Mount Rainier–
Learning to Live with Volcanic Risk

Volcano Hazards

Mount Rainier

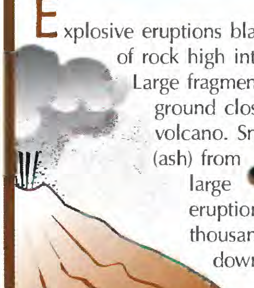
LAVA FLOWS

Lava is molten rock that flows or oozes onto the earth's surface. Mount Rainier consists largely of numerous lava flows interbedded with rock rubble.

PYROCLASTIC FLOWS

Pyroclastic flows are hot avalanches of lava fragments and gas formed by the collapse of thick lava flows and eruption columns.

TEPHRA



Explosive eruptions blast fragments of rock high into the air. Large fragments fall to the ground close to the volcano. Small fragments (ash) from large eruptions can travel thousands of miles downwind.

LAHARS

Lahars are fast-moving slurries of volcanic rock, mud, and water that look and behave like flowing concrete. They originate either from massive volcanic landslides or from surges of eruption-generated meltwater.

Mount Rainier in Washington state is an active volcano reaching more than 2.7 miles (14,410 feet) above sea level. Its majestic edifice looms over expanding suburbs in the valleys that lead to nearby Puget Sound. USGS research over the last several decades indicates that Mount Rainier has been the source of many volcanic mudflows (lahars) that buried areas now densely populated. Now the USGS is working cooperatively with local communities to help people live more safely with the volcano.

Lahars are the greatest hazard

Mount Rainier (fig. 1) is an active volcano that is currently at rest between eruptions. Its next eruption might produce volcanic ash, lava flows, or pyroclastic flows. The latter can rapidly melt snow and ice, and the resulting meltwater torrent could produce lahars (a word of Indonesian origin that has come to mean volcanic mudflow) that travel down valleys beyond the base of the volcano to areas now densely populated. Lahars caused by large landslides can also occur during non-eruptive times–without the seismicity and other warnings that normally precede eruptions.

FIGURE 1.—*View across Puyallup River valley toward Mount Rainier (Photograph by David Wieprecht, U.S. Geological Survey.)*

Lahars look and behave like flowing concrete, and their impact forces destroy most man-made structures. At Mount Rainier, they have traveled 45-50 miles per hour at depths of 100 feet or more in confined valleys, slowing and thinning in the wide, now-populated valleys.

At Mount Rainier, lahars are a greater hazard than other volcanic products such as lava and poisonous gases that have been popularized by TV and film. Lava flows and pyroclastic flows are unlikely to extend more than a few miles beyond the National Park boundaries. Volcanic ash (tephra) will be distributed downwind, 80 percent of the time toward the east away from large populations (fig. 2).

The USGS, in cooperation with the University of Washington, monitors many Cascade Range volcanoes, including Mount

Rainier, to detect precursors to eruptive activity. Mount Rainier last erupted in the 19th century; one or more small eruptions from one of the summit craters produced local ashfall.

Mount Rainier is one of the most hazardous volcanoes in the United States

Although Mount Rainier has erupted less often and less explosively in recent millennia than its neighbor, Mount St. Helens, the proximity of large populations makes Mount Rainier a far greater hazard to life and property.

1. *The population at risk*—More than 150,000 people reside on the deposits of previous lahars.
2. *The size and frequency of lahars*—During the past few millennia lahars that have reached the Puget Sound lowland have occurred, on average, at least every 500 to 1,000 years. Smaller flows not extending as far as the lowland occur more frequently. If lahars of the future happen at rates similar to those of the past, there is at least a one in seven chance of a lahar reaching the Puget Sound lowland during an average human life-span.
3. *We may not have advance warning*–USGS research shows that some lahars occur with little or no warning. Our only warning could be a report that a flow is under way.

Past lahars indicate future hazards

Geologists determine the size and timing of past lahars and use this information to indicate future hazard potential. For example, in figure 3, the areas inundated by the 2,300 year-old National Lahar in the Nisqually Valley, and the 500 year-old Electron Mudflow in the Puyallup Valley are superimposed on all valleys surrounding Mount Rainier. They illustrate areas that could be inundated if flows of those sizes occurred in each valley.

A lahar flowing downvalley from Mount Rainier leaves a thick valley-bottom deposit of boulders and hardened mud that may envelop stump

Probability of Tephra Accumulation

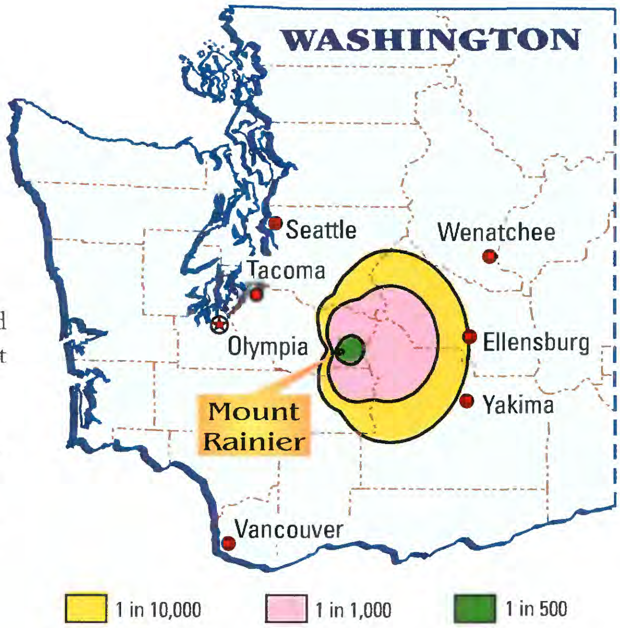


FIGURE 2.—*Map showing the annual probability that volcanic ash will be deposited to a thickness of 1/3 inch or more from an eruption of Mount Rainier. Volcanic ash, of this thickness or less, can cause disruption of ground and air transportation, and can cause damage to electronics and machinery.*

and logs, forming a buried forest. Some of the deposits can be traced upstream to the volcano's flanks, and all contain volcanic fragments unique to Mount Rainier. Geologists map the deposits and determine the tree ages to learn when the trees were engulfed and killed by the lahar. Old-timers recall encountering huge buried stumps and logs when plowing fields and digging wells. The youngest such forest was buried about 500 years ago and uncovered during excavations for new homes in the Puyallup River valley.

Lahars form in several ways

Some of the largest lahars have originated by collapse of weakened rock from the flanks of the volcano—a large landslide known as a flank collapse. During eruptions, molten rock is injected into cracks of the volcano and solidifies as slabs of rock called dikes. The cooling magma releases gases and heat into groundwater, making it hot and acidic. The hot, acidic waters convert hard volcanic rock into soft, clay-rich rock by a process called hydrothermal alteration. When masses of water-rich rock collapse, they transform rapidly into a muddy slurry—a clay-rich (also called cohesive) lahar that is funneled into one or more surrounding valleys.

Sand-rich lahars, also known as noncohesive lahars, form during eruptions of Mount Rainier when hot pyroclastic flows melt snow and ice. (Mount Rainier supports more than one cubic mile of glacial ice—as much as all other Cascade Range volcanoes combined.) Because sand-rich lahars occur during eruptive activity, they are likely to be preceded by events that will warn of an impending eruption, and thus of increased lahar potential.

Small lahars, traveling only a few miles, are caused by local avalanches of rock debris, sudden releases of glacial meltwater, or intense rainfall. These lahars occur many times each century.

New lahar deposits may get redistributed downstream over a period of many years as the disrupted drainage network is re-established. Thus, valley-floor areas that were not inundated by the initial lahar deposits may suffer enhanced flooding and progressive burial by remobilized sediment (zone of post-lahar sedimentation in figure 3).

Weakened rock and rising magma can cause flank collapse

Flank collapses can be triggered when magma intrudes into a volcano and destabilizes it, as happened at Mount St. Helens in 1980.

A neighboring volcano—Mount Baker—produced flank collapses in the 1840's that were apparently triggered by steam explosions related to volcanic activity. Steam explosions at Mount Rainier could trigger flank collapses and lahars with little or no advance warning. Although many flank collapses occur during eruptive periods, it is possible for them to be triggered by earthquakes or they may be the result of progressive weakening of the rock, saturation by groundwater and the continuing pull of gravity.

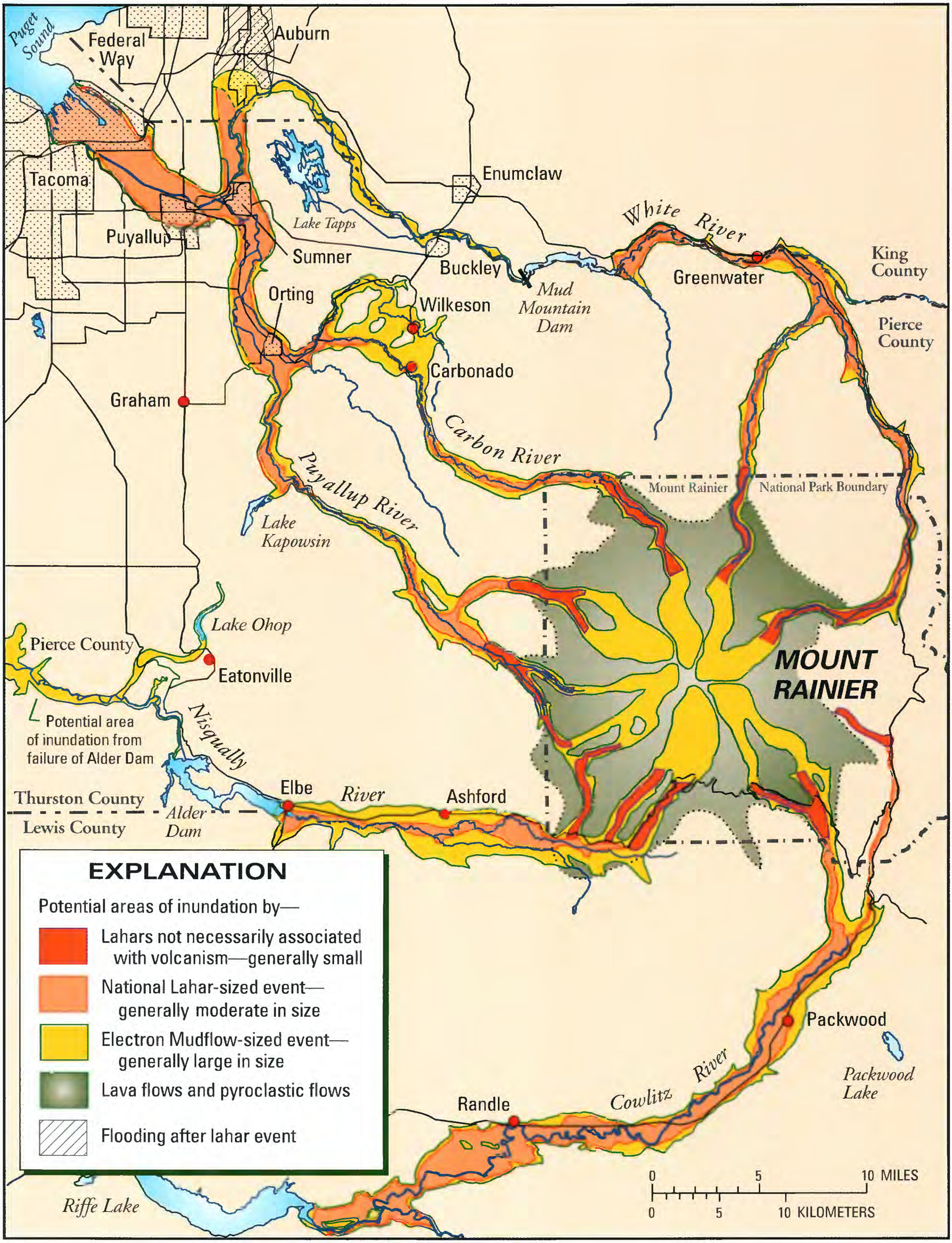


Figure 3.—*Hazard zones for lahars, lava flows, and pyroclastic flows from Mount Rainier (Hoblitt and others, 1998; US Geological Survey Open-File Report 98-428). The map shows areas that could be inundated if events similar in size to those of the past occurred today. Lahar hazard is not equal in all valleys. Puyallup Valley is the valley most susceptible to lahars caused by flank collapse. Risk to individual drainages will be refined as scientists learn more about the volcano.*

Flanks of volcano can unleash flank collapses and rockfalls

The west flank at the head of the Puyallup River valley has the greatest potential for collapse because it has the largest area of weakened clay-rich rock remaining at high altitude. The east and northeast sides of the volcano can let loose large rockslides, such as that of December 1963, because of fractures in the ridges.

One collapse can yield lahars in multiple valleys

Future lahars will follow river valleys that drain Mount Rainier. Four of the five major river systems flow westward into suburban areas of Pierce County. These flow pathways are mapped by the USGS (fig. 3), just as flood-inundation maps show the areas at risk of flooding. Lahars occurring during an eruption may affect valley areas miles from the volcano, but a precursory warning should allow ample time for evacuation.

A catastrophic flow will likely spread into multiple valleys. The largest known flow entered all five drainages, and most of the known large flows have entered two or more.

Monitoring and emergency planning are ongoing

The USGS, in cooperation with the University of Washington, monitors the state of the volcano and assesses hazards from volcanic activity. The lahar pathways mapped by the USGS guide the hazard-area regulations of the comprehensive land-use plan for local counties. The plan's urban growth boundary and its proposed land uses in unincorporated areas are designed to minimize population growth, where possible, within hazard zones.

Local, county, state, and federal agencies including the USGS have joined to develop a Mount Rainier volcanic hazards response plan that addresses such issues as emergency-response operations and strategies for expanded public awareness and mitigation of volcanic hazard.

Lahar-warning system reduces risk

Because of the higher level of risk from lahars in the Carbon and Puyallup River valleys, the USGS and Pierce County Department of Emergency Management have installed a lahar-detection and warning system. The system consists of arrays of five acoustic flow monitors (AFM's) that detect the ground vibrations of a lahar. Computerized evaluation of data confirms the presence of a flowing lahar and issues an automatic alert to emergency management agencies. Emergency managers then can initiate response measures such as evacuations. This system for automatic detection and notification of a lahar reduces, but does not eliminate, risk in the lahar pathways.

Lahar travel times are short

The estimated time between detection of a lahar and its arrival in Orting is about 40 minutes. Dispersed populations closer to Mount Rainier would be affected sooner. Time is short, and successful evacuation will depend on detection of the approaching lahar, effective notification of people at risk, public understanding of the hazard, and prompt response by citizens.

Mount Rainier is an active volcano...

Reducing population growth in the paths of lahars, implementing a warning system, and planning and practicing evacuations can lower the potential loss of life and property during future eruptions and lahars. These actions can reduce the risk from lahars and provide a measure of safety for those who enjoy living, working, and playing in valleys surrounding Mount Rainier.

Volcanoes often show signs that they are getting ready to erupt days to weeks or months in advance. Scientists of the U.S. Geological Survey and University of Washington evaluate signs of unrest and look for increased seismic activity, increased emission of volcanic gases and swelling of the volcano. When unrest is detected, scientists will increase monitoring efforts and notify emergency management officials.

What can you do?

Learn: Determine whether you live, work, or go to school in a lahar hazard zone. Learn about all volcanic processes that could affect your community.

Inquire: Ask public officials to advise you about how to respond during any emergency.

Plan: Develop an emergency plan with your family so that you are prepared for natural hazards and emergencies.

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This fact sheet supersedes *Mount Rainier–Living with Perilous Beauty* (Fact Sheet 065-97).

See also *Volcano Hazards from Mount Rainier, Washington* (U.S. Geological Survey Open-File Report 98–428).

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