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Testimony on "H.R. 3479 NATURAL HAZARDS RISK REDUCTION ACT OF 2011"

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This testimony is submitted in support of the reauthorization of the National Earthquake Hazards Reduction Program (NEHRP) under H.R. 3479 Natural Hazards Risk Reduction Act of 2011. The thrust of my comments is to call for increased authorization and appropriations to the US Geological Survey (USGS) for NEHRP activities compared to the appropriation allocated during the past few federal fiscal years. I further call for increased NEHRP funding to Weston Observatory of Boston College for regional earthquake monitoring in New England and to other organizations external to the USGS who are engaged in earthquake monitoring and research at the local and regional level throughout the country. Such funding is crucial if NEHRP is to meet its long-term goals of reducing the losses from future earthquakes that take place in the U.S.

For FY12 the USGS is expecting a NEHRP appropriation of about $57 million, which is reduced almost 10% from its NEHRP appropriation of about $62 million in FY10 and $61 million in FY11. In response to this reduction for FY12, the USGS has indicated that it intends to end funding for the regional earthquake monitoring in New England by Weston Observatory of Boston College as of February 1, 2012. The USGS has indicated that this termination of funding is due to an expected decrease in NEHRP appropriations for FY12 and beyond. In my opinion, this is a short-sighted decision that severely hurts the earthquake risk reduction activities in New England and other parts of the eastern U.S. If any lesson is to be learned from the occurrences of the recent damaging earthquakes in Japan and Virginia, it is that the United States needs to be increasing, not decreasing, its funding for NEHRP activities.

For the New England region, Weston Observatory needs funding of $500,000 for one year to expand its regional earthquake monitoring capabilities in the New England region, followed by annual funding levels of $350,000 to operate and maintain its regional seismic network. This regional seismic network monitoring is targeted to study the seismic hazards and to reduce the seismic risk in an area of the country that has a population in excess of 14,000,000 people, that has experienced several damaging earthquakes throughout historic time, and that has cities and towns with many old buildings that have little earthquake reinforcement sitting on soils which are highly vulnerable to earthquake shaking.

The Need for Continuing Regional Earthquake Monitoring and Research in New England under NEHRP by the Weston Observatory of Boston College

Regional earthquake monitoring and earthquake studies by local experts in each part of the country are essential if earthquake hazards are to be most clearly defined and earthquake risks are to be most effectively mitigated. In New England, Weston Observatory performs this function for this highly populated part of our country. It is the experts at Weston Observatory of Boston College who best understand the local scientific problems that need to be addressed regarding the seismic hazard in New England, and these experts best know how to attack those problems. Each year Weston Observatory detects dozens of earthquakes that take place in the New England region, and it reports their locations and magnitudes. Weston Observatory also has carried out numerous studies to look for seismically active faults, to assess the probabilities of future strong earthquakes that could affect New England, and to better understand the causes of the damaging earthquakes that have taken place in New England in the historic past.

There have been many damaging earthquakes that have affected the New England region in the past, and many more that have affected the middle Atlantic states or Canada and have caused strong shaking in New England. The most damaging earthquake In New England in historic time took place in 1755. Called the Cape Ann earthquake because of its suspected epicenter east of Cape Ann, MA, it caused damage in Boston, Portsmouth, NH and Portland, ME, and was felt up and down the east coast of North America. Its magnitude is estimated as about 6.2. An earlier strong earthquake affected the New England region in 1638 shortly after the Pilgrims first landed at Plymouth, MA in 1620. While only a few details about the 1638 earthquake are known from the existing historical records from that time, the magnitude of this earthquake has been estimated as 6.5 and its location is postulated to have been in central New Hampshire. If this earthquake were to take place today, it would cause many billion dollars worth of damage. Another strong earthquake was centered northeast of Quebec City in 1663. This earthquake caused chimney damage in the Boston area at a distance of about 400 miles from its epicenter. In a recent study, I estimate that the magnitude of this earthquake was 7.5, comparable to the largest earthquakes that took place in the New Madrid seismic zone in 1811 and 1812. Other earthquakes between magnitude 5 and magnitude 6 that have taken place in New England were in 1727, 1904 and 1940. In particular, the 1727 earthquake caused damage in northeastern Massachusetts and had an estimated magnitude of about 5.5. Damaging earthquakes that were centered outside of New England but were felt strongly in the New England region took place in 1732, 1737, 1791, 1870, 1884, 1925, 1929, 1944, 1935, 1982, 1983, 1988, 2002, 2010 and 2011.

Each year, regional earthquake monitoring by Weston Observatory provides important new data for studies of the seismic hazard in New England and nearby areas. While many examples can be cited, a couple examples are given here to show what can be learned from regional seismic network monitoring of the frequent small earthquakes in New England. In 2006 and 2007 a swarm of small earthquakes took place at Bar Harbor, ME, the largest of which was magnitude 4.2. The magnitude 4.2 event caused several rockfalls in Acadia National park, and it scared the local

residents who had been feeling the several dozen smaller earthquakes that were part of the swarm. A detailed study of this earthquake sequence by Weston Observatory revealed that the earthquakes originated on a fault that comes to the surface under Frenchman Bay just a mile east of Bar Harbor. The existence of a seismically active fault in this area had not been previously suspected. In a second example, a very small earthquake with magnitude 0.8 was detected on 11/30/2011 in Wilmington, MA, a suburb northwest of Boston. This earthquake was too small to be detected by the automated earthquake monitoring system at Weston Observatory, but rather it was detected by the astute work of a Weston Observatory seismologist. Once it learned of the earthquake, the local news media were curious about the occurrence of this earthquake in the greater Boston area and what it might portend about future earthquake activity. This very small earthquake, which apparently was not felt by local residents, gave Weston Observatory yet another an opportunity to reinforce information about the New England earthquake hazard to the local population.

There are many scientific reasons why continuing to monitor and study the small earthquake activity that routinely takes place in New England and vicinity each year is an important activity for earthquake hazards analysis and earthquake risk reduction. For example, in order to assess the possible locations and probabilities of future strong earthquakes in the New England region, it is necessary to find and study the active faults in the region. At present, no active faults have been mapped in the surface geology in New England or the middle Atlantic states, and only a few suspected active faults have been identified in the surrounding areas of Canada. Several years ago I published a scientific paper in which I argued that many of the small earthquakes that routinely take place in eastern North America are remnant aftershocks of strong earthquakes that took place several hundred to a few thousand years ago. Thus, by studying the small earthquake activity of the region, the locations of past strong earthquakes may be discerned, and from these data the locations of possible active faults might be found. In another study, my colleague Alan Kafka and I showed that most strong earthquakes in eastern North American take place near the locations where past smaller earthquakes have been detected. Based on this study, a small earthquake like the November event at Wilmington, MA may indicate the possible location of a future strong earthquake. These two studies show that monitoring the small earthquake activity in this region can help improve our understanding of the seismic hazard of New England and vicinity. The response of the news media and the general public in New England to the occurrences of the frequent small earthquakes, even those that are not felt, helps to regularly reinforce to the population that New England is at risk from damaging earthquakes and that mitigation measures should be taken now before the next strong earthquake strikes.

The magnitude 5.8 Mineral, VA earthquake on 8/23/2011, which was widely felt throughout the eastern U.S., is illustrative of how much still needs to be understood about earthquake activity along the U.S. east coast. This earthquake took place in a known seismic zone that is similar to seismic zones in many parts of New England, but the earthquake was about 1 magnitude unit larger than any previous

earthquake known to have occurred historically in central Virginia. One lesson that this earthquake makes clear is that the seismic events that are larger than any observed in the historic past are possible along the U.S. east coast. In the Mineral earthquake the most widespread and severest damage was in relatively sparsely populated areas near the epicenter, but there was also scattered damage in the Washington, D.C. and Baltimore, MD areas. The earthquake was widely felt throughout the eastern U.S. For example, in New England the shaking was well below the level for damage, but even so several buildings in New England were evacuated by occupants who were scared by the notable shaking of the buildings. A number of nuclear power plants were affected by ground shaking from the earthquake. The North Anna nuclear power plant, only about 11 miles from the epicenter, safely shut down following the earthquake even though the plant experienced a peak ground acceleration that was approximately twice its design value.

Understanding the earthquake hazard in New England and vicinity is important for reassessing the safety of critical structures in the region, such as nuclear power plants. Shortly after the occurrence of the 3/11/2011 magnitude 9.0 earthquake in Japan, emergency managers from Vermont, Massachusetts and New Hampshire contacted Weston Observatory about the seismic safety of nuclear power plants in their states. I also talked to members of the news media and general public who were concerned about the seismic safety of the nuclear power plants in New England as well as of the Indian Point nuclear power plant outside New York City. Following the occurrence of the 8/23/2011 magnitude 5.8 earthquake centered at Mineral, VA, Weston Observatory received more press and public inquiries about the safety of nuclear power plants in the northeastern U.S. To fully determine the seismic hazard to nuclear power plants in the northeast, there are many datasets that need to be accumulated and analyzed: a long-term catalog of the locations and magnitudes of the small and large earthquakes that have taken place in the northeastern U.S. and nearby Canada; a dataset of the strong ground motions that have been recorded from all strong earthquakes in the region; and targeted geological studies of possibly active faults near operating or proposed nuclear power plants. The continued acquisition of regional seismic network data in New England and surrounding areas is needed to satisfy the stringent requirements for assessing the seismic safety of nuclear power plants. It is vital that local seismic experts participate in the acquisition and study of past and future earthquake data, since they are in the most knowledgeable about the local earthquake data and the local geology.

Another hazard question that needs further data and study is the possibility of a damaging tsunami along the New England coast. In 1929 there was a magnitude 7.3 centered off the coast of Newfoundland. This earthquake was felt throughout New England, and in Newfoundland it caused a major tsunami that inundated many coastal towns and killed 28 people. About 10,000 were left homeless after the tsunami. Modern regional seismic network monitoring has revealed scattered small-magnitude earthquakes from the offshore region east and south of New

England. Could such an earthquake and tsunami like the one that affected Newfoundland in 1929 occur farther to the south and impact the New England coast? So far there is no clear answer to this question, although there may be evidence of a tsunami about 2300 years ago along the coast of New Hampshire. A systematic search for tsunami deposits along the New England is needed along with further study of the offshore earthquake activity.

Accomplishments of Past Earthquake Monitoring and Research in New England under NEHRP

Although there is still much work that must be done to improve the understanding of seismic hazard and to better reduce the seismic risk from strong earthquakes in New England and vicinity, much has already been accomplished with past NEHRP funding. One very visible evidence of this is the adoption of building codes in the northeastern U.S. For example, in 1980 the only New England state that had a seismic provision in its building code was Massachusetts, and that provision applied to new buildings only. Today, all of the New England states have adopted earthquake provisions in their building codes for new buildings. Furthermore, in 1996 Massachusetts started requiring seismic retrofit for buildings that are under major refurbishments. Another evidence of the impact of NEHRP is that emergency management agencies in the region now regularly conduct tabletop exercises to practice dealing with earthquake disasters. There was one such exercise conducted in Massachusetts earlier this year. Some of these exercises have involved multiple states, since a damaging earthquake in one New England state is likely also to cause damage in neighboring states. Even private firms in the region have begun taking earthquakes into account in their emergency planning. A few years ago I participated in an earthquake planning exercise conducted by a major financial firm in the Boston area based on the scenario that a major earthquake had struck the Boston area. In another example, just last week Boston College conducted its first earthquake planning exercise. Regarding earthquake education, school children in New Hampshire are regularly trained in earthquake safety, and such exercises are carried out at some other schools in New England. Children at some schools in Massachusetts learn about earthquake safety as part of the Boston College Educational Seismology Project (BC-ESP), a Weston Observatory program based on students operating their own seismograph in their classroom and recording global and regional earthquakes.

Another project that is currently under way is the New England Scenario Earthquake Project. This is an example of a project that makes use of expertise funded under NEHRP. Initiated by the Northeastern States Emergency Consortium (NESEC), this project, which has been organized by FEMA, involves the development of a number of earthquake scenarios to be used for emergency management planning. The scenario earthquakes were provided by seismologists at Weston Observatory, and each earthquake scenario is based on a past strong or damaging earthquake that affected the New England region. The USGS is producing ShakeMaps of each scenario earthquake for this project, and then local experts in

New England provide modifications to the ShakeMaps for local soil conditions where known. NESEC and FEMA are each using each of these earthquake scenarios to make loss estimates and to determine where better earthquake hazard information is needed. This project is not formally funded under NEHRP, but rather it is using resources from other NEHRP projects, such as the earthquake monitoring funding to Weston Observatory from the USGS for the input seismic data. The results of this project will provide valuable information for future state and local earthquake planning efforts in New England.

One important aspect of the earthquake monitoring carried out in New England by Weston Observatory is that it is very cost-effective. For example, there are fewer than 30 seismic stations that are operating in New England, although another 10 or so stations are needed in New England to spread the seismic station coverage more uniformly throughout the region. For comparison, in California a comparably sized area would have over 300 seismic stations. The paucity of seismic stations and the relatively low funding level for seismic station operations in New England has forced Weston Observatory to find cost effective ways to operate its seismic stations and to analyze its seismic data. Specialized automated seismic data analysis programs and careful scrutiny looking for small earthquakes in all seismic data by Weston Observatory seismologists provide some compensation for the sparse seismic station coverage throughout the area. Whereas the USGS spends millions of dollars for regional seismic network monitoring in California, it is providing Weston Observatory with just over $200,000 for seismic network operations in New England in 2011. Also in 2011 about another $85,000 in ARRA funds was provided to Weston Observatory for seismic station upgrades. To provide the most effective regional seismic network monitoring in New England, Weston Observatory needs one-year funding of $500,000 to purchase and install an additional 10 or so seismic stations in the region followed by annual operational funding of $350,000 for its regional seismic network. This is a very cost-effective investment for regional earthquake monitoring in this heavily populated part of the U.S.

The National Perspective of the USGS under NEHRP: Lack of a Local Perspective of the Earthquake Hazard in New England

Learning more about the seismic hazard and earthquake potential in New England and other regions of the U.S. demands steady monitoring and research by scientists with specific knowledge and expertise with regard to the local earthquakes and earthquake hazards, as well as to the specific needs of the local population. Although the USGS has many scientists on its staff, they generally take a national perspective rather than a local perspective when addressing seismic hazard questions in the U.S. For example, in its preparation of the U.S. National Seismic Hazard Maps the USGS relies on the detailed input from local experts from different parts of the country. Outside of California, Hawaii, the Pacific Northwest, Alaska and Memphis, the USGS does not have experts on the local seismicity in many parts of the U.S. For example, the National Earthquake Information Center (NEIC) of the USGS is concerned primarily with monitoring the large earthquakes in most parts of

the country, and it pays less attention to the smaller earthquake activity. New England is one such region where this is true. The NEIC is not set up to detect all of the small, local earthquake activity in New England that is regularly found by Weston Observatory scientists. Thus, advancements in the understanding of the seismic hazard in parts of the country like New England are made primarily by scientists outside of the USGS rather than by scientists within the USGS.

An example of how the national perspective rather than local perspective of the USGS in earthquake monitoring hinders advancements in the study of seismic hazards in many parts of the central and eastern U.S. comes from central Virginia. In 2007 the USGS ended funding for regional seismic network operations in Virginia, even though there are active seismic zones in both the center and the western part of the state. The rationale for this decision is that Virginia, like New England, is classified by the USGS as a "low seismic hazard" region, even though both areas have experienced persistent small earthquake activity on a regular basis and New England has experienced damaging earthquakes in the past. The occurrence of the magnitude 5.8 Mineral, VA earthquake on 8/23/2011 demonstrates conclusively that central Virginia should be classified as "moderate seismic hazard" rather than "low seismic hazard", as should New England. Because of the cessation of funding for seismic network operations in Virginia, there were only a few seismic stations operated by Virginia Tech in the state when the Mineral earthquake occurred, and only one station was operating close to the epicenter. Because of the lack of seismic stations, this was a missed opportunity to look for foreshocks or other precursory patterns of small earthquakes that may have indicated the coming of the magnitude 5.8 shock. This was a missed opportunity in Virginia because the USGS took a national perspective rather than a local perspective in its approach to regional seismic network monitoring. In the case of central Virginia, the local expert was correct in his assessment that the earthquakes of central Virginia represented a significant seismic hazard, but this assessment was not accepted by the USGS before the occurrence of the Mineral earthquake.

Another way in which the national perspective of the USGS hinders seismic hazard research at the local level is in the USGS definition of urban seismic hazard. The USGS has specified certain urban areas as targets of special studies for their seismic hazard. In the northeastern U.S. there are two such targeted urban areas: New York City and Boston. However, in New England there are many cities that face comparable seismic hazards to Boston and New York. These cities include Providence, RI, Hartford, CT, Manchester, NH, Portland, ME and New Haven, CT. Many other smaller cities and towns in New England also face an approximately comparable seismic hazard. Outside of New England, other major cities including Philadelphia, Baltimore and Washington, D.C. face some measure of seismic hazard that needs to be addressed by the residents of those cities. The damage in Washington and Baltimore due to the Mineral earthquake illustrates the seismic hazard to these cities. Furthermore, the Mineral earthquake demonstrates that a city can experience damage from an earthquake that is centered many tens of miles from the city. In the case of Washington, D.C., the damage in that city took place at a

distance of over 80 miles from the earthquake epicenter. Thus, as has been observed many times in the past, in the eastern U.S. earthquakes centered far from the major urban areas still can pose a seismic hazard to those cities. It is for this reason that studies of the earthquake activity throughout the eastern and central U.S. are needed. Furthermore, those residents in areas like New England who live away from the major cities face a seismic hazard that is significant to those residents, and those residents should also be encouraged to undertake earthquake hazard mitigation measures.

The USGS has many national-level earthquake information products like ShakeMaps and Did-You-Feel-It (DYFI) maps that are very popular and used by emergency management officials throughout the country. However, even these products lack details that are important for local emergency management officials. An example is the USGS ShakeMap product. ShakeMap is a map produced by the USGS after a strong earthquake to represent the strength of ground experienced in the region affected by the earthquake. For earthquakes in the central and eastern U.S., the ShakeMaps produced by the USGS focus on the areas of stronger ground shaking, and they often cut off those areas far from the epicenter where the earthquake shaking is weak and not damaging. An example of this problem arose after the Mineral, VA earthquake. The initial ShakeMap produced by the USGS did not show all of New England even though the earthquake was felt by some residents throughout all of the New England states. Furthermore, the USGS ShakeMap showed low levels of earthquake shaking throughout New England, even though the emergency managers in the New England states were inundated with telephone calls reporting strong ground shaking from some localities. Clearly, there were local soil conditions in parts of New England where the ground shaking was amplified more than that shown on the USGS ShakeMap that was produced after this earthquake. The seismologists at Weston Observatory have long been aware of this problem, although the problem is not well appreciated by the USGS. Here again is an example of a case where local seismological experts are in the best position to produce a seismic hazard product that is of greatest use to the local emergency management community in New England. It is the desire of Weston Observatory to work cooperatively with the USGS to produce ShakeMaps that meet the needs of the emergency managers in New England, but this can only happen if the USGS continues to fund earthquake-monitoring activities at Weston Observatory of Boston College.

The expected FY12 appropriation to the USGS for NEHRP activities is about $57 million, a drop of about $4 million compared to its FY11 appropriation. The USGS response to this decrease in NEHRP funding has been to cut its funding to the NEHRP external grants program and to cut its funding for the Weston Observatory earthquake monitoring in New England. Thus, the USGS response to the FY12 decrease in NEHRP funding has been to protect its internal, national-level programs and to cut its support for local seismological experts external to the USGS. This runs exactly counter to the arguments that I have advanced in this testimony, where I show that local seismologists are best able to carry out earthquake monitoring and

research and to promote earthquake hazard mitigation activities in many parts of the U.S., including New England.

Conclusions

Of the four federal agencies funded under NEHRP the USGS has taken on the task of monitoring and studying the earthquake activity of the U.S. For this reason the decision of the USGS to end support for earthquake monitoring in New England to Weston Observatory of Boston College effectively dismantles this local source of information and expertise for the New England region. There is no other source of support, nor are there any other seismological experts who can carry out the earthquake hazard activities now being conducted at Weston Observatory.

It is for this reason that the NEHRP authorization to the USGS in H.R. 3479 for future years needs to increase beyond the $62 million that was appropriated to the USGS in FY10. The USGS must increase its support for the earthquake monitoring and research activities by local seismological experts in many parts of the U.S., and this should be one of the specific requirements of this and future NEHRP legislation. One center that should receive continued external funding from the USGS for its earthquake monitoring and research in New England is Weston Observatory of Boston College. During the past three decades Weston Observatory has made great strides in understanding the earthquake hazard of the New England region and in promoting earthquake hazard mitigation activities in New England. Continued funding to Weston Observatory for earthquake monitoring and research is needed to further promote earthquake risk reduction to the 14 million people who live in New England.