ADDENDUM 7
Volcanic Lahar

Background

When the *Natural Hazards Mitigation Plan for the Thurston Region* was prepared in 2003, there was interest by emergency management stakeholders to include volcanic lahar as a sixth element at a future date. This addendum has been prepared in response to that request.

The addendum in its draft form will undergo review by stakeholders. It will then be presented to the Emergency Management Council of Thurston County (EMC) for review and consideration as an addendum to the plan.

Once reviewed and approved by the EMC, the addendum will be submitted to the State of Washington Emergency Management for review. After review by State Emergency Management, it will be forwarded to the Federal Emergency Management Agency (FEMA), Region X for review.

When fully adopted, this document will remain as a plan addendum until the next scheduled plan update in 2008. At that time, plan participants could propose and adopt mitigation initiatives for their specific entities as outlined in Chapter 5 of the Natural Hazards Mitigation Plan.

Volcanic Lahar Hazard Description

Mount Rainier, which is an intermittently active volcano, is the highest peak in the Cascade Range at 14,410 feet. Lahar is an Indonesian word describing mudflows and debris flows that originate from the slopes of a volcano. Lahars originate on volcano flanks and can surge tens or even hundreds of miles downstream from a volcano. This can occur either during eruption or during periods of repose. Historically, lahars have been one of the most destructive volcanic hazards.

Lahars can vary in size. They can be as small as several inches wide and deep or on the other end of the continuum, they can be hundreds of feet wide and deep and may travel several miles from the volcano itself. These large lahars are caused by volcanic eruptions or by large landslides occurring on the flank of the volcano.

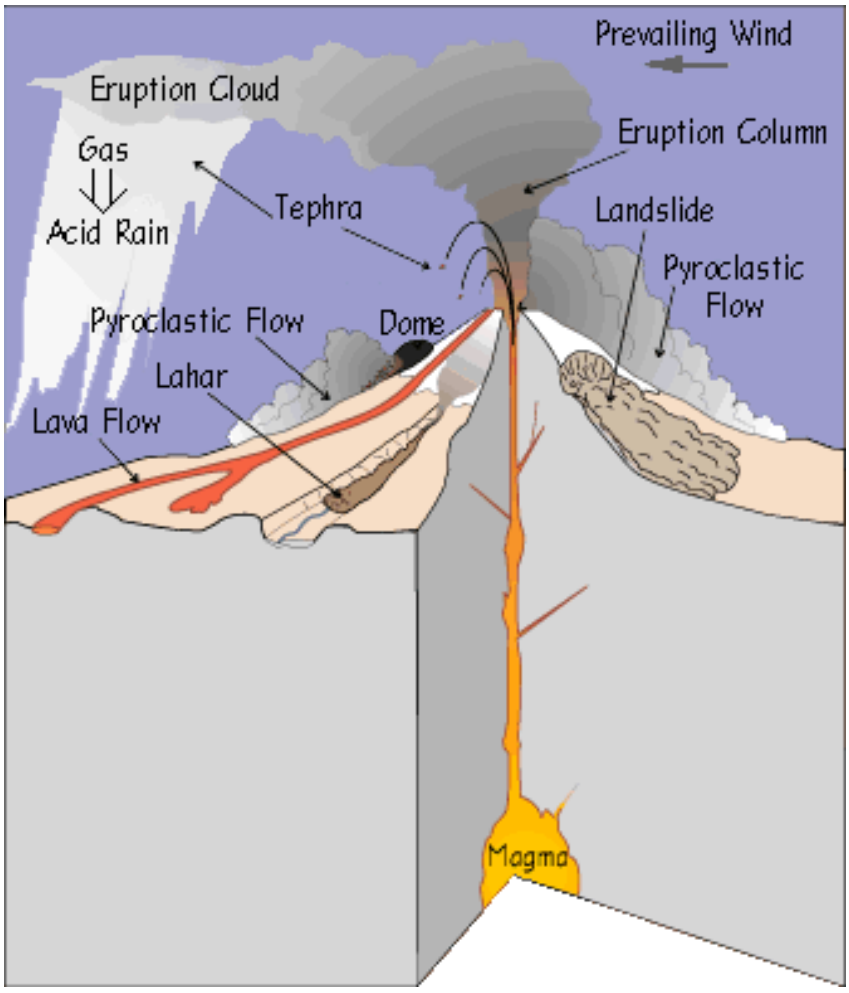
Lahars are commonly initiated by:

- large landslides of water-saturated debris,
- heavy rainfall eroding volcanic deposits,
- sudden melting of snow and ice near a volcanic vent by radiant heat or on the flanks of a volcano by pyroclastic flows, or
- Breakout of water from glaciers, crater lakes, or from lakes dammed by volcanic eruptions.

(Brantley and Power, 1985, Reports from the U.S. Geological Survey's Cascades Volcano Observatory at Vancouver, Washington: Earthquake Information Bulletin, v.17, n.1, January-February 1985, p.20).

The United States Geological Service defines a lahar as follows:

> *A lahar is a flowing mixture of water-saturated debris that moves downslope under the force of gravity. Debris flows consist of material varying in size from clay to blocks several tens of meters in maximum dimension. When moving, they resemble masses of wet concrete and tend to flow downslope along channels or stream valleys. Debris flows are formed when loose masses of unconsolidated wet debris become unstable. Water may be supplied by rainfall or by melting of snow or ice. Debris flows may be formed directly if lava or pyroclastic flows are erupted onto snow and ice. Debris flows may be either hot or cold, depending on their manner of origin and temperature of their constituent debris.*
>
> *(Miller, 1989, Potential Hazards from Future Volcanic Eruptions in California: USGS Bulletin 1847)*



(Graphic: US Geological Survey)

Volcanic Lahar Historical Occurrences and Impacts in Thurston County

In Thurston County, historically, volcanic lahars flowed down the slopes of Mount Rainier into the Nisqually River valley and sometimes all the way to the Puget Sound. Scientists have used radiocarbon dating to analyze wood from trees in certain areas along the Nisqually River. There is evidence (dated to have occurred approximately 300 years ago), that lahars have buried forests near what are now the City of Yelm and the Nisqually Indian Reservation.

Historically, lahars originating from Mount Rainier have been a fairly common occurrence; they vary in size and magnitude and are fairly unpredictable. The USGS provides the following short history of major lahar events originating from Mount Rainier:

> *The largest lahar originating at Mount Rainier in the last 10,000 years is known as the Osceola Mudflow. This cohesive lahar, which occurred about 5600 years ago, was at least 10 times larger than any other known lahar from Mount Rainier. It was the product of a large debris avalanche composed mostly of hydrothermally-altered material, and may have been triggered as magma forced its way into the volcano. Osceola deposits cover an area of about 550 square kilometers (212 square miles) in the Puget Sound lowland, extending at least as far as the Seattle suburb of Kent, and to Commencement Bay, now the site of the Port of Tacoma. The communities of Orting, Buckley, Sumner, Puyallup, Enumclaw, and Auburn are also wholly or partly located on top of deposits of the Osceola Mudflow and, in some cases, of more recent debris flows as well.*
>
> *At least six smaller debris avalanches have spawned lahars in the past 5,600 years. One of these, the Electron Mudflow, which was derived from a slope failure on the west flank of Mount Rainier about 600 years ago, has not been correlated with an eruption. The Electron Mudflow was more than 30 meters (yards) deep where it entered the Puget Sound lowland at the community of Electron. Its deposits at Orting are as much as 6 meters (yards) thick and contain remnants of an old-growth forest.*
>
> *Large non-cohesive lahars at Mount Rainier are associated with volcanism. About 1,200 years ago, a lahar of this type filled valleys of both forks of the White River to depths of 20 to 30 meters (60 to 90 feet) and flowed 100 km (60 miles) to Auburn. Hot rock fragments flowing over glacier ice and snow generated huge quantities of melt water, which mixed with the rock debris to form lahars. Less than 2200 years ago, another lahar of similar origin, named the National Lahar, inundated the Nisqually River valley to depths of 10 to 40 meters (30-120 feet) and flowed all the way to Puget Sound. More than a dozen lahars of this type have occurred at Mount Rainier during periods of volcanism in the past 6,000 years.*
>
> *(R.P. Hoblitt, J.S. Walder, C.L. Driedger, K.M. Scott, P.T. Pringle, and J.W. Vallance, 1998, Volcano Hazards from Mount Rainier, Washington, Revised 1998: U.S. Geological Survey Open-File Report 98-428).*

Volcano Lahar – Assessing Vulnerability

Summary Assessment

Scientists with the United States Geological Survey (USGS) have studied artifacts from past lahars to predict what future vulnerabilities may be. Deposits are analyzed to determine the types, frequencies, and magnitude of past events. Through these studies, scientists predicted a potential inundation hazard in the lower Nisqually River valley caused by a lahar entering and possibly flowing beyond Alder Reservoir.

Because Alder Dam exists for power generation, Alder Lake is never empty. Scientists are concerned that a lahar entering the reservoir could either cause dam failure or catastrophically displace a significant volume of the water in storage.

The most recent lahar to flow down the Nisqually River originated at the Kautz Glacier during October 1947. At that time, an intense cloudburst occurred causing the lower portion of the glacier to collapse. The collapse created elevated flows in the Nisqually River as far as the town of National.

Large lahars could be high in consequence and pose a major hazard to human life and property in the Nisqually River valley. The major hazard to human life is from debris flows with the potential to bury or smash those in its path. People and animals also can be severely burned by such flows carrying hot debris. Buildings and other property in the path of a debris flow can be buried or carried away. Because of their relatively high density and viscosity, these flows can move and even carry away vehicles and other objects as large as bridges.

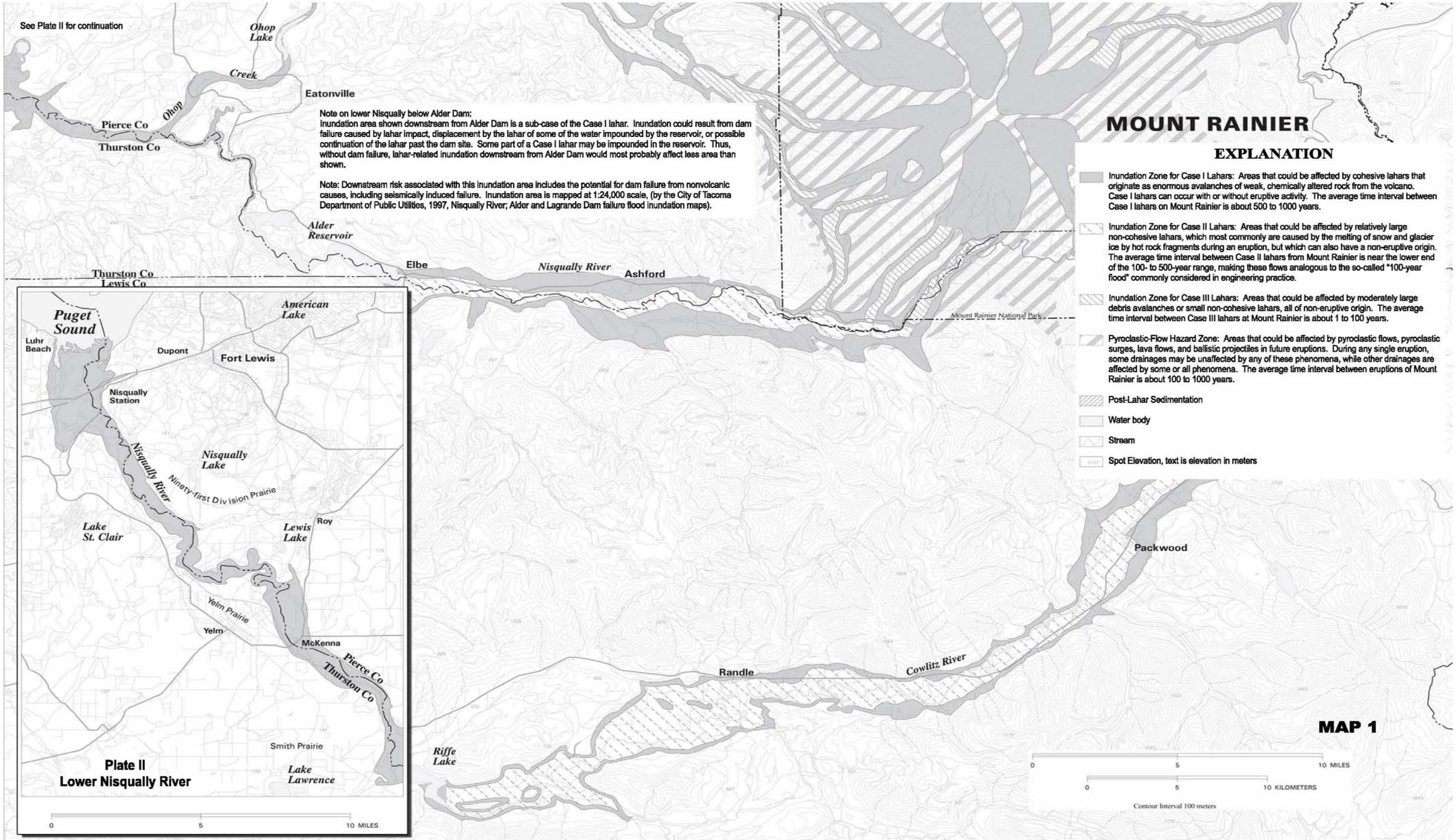
Because debris flows are confined to an area's downslope and down-valley from their points of origin, people can avoid them by seeking high ground. The debris-flow hazard decreases gradually down-valley from possible source volcanoes, but more abruptly with increasing altitude above valley floors. People seeking to escape flows should climb valley sides rather than try to outrun the flows in valley bottoms. During eruptive activity or precursors to eruptions, local government officials may ask for prompt evacuation of areas likely to be affected.

Delineation of Lahar Area

Map 1 shows the inundation zone for Case I lahars. These are areas that could be affected by cohesive lahars that originate as enormous avalanches of weak, chemically altered rock from the volcano. Case I lahars can occur with or without eruptive activity. The average time interval between Case I lahars on Mount Rainier is about 500 to 1000 years.

On the lower Nisqually River below Alder Dam, the inundation area shown downstream from Alder Dam is a sub-case of the Case I lahar. Inundation could result from dam failure caused by lahar impact, displacement by the lahar of some of the water impounded by the reservoir, or possible continuation of the lahar past the dam site. Some part of a Case I lahar may be impounded in the reservoir. Thus, without dam failure, lahar-related inundation downstream from Alder Dam would most probably affect less area than shown in Map 1.

Source: "Volcano Hazards from Mount Rainier, Washington. Revised 1998. R.P. Hoblitt, J.S. Walder, C.L. Driedger, K.M. Scott, J.W. Wallace.


See Plate II for continuation
Ohop Lake
Creek
Ohop
Eatonville
Pierce Co
Thurston Co
Note on lower Nisqually below Alder Dam:
Inundation area shown downstream from Alder Dam is a sub-case of the Case I lahar. Inundation could result from dam failure caused by lahar impact, displacement by the lahar of some of the water impounded by the reservoir, or possible continuation of the lahar past the dam site. Some part of a Case I lahar may be impounded in the reservoir. Thus, without dam failure, lahar-related inundation downstream from Alder Dam would most probably affect less area than shown.
Note: Downstream risk associated with this inundation area includes the potential for dam failure from nonvolcanic causes, including seismically induced failure. Inundation area is mapped at 1:24,000 scale, (by the City of Tacoma Department of Public Utilities, 1997, Nisqually River; Alder and Lagrande Dam failure flood inundation maps).
Alder Reservoir
Elbe
Nisqually River
Ashford
Thurston Co
Lewis Co
Mount Rainier National Park
MOUNT RAINIER
EXPLANATION
Inundation Zone for Case I Lahars: Areas that could be affected by cohesive lahars that originate as enormous avalanches of weak, chemically altered rock from the volcano. Case I lahars can occur with or without eruptive activity. The average time interval between Case I lahars on Mount Rainier is about 500 to 1000 years.
Inundation Zone for Case II Lahars: Areas that could be affected by relatively large non-cohesive lahars, which most commonly are caused by the melting of snow and glacier ice by hot rock fragments during an eruption, but which can also have a non-eruptive origin. The average time interval between Case II lahars from Mount Rainier is near the lower end of the 100- to 500-year range, making these flows analogous to the so-called "100-year flood" commonly considered in engineering practice.
Inundation Zone for Case III Lahars: Areas that could be affected by moderately large debris avalanches or small non-cohesive lahars, all of non-eruptive origin. The average time interval between Case III lahars at Mount Rainier is about 1 to 100 years.
Pyroclastic-Flow Hazard Zone: Areas that could be affected by pyroclastic flows, pyroclastic surges, lava flows, and ballistic projectiles in future eruptions. During any single eruption, some drainages may be unaffected by any of these phenomena, while other drainages are affected by some or all phenomena. The average time interval between eruptions of Mount Rainier is about 100 to 1000 years.
Post-Lahar Sedimentation
Water body
Stream
Spot Elevation, text is elevation in meters
Puget Sound
American Lake
Luhr Beach
Dupont
Fort Lewis
Nisqually Station
Nisqually River
Nisqually Lake
Ninety-first Division Prairie
Lake St. Clair
Lewis Lake
Roy
Yelm Prairie
Yelm
McKenna
Pierce Co
Thurston Co
Smith Prairie
Lake Lawrence
Plate II
Lower Nisqually River
0
5
10 MILES
Packwood
Randle
Cowlitz River
Riffe Lake
MAP 1
0
5
10 MILES
0
5
10 KILOMETERS
Contour Interval 100 meters