Whatcom County

Natural Hazards Mitigation Plan

A MULTI-HAZARD, MULTI-JURISDICTIONAL PLAN DEVELOPED FOR THE BENEFIT OF ALL CITIZENS AND GOVERNMENTAL JURISDICTIONS WITHIN WHATCOM COUNTY

Prepared by:
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June 1, 2015

VOLCANOES

A. DEFINITIONS

Blast Zone — The area immediately surrounding a volcano, up to several tens of kilometers, that is destroyed by a volcano's blast.

Lava Flow — A stream of molten rock that pours or oozes from an erupting vent.

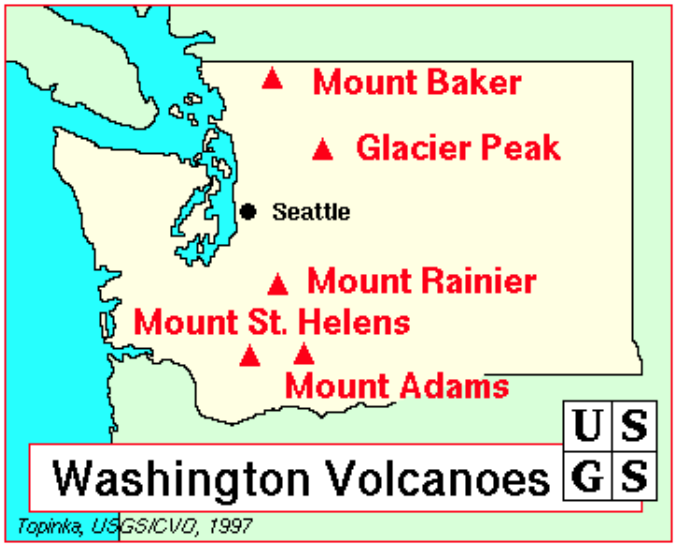
Lahar — A mudflow or debris flow that originates from the slope of a volcano; pyroclastic flows can generate lahars by rapidly melting snow and ice.

Pyroclastic Flows — High-density mixtures of hot, dry rock fragments and hot gases that move away from the vent that erupted them at high speeds.

Tephra — General term for fragments of volcanic material, regardless of size, that are blasted into the air by explosions or carried up upward by hot gases in eruption columns or lava fountains.

Volcano — A vent in the earth's crust through which magma (molten rock), rock fragments, associated gases, and ashes erupt, and also the cone built by effusive and explosive eruptions.

B. BACKGROUND INFORMATION



The Cascade Range (Cascades) extends more than 1,000 miles, forming an arc-shaped band extending from Southern B.C. to Northern California. The Cascades roughly parallels the Pacific coastline, and at least 17 major volcanic centers. Whatcom County's eastern boundary follows the crest of the Cascade Range.

The central and southern Cascades are made up of a band of thousands of much older, smaller, short-lived volcanoes that have built a platform of lava and volcanic debris. Rising above this volcanic platform are a few large younger volcanoes that dominate the landscape. The North Cascades, including Whatcom County, present younger (Quaternary) volcanoes overlying much older metamorphosed basement rock.

The Cascades volcanoes define the Pacific Northwest section of the "Ring of Fire," a fiery array of volcanoes that rim the Pacific Ocean. Many of these volcanoes have erupted in the recent past and will most likely be active again in the future. Given an average rate of two eruptions per century during the past 12,000 years, these

disasters are not part of our everyday experience.

The largest of the volcanoes in Washington State are Mount Baker, Glacier Peak, Mount Rainier, Mount Saint Helens, and Mount Adams. Eruptions from Mount Baker, located in the central portion of Whatcom County, and Glacier Peak, in Snohomish County, would severely impact Whatcom County. Mount Baker and Glacier Peak have erupted in the historic past and will likely erupt again in the foreseeable future. Due to the topography of the region and the location of drainage basins and river systems, eruptions on Mount Baker could severely impact large portions of Whatcom County. A Mount Baker eruption would generate lahars, pyroclastic flows, tephra or ash fall, and lava flows that would decimate affected areas. Glacier Peak, which is in Snohomish County, is of concern due to its geographic proximity to the County. Ash fall from an eruption at Glacier Peak could significantly impact Whatcom County.

1. Mount Baker

Mount Baker (3,285 meters; 10,778 feet) is an ice-clad volcano in the North Cascades of Washington State about 50 kilometers (31 miles) due east of the city of Bellingham. After Mount Rainier, it is the most heavily glaciated of the Cascades volcanoes: the volume of snow and ice on Mount Baker (about 1.8 cubic kilometers; 0.43 cubic miles) is greater than that of all the other Cascades volcanoes (except Rainier) combined. Isolated ridges of lava and hydrothermally altered rock, especially in the area of Sherman Crater, are exposed between glaciers on the upper flanks of the volcano; the lower flanks are steep and heavily vegetated. The volcano rests on a foundation of non-volcanic rocks in a region that is largely non-volcanic in origin.

2. Glacier Peak

Glacier Peak is the most remote of the five largest volcanoes in Washington State. It is not prominently visible from any major population center, and so its attractions, as well as its hazards, tend to be overlooked. Yet since the end of the last ice age, Glacier Peak has produced some of the largest and most explosive eruptions in the state. During this time period, Glacier Peak has erupted multiple times during at least six separate episodes, most recently about 250 years ago.

C. HISTORY

Eruptions in the Cascades have occurred at an average rate of 1 to 2 per century during the past 4,000 years, and future eruptions are certain. Seven volcanoes in the Cascades have erupted within the past 225 years (see Table 6).

Table 6
History of Major Volcanic Eruptions in the Cascade Mountain Range in the Past 225 Years

Volcano	Eruption Type	Eruptions in the Past 225 Years	Recent Activity
Mount Baker	Ash, lava	1?	1792, 1843 to 1865, 1870?, 1880, and 1975 steam emission
Glacier Peak	Ash	1+?	Before 1800 (1750?)
Mount Rainier	Ash, lava	1?	Tephra between 1830 and 1854
Mount St. Helens	Ash, lava, dome	2 eruptive periods	1980 to present
Indian Heaven Volcanic Field	Lava, scoria	None	8,000 years ago?
Mount Adams	Lava, ash	None	3,500 years ago
Mount Hood, Oregon	Ash, dome	2+?	1865, major eruption in the late 1700s

***Note**: Information obtained from WDNR*

Four of the eruptions listed in Table 6 would have caused considerable property damage and loss of life if they had occurred post-development of Whatcom County without warning and the next eruption in the Cascades could affect hundreds of thousands of people. The most recent volcanic eruptions within the Cascade Range

occurred at Mount Saint Helens in Washington (1980 to 1986; 2004 to 2008) and at Lassen Peak in California (1914 to 1917).

We know from geological evidence that Mount Baker has produced numerous volcanic events in the past that, were they to occur today, would place Whatcom County communities at considerable risk. Volcanic hazards from Mount Baker result from a variety of different eruptive phenomena such as lahars, ash fall, tephra fall, and pyroclastic flows. Figure 3 displays a model of the inner workings and hazards associated with volcanoes.

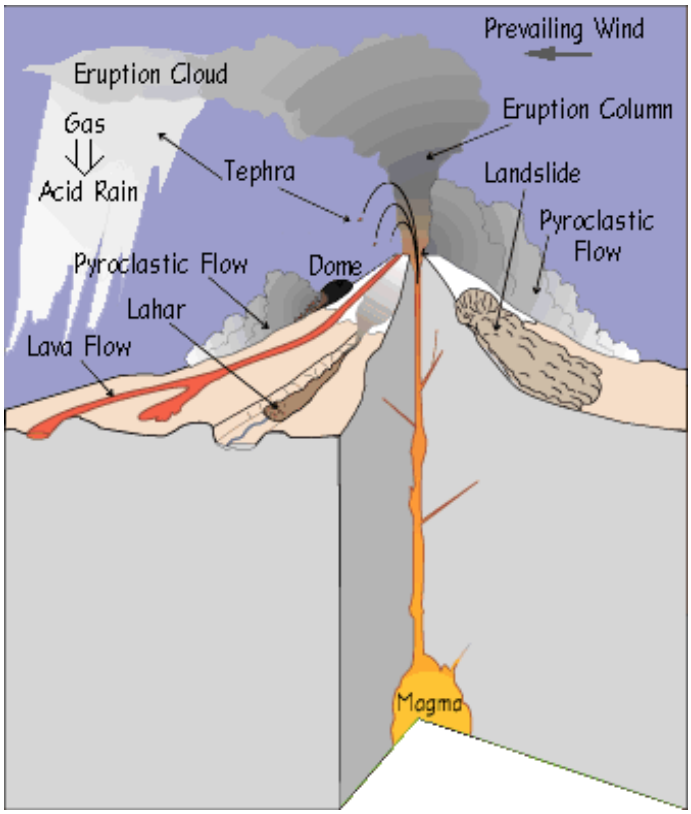


Figure 3 – Effects of a Volcano Eruption
(Diagram courtesy of USGS Cascade Volcano Observatory)

1. Mount Baker's Eruption History

Geologic evidence in the Mount Baker area reveals a flank collapse near the summit on the west flank of the mountain that transformed into a lahar, estimated to have been approximately 300 feet deep in the upper reaches of the Middle Fork of the Nooksack River and up to 25 feet deep 30 miles downstream. This lahar may have reached Bellingham Bay. A hydrovolcanic (water coming into contact with magma) explosion occurred near the site of present day Sherman Crater, triggering a second collapse of the flank just east of the Roman Wall. This collapse also became a lahar that spilled into tributaries of the Baker River.

Finally, an eruption cloud deposited several inches of ash as far as 20 miles downwind to the northeast. Geologic

evidence shows lahars large enough to reach Baker Lake have occurred at various times in the past. Historical activity at Mount Baker includes several explosions during the mid-19th century, which were witnessed from the Bellingham area.

Sherman Crater (located just south of the summit) probably originated with a large hydrovolcanic explosion. In 1843, explorers reported a widespread layer of newly fallen rock fragments and several rivers south of the volcano were clogged with ash. A short time later, two collapses of the east side of Sherman Crater produced two lahars, the first and larger of which flowed into the natural Baker Lake, raising its water level at least 10 feet.

In 1975, increased fumarolic activity in the Sherman Crater area caused concern an eruption might be imminent. Additional monitoring equipment was installed and several geophysical surveys were conducted to try to detect the movement of magma. The level of the present day Baker Lake reservoir (located to the east and south of the mountain) was lowered and people were restricted from the area due to concerns that an eruption-induced debris avalanche or debris flow might enter Baker Lake and displace enough water to either cause a wave to overtop the Upper Baker Dam or cause complete failure of the dam. However, few anomalies other than the increased heat flow were recorded during the surveys nor were any other precursory activities observed to indicate magma was moving up into the volcano. This volcanic activity gradually declined over the next 2 years but stabilized at a higher level than before 1975. Several small lahars formed from material ejected onto the surrounding glaciers and acidic water was discharged into Baker Lake for many months.

D. VULNERABILITY ASSESSMENT

Lahars are the primary threat from volcanic activity at Mount Baker. Originating from melted snow and ice, lahars could create torrents of ash, rock, and water. Flank collapses may also create volcanic landslides that may form into lahars. Lahars resulting from flank collapses can also be triggered by earthquakes, gravity, or increases in hydrovolcanic activity. Debris flows can remain hazardous for many years if the deposited material remobilizes from heavy rains.

Most cohesive debris flows will be small to moderate in volume and will originate as debris avalanches of altered volcanic rock, most likely from the Sherman Crater, Avalanche Gorge, or the Dorr Fumarole area. Small volume debris flows will pose little risk to most people, but moderate volume debris flows could travel beyond the flanks of the volcano.

The probability of either Mount Baker or Glacier Peak erupting, collapsing, or causing slides is low. However, volcanic activity from either mountain could result in massive destruction of property and probable loss of lives in or near the floods, lahars, earthquakes, landslides, and ash fall.

Examples of hazards and “worst-case scenarios” in Whatcom County, including adjacent counties and Canadian Provinces, as follows:

1. Small to moderate collapse in the area of Sherman Crater may produce lahars flowing into Baker Lake and result in the following:

    a. Raised level of Baker Lake
    b. Baker Lake Dam failure

c. Flooding of the entire Skagit floodplain to Puget Sound

2. Large flank collapses or pyroclastic flows could result in the following:

   a. Inundation of Skagit River Valley by displacement of water in reservoirs by lahars
   b. North Fork, Middle Fork, and Nooksack River to Bellingham Bay could be inundated, and enough debris flow could be deposited in the stretch of river between Lynden and Everson to raise the riverbed enough to spill into the Sumas River or to divert the Nooksack River into the Sumas River Basin (such an event is considered high consequence but low probability)
   c. Floodwaters could extend from Sumas into Huntingdon and Abbotsford, B.C.
   d. Flooding all the way to Bellingham Bay

3. Hospitals: Bellingham's Saint Joseph Hospital and the Outpatient Center would be isolated from other communities

4. Transportation Routes: I-5 flooded at Nooksack and/or Skagit Rivers; Highway 9 flooded at Deming and Sedro Woolley (Skagit County); Mount Baker Highway (SR 542) flooded

5. Ash fall: will depend on direction of the wind (prevailing winds are toward the East); the ash may cause reduced visibility or darkness; air filters and oil filters in automobiles and emergency vehicles become clogged

6. Airports: All local airports may be impacted by ash fall

7. Railroad tracks, power lines, radio towers, highways, campgrounds, natural gas pipelines, and water supplies in these more remote areas may be inundated

8. Forest fires from ash and volcanic eruption may be expected

9. Earthquakes may occur

10. Lightning and thunderstorms often accompany volcanic eruptions

11. City of Bellingham's Middle Fork water supply diversion dam, tunnel, and pipeline to Lake Whatcom possibly buried and/or destroyed

12. Large numbers of farm animals, people, fish, and wildlife may be killed

Those most vulnerable initially would be those nearest the pyroclastic, lahar, and lava flows, or heavy ash and rock fall during the eruption. Those people in this recreational area of forests and wildlife may be impossible to locate and rescue. Baker Lake and its dams are vulnerable and, if impacted, could cause extensive loss of property and lives downstream in Skagit County.

Lahars flowing down and flooding the Nooksack, Baker, and Skagit Rivers may provide very little warning for evacuation to nearby populations. Earthquakes accompanying an eruption may cause bridge or road damage and trigger landslides. Fine ash fall, even if only an inch thick, may make asphalt road surfaces slippery, causing traffic congestion on steep slopes or accidents at corners and junctions. Even a minor eruption or large flank collapse of Mount Baker could impact some populations physically, psychologically, and economically.

Potential Volcanic Hazards

1. Flooding: Baker Lake and Lake Shannon – possibly dams destroyed
    a. Nooksack River from origins to Bellingham Bay
    b. Skagit River from Baker River junction throughout Skagit River Valley to Puget Sound
2. Transportation: severe disruption
3. Water lines, water reservoirs: contaminated or broken and depleted
4. Communication: landlines down, wireless phones overwhelmed
5. Electric power: some or all power lost from Mount Vernon to Lynden and possibly further in all directions
6. Gas and fuel pipelines: possibly broken
7. Toxic waste, sewer, and household chemicals in flood areas

E. MITIGATION STRATEGIES

Generally, technology and tell-tale signs of eruptions from volcanoes allow experts to predict volcanic activity, such as the predictions of the 1980 Mount Saint Helen's eruption that saved many lives. However, the magnitude and timing of volcanic activities cannot be precisely predicted, giving the public little to no warning to prepare for a volcano emergency. Because of this, the best way to mitigate against volcanoes is to educate and

raise awareness of affected citizens. In 2013 Whatcom Division of Emergency Management, United States Geological Survey, and the Washington State Emergency Management Division participated in the US/ Columbia Volcanic Exchange. Best practices concepts were brought back from the participants , and a focused effort led to a completion of a public information campaign for the Northern Cascade volcanos. According to FEMA, one of the best ways to generate awareness and preparedness of volcanoes is to use the media to spread important information to the community. FEMA suggests:

1. In a volcano prone area, publish a special section in the local newspaper with emergency information on volcanoes. Localize the information by including the phone numbers of local emergency services offices, the American Red Cross, and hospitals.

2. Feature an interview with a USGS representative, talking about how he/she determines the likelihood of a volcanic eruption.

3. Conduct a television or radio series on how to recognize the warning signals of a possible volcanic eruption.

4. Work with local emergency services and American Red Cross officials to prepare special reports for people with mobility impairments on what to do if an evacuation is ordered.

5. Obtain 72-hour kits that include contacts and information during natural hazards.

6. Develop Community Emergency Response Teams.

7. Distribute neighborhood maps.

WILDLAND FIRES

A. DEFINITIONS

Structure Fire — A fire of natural or human-caused origin that results in the uncontrolled destruction of homes, businesses, and other structures in populated, urban or suburban areas.

Wildland fire — Fire of natural or human-caused origin that results in the uncontrolled destruction of forests, field crops and grasslands.

Wildland Urban interface — A fire of natural of human-caused origin that occurs in, or near, forest or grassland areas, where isolated homes, subdivisions, and small communities are also located.