Appendix D
Earthquake Profile

In February of 2001, FEMA produced a report entitled, "HAZUS®99 Estimated Annualized Earthquake Losses for the United States." Likely direct losses to building inventory due to potential earthquakes were estimated and ranked for all 50 states and the District of Columbia. Oregon appeared third on the list behind California and Washington. A separate 1999 study conducted by Wang and Clark for the Oregon Department of Geology and Mineral Industries (DOGAMI) found that a major earthquake along the Cascadia Subduction Zone could likely result in 8,000 casualties, $12 billion dollars in direct damages and over 30,000 destroyed buildings. Lane County topped the list of combined economic loss and loss ratio due to a major earthquake. Neither of these studies accounted for indirect losses that would push damage numbers far higher. In addition to economic studies, many recent geologic studies show that Oregon has a history of significant seismic activity. The Cascadia Subduction Zone has produced magnitude 8.0-9.0 earthquakes, though none have occurred during the relatively short period of Oregon's written history. All of Western Oregon remains vulnerable to a large Cascadia event and the heavily populated metropolitan areas of Portland, Salem, and Eugene would likely experience major damage.[1]

Characteristics & Terminology

Most large earthquakes in the Pacific Northwest are shallow crustal, deep intraplate, or subduction zone earthquakes.

Crustal Fault Earthquakes

Crustal fault earthquakes are the most common earthquakes and occur at relatively shallow depths of 6-12 miles below the surface.[2] While most crustal fault earthquakes are smaller than magnitude 4.0 and generally result in limited damage, some have produced earthquakes of magnitudes 7.0 and higher and caused extensive damage.

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1 State of Oregon Pre-Disaster Mitigation Plan (http://csc.uoregon.edu/PDR_website/projects/state/SNHMP_WEB/hazard-pages/earthquakes_web.htm)

2 Wong, Ivan G and Bott Jacqueline D.J. (November 1995). A look back at Oregon's earthquake history, 1841- 1994. Oregon Geology 57 (6). 125.

Deep Intraplate Earthquakes

Occurring at depths from 25 to 40 miles below the earth's surface in the subducting oceanic crust, deep intraplate earthquakes can reach magnitude 7.5.[3] The February 28, 2001 earthquake in Washington State was a deep intraplate earthquake. It produced a rolling motion that was felt from Vancouver, British Columbia to Coos Bay, Oregon and east to Salt Lake City, Utah. A 1965 magnitude 6.5- intraplate earthquake centered south of the Seattle-Tacoma International Airport caused seven deaths.[4]

Subduction Zone Earthquakes

The Pacific Northwest is located at a convergent plate boundary where the Juan de Fuca and North American tectonic plates meet. The two plates move 1-2 inches per year, which forces the Juan de Fuca plate to fold under the North American plate. This boundary where the plates meet is called the Cascadia Subduction Zone and extends from British Columbia to northern California. Subduction zone earthquakes are caused by the abrupt release of slowly accumulated stress. Situations similar to the Cascadia Subduction Zone have produced earthquakes with magnitudes of 8.0 or larger. Such earthquakes may cause great damage to the coastal area of Oregon as well as inland areas in western Oregon. It is estimated that shaking from a large subduction zone earthquake could last up to five minutes.

Earthquake Related Hazards

Ground Shaking

Ground shaking is the motion felt on the earth's surface caused by seismic waves generated by an earthquake. It is the primary cause of earthquake damage. The strength of ground shaking depends on the magnitude of the earthquake, the type of fault, and distance from the epicenter (where the earthquake originates). Buildings on poorly consolidated and thick soils will typically see more damage than buildings on consolidated soils and bedrock.

Liquefaction

Liquefaction occurs when ground shaking causes wet granular soils to change from a solid to a liquid state. This results in the loss of soil strength and three potential types of ground failure: lateral spreading, flow failure, and loss of bearing strength. Buildings and their occupants

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3 Wong, Ivan G and Bott Jacqueline D.J. (November 1995). A look back at Oregon's earthquake history, 1841- 1994. Oregon Geology 57 (6). 125.

4 Hill, Richard. "Geo Watch Warning Quake Shook Portland 40 Years Ago." The Oregonian, October 30, 2002

are at risk when the ground is unable to support the weight of the structure. Increased susceptibility to liquefaction occurs in areas with high ground water tables and sandy soils.[5]

Amplification

Soils and soft sedimentary rocks near the earth's surface can result in localized areas of intensified ground shaking during an earthquake. This hazard is known as amplification and the amount of amplified motion depends on the physical properties and depth of the soft material. Buildings and structures built on soft and unconsolidated soils face greater risk of damage.[6] IMS-14, a DOGAMI report on the relative earthquake hazard level in Eugene and Springfield revealed that the campus soil does not amplify ground motion.

Location and Extent of Earthquake Hazard

The University of Oregon is located in seismic region 3, indicating a moderate to high earthquake threat. The state of Oregon is designated as a, "Very High Seismic Hazard," due to the types and magnitudes of earthquakes that are likely. The geographical position of the university makes it susceptible to earthquakes from four sources: 1) the off-short Cascadia Fault Zone, 2) deep intra-plate events within the subducting Juan de Fuca place, and 3) shallow crustal events within the North America Plate, and 4) earthquakes associated with renewed volcanic activity. All are related to the subduction of the dense, oceanic Juan de Fuca Plate under the light, continental North America Plate.[7] According to DOGAMI report IMS-14 in 2000 the University is most likely to be effected by either a great Cascadia subduction zone event or a local crustal fault earthquake. Parameters characterizing these two events were used to create HAZUS simulations and are described in the chart below.

Table D.1. Potential Earthquakes Effecting Lane County

	Cascadia Subduction Zone	Local Crustal Fault
Magnitude	M8.5	M6.7
Location	44.05 N 124.5 W	44.07 N 122.5 W
Fault Type	Reverse Slip	Reverse Slip
Fault Dip	10°	80°
Ruptre Depth	20km	8.5km

5 City of Portland Natural Hazard Mitigation Plan, 2004

6 City of Portland Natural Hazard Mitigation Plan, 2004

7 State of Oregon Natural Hazards Mitigation Plan

Previous Occurrences of Earthquakes

Although the University of Oregon has felt tremors and after-shocks from earthquakes that have occurred within the last 100 years, it has not sustained any damage. Earthquakes felt in Eugene occurred on the following dates: January 14, 1932; May 12, 1942; August 18, 1961; and March 7, 1963. Details of these events can be found in the table below.

Table D.2. Eugene Earthquake History

Date of Earthquake	Earthquake Details
January 14, 1932	Portland and Willamette Valley. 4 Magnitude.
May 12, 1942	Maximum 5 Magnitude at Corvallis.
August 18, 1961	Northwestern Oregon. Felt from southwest Lane County to Cowlitz County, Washington. 4.5 Magnitude.
March 7, 1963	Northwestern Oregon, west of Salem. Felt from Portland to Eugene. 4.6 Magnitude.

According to a Oregon Department of Geology and Mineral Industries report on "Selected Earthquakes for Oregon 1841-2002," by Niewendorp and Neuhaus, many other significant earthquakes have effected Oregon and the Northwest Region. A few of the largest are described in the table below.

Table D.3. Northwest Region Earthquake History

Date	Location	Magnitude	Comments
	Cascadia Subduction Zone	8-9	Research on coastal wetlands sediment deposits by Kelsey, Witter and Hemphill-Haley indicate that over the past 6700 years, the Cascadia Subduction Zone has produced 12 major earthquakes with an average recurrence interval between 570-590 years. Intervals between quakes have varied from 300 to more than 1000 years.
Jan 26, 1700	Offshore, Cascadia subduction zone	9	Gerated tsunamis in Oregon, Washington and Japan. Native American villages along the coast were destroyed.
Nov 23, 1873	OR/CA birder near Brookings	6.8	Felt in Portland and San Francisco. Lack of aftershocks has led scientists to believe it was an intraplate earthquake.
July 15, 1936	Milton-Freewater	6.4	2 foreshocks and many aftershocks caused $100,000 (1936 dollars) in damage.
April 13, 1949	Olympia, WA	7.1	Resulted in 8 deaths and $25 million (1949 dollars) in damage. Caused minor damage in northwest Oregon.
Nov 5, 1962	Portland/Vancouver	5.5	Shaking lasted 30 seconds and caused damage to masonry and windows.
1968	Adel	5.1	Swarm lasted from May through July and increased flow at a local hot spring.
April 12, 1976	Near Maupin	4.8	Sounds described as distant thunder, sonic booms and strong wind.
April 25, 1992	Cape Mendocino, CA	7.0	Subduction zone earthquake at the triple junction of the Cascadia subduction zone, and the San Andreas and Medicino faults.
March 25, 1993	Scotts Mills	5.6	$30 million in damage.
Sept 20, 1993	Klamath Falls	5.9 and 6.0	Resulted in 2 deaths and $10 million in damages
Feb 28, 2001	Near Olympia, WA	6.8	Resulted in 400 injuries and $3.9 billion in damages in the Seattle Tacoma area.

Scientific evidence from liquefaction features, carbon dating, tree ring dating as well as Japanese records of a Pacific Tsunami and Native American legends, indicate that what is now commonly accepted as a M9 earthquake occurred in January of 1700. [8] Further research on coastal wetlands sediment deposits by Kelsey, Witter and Hemphill-Haley indicate that over the past 6700 years, the Cascadia Subduction Zone has produced 12 major earthquakes with an average recurrence interval between 570-590 years. Intervals between quakes have varied from 300 to more than 1000 years.[9] Between 1873 and 2001, 10 major earthquakes ranging in magnitude from M4.8 to M7.1 have affected the state of Oregon and more than 14,000 additional smaller earthquakes have been recorded.[10] Further, a potential loss estimation study

8 Wang and Clark, DOGAMI Special paper 29

9 Witter, Kelsey and Hemphill-Haley, "Great Cascadia earthquakes and tsunamis of the past 6700 years, Coquille River estuary, southern costal Oregon." pgs 1289-1306, Geological Society of America, October 2003.

10 McConnell, Map of Selected Earthquakes for Oregon, 1841 through 2002. Oregon Department of Geology and mineral Industries, 2003.

undertaken by the Oregon Department of Geology and Mineral Industries (DOGAMI) in 1999, ranks Lane County highest in the state for potential losses resulting from a large Cascadia Subduction Zone Earthquake and third highest for an average crustal fault earthquake.[11]

11 Wang and Clark, DOGAMI Special Paper 29