Report of the
Scientific Earthquake Studies Advisory Committee
of the Department of the Interior
to the Director of the United States Geological Survey

December 2003

This annual report is being issued by the Scientific Earthquake Studies Advisory Committee (SESAC) of the Department of the Interior, to the Director of the United States Geological Survey (USGS) for submission to Congress. The report describes the Committee's activities of the past year, and addresses policy issues and matters relating to the participation of the USGS in the National Earthquake Hazards Reduction Program (NEHRP). With the proposed change in the leadership of the NEHRP, we believe this report (and last year's) will be particularly useful to the NEHRP Advisory Committee on Earthquake Hazards Reduction that is in the process of being established.

SESAC MANDATE

The Scientific Earthquake Studies Advisory Committee was appointed and charged, through Public Law 106-503, to advise the Director of the United States Geological Survey on matters relating to that agency's participation in the National Earthquake Hazards Reduction Program. The charge includes review of the USGS Earthquake Hazard Program's roles, goals, and objectives, assessment of its capabilities and research needs, guidance on achieving major objectives, and establishment of performance goals.

ACTIVITIES OF THE COMMITTEE TO DATE

Two meetings were held in 2002, this Committee's first year, and an annual report was issued in September 2002. The report is recommended reading, as the program structure and current trends are not redescribed in this 2003 report. In 2003, we met in January, June, and August, and prepared this annual report. Committee members also participated in many related activities, which are summarized below.

The USGS efforts in NEHRP have been underway for two and a half decades. The accomplishments of the program were highlighted in a silver anniversary symposium convened by the National Academies' National Research Council in February 2003, at which members of the SESAC made presentations. Lloyd Cluff spoke on the accomplishments and challenges of implementing the NEHRP from the perspective of private-sector stakeholders, and Tom Jordan addressed research issues from the perspective of the science community.

Dan Abrams and Tom Jordan served on an oversight committee for the development of *The Plan to Coordinate NEHRP Post-Earthquake Investigations*, prepared in coordination with the USGS, the Federal Emergency Management Agency (FEMA), the

National Science Foundation (NSF), and the National Institute of Standards and Technology (NIST) (USGS Circular 1242, 2003).

At our June meeting, the Advisory Committee appointed Sharon Wood chair of the Advanced National Seismic System (ANSS) Steering Committee. Jon Price also serves on this committee, which reports to the SESAC.

On May 8, Chairman Lloyd Cluff represented the Advisory Committee at the hearing of the U.S. House of Representatives Science Committee's Subcommittee on Research regarding NEHRP reauthorization (H.R. 2608). He testified to the value of the NEHRP program, and the USGS contributions to this program.

REVIEW OF THE USGS EARTHQUAKE HAZARDS PROGRAM

Director Groat met with the Committee in January and stressed his commitment to the USGS Earthquake Hazards Program as the leading-edge, top priority program within the Survey. This level of support was not manifest in 2004 funding, however.

The various accomplishments of, issues pertaining to, and opportunities for the USGS Earthquake Hazards Program were identified and reviewed at our January, June, and August meetings, and are discussed below.

Five-Year Plan

The first 2003 meeting of the Advisory Committee was held January 8 and 9 at USGS headquarters in Reston. We reviewed the draft five-year plan for the USGS's Earthquake Hazards Program with its senior leadership. We recommended the plan be reworked to have a bolder vision, better articulation of its goals and objectives, and a clearer recognition of unmet needs and opportunities to pursue earthquake loss reduction, as well as promote integration of the research conducted at each regional office, as there seemed to be barriers to such collaboration. We believed an important focus of the plan should be the establishment of a National Earthquake Information System. We recommended the five-year plan be completed by the May NEHRP reauthorization hearings, but it was not.

A draft of the plan was presented to the Committee at our meeting on June 11 and 12, at the University of Southern California. The Committee made further recommendations to make the plan more dynamic, although five-year plans are inherently poor documents to serve to communicate vision or exciting opportunities. We understand the plan must be a highly structured document to manage a program of this size and scope. The Advisory Committee, however, sees the need for a document that conveys the vision, scientific promise, and exciting opportunities of the program.

Senior Leadership Position

At our January meeting, we expressed our gratitude to John Filson upon his retirement from the USGS and the Earthquake Hazards Program. With regard to the new Senior Leadership position, which will now encompass all hazards, we recommended an

innovative and aggressive recruitment process to attract a visionary, dynamic leader. This person must be highly respected within the Survey and be capable of being a spokesperson for not only earthquakes, but the hazards of volcanoes, landslides, and subsidence, as well. The person must have credibility within the overall earthquake community, as well as within the NEHRP agencies.

The Advisory Committee is individually and collectively committed to assist in finding a qualified person for this critical position, as we feel it is urgent that this leader be in office to guide the NEHRP to the level the Nation needs, especially as strategic interagency leadership for the NEHRP has been waning over the past couple of years.

In June, we reviewed the process of establishing the Senior Leadership position and the progress in filling the position. We were pleased that the selection process was moving forward, and had a target hiring date of October 1. Tom Jordan will serve as one of the advisors to the USGS as candidates are selected.

By the end of August, progress on filling the Earthquake Hazards Program Senior Leadership position was slow. Many qualified applicants found the salary level too low. Although there are still interested and qualified applicants being considered for the position, it probably will not be filled until late this year or early next year.

Denali Earthquake

In January, we heard a presentation by the USGS reconnaissance team that responded to the November 3, 2002 magnitude 7.9 earthquake in Alaska. This event on the Denali fault was the country's largest strike-slip earthquake in more than 150 years. Major earthquakes can provide critical information on earthquake processes, ground shaking, and the performance of the built environment. Importantly, the Denali earthquake is the best U.S. analogy for gaining modern information on a devastating earthquake on the San Andreas fault. Thus, it was critical that the USGS collect key and, in many cases, fragile information quickly, before other geologic processes obliterated it. We recommended follow-up studies be carried out in the summer.

Following the Denali fault earthquake, organizations in both the public and private sectors found themselves in urgent need for information about the Denali earthquake and its effects. The USGS seized this opportunity to forge a partnership with the Alyeska Pipeline Service Company and Pacific Gas and Electric Company (PG&E) in California to combine resources to gather the most-critical, time-sensitive information on the earthquake. A Cooperative Research and Development Agreement (CRADA) between the USGS and these companies was proposed, and formed the basis for planning joint investigations in the summers of 2003 and 2004. The results of these investigations will play a critical role in the review and possible retrofit of earthquake safety systems for the Trans-Alaska Pipeline and will be used by the Joint Pipeline Authority in the evaluation of those activities.

PG&E also plans to use the results of the Denali fault investigations to review the seismic safety and reliability of its utility lifelines in California. Because the Denali fault has

characteristics similar to potentially dangerous strike-slip faults in California, scientific and engineering data from the 2002 earthquake and fault rupture in Alaska are of immense value to the understanding of strike-slip faults in California and the ways in which they will impact nearby populations.

By the time of our June meeting, the USGS (Menlo Park, Golden, and Anchorage) geologists were planning to return to Alaska for the summer field season, budget permitting. Secretary of the Interior Gale Norton was among those who visited the field sites along the Denali fault this past summer.

On August 24 to 26, the Committee met in Delta Junction, Alaska, to compile this report, to review the progress of the USGS/industry joint research on the effects of the Denali fault earthquake, and to observe the performance of the Trans-Alaska Pipeline System in the field. The quake was caused by about 340 kilometers of surface fault rupture distributed along three tectonically related faults. Because it occurred in rural Alaska, a remote part of the country having low population density, there was minor damage to works of man; however, hundreds of landslides were triggered, and the effects of several massive debris avalanches were breathtaking. Two major highways (the Richardson and Tok Cutoff Highways) were disrupted by surface fault rupture and disabled for short periods of time.

The Trans-Alaska Pipeline System crosses the Denali fault near the Richardson highway and the Delta River in the Alaska Range. Had the fault displacement caused the pipeline to rupture, the consequences would have been catastrophic: the pipeline delivers 16percent of the U.S. domestic crude oil supply , oil revenue contributes 80 percent of the Alaskan economy, and a pipeline rupture could have resulted in a massive oil spill into the Delta River and serious environmental impacts. The pipeline would have been shut down for a prolonged period, perhaps many months, for cleanup and repairs. The cost to the State of Alaska and the Nation would have been enormous. However, due to good science and engineering, the pipeline did not rupture. Because of the comprehensive earthquake fault evaluations along the proposed pipeline route in 1972 and 1973, the Denali was identified as the most dangerous fault to be crossed by the pipeline, and innovative engineering designs and prudent planning resulted in protecting the integrity of the pipeline, even though 18 feet of fault displacement occurred beneath it on November 3, 2002.

This venue provided an opportunity for SESAC members to view first-hand the Denali fault earthquake effects, the excellent performance of the pipeline at the fault crossing, and how the USGS filled a strategic need. Alaska is a real-life laboratory that demonstrates how the USGS Earthquake Hazards Program should work. The collaboration between industry and government, which was started when the pipeline was designed, continues today. The USGS recorded the earthquake, recognized its educational value and studied it immediately, is installing additional instruments through the ANSS program, has intermediate-term and long-term plans for further research, and is disseminating the information it is amassing. When there is funding and the appropriate instrumentation in place, the Nation reaps important benefits.

The funding, however, was problematical. The CRADA was to provide $50,000 from Alyeska and $50,000 from PG&E, to be matched by $100,000 from the USGS Director's Office. Because of time-consuming bureaucratic procedures, the CRADA was not in place in time for the summer field season. Alyeska-retained geologists were able to be in the field much longer than USGS geologists, who had to restrict their studies. The good news is that most of the funds will be available for the 2004 investigations.

Earthquake Hazards Programs in California

One purpose of meeting in Los Angeles in June was to review the USGS's Earthquake Hazards Program work in California. We heard presentations by scientists from the USGS offices in Pasadena and Menlo Park and from the Southern California Earthquake Center (SCEC).

Southern California Earthquake Center - The Southern California Earthquake Center is jointly funded by the NSF and USGS to gather earthquake data in Southern California, integrate the data into a comprehensive and predictive understanding of earthquake phenomena, and communicate this understanding to increase earthquake awareness and reduce earthquake risk. In 2003, the Center received $1.1 million from the USGS Earthquake Hazards Program and $4.9 million from the NSF. SCEC is the only NSF-sponsored earthquake science center, and therefore plays a complementary role to the three NSF-sponsored earthquake engineering centers, such as PEER (described below). It is also the largest university-based collaboration in the USGS Earthquake Hazards Program, comprising 14 core institutions and 30 additional participating research organizations nationwide. The core institutions now include the three USGS offices in Pasadena, Menlo Park, and Golden. USGS scientists participate in all aspects of SCEC research.

Since it was founded in 1991, SCEC has used Southern California as a natural laboratory for studying earthquake phenomena from a fault-system perspective and it has produced a number of important reports on earthquake probabilities, ground-motion intensities, and other aspects of seismic hazard analysis. The Center sustains disciplinary science through standing committees in seismology, geodesy, geology, and fault and rock mechanics, and it organizes interdisciplinary research into five focus areas: structural representation, fault systems, earthquake source physics, ground motion, and seismic hazard analysis. The disciplinary committees and focus groups are responsible for integrating the available information into "community models" that describe aspects of the Southern California fault systems, such as crustal motions, fault geometries, and seismic velocity variations. The Advisory Committee recognizes that this type of data integration and modeling is crucial to improving seismic hazard analysis.

Through a major grant from the NSF Information Technology Research Program, the Center is setting up a "community modeling environment" (SCEC/CME) that will provide a cyber infrastructure for physics-based earthquake modeling and seismic hazard analysis. A major USGS-led activity within the SCEC/CME project has been the development of a new software package, OpenSHA, which provides an easily used and

readily extended platform for seismic hazard analysis. Owing to its generality and state-of-the-art design, OpenSHA is expected to be widely used outside Southern California.

We note that other new technologies being developed at SCEC are also applicable to seismic hazard analysis in other regions. Although the increased participation by the USGS in SCEC will facilitate the transfer of this technology, the degree of coordination between SCEC and other regions, such as Northern California, could be substantially improved.

Pacific Earthquake Engineering Research Center - In Northern California, the USGS participates in programs of the Pacific Earthquake Engineering Research (PEER) Center. The PEER Center is a unique public/private partnership that has an emphasis on user-driven research directly applicable to reducing earthquake risk. One key goal of this research program is the reduction of uncertainty in estimates of earthquake effects and consequences. Improvements in (1) estimates of surface faulting, (2) the knowledge of subsurface geologic conditions, and (3) the characterization of strong ground motion attenuation, can significantly reduce costs associated with design of new structures, retrofit of existing structures, and other earthquake mitigation activities.

Ground displacement caused by fault surface rupture beneath buildings or lifelines can cause severe damage or collapse. This behavior has been repeatedly demonstrated in recent earthquakes in Turkey, Taiwan, and Alaska. PEER researchers, working with the USGS and the California Geological Survey, are developing tools to better characterize active faults, and the variability of displacement along strike of a fault.

Tremendous amounts of geotechnical exploratory data have been, and continue to be, generated for characterization of subsurface conditions and materials. For example, data sets for the Los Angeles region used by the California Geologic Survey for seismic hazard mapping exceed 12,500 borings. Caltrans and PG&E contribute data on hundreds of borings statewide. Other sources of data include a variety of state and federal agencies, as well as private consulting firms. Access is the primary barrier to realizing the full potential of the available subsurface data. Emerging information technologies are now making it possible to overcome key data-access barriers using the concept of a "virtual data center" (VDC). A VDC allows multiple data providers to make their data available through a uniform web interface, while each provider retains possession and control of the data itself. Through PEER support, Caltrans, PG&E, the California Energy Commission, and the USGS are in the process of developing a pilot VDC demonstration project.

Earthquake attenuation relations, which characterize ground shaking as a function of magnitude, travel path, and distance from the earthquake source, are the backbone of modern earthquake hazards assessments. These relationships are used in all earthquake hazard assessments, ranging from national seismic hazard maps and California seismic hazard maps (produced jointly by the USGS and the California Geological Survey), to site-specific assessments, both deterministic and probabilistic, for specific facilities ranging from bridges to dams to power plants and substations. Significant recent seismological advances, including new earthquake data, new computer simulation capabilities, and improved scientific and engineering understanding, warrant the development of Next Generation Attenuation (NGA) models. Changes on the order of

20to 40percent in median ground motions relative to existing models might be expected for California design conditions involving large earthquake magnitudes and close site-to-fault distances. The NGA project represents a capstone initiative that is undoubtedly the most complex research coordination and consensus-building effort initiated by PEER to date. It involves the coordination of more than 30 individuals and the synthesis of the results from more than 40 projects. Partnerships established with Caltrans, PG&E, the California Energy Commission, the USGS, and the SCEC assure broad technical participation and review, additional research capabilities, and assistance in the leadership and coordination of key working group activities.

Working Group on California Earthquake Probabilities - The USGS released a comprehensive new report on the likelihood that a major earthquake will strike the San Francisco Bay Region. The probabilities were based on a comprehensive analysis by the Menlo Park USGS-led Working Group on California Earthquake Probabilities, which included earthquake scientists from government, academia, and the private sector. This Working Group report continued the evolution of the methods for estimating long-term earthquake probabilities by building on the foundation established in the 1988, 1990, 1995, and 1999 Working Group reports. Key findings included a 62-percent chance of an earthquake of magnitude 6.7 or greater in the Bay Area by 2031. The findings of this report were incorporated into the 2003 revision to the National Seismic Hazard maps and are being used by the California Earthquake Authority to set earthquake insurance rates.

The methods developed by the Working Group will form the basis of a revision to the 1995 report on earthquake probabilities in Southern California that is now underway. During the past 15 years, the results from the USGS studies and the reports from the Working Group on California Earthquake Probabilities have been extremely valuable in motivating decision-makers to plan for and implement earthquake damage mitigation efforts, as well as stimulating earthquake preparedness activities in local and regional communities. Time-dependent forecasting of earthquakes in a probabilistic framework is proving to be a valuable tool for use in performance-based planning and engineering.

ShakeMap

ShakeMap has become an accepted platform for conveying ground-shaking information to federal and state agencies, emergency response officials, and lifeline operators immediately following an earthquake. The Committee learned that increasingly, delivery of ShakeMap, which the USGS pushes to critical users over the Internet, is hampered by pervasive introduction of firewalls. In addition, the inability to automatically incorporate ShakeMap seamlessly into GIS systems for rapid facility analysis limited the full utilization of ShakeMap.

To address these issues, the USGS has recently completed the first phase of development of a ShakeMap Broadcast system (ShakeCast) that circumvents the firewall barriers and provides a user interface that has full customization for ShakeMap integration into corporate systems. ShakeCast is being prototyped by Caltrans, which is using the system to prioritize earthquake response efforts for bridges and overpasses in California. The

first phase of ShakeCast was installed in Caltrans Traffic Management Centers for testing during the summer of 2003.

Seismic Hazard Maps

The USGS is in the final stages of completion of a five-year effort to develop seismic hazard maps for Memphis and Shelby County, Tennessee. They reported that future work in Memphis will focus on communication of these results and production of derived products that can directly lead to applied hazard reduction efforts in the region. In addition, efforts will also be initiated in the St. Louis, Missouri and Evansville, Indiana areas to define the seismic hazard, in conjunction with local and state partners. This work will build on the experience gained in Memphis and will continue through 2007.

Advanced National Seismic System

In the 2002 SESAC annual report, the Committee recognized an area of immediate concern, namely, the current level of support for the Advanced National Seismic System (ANSS) initiative. Support of this program is essential to modernize and expand earthquake monitoring nationwide, particularly in our vulnerable urban areas. The Committee continues to emphasize that ANSS funds must be appropriated at the amount authorized by Congress during the current NEHRP legislation.

The ANSS data are crucial for emergency response to future earthquakes, as well as in the post-earthquake recovery period in developing safer, less vulnerable buildings, lifelines, critical facilities, and hardened military complexes, as well as in developing performance-based design procedures for structures and systems of all types. The ANSS, if adequately supported, will play a significant role in the nation's homeland security by providing data on the integrity of structures and infrastructures, and by assessing the readiness of military bases and other critical facilities following an earthquake.

As with ShakeMap, information technology has provided a stumbling block in the implementation of the ANSS program. Funding this year was withheld until the Office of Management and Budget was satisfied with the program's compliance with the Government Security Resources Act (GSRA). The security issue has been resolved, but the GSRA annual reviews may be misused to manage the budget in the future.

To date, the USGS has installed more than 400 ground-based strong motion ANSS stations in several metropolitan areas across the United States. Several regional stations have been upgraded, and new ANSS backbone stations (Texas and Colorado) have been installed. Support for the acquisition and installation of an additional 27 backbone stations (both upgraded stations and new sites) will be provided by EarthScope's U.S. Array, in cooperation with the USGS. The ANSS is beginning to focus on structural instrumentation as well. To date, this effort has been modest: two structures have been instrumented in California, and a structure was recently instrumented in Anchorage. The latter will include borehole sensors, thereby allowing a complete record of the ground input and building response to seismic shaking. Going forward, an ANSS national review committee for structural instrumentation is planned and will guide the selection of structures for future instrumentation. The ANSS also has made important progress in

product development, with the delivery of a model-based ShakeMap for the central and south-central Alaska region. Efforts are underway to implement an automated ShakeMap capability for the Anchorage metropolitan area, building on the network of ANSS strong motion sensors in the region. Efforts also are underway to implement automated ShakeMaps in Seattle.

The committee feels the effort is at a critical juncture, and is concerned the ANSS initiative, with its current unacceptable level of support, will wither and fail. Sustained, broad-based community support for the initiative is likely to wane if it falls into an operation-and-maintenance mode after achieving only a small fraction of its goals and intended purposes. For example, there were no permanent ANSS seismic monitoring instruments to provide critical near-fault information from the magnitude 7.9 Denali event last year. The only near-fault information from the Denali earthquake came from a ground-motion instrument installed and maintained by Alyeska Pipeline Service Company. And just recently, on December 22, the magnitude 6.5 rupture of the Oceanic fault in central coastal California was not well captured due to inadequate seismic instrumentation. This is in contrast to the 1999 Chi-Chi, Taiwan earthquake, where many near-field records were collected. Without a more extensive array of instruments, we risk missing the effects of yet another large earthquake.

Interagency Coordination

At our meeting in January, we conducted a very successful, open, and forthright meeting with the leaders of the earthquake research programs at FEMA, NIST, and NSF, the other NEHRP agencies. We learned that such communication was rare, and we strongly recommend the USGS take the leadership to continue such dialog. In June, we were pleased to learn that progress was being made in meetings with senior decision makers to gain the support of the Department of Interior for increased funding of high-priority projects in the Earthquake Hazards Program. We believe the USGS should work with the other NEHRP agencies, and the Office of Management and Budget, as appropriate, to eliminate duplication of effort and to coordinate the funding of programs that complement one another. In fact, the Earthquake Hazards Program should also coordinate its programs with complementary programs in other parts of the Federal Government.

The Committee was enthusiastic about the formation of the Interagency Coordinating Committee on Earthquake Hazards Reduction within the 2003 reauthorization of the National Earthquake Hazards Reduction Program. The interagency committee will provide a mechanism for ensuring that the Office of Management and Budget and the Office of Science and Technology Policy are engaged in the earthquake risk mitigation efforts within the USGS, NIST, FEMA, and NSF.

Within the next year, the interagency committee is charged with developing the NEHRP strategic plan, developing a detailed management plan for implementing the strategic plan, and developing a coordinated interagency budget for NEHRP. Although the Director of the USGS does not chair the interagency committee, the Director is encouraged to take a leadership role in developing these plans within the committee. The importance of the Advanced National Seismic System must be clearly stated in the strategic plan and funding to complete the ANSS should be included in the interagency

budget. In addition, the strategic plan should address coordination of activities within the ANSS with the research funded by the NSF in the Directorate for Geosciences through EarthScope, and in the Directorate for Engineering through the George E. Brown, Jr. Network for Earthquake Engineering Simulation.

The Committee recommends that a joint meeting between the SESAC and the Advisory Committee on Earthquake Hazards Reduction be held shortly after the formation of this new committee. The meeting will facilitate communication between the two advisory committees, as required in the NEHRP reauthorization bill, and provide the SESAC with a basis for evaluating the ongoing work within the USGS that supports the development of performance-based seismic engineering tools.

Learning from Future Earthquakes

The occurrence of large earthquakes provides scientists and engineers with unexpected opportunities to study the behavior of dangerous faults and their damaging effects. These events provide excellent test beds to assess and validate various theories and methods for quantifying earthquake potential and size. Furthermore, data collected from these events can help sharpen tools to better predict when the next major event could occur on that fault.

The USGS has statutory responsibility for coordinating such investigations, and thus took the lead in developing the NEHRP post-earthquake coordination plan. *The Plan to Coordinate NEHRP Post-Earthquake Investigations*, finalized in 2003 and published as USGS Circular 1242, addresses coordination not only among the four participating agencies, but also broadly across the engineering and earth science communities. The plan was implemented during the November 2002 response to the magnitude 7.9 Denali earthquake in Alaska.

The event on the Denali fault last year is significant because it replicates what is considered the maximum magnitude for that fault. Preliminary fieldwork revealed many interesting findings, including the possibility of smaller, more frequent earthquakes on this fault. This work is significant and has far-reaching impacts. The San Andreas fault in California—often considered the source of the "Big One"—is similar in structure and size to the Denali fault. Studying the 2002 Denali earthquake will shed new light on the behavior of San Andreas-type faults, thus providing invaluable data that could possibly save thousands of lives in California and other earthquake-prone regions.

Despite the significance of the Denali earthquake, limited resources were available to study this event. The earthquake exposed the difficulty the USGS has in responding effectively to surprise events. In large part, the problem is due to a lack of flexibility and insufficient funding for post-earthquake investigations. For example, there was inadequate deployment of post-event instruments to study the aftershock sequence of this event. Limited NSF support provided some instrumentation; however, lack of broader deployment prevented a more thorough understanding of the earthquake. Also, the amount of effort that went into field investigations (mapping of surface ruptures and landslides), although intense, left many important questions unexplored due to lack of resources. Important data that could help understand the extent and recurrence time of

this fault rupture may be lost due to other geologic processes, such as landslides and erosion, or reconstruction.

To avoid missing similar opportunities in the future, the Committee recommends the USGS budget ample funding for investigating new earthquakes. There is currently a mechanism for this type of funding in Sec. 11 of the Bill on post-earthquake investigation programs. In lieu of an annual budget, the Committee believes that a multi-year fund (for example, 5 years) would be more practical for such investigations. We understand the difficulty given current funding levels; however, establishing such a contingency fund is vital to enable the USGS to react more quickly and effectively to unexpected events.

To ensure the broadest level of support from all NEHRP agencies, post-earthquake investigations should be coordinated to the greatest extent possible with the Interagency Coordinating Committee on Earthquake Hazards Reduction. A comprehensive post-earthquake investigation will focus on a broad set of issues and problems, including the geologic and seismological aspects, the structural performance of buildings and lifelines, and the societal and economic impacts.

Work with NEES and EarthScope

The National Science Foundation is currently funding two Major Research Equipment and Facilities Construction (MREFC) projects related to earthquake science and risk reduction. The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), within the Division of Civil and Mechanical Systems in the Directorate for Engineering, is scheduled to be operational in 2004. EarthScope, within the Division of Earth Sciences in the Directorate for Geosciences, is scheduled to be completed in 2007. Opportunities exist to for the USGS to enhance its internal and external research programs by collaborating and using these unique facilities.

NEES is a network of 15 geographically distributed equipment sites for studying seismic response and improving the design of civil infrastructure. The NEES laboratories include shaking tables, geotechnical centrifuges, a tsunami wave basin, unique large laboratory testing facilities, structural and geotechnical field-testing equipment, and mobile and permanently installed field equipment. These shared-use facilities will be linked by a network, NEESgrid, to provide collaborative tools for facilitating on-line planning, execution, and post-processing of experiments, a repository for all measured data, and a simulation tools archive.

The data and metadata standards being developed as part of NEES can also be used to archive and distribute information about the buildings and structural systems that are instrumented as part of the ANSS. By providing detailed information about the design of the building, geologic and soil conditions, and measured structural and free-field response, engineers will be able to take full advantage of the ANSS by evaluating the performance of the instrumented buildings. It also may be possible to use the NEES field equipment to excite structures instrumented as part of ANSS before and after an earthquake, providing valuable information about changes in basic response characteristics.

EarthScope is a project of unprecedented scale in the solid-earth sciences that will significantly expand our observational capabilities and understanding of the structure, evolution, and crustal deformation of the North American continent. It involves three components: the U.S. Array, a mobile seismic array; a network of Global Positional System receivers and strain meters; and an observatory at depth on the San Andreas fault. EarthScope will complement and not duplicate or replace ANSS instruments, which are deployed to provide long-term instrumentation for locating and measuring earthquakes and their effects on buildings and lifelines in urban areas.

Additional Opportunities

Although it is difficult to recommend additional programs when there is little additional funding, the Committee believes there are several areas that should not be forgotten. Real-time response efforts are important, but without parallel efforts in basic earthquake research, applied methodolgy will suffer in the long run. Basic earthquake research must remain a core component of the USGS program to continue to achieve the important recent developments we have seen, such as stress-transfer theory, time-dependent hazard assessment, and improved dynamic models of earthquake sources.

Broader Outreach - The geographic distribution of "Did You Feel It" reports for the year indicates earthquakes were felt over larger areas in the central and eastern U.S. than in the west. Earthquake risk is not just an issue for California, Alaska, or the western United States. Earthquake events in 2003 have particularly drawn attention to seismic activity in the central and eastern areas of the country, and the understanding in these regions needs improvement. There is an opportunity for the USGS to strengthen its commitment and increase public awareness of the earthquake threat in these states in an effort to improve scientific understanding in these regions.

The USGS Earthquake Hazard Program should be viewed as a national program, not a regional program for a regional problem. Information gained through program research and projects should be shared on a national level and applied to all areas of the U.S. having similar seismic conditions. Effective procedures should be in place to communicate and integrate with the other NEHRP agencies in all parts of the country. When decision makers on a national level are aware of the problem, they can fully support and embrace the value of USGS earthquake research and the importance of NEHRP to the Nation as a whole.

Earthquake Prediction - There is excellent progress toward predicting where damaging earthquakes are most likely to occur, how big they are likely to be, the recurrence intervals of destructive events, and the likely damaging effects on the built environment. We believe the products resulting from research in these predictive areas are far more valuable than highly uncertain short-term earthquake predictions, for which there is at present no accepted basis, and, when announced, can create more social disruption than social benefit. However, short-term earthquake prediction is being reexamined in the earth science and engineering communities. Well-funded agencies, such as NASA, that have an earth-science component to their missions are showing a strong interest in short-term earthquake prediction, and may likely fund such efforts in the near future. The

USGS does not currently directly support research toward short-term prediction of earthquakes.

We see an opportunity for the USGS to lead the scientific community and provide a unified position on short-term earthquake prediction to achieve the proper political and public support needed for its research. The USGS must take on an aggressive role in evaluating and validating proposed prediction tools so the public understands the true risks associated with a given seismic area. A comprehensive, physics-based earthquake model coupled with a viable program to test the results of the prediction tool should be developed by the USGS. Emerging theories and technology should be held to proven scientific standards and subjected to intense peer review. Recognizing that short- or even intermediate-term earthquake prediction can result in serious ramifications for public policy, the strong technical abilities of USGS staff can lend credibility to the independent work of other federal agencies, academia, and private consultants. The Committee encourages the USGS to consider reestablishing the National Earthquake Prediction Council to serve as the forum to review predictions and resolve scientific debate prior to public controversy or misrepresentation, so decision makers are not mislead by unfounded short-term earthquake predictions.

New Approaches - The USGS Earthquake Hazard Program should address scientifically credible information that has the potential of making a major contribution to its mission but is outside the mainstream of its current work. For example, new approaches to assessing strong ground motion have begun to be recognized as potentially useful by the scientific community. These include the analysis and mapping of locations of precarious rocks, and the analysis of the age and geographic distribution of turbidites in marine sediments. The USGS should evaluate the usefulness of these approaches in their overall hazard assessment and related earthquake-science programs. This could be accomplished either through internal USGS work or external grants.

RECOMMENDATIONS

We have made many suggestions and recommendations throughout the discussions above; however, we believe there are three especially important and high-priority recommendations for the USGS Earthquake Hazards Program at this time.

1. The SESAC strongly recommends to the Director of USGS that full funding of the ANSS at the level authorized in the current NEHRP legislation be appropriated. The USGS must make a commitment to work through the Department of the Interior and the Office of Management and Budget to ensure that this objective is met.

2. The USGS Earthquake Hazard Program should improve its ability to closely coordinate its research activities with complementary programs in other parts of the Federal government. There are many opportunities for collaboration between the users of the Advanced National Seismic System and the U.S. Array component of the National Science Foundation's EarthScope initiative. Similar synergies are possible between the ANSS and the NEES. The USGS and the NSF should develop memoranda of understanding that clearly state the responsibilities

and expectations of the respective agencies, and should communicate regularly to avoid duplication of effort. Furthermore, the USGS should work with other federal agencies, including NASA, which acquire data that may be relevant to earthquake-hazard assessment or earthquake science.

3. The USGS needs ample budget and more flexible strategies for learning from future earthquakes. Discretionary funds should be set aside for multiple years, instead of annually. To ensure the broadest level of support from all NEHRP agencies, post-earthquake investigations should be coordinated to the greatest extent possible with the Interagency Coordinating Committee on Earthquake Hazards Reduction.