Measuring earthquakes in Oregon

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How do we know when earthquakes occur? Sometimes, earthquakes are felt by people. Sometimes, they are recorded by seismic instruments. In some cases where there are no people and the seismic instrument coverage is poor, earthquakes are not detected at all. A primary goal of earthquake monitoring with specialized instruments is to detect and locate earthquakes and to obtain a better understanding of potential earthquake sources. Instruments measure data that help scientists understand the likely sizes, locations, frequency of occurence, and types of earthquakes and their effects. In the Pacific Northwest, modern seismic instruments have been recording since about 1950 (Shedlock and Weaver, 1991).

The three main types of seismic instruments are strong-motion instruments, short-period instruments, and broadband instruments. These instruments record ground motions for various levels of shaking (i.e., amplitudes) and frequencies. To explain frequencies in terms of sound: A high pitch is characterized by high frequencies, and a low pitch by low frequencies. In general, strong-motion instruments measure strong levels of shaking over a wide range of frequencies (i.e., a wide bandwidth). In contrast, short-period and broadband instruments measure low levels of shaking; at high levels of shaking, the ground motions are "clipped" or "saturated" and are not recorded. Broadband instruments can measure a wide range of frequencies, whereas short-period instruments measure only high frequencies. Oftentimes, at important locations, both broadband and strong-motion instruments are installed so that a full range of amplitudes and frequencies is recorded.

Other important features of seismic instruments include the type of data-recording system and communication linkage. The age and available resources often dictate the data functionality and accessibility. For example, many older instruments record in analog form on photographic film and usually require on-site visits to download data. Newer instruments record data in a digital format. Recorded data may be designed to be accessed via modem (i.e., phoning the site to retrieve data) or even automatically telemetered back to a central network in real time.

The Pacific Northwest Seismic Network (Network) covers a large part of the Pacific Northwest. The Network is operated through the University of Washington (UW) and the U.S. Geological Survey (USGS) at UW in Seattle, Washington. DOGAMI coordinates with Network staff and helps facilitate the development of the Network. The Network maintains an array of strong-motion, short-period, and broadband instruments. These instruments have communication links that include (a) real-time, (b) dial-up, and (c) on-site downloading. The Network archives the data collected, performs routine processing, and provides information to researchers and the public, including DOGAMI.

The latest technological trend involves "real-time warning systems." It is possible to provide real-time information on earthquakes, provided that adequate instruments and communication links are in place. This new technology can determine the magnitude and location of the earthquake while it is in progress. The goal is to relay information to nearby communities before the onset of damaging shaking. Early warning information has a number of applications. One example is to stop trains so that derailment and loss of shipment does not occur. Several real-time systems are currently operational in the United States. The most advanced system, called California Institute of Technology/U.S. Geological Survey Broadcasting Earthquakes (CUBE), is located in southern California.

The Network is developing a real-time monitoring network, called Rapid Alert of Cascadia Earthquakes (RACE). Ground motions from earthquakes are automatically telemetered to central recording facilities in Seattle. A detection algorithm is immediately applied to these data, and the earthquakes are analyzed by a computerized system that determines earthquake arrival times and epicentral locations. For earthquakes larger than magnitude 2.9, magnitude and location information is quickly disseminated via commercial pager to RACE test sites. DOGAMI, which was the first test site for RACE, is helping the Network by testing an off-site prototype.

Over the next few years, the USGS plans to add several instruments along the coast. The purpose is twofold: (1) to detect Cascadia subduction zone earthquakes that can produce near-field tsunamis, that is, big waves that are generated from nearby offshore earthquakes, and (2) to minimize false alarms of tsunamis, that is, to distinguish inland earthquakes that cannot initiate tsunamis from subduction zone earthquakes that can. The sites will include both strong-motion and broadband instruments. A long-term goal is to develop a real-time, near-field tsunami warning system. This system will warn the citizens in tsunami prone (low-lying coastal) areas to evacuate.

The remaining discussion focuses on DOGAMI's involvement with seismic instruments in Oregon.

DOGAMI's instrumentation program focuses on three fundamental areas:

1 To improve the regional seismic network.
2 To evaluate ground response in the greater Portland area.
3 To satisfy regulations stipulated by Oregon Building Code statutes.

IMPROVE REGIONAL SEISMIC NETWORK

The current instrument density in Oregon is low and needs improvement. DOGAMI's recent survey of all known strong-motion instruments is shown in Figure 1. Public sector owners include the Oregon Department of Transportation Bridge Section, the U.S. Army Corps of Engineers, the U.S. Geological Survey, the Oregon State System of Higher Education, and several local governments. There is only one private-sector owner, who has several instruments at the Trojan power plant in Columbia County.

Strong-motion accelerographs are deployed primarily to record ground motion accelerations generated by earthquakes that might have significant impacts on engineered structures. The primary uses are to provide data for seismological and geotechnical modeling studies and for the design and analysis of engineered structures (e.g., bridges and buildings). Most current systems are designed to trigger the recording mechanism only during substantial shaking (Shaking greater than 0.01 *g* can be felt.) A low level of shaking, for example from traffic vibrations, is ignored.

DOGAMI supports the expansion of the Network to better serve the citizens of Oregon. Oregon's population is concentrated in the greater Portland area and the Willamette Valley. DOGAMI's current records indicate approximately nine strong-motion instruments in this area, of which three belong to the USGS. Instrument density is sparser outside this populated corridor.

DOGAMI has recently proposed to expand the Network in the Portland metropolitan area and the Willamette Valley. We have recommended that 50 free-field strong-motion instruments be added to improve the regional geographic coverage for earthquake monitoring. This would allow scientists to better characterize earthquake seismicity and ground response in developed areas and may lower the current detection threshold for very small earthquakes.

EVALUATING GROUND RESPONSE IN PORTLAND

Currently, DOGAMI and the University of Oregon Department of Geological Sciences (UO) are deploying a temporary seismic network in the greater Portland area. The purpose is to measure and analyze actual earthquake ground response and to evaluate the ground motion amplification portion of the 1997 DOGAMI/Metro relative earthquake hazard map (Mabey and others, 1997). To collect ground motion data, a total of approximately 12 sites will be occupied for six- to eight-week periods over a one-year time span. DOGAMI is responsible for the site selection, which is based on geologic conditions. UO deploys the portable broadband instruments and performs data analyses. This effort is funded by the U.S. Federal Emergency Management Agency (FEMA) and is scheduled to be completed in late 1998.

OREGON BUILDING CODE STATUTES AND RULES

In the 1994 Uniform Building Code, Chapter 16 (Structural Forces), Division II, the sections 1646–1649 (Earthquake Recording Instrumentation) describe the

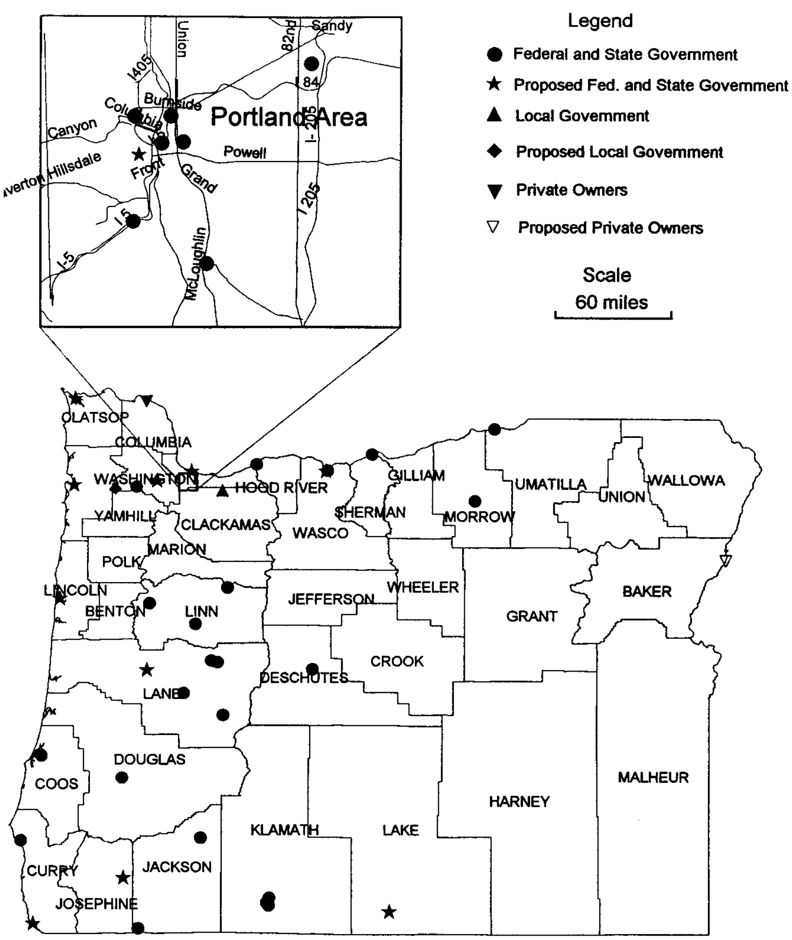

Figure 1. Strong-motion accelerograph stations in Oregon.

requirements of seismic instrumentation for certain newly constructed buildings. The owner/developer of these buildings is required to install seismic monitoring equipment and monitor and maintain the equipment once installation is complete. The purpose of instrumenting buildings is to understand and improve the dynamic response of buildings during earthquakes. Alternately, the owner/developer may be allowed to provide DOGAMI with funds equivalent to the cost of instrumenting the building. DOGAMI will use these funds to acquire and install strong-motion instruments. Sites selection will be focused on such sites that will increase our understanding of structural and regional ground motion response during earthquakes.

DOGAMI is adding two new free-field strong-motion instrument sites in 1998 with the fund moneys. The sites will be located in the greater Portland metropolitan area and integrated into the Network. DOGAMI has identified several possible sites. Characteristics influencing site selection include geologic conditions, security, electrical and communication access, and local background "noise" due to culturally induced vibrations (e.g., traffic).

The Department is also pursuing a cooperative project with USGS staff associated with the Network. DOGAMI has selected the potential sites, and the USGS would evaluate the suitability of these sites with respect to background noise. In addition, DOGAMI would like the USGS to perform initial tests of the newly purchased instruments, install and maintain the instruments, and help collect, analyze, and disseminate data.

REFERENCES CITED

Mabey, M.A., Black, G.L., Madin, I.P., Meier, D.B., Youd, T.L., Jones, C.F., and Rice, J.B., 1997, Relative earthquake hazard map of the Portland metro region, Clackamas, Multnomah, and Washington Counties, Oregon: Oregon Department of Geology and Mineral Industries Interpretive Map Series IMS-1, scale 1:62,500.

Shedlock, K.M., and Weaver, C.S., 1991, Program for earthquake hazards assessment in the Pacific Northwest: U.S. Geological Survey Circular 1067, 29 p. □

DOGAMI PUBLICATIONS

Released February 12, 1998

Best Management Practices for Reclaiming Surface Mines in Washington and Oregon, revised edition, December 1997, by David K. Norman, Peter J. Wampler, Allen H. Throop. E. Frank Schnitzer, and Jaretta M. Roloff. Open-File Report O–96–02 rev., approx. 130 p., $8.

The manual describes reclamation and mining practices for landowners, land-use planners, and mine operators in Oregon and Washington. The revision incorporates comments from the mining industry as well as other reviewers of the initial 1996 release. In addition, several new diagrams and innovative best management practices have been added.

Best Management Practices was produced cooperatively by members of the Washington Department of Natural Resources, Division of Geology and Earth Resources, and the DOGAMI Mined Land Reclamation Program. The project was supported in part by the U.S. Environmental Protection Agency and conducted under the Tri-State Agreement for Mining between Idaho, Oregon, and Washington.

The approximately 130-page, extensively illustrated manual provides information about managing a surface mine from start-up to final reclamation, incorporating water and erosion control during operation and reclamation, soil salvage and replacement, land shaping, and revegetation. The authors urge miners to use this manual as a resource in developing an environmentally and financially sound mine.

The Capes Landslide, Tillamook County, Oregon, by George R. Priest. Open-File Report O-98-02, 10 p., $5.

The report concerns the current landslide threat to The Capes development near Netarts on the coast of Tillamook County. It contains a preliminary assessment of the geologic conditions and discusses some possible options for mitigating this hazard.

It was prepared by Dr. Priest as a memorandum to the Director of the Oregon Emergency Management Division of the Oregon State Police Department. The report includes two draft illustrations showing the location of the landslide and a cross section.

Released February 12, 1998

Tsunami Hazard Map of the Yaquina Bay Area, Lincoln County, Oregon, by George R. Priest, Edward Myers, António M. Baptista, Robert A. Kamphaus, Curt D. Peterson, and Mark E. Darienzo. Interpretive Map Series IMS-2, two-color, scale 1:12,000 (aerial-photo base map), $6.

The new map is intended primarily for evacuation planning for the event of a tsunami but could also be adopted as a basis for planning and decisions in the areas of building code, construction, or insurance ratings.

The map was produced by Dr. George R. Priest in cooperation with scientists from the Oregon Graduate Institute of Science and Technology, the Center for

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