

**WESTERN STATES SEISMIC POLICY COUNCIL  
POLICY RECOMMENDATION 17-3**

**Earthquake Monitoring Networks**

**Policy Recommendation 17-3**

WSSPC supports the continued expansion and modernization of earthquake monitoring networks as envisioned and articulated by the Advanced National Seismic System (ANSS), with emphasis on expanded strong-motion monitoring in areas prone to large earthquakes and in urban areas, including selected engineered structures; increased regional broadband seismograph instrumentation; increased geodetic instrumentation; and earthquake early warning capabilities. The resulting data will provide better understanding of future ground shaking potential, tsunami generation potential, more rapid information for emergency response, and insights for the improved design of more earthquake and tsunami-resistant construction.

**Executive Summary**

Earthquake monitoring and tsunami warning are essential to provide accurate and timely data and information on earthquakes and tsunamis that can damage buildings and infrastructure. Reliable and optimally useful monitoring must employ modern methods and technologies in conjunction with comprehensive regional coverage. Current challenges include obtaining funding to replace outdated, inadequate, analog weak-motion instrumentation with digital systems that include broadband and strong-motion sensors, and improving the operational efficiency and reliability of seismic networks. An important issue affecting many areas is the lack of sufficient and uniform geographic coverage in areas of relatively high earthquake hazard. Large and damaging earthquakes are not limited to the west coast. Of the thirty-one  $M > 7$  earthquakes that occurred in the lower 48 states during the past six decades, five occurred in the western states (nineteen occurred in California, five in the central and eastern U.S., and two in Washington). Yet many areas in the western states remain inadequately covered by modern instrumentation, as do large regions of Alaska. Support for the continuing expansion of the nation's monitoring networks will be crucial in the coming decades for refinement of seismic hazard maps and emergency planning, for acquisition of data for earthquake engineering research, and to implement earthquake early warning.

## Background

Earthquake monitoring networks are essential both to respond effectively to earthquakes where and when they occur and to characterize future earthquake hazards. The earthquake parameters produced by modern seismic networks, when combined with historic earthquake catalogs and the paleoseismic record, are essential input for refining the National Seismic Hazard Map. Automated processing of earthquake information by seismic networks in the United States provides near-real-time information on earthquake locations, magnitudes, and patterns of moderate and damaging ground shaking. In the last decade, seismologists have expanded the capabilities of the seismic monitoring systems throughout the nation to routinely produce ShakeMaps for quakes with  $M > 3.5$ , fault rupture orientations, fault slip distributions and aftershock probabilities for quakes with  $M > 6$ . ShakeMap has become a valuable tool to assist emergency responders in identifying the likely extent of earthquake damage. Strong-motion data (now increasingly available in real-time) can be correlated with documentation and evaluation of the performance of the built environment, leading to understanding the causes of earthquake damage and the occurrence of good structural and non-structural performance.

Since the 1960s, the U.S. Geological Survey (USGS) has operated, supported and coordinated local seismic networks to detect micro-earthquakes, including aftershocks of larger earthquakes. Seismologists have used data from these early seismograph networks to delineate the spatial relationships between earthquake hypocenters and active faults. Modern earthquake monitoring networks provide fundamental earthquake data in the form of catalogs specifying hypocenter location, time of occurrence, and magnitude, along with compiled recordings of strong earthquake shaking in urban areas and in the vicinity of surface fault ruptures. These data find uses in diverse applications ranging from earthquake hazard analysis to disaster response. Seismic networks throughout the U.S. have provided fundamental data for the U.S. Geological Survey's National Seismic Hazard Mapping Project, which is generating ever-advancing state-of-the-art earthquake hazard maps for the U.S. The availability of earthquake monitoring network data has led to new and innovative research that has advanced the science of seismology through an improved understanding of the physics of earthquake occurrence and development of modern ground motion prediction equations.

For the western states, modern monitoring of regional earthquake activity is crucial for better understanding earthquakes and their associated hazards. The largest proportion of the Nation's seismic hazard is in the western states, which are all exposed to large and damaging earthquakes. Eleven of the thirty-four earthquakes  $M 6.5$  or greater in the lower 48 states since 1900 have occurred in the Basin & Range Province, including the  $M 7.2$  1959 Hebgen Lake, Montana;  $M 6.9$  1983 Borah Peak, Idaho;  $M 6.8$  1915 Pleasant Valley, Nevada;  $M 6.8$  1932 Cedar Mountain, Nevada; and  $M 7.1$  1954 Fairview Peak, Nevada earthquakes. Yet the Rocky Mountain region remains the largest seismically active region of the lower 48 states without sufficient modern instrumentation to fully locate and characterize earthquakes to meet ANSS standards. In particular, many areas of the

southwest (Rio Grande Rift, southern Colorado Plateau) and the northern Rocky Mountains are inadequately instrumented. Similar deficiencies exist in many large, active seismic regions of Alaska.

The advent of digital instrumentation since 1990 has revolutionized seismology. High-fidelity earthquake data transmitted in real-time via terrestrial and satellite communication links are essential for all aspects of seismology. Digital dataloggers coupled with broadband and strong-motion sensors have the capability to record the full spectrum of earthquake-related ground motions—everything from the high frequencies of nearby earthquakes to the low-frequency, rolling motion of distant earthquakes. Most importantly, digital instruments have dynamic range sufficient to detect tiny earthquakes and remain on-scale for major, nearby earthquakes. Additionally, all three axes of ground motion (up-down, north-south, and east-west) are recorded (as opposed to only the vertical direction of ground motion recorded by older seismographs). High-quality recordings by even a few broadband seismographs from earthquakes with magnitudes as small as 3.5 allow computations that uniquely characterize the type of faulting, amount of energy released, and the stress field responsible for the quake. Likewise, high-quality strong-motion recordings in the urban environment are necessary to understand how seismic shaking can cause damage to buildings and other structures. This information is rapidly posted to the Internet, and data centers provide ready access to the information for rapid response and recovery as well as long-term research.

The vision of the next generation of national earthquake monitoring, the Advanced National Seismic System (ANSS), was issued in 1999 by the U.S. Geological Survey. Its design and partial implementation has been developed in consultation with earthquake specialists in academia and the States together with the engineering community. The mission of the Advanced National Seismic System (ANSS) is to provide accurate and timely data and information on earthquakes and their effects on buildings and structures, employing modern monitoring methods and technologies.

Since the ANSS was established by Congress in 2000, the USGS has fostered the organization of regional seismic networks developed through incorporation of local efforts into regional systems. ANSS regions are established for California, the Pacific Northwest, Alaska, Hawaii, the Intermountain region, the Central U.S. (including the Southeast), and the Northeast. The ANSS has deployed more than 2990 modern monitoring stations throughout the U.S. since its inception, with many installed in urban areas with the highest earthquake hazard.

Automated processing and distribution of earthquake information by regional seismic networks and the USGS National Earthquake Information Center provides near-real-time information to the public about earthquake location, magnitude, fault orientation, slip distribution, and aftershock probabilities. Together with other

parties, the USGS has developed ShakeMap, an analytical methodology that creates maps of the predicted severity of ground shaking computed from observed peak ground motions recorded by modern instrumentation and from the computed earthquake magnitude. ShakeMaps are posted to the Internet within minutes following earthquakes and also are distributed to emergency responders and other users through technologies like CISM Display and ShakeCast. The initial maps are automatically revised as new seismic data become available. In areas with a relatively dense distribution of strong-motion sensors, ShakeMap can help emergency managers immediately identify areas that have been exposed to strong shaking before damage reports are available. ShakeMap is being used in conjunction with earthquake loss modeling to make preliminary estimates of casualties and earthquake damage costs, such as through the USGS Prompt Assessment of Global Earthquakes for Response (PAGER) system.

ANSS instrumentation of engineered buildings and other structures to monitor their responses to earthquake ground motion remains less developed. Because of limited funding, a comparatively small number (~168) of structures have been instrumented so far. This type of monitoring is very important to the establishment of better building code requirements and design practices to achieve improved earthquake resistance in both new construction and retrofitted structures. Following damaging earthquakes, real-time monitoring of the response of lifelines and buildings is also valuable in emergency response.

ANSS funding to date is a fraction of the planned and requested capitalization needed to build out the system. In terms of the number of stations, ANSS is only 42% complete, with more than 4,100 stations still needed to meet the ANSS requirements. In a disturbing turn of events, three ANSS member networks were cut from funding during the 2015 reauthorization. Citing lack of funding, the Montana Regional Seismograph Network, a 10-year cooperating ANSS network, lost all USGS support for operation and maintenance.