10.0 VOLCANIC HAZARDS

10.1 Overview

The Cascades, which run from British Columbia through Washington and Oregon into northern California, contain more than a dozen major volcanoes and hundreds of smaller volcanic features. In the past 200 years, seven of the Cascade volcanoes in the United States have erupted, including: Mt. Baker, Glacier Peak, Mt. Ranier, Mount St. Helens, Mt. Hood, Mt. Shasta, and Mt. Lassen.

Over the past 4000 years (a geologically very short time period) in Oregon there have been three eruptions of Mt. Hood, four eruptions in the Three Sisters area, and two eruptions in the Newberry Volcano area and minor eruptions near Mt. Jefferson, at Blue Lake Crater, in the Sand Mountain Field (Santiam Pass), near Mt. Washington, and near Belknap Crater. During this time period, the most active volcano in the Cascades has been Mount St. Helens with about 14 eruptions.

In addition, many other volcanoes in Oregon are deemed active or potential active. The Smithsonian Institutions Global Volcanism Project lists 20 active volcanoes in Oregon. These volcanoes are listed below in Table 10.1.

Table 10.1
Active Volcanoes in Oregon

Volcano	Type	Last Eruption
Mt. Hood	Stratovolcano	1866
Mt. Jefferson	Stratovolcano	950 main volcano inactive for >10,000 years
Blue Lake Crater	Crater	1490 BC
Sand Mountain Field	Cinder cones	1040 BC?
Mt. Washington	Shield volcano	620 main volcano inactive
Belknap Field	Shield volcanoes	460?
North Sister Field	Complex volcano	350
South Sister	Complex volcano	50 BC?
Mt. Bachelor	Stratovolcano	5800 BC
Davis Lake	Volcanic field	2790 BC?
Newberry Volcano	Shield volcano	620 crater formation 300,000 to 500,000 years ago
Devis Garden	Volcanic field	unknown
Squaw Ridge Lava Field	Volcanic field	unknown
Four Craters Lava Field	Volcanic field	unknown
Cinnamon Butte	Cinder cones	unknown
Crater Lake	Caldera	2290 BC Crater formation about 7,700 years ago
Diamond Craters	Volcanic field	unknown
Saddle Butte	Volcanic field	unknown
Jordan Craters	Volcanic field	1250 BC
Jackies Butte	Volcanic field	unknown

On a longer geological time scale, volcanic activity in the Cascades has been very widespread. A DOGAMI report on prehistoric and historic volcanic eruptions in Oregon (see website below) notes that in the Cascades as a whole, over 3,000 large and small volcanoes have erupted over the past five million years. Within historical times, between 1843 and 1860 there were a series of 21 eruptions in the Cascades and there is some scientific speculation that the Northwest may be entering another period of volcanic activity.

A great deal of general background information on Oregon volcanoes and on volcanoes in general is available on several websites, including the following.

Table 10.2
Volcano Websites

Institution	Website
Smithsonian Institution (Global Volcanism Project)	www.volcano.si.edu
United States Geological Survey (USGS) - general site	www.usgs.gov
USGS Cascades Volcano Observatory (Vancouver, WA)	http://vulcan.wr.usgs.gov
DOGAMI	www.oregongeology.com

The numerous volcanoes of the Cascades differ markedly in their geological characteristics. The largest volcanoes are generally what geologists call composite or stratovolcanoes. These volcanoes may be active for tens of thousands of years to hundreds of thousands of years. In some cases, these large volcanoes may have explosive eruptions such as Mt. St. Helens in 1980 or Crater Lake about 7,700 years ago. The much more numerous sites of volcanic activity are generally what geologists call mafic volcanoes. This type of volcano is typically active for much shorter time periods, up to a few hundred years, and generally forms small craters or cones. Mafic volcanoes are not subject to large explosive events.

10.2 Volcanic Hazard Types

In Oregon, awareness of the potential for volcanic eruptions was greatly increased by the May 18, 1980 eruption of nearby Mount. St. Helens in Washington which killed 57 people. In this eruption, lateral blast effects covered 230 square miles and reached 17 miles northwest of the crater, pyroclastic flows covered six square miles and reached 5 miles north of the crater, and landslides covered 23 square miles. Ash accumulations were about 10 inches at 10 miles downwind, 1 inch at 60 miles downwind, and ½ inch at 300 miles downwind. Lahars (mudflows) affected the North and South Forks of the Toutle River, the Green River, and ultimately the Columbia River as far as 70 miles from the volcano.

Volcanic eruptions often involve several distinct types of hazards to people and property, as well evidenced by the Mount St. Helens eruption. Major volcanic hazards include: lava flows, blast effects, pyroclastic flows, ash flows, lahars, and landslides or debris flows. Some of these hazards (e.g., lava flows) only affect areas very near the

volcano. Other hazards may affect areas 10 or 20 miles away from the volcano, while ash falls may affect areas many miles downwind of the eruption site.

Lava flows are eruptions of molten rock. Lava flows for the major Cascades volcanoes tend to be thick and viscous, forming cones and thus typically affecting areas only very near the eruption vent. However, flows from the smaller mafic volcanoes may be less viscous flows that spread out over wider areas. Lava flows obviously destroy everything in their path.

Blast effects may occur with violent eruptions, such as Mount St. Helens in 1980. Most volcanic blasts are largely upwards. However, the Mount St. Helens blast was lateral, with impacts 17 miles from the volcano. Similar or larger blast zones are possible in future eruptions of any of the major Cascades volcanoes.

Pyroclastic flows are high-speed avalanches of hot ash, rock fragments and gases. Pyroclastic flows can be as hot as 1500 ^{o}F and move downslope at 100 to 150 miles per hour. Pyroclastic flows are extremely deadly for anyone caught in their path.

Ash falls result when explosive eruptions blast rock fragments into the air. Such blasts may include tephra (solid and molten rock fragments). The largest rock fragments (sometimes called “bombs”) generally fall within two miles of the eruption vent. Smaller ash fragments (less than about 0.1”) typically rise into the area forming a huge eruption column. In very large eruptions, ash falls may total many feet in depth near the vent and extent for hundreds or even thousands of miles downwind.

Lahars or mudflows are common during eruptions of volcanoes with heavy loading of ice and snow. These flows of mud, rock and water can rush down channels at 20 to 40 miles an hour and can extend for more than 50 miles. For some volcanoes, lahars are a major hazard because highly populated areas are built on lahar flows from previous eruptions.

Landslides or debris flows are the rapid downslope movement of rocky material, snow and/or ice. Volcano landslides can range from small movements of loose debris to massive collapses of the entire summit or sides of a volcano. Landslides on volcanic slopes may be triggered be eruptions or by earthquakes or simply by heavy rainfall.

10.3 Volcanic Hazards for Lane County

Several of the 20 active volcanoes in Oregon (See Table 10.1) are located along the crest of the Cascades near the eastern boundary of Lane County. These volcanoes include the Three Sisters, Mt. Bachelor and the Davis Lake volcanic field. Other relatively nearby active volcanoes include several near the eastern boundary of Linn County, including: Mt. Jefferson, Blue Lake Crater, Mt. Washington, the Belknap Crater field, and the Sand Mountain field. Other relatively nearby volcanoes include

the Newberry Volcano in Deschutes County and Crater Lake in Klamath County.

Among the Linn County volcanoes, Mt. Jefferson has not been active for perhaps 15,000 years and Mt. Washington has not been active for several hundred thousand years. Mt. Jefferson is potentially active, while Mt. Washington is probably extinct. Most of the other Linn County volcanoes are smaller mafic volcanoes or volcanic fields (clusters of cones, vents, craters) that typically have smaller, much more localized eruptions compared to the larger volcanoes. Newberry Volcano had minor eruptions about 1,500 years ago, but the major crater formation probably occurred about 300,000 to 500,000 years ago. Crater Lake has not been active for about 4,000 years, with major crater formation about 7,700 years ago.

The Eugene/Springfield Metro Area is approximately 50 miles from the nearest volcanoes (Three Sisters). This distance is large enough that the Eugene/Springfield Metro Area is extremely unlikely to have major impacts from eruptions of any of these volcanoes. Smaller communities in northeastern Lane County, including Belknap Springs and McKenzie Bridge are much closer to active or potentially active volcanoes.

We review the volcanic hazards posed by the Three Sisters, which are the nearest, most recently active major volcanoes affecting Lane County. Awareness of potential volcanic activity at the Three Sisters has been raised because of the recent discovery of an uplift (bulge) on the west side of South Sister. In May 2001, the USGS announced that it had detected a slight swelling or uplift of the west side of South Sister. This bulge, which occurred between 1996 and 2000, covers an area about 9 to 12 miles in diameter, with a maximum bulge in the center of about 4 inches. The cause of this uplift (bulge) is most likely intrusion of a small amount of magma (molten rock) deep under the surface, probably at a depth of about 4 miles.

This observation confirms that South Sister is still an active volcano, but needs to be interpreted cautiously. For comparison, a bulge was also observed on the north side of Mount St. Helens in the months prior to the May 18, 1980 eruption. However, the Mount St. Helens bulge was 450 feet high and growing at a rate of 5 feet per day prior to the eruption. Thus, the South Sister bulge of 4 inches is certainly <u>not</u> an indication of an imminent eruption.

The UGSG analysis of Volcano Hazards in the Three Sisters Region, Oregon was published in 1999 (Open-File Report 99-437).

The Three Sisters area includes two large composite volcanoes (Middle and South Sister). Large composite volcanoes in the Cascades (e.g., Mt. Hood, Mt. Jefferson, Newberry Volcano, Crater Lake) are often active for hundreds of thousands of years and are subject to sometimes explosive eruptions (e.g., Mount St. Helens in 1980). Hazards from eruptions of composite volcanoes include all of the hazards listed above in Section 10.2.

Between the major composite volcanoes, the crest of the Cascades is built up of hundreds of “mafic” volcanoes. Mafic volcanoes typically erupt for a few weeks to a few centuries, although some can be nearly as large as the composite volcanoes. Prominent mafic volcanoes in the Three Sisters area include North Sister, Mount

Bachelor, Belknap Cater, Black Butte, and Mount Washington. Mafic volcanoes often form broad fields of volcanic vents such as in the Sand Mountain Field near the Santiam Pass, north of the Three Sisters.

Mafic volcanoes typically erupt less explosively than do composite volcanoes, so that impacts of eruptions are less widespread. Most mafic eruptions in the Three Sisters areas have produced tephra deposits and lava flows that typically traveled 3 to 9 miles from the vents and rarely 9 to 12 miles from the vents. Tephra deposits rarely exceed 4 inches in thickness at distances 6 miles from the vent.

Belknap Crater, about 1,500 years old, is one of the youngest mafic volcanoes in the Cascades. The Sand Mountain field, a cluster of cones and lava flows west of Santiam Pass, was formed during three eruptive periods between about 2,000 and 4,000 years ago.

The USGS study of Volcano Hazards in the Three Sisters Region includes three hazard zones: proximal hazards, distal hazards, and a regional lava flow hazard zone.

> **The proximal hazard zone** is limited to the immediate area around the Three Sisters and is an oval area about 8 miles (east-west) by 10 miles (north-south). The proximal hazard area is the area subject to the most intense volcanic hazards including lava flows, tephra flows, pyroclastic flows, landslides and debris flows and lahars. Fortunately, this area is predominantly wilderness with very low population.
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> **The distal hazard zones** are river valleys extending away from the proximal hazard zone that are subject to landslides, debris flows and lahars. The distal hazard zone has three levels for areas subjected to lahars (and other flows) of varying sizes. Areas subjected to lahars include Squaw Creek into Sisters, Tumalo Creek into Bend, the valley between Sparks Lake and Crane Prairie Reservoir, and the McKenzie River (and tributaries) west of the Three Sisters.
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> **The regional lava flow hazard** zone includes a band about 30 to 40 miles wide covering the entire crest of the Cascades. Locations throughout this zone, which includes Sisters, Bend, and the Santiam Pass, are subject to lava flows from mafic volcanism would could occur anywhere in this entire zone.

Of these Three Sisters volcanic hazards zones, the distal hazard zone (river valleys subject to landslides, debris flows and lahars) affects the populated areas in northeastern Lane County. To a much lower extent, volcanic at the Three Sisters could affect the Eugene/Springfield Metro Area and other downstream communities. Landslides, debris flows and lahars into the McKenzie River (or into tributaries) might result in minor flooding impacts downstream. Substantial landslides, debris flows, lahars, or ash falls affecting the McKenzie River would impact the water system in the Eugene/Springfield Metro Area. Water drawn from the McKenzie River would likely have high turbidity and potentially cause operational problems at water treatment plants.

Importantly, because of distance and topography, possible lahar effects do not affect the Blue River or Cougar Reservoirs in northeastern Lane County or any of the upstream reservoirs on the Willamette.

Thus, the extent of volcanic hazards for most of Lane County appears limited to the possibility of minor ash falls from eruptions at the Three Sisters, at other locations in the Cascades or elsewhere (e.g., Mount St. Helens) and possible impacts on the water system. In all but the most extreme events, ash falls for most communities are likely to be very minor with an inch or less of ash likely. In addition, volcanic events in the Three Sisters area, the McKenzie Pass area or in the Santiam Pass area could temporarily close some highways thus affect transportation systems to some minor extent.

There is also a possibility that a major eruption in the Cascades could affect public water supplies via heavy ash falls or lahars into streams/rivers upstream from public water supply intakes. Thus, there is some potential for high turbidity or other water quality issues arising from future volcanic events.

Ash falls can also disrupt electric power systems because of short circuits when ash covers insulators and thus significant ash falls may also be accompanied by temporary outages of electric power systems.

In addition the potentially widespread, but relatively minor impacts of ash falls, which could affect all or most of Lane County, the small communities in northeastern Lane County are subject to heavier ash falls, and to more direct impacts including lahars, landslides, and river valley flooding.

The probable impacts of potential volcanic eruptions on Lane County are summarized below in Table 10.3.

Table 10.3
Probable Impacts of Potential Volcanic Eruptions on Lane County

Inventory	Probable Impacts
Portion of Lane County affected	Entire County and surrounding region. Small lightly-populated areas in eastern Lane County are likely to have heavier ash falls and could be affected by lahars or other results of eruptons.
Buildings	Negligible impact, other than minor cleanup required
Streets within Lane County	Negligible impact, other than minor cleanup required
Roads to/from Lane County	Negligible impact, other than minor cleanup required
Electric power	Power outages likely from short circuits caused by ash falls
Other Utilities	Negligible impact, other than minor cleanup required for most utilities. Potential to impact water treatment plants which may require additional maintenance to deal with high turbidity water
Casualties	Some potential for health impacts, especially for frail people with respiratory problems.

10.4 Mitigation of Volcanic Hazards

Mitigation of volcanic hazards is predominantly in the areas of monitoring volcanic activity, warnings and evacuation, and emergency response. That is, there are few, if any, practical physical measures to mitigate the direct impacts of volcanic activity.

The USGS actively monitors volcanic activity in the Cascades via networks of seismic sensors (which can detect earthquakes related to magma movements) as well as very accurate ground surface measurements, such as that which has detected the very small bulge on South Sister. The USGS also has a volcanic warning system with several levels of alert as a potential eruption becomes more likely and more imminent.

For the Cascades, the USGS volcano warning system (www.usgs.gov) has three levels. Level One (Volcanic Unrest) means anomalous conditions that could be indicative of an eventual volcanic eruption. Level Two (Volcanic Advisory) means that processes are underway that have a significant likelihood of culminating in hazardous volcanic activity, but when the evidence does not indicate that a life- or property-threatening event is imminent. Level Three (Volcano Alert) means that monitoring or evaluation indicate that precursory events have escalated to the point where a volcanic event with attendant volcanologic or hydrologic hazards threatening to life and property appears imminent or is underway.

For most of Lane County, which is located well outside of any of the likely direct hazard zones for any Cascades volcanic events, mitigation for volcanic activity is likely a low priority. In the event of a minor ash flow, public warnings directing people (especially those with respiratory problems) to remain indoors, and minor cleanup are most likely the only necessary responses for most of Lane County. In addition, water treatment plants should be evaluated to ensure that they can handle possible high turbidity events from volcanic ash falls into water supplies.
Communities in northeastern Lane County may wish to upgrade the volcanic eruptions portions of their emergency plans.

The following table includes the volcanic hazards mitigation action items from the master Action Items table in Chapter 4.

Table 10.4
Volcanic Hazards Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Ideas	Plan Goals Addressed					
					Public Awareness	Life Safety	Protect Property Minimize Losses	Partnerships & Implementation	Emergency Services	Protect Environment
Volcanic Hazards Mitigation Action Items										
Short-Term #1	Update publilc emergency notification procedures for ash fall events		1-2 Years	pg. 4-4 pg. 11-6		X			X	
Short-Term #2	Update emergency response planning for ash fall events		1-2 Years	pg. 4-4 pg. 11-6		X			X	
Short-Term #3	Evaluate capabililty of water treatment plants to deal with high turbidity from ash falls and upgrade treatment facilities and emergency response plans to deal with ash falls	Water agencies	1-2 Years	pg. 4-4 pg. 11-6					X	