7.0 Volcanoes[1]

The following hazard description is derived from the Alaska Division of Homeland Security and Emergency Management's All-Hazard Mitigation Plan (October 2007). Although the text was edited slightly to focus on volcanoes with the highest potential to impact KPB communities, most of the description is state rather than region-specific. The State Plan is available at www.ak-prepared.com/plans/mitigation/mitigationplan.htm.

The term volcano is used to describe both the vent at the Earth's surface through which magma (molten rock) and associated gases erupt, and the landform built by effusive and explosive eruptions. Alaska is home to 52 historically active volcanoes stretching across the entire southern portion of the state from the Wrangell Mountains to the far western Aleutians[2]. An average of one to two eruptions per year occur in Alaska. Volcanoes display a wide variety of shapes, sizes, and behavior; however, they are commonly classified among three main types: cinder cone, composite and shield.

Volcanoes are also categorized according to the age of their eruptive activity. Active volcanoes are those that are currently erupting or showing signs of unrest, such as unusual earthquake activity or significant new gas emissions. Dormant volcanoes are those that are not currently active, but could become restless or erupt again. Extinct volcanoes are those that are considered unlikely to erupt again. This can be difficult to determine as a volcano could go tens of thousands of years, or longer, between eruptions. There are over 80 volcanic centers in Alaska but only 52 are considered active.

Redoubt Volcano – a composite volcano - is one of the active volcanoes of the Cook Inlet region. Steam and volcanic gas rise above the summit crater of the volcano during the 2009 eruption. Photograph courtesy of G. McGimsey, USGS/Alaska Volcano Observatory.

There are five active volcanoes within the KPB on the west side of Cook Inlet: Fourpeaked, Augustine, Iliamna, Redoubt and Mount Spurr.

1 Alaska Division of Homeland Security and Emergency Management (ADHS&EM). 2007. State Hazard Mitigation Plan.

2 Alaska Volcano Observatory 2010.

7.1 Types of Volcanoes

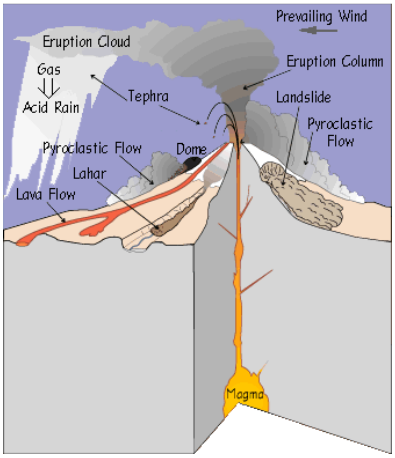
Cinder cones

Cinder cone volcanoes are built from particles and blobs of congealed lava ejected from a single vent. As the lava is blown into the air, it breaks into small fragments that solidify and fall as cinders and bombs around the vent to form a circular or oval cone. Most cinder cones have a bowl-shaped crater or craters at the summit and are rarely more than a thousand feet above their surroundings. Cinder cones may form as flank vents on the sides of larger composite or shield volcanoes. They often occur in clusters and produce lava flows. Cinder cones are common in western North America.

Composite volcanoes

Composite volcanoes, sometimes called stratovolcanoes, are typically steep-sided, symmetrical cones of large dimension built of alternating layers of lava flows, volcanic ash, blocks and bombs and may rise as much as 8,000 feet above their bases.

Composite volcanoes have a principal conduit system through which magma from a reservoir deep in the earth's crust rises to the surface repeatedly to cause eruptions. The volcano is built up by the accumulation of material erupted through the conduit and increases in size as lava, ash, etc., are added to its slopes. Stratovolcanoes tend to erupt explosively because of the silica-based nature of magmas associated with these volcanoes. Some stratovolcanoes produce enormous explosive eruptions that destroy a large part of the volcano itself, leaving a wide, roughly circular depression called a caldera. Eruptions that produce calderas are among the most explosive and largest eruptions known. Most Alaskan volcanoes are stratovolcanoes, including Fourpeaked, Redoubt, Spurr and Iliamna in the Cook Inlet Region.



Volcanic hazards.

Shield volcanoes

Shield volcanoes are formed by lava flowing in all directions from a central summit vent, or group of vents, or rift zones building a broad, gently sloping cone with a dome shape. They are built up slowly by the accretion of thousands of highly fluid lava flows that spread widely over great distances, and then cool in thin layers.

7.2 Volcanic Hazards

Lava Flows

Lava flows are streams of molten rock that flow from a volcano. The distance traveled by a flow (typically 6-30 miles) is dependant on several variables including viscosity, volume, slope steepness and obstructions in the flow path. Lava flows cause damage by burning, crushing, or burying people and objects. The high flow temperatures may trigger wildfires or cause flooding by melting ice and snow.

A pyroclastic flow sweeping down the north flank of 1,282-m (4,206 ft) high Augustine Volcano. Image courtesy M.E. Yount, USGS.

Pyroclastic Flows

Pyroclastic flows are high-density mixtures of hot gasses and dry rock that are usually released explosively from a volcano. The flows travel at speeds of 30 to 90 miles per hour (or greater) and the debris or associated high winds can destroy or move objects.

Pyroclastic Surges

Pyroclastic surges are turbulent low-density clouds of rock debris, air, and other gases that move over the ground at speeds similar to pyroclastic flows. There are two types: hot surges consisting of dry materials over 212ºF and cold surges consisting of cooler rock debris and water or steam.

Cleaning up ash from the 1992 Mt. Spurr eruption. Photographer Bill Roth, Anchorage Daily News (file 920917).

Lava Domes

Volcanic or lava domes are formed when viscous lava erupts slowly from a vent. This causes it to solidify near the vent forming the dome instead of flowing away from the vent. A dome grows largely by expansion from within. As it grows its outer surface cools and hardens, then shatters, spilling loose fragments down its sides. Volcanic domes commonly occur within the craters or on the flanks of large composite volcanoes.

Volcanic Ash and Bombs

Volcanic ash, also called tephra, consists of fine fragments of solidified lava ejected into the air by an explosion or rising hot air. The fragments range in size, with the larger falling nearer the source. Ash is a problem near the source

because of its high temperatures (may cause fires), burial (the weight can cause structural collapses), and impact of falling fragments. Further away from the source the primary hazard to humans is decreased visibility and lowered air quality. Ash also interferes with mechanical equipment operation.

Volcanic Gases
Volcanic gases consist mostly of steam, carbon dioxide, sulfur dioxide, hydrogen sulfide and chlorine compounds, but may include other substances. The gases can damage eyes, respiratory systems and cause suffocation in high concentration (usually near the vent). They can also be very corrosive.

Lateral Blasts
Lateral blasts are inflated mixtures of gases, ash and hot rock debris. They may be hundreds of feet thick and travel at speeds up to 370 miles per hour. They cause damage through abrasion, impact, burial, and heat. They may also trigger pyroclastic flows or surges.

Debris Avalanches
A debris avalanche is a sudden downward movement of unconsolidated material (mostly rock and soil). They occur without warning and travel quickly. Debris avalanches can extend over 300 square miles causing damage from impact or burial.

Debris Flows
Debris flows, also known as lahars, are rapidly flowing mixtures of rock debris and water that originate on the slopes of a volcano. They form in a variety of ways including the rapid melting of snow and ice by pyroclastic flows, the intense rainfall on loose volcanic rock deposits, the breakout of a lake dammed by volcanic deposits, or as a consequence of debris avalanches. They generally have the consistency of wet cement and have the ability to destroy or bury anything in their path.

Lahars from the 1989 to 1990 eruptions of Redoubt Volcano inundated this structure near the mouth of Drift River. Photograph courtesy of C. Gardner, USGS.

7.3 Historic Volcanic Activity

The largest volcanic eruption of the 20th century occurred at Novarupta Volcano in June 1912. It started by generating an ash cloud that grew to become thousands of miles wide during the three-day event. Within four hours of the eruption, ash started falling on Kodiak, darkening the city. It became hard to breathe because of the ash and sulfur dioxide gas. The water became

undrinkable and unable to support aquatic life. Roofs collapsed under the weight of the ash. Some buildings were destroyed by ash avalanches while others burned after being struck by lightning from the ash cloud. Similar conditions could be found all over the area. Some villages ended up being abandoned, including Katmai and Savonoski villages. The ash and acid rain also negatively affected animal and plant life. Large animals were blinded and many starved because their food was eliminated.

The ash fall from this eruption was significantly greater than the recent eruptions of Fourpeaked, Redoubt, Spurr and Augustine Volcanoes. Fourteen earthquakes of magnitude 6 to 7 were associated with this event. At least ten Alaskan volcanoes are capable of this type of event.

A more recent eruption occurred on Augustine Volcano in 2006. An ash plume disrupted air traffic and deposited ash in Homer, Nanwalek, Port Graham, Seldovia, Iliamna and Kodiak. A dome formed in the crater, and caused some to fear it would subsequently collapse and trigger a tsunami along the east shore of Cook Inlet, as happened in 1883.

Redoubt Volcano erupted in 1989-1990 and again in 2009. Both events resulted in debris flows. This caused the temporary closing of the Drift River Oil Terminal in 1989/90, and more extensive closures of the terminal and associated Cook Inlet platforms in 2009. In 1990, a KLM 747 jet aircraft, Flight 867, temporarily lost power in all four engines when it entered the volcanic ash plume. It would have crashed into the mountains had they not been able to restart their engines about 4,000 feet (1,219 meters) above ground.

7.4 Volcano Risk Assessment

The responsibility for hazard identification and assessment for the active volcanic centers of Alaska falls to the Alaska Volcano Observatory (AVO) and its constituent organizations (USGS, DNR/DGGS, and UAF/GI). AVO is in the process of publishing individual hazard assessments for each active volcano in the State. As of January 2010, published or in-press hazard assessments cover the following volcanoes: Hayes, Spurr, Okmok, Great Sitkin, Kanaga, Redoubt, Iliamna, Augustine, the Katmai Group, Aniakchak, Shishaldin, Akutan, and Makushin[1]. Each report contains a description of the eruptive history of the volcano, the hazards they pose and the likely effects of future eruptions on populations, facilities and ecosystems.

AVO has the primary responsibility to monitor all of Alaska's potentially active volcanoes and to issue timely warnings of activity to authorities and the public. During episodes of volcanic unrest or eruption, AVO is also the agency responsible for characterizing the immediate hazards and describing likely

[1] Alaska Volcano Observatory 2010

scenarios for an evolving volcanic crisis. AVO uses a four-color Level of Concern Color Code to succinctly portray its interpretations of the state of activity and likely course of unrest at a given volcano.

Basic information about vulnerable assets and populations are identified in these assessments. However, DCCED and other state agencies could work with AVO map data to integrate quantitative, current information regarding communities and other at-risk elements to improve our analysis of vulnerability. The NWS participates in producing weather models to assist in producing ash travel and possible fall at various elevations. NWS is able to provide this information in approximately six-hour increments, greatly enhancing ability to notify the public and to minimize impact on community health.

One of the most vulnerable sectors is the aviation industry, which is at risk from the effects of airborne volcanic ash. The significant trans-Pacific and intrastate air traffic in Alaska, directly over or near 52 potentially active volcanoes, has necessitated development of a strong communication and warning link between AVO, other government agencies with responsibility in aviation management, and the airline and air cargo industry.

The following maps depict approximate extent of ash fallout for eruptions of four of the five volcanoes within the KPB. These maps are from four U.S. Geological Survey Open-File reports:

Waythomas, C.F., J.M. Dorava, T.P Miller, C.A. Neal and R.G. McGimsey. 1998. Preliminary Volcano-Hazard Assessment for Redoubt Volcano, Alaska. U.S. Geological Survey, Open File Report 97-857 [www.avo.alaska.edu/pdfs/redoubt.hazards.ofr.pdf].

Waythomas, C.F. and R.B. Waitt. 1998. Preliminary Volcano-Hazard Assessment for Augustine Volcano, Alaska. U.S. Geological Survey, Open File Report 98-106 [www.avo.alaska.edu/pdfs/augustine_ofr.pdf].

Waythomas, C.F. and T.P Miller. 1999. Preliminary Volcano-Hazard Assessment for Iliamna Volcano, Alaska. U.S. Geological Survey, Open File Report 99-373 [www.avo.alaska.edu/pdfs/Iliamna.Haz.OFR.99.373.pdf].

Waythomas, C.F. and C.J. Nye. 2002. Preliminary Volcano-Hazard Assessment for Mount Spurr Volcano, Alaska. U.S. Geological Survey, Open File Report 01-482 [www.avo.alaska.edu/pdfs/of01-482.pdf].

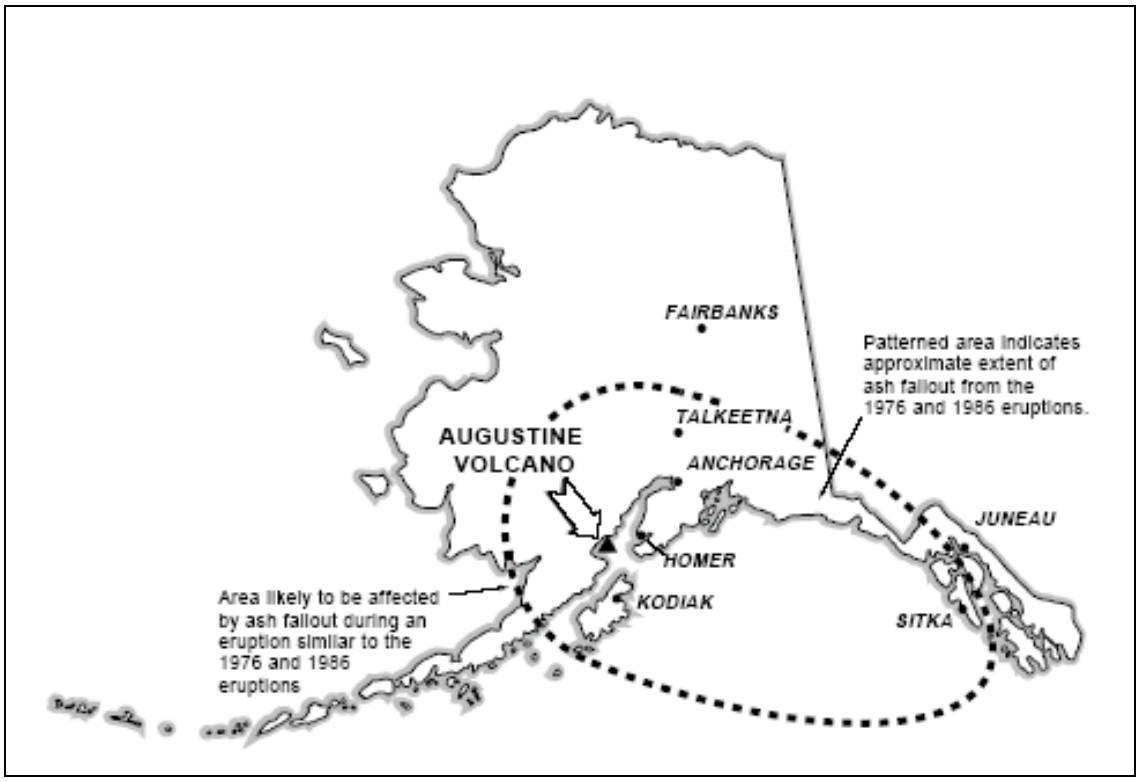


Figure 7-1. Area likely to be affected by ash fallout during a typical eruption of Augustine Volcano. Specific area of ash fallout depends on wind direction[1].

[1] Waythomas, C.F. and R.B. Waitt. 1998. Preliminary Volcano-Hazard Assessment For Augustine Volcano, Alaska. U.S. Geological Survey, Open File Report 98-106 [http://www.avo.alaska.edu/pdfs/augustine_ofr.pdf].

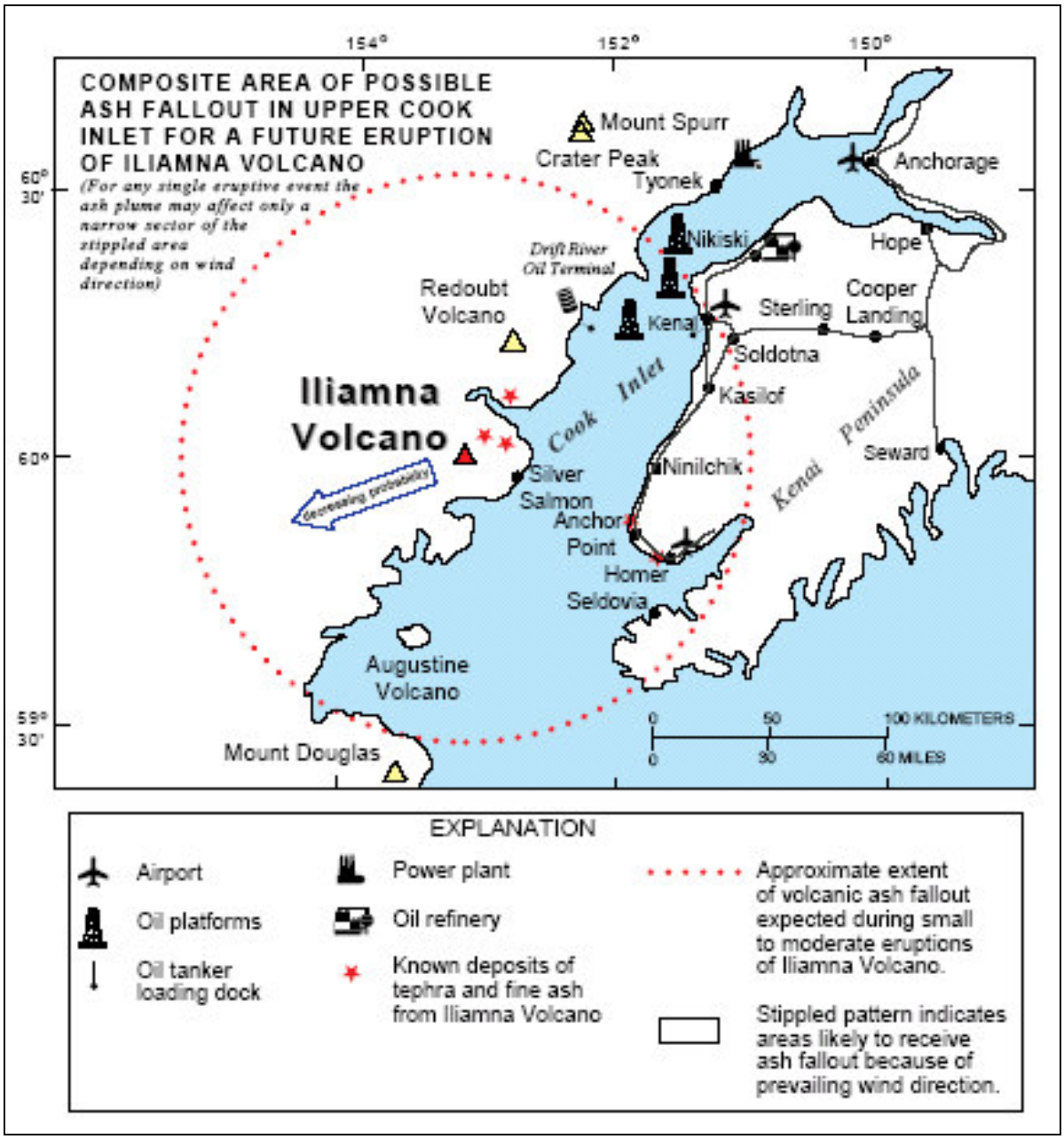


Figure 7-2. Approximate extent of volcanic ash fallout for small to moderate eruptions of Iliamna Volcano[1].

[1] Waythomas, C.F. and T.P Miller. 1999. Preliminary Volcano-Hazard Assessment For Iliamna Volcano, Alaska. U.S. Geological Survey, Open File Report 99-373 [www.avo.alaska.edu/pdfs/Iliamna.Haz.OFR.99.373.pdf].

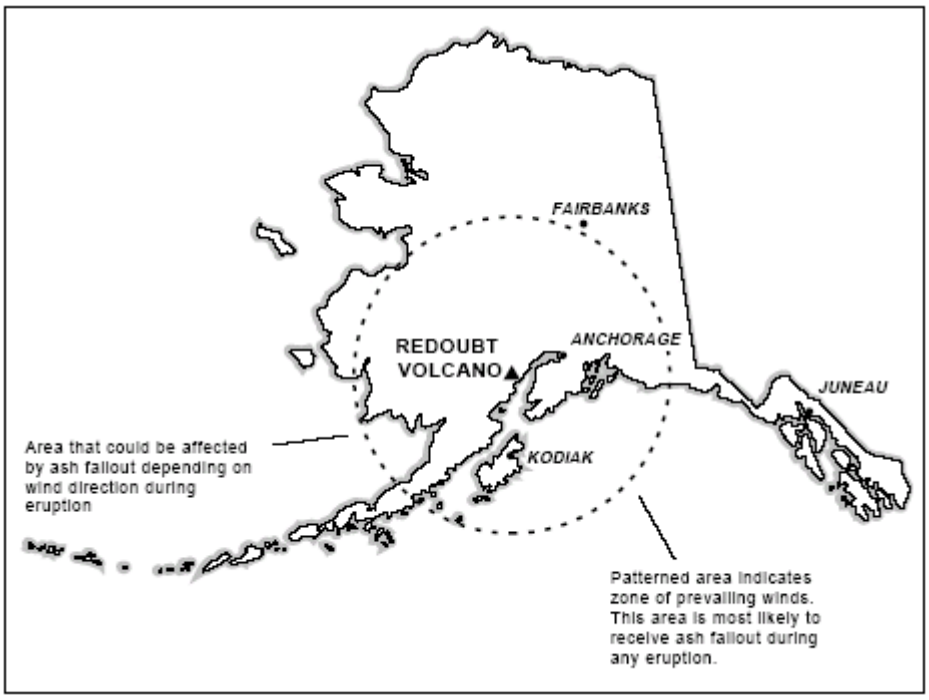


Figure 7-3. Area likely to be affected by volcanic ash fallout from eruptions similar to 1989-90 eruption of Redoubt Volcano[1].

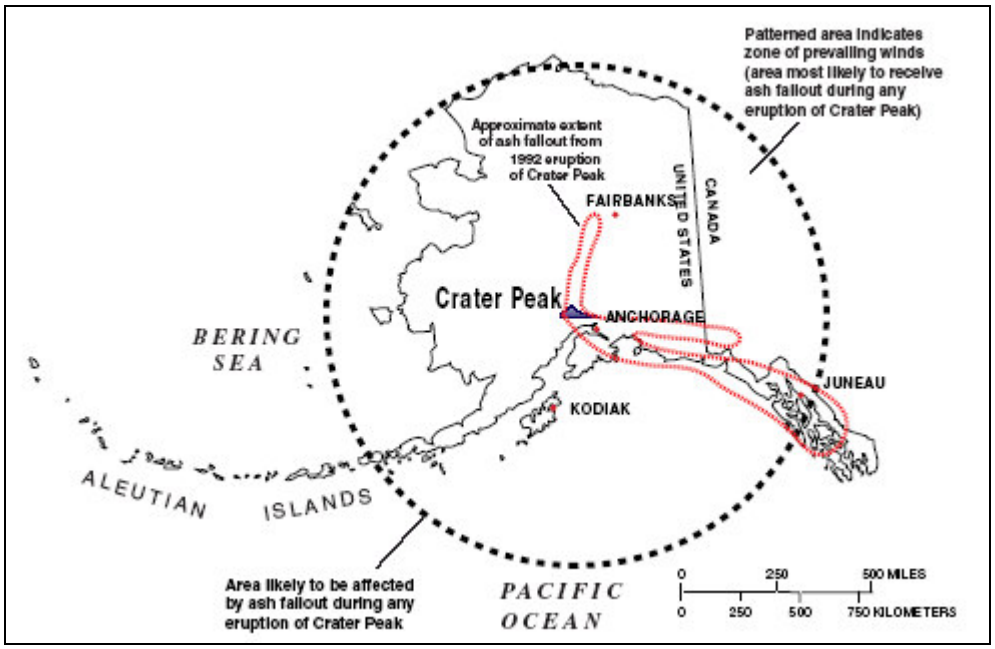


Figure 7-4. Areas most likely to receive ash fallout from future eruption of Crater Peak [a vent associated with Mount Spurr Volcano], given prevailing winds[1].

[1] Waythomas, C.F., J.M. Dorava, T.P Miller, C.A. Neal and R.G. McGimsey. 1998. Preliminary Volcano-Hazard Assessment for Redoubt Volcano, Alaska. U.S. Geological Survey, Open File Report 97-857 [www.avo.alaska.edu/pdfs/redoubt.hazards.ofr.pdf].

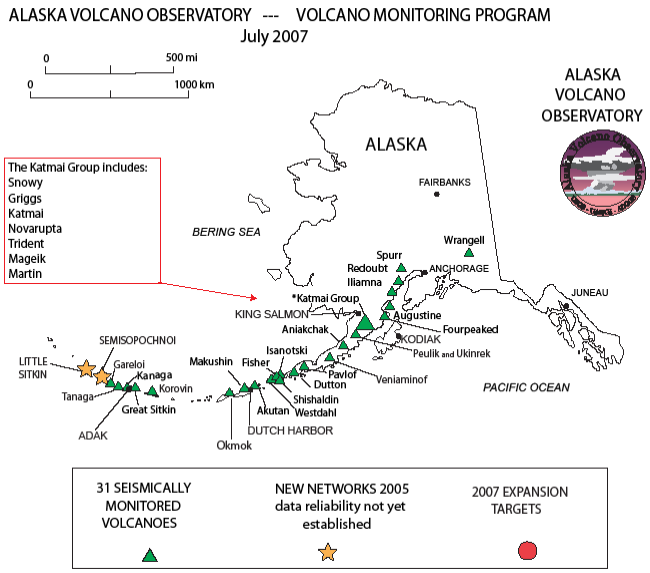
7.5 Existing Programs

Alaska Volcano Observatory[2]

The Alaska Volcano Observatory, a joint program of USGS, DNR/DGGS, and UAF/GI, is the State's principal agency with responsibility to assess, monitor, and issue early warning of volcanic activity and hazards in Alaska. AVO was formed in 1988, and uses federal, state and university resources to monitor and study Alaska's hazardous volcanoes, to predict and record eruptive activity, and to mitigate volcanic hazards to life and property.

As of February 2010, AVO maintains seismic monitoring networks on 27 of Alaska's 52 active volcanoes. Data from these networks are recorded 24 hours a day and examined for precursory signs of eruptive activity. Several times a day, AVO also examines satellite images of Alaskan, Kamchatkan and northern Kuril volcanoes for signs of eruptive activity or possible precursory heating of the ground. These two primary data streams are used routinely to assess the likelihood and character of volcanic activity. Additional monitoring methods such as space-based satellite radar interferometry, are under development.

AVO regularly disseminates information about the status of volcanoes in Alaska and neighboring Kamchatka. Each week, AVO distributes a written status report to federal, state and local agencies, the media and the public. Volcanic crises, or if precursors to eruptive activity are noted, AVO follows a rigid emergency call-down protocol, as well as using Internet and fax outlets to notify authorities, the media, the aviation industry, and the public.



1 Waythomas, C.F. and C.J. Nye. 2002. Preliminary Volcano-Hazard Assessment for Mount Spurr Volcano, Alaska. U.S. Geological Survey, Open File Report 01-482 [www.avo.alaska.edu/pdfs/of01-482.pdf].

2 Alaska Volcano Observatory website [www.avo.alaska.edu].

7.6 Hazard Mitigation Successes

Alaska Volcano Observatory

Since its formation 1988, AVO scientists have responded to numerous volcanic crises in Alaska, providing early warning for such explosive eruptive events at Redoubt (1989-90/2009) and Mt. Spurr (1992) and Augustine (2006). Advanced warning of eruptions and accurate analysis of data from seismic monitoring networks and satellite platforms prevents needless evacuations and economic impacts to the aviation industry. AVO staff works closely with Russian colleagues in Kamchatka to monitor, track and disseminate warnings of eruptions and ash clouds from volcanoes in the Russian Far East that may threaten Alaskan air space.

Interagency Plan for Volcanic Ash Episodes

In December 1989, a KLM flight 867 that encountered an ash cloud from Redoubt Volcano highlighted a serious weakness in the aviation and volcanic ash warning system. Following this incident, a consortia of federal, state and private sector parties worked to develop an improved early warning system and ash avoidance protocols for the heavily traveled North Pacific airways. In Alaska, this effort resulted in the growth and increased capacity of the AVO and formal adoption of a Alaska Interagency Plan for Volcanic Ash Episodes (signatories include USGS, NOAA/NWS, Federal Aviation Administration (FAA), Department of Defense (DOD) /United States Air Force (USAF), and DHS&EM. An updated plan was adopted in April 2004, with the United State Coast Guard and the Alaska Volcano Observatory as additional participants. The plan documents specific responsibilities and protocols for each agency before, during, and after a volcanic event. Since the 1989 KLM ash encounter, no serious ash-aircraft incidents have been reported in Alaska, despite dozens of additional eruptions. This multi-agency early warning and response program is a model endorsed by the International Civil Aviation Organization and emulated in many volcanically active regions around the world.

7.7 Volcano Mitigation Goals

Below are hazard mitigation goals and objectives taken from the State of Alaska October 2007 All-Hazard Mitigation Plan[1]. KPB-specific volcano mitigation goals will be developed in the next KPB All-Hazard Mitigation Plan update.

Goal 1: Public Education

Mitigation Measures: Educational

Priority: Medium

Objective: 1.1 Conduct specific outreach to the Alaskan aviation community regarding the hazards posed by volcanoes.

[1] Alaska Division of Homeland Security and Emergency Management (ADHSEM). 2007. State Hazard Mitigation Plan.

Lead Agency: AVO
Support Agencies: DHS&EM, FAA, NWS, Alaska Air Carriers Association
Time Frame: Ongoing

Action 1.1.1: Revise the fact sheet on Volcano Hazards and Aviation Safety.

Lead Agency: AVO
Support Agencies: DHS&EM, FAA, NWS, Alaska Air Carriers Association

Action 1.1.2: Develop a fact sheet about mitigating the risk to aviation from Kamchatkan volcanoes.

Lead Agency: AVO
Support Agencies: DHS&EM, FAA, NWS, Alaska Air Carriers Association

Objective 1.2: Ensure all Alaskan communities at risk from volcanic eruptions are aware of the hazard and what can be done to mitigate risk.

Lead Agency: DHS&EM, AVO
Support Agencies: USGS, DNR/DGGS, UAF/GI, ARC, DEC, Alaska Public Lands Information Center, local jurisdictions, Native corporations
Time Frame: Ongoing

Action 1.2.1: Distribute free USGS literature on volcano hazards.

Lead Agency: AVO
Support Agencies: USGS
Time Frame: Ongoing

Goal 2: Increase planning for volcanic hazards

Mitigation Measures: Educational; Preventative

Priority: Medium

Objective 2.1: Ensure volcanic hazards are addressed in the ongoing revision of the State Emergency Response Plan.

Lead Agency: DHS&EM
Support Agencies: AVO, USGS, DNR/DGGS, UAF/GI
Time Frame: Ongoing

Action 2.1.1: Revise State ERP[1]

Lead Agency: DHS&EM
Support Agencies: All Agencies

[1] Submitted to the Governor for promulgation summer 2004.

Goal 3: Improve monitoring

Mitigation Measures: Educational; Preventative

Priority: Medium

Objective 3.1: Expand real time seismic monitoring to high-priority western Aleutian volcanoes.

Lead Agency: AVO
Support Agencies: USFWS, DOD
Time Frame: Ongoing (in progress)

Action 3.1.1: Install monitoring equipment on selected volcanoes

Lead: AVO
Timeline: Ongoing

7.8 Volcano Resource Directory

Alaska Department of Environmental Conservation, Division of Air Quality

The Division of Air Quality, Air Monitoring & Quality Assurance Program operates and oversees air quality monitoring networks throughout Alaska.

Contact: Division of Air Quality, Alaska Dept. of Environmental Quality
Address: 619 E. Ship Creek, Ste. 249, Anchorage, AK 99501
Phone: (907) 269-6249
Website: www.dec.state.ak.us/air/am/aq_sr.htm

Alaska Volcano Observatory

The Alaska Volcano Observatory (AVO) is a joint program of the United States Geological Survey (USGS), the Geophysical Institute of the University of Alaska Fairbanks (UAFGI), and the State of Alaska Division of Geological and Geophysical Surveys (ADGGS).

Contact: Alaska Volcano Observatory
Address: 4200 University Drive, Anchorage, AK 99508
Phone: (907) 786-7497
Email: avo_sci@usgs.gov
Website: www.avo.alaska.edu

American Red Cross

The American Red Cross is a volunteer humanitarian organization, which provides relief to disaster victims and helps people prevent, prepare for, and respond to emergencies.

Contact: American Red Cross
Address: 235 E. 8th Avenue, Anchorage, AK 99501
Phone: (907) 646-5401
Website: alaska.redcross.org

National Weather Service, Alaska Region Headquarters

The National Weather Service provides information on wind and weather patterns and ashfall predictions in the event of an eruption.

Contact: Alaska Region Headquarters
Address: 222 West 7th Ave, #23, Anchorage, AK 99513-7575
Phone: 907-271-5088
Fax: 907-271-3711
Website: pafc.arh.noaa.gov/volcano.php

National Weather Service, Anchorage Center Weather Service Unit

The Anchorage CWSU supports Air Traffic Managers at the Anchorage Center through verbal briefings and written warnings. Center Weather Advisories (CWA) are short-term warnings, valid for zero to 2 hours, of hazardous weather conditions provided to all aviation interests including private pilots, towers, flight service stations, and commercial airlines.

Contact: CenterWeather Service Unit
Address: 700 North Boniface Parkway, Anchorage, AK 99506
Phone: 907- 338-1010
Fax: 907- 338-1510
Website: cwsu.arh.noaa.gov

NOAA Air Resource Laboratory

The National Oceanic and Atmospheric Administration Air Resource Laboratory provides ashfall trajectory forecasts for several Alaska volcanoes.

Contact: NOAA Air Resource Laboratory
Address: Silver Spring Metro Center #3, Rm. 3316, 1315 East West Highway, Silver Spring, Maryland 20910
Phone: (301) 713-0295
Website: ready.arl.noaa.gov/READY_traj_alaska.php