthquake risk scenarios and risk assessments; to support development of seismic standards and building codes and advocate their adoption and enforcement; to promote the implementation of earthquake-resilient measures in professional practice and in private and public policies; to increase public awareness of earthquake hazards and risks; and to develop the nation’s human resource base in earthquake safety fields. Some representative accomplishments are described below.

Information dissemination and training

FEMA conducted a variety of activities to support practical implementation of risk reduction measures, including developing and distributing publications. More than 200,000 FEMA Building Science Branch publications were distributed to FEMA customers nationwide, including homeowners, businesses, schools, non-profit groups, governmental and non-governmental organizations, engineering and design professionals, and building code officials. FEMA also worked to develop training materials and provide training. FEMA completed FEMA P-752CD, *2009 NEHRP Recommended Seismic Provisions: Training Materials* and FEMA P-940CD, *Multi-Hazard Mitigation and Design Concepts: Wind, Flood, and Earthquake Training Videos*. FEMA conducted, hosted, or sponsored training sessions that reached approximately 5,000 constituents.

⁷ See footnote 2.

Adoption of building codes with seismic safety elements

FEMA conducted numerous activities to monitor building code adoption and ensure that building code standards reflect the best technical knowledge, including promoting updates to the next edition of the *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures* and the *International Residential Code*. FEMA also determined that 57 percent of the jurisdictions in hazard-prone regions (earthquake, wind, and flood) adopted disaster-resistant building codes equivalent to the International Codes, up from 55 percent in 2012.

Technical publications for practicing engineers

Complementing NSF-supported research on Concentric Braced Frames (CBF's) described under Goal A, NIST released another volume in its series of “techbriefs,” which are concise publications designed to help transfer research results into practice: *Seismic Design of Steel Special Concentrically Braced Frame Systems: A Guide for Practicing Engineers* (NIST GCR 13-917-24). Techbriefs target practicing engineers, to help them assimilate the technical literature on engineering advances that is often voluminous and difficult to examine or evaluate.

Seismic safety for container ports

Many large U.S. container ports are located in areas of significant seismic hazard, and seismic risk management practices at these facilities have not kept pace with the growing importance of container ports to the nation's economy. With support from NIST, the NCJV completed a *Program Plan for the Development of Seismic Design Guidelines for Port Container, Wharf, and Cargo Systems* (NIST GCR 12-917-19). This report outlines a multi-phase program for the development of nationally-accepted guidelines for seismic performance improvement of container cargo systems including cranes, wharves, and container storage yards.

Public earthquake safety exercises

FEMA, NSF, and USGS again supported *ShakeOut*, the world's largest earthquake preparedness drill for schools, organizations, and homes. Almost 19 million people participated in *ShakeOut* activities worldwide, including participants from 42 States and Territories. New *ShakeOut* exercises were conducted in the Northeastern U.S., the Rocky Mountain region, American Samoa, and Hawaii. NEHRP provides direct financial support to States and Territories for *ShakeOut* websites, templates, drill guides, registration support, and for technical planning assistance. All *ShakeOut* exercises benefit from the direct involvement of the staff of the NEHRP agencies.

Building the future professional base

Since 1996, three NSF awards have supported partnering senior researchers with promising young faculty working in the areas of hazards, disasters, and risk research. Senior researchers mentor junior faculty and provide technical training and professional development to build their research skills and foster a broad understanding of emerging issues in disaster research. The project, called *Enabling New Leaders in Disaster Research*, has drawn researchers from other fields to disaster research, enhancing the community's depth

and enabling multidisciplinary collaborations, leading to innovative solutions. This has enabled transformative research on topics such as homeland security, enhanced emergency response, emergency medical services, protecting power and other lifelines, community resilience, and frameworks to reduce losses and speed recovery in vulnerable areas, with almost 600 peer reviewed articles having been produced.

NSF also supports a number of Research Experiences for Undergraduates (REU) programs focused on earthquake issues, including programs through NEES Operations at Purdue University, and at the Pacific Earthquake Engineering Research Center, based at UC Berkeley.

Earthquake early warning

In January 2012, the USGS and its partners began testing a limited-capability earthquake early warning (EEW) system in California that builds upon prior USGS investments in the Advanced National Seismic System (ANSS). Because earthquake shaking travels much more slowly than electronic signals, it is technically possible to broadcast warnings after an earthquake has occurred but before strong shaking arrives in communities that will be affected. The goal of EEW is to warn residents and operational entities in populated areas of imminent strong ground shaking immediately after a large earthquake has occurred nearby. The prototype early warning system in California now has more than 75 users receiving alerts. One user, the San Francisco Bay Area Rapid Transit District (BART), is applying the system to slow and stop trains automatically if damaging ground shaking is detected. Related research and development efforts, supported by grants from the Gordon and Betty Moore Foundation, will be completed by the end of calendar year 2015. The EEW research and testing is beginning to attract significant interest. As one example, in FY 2013, the Governor of California signed into law California Senate Bill 135. This legislation directs the California Governor's Office of Emergency Services (Cal OES), in collaboration with the USGS, the California Integrated Seismic Network, other State agencies, and private partners, to "develop a comprehensive statewide earthquake early warning system in California."

3.4 NEHRP Statutory Activity: Program Leadership

There are several statutory NEHRP program management, coordination, and oversight functions. In FY 2013, the Advisory Committee on Earthquake Hazards Reduction (ACEHR)⁸ met twice, including one teleconference, and the working-level Program Coordination Working Group (PCWG) met seven times, including two teleconferences. The Interagency Coordinating Committee (ICC)⁹ did not meet in FY 2013.

⁸ ACEHR is composed of 16 nationally recognized, leading earthquake professionals who are not Federal employees and who are appointed to 3-year terms of service.

⁹ The ICC is composed of the Directors/Administrators of the four NEHRP agencies and the Directors of the Office of Management and Budget and the Office of Science and Technology Policy of the Executive Office of the President.

Responses to ACEHR recommendations

The ACEHR provided several observations and recommendations regarding NEHRP activities to the ICC in FY 2013. The full text of the recommendations and corresponding NEHRP agency responses are available on the NEHRP website.¹⁰

NEHRP Secretariat Operations

The NIST NEHRP Secretariat continued to provide support and leadership for program coordination. The office organized and conducted the ACEHR and PCWG meetings and maintained the NEHRP website (www.nehrp.gov). This website provides information on NEHRP management efforts and products, as well as links to the four program agencies where further information on earthquake research results, current seismic activity, seismic hazard and risk, and earthquake mitigation practices can be found.

3.5 NEHRP Statutory Activity: Develop, Operate, and Maintain NEHRP Facilities

Public Law 108–360 requires that NEHRP “develop, operate, and maintain” certain facilities essential to the NEHRP mission. These facilities are the Advanced National Seismic System (ANSS), maintained and operated by USGS; the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), maintained and operated by NSF; and the Global Seismographic Network (GSN), maintained and operated cooperatively by USGS and NSF. Below are reports on the FY 2013 activities and status of these facilities.

Advanced National Seismic System

The Advanced National Seismic System (ANSS) is an effort led by the USGS to support, coordinate, and modernize earthquake monitoring nationwide. The ANSS consists of USGS national-level monitoring and data analysis facilities, and several regional monitoring facilities supported by universities, States, and the USGS.

In FY 2013, the ANSS completed several earthquake information content and delivery improvements. These included development of improved, mobile-friendly web pages, a new earthquake archive catalog, a new atlas of observed earthquake shaking (covering the period 1973-2011), and an operational system for the rapid estimation of the characteristics of geologic faulting that has caused earthquakes.

The ANSS also completed installation of advanced structural monitoring systems in 24 Department of Veterans Affairs hospitals in seismically active areas. These systems will

¹⁰ See <http://www.nehrp.gov/pdf/2013ACEHRReportFinal.pdf> and <http://www.nehrp.gov/pdf/Agency%20Responses%20to%202013%20ACEHR%20Recommendations%20081414.pdf>.

allow determination of the structural integrity and safety of these hospitals immediately following an earthquake and provide valuable information on the responses of buildings to earthquake shaking.

Global Seismographic Network

The Global Seismographic Network (GSN) provides high-quality seismic data to support earthquake alerts, tsunami warnings, hazard assessments, national security (through nuclear test treaty monitoring), earthquake loss reduction, and research on earthquake sources and the structure and dynamics of the Earth.

By the end of FY 2013, 90% of the planned equipment upgrades of the entire GSN were completed; the remaining upgrades are planned for FY 2014. The upgrades have improved station reliability and improved data return from all of the GSN stations from 71.9% in FY 2005 to 89.9% in FY 2012. This effort included initiating the upgrade of ten seismic recording stations in the China Digital Seismographic Network, a part of the GSN, thus marking 33 years of cooperation between the USGS and the China Earthquake Administration.

The USGS developed and implemented new software to automatically assess the quality of GSN data, allowing staff at the Albuquerque Seismological Laboratory to identify, diagnose and fix station performance problems quickly. This has resulted in unprecedented data quality and availability for the USGS-operated stations of the network.

George E. Brown, Jr. Network for Earthquake Engineering Simulation

The George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES) is a network of state-of-the-art laboratories and testing facilities, linked by a shared cyberinfrastructure, for research in earthquake and tsunami engineering. NEES consists of a managing headquarters (known as *NEEScomm*) located at Purdue University; 14 state-of-the-art earthquake engineering experimental facilities located at and locally operated by universities across the U.S.; the *NEEShub* cyberinfrastructure framework; and the NEES Academy for education, outreach, and informal science education. NEES experimental facilities and other infrastructure have enabled more than 100 projects over ten years of operation testing various aspects of earthquake and tsunami risk.

NEEScomm organizes NEES annual meetings that bring together NSF-supported researchers who use the NEES infrastructure and NEES operations team members to share research findings, information about NEES experimental and cyberinfrastructure resources, and effective methods for education and outreach in earthquake engineering. The 2013 annual meeting, Quake Summit 2013, was held August 7-8, 2013, at the University of Nevada, Reno.

An example of FY 2013 NEES informal science education efforts is the Howard University Ambassadors Program, which engaged a diverse group of engineering students to work with underrepresented K–12 students in the Washington, D.C. area. This activity allowed students to build model structures and test how they would perform in a tsunami using a 16-foot mini-wave flume. The activity stimulated interest in engineering among participating children and generated interest in undergraduate research related to tsunamis among participating ambassadors.

NEES will complete its 10 years of NSF funding at the end of FY 2014. Through an FY 2013 program solicitation it issued, NSF re-competed NEES as an integrated research infrastructure with a managing headquarters, cyber-infrastructure, reduced number of experimental facilities, and education and outreach activities, referred to as “NEES2,” for 2015 through 2019. No award was made following this competition. NSF now plans to issue a new solicitation for supporting state-of-the-art laboratories and testing facilities, linked by a shared cyber-infrastructure that covers multiple hazards.

Section 4

State and Territory Activities to Promote Implementation of Research Results and Hazard Mitigation Efforts

The NEHRP Reauthorization Act of 2004 (Public Law 108–360) directed FEMA to operate a program of direct assistance to States to accomplish various relevant earthquake safety and mitigation activities.

FEMA created the NEHRP Earthquake State Assistance Program to increase and enhance the effective implementation of earthquake risk reduction at the local level. Under this program, FEMA awards cooperative agreements to States and Territories with moderate to high seismic risks to fund eligible earthquake safety and risk-reduction (mitigation) activities at the State or local levels.¹¹ Eligible risk-reduction activities include developing seismic mitigation plans; preparing inventories and conducting seismic safety inspections of critical structures and lifelines; updating building codes, zoning codes, and ordinances to enhance seismic safety; increasing earthquake awareness and education; and developing local consortia for earthquake risk reduction.

FEMA continues to work in close partnership via cooperative agreements with the States and organizations such as the Earthquake Engineering Research Institute (EERI), the Federal Alliance for Safe Homes (FLASH), the Southern California Earthquake Center (SCEC) and the four regional earthquake consortia: the Northeast States Emergency Consortium (NESEC), the Central U.S. Earthquake Consortium (CUSEC), the Western States Seismic Policy Council (WSSPC), and the Cascadia Region Workgroup (CREW). The regional consortia are long-time partners of FEMA and play an invaluable role in coordinating multi-State response and recovery planning and in public awareness, education, and outreach. The regional consortia are also very active partners in the *ShakeOut* earthquake drills that take place in schools, businesses, and homes across the United States. An important focus of these cooperative agreements in FY 2013 was support to the States. FEMA is collaborating and coordinating with these grantees to ensure substantial involvement and mutual partnership in executing local and regional risk reduction outreach and implementation activities for earthquakes and other hazards. This includes earthquake mitigation planning, property inventory and seismic inspection of critical facilities, updating building codes and zoning ordinances, earthquake outreach and education, and the development of multi-State groups in support of local earthquake and other multi-hazard initiatives.

¹¹ The USGS also provides assistance funds to States for NEHRP-related earthquake hazard research and monitoring. Details on that activity are available at: <http://earthquake.usgs.gov/research/external/>.

In FY 2013, FEMA awarded more than \$1.2 million to eligible States and Territories to support the effective implementation of earthquake risk reduction activities. Brief highlights of successful State, territorial, and local government efforts are presented below. More complete information is available in FEMA's annual report, *The FEMA National Earthquake Hazards Reduction Program Accomplishments in Fiscal Year 2013*.¹²

Alabama

Alabama conducted a HAZUS¹³ analysis of potential damage from large earthquakes associated with the Southern Appalachian Seismic Zone. This analysis considered seismic amplification, liquefaction, and landslide susceptibility, using information developed with FEMA funding from previous years. Alabama also conducted additional HAZUS analyses of the effects on northern Alabama from a potential earthquake in the East Tennessee Seismic Zone.

Alabama continues planning for earthquake education outreach through public schools. Newsletters were sent to the superintendents of K-12 schools with information to develop earthquake awareness and to incorporate earthquake drills into their preparedness. In addition, Alabama continued planning and preparing for the New Madrid CAPSTONE-14¹⁴ earthquake exercise.

Alaska

Continuing the state's efforts to assess and mitigate seismic risks of school buildings, Alaska funded a seismic hazard safety assessment and retrofit plan for Kenai Peninsula Borough and Matanuska-Susitna Borough School Districts. These districts will serve as models for earthquake risk assessment and mitigation for other school districts in Alaska.

Alaska also worked to develop, plan, and implement an earthquake and tsunami outreach campaign, culminating and extending beyond the 50th Anniversary of the Good Friday Earthquake (1964) in FY 2014. As part of the campaign, the Alaska Division of Homeland Security Preparedness and Planning Teams developed new awareness tools that were demonstrated at different venues throughout Alaska.

American Samoa

There was island-wide participation in the first Great American Samoa *ShakeOut*, with a focus on schools and government offices. Activities prior to *ShakeOut* events included distributing posters and drill manuals and conducting presentations about earthquakes.

¹² See <http://www.fema.gov/media-library-data/1397678479200-9784078b993ca25a9deb13b7eb8d9393/NEHRP%20Report%20FY%202013.pdf>.

¹³ A software tool for analysis and assessment of risk from earthquakes and other hazards.

¹⁴ See <http://www.cusec.org/plans-a-programs/capstone14/173>.

“Drop, Cover, Hold On” signs, posters, and radio and newspaper advertisements were prominent throughout the year.

Arizona

More than 116,000 Arizonans participated in the Great Arizona *ShakeOut*, an 86 percent increase in participation from 2012. Arizona built a new promotional campaign using *ShakeOut* “superhero kids” to engage and excite the K-12 community. This campaign, coupled with aggressive recruiting of schools, resulted in more than 84,000 K-12 students and faculty participating in *ShakeOut* 2013.

Arizona continued the successful AZ Shakes program, which is an outreach vehicle to deliver information on earthquake activity. Products developed include an “Arizona is Earthquake Country” safety guide and brochures for three counties with the State’s greatest seismic risk.

Arkansas

In FY 2013, Arkansas continued to promote earthquake loss reduction practices and policies through mitigation, sponsorship of earthquake awareness and preparedness programs, and the development of better response and recovery capabilities. The State is working with the Arkansas State University Science, Technology, Engineering, and Math (STEM) program to provide earthquake models for a “suitcase” program that provides teachers with a suitcase of teaching aids for K-12 classrooms.

California

NEHRP funding helped to support the Earthquake Country Alliance (a public-private partnership promoting earthquake safety) through leadership workshops and steering committee meetings, all of which provide opportunities for collaboration in setting earthquake policy for California.

More than 9.6 million people participated in the Great California *ShakeOut*. California worked to fully establish *ShakeOut* social media, engage partner agencies, and increase recruitment support and event participation statewide, and to set the stage for increased national and international participation.

California continued its California Vital Infrastructure Vulnerability Assessment (Cal VIVA) project, which identifies, evaluates, and develops basic retrofit actions for seismically vulnerable State buildings that are essential to post-earthquake response and recovery efforts. The most recent and second phase of the project, Cal VIVA II, has expanded the number of assessments of buildings.

Colorado

Colorado conducted a statewide hazard analysis by county and supported local hazard mitigation planning. Colorado also participated in the first 2013 Rocky Mountain *ShakeOut*. The *ShakeOut* was supported by the Colorado Earthquake Hazard Mitigation Council.

Guam

The Guam Earthquake Program worked to adopt and promote seismic mitigation through activities such as updating building codes, zoning codes, and ordinances to enhance seismic safety. The Great Guam *ShakeOut* was promoted by a comprehensive outreach campaign that included the production and distribution of seismic mitigation materials, including flyers, posters, TV advertisements, and radio public service announcements. More than 67,000 people participated in the Great Guam *ShakeOut*.

Hawaii

The Hawaii State Earthquake Advisory Committee assisted State efforts to mitigate the impact of seismic events by reviewing and updating the seismic portions of the State and county mitigation plans and building and zoning codes. Hawaii's public outreach program addressed earthquake risks by developing and disseminating outreach tools. These efforts included providing hazards awareness training to Hawaii's school teachers to enhance their natural sciences curriculum. Hawaii promoted a *ShakeOut* exercise that included 16,000 participants.

Idaho

Idaho provided earthquake-related training in seven school districts with 140 buildings. In addition, 2013 was the third year of Idaho's participation in a *ShakeOut* exercise. The State developed a new version of the publication, "Putting Down Roots in Earthquake Country," a handbook for household earthquake safety.

Illinois

Illinois participated in two *ShakeOut* drills during 2013. Before each drill, the State encouraged participation through a combination of mailings, personal contacts, websites and social media, print and radio ads, and media events. Registrants numbered over 500,000 for each event.

ATC-20¹⁵ courses were held in Chicago, Glenview, and O'Fallon. Architectural, engineering, and building inspection professionals from State government and the private sector continued to develop a framework for training, equipping, and deploying post-disaster safety inspection teams; Illinois has assembled supplies to equip 15 teams. Teams trained under this program were deployed twice in FY 2013 for flooding and tornado disasters, thereby testing

¹⁵ *Procedures for Postearthquake Safety Evaluation of Buildings*, ATC-20, Applied Technology Council, 1989.

their deployment procedures before an earthquake event. Illinois also worked on CAPSTONE-14 planning activities.

Indiana

Indiana participated in CAPSTONE-14 planning conferences, workshops, and meetings, and worked with the Indiana Building Emergency Assessment and Monitoring Team, an organization of volunteer professionals trained for post-disaster safety inspections of buildings, to train for response to future events. In addition, the State worked with the Polis Center at Indiana University-Purdue University Indianapolis (IUPUI) on the Indiana Earthquake Assessment to be used in the State Mitigation Plan.

Kentucky

Activities in Kentucky focused on a *ShakeOut* exercise and outreach for children, including providing earthquake-related coloring books, calendars, and poster and writing contests in elementary schools and high schools.

Maine

Maine developed an earthquake information and safety pamphlet and participated in *ShakeOut* activities.

Mississippi

Mississippi participated in two *ShakeOut* events. *ShakeOut* registrations exceeded 180,000 for the first event and 220,000 for the second event. Other outreach and education included the distribution of 2,000 earthquake preparedness posters and 7,000 textbook covers to school districts; 2,500 magnetic pocket guides and 2,700 trifold brochures at the annual preparedness conference; and 7,000 laminated fact sheets to counties in the highest risk areas. In addition, Mississippi staff attended the CAPSTONE-14 Initial Planning Conference in Indianapolis.

Missouri

Missouri completed non-structural seismic mitigation projects on Doniphan School and Nell Holcomb School. These projects included replacing gas lines, securing heavy objects that might fall during an earthquake, and other life safety measures. State assistance funds were used to support the Missouri Structural Assessment and Visual Evaluation (SAVE) Coalition, a group of volunteer specialists that can assist with building damage inspections after a disaster.

Outreach activities included earthquake-related museum displays and support for the Great Central U.S. *ShakeOut*. Missouri also produced and distributed a new poster on earthquakes and supported the Safety Outreach Program, "Map Your Neighborhood," with training and presentations in six communities. In February, an "Earthquakes: Mean Business" seminar for

local business interests was held at St. Louis University. FEMA earthquake materials were distributed at the Earthquake Awareness Month events in Cape Girardeau and Leasburg.

Montana

The Montana Bureau of Mines and Geology made Montana's 1982-2013 earthquake catalog available as a data layer on its Online Mapping Application, thus providing visual, easy, and versatile access to Montana's extensive historical earthquake record.

Montana also participated in its first *ShakeOut* exercise. More than 107,000 Montana residents, about 10 percent of the State's population, participated in this inaugural event coordinated by the Earthquake Country Alliance, the Governor's Office of Community Service, the Montana Bureau of Mines and Geology, the State of Montana Disaster and Emergency Services, and the American Red Cross of Montana.

Nevada

The Nevada Seismic Network worked to automate ShakeMap production to be used for rapid estimates of the severity and location of shaking after earthquakes and for estimates of damage patterns and locations. Using scenario earthquakes, ShakeMap results can be combined with the HAZUS analytical software to estimate potential damage patterns and losses from future events.

Participation in the *ShakeOut* exercise increased from prior years and included increased registration from all 17 school districts, multiple casinos, universities, businesses, and government agencies. More than 560,000 people in Nevada participated in the earthquake drill.

New York

New York incorporated earthquake risk into its hazard mitigation planning and documentation. Activities included developing guidance for plan developers; developing information on the earthquake hazard; conducting workshops to train communities on how to develop mitigation plans; and developing procedures for assessing risk.

North Carolina

Several non-structural system retrofit projects were completed, including low-cost projects for Emergency Operations Centers and police departments in Yancey County, a retrofit of the Emergency Operations Center in Buncombe County, and a unique retrofit of hazardous materials facilities on the campus of Appalachian State University.

Oklahoma

The Oklahoma Geological Survey re-evaluated the potential size of earthquakes that could occur on the Meers fault in southwest Oklahoma. One focus of the research was to determine if a single recurrence interval of 5,400 years is appropriate, using published

literature on the Meers fault and other related geologic information. In addition to providing a report to the Oklahoma Department of Emergency Management, the outcomes of this work will be included in future USGS Hazard Map updates. The information will also be used by the Oklahoma Department of Emergency Management in updating the State Hazard Mitigation Plan.

More than 60,000 Oklahomans participated in the February 2013 Central U.S. *ShakeOut* exercise. New workbooks and lesson plans were distributed to participating schools, reaching about 12,000 students and their families. The Oklahoma Department of Emergency Management also published Emergency Go-Kit Passports for families to record vital information, such as who lives in the home, family emergency plan information, and emergency phone numbers.

Oregon

The city of Portland developed a new Residential Seismic Strengthening Program to help residents make their homes more secure in earthquakes. The program is designed to reduce the likelihood of severe damage to homes as a result of displacement from their foundations or cripple wall failures in earthquakes. The program provides homeowners and contractors with a simple guide to evaluate existing homes and determine if specific improvements will reduce the risk of earthquake damage.

Oregon continued to support preparedness and outreach efforts to local communities. Oregon participated in the yearly *ShakeOut* exercise, with more than 160,000 Oregonians participating. In addition to preparedness initiatives, Oregon worked on long-term resiliency through the development of the Oregon Resiliency Plan. The Oregon Seismic Safety Policy Advisory Commission has assembled eight task groups of volunteer experts from government, universities, the private sector, and the public to develop the portfolio of chapters that make up the Resiliency Plan.

Puerto Rico

Puerto Rico continued to be actively involved in *ShakeOut* activities. Activities included press releases, updates to the *ShakeOut* web page, and the hosting of a *ShakeOut* press conference with FEMA.

South Carolina

Activities in South Carolina included updating and distributing the South Carolina Earthquake Guide, which won 1st place in the 2013 Blue Pencil and Gold Screen Awards conducted by the National Association of Government Communicators.

The State purchased equipment and supplies to support the ROVER Critical Asset inventory project; supported *ShakeOut* coordination and collaboration; and sponsored partnership

projects with the South Carolina Earthquake Education and Preparedness Program located at the College of Charleston (<http://scearthquakes.cofc.edu/>).

Tennessee

Tennessee produced a 22-minute documentary on the unique geology of the New Madrid Seismic Zone (NMSZ), which also discusses earthquake preparedness and mitigation issues facing those living in the NMSZ. The documentary was shown in all major TV markets in Tennessee and was approved by National Public Television to be shown on a regular basis on all PBS network affiliates throughout the U.S. The documentary appeared more than 300 times and has been viewed by nearly 16 million people.

Utah

In April 2013, Utah State lawmakers approved legislation titled *Public School Seismic Studies* and a \$150,000 budget item for a School Building Earthquake Inspection program.¹⁶ In FY 2010, FEMA used NEHRP funds to assist a pilot project to screen over 100 Utah public school buildings using the FEMA 154 Rapid Visual Screening methodology through the ROVER tool, conducted by the Utah Seismic Safety Commission (USSC) and the Structural Engineers Association of Utah (SEAU). This survey found that a high percentage of the Utah school buildings that were screened were potentially at high risk of damage during a major earthquake. The Utah legislation and seismic inspection program will expand the FEMA 154 screenings to include all school buildings statewide built before 1975 for potential earthquake risks.

The Utah Geological Survey and its partners, including the Utah Division of Emergency Management, USGS, FEMA, the Salt Lake County Surveyor's Office, and local cities, collaborated with the Utah Automated Geographic Reference Center to acquire high-resolution (0.5-meter) Light Detection and Ranging (LiDAR), a technology that can produce high resolution maps, for the entire Wasatch fault zone. LiDAR coverage also will be acquired for all of Salt Lake and Utah Valleys. The Utah Geological Survey will use these data to begin mapping Wasatch fault zone traces at a scale of approximately 1:10,000. Fault trace mapping will be used to update the State and USGS fault inventories, and to update or create new surface-fault-rupture-hazard maps showing special study zones for development.

The Utah Division of Emergency Management held its second annual Great Utah *ShakeOut* drill and exercise on April 17-18. Schools, colleges and universities, and the business sector participated. After the drill, a day-long functional exercise was conducted in the State's Emergency Operations Center.

¹⁶ Utah House Bill 278S01.

The Utah Division of Emergency Management also partnered with the Utah Seismic Safety Commission on certification of volunteer building inspector program.

Vermont

Vermont continued to work on soils mapping to support risk analyses, HAZUS modeling, and outreach about earthquake risk to the owners of critical facilities.

Virgin Islands

FEMA earthquake funding to the U.S. Virgin Islands was used to support and encourage participation in the Great U.S. Virgin Islands *ShakeOut* exercise. Activities included developing a *ShakeOut* web page, press releases and media advisories, and updates to a calendar of *ShakeOut* related events.

Washington

The Washington State Earthquake Program at the Washington Emergency Management Division promotes earthquake planning, preparedness, and hazard mitigation among Washington's at-risk communities, in cooperation with FEMA and other Federal, State and local agencies, and Tribes. Washington supported the *ShakeOut* exercise, with more than 710,000 Washingtonians participating in the State-level "Drop, Cover, and Hold On" drill and other earthquake preparedness initiatives.

Washington also supported efforts to increase post-earthquake transportation functionality. The Washington Department of Transportation identified 900 bridges for its seismic retrofit program, which aims to minimize and avoid catastrophic bridge failures.

Wyoming

Wyoming improved its database of critical infrastructure and lifelines to identify those with the highest seismic risk. Wyoming also conducted HAZUS modeling and participated in training through FEMA's National Earthquake Technical Assistance Program. For the HAZUS modeling, students in Jackson, Wyoming conducted field work to update the database inventory. Wyoming also participated in the first Rocky Mountain *ShakeOut* exercise.

Section 5

NEHRP Response to Major Earthquakes in 2013

Worldwide in FY 2013, the USGS reported 1,194 quakes of magnitude 5.0 or larger, including notable earthquakes in Guatemala, China, Pakistan, Afghanistan, Iran, and Indonesia. There were two magnitude 8.0 or greater earthquakes; seventeen reached magnitude 7.0-7.9. Earthquakes were responsible for about 1,400 deaths in 2013, with 825 of those deaths occurring in the magnitude 7.7 Pakistan event on September 24, as reported by the United Nations Office for Coordination of Humanitarian Affairs. Deadly quakes also occurred in the Philippines, Iran, China, Indonesia, the Santa Cruz Islands, and Afghanistan.

Domestically, the year was relatively quiet seismically and there were no major, NEHRP-supported earthquake investigation efforts. The largest earthquake in the United States, and the 6th largest quake of calendar year 2013, was a magnitude 7.5 earthquake that occurred off the coast of Craig, Alaska on January 5. Several earthquakes below magnitude 5.0 rattled Oklahoma, Texas, Kansas, and Arkansas throughout the year. An unusual seismic event happened near Chicago, Illinois on November 4: a magnitude 3.2 rockburst occurred within seconds after a routine explosion at a quarry.

The USGS estimates that several million earthquakes occur throughout the world each year, although most go undetected because they hit remote areas or have very small magnitudes. On average, the USGS National Earthquake Information Center publishes the locations for about 40 earthquakes per day, or about 14,500 annually. Typically, 18 of these earthquakes have a magnitude of 7.0 or higher each year. USGS maintains an online list of significant earthquakes at: <http://earthquake.usgs.gov/earthquakes/eqinthenews>.

To monitor earthquakes worldwide, the USGS National Earthquake Information Center receives data in real-time from about 1,000 stations in 85 countries, including the 150-station Global Seismographic Network. Domestically, the USGS partners with 13 regional seismic networks operated by universities; these networks provide detailed coverage for the areas of the country with the highest seismic hazards.

Section 6

Related Activities Supporting NEHRP Goals

Public Law 108–360, the Earthquake Hazards Reduction Program Reauthorization Act of 2004, requires that NEHRP’s annual report to Congress include a description of activities being carried out by the NEHRP agencies that contribute to program goals but are not officially included in the program. Highlights of these programs and activities in FY 2013 are described below.

6.1 EarthScope

EarthScope is a multidisciplinary earth science program aimed at exploring in unprecedented detail the four-dimensional structure, dynamics, and evolution of the North American continent. EarthScope is supported by NSF in partnership with the USGS and the National Aeronautics and Space Administration. The EarthScope Facility is composed of three core components: the San Andreas Fault Observatory at Depth (SAFOD), the Plate Boundary Observatory (PBO), and the United States Seismic Array (USArray).

The deployment of the USArray was successfully completed in the contiguous 48 States, on time, on budget, and to specification, with the installation of Transportable Array station I64A near Boothby, Maine. More than 1,700 Transportable Array temporary stations have been installed and operated during the past ten years.

The Central and Eastern United States Seismic Network (CEUSN) project began with funding from NSF, in partnership with USGS, the United States Nuclear Regulatory Commission, and other agencies. Approximately 160 Transportable Array stations from USArray will be converted to long-term operations and maintenance through the CEUSN project, with funding split between NSF and USGS, between calendar years 2013 and 2017. This greatly increases the density of long-term, continuously-recording seismic stations in the region.

NSF conducted a review of proposals to unify components of the EarthScope Facility with long-standing core facilities operated by the Incorporated Research Institutes for Seismology (IRIS), a consortium of over 100 U.S. universities dedicated to the operation of science facilities for the acquisition, management, and distribution of seismological data, and UNAVCO, a nonprofit university-governed consortium that facilitates geosciences research using geodesy. The Geodetic Advancing Geoscience and EarthScope (GAGE) facility proposal from UNAVCO united the Plate Boundary Observatory component of the EarthScope Facility and the core geodetic facilities that UNAVCO has historically operated and managed. The Seismological Facilities for the Advancement of Geoscience and EarthScope (SAGE) facility proposal from IRIS united the USArray component of the EarthScope Facility and the core seismic facilities IRIS has historically operated and managed. The year-long review process for these two proposals culminated in National Science Board approval of awards to IRIS and UNAVCO to operate SAGE and GAGE,

respectively, through September 30, 2018. SAGE includes the Global Seismographic Network, a long-standing component of NEHRP jointly supported by NSF and USGS.

6.2 Subcommittee on Disaster Reduction

The Subcommittee on Disaster Reduction (SDR) is an element of the President’s National Science and Technology Council that facilitates the development of national strategies for reducing disaster risks and losses that are based on effective use of science and technology. Mitigating natural and technological disasters requires a solid understanding of science and technology, rapid implementation of research information into disaster reduction programs and applications, and efficient access to diverse information available from both public and private entities. Chartered in 1988, the SDR provides a unique Federal forum for information sharing; the development of collaborative opportunities; the formulation of science and technology-based guidance for policy makers; and dialogue with the U.S. policy community to advance informed strategies for managing disaster risks.

Representatives of NEHRP participate in SDR meetings and provide briefings on program developments. The SDR serves as a forum that NEHRP agencies can use for reaching out to and coordinating with other Federal agencies doing work related to NEHRP goals and objectives.

6.3 International Activities

U.S.-Japan Cooperative Program on Natural Resources

In 1964, the United States and Japan established the U.S.-Japan Cooperative Program on Natural Resources (UJNR) to promote bilateral cooperation in research and data exchange. The UJNR now involves 18 U.S. agencies and 10 Japanese agencies. The NEHRP agencies play important roles in the UJNR panels on earthquake research and on wind and seismic effects. The U.S. sides of these panels are chaired by USGS and NIST, respectively.

U.S.-Japan Panel on Earthquake Research

USGS made preliminary plans to participate in a meeting of this panel in Japan in late FY 2014.

U.S.-Japan Panel on Wind and Seismic Effects

This panel met at NIST in February 2013. The panel heard technical presentations from a number of engineers from each country, and leaders for all panel task committees met during the meeting. The panel task committee on Transportation Systems planned a workshop on bridge engineering for late FY 2013.

U.S.-China cooperation in earthquake studies

Highlights of USGS cooperation with the China Earthquake Administration during FY 2013 include: publication of an analysis of the strong ground motion data recorded from the 2008 Wenchuan and 2013 Lushan earthquakes; publication of the first LiDAR data recorded over an active fault; and publication of crustal stress changes caused by the Wenchuan earthquake. Four Chinese visiting scholars spent time at the USGS in Menlo Park and Pasadena, California, and USGS staff presented a three-day short course in Beijing entitled, “Recent Advances in Earthquake Hazard Studies by the U.S. Geological Survey.”

U.S.-India cooperation in earthquake studies

Highlights of USGS cooperation with the National Geophysical Research Institute in Hyderabad, India, include studies in the Koyna region, site of one of the largest reservoir-induced earthquakes. The 1967 Koyna earthquake had a magnitude of 6.3 and killed over 100 people. The government of India is presently drilling two 3-kilometer-deep research boreholes in the Koyna region to measure stress, and USGS scientists are participating in collaborative research.

NEES sharing results and facilities with foreign interests

In FY 2013, NEES Operations at Purdue University conducted two workshops with international partners. One workshop was co-organized with the European Commission’s 7th Framework Programme for Research and Technological Development, Seismic Engineering Research Infrastructures for European Synergies (SERIES). Participants at this workshop presented the main outcomes of the SERIES project and of parallel developments within NEES. Another workshop, the 4th Workshop on China-USA Collaboration for Disaster Evolution/Resilience of Civil Infrastructure and Urban Environment, was held in partnership with the National Natural Science Foundation of China (NSFC) and researchers in China. Reports from these workshops are available at www.nees.org.

Appendix A

List of Acronyms and Abbreviations

ACEHR	Advisory Committee on Earthquake Hazards Reduction
ANSS	Advanced National Seismic System
AOAM	Agency Operations and Award Management
ATC	Applied Technology Council
BART	Bay Area Rapid Transit District
BSSC	Building Seismic Safety Council
Cal OES	California Governor’s Office of Emergency Services
Cal VIVA	California Vital Infrastructure Vulnerability Assessment
CBF	Concentrically braced steel frame
CEUSN	Central and Eastern United States Seismic Network
CREW	Cascadia Region Workgroup
CUREE	Consortium of Universities for Research in Earthquake Engineering
CUSEC	Central United States Earthquake Consortium
DFO	Designated Federal Official
DHS	Department of Homeland Security
ECA	Earthquake Country Alliance
EERI	Earthquake Engineering Research Institute
EEW	Earthquake early warning
FEMA	Federal Emergency Management Agency
FLASH	Federal Alliance for Safe Homes
FY	Fiscal Year
GAGE	Geodetic Advancing Geoscience and EarthScope
GPS	Global Positioning System
GSN	Global Seismographic Network
HAZUS	Hazards U.S.
ICC	(NEHRP) Interagency Coordinating Committee
IRIS	Incorporated Research Institutions for Seismology
IUPUI	Indiana University-Purdue University Indianapolis
LiDAR	Light detection and ranging
NCJV	NEHRP Consultants Joint Venture
NEES	George E. Brown, Jr. Network for Earthquake Engineering Simulation
NEHRP	National Earthquake Hazards Reduction Program

NESEC	Northeast States Emergency Consortium
NIST	National Institute of Standards and Technology
NMSZ	New Madrid Seismic Zone
NSF	National Science Foundation
NSFC	National Natural Science Foundation of China
PBO	Plate Boundary Observatory
PCWG	(NEHRP) Program Coordination Working Group
PL	Public Law
REU	Research Experiences for Undergraduates
ROVER	Rapid Observation of Vulnerability and Estimation of Risk
S&E	Salaries and Expenses
SAFOD	San Andreas Fault Observatory at Depth
SAGE	Seismological Facilities for the Advancement of Geoscience and EarthScope
SAVE	Missouri Structural Assessment and Visual Evaluation Coalition
SCEC	Southern California Earthquake Center
SDR	Subcommittee on Disaster Reduction
SEAU	Structural Engineers Association of Utah
SEES	Hazards Science, Engineering, and Education for Sustainability
SERIES	Seismic Engineering Research Infrastructures for European Synergies
STEM	Science, Technology, Engineering, and Math
SSI	Soil-structure interaction
UCERF	Uniform California Earthquake Rupture Forecast
UJNR	U.S.-Japan Cooperative Program on Natural Resources
USArray	United States Seismic Array
USGS	U.S. Geological Survey
USSC	Utah Seismic Safety Commission
WSSPC	Western States Seismic Policy Council