



Central Cascades Volcano
COORDINATION PLAN

July 2019

Prepared by:

The Central Cascades Volcano Facilitating Committee



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PREFACE

Oregon Office of Emergency Management and Washington Emergency Management sincerely appreciate the cooperation and support from the agencies and local jurisdictions that have contributed to the development and ultimate publications of the Central Cascades Volcano Coordination Plan.

The plan provides vital Central Cascades volcanic event response information for the areas that can most likely be most affected by a volcanic event. This can aid planning efforts for several Oregon counties, multiple State and Federal agencies, the Confederated Tribes of the Warm Springs Reservation, and the Klamath Tribes. The plan is consistent with the National Incident Management System (NIMS), supports and complements local response plans, the National Response Framework, the Oregon State Emergency Management Plan, and the Washington State Comprehensive Emergency Management Plan.

The Central Cascades Volcano Coordination Plan is an important element in a coordinated effort to enhance our region's preparedness for emergencies and disasters. The plan embraces the philosophy and vision of a Disaster Resistant State and should empower local communities to minimize the impacts of volcanic activity on people, property, the environment and the economy of the Pacific Northwest. The plan should be updated to reflect necessary enhancements identified in exercises and real world events. These updates should not require renewal of signatures.

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PURPOSE

The purpose of this plan is to coordinate the actions that various agencies must take to minimize the loss of life and damage to property before, during, and after hazardous volcanic events in the Central Cascades. The plan strives to ensure timely and accurate dissemination of warning products and public information. The framework provided by this plan should enable a coordinated response by the affected agencies and communities. This plan also includes the necessary legal authorities as well as statements of responsibility of County, State, Federal, and Tribal agencies.

INTRODUCTION

Volcanoes dominate the skyline in many parts of the Pacific Northwest, although their fiery past is often unrecognized. These familiar snow-clad peaks are part of a 1,000-mile-long chain of volcanoes, the Cascade Range, which extends from northern California to southern British Columbia. Seven of those volcanoes have erupted or shown signs of unrest since the birth of this nation. These include Mount Baker, Glacier Peak, Mount Rainier, Mount St. Helens, Mount Hood, Mount Shasta, and Lassen Peak. These and many others could erupt again. Many people do not consider the Cascade volcanoes to be hazardous because the time between eruptions is often measured in centuries or millennia, and volcanic activity is not part of our everyday experience. However, the vast destructive power unleashed by the 1980 eruption of Mount St. Helens reminds us of what can happen when they do erupt. As populations increase in the Pacific Northwest, areas near the Cascade volcanoes are being developed and recreational use is expanding. Consequently, more and more people and property are at risk from future volcanic activity.

The Central Cascades extends from Mount Jefferson in the north to Diamond Peak in the south. The most active volcanoes in this stretch have been Three Sisters and Newberry. The last eruptive period in the Three Sisters area was 1000-2000 years ago. The most recent eruption (Big Obsidian Flow) in Newberry was 1300 years ago. Recently ground uplift (bulge) and anomalous water chemistry have been recorded west of Three Sisters. Because there are no written chronicles of past major eruptions, most of our information about the Central Cascades past comes from geologic study of deposits produced during those eruptions. We also use observations of recent eruptions at other similar volcanoes around the world to help us understand how future eruptions of the Central Cascades volcanoes may develop and to help delineate areas that are likely to be at risk during future eruptions.

Earthquake occur regularly and geothermal activity at Newberry volcano remind us that this volcano still hosts active geologic processes that present potential hazards to the region. For this reason, the Central Oregon Volcanoes Coordination Plan was drawn up by emergency managers from Deschutes, Crook, Klamath, Wasco, Hood River, Linn, Lane, Jefferson, and Marion counties, the Confederated Tribes of Warm Springs, the State of Oregon, Federal Emergency Management Agency (FEMA), Oregon Department of Geology and Mineral Resources (DOGAMI), Oregon Department of Transportation, Oregon Military Department, the U.S. Forest Service (USFS), the U.S. Geological Survey (USGS), and the National Weather Service (NWS).

ORGANIZATION AND RESPONSIBILITIES

Central Cascades Volcano Facilitating Committee (FAC)

The FAC has been established to maintain preparedness during times of volcanic quiescence and to review plan implementation after an incident has ended. It is composed of members from each jurisdiction with statutory responsibility for emergency response (Table 1). Additional agencies (Associate Members in Table 1) may also attend meetings of the FAC. The FAC may be called together by any member who identifies a need for coordinated discussions. The FAC is responsible for maintaining the plan, including exercises, as needed. Oregon Office of Emergency Management is responsible for assembling the FAC for an annual review of this plan, incorporating updates into the plan document, and disseminating the updated plan. Although agencies represented on the FAC should be involved in management of volcanic incidents in the Central Cascades, the FAC itself does not have a response role. Onset of volcanic activity should trigger FAC notification and a conference call among members. If the FAC determines that a command or coordination organization needs to be established, that recommendation should be made to the USFS Forest Supervisor and Oregon OEM. The determination to activate such an organization for a volcanic incident in the Central Cascades should terminate FAC activities per se until after-action activities at the close of the response phase.

Table 1. FAC Membership

| Members shall include | Associate Members may include |
|--|---|
| <ul style="list-style-type: none"> • Oregon Emergency Management • Oregon Department of Geology and Mineral Industries • Crook County • Deschutes County • Jefferson County • Klamath County • Lane County • Linn County • Marion County • Confederated Tribes of the Warm Springs Reservation • U.S. Geological Survey • U.S. Forest Service, Deschutes National Forest • U.S. Forest Service, Willamette National Forest • FEMA Region X • National Weather Service • Klamath Tribes • Oregon Military Department • Prineville BLM | <ul style="list-style-type: none"> • Oregon Department of Transportation • US Army Corps of Engineers • Oregon Department of Environmental Quality • Oregon Department of Public Health • Pacific Northwest Seismograph Network (PNSN) • Businesses in the Central Cascades volcanic impact zone • Bureau of Reclamation • EWeb • Ochoco National Forest • Oregon State Police • Oregon National Guard |

Interagency Organizations

The overriding principle in a volcanic emergency is that preservation of human life takes precedence over protection of property. Federal, State and/or local jurisdictional authorities may protect life and property by, among other actions, closing high-risk areas to public access, or evacuating local residents from hazard zones.

During a response, each agency and organization should provide resources and administrative support, and should conduct operations within a NIMS Incident Command System (ICS) structure. Interagency operations should be conducted under a Unified Command structure. County emergency management agencies, Oregon Office of Emergency Management (OEM), and the U.S. Department of Homeland Security's (DHS) Federal Emergency Management Agency (FEMA) have primary responsibilities for coordinating local, regional, State and Federal responses, respectively. The responsibilities of local, State and Federal agencies are summarized in Table 2. The authorities under which these agencies operate are described in Appendix I.

Table 2. Responsibilities and contact information for members of the Central Oregon volcanoes FAC

| Jurisdiction and Responsibilities | Contact Information | Main Phone Line |
|--|---|-----------------|
| <p>LOCAL GOVERNMENT</p> <p>Local jurisdictions are responsible for the overall direction and control of emergency activities undertaken within their jurisdictions. Each County may activate its emergency operations center.</p> | Crook County | |
| | Deschutes County | |
| | Jefferson County | |
| | Klamath County | |
| | Lane County | |
| | Linn County | |
| | Marion County | |
| | Confederated Tribes of the Warm Springs | |
| | The Klamath Tribes | |

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| <p>STATE GOVERNMENT</p> <p>The Governor, the Governor’s cabinet(composed of Directors of State agencies or their representatives), and staff from the State Emergency Management Agency, are responsible for the conduct of emergency functions and should exercise overall direction and control of State government operations</p> | Oregon Emergency Management | |
| | Emergency Coordination Center (ECC) Salem | |
| | Oregon Department of Geology and Mineral Industries (DOGAMI) Portland, OR | |
| | Oregon Department of Transportation | |
| | Oregon Department of Environmental Quality | |
| | Oregon Department of Public Health | |

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| <p>FEDERAL GOVERNMENT</p> <p>The Federal Emergency Management Agency (FEMA; part of DHS) is responsible for Federal agency coordination and operations of the Regional Response Coordination Center (RCCC).</p> <p>The U.S. Geological Survey (USGS) is responsible for monitoring volcanic activity and assigning alert status levels. The USGS may locate with the USFS in Sandy or with an appropriate county.</p> <p>The U.S. Forest Service (USFS), The Willamette and the Deschutes National Forests are responsible for management of lands within their boundaries.</p> | | |
| | <p>FEMA Region 10 Bothell, WA</p> | |
| | <p>U.S. Geological Survey Cascades Volcano Observatory Vancouver, WA</p> | |
| | <p>U.S. Forest Service, Deschutes National Forest U.S. Forest Service, Willamette National Forest</p> | |
| <p>The National Weather Service (NWS) is responsible for operational forecasting and monitoring of the atmosphere, including the presence of volcanic ash</p> | <p>National Weather Service – Portland 5241 NE 122nd Ave, Portland, OR</p> | |

| | | |
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| clouds injected into the atmosphere by eruptions. | | |
| | US Army Corps of Engineers | |
| | Pacific Northwest Seismograph Network (PNSN) | |

INCIDENT MANAGEMENT

A volcano-related incident demands coordinated response. The Incident Command System (ICS) shall be used to establish incident goals, priorities, and strategies; to coordinate incident resource management, and to provide incident support for eruptions, lahars, or other significant volcanic events. The U.S. Forest Service Incident Commander (IC) should provide initial strategic guidance and decisions on emergency needs until a Unified Command organization can be established (see next section). The Incident Commander has ultimate responsibility for management of assigned resources to effectively accomplish stated objectives and strategies pertaining to a volcanic event at one of the Central Oregon volcanoes. The IC initially should report directly to the Deschutes or Willamette Forest Supervisor. The IC should have key positions filled as soon as possible to meet known and projected incident needs.

Unified Command

For a volcanic incident in the Central Cascades, Unified Command would likely comprise the USGS, USFS, FEMA, affected local jurisdictions (i.e., one or more among Deschutes, Jefferson, Wasco, Lane, Linn, Crook, Klamath, and Marion and possibly cities as well), the Confederated Tribes of Warm Springs and the Klamath Tribes.

Agency Responsibilities

Local Divisions or Departments of Emergency Management

Information about the status of a volcano is normally transmitted from the USGS through OEM to county Emergency Management agencies (DEM's). As needed, the county DEM's:

- Relay the information to local jurisdictions and agencies.
- Implement Emergency Operations Plans, maintain and activate Emergency Operations Centers (EOC).
- Provide local public warnings and information.
- Activate the Emergency Alert System (EAS).
- Assist Incident Commander(s).
- Participate in establishing a unified command structure.
- Provide Public Information Officer(s) (PIOs) for a Joint Information Center (JIC.)
- Assist the USGS in establishing a temporary Volcano Observatory.
- Initiate and coordinate local declarations of emergency or requests for assistance from mutual aid partners, State and/or Federal resources.
- Implement response and recovery plans in their jurisdiction.
- Facilitate information and training on volcano-hazard response to emergency workers and the public.
- Assess volcanic risks as part of a comprehensive Hazard Identification and Vulnerability Analysis.
- Evacuation and Traffic/access control.

State Emergency Management: OEM and EMD

Oregon Office of Emergency Management (OEM), through its 24-hour Oregon Emergency Response System (OERS), is responsible for providing alert and warning to local jurisdictions within the State. Additionally, OEM/OERS should notify specific State and Federal agencies that have a response role during a volcanic event. OEM works with other entities in order to coordinate resources to support local and State agency response. OEM's and EMD's responsibilities in support of this plan include:

- Coordinating the acquisition and distribution of resources to support response.
- Developing plans and procedures.
- Acting as the central point of contact for local government requests for specific State and Federal disaster related assets and services.
- Activating and staffing the State Emergency Coordination Center (ECC) /Emergency Operations Center (EOC).
- Supporting EAS activations by local jurisdictions as necessary by serving as a backup activation point.

- Supporting public information efforts, whether through an initial lead agency or a Joint Information Center (JIC).
- Coordinating with the Federal government on supplemental disaster assistance necessary to preserve life and property, and on recovery assistance.
- Activating, if necessary, the Emergency Management Assistance Compact (EMAC) for interstate assistance.
- Deploying County Liaison Officers to affected jurisdictions.
- Calling the yearly meeting of the FAC to review and update this plan.
- Focal point to access scientific and technical advice for hazard mitigation plans.

U.S. Geological Survey

The Disaster Relief Act of 1974 (PL 93-288) assigns to the U. S. Geological Survey (USGS) the delegated responsibility of providing timely warnings of volcanic eruptions and related activity. This responsibility is achieved by monitoring active and potentially active volcanoes, assessing their hazards, responding to crises, and conducting research on how volcanoes work. More specifically, these activities include:

- Issuing timely warnings of potential geologic hazards to responsible emergency management authorities and to the public via alert level notification, the media and the CVO web site.
- Supporting public information efforts, whether through an initial lead agency or a Joint Information Center (JIC).
- Monitoring volcanic unrest, tracking its development, forecasting eruptions, and evaluating the likely hazards.
- Establishing a temporary volcano observatory, if needed, in order to provide ready access to the volcano for the USGS hazard-assessment team, as well as technical assistance to the emergency managers. (See Appendix E for temporary volcano observatory requirements.)
- Coordinating ash fall and lahar warning messages with NWS.
- Provide liaison staff in Unified Command

U. S. Forest Service

The U.S. Forest Service (USFS) manages public lands on and around the Central Cascades. Authorities include land management responsibilities related to use, management and protection of these lands. Roles and responsibilities during a disaster or emergency include protection of life, property and national forest resources on USFS-managed lands. Control of access and use of national forest lands is regulated by the USFS in coordination with law enforcement, adjoining landowners, and agencies.

USFS responsibilities include:

- Establishing, maintaining, and providing Public Information Officer (PIO) support for a Joint Information Center (JIC).
- Restricting access to hazard areas within the Deschutes and Willamette National Forests.
- Coordinating with transportation agencies and tribal agencies on road closures.
- Establishing and maintaining an Incident Command Post for involved agencies
- Other activities necessary based on volcanic conditions.
- Request TFR (Temporary Flight Restriction) from FAA as needed.

Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) roles and responsibilities during a disaster are governed by the Robert T. Stafford Disaster Assistance and Emergency Relief Act, as amended, 42 USC 5121, et seq. The primary disaster relief responsibility of FEMA is to coordinate and deliver assistance and support to State and local governments when requested, typically through the Governor as a Request for a Presidential Disaster Declaration. A volcanic eruption would be handled in much the same way as any other natural disaster.

FEMA's responsibilities include:

- Monitoring situations with the potential for widespread impacts.
- Coordinating Federal level emergency planning, management, mitigation and assistance functions of Federal agencies in support of State and local efforts.
- Providing and maintaining the Federal and State National Warning System (NAWAS).
- Providing and maintaining the Integrated Public Alert and Warning System (IPAWS).
- Providing liaison staff to the Unified Command organization and the State ECC.
- Following a Presidential Disaster Declaration:
 - Establishing a Joint Field Office (JFO).
 - Coordinating State and Tribal requests for Federal assistance.
 - Coordinating Federal Assistance operations and programs.

National Weather Service

NOAA's National Weather Service (NWS) is responsible for operational forecasting and monitoring of the atmosphere, including the presence of volcanic ash clouds injected into the atmosphere by eruptions, floods, and lahar. The NWS maintains the observational, analytical, and forecasting capabilities required to estimate the location and movement of volcanic ash throughout its areas of responsibility. National Weather Service responsibilities include:

Weather Forecast Office (WFO) in Portland is responsible for:

- Issuing volcanic ash fall statements, forecasts, advisories and warnings to the public, aviation and marine communities in cooperation with the USGS.
- Issuing public warnings of lahars via the flash flood program in cooperation with the USGS.
- Dissemination of warnings and advisories over various communication systems.
- In coordination with USGS Cascades Volcano Observatory (CVO), preparing and disseminating volcanic plume forecasts.
- Issuing aviation SIGMETs (Significant Meteorological Information) for meteorological information concerning safety for aircraft operating in the Continental U.S. (issued through the Aviation Weather Center in Kansas City, MO).

- Issuing Volcanic Ash Advisories that provide current locations and forecast movement/locations of ash clouds (issued through NOAA's Volcanic Ash Advisory Center (VAAC) in Washington D.C.).

See Appendix K: REFERENCES and WEBSITES for a reference to the Pacific Northwest Interagency Operating Plan for Volcanic Events which pertains to how the aviation sector responds to airborne ash hazards to aircraft.

Tribal Relations

During and after emergencies, OEM encourages counties to coordinate with the Tribes within their areas to ensure that responses are coordinated and that any potential damage assessment information is captured. The Tribes often rely on pre-established relationships with local governments for assistance in emergency situations.

For information on the roles and responsibilities of Federal agencies in support of tribal relations, see the **Tribal Relations Support Annex** of the **National Response Framework**.

Concept of Operations

This plan is based on the premise that each agency with responsibility for preparedness, response or recovery activities has, or should develop, an operations plan or Standard Operating Guidelines that covers its organization and emergency operations. The local land management agencies are the official responsible for managing the lands surrounding that volcano, including during times of emergency. The USFS practices coordinated management of incidents with surrounding landowners and expects to do so in a volcanic event as well, consistent with the Unified Command discussion above. This plan establishes a mechanism for coordination of each agency's efforts.

The Concept of Operations can be defined with respect to the three phases of volcanic activity: 1). Volcanic Quiescence, 2). Volcanic Activity, 3). Subsiding Volcanic Activity.

Volcanic Quiescence (when volcanoes are in repose)

Members of the FAC should:

- Develop local and agency hazard mitigation plans that include the volcano hazard.
- Prepare emergency plans and programs to ensure continuous readiness and response capabilities.
- Meet yearly to: coordinate, revise, and exercise this plan.
- Develop and evaluate alert and warning capabilities for the volcanic hazard risk areas.
- Continue research on the volcano and associated hazards.
- Review public education and awareness requirements and implement an outreach program on volcano hazards.
- Educate public officials and local response agencies.

Volcanic Activity

Members of the FAC should:

- Confer whenever any member deems it necessary.
- Using teleconferences or in-person meetings, share information on the current activity in the Central Cascades and coordinate data relating to hazard assessment, evaluation and analysis.
- Coordinate any needed public information (JIS) and/or establish a scalable JIC for this purpose.

Upon activation, members of the Unified Command team should consider the following volcano specific tasks:

- Facilitate accurate and timely collection and exchange of regional incident information.
- Coordinate regional objectives, priorities and resources.
- Analyze and anticipate future agency/regional resource needs.
- Coordinate regional information through a JIC.
- Communicate decisions to jurisdictions/agencies.
- Review need for other agency involvement in the command team.
- Provide necessary liaison with out-of-region facilities and agencies as appropriate.
- Designate regional mobilization centers as needed.
- Coordinate damage assessment and evaluation.
- Evaluate disaster magnitude and local disaster assistance and recovery needs.
- Obtain detailed data on casualties, property damage and resource status.

Subsiding Volcanic Activity

When hazardous geologic activity has subsided to a point where reconstruction and restoration activities may be initiated, even if the volcano is still in an eruptive state and response activities continue, recovery efforts may be initiated and carried out. In addition to the functions previously noted, the Unified Command team shall:

- Continue to follow common ICS procedures. Continue to coordinate the collection and dissemination of disaster information including informing the public about hazardous conditions, health, sanitation, and welfare problems, recovery services and the need for volunteers.

The FAC should:

- Conduct a review of the Central Cascades Volcano Coordination Plan and make changes to this plan as necessary.
- Participate in local, state, tribal, and federal After Action reviews.

NOTIFICATION LIST FOR the Central Cascades EVENTS

These lists are suggestions for creating your own internal call lists.

USGS

The USGS has the responsibility to issue timely and effective warnings of potential volcanic activity. The USGS' Cascades Volcano Observatory (CVO) has that responsibility for the Central Cascades volcanoes as well as other volcanoes in Washington, Oregon, and Idaho. Although CVO has the sole responsibility to issue volcano alert levels, it will do so to the best of their ability in coordination with the land management agency and with Oregon Emergency Management. Prior to changing an alert level, CVO will notify both the land management agency and OEM by phone for a brief consultation regarding wording of the alert level change. Because time can be important in issuing an alert level change, this call is for brief consultation only. The USGS will reserve the right to make any final changes to wording prior to sending the alert level change. Once the wording is finalized, CVO will commence with its call down procedure and send the alert level change out via FAX, e-mail, RSS feed, the web, and other social media outlets.

- USFS – Deschutes/Willamette Supervisor's Office
- BLM
- University of Washington's Pacific Northwest Seismic Network
- Oregon Emergency Management
- Federal Aviation Administration (FAA) ARTCC center in Seattle
- National Weather Service Forecast Office – Portland
- Washington Volcano Ash Advisory Center
- FAA HQ Com Center

- Air Force Weather Agency

USFS/BLM

- Internal Notifications (Special Agent, Unit Managers)
- External Notification
 - Stakeholders
- Northwest Interagency Coordination Center (NWCC)
- Tribal Nations
- U.S. Army Corps of Engineers (Portland District)
- Others as appropriate

National Weather Service

- NWS Aviation Weather Center
- NWS Center Weather Service Unit – Auburn, WA
- Portland International Airport Control Tower
- FAA Flight Service Station – Prescott, AZ
- NOAA's Volcanic Ash Advisory Center – Washington, DC
- Air Force Weather Agency – Omaha, NE
- Neighboring NWS Offices

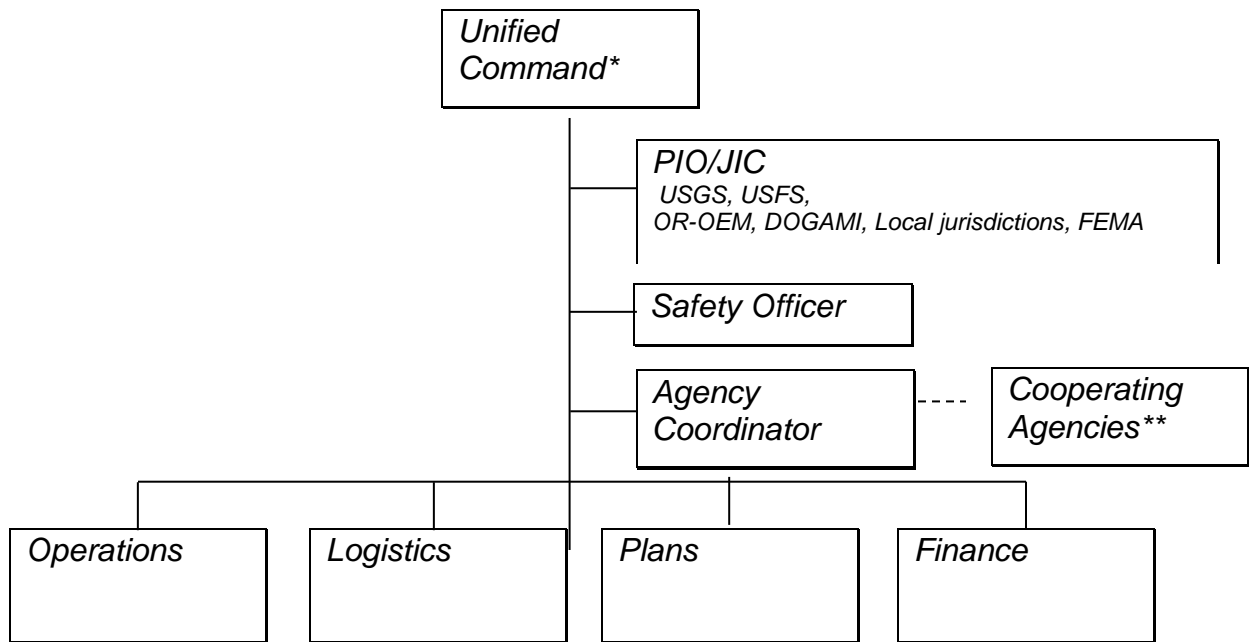
State EOC /ECC

- State ESF agencies
- Counties
- FEMA Region 10
- Bonneville Power Administration (BPA)
- Neighboring states
- Others as appropriate

County EOCs

- Internal agencies as appropriate
- Cities, school and special service districts
- Others as appropriate
- Hospitals

Organizational Chart: Volcano Incident in the Central Cascades



* Unified Command: USGS, USFS, FEMA, impacted local jurisdiction (e.g., /Multnomah/Wasco/, Crook ,Deschutes), Confederated Tribes of Warm Springs.

**Cooperating Agencies: FAA (Seattle, Portland), NWS (Portland), U.S. Army Corps of Engineers, Northwest Coordination Center (NWCC), ODOT/, DOGAMI, OSP/, OR-OEM, and local jurisdictions. Other entities could be included depending on the circumstances of the incident.

ORGANIZATION AND RESPONSIBILITIES

ACCORDING TO ALERT LEVELS

. The USGS Alert Notification System for volcanic activity provides the framework for the preparedness activities of local jurisdictions, tribal governments; and county, state, and federal agencies. The USGS Cascades Volcano Observatory (CVO) reports the level of activity at a U.S. volcano using the terms **Normal, Advisory, Watch and Warning**, see Table 1 for detailed descriptions. These levels reflect conditions at a volcano and the expected or ongoing hazardous volcanic phenomena. Even in **Normal** seismic activity, USGS CVO may issue an **Information Statement** describing events at a volcano that may be of interest to the public and media. Every effort will be made to alert the entities listed in this plan prior to the issuance of such statements. The information sharing may occur through e-mail and I or a conference call. Upon a change of an alert level or recognition of the start or cessation of volcanic activity, the USGS CVO will issue a formal **Volcanic Activity Notice (VAN)**. The VAN consists of a formatted text message describing the current activity at the, reasons for increasing or decreasing the alert level, or significant activity within an

alert level. Following a telephone call down, the VAN goes out via email and FAX to federal, state, county, local and tribal governmental agencies and the media. VAN messages are also pushed to subscribers of the **USGS Volcano Notification Service (VNS)**. The VNS is a subscription service available here: <http://volcanoes.usgs.gov/vns/>. The VAN is also immediately posted on the USGS CVO website, on USGS Volcanoes on Facebook, and other social media.

For a more details description of volcanic activity at each alert levels, visit Appendixes.

Following are the detailed responsibilities and tasks of jurisdictions and agencies at the various volcano alert levels. More detail about USGS Volcano Alert Levels is found in Appendix D.

Normal:

*A **Normal** level of background activity generally requires no special activities by stakeholders in this volcanic region beyond the usual planning activities. However, the USGS CVO may issue an **Information Statement** in response to unusual but nonthreatening events or to an increase in interest by the public or media. For situational awareness, every effort will be made to alert the entities listed in this plan prior to the issuance of information statements. The information sharing may occur through e-mail and / or a conference call.*

FAC

- Ensure that the plan is up-to-date and practiced.
- Disseminate public information through normal emergency preparedness venues.
- Maintain contact lists.

Volcanic ADVISORY:

(During a period when volcano is exhibiting signs of elevated unrest above known background level)

FAC

- Discuss and evaluate developing events and information.
- Review this plan.
- Disseminate public information through the JIC.
- Consider recommending the USFS implement an Incident Command System organization.

Local jurisdictions and agencies:

- Convene the FAC.
- Review plans and procedures for response to the volcanic hazard threat.
- Designate staff that should be responsible for filling positions in the local ICS and/or Unified Command Structure as requested, including a JIC.
- Provide orientation sessions on current plans and organizational structure.
- Update call-up procedures and listings for response staff.
- Conduct briefings as needed.

Oregon OEM

- Convene the FAC.
- Review internal plans and procedures.
- Implement notifications.
- Provide technical assistance to local jurisdictions.
- Coordinate with Emergency Support Function agencies that may be called upon to provide assistance.
- Coordinate mutual aid agreements with neighboring states.
- Evaluate the need for assistance from additional agencies.
- Evaluate resource requirements.
- Issue advisories and state-level policies in consultation with the FAC.
- Conduct hazard specific training.
- Conduct briefings as necessary.
- Provide staff to the JIC.

USGS

- Convene the FAC.
- Monitor the status of the volcano and determine the need for additional instrumentation and/or other resources.
- Issue alert-level notifications and updates.
- Consider establishing a temporary field observatory.
- Conduct briefings as necessary.
- Assign liaison(s) to the JIC as needed.
- Assign liaison(s) to the Incident or Unified Command if needed.
- Coordinate with NWS on volcanic ash (steam and ash explosions) and lahar (volcanic mudflows) warning messages.

USFS/BLM

- Convene the FAC.
- Prepare to assume role of incident command and coordinate unified command of field operations.
- Identify appropriate location for an emergency operations center (EOC).
- Convene the JIC, if necessary.
- Evaluate need for access control and implement as needed.
- Consider requesting a Temporary Flight Restriction (TFR) over the volcano.
- Authorize placement of additional instrumentation as needed.

NWS

- Convene the FAC.
- Coordinate with USGS CVO on types of products to provide such as volcanic ash forecasts (steam and ash explosions), winds aloft forecasts, and lahar (volcanic mudflows) messages.

Volcano WATCH

(During a period of increased volcanic unrest or eruption that poses limited ground-based hazards):

Local jurisdictions and agencies:

- Continue activities initiated under **Advisory** Alert Level Activities.
- Establish local Incident Command and consider the possible need for Unified Command with other jurisdictions.
- Conduct surveys on resource availability and reaffirm prior commitments.
- Test communications systems and assess communications needs.
- Begin procurement of needed resources.
- Assign PIO's to the JIC as needed.
- Provide briefings and direction to all response personnel.
- Request all assigned personnel to stand by for orders to activate the jurisdiction's emergency plan.
- Coordinate support requirements for USGS Field Observatory if USFS offices unavailable.
- Take readiness and precautionary actions to compress response time and to safeguard lives, equipment and supplies.

Oregon OEM

- Implement plans for State level communications support for the affected area.
- Coordinate joint public education programs.
- Increase, as needed, the staffing at the EOC.
- Support local governments with PIO information.
- Ensure State agencies are alerted to potential problems and review their operational responsibilities.
- Assign liaison(s) to local Incident Command and/or Unified Command organization upon request.

USGS

- Establish field observatory if not already established.

- Monitor the status of the volcano and determine the need for additional instrumentation and/or other resources.
- Issue alert-level notifications and updates.
- Conduct briefings as necessary.
- Assign liaison(s) to the JIC as needed.
- Assign liaison(s) to the Incident or Unified Command if needed.
- Coordinate with NWS on volcanic ash (steam and ash explosions) and lahar (volcanic mudflows) warning messages.

USFS/BLM

- Provide space for the Unified Command structure.
- Identify staff to support Unified Command structure.
- Consider requesting a Temporary Flight Restriction (TFR) over the volcano.
- Evaluate need for access control and implement as needed.

NWS

- Coordinate with USGS CVO on the type and frequency of guidance products to provide on a routine basis such as ashfall forecasts, winds aloft forecasts, and lahar information.
- Begin Volcanic Decision Support Activities to provide information to various customers.

Central Cascades Volcano Planning Working Group:

- Is an ad hoc organization which develops the coordination plan for volcanic incidents.
- Is made up of members from each jurisdiction, agency, and I or private business with responsibilities or pertinent knowledge.
- Will meet on a regular basis until the plan is completed and approved, and then on an "as needed" basis.
- Will serve as subject matter experts in the update of this plan.

- Will provide expertise to WEMD for the development, delivery, and evaluation of training and exercising of this plan.
- Has no operational role.

Volcano WARNING

(Following a notice that an eruption is imminent or occurring):

Local jurisdictions and agencies:

- Fully mobilize all assigned personnel and activate all or part of the Central Cascades Coordination Plan.
- Activate Comprehensive Emergency Management Plans.
- Continually broadcast emergency public information.
- Direct and control emergency response activities in each jurisdiction in accordance with ICS procedures.
- Ensure Incident Command Post (ICP) is adequately staffed and equipped.
- Consider requesting state mobilization and possible activation of an IMT.
- Provide staff to the JIC.

Oregon OEM

- Activate the State of Oregon Office of Emergency Management Plan (Volume II Emergency Operations Plan)
- Coordinate interstate mutual aid.
- Coordinate Federal response.
- Provide staff to the JIC.

USGS

- Monitor status of volcanic activity in the hazard area.
- Issue alert-level notifications and updates.
- Provide Liaison to the Unified Command Structure to provide on-going information and advice.
- Coordinate with NWS on volcanic ash (steam and ash explosions) and lahar (volcanic mudflows) warning messages.
- Assign liaison(s) to the JIC as needed.

USFS/BLM

- Implement plans to participate directly in the following coordinated response operations within the affected areas:
 - Fire
 - Evacuation
 - Security
 - Access Control
 - Search and Rescue
 - Alert and Notification
- Provide personnel for Unified Command Structure.
- Support operations, logistics and planning functions with personnel and resources.
- If necessary, request FAA restrict airspace.
- Evaluate need for access control and implement as needed.

FEMA

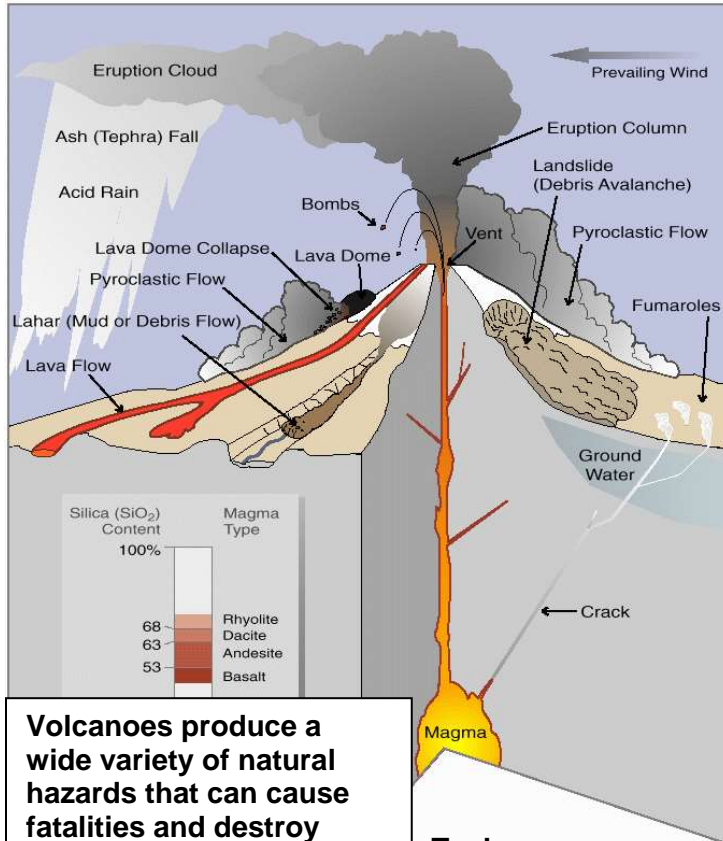
- Activate the National Response Plan.
- Administer disaster relief programs following declaration of Emergency or Major Disaster by the President.
- Coordinate Federal response efforts.

NWS

- Issue Volcanic Ash advisories or warnings in coordination with USGS CVO.
- Issue public warning for lahar via Flash Flood Warning, if needed, in coordination with the USGS CVO.
- Other Volcanic Decision Support Activities to provide information to various customers.
- Issue other statements as needed for volcanic activity that poses a threat to the public, marine or aviation communities, in coordination with the USGS CVO.

APPENDIX A: What Are The Volcano Hazards?

Selection from U.S. Geological Survey Fact Sheet 002-97 <http://pubs.usgs.gov/fs/fs002-97>



Volcanoes produce a wide variety of natural hazards that can cause fatalities and destroy property.

This simplified sketch shows a volcano typical of many found in the Western United States and Alaska, but some of these hazards also pose risks at complex volcanoes, such as Newberry Volcano and in Hawai'i.

Some hazards, such as lahars and landslides, can occur even when a volcano is not erupting.

Definitions

Lava Flows and Domes

Lava is molten rock that flows onto the earth's surface.

Lava flows move downslope away from a vent and bury or burn everything in their paths.

Lava domes form when lava piles up over a vent.

Pyroclastic Flows

Pyroclastic flows are high-speed avalanches of hot rock, gas, and ash that are formed by the collapse of lava domes or eruption columns. They can move up to 100 miles per hour and have temperatures up to 1500°F. They are lethal, burning, burying, or asphyxiating all in their paths.

Tephra

Explosive eruptions blast lava fragments (**tephra**) and gas into the air. Tephra can also be carried aloft in billowing ash clouds above pyroclastic flows. Large fragments fall to the ground close to the volcano, but smaller fragments (**ash**) can travel hundreds to thousands of miles downwind.

Debris Avalanches and Lahars

Debris avalanches are rapid landslides of rock, soil and overlying vegetation, snow or ice. **Lahars** are fast-moving slurries of rock, mud, and water that move down river valley. Lahars form when pyroclastic flows melt snow or ice, or by the mobilization of loose debris on the flanks of volcanoes. Both lahars and debris avalanches can bury, move, or smash objects in their path.

APPENDIX B: Volcanic Hazards in the Central Cascades

The Cascade volcanic arc in central Oregon, from Mount Jefferson to Diamond Peak, is composed of hundreds of individual volcanoes that lie among the major volcanic centers of Mount Jefferson, Three Sisters, and Newberry Volcano. The area has witnessed numerous eruptions during the past 14,000 years (Fig. 1). Some future eruptions will be focused at the major long-lived composite volcanoes. Composite volcanoes host a wide array of eruption types and sizes over life spans of hundreds of thousands of years. In contrast, new mafic (basaltic) cinder cones and small and short-lived shield volcanoes could be born almost anywhere in the range. They produce chiefly lava flows and falls of bombs and cinders near vents and modest amounts of ash or tephra that fall out from eruption clouds farther downwind. Aviation could be disrupted by any eruption that generated tephra, although mafic eruptions are much less likely than silicic eruptions to produce large volumes of tephra. Numerous mafic cinder cones dot the landscape. Close to the vents, volcanic bombs and scoria would be deposited, with ash depositing as much as a few kilometers away. Close to the vents, these mafic ash deposits could be several meters thick, but such deposits typically thin quickly away from their vents. Each of the major volcanic centers represents a specific set of eruptive characteristics and history, and each poses a variety of potential hazards from future eruptions. The key aspects of each center are summarized below, followed by a discussion of the broad field of mafic volcanoes within which the major centers lie. Past eruptive events help to define zones of potential hazards during future eruptions; these are shown in a volcano-hazard map (Fig. 1).

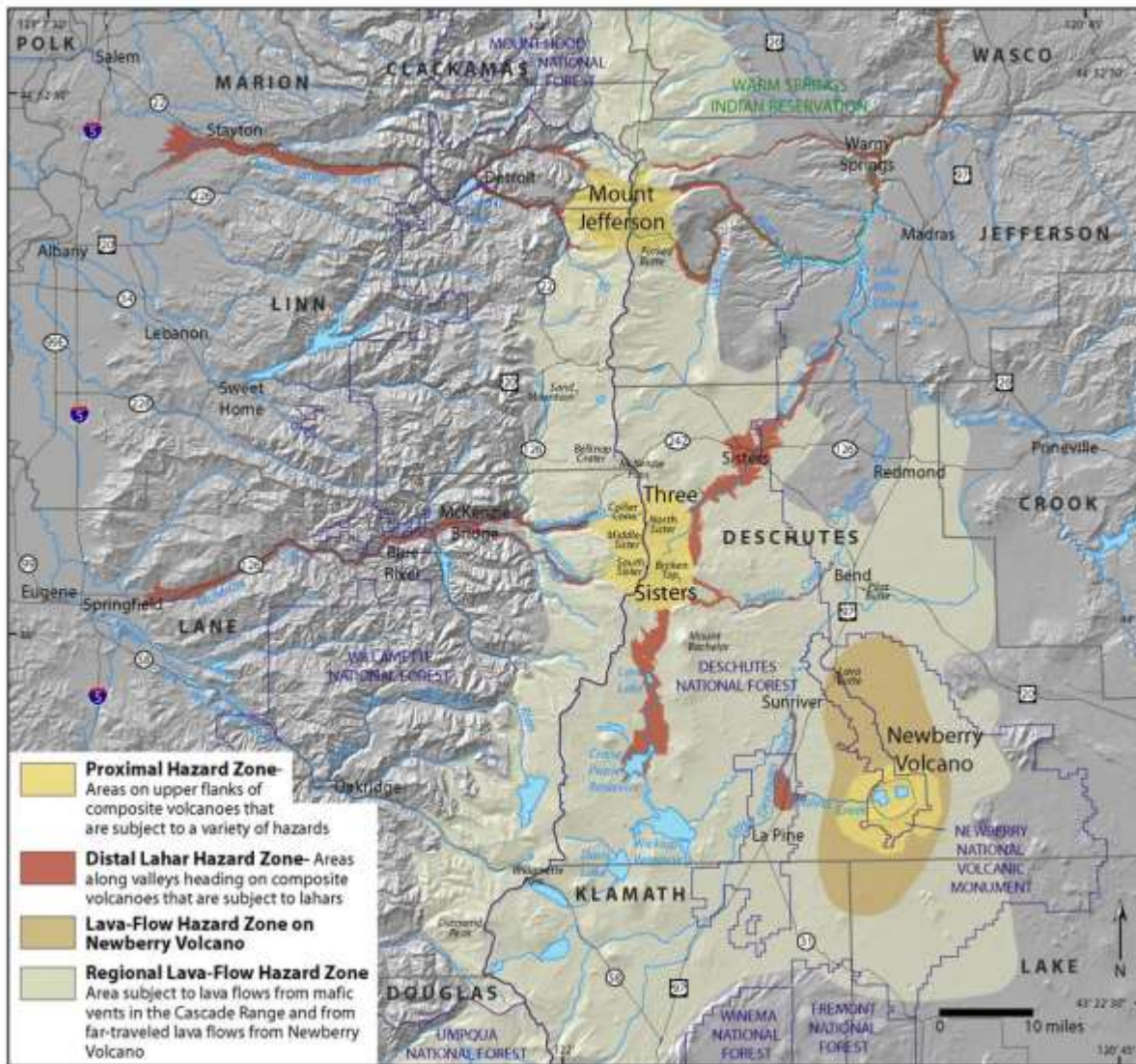


Figure 1.

Volcano hazards in central Oregon. Hazard zones are modified from the USGS hazard assessments for Mount Jefferson, Three Sisters, and Newberry Volcano listed in References Of this Central Cascades Volcano Coordination Plan

Mount Jefferson

Of the 13 volcanic centers in the Cascade Range, Mount Jefferson has been the least active in the recent geologic past. In fact, the volcano has been dormant for more than 15,000 years, but is still considered capable of erupting in the future. Mount Jefferson has hosted large explosive eruptions in the past that blanketed areas near present Lake Billy Chinook with more than 1 meter (3 feet) of pumice and showered tephra over a broad area of the western United States. Eruptions also generated **pyroclastic flows** of ash and pumice that moved rapidly down valleys near the volcano and melted snow and ice to form **lahars**, or volcanic debris flows, that traveled

even farther down the Deschutes and North Santiam river valleys. Lahars in the North Santiam valley nearly reached Salem. Past eruptions have also produced **lava flows** and **lava domes**, the latter of which can collapse during their growth and produce pyroclastic flows and lahars. The steep upper parts of the volcano could also be susceptible to landslides, or **debris avalanches**, that could be triggered by renewed volcanic activity. Such avalanches bury valleys near the volcano and can transform to lahars that travel much farther down valley.

Unlike other major volcanic centers in central Oregon, all valleys that drain Mount Jefferson contain large reservoirs, Detroit Reservoir on the North Santiam and Lake Billy Chinook on the Deschutes River. If water levels are lowered, such impoundments can provide traps for avalanches and lahars. But, if full, they can compound downstream problems. Large avalanches or lahars that enter full reservoirs can generate waves that overtop dams and cause downstream flooding or endanger the integrity of the dam itself.

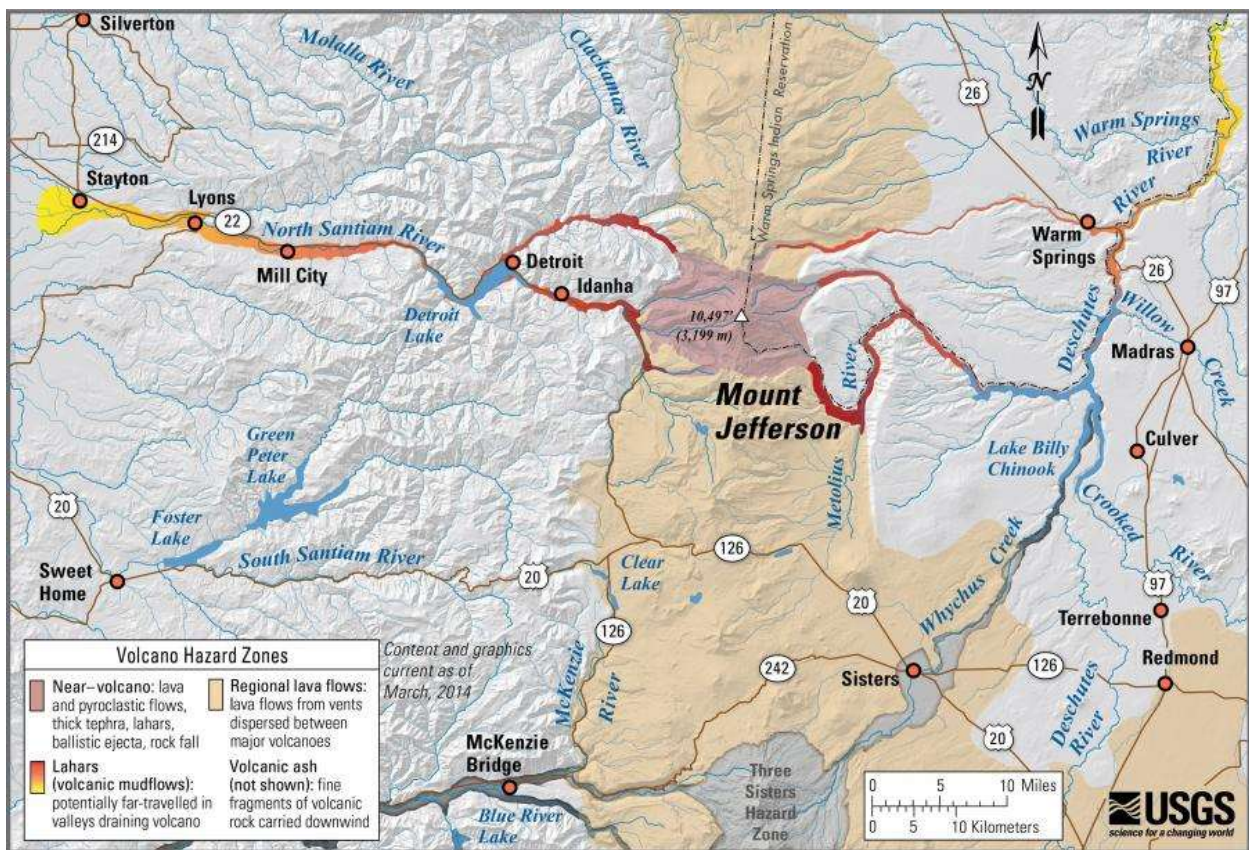


Figure 2. **Volcano hazards at Mount Jefferson.** Hazard zones are simplified from the USGS hazard assessment for Mount Jefferson.

Three Sisters

Unlike other major Cascade volcanic centers, the Three Sisters center contains two young composite volcanoes, South Sister and Middle Sister, rather than one. The third sister, North Sister, and other nearby conspicuous volcanoes such as Mount Bachelor are large mafic volcanoes. Broken Top is a composite volcano that has not erupted for tens of thousands of years. Eruptions about 2000 years ago from vents on South Sister produced conspicuous blocky lava flows, such as Rock Mesa. These eruptions also produced a modest amount of pumice and ash that blanketed downwind areas. Probably no more than 1 or 2 centimeters (less than one inch) of ash fell in the area now occupied by Bend. Similar, but larger, eruptions occurred during the last ice age, which ended about 12,000 years ago, and had more widespread effects. Such eruptions occurred from both Middle Sister and South Sister. Three eruptions during the past one-half million years have been significantly larger and produced pyroclastic flows that swept over present-day Bend and Sisters. Fortunately such eruptions are rare—the last one occurred more than 200,000 years ago—and there is no sign that the Three Sisters system is capable of producing such an eruption during our lifetimes. Owing to the prevailing westerly winds in central Oregon, areas east of Three Sisters have the greatest probability of being affected by **tephra falls** from future eruptions. Eruptions that produce higher eruption clouds and greater volumes of tephra will affect progressively larger areas. Although seldom life threatening, ash fall can greatly disrupt life. Darkness and swirling clouds of ash limit visibility and affect transportation *in Appendix*). If wet, ash creates slippery conditions on roads. Ash is electrically conductive, especially if wet, and abrasive, so it can severely affect electrical and mechanical systems. Ash is also extremely dangerous to aircraft in flight.

The three major drainage systems that head in the Three Sisters area are all potentially at risk from lahars during future eruptions (Fig. 2). The location and size of lahars will depend on the site of the eruption and its character.

- Separation Creek and White Branch lead to several small communities in the McKenzie valley, including McKenzie Bridge and Blue River, which could be in the paths of lahars flowing westward. Large-volume lahars could reach communities farther west. Oregon Highway 126 and municipal water and hydroelectric facilities could be affected by lahars and excess sediment in the McKenzie.
- Broad basins in the upper Deschutes valley, such as those occupied by Sparks, Elk, and Lava lakes, provide traps for lahars and sediment moving south, as do Wickiup and Crane Prairie Reservoirs.
- The Sisters area represents the largest concentration of residents and development in a lahar-hazard zone. The city lies less than 30 kilometers (19 miles) downstream from Middle and South Sisters along Whychus Creek. Below Sisters, Whychus Creek flows into a deep canyon and joins the Deschutes River.

Eruptions that disrupt watersheds by removing vegetation and adding large quantities of sediment from tephra fall, pyroclastic flows, debris avalanches, and lahars, typically initiate a period of years to decades during which streams carry increased sediment loads and channels become unstable and migrate. Such effects propagate downstream and can disrupt channels and flood plains far from where direct impacts of eruptions end. The Springfield-Eugene area along the lower McKenzie River and Sunriver and Bend along the Deschutes River below Wickiup Reservoir could be vulnerable to such events in the years following eruptions. Similarly the Tumalo Creek watershed that supplies part of Bend’s municipal water, although not likely to be affected directly by volcanic flows, is likely to receive ash fall from any eruption in the Three Sisters area.

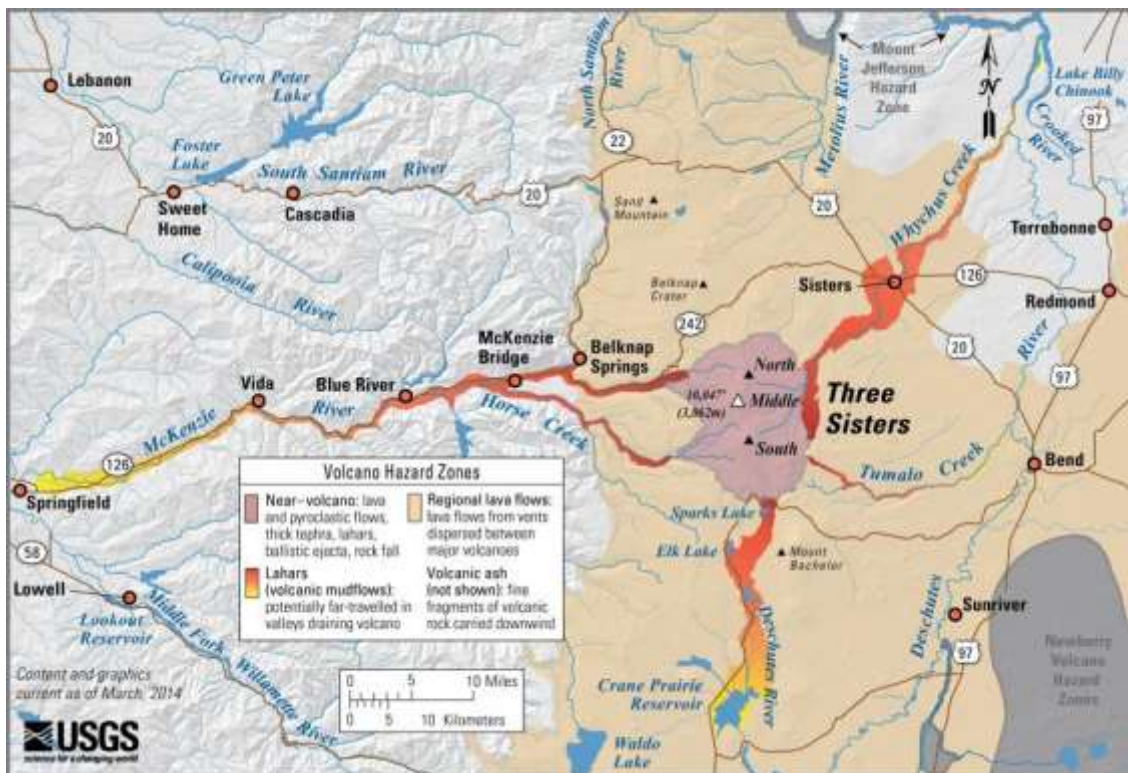


Figure 3. **Volcano hazards at Three Sisters.** Hazard zones are simplified from the USGS hazard assessment for the Three Sisters volcanic area.

Eruptive and major debris-flow and flood events in the central Cascades of Oregon during the past 14,000 years

| Years ago | Mount Jefferson area | Three Sisters | Mafic volcanoes north and south of Three Sisters | Newberry volcano |
|----------------------------|--|--|--|---|
| Present | Floods and debris flows from moraine-dammed lakes, and intense precipitation | Floods and debris flows from moraine-dammed lakes and other sources | | |
| | | | Lava flows and tephra falls from Belknap Crater; numerous vents in McKenzie/Santiam Pass areas | Tephra fall, pyroclastic flow, and Big Obsidian flow in caldera |
| 2,000 | | Tephra falls, pyroclastic flows, lava domes and lava flows from South Sister flank vents-Rock Mesa and Devil's Chain | | |
| | | | Lava flows and tephra falls from Sand Mountain vents and Twin Craters | Large flood along Paulina Creek |
| 4,000 | | | Lava flows and tephra falls in Davis Lake area | Tephra falls and East Lake obsidian flows in caldera |
| | | | | |
| 6,000 | Lava flows and tephra falls from Forked Butte and other nearby vents | | | Central Pumice cone, tephra falls, and several obsidian flows in caldera. Lava flows, scoria cones, and tephra falls from vents |
| Mount Mazama tephra | | | | |
| 8,000 | | | <i>Final lava flows and tephra falls from Mount Bachelor volcanic chain</i> | |
| | | | | |
| 10,000 | | | <i>Lava flows and tephra falls from Sim Butte and Cayuse and Le Conte Craters</i> | Lava flows and tephra falls from East Rim fissure vents |
| 12,000 | | | | |
| | | Tephra falls and lava flows from Middle Sister | | Lava flows and tephra falls from vents on north, and southeast flanks |
| 14,000 | | | <i>Lava flows and tephra falls during later stages of Mount Bachelor volcanic chain</i> | |

FIGURE 4 Eruptive and major debris-flow and flood events in the central Cascades of Oregon during the past 14,000 years. The events in italics are poorly dated, so their ages are less well known than those in normal font. The Mazama tephra fall was produced by the cataclysmic eruption of Mount Mazama that created Crater Lake 7,700 years ago.

Newberry Volcano

Overview—Newberry Volcano is among the largest and most voluminous of Cascade volcanoes. Even though it is not of great height, it is very broad. Newberry lavas extend about 120 kilometers (75 miles) north to south and 43 kilometers (27 miles) east to west, the volcano and its broad apron of lavas cover a total of almost 3,000 kilometers (1,200 square miles), making it by area the largest volcano of the Cascades volcanic chain. The edifice covers more than 3,000 square kilometers (1,300 square miles). Beyond the edifice, Newberry lava flows cover an additional 700 square kilometers (270 square miles), and reach about 25 kilometers (16 miles) north of Redmond. Hundreds of volcanic vents exist on the flanks of Newberry, many arranged in linear arrays, or rift zones, that extend far down the flanks. The youngest rift-zone eruption occurred about 7,000 years ago. At that time, a 32-kilometer long (20-mile-long) fissure system opened extending northwest from the caldera. On this Northwest Rift Zone, lava fountains and small explosive eruptions created cinder cones, such as 150-meter high (500-foot-high) Lava Butte, and wind spread blankets of cinders and ash downwind, often preceding lava flows. Lava flows from Lava Butte temporarily dammed the Deschutes River and traveled more than 8 kilometers (5 miles) from the butte.

Lava flows—Most of the City of Bend east of the Deschutes River is built on lava flows from Newberry. Potential future eruptions from rift zones on the north flank of Newberry represent the most credible lava-flow threat to a large settled area in the United States outside of Hawai'i. Lava flows advance relatively slowly compared to rapid flows such as lahars and pyroclastic flows, so they rarely threaten human life. But an advancing lava flow ensures almost total destruction owing to burial and incineration. Once lava begins to flow from a vent, scientists are typically able to forecast which areas downslope are at greatest risk. Damming of the Deschutes River by lava flows could happen again as it did during an eruption 7,000 years ago, and initially trigger flooding upstream and later downstream if the lava dam fails.

Explosive eruptions—Newberry has also produced some notable explosive eruptions. Most of these originated from vents located in the broad depression, or caldera, that forms the summit of the volcano. The most recent eruption in the caldera occurred 1300 years ago. It generated thick tephra falls and pyroclastic flows. Larger events are known in the more distant geologic past at Newberry, including some that transported tephra over broad areas of the western United States and sent pyroclastic flows down the volcano's flanks.

During potential future explosive eruptions, cinder cone eruptions on the volcano's flanks could generate modest amounts of tephra that would accumulate near the erupting vent. But, explosive eruptions from Newberry caldera could send large amounts of ash several kilometers in to the atmosphere where it could be blown by wind to populated regions and become a hazard to aviation. Close to the vents, the ash deposits could be several meters thick, but would typically thin quickly with distance from the vents.

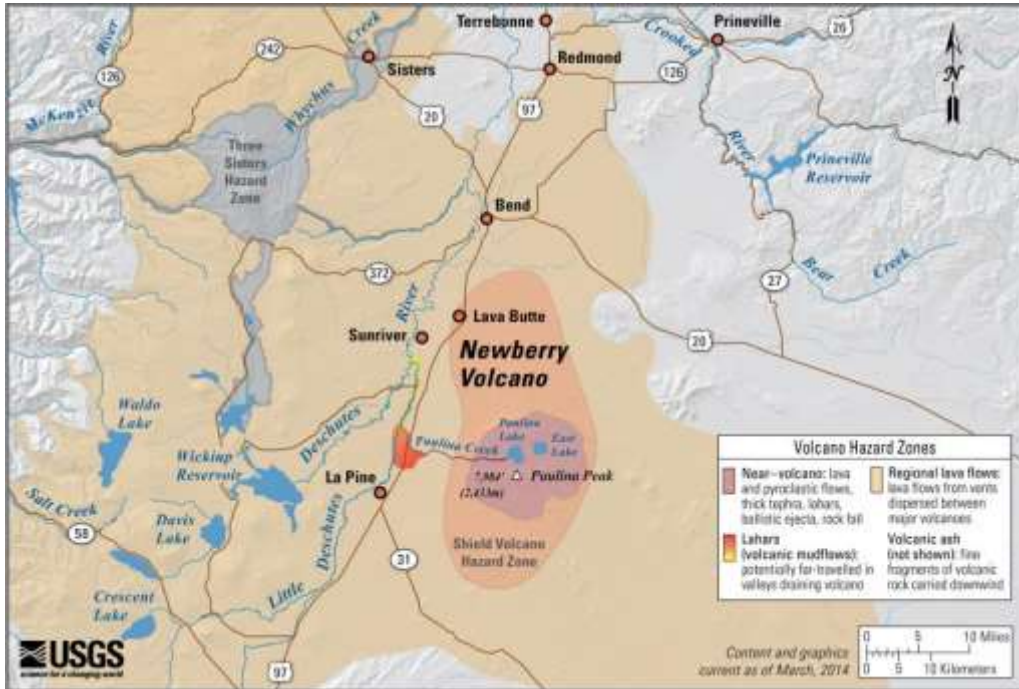


Figure 5. This Simplified Hazard Map is modified from <http://pubs.er.usgs.gov/publication/ofr97513> , where the user can find more in-depth descriptions of hazards and a map of hazard zones.

Volcanic gases—The presence of the summit caldera and closed basins within it create conditions favorable for accumulation of heavier-than-air volcanic gases, notably carbon dioxide, which could lead to dangerous conditions if increased emission of gas occurs during volcanic unrest or an eruption. Heavier than air gases could result in asphyxiation for anyone within the caldera.

Geothermal—Several lines of evidence indicate that an active magma system exists beneath Newberry Volcano. Currently, both lakes within the caldera, Paulina and East Lake, contain hot springs with temperatures as high as 135 degrees F. A USGS drill hole made in 1981 found temperatures higher than 500-degrees at a depth of 3,000 feet. Near its margins, Newberry Volcano is being explored as a potential source for geothermal energy. High temperatures encountered now by hot spring users, and by geothermal drillers could become elevated during volcanic reawakening. If a volcanic vent opened beneath the caldera lakes or through groundwater, the eruption would almost certainly be highly explosive and would deposit wet, muddy tephra over the immediate area.

Hydrologic hazards—As has happened in the past, rapid release of water from the Paulina Lake or from rapid snowmelt could produce lahars or floods that descend the Little Deschutes River and inundate the Paulina Prairie area north of La Pine.

Fields of Mafic Volcanoes

Hundreds of geologically young volcanoes composed of cinders, ash, and lava flows dot the central Oregon landscape among the major volcanic centers. Many, such as Collier Cone on the north flank of Middle Sister, lie near one of the composite volcanoes; others lie far from one. Some are small cones; others, such as Mount Bachelor, are large shield volcanoes that stand more than 1000 meters (3300 feet) above their bases and can be more than 10 kilometers (6 miles) wide. The youngest mafic volcano in the region is Belknap Crater, north of McKenzie Pass, which formed about 1500 years ago. Geologic evidence suggests that the eruptions that formed these features may have lasted for centuries in the case of the largest cones to weeks to months for smaller ones. In some cases, vents in linear chains as long as 10 kilometers (6 miles) were erupting concurrently, or nearly so. Since the last ice age waned, about 12,000 years ago, vents of mafic volcanoes have been concentrated in a narrow zone about 80 kilometers (50 miles) long, extending from south of Mount Bachelor to north of Santiam Junction. A few scattered vents in the area between Davis Lake and Oregon Highway 58 and a few south of Mount Jefferson were also active during this time period.

Future eruptions of mafic volcanoes are possible anywhere in the broad central Cascades region, although eruptions are probably more likely to occur in the greater Three Sisters area, judging from the volcanic history of the past 14,000 years. Tephra from eruptions of mafic volcanoes will affect areas chiefly east of the Cascade crest. Tephra falls from ongoing eruptions of mafic volcanoes, which could last months to years or even longer, would be a chronic nuisance in Deschutes County. Once an eruption begins, ultimate extent of lava flows will depend on vent location, local topography, and the total volume and rate of lava erupted, but scientists will be able to make forecasts about areas at greatest risk. Fortunately most future lava-flow eruptions in the central Cascades will occur away from populated areas. Impacts are more likely to affect forests and stream channels. Less likely to be affected are major highways and power-line corridors.

Uplift at Three Sisters 1997-to present

Beginning around late 1997, a broad dome-shaped area about 20 kilometers (12 miles) in diameter centered 5 kilometers (3 miles) west of South Sister slowly rose). At its center the average rate of uplift was about 3 cm (a little more than 1 inch) per year until 2004, when the rate slackened. Such activity is known from many volcanic areas around the world and is thought to be caused by intrusion of magma, or molten rock, at depth. Close monitoring of the area by satellite and ground-based methods showed that the rate of uplift decreased to about 1.4 cm (0.5 in.) per year during 2004–2006 and in 2017 to a rate of 0.4 cm 1/8—3/16 inches per year. As of early 2017, the total amount of uplift so far has been about 30 cm (1 foot). Modeling of the uplift (inflation) suggests that it was caused either by the intrusion of 50-70 million cubic meters (65-90 million cubic yards) of magma at about 5-km (3-mi) depth or by rise of a hot, buoyant plume of hot water and gas to a similar level that caused heating and expansion of surrounding rock. In either case, an eruption is unlikely in the near future if current

trends continue. Similar inflation episodes have been recognized at many volcanoes around the world, and others probably went unnoticed before the development of modern monitoring techniques such as GPS and InSAR.

Status of Volcano Monitoring at the Central Oregon Cascades

Techniques for monitoring active or potentially active volcanoes focus on three areas—earthquakes (seismicity), ground deformation, and volcanic gases. Magma intruding a volcanic system breaks rock and causes slippage on faults, thereby creating earthquakes; it adds material at depth and heats and pressurizes ground water, thereby bowing up the ground surface; and it releases volcanic gases, mainly water vapor, carbon dioxide, and sulfur dioxide. Heat and volcanic gases from magma warm and add telltale chemicals to the ground water, which affects the composition of spring water throughout the area. Some monitoring occurs in real-time or near real-time as data are telemetered from field sites to base stations; other monitoring is done on a periodic basis and requires visits to the field or gathering data from satellites.

Earthquakes in central Oregon are detected and located in real-time by the Pacific Northwest Seismic Network at the University of Washington (UW), a cooperative undertaking of the UW, the USGS Earthquake and Volcano Hazards Programs, and the University of Oregon. The station spacing in central Oregon is relatively large, so only earthquakes greater than magnitude (M) 1 or 2 are able to be located routinely. Six stations added by the UW and the USGS Cascades Volcano Observatory (CVO) in the Three Sisters area since ongoing uplift was recognized in 2001 have reduced the magnitude threshold for location there to about M 0.5 to 1, if all stations are operating. In 2011 CVO installed eight seismic and GPS stations around Newberry, which had previously been monitored by a single seismic station. Prior to the installation of this network, a total of 13 earthquakes had been located in the Newberry area since 1980, none within 15 km of the caldera, and the smallest of these had a magnitude of M 1.1. Since installation of the new network, the PNSN has recorded hundreds of events in the Newberry area including ~300 associated with AltaRock EGS stimulation activities in 2013-2014. Over 100 events have been recorded that are not attributable to stimulation, including 45 events that locate inside the caldera (the smallest of these being a magnitude M -1.2; the largest being M2.6). The new network has significantly improved detection and location capabilities in the Newberry area, which turns out to be much more seismically active than had been previously recognized. In addition, the Newberry network has facilitated detection of earthquakes well west of Newberry in areas containing cinder cones, including several in the vicinity of a chain of cones extending south from Mount Bachelor and several others near Lookout Mountain.

In addition, a cache of instruments at USGS Cascades Volcano Observatory is available to rapidly augment the existing network should conditions warrant. Continuous Global Positioning System (CGPS) receivers are able to track ground deformation in real time for a single point on Earth's surface. At present CGPS receivers at Redmond, Mount Bachelor, and two near the center of the ongoing uplift near South Sister operate in real time. Such a sparse network is of limited use in understanding the complex nature of ground deformation in a volcanic environment. Additional instruments are planned. Broader regional coverage is afforded by periodic USGS surveys (typically annual or every few years; more often if conditions warrant) of an array of benchmarks in the Three Sisters and Newberry areas by temporary deployment of GPS instruments. Both areas also have a system of precisely surveyed lines along roads or trails that are

used for tilt leveling, a procedure that is capable of measuring slight crustal movements. Another technique called InSAR uses satellite radar data to detect crustal movements over broad areas. It discovered the uplift in the Three Sisters area but has had limited use since, owing to problems with the satellite. Its utility should improve with launch of new satellites.

USGS scientists measure output of volcanic gases by airborne surveys. Flights to central Oregon volcanoes are made every few years in order to develop baseline information; additional flights occur as conditions warrant. During times of increased concern, flights could occur as often as atmospheric conditions allow. Annual sampling and chemical and isotopic analysis of spring water from the area permit a broad regional view of how magmatic intrusion is affecting the chemical composition of shallow ground water.

By combining the results of these and other techniques and an understanding of a volcano's past behavior, the goal of volcano monitoring is to issue forecasts as accurately as possible about the state of a volcanic system and the probability for the onset of potentially hazardous conditions.

Once an eruption has begun, monitoring information is used to forecast the character and expected outcome of the eruption, as well as its end.

NOTE: The USGS-Cascade Volcano Observatory (CVO) maintains summary volcano information on its public website <http://vulcan.wr.usgs.gov/>

Warning time and duration of eruption--long or short?

At volcanoes around the world, the amount of warning time between the first appearance of volcanic unrest and the onset of a hazardous eruption has ranged from about one day to several years. At Redoubt Volcano in Alaska, increased steaming was noted in early November 1989; but seismic activity remained low until December 13, about 25 hours before the onset of a major explosive eruption. Three more explosive events on December 15 were followed by six months of dome growth and dome collapse until activity ceased in early summer of 1990. At Soufriere Hills Volcano on the island of Montserrat, British West Indies, the initial seismic unrest in January 1992 preceded the first eruption by three years. The first small steam explosion in July 1995 was followed by the appearance of a lava dome in September of that year. Pyroclastic flows from the growing dome began piling into surrounding valleys in March 1996, leading to the gradual destruction of Plymouth, the capital city, and surrounding towns and farmland over the next two years. Dome growth and periodic explosions continue at Montserrat today (2012).

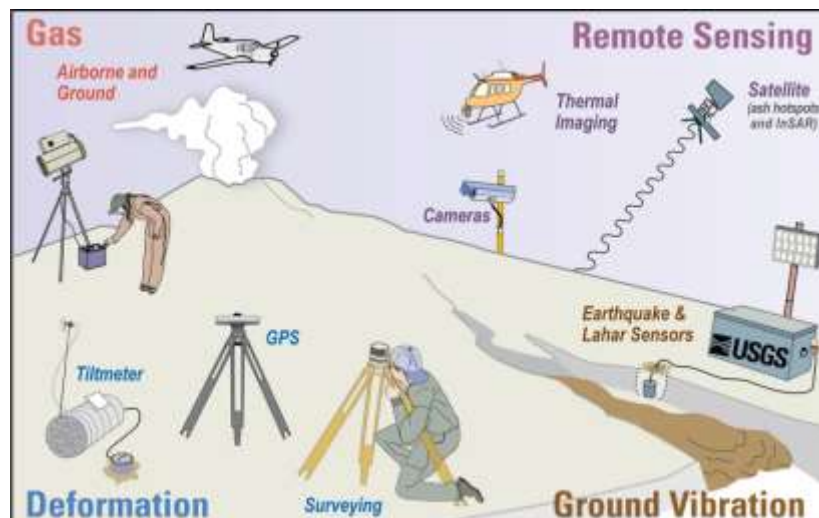
For a variety of reasons, hazardous magmatic eruptions at Central Oregon volcanoes would likely be preceded by weeks or more of unrest. Chief among those reasons is that they have been dormant for more than a century; the conduit system that conveys magma to the surface has solidified and should have to be fractured and reopened for

the next magma to reach the surface. In the Cascades chain of volcanoes, two volcanoes have produced magmatic eruptions during the twentieth century. At Mount St. Helens, the climactic eruption of May 18, 1980, was preceded by increased seismicity, ground deformation and steam eruptions that began in late March of that year. At Lassen Peak in California, small steam and ash explosions began on June 30, 1914, and continued sporadically for almost a year before the onset of large magmatic eruptions in May 1915.

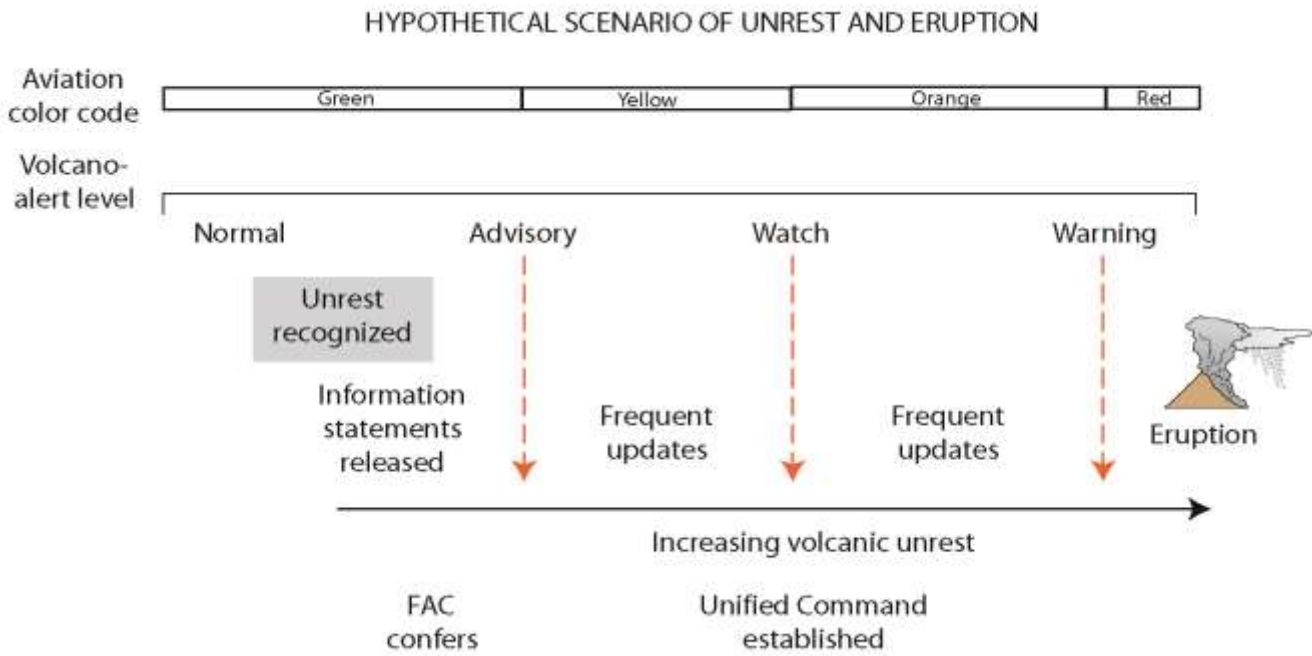
APPENDIX C: MONITORING VOLCANIC UNREST

In response to developing volcanic unrest at a Central Oregon volcano, a USGS response team expects to:

- Install additional monitoring instruments to collect and analyze visual, seismic, lahar-detection, deformation, and gas-emission data. As an important element of redundancy, critical seismic data should be received and analyzed at the Pacific Northwest Seismograph Network at the University of Washington, the USGS Cascades Volcano Observatory, and the local temporary volcano observatory.
- Establish a temporary volcano observatory with the USFS/BLM,. The observatory should maintain close contact with emergency managers and should be sited to allow efficient daily helicopter access to the volcano. The primary function of the USGS response team is to monitor all volcanic developments and to provide eruption-forecasting and hazard-assessment information to support decisions by public officials. If the volcanic activity is on other flanks of the peak than anticipated, alternate locations should likely be identified.



The figure below is intended to provide perspective on how a volcanic crisis might unfold. Many other potential scenarios exist. The first sign of significant earthquake activity or other signs of unusual unrest should prompt the USGS to issue an Information Statement. If significant unrest continues, then eventually a Notice of Unrest may be issued, etc.



APPENDIX D: EVENT NOTIFICATION AND ALERT LEVELS

Please see: USGS Fact Sheet 2006-3139 [Http://pubs.usgs.gov/fs/2006/3139/fs2006-3139.pdf](http://pubs.usgs.gov/fs/2006/3139/fs2006-3139.pdf)

The consequences of an eruption can vary and are dependent upon the eruption type, size, and directions in which the hazards (lahar, tephra plumes, pyroclastic flows, etc.) are transported. Local agencies require information on hazards that affect nearby areas, whereas airlines and the Federal Aviation Administration (FAA) require information on tephra plumes that can be hazardous to aircraft hundreds of miles from source. The information required by these two groups is not always the same and therefore the Volcano Science Center, in cooperation with various agencies, has developed two hierarchies of alert levels; one directed toward emergency response on the ground and the other toward ash hazards to aircraft. These two hierarchies are described below.

For ground-based hazards, the USGS issues statements in coordination with the appropriate land management agency (in this case USFS) and to Oregon Office of Emergency Management (OEM). OEM transmits the statements, as appropriate, to other state agencies, counties, and adjacent states. The counties then transmit the notifications, as appropriate, to their own emergency management agencies, cities, city-government organizations, special purpose districts, and citizens.

For aviation hazards, the USGS issues statements to the Seattle Center of the Federal Aviation Administration (FAA), the Washington D.C. Volcano Ash Advisory Center (WVACC), and the National Weather Service (NWS). The Interagency Operating Plan for Volcanic Ash Events was developed in 2011 to coordinate actions by the USGS, FAA, and NWS to mitigate the threat of volcanic ash in Washington and Oregon to the nation's aviation system.

Notification of Ground-Based Hazards

Event notification by the USGS may occur under two distinctly different circumstances:

- (1) In response to unexpected short-lived events;
- (2) In response to developing volcanic unrest that may culminate in eruptive activity with attendant volcanic and hydrologic hazards.

The former is handled through information statements, the latter through Staged Alert Levels. Both are issued by the USGS.

Information Statements

Events such as steam bursts (with or without minor ashfall), small avalanches, or rock falls often attract media and public-interest inquiry. This type of event is short-lived, usually concluding within minutes. Since this type of event almost always occurs without specifically recognized precursors, there is no opportunity to provide warning or evacuation. Thus, persons in proximity to such an event are at some personal risk and should need to make their own safety decisions.

Information about a discrete natural event may come from a variety of sources. Owing to frequent public and media inquiries that result from such events, USGS-CVO should attempt to verify the nature and extent of the event, issuing commentary as appropriate in "Information Statements". Information Statements may also be issued to provide commentary about notable events occurring within any alert level during volcanic unrest. The USGS should convene the Facilitating Committee (FAC) prior to issuing a second Information Statement due to an event that may signify increasing volcanic unrest. Depending on the situation, this may be a conference call rather than a face-to-face meeting.

Staged Alert Levels

A system of staged alert levels (“**Normal**”, “**Advisory**”, “**Watch**”, and “**Warning**”) indicates the activity at the volcano from quiescence to hazardous eruptive activity. Alert-level notifications (USGS’ Volcano Activity Notices or VANs), are accompanied by brief explanatory text to clarify hazard implications as fully as possible. Updates may be issued to supplement any alert-level statement.

Alert-level assignments are based on a volcano’s level of activity. Alert levels are not always issued sequentially. The highest two alert levels (**Watch** and **Warning**) use National Weather Service (NWS) terms for notification of hazardous meteorological events, terms already familiar to emergency managers and the public; however, unlike the NWS terms, volcanic alert levels of **Watch** and **Warning** do not signify the time frame in which an event may occur.

Staged Alert Level Details

In 2006 the USGS adopted a single system for characterizing the level of hazardous activity at U.S. volcanoes. The system is a means to communicate the status of a volcano in a clear, direct form to non-volcanologists and to prompt people and organizations potentially at risk to seek further information or to decide upon mitigation measures. The system employs a set of general terms, the latter two of which, **Watch** and **Warning**, are used in a manner similar to that used by the National Weather Service for hazardous meteorological phenomena and thus familiar to emergency managers and the public. As part of the system, color codes (described in a later section) are used to provide quick information about volcanic-ash hazards to the aviation sector. They are part of an integrated worldwide warning system that follows procedures sanctioned by the International Civil Aviation Organization (ICAO) and that in the United States involves the Federal Aviation Administration (FAA) and National Weather Service (NWS).

Description of Volcano Alert Levels

The USGS ranks the alert level at a U.S. volcano using the terms **Normal**, **Advisory**, **Watch**, and **Warning** (table 1). These levels reflect conditions at the volcano and the expected or ongoing hazards. Assigning an alert level depends upon monitoring data and interpretation of changing phenomena. Alert levels are not always followed sequentially and escalate or de-escalate depending on volcanic behavior. Volcano-

alert notices are accompanied by explanatory text to give fuller explanation of the observed phenomena and to clarify hazard implications to affected groups. Updates that describe the ongoing activity are issued on a regular basis, at increasing frequency at higher activity levels.

Volcanic events are different enough that it is not possible to predetermine a detailed set of geophysical and geochemical criteria for each level that would be applicable universally. The alert-level definitions are guidelines for scientists to use to gauge the level of hazardous activity and for public officials and the public to consider when deciding what actions they need to take. Note that **Watch** is used for both heightened precursory unrest and for minor eruptive activity because both states bear close watching but do not have immediate, major hazardous effects. Because the size, style, and reach of eruptions can vary substantially, a higher level (**Warning**) is needed to highlight very hazardous eruptive activity.

Normal: *Typical background activity of a volcano in a noneruptive state*

This level applies to inactive, non-erupting volcanoes, with allowance for periods of increased steaming, seismic events, deformation, thermal anomalies, or detectable levels of degassing as long as such activity is within the range of typical non-eruptive phenomena seen at a volcano during its monitoring history (or at similar types of volcanoes).

Advisory: *Elevated unrest above known background activity*

This level is declared when a volcano is exhibiting signs of elevated unrest above known background levels. Progression toward eruption is by no means certain. After a change from a higher level, **Advisory** means that volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.

Watch: *Heightened or escalating unrest with potential for eruptive activity OR a minor eruption underway that poses limited hazards*

This level is declared for two situations: (1) when a volcano is exhibiting heightened or escalating unrest with potential for eruptive activity (not necessarily imminent) or (2) when a minor eruption is underway with limited hazardous impact. When changing from **Advisory**, this level implies increased potential for an eruption (timeframe variable). When changing from **Warning**, this level signifies that the volcano is still showing signs of heightened activity that may lead to renewed highly hazardous activity or that the volcano has settled into minor eruptive activity with limited hazards.

Warning: *Major or highly hazardous eruption underway or imminent*

This level is declared by the USGS when a major or highly hazardous eruption appears to be imminent or is confirmed or suspected to be underway. Owing to remoteness or poor weather conditions, some

eruptions may not be confirmed visually or by satellite imagery, but ground-based monitoring data may strongly suggest that eruptive activity is occurring; in such cases, the accompanying information will say that a “suspected” rather than a “confirmed” eruption is underway.

Accompanying information will indicate in as much detail as possible the eruption’s time of onset, duration, size, intensity or explosivity, and impact on the landscape and atmosphere. When the major eruptive period ends or settles into milder, less hazardous activity, the level is downgraded.

Information Statement: *Notable event at a volcano, not necessarily eruptive* Phenomena such as prominent steam plumes, small avalanches and rock falls, minor mudflows, changes in appearance of a lake in a volcanic crater, and minor seismic activity may occur while a volcano is at a **Normal** level. Most such events are short-lived and lack recognizable precursors and do not necessarily suggest volcanic unrest or major flank instability that would warrant a crisis response. However, owing to public and media inquiries that often result from a notable event, the USGS along with other involved agencies will attempt to verify the nature and extent of the event and issue explanations in the form of an **Information Statement**. An **Information Statement** also may be issued periodically to provide commentary about a significant event or change occurring within higher alert levels.

Aviation Color Codes

Eruptions threaten aviation safety when plumes of volcanic ash are explosively erupted and disperse as airborne clouds in flight paths of jet aircraft. Numerous instances of aircraft flying into volcanic-ash clouds have demonstrated both the economic costs and life-threatening potential of this hazard. The accepted mitigation strategy is to avoid encounters of aircraft with ash clouds, which requires that pilots, dispatchers, and air-traffic controllers quickly learn of occurrences of explosive eruptions and the whereabouts of airborne ash clouds globally.

For the aviation sector, in accord with recommended ICAO procedures, the USGS issues color-coded activity levels – **Green, Yellow, Orange, and Red** – focused on ash hazards (table 2). Color-codes are especially suitable for the aviation sector because pilots, dispatchers, and air-traffic controllers planning or executing flights over broad regions of the globe quickly need to ascertain the status of numerous volcanoes and determine if continued attention, re-routing, or extra fuel is warranted. As with the **Watch** term, **Orange** is used for both heightened precursory unrest and minor eruptive activity, and there are two levels (**Orange** and **Red**) to cover the range of eruption size and impact.

All Volcano Advisories, Watches, and Warnings will include the “Aviation Color Code,” clearly identified as such to differentiate it from other hazard statements. In most

cases, the term and aviation-specific color code will move together (e.g., **Normal** and **Green**; **Advisory** and **Yellow**; **Watch** and **Orange**; **Warning** and **Red**). However, there may be occasions when activity at a volcano poses a hazard to the aviation sector that is significantly lower than hazards posed to ground-based communities. In those cases, the aviation color code will be lower than what is normally associated with the alert term. An example is a large lava flow heading towards a town (Volcano **Warning** in effect) that is unlikely to produce any ash in flight routes or near an airport (Aviation Color Code **Orange**). Conversely, an ash plume that does not yield significant ash fall onto ground communities but does drift into air routes might warrant a Volcano **Watch** and Aviation Color Code **Red**.

| Table 1. VOLCANO ALERT LEVELS | |
|---|---|
| NORMAL | Volcano is in typical background, noneruptive state or, <i>after a change from a higher level</i> , volcanic activity has ceased and volcano has returned to noneruptive background state. |
| ADVISORY | Volcano is exhibiting signs of elevated unrest above known background level or, <i>after a change from a higher level</i> , volcanic activity has decreased significantly, but continues to be closely monitored for possible renewed increase. |
| WATCH | Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, OR eruption is underway but poses limited hazards. |
| WARNING | Hazardous eruption is imminent, underway, or suspected. |

| Table 2. AVIATION COLOR CODES | |
|---|--|
| GREEN | Volcano is in typical background, noneruptive state or, <i>after a change from a higher level</i> , volcanic activity has ceased and volcano has returned to noneruptive background state. |
| YELLOW | Volcano is exhibiting signs of elevated unrest above known background level or, <i>after a change from a higher level</i> , volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase. |

| | |
|---------------|---|
| ORANGE | Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, OR eruption is underway with no or minor ash emission [<i>plume height specified, if possible</i>]. |
| RED | Eruption is imminent with significant emission of ash into the atmosphere likely or eruption is underway or suspected with significant emission of ash into the atmosphere [<i>plume height specified, if possible</i>]. |

APPENDIX E: Field Volcano Observatory Requirements

The following is a rough guide to USGS requirements for a field observatory in, or close to, an established EOC. There is flexibility in these requirements. For example, if necessary, the USGS could set up operations in a temporary structure (e.g., trailer in the parking lot) if government owned or leased office space is not available. The bottom line is: The USGS can probably adapt to most situations, especially for the first few weeks of an incident. If an Incident/Unified Command structure has been established, USGS staff would work with the Logistics Section for facilities, supplies, and other support needed to establish a field observatory.

Space Requirements:

Space requirements can be separated into five areas; (1) Roof or tower space for mounting radio communications antennas; (2) an “operations” room that would be the focus of the real-time monitoring activities and coordination of field work; (3) an area where staff could set up desks and computers for data analysis, preparations for field activities, and hold staff meetings; (4) storage space for items such as batteries, spare parts and helicopter sling equipment; and (5) a media area separate from the other work areas.

- **Antennas:** Real-time data from the volcano should be radio-telemetered to our field observatory. We should need space to mount approximately ten (10) panel (12inx12In) antennas, with a minimum of four feet separation between antennas. Line-of-sight access to the volcano is necessary as well as being within 100-foot proximity of the Operations room.

- **Operations Room:** Approximately 300 sq. ft of space required. All data are funneled into the Operation room for coordination and display. Voice radios for communication with field crews as well as telephones for both voice and data are necessary in the Operations room. Space requirements should also take into account that it should be available to the media for photo opportunities and backdrops for interviews during slow periods of activity.
- **Staff Office Area:** Approximately 400 sq. ft. of space required. Staff should use this area not only for office functions but also to store limited field supplies, rock samples, equipment, etc. The Staff area should be sufficiently large so as to contain some chairs, desks, tables and still have room to hold a meeting of 15-20 people. Close proximity to Operations Room desirable and phones desirable.
- **Storage Space:** Approximately 300 sq. ft. of space required. A secure area for field equipment, supplies (batteries, concrete mix, water jugs, spare parts, etc.) and materials that is separate from the Operations Room and Staff Office Area. This could be commercial leased space but would need to be in close proximity to Operations.
- **Parking Space for Trailer near AC Power:** a trailer, it is 15 feet long and 10 feet high, we would likely bring it along for any response, so parking it relatively close to the operations and AC power would be crucial. It could act as a separate operations center for field instrumentation productions, testing and data collection if it is determined the requested space ends up being a little cramped.
- **Media Area:** It is anticipated that a suitable media briefing area at the proximal EOC should already be in place. If none exists, the more physically separated from the Operations and Staff offices, the better.

Communication requirements:

Six (6) standard voice phone lines (1 for fax, 2 'hot' lines, 1 for recorded volcano information, and 2 for normal use).

Two (2) standard lines for data communications. Either dial-up access to the USGS computer network or remote colleagues dialing into the temporary observatory's computer network.

Concurrent with setting up the observatory, USGS should negotiate the installation of a dedicated relatively high-speed data link between the observatory and the nearest Department of Interior facility.

Power requirements:

Observatory equipment does not draw large current loads, but does require reliable power. Approximately 15 computers (approx. 5kW), Doppler radar (1kW), plus radio and other equipment should be supported. If reliable commercial AC power is not available, it should be necessary to obtain an emergency generator and quality uninterruptible power supply(s) (UPS).

Doppler radar:

Doppler radar may be deployed to support operations. It requires a 6' x 6' secure roof area capable of supporting about 300 lbs. Line-of-sight access to the volcano is essential for proper operation of the system. Ideally, the radar would be located within a few hundred feet of the Operations room. The radar requires about 1kw of power.

Other Parking:

Workers should travel frequently between the volcano, a local heli-pad, motel rooms, etc. Convenient parking for 8-10 vehicles should support efficient operations.

APPENDIX F: Glossary of Acronyms and Abbreviations

| | |
|----------------|--|
| CVO: | Cascades Volcano Observatory |
| DEM: | (Local) Department (or Division) of Emergency Management |
| DFO: | (FEMA/State) Disaster Field Office |
| DoD: | Department of Defense |
| DOGAMI: | (Oregon) Department of Geology and Mineral Industries |
| EAS: | Emergency Alert System |
| ECC: | Emergency Coordination Center |
| EMAC: | Emergency Management Assistance Compact |
| EMD: | (Washington) Emergency Management Division |
| EOC: | Emergency Operations Center |
| ERT: | Emergency Response Team |
| ESF: | Emergency Support Function |
| FAA: | Federal Aviation Administration |
| FAC: | Central Cascades Facilitating Committee |
| FEMA: | Federal Emergency Management Agency |
| HIVA: | Hazard Identification Vulnerability Assessment |
| IC: | Incident Commander |
| ICS: | Incident Command System |
| IMT: | Incident Management Team |
| ICP: | Incident Command Post |

| | |
|---------------|---|
| JFO: | (FEMA/State) Joint Field Office |
| JIC: | Joint Information Center |
| NAWAS: | (FEMA's) National Warning System |
| NIMS: | National Incident Management System |
| NOAA: | National Oceanic and Atmospheric Administration |
| NRF: | National Response Framework |
| NWCC: | Northwest Coordination Center |
| NWS: | National Weather Service |
| ODOT: | Oregon Department of Transportation |
| OEM: | Oregon Emergency Management |
| OERS: | Oregon Emergency Response System |
| OSP: | Oregon State Police |
| PIO: | Public Information Officer |
| PNSN: | Pacific Northwest Seismograph Network |
| RRCC: | (FEMA) Regional Response Coordination Center |
| UPS: | Uninterruptible Power Supply |
| USFS: | United States Forest Service |
| USGS: | United States Geological Survey |
| VAAC: | (NOAA) Volcanic Ash Advisory Center |
| WFO: | Weather Forecast Office |

APPENDIX G: Joint Information Center Purpose and Structure

Coordination of Information Flow

The purpose of the Joint Information Center (JIC) is to coordinate the flow of information about volcanic activity and related response issues among agencies, and to provide a single information source for the media, general public and businesses. The JIC is an element of the Emergency Operations Center(s) (EOC) where the emergency response is being coordinated. Communications between agencies and to the media/public must be rapid, accurate and effective. A JIC provides a forum for the necessary information exchange. Public information between and from all responding agencies, EOCs, political jurisdictions, and the media is handled through this one center, thereby allowing the coordination of information from all sources, and reducing or eliminating conflicting information and rumors. Temporary and alternate media offices should be identified. All participants should be encouraged to facilitate an efficient flow of information from the JIC.

A JIC may be necessary in one or more of the following circumstances:

- Multiple local, State and/or Federal agencies are involved in an incident.
- The volume of media inquiries overwhelms the capacities of the Public Information Officer(s) (PIOs) within the EOC.
- A large-scale public phone team effort must be mounted over an extended period of time.

When conditions warrant, or when a Volcano Advisory (or Alert) is declared, a JIC should be activated by the FAC or Unified Command. A JIC must have:

- Office space for the PIOs
- Facilities for communication by phone, fax and email
- Briefing rooms
- Easy access for the media
- Proximity to restaurants or available food service
- Security

Recommended Structure of JIC during Volcanic Incidents

A. Potential Participants:

- Oregon Emergency Management
- U.S. Geological Survey
- U.S. Forest Service
- Counties on the FAC
- City of Portland
- DOGAMI
- FEMA
- Tribes
- Others as required or conditions dictate

B. Operating Assumptions:

All information should be coordinated among the JIC staff in order to ensure timely and accurate information flow to the public, to quell rumors and to prevent impediments to the response effort.

The JIC should operate under the Incident Command System.

The JIC should adjust its size and scope to match the size and complexity of the incident.

State and local agencies may be requested to provide staff for the JIC, including augmentation.

The JIC should be established (at least via conference call) prior to the issuance of a second Information Statement by USGS on an incident.

APPENDIX H: Characteristic Challenges of Volcanic Crises

Controlling access

During the crisis at Mount St. Helens in March and April, 1980, volcano-watchers bypassed road blocks to view the volcano, staged illegal climbs to the summit, and even landed helicopters at the summit. The difficulty of controlling access to the mountain was compounded by the checkerboard pattern of public and private land ownership, and the network of logging roads. Much of this has been alleviated by the creation of the Mount St. Helens National Volcanic Monument. Unlike at Mount St. Helens, however, access control around the Central Oregon volcanoes would necessitate traffic restriction on major regional thoroughfares, US Highway 20, 26, 97, 197, and Oregon Highway 22, 120, and 126.

Uncertainty: Restless volcanoes can challenge public officials more than most other natural hazards because they present multiple uncertainties about when eruptive or other hazardous activity will begin, how long it will last, and who will be affected. Unlike floods and earthquakes, volcanic eruptions are seldom singular events; unrest is often prolonged over a period of months to years with no predictable end. Periods of intermittent volcanic eruptions can continue for decades.

Volcanoes commonly produce multiple hazards, each of which requires vigilant attention of authorities and the public. For example, volcanic ash can fall over vast areas and disturb the routines of people living even at great distances from the volcano. The paths of lahars can be more closely estimated, but their timing and size remain unpredictable. At the Central Oregon volcanoes, the risk of annual small debris flows in river valleys adds uncertainty, even when the volcano is quiet.

The volcano could be in an *Advisory* phase of unrest for a protracted period of time. Officials will need to give all response measures careful consideration. Some measures

might be difficult to maintain over long durations in the absence of an emergency declaration. The disquieting effects of eruption uncertainty may be reduced by pre-crisis education and honest dialogue with the public, and with frequent planning and plan exercising by the Central Oregon volcanoes FAC, but those involved in an actual event should anticipate the need to, and the challenges associated with, such uncertainty.

Consider these case studies. In 1975, Mount Baker, Washington, increased steam output for a few months, and then subsided with no indication of magma movement. Since 1993, Popocatepetl Volcano near Mexico City has periodically threatened nearby communities, causing multiple evacuations of villagers, despite failures of the volcano to erupt. In 1902, local authorities at St. Pierre in Martinique (French West Indies, opted not to evacuate in spite of four months of seismicity and steam explosions at Mont Pelee, five miles to the north. On May 8, a major eruption produced a pyroclastic flow that destroyed the town and killed 29,000 residents. In 1982, in response to earthquake swarms and uplift at Long Valley, California, the USGS issued a notice of potential volcanic hazard. Activity subsided, frustrating citizens and the scientists who felt that they were providing the best information available.

While these examples portray frustrating circumstances for officials and communities, there are many examples of successful evacuations where tens to tens of thousands of lives were saved due to pre-crisis education and careful official planning (Mount Philippine's Pinatubo, 1991; Mount St. Helens, 2004; Colombia's Nevado del Huila during 2007-08; Indonesia's Merapi volcano during 2010).

APPENDIX I: Authorities

Federal – United States

Public Law 93-288 Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974 as amended

Public Law 920 Federal Civil Defense Act of 1950 as amended

Public Law 96-342 The Improved Civil Defense Act of 1980

Public Law 84-99 Flood Control and Coastal Emergencies

Federal Response Plan 1999

Flood Control Act of 1950

Department of Transportation Act of 1966

Federal Aviation Administration Act of 1958

Federal Energy Regulation Commission Order 122

USFS Incident Management Team Delegation of Authority Letter

State of Oregon

Oregon Revised Statute Chapter 401

Oregon Administrative Rules Chapter 104

Oregon Office of Emergency Management Plan, Volume II, 2001

Emergency Management Assistance Compact (EMAC)

Local Government

Each of the counties has established authorities governing emergency management and operations.

APPENDIX J: References and Websites

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Gardner, C.A. and Guffanti, M.C., 2006, U.S. Geological Survey's Alert-Notification System for Volcanic Activity: U.S. Geological Survey Fact Sheet 2006-3139 , 4 pgs.

USGS, NWS and FAA Pacific Northwest Interagency Operating Plan for Volcanic Ash Events, issued May 9, 2011: url: <http://www.ofcm.gov/p35-nvaopa/fcm-35.htm>
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Web Sites:

Pacific Northwest Seismic Network
<http://www.ess.washington.edu/recenteqs/latest.htm>

Smithsonian Institution Global Volcanism Program
<http://www.volcano.si.edu/>

USGS Volcano Hazards Program
<http://volcanoes.usgs.gov/>

Volcanic ash—what it can do and how to prevent damage
<http://volcanoes.usgs.gov/ash/>