USGS
science for a changing world

Technical-Information Products for a National Volcano Early Warning System

By Marianne Guffanti, Steven R. Brantley, Peter F. Cervelli, Christopher J. Nye, George N. Serafino, Lee Siebert, Dina Y. Venezky, and Lisa Wald

2007

Open File Report 2007–1250

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2007

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS—the Federal source for science about the Earth,
its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

Suggested citation
Guffanti, M., Brantley, S. R., Cervelli, P. F., Nye, C. J., Serafino, G. N., Siebert, L., Venezky, D. Y., and Wald, L., 2007, Technical-information products for a National Volcano Early Warning System: U.S. Geological Survey Open File Report 2007-1250, 23p. [http://pubs.usgs.gov/of/2007/1250].

Contents

Tables

Appendices

Technical-Information Products for a National Volcano Early Warning System

By Marianne Guffanti,[1] Steven R. Brantley[2], Peter F. Cervelli[3], Christopher J. Nye[4], George N. Serafino[5], Lee Siebert[6], Dina Y. Venezky[7], and Lisa Wald[8]

[1] U.S. Geological Survey, Reston, Virginia

[2] U.S. Geological Survey, Hawaiian Volcano Observatory, Hawaii

[3] U.S. Geological Survey, Alaska Volcano Observatory, Anchorage, Alaska

[4] Alaska Division of Geological and Geophysical Surveys, Fairbanks, Alaska

[5] National Oceanic and Atmospheric Administration, Camp Springs, Maryland

[6] Smithsonian Institution, Washington D.C.

[7] U.S. Geological Survey, Menlo Park, California

[8] U.S. Geological Survey, Golden, Colorado

Introduction

Technical outreach – distinct from general-interest and K-12 educational outreach – for volcanic hazards is aimed at providing usable scientific information about potential or ongoing volcanic activity to public officials, businesses, and individuals in support of their response, preparedness, and mitigation efforts. Within the context of a National Volcano Early Warning System (NVEWS) (Ewert et al., 2005), technical outreach is a critical process, transferring the benefits of enhanced monitoring and hazards research to key constituents who have to initiate actions or make policy decisions to lessen the hazardous impact of volcanic activity.

This report discusses recommendations of the Technical-Information Products Working Group convened in 2006 as part of the NVEWS planning process. The basic charge to the Working Group was to identify a web-based, volcanological "product line" for NVEWS to meet the specific hazard-information needs of technical users. Members of the Working Group were:

Marianne Guffanti (Chair), USGS, Reston VA
Steve Brantley, USGS, Hawaiian Volcano Observatory HI
Peter Cervelli, USGS, Alaska Volcano Observatory, Anchorage AK
Chris Nye, Division of Geological and Geophysical Surveys and Alaska Volcano Observatory, Fairbanks AK
George Serafino, National Oceanic and Atmospheric Administration, Camp Springs MD
Lee Siebert, Smithsonian Institution, Washington D.C.
Dina Venezky, USGS, Volcano Hazards Team, Menlo Park CA
Lisa Wald, USGS, Earthquake Hazards Program, Golden CO

Current State of Volcanological Technical-Information Products

Under the Stafford Act (Public Law 93-288), the U.S. Geological Survey (USGS) has the federal responsibility to issue timely warnings of potential volcanic hazards to the affected populace and civil authorities. Such warnings are based on data and observations collected by the five U.S. Volcano Observatories (Alaska, Cascades, Hawaiian, Long Valley, and Yellowstone) which are supported by the USGS Volcano Hazards Program (VHP) in partnership with academic institutions and other government agencies.

The NVEWS product line recommended in this report builds on the various technical-information products that have been developed and used by the VHP and its partners over the past three decades. The main types of volcanological technical-information products currently available are:

Alerts of Current Volcanic Activity (short-term): Notices and status reports of the level of activity at monitored volcanoes are issued daily to monthly by the five Volcano Observatories and distributed to interested parties by email, fax, and RSS feed and also are posted on web sites (http://volcano.wr.usgs.gov/vhpstatus.php). Examples of monitoring data collected by the Volcano Observatories to track volcanic activity (seismograms, earthquake-location maps, graphs of ground deformation, remote-sensing images, webcam images, etc.) also are provided via Observatory and partner websites, along with explanatory captions.

The VHP recently adopted a common system nationwide for characterizing the level of unrest and eruptive activity at volcanoes, to replace three separate systems previously used by the Volcano Observatories. Under the common system, an Observatory ranks the level of activity at a U.S. volcano using the terms "Normal" for typical volcanic activity in a quiet or "background" state; "Advisory" for elevated unrest; "Watch" for escalating unrest or a minor eruption underway that poses limited hazards; and "Warning" if a highly hazardous eruption is underway or imminent. When an alert level is assigned by an Observatory, accompanying text gives a fuller explanation of the observed phenomena and clarifies hazard implications to affected groups. As part of the alert-level system, color codes (Green, Yellow, Orange, and Red) are used to provide succinct information about volcanic-ash hazards to the aviation

sector. The color codes are in accordance with recommended procedures established by the International Civil Aviation Organization (ICAO) to prevent aircraft from flying through ash-contaminated airspace. The alert levels and color codes are described further by (Gardner and Guffanti, 2006; online at http://pubs.usgs.gov/fs/2006/3139).

For a global overview of recent volcanic activity, the VHP collaborates with the Smithsonian Institution's Global Volcanism Program to produce the online Weekly Volcanic Activity Report (http://www.volcano.si.edu/reports/usgs/).

Hazard-Assessment Reports (long-term): A volcano-hazard assessment report is a publication, typically including a hazard-zonation map, that summarizes the type and likelihood of future hazardous phenomena expected to occur at a given volcano or volcanic region over the long term (decades to centuries). Such assessments are based on geologic evidence of the magnitudes, styles, and frequencies of previous volcanic activity. The target audience for these reports includes land managers, emergency-management officials, and at-risk property owners. Volcano-hazard assessments usually are published as USGS Open-File Reports or, in Alaska for the Alaska Volcano Observatory (AVO), as Department of Natural Resources Reports of Investigations. Assessments are updated and modified as needed when new data are acquired or scientific understanding improves. A bibliography of published hazard-assessment reports listing the most recent report for any given U.S. volcano is given in Appendix 1. As of September 2007, hazard-assessment reports for 33 U.S. volcanoes have been published for 16 Alaskan volcanoes, 10 volcanoes in the Washington and Oregon Cascades, 4 volcanoes in California, 2 in Hawaii, and 1 in Wyoming. In addition, various regional (multi-volcano), state-wide, and multi-state assessments have been prepared.

Response Plans: Interagency volcano-response plans define the responsibilities and actions of various government agencies in dealing with a restless or active volcano. An agency involved in the plan also may prepare its own internal plan for action in concert with the interagency plan. Response plans typically are updated on a regular schedule to keep current with agency changes. Plans exist for five Cascade Range volcanoes and for volcanic-ash hazards to aviation from volcanoes in Alaska and the Commonwealth of the Northern Marianas Islands. The first national-level volcanic-ash operating plan for aviation, involving the USGS, Federal Aviation Administration (FAA), National Oceanic and Atmospheric Administration (NOAA), and Air Force Weather Agency, was completed in 2007. A list of interagency volcano response plans developed as of September 2007 is given in Appendix 2.

Topical Hazard Guidance: Various means are used to present topical hazard information, including web pages (for example, http://volcanoes.usgs.gov/ash), training videos, and fact sheets (http://volcano.wr.usgs.gov/volcinfo/factsheets.php).

Research Results: Published research papers and geologic maps of volcanic centers document the scientific findings that provide the foundation for credible forecasts and assessments of volcanic behavior and for additional research investigations. Bibliographies of scientific publications since 1994 resulting from work funded by the VHP are online at http://volcanoes.usgs.gov/Products/sproducts.html.

The VHP provides substantial information about volcanic activity and hazards online. Each of the five U.S. Volcano Observatories maintains a website to present hazard information to both

the general public and more technical users. The websites have distinct regional perspectives and focus on the information needs and interests of their local communities.

The Observatory websites are:

Alaska Volcano Observatory – http://www.avo.alaska.edu/
Cascades Volcano Observatory – http://vulcan.wr.usgs.gov/
Hawaiian Volcano Observatory – http://hvo.wr.usgs.gov/
Long Valley Observatory – http://lvo.wr.usgs.gov/
Yellowstone Volcano Observatory – http://volcanoes.usgs.gov/yvo/

The VHP also maintains a program website (http://volcanoes.usgs.gov) for the purpose of presenting information that is common to or spans all the observatories (for example, background information on types of monitoring techniques, the weekly worldwide volcanic activity report, guidance on dealing with ash hazards).

An important source of volcano information is the website of the Smithsonian Institution's Global Volcanism Program (http://www.volcano.si.edu/), which offers both a contemporary and retrospective look at Earth's volcanoes. A section on "Volcano Activity Reports" includes brief weekly summaries on current activity and unrest around the globe (compiled in collaboration with the USGS VHP) and more extensive monthly reports that incorporate images, graphics and monitoring data. A section on "Volcanoes of the World" features data on the world's known and inferred Holocene volcanoes, including eruption chronologies, characteristics, and magnitudes. The website includes images of most of the world's volcanoes.

Types of Users of NVEWS Technical-Information Products

Volcanoes produce different kinds of hazardous phenomena with effects on people and infrastructure that mimic those of floods, fires, explosions, landslides, toxic chemical releases, atmospheric pollution, and severe storms. Moreover, many volcanoes are located on various types of federal lands (especially National Parks, Forests, and Wildlife Refuges). As a result, the target audience for users of NVEWS technical-information products comprises a diverse group that includes:

Department of Homeland Security/Federal Emergency Management Agency (FEMA)
FEMA's National Response Coordination Center
Dept. of Homeland Security/U.S. Coast Guard units
Dept. of Defense/U.S. TRANSCOM, U.S. SOUTHCOM, U.S. NORTHCOM
Operators of specific U.S. military bases
Technical staff of the Air Force Weather Agency/Satellite Applications Branch
Department of Interior Watch Office
Analysts of the National Geospatial-Intelligence Agency
Technical staff of the Environmental Protection Agency
Technical staff of the Army Corp of Engineers
Air-traffic controllers of the Federal Aviation Administration
Meteorologists of the National Oceanic and Atmospheric Administration
Supervisors and staff of specific National Parks
Supervisors and staff of specific National Forests
Refuge managers of the Fish and Wildlife Service

Native American and Native Alaskan land-owners
Governor's Offices
State Emergency Management Departments
State Geologists
Staff of State and local transportation departments
County/Borough Emergency Response Divisions
Commercial transportation entities
Airline pilots, dispatchers, and meteorologists
Airport managers
Electric power suppliers and distributors
Local public safety units (police, fire, etc.)
Local offices and regional distribution centers of the U.S. Postal Service
School districts
Individual households and businesses
Travelers within the US and to other volcanic countries
Scientific researchers

Guidelines for NVEWS Technical-Information Products

The Working Group identified six overall guidelines for NVEWS technical-information products and related functionalities:

- An NVEWS web-based product line should provide a synoptic, national-scale view of U.S. volcanic activity, organizing hazard information in such a way as to make it easier to find across Volcano Observatory lines. Some users of technical information are concerned about one or a few volcano(es) in a specific forest, park, county, or state, and such users primarily will interact directly with staff at a particular Observatory and refer almost exclusively to its website. But other users look for information topically or follow volcanic activity across Observatory lines, and these users would benefit from organization of hazard information on a national scale. An example of such users is the aviation sector, which regularly seeks and uses online information to ascertain the status of numerous volcanoes at any given time for planning and executing flights over regions that pose volcanic-ash cloud hazards to aircraft.

- Displays of current monitoring data should be available for every monitored volcano, to the extent possible without posting misleading or inaccurate information (for example, automatically generated map plots of earthquake locations can be problematical owing to the inability of computers to correctly recognize subtle seismic signals at some volcanoes).

- The online NVEWS presence should be a web space within the USGS VHP website, using links as needed to Observatory web pages. Although the Observatory websites would retain their individual characters, some similarity among them is necessary in how certain key information products are organized and presented on them.

- Now that a common alert-level system has been adopted for use by all the Observatories, the alert notices themselves should have a common format used by all the Observatories.

- Hazard data on U.S. volcanism should be stored in a common database(s) so that products readily can be generated dynamically from the contents of the database(s).

- Information should be disseminated in a manner that is user defined and thus allows recipients to choose the type and frequency of products they receive.

Recommended NVEWS Web-Based Products and Functionalities

With these guidelines in mind, the Working Groups recommended a suite of NVEWS web-based technical products and functionalities, described below and summarized in Table 1.

Alerts and Notifications of Volcanic Activity

(1) (A) **A Volcanic Activity Notice (VAN) for reporting changes in alert levels and aviation color codes, with a common format used by all the U.S. Volcano Observatories.** The process of producing VAN can be streamlined by a single computerized system that guides observatory staff to enter the necessary information into the fields of an underlying database that is common to all the Observatories. The system then automatically generates the various desired output such as the VAN, a version formatted in the Common Alerting Protocol (CAP) for an RSS feed, a customized message for airlines and other aviation users (a Volcano Observatory Notification for Aviation, VONA, as recommended by the International Civil Aviation Organization), etc. A list of the database fields needed to construct a VAN is given in Appendix 3. An automated numbering system will have to be developed to give every VAN a unique identifier. In addition to issuing VAN, which are *event-driven* messages used to highlight significant changes in the behavior of volcanoes, Observatories would continue to produce *time-driven* (daily or weekly) updates along with information releases about notable miscellaneous events.

(B) **A single archive of VAN and related VONA and daily or weekly updates, with filtering by volcano, region, and date.** A series of drop-down menus would allow the user to search the archive database.

(C) **A standardized timeline of alert level and aviation color code changes for each monitored volcano, with a filter for date.** With all VAN archived in a common database, this product could be generated dynamically by user query.

(2) **A Volcanic Notification Service (VNS) similar to the Earthquake Hazard Program's "Earthquake Notification Service" (ENS).** A VNS would allow individuals to select the types and geographic area of notices they receive by email or RSS feed. Subscription to the VNS should be offered on the same page as the ENS (http://earthquake.usgs.gov/eqcenter/ens/) with a link on the VHP site directing subscribers to that page.

Map-Based Hazard Information

(3) (A) **A synoptic, web-based, status map of all U.S. volcanoes showing alert levels and aviation color codes.** The map should be updated automatically every few minutes, have zoom-in capability, provide user-specified filters by region, alert level, etc., and give links to fuller information on Observatory sites.

(B) **Clear paths to current monitoring-data displays for specific volcanoes on the synoptic status map.** For example**,** a link to "X Volcano Page" on an Observatory site would convey the level of volcanic threat in concert with the delivery of real-time information about the situation. The Yellowstone Volcano Observatory web site offers a good example of how real-time monitoring data can be made available online (http://volcanoes.usgs.gov/yvo/monitoring.html).

(4) **Maps and tables of *in-situ* instruments that are used for monitoring by the Volcano Observatories.** Maps by volcano can be pre-made; other maps could be dynamically generated by queries to an instrumentation database.

(5) **Downloadable files of 30-meter digital elevation models (DEM) for U.S. volcanoes rated as high and very high threat in the NVEWS assessment.** When available, 10-meter DEM should be provided.

(6) **Downloadable files of hazard-zonation layers from the published hazard assessment reports.** Hazard zones should be displayed in file formats compatible with a variety of GIS software programs. If possible, there should be a built-in restriction on the zoom capability for map depictions so that the zone boundaries cannot be analyzed at an inappropriate scale.

(7) **Maps showing U.S. volcanoes on federal lands.** Pre-made maps would probably suffice for major federal and state land units. An issue to resolve is how to define the "footprint" of a particular volcano (topographic expression? expected extent of flowage deposits?).

Access to Published Articles, Assessments and Reports

(8) **A menu of all the recent published hazard-assessment reports**. An easy product to create is a single table that includes links to all reports available online (as pdf files). Eventually, greater search capability should be offered so users can search by jurisdictional boundaries (e.g., county, city, zip code).

(9) **Dynamic tables of the current scores for hazard and exposures factors at each U.S. volcano that form the basis of the NVEWS volcanic-threat assessment** (see Appendix 3 of Ewert et al., 2005). Tables should be generated from an underlying database of the most current information and data used in scoring those factors for each volcano to ensure up-to-date content is presented.

(10) **A fact sheet for each very-high and high threat volcano**. The fact sheets should have as standardized a format as possible, including a simplified summary of the volcano's eruptive history and the hazard-zonation map if available. A good example is the existing fact sheet

for Mount Hood by Gardner and others (2000) at http://pubs.usgs.gov/fs/2000/fs060-00/. Information about a volcano's eruptive history also should be easily accessed from various web pages. For example, AVO currently provides eruptive-history information for Alaskan volcanoes at http://www.avo.alaska.edu/searches/eruption_search.php. Until eruptive histories for other volcanoes are fully developed by the Observatories, the Smithsonian Institution's global volcanism database can be used (http://www.volcano.si.edu/).

(11) **A searchable bibliographic database of articles and maps published by scientists supported by the USGS Volcano Hazards Program.** Currently, bibliographies of publications since 1994 (http://volcanoes.usgs.gov/Products/sproducts.html) are minimally searchable with a word-processing function. An example of a searchable bibliography is on the AVO website at http://www.avo.alaska.edu/downloads/searchbib.php

Digital Imagery

(12) **A webcam menu (single table) of links to all of the relevant web cam pages**. Eventually a web cam should be installed at all of the 18 highest-threat U.S. volcanoes

(13) **An image library for U.S. volcanoes.** This should build on observatory image libraries by creating a common database structure and search tools for storing and retrieving images. In addition, this product could be supplemented by linkage to the image library of the Smithsonian's online global volcanism database. The Working Group noted, however, that creating a comprehensive image library is a major, long-term effort that requires knowledgeable people to attach index terms and captions to each image.

Summary Texts

(14) **A "Volcanic State of the Country" text report**. A brief, pre-formatted text report would be dynamically generated from the VAN database to give a snapshot summary of eruptive activity and unrest for a given date specified by the requester.

(15) **An annual summary of U.S. volcanism.** This could be published as an online text report.

Interactive and Background Resources

(16) **A Citizen Science webpage for volcanic activity**. Such a page could be used for logging reports about ash fall in communities, observations on fumaroles from climbers, observations from pilots, submission of photos, etc. This product is along the lines of the USGS Earthquake Hazard Program's "Did you feel it?" site (http://earthquake.usgs.gov/eqcenter/dyfi.php); however, a volcano site cannot be operated in a fully automatic, receive-and-post mode. Checking of entries by the relevant observatory will be necessary to filter out misleading or inappropriate comments during volcanic crises and prevent it from becoming a mere blog for volcano enthusiasts.

(17) **Web pages with technical guidance on aspects of mitigation and hazard response**. An example of this type of product is the USGS web presentation on volcanic ash which gives information about what ash is and what actions to take to mitigate its effects on transportation, buildings, power supply, water supply, agriculture, human health, etc.

(http://volcanoes.usgs.gov/ash). Other topics should be identified by discussion with users such as local emergency managers.

Implementation

The highest-priority product for implementation is a web-accessible, synoptic status map of U.S. volcanoes showing alert levels and aviation color codes with clear links to Observatory hazard and monitoring data (#3A & B). Also of very high priority are the common-formatted VAN (#1A) and a web-based "Volcano Notification System" (#2) whereby users can customize a subscription to receive the desired hazard information.

Databases

Several of the recommended products can be created readily with proper construction of relational databases that store the relevant information. For example, by utilizing an activity-notification database:

- various types of notifications (for example, VAN and VONA) can be generated easily in the appropriate format,
- an archive of past VAN with volcano/date filtering can be offered,
- a synoptic map showing all current alert levels and aviation color codes can be created,
- a standardized chronology of alert-level and color-code changes for monitored volcano can be dynamically generated, and
- a summary of volcanoes active during a specified time period can be dynamically generated.

Likewise, a database of volcano-monitoring instrumentation can be used to generate station maps of various types, and a hazard-assessment database can be used to serve a national menu of published reports, downloadable GIS layers, and DEM.

The databases mentioned above are part of a larger effort to build a relational, web-accessible database system that can fully utilize the NVEWS threat and monitoring assessments for further analysis, as well as document how U.S. volcanoes were ranked in the NVEWS methodology of Ewert and others (2005). Given the central role of databases in the NVEWS initiative, sufficient resources – staff and hardware – should be allocated to the tasks of creating them and maintaining them. Although the VHP and its partners, particularly in Alaska, have added new staff with GIS and web expertise, a need remains for additional staffing at various locations.

Website

The USGS VHP website is in the process of evolving from primarily an educational site for volcanophiles to one that also is a national-scale source of dynamic hazard information and notifications and that functions reliably in an operational mode (Venezky et al., 2006). The NVEWS volcanological product line provides the organizing framework for re-designing the website of the USGS Volcano Hazards Program into a national clearinghouse for technical hazards information. The redesign of the VHP site will be a major effort that must take into consideration how best to present the recommended NVEWS product line and how to link to the wealth of information about specific volcanoes that is presented on the Observatory websites.

The recently revamped website of the Earthquake Hazards Program, which features regional seismic-network sites along with a national "Earthquake Center," can be a guide for the VHP effort.

Operational Issues

Disseminating notifications of volcanic hazards is a critical 24/7 operational duty that has significant implications for the server architecture used by the Volcano Observatories:

- The server architecture must support dissemination of notifications as quickly as possible and include the ability to update notifications on short notice when hazard conditions change and to re-disseminate the information with minimal delay.
- The architecture also must have very high availability to the Internet and to the Volcano Observatories, as people increasingly rely on the Internet for receipt of hazards notification. (A telephone call-down is, and will remain, the first method for delivering abbreviated messages but only to a short list of key users.)
- Near-zero down time is required because significant changes in volcanic activity can occur at any time with little warning, and the dissemination system must be up and ready.
- Overall, the server architecture must be sufficiently robust and fault-tolerant to permit routine maintenance and to withstand hardware failures, both without disruption. Server architecture also affects inter-operability among Observatories (the topic of another NVEWS Working Group), and hardware solutions should meet those operational requirements as well the ones outlined here.

Discussion

With respect to volcanic ash, which is both a volcanological and meteorological phenomenon, NOAA also provides important technical-information products. The Washington and Anchorage Volcanic Ash Advisory Centers issue advisory forecasts about the expected dispersion of airborne ash clouds, and National Weather Service forecast offices issue short-term warnings about airborne ash and advisories of expected ash fall (accumulation on the ground). Currently the USGS and NOAA, along with the Air Force Weather Agency (which provides ash-hazard notifications for U.S. Forces worldwide) and the FAA, actively collaborate to share data and refine communication protocols so that information about airborne-ash hazards quickly reaches commercial and military pilots, dispatchers, and air-traffic controllers. However, as noted at the 2006 NVEWS Stakeholders Workshop (Guffanti and others, 2006), there is an opportunity for the USGS and National Weather Service to work together to improve ash *fall* forecasts and advisories. There is a need to develop an ash-dispersion and deposition model for operational use in both hypothetical and actual eruptions with map-based depiction of where, when, and how much ash deposition is forecast to occur, along with guidance about what actions affected groups should take (#18 in Table 1).

Delivery of the recommended NVEWS products and functionalities will result in both improved responsiveness to users and higher visibility for volcano-monitoring efforts. However, it is important to note that in addition to offering the web-based information discussed here, an effective technical-outreach program also must include the direct interaction of Observatory staff with the people who make decisions about public safety. Scientists need to work closely with users during the decision-making process to interpret monitoring data, explain uncertainty in

forecasts of expected hazards, help formulate appropriate mitigation/response plans, and provide full situational awareness during crises. Through their direct participation, scientists can advance the transformative process by which technical knowledge is changed into specific actions taken by communities and officials.

References Cited

Ewert, J. W., Guffanti, M., and Murray, T. L., 2005, An Assessment of Volcanic Threat and Monitoring Capabilities in the United States – Framework for a National Volcanic Early Warning System (NVEWS): U.S. Geological Survey Open-File Report 2005-1164, 62 p. Online at http://pubs.usgs.gov/of/2005/1164

Gardner, C. A., Scott, W. E., Major, J. J., and Pierson, T. C., 2000, Mount Hood—History and Hazards of Oregon's Most Recently Active Volcano: U.S. Geological Survey Fact Sheet 2000-60, 4 p. Online at http://pubs.usgs.gov/fs/2000/fs060-00/

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 p. Online at http://pubs.usgs.gov/fs/2006/3139

Guffanti, M., Scott, W. E., Driedger, C. L., and Ewert, J. W., 2006, Summary of the Stakeholders Workshop to Develop a National Volcanic Early Warning System (NVEWS): U.S. Geological Survey Open-File Report 2006-1224, 7 p. Online at http://pubs.usgs.gov/of/2006/1224

Venezky, D. Y., Snedigar, S., Guffanti, M., Bailey, J. E., and Wall, B. G., 2006, Using Google Maps to access USGS volcano hazards information (abs.): Eos Transactions American Geophysical Union, v. 87, n. 52, Fall Meeting Supplement, Abstract IN43A-0901.

Table 1. Recommended web-based technical-information products and functionalities for a National Volcano Early Warning System.

Item	Product	Comments
I. Alerts and Notifications		
1A	Common-formatted Volcanic Activity Notice (VAN) used by all observatories for reporting changes in alert levels and activity.	Requires interface to enter information into common database to produce VAN, CAP feed, aviation notice, etc.
1B	Single queriable archive of VAN and related notices with filtering by volcano/region/date.	Generated from common VAN database.
1C	Standardized chronology per volcano of alert level/aviation color code changes with filter by date.	Generated from common VAN database.
2	Volcanic Notification Service (ala EQ Notification Service)	Make part of VHP/NVEWS site redesign; can apply some Earthquake Hazards Program tools.
II. Map-Based Hazard Information		
3A	Synoptic status map of all US volcanoes showing alert levels & aviation color codes with filtering by region, alert level/ACC, etc.	User-specified filtering; links to more information on Observatory sites.
3B	Clear paths to online real-time monitoring-data displays for each volcano on the status map.	Variable effort to create; overlap with Inter-operability Working Group and observatory sites.
4	Maps and tables of monitoring instrumentation, pre-made and user-defined.	Requires that instrumentation database is maintained and current.
5	30-m DEM (10-m if available) for U.S. volcanoes rated as high and very-high threat in NVEWS report.	30-m exist for AK and all western US; 10-m exist for most of the Cascade peaks except those in Northern California.
6	Downloadable GIS and Google-Earth layers from hazard zonation maps.	Total effort is major.
7	Maps of volcanoes on federally managed land.	Pre-made maps not difficult.
III. Access to Assessments and Reports		
8	"National" menu of recent hazard assessment (PDFs).	Make database extensible to include related publications.
9	Tables of NVEWS hazard and exposure scores for all volcanoes.	Minor effort to post tables online, major effort to create underlying US volcanism database.
10	Fact Sheet for each high- and very-high-threat U.S. volcano, including eruptive history. Standardized format.	Major effort to do all, but some could be done with moderate effort.
11	Searchable VHP bibliography.	Start with existing bibliography of publications since 1994.
IV. Digital Imagery		
12	Webcam Menu	Minor effort with current staff.
13	Image library for US volcanoes.	Need common database schema for archiving and retrieval; major effort to attach index terms & captions to each image.
V. Summary Texts		
14	Dynamically-generated “Volcanic State of the Country” report	Will take thoughtful development but then can be produced automatically from VAN database at time of user query.
15	Annual summary of U.S. volcanism	Recurring duty of 1-2 scientists.
VI. Interactive and Background Resources		
16	Citizen Science webpage for reports about ash fall, pilot reports, observations from climbers, etc., including feedback mechanism	May be able to adapt some EHP "Did you feel it?" tools, but not automatic receive-and-post mode.
17	Mitigation and response guidance web pages (like current pages on ash).	Major effort. Check with Reducing Community Vulnerability Working Group to solicit input about priority topics.
18	Ash-deposition model for operational use that produces maps of where, when, how much ash for hypothetical & actual eruptions.	Can use or adapt existing models.

Appendix 1.

PUBLISHED VOLCANO-HAZARD ASSESSMENTS FOR U.S. VOLCANOES
As of September 2007

(When multiple assessments for a volcano have been published, only the most recent version is listed.)

MULTI –STATE

- Mullineaux, D. R., 1976, Preliminary overview map of volcanic hazards in the 48 conterminous United States: U.S. Geological Survey Miscellaneous Field Studies Map MF-786, 1 plate, scale 1:7,500,000.

- Shipley, Susan, and Sarna-Wojcicki, A. M., 1983, Distribution, thickness, and mass of late Pleistocene and Holocene tephra from major volcanoes in the northwestern United States: A preliminary assessment of hazards from volcanic ejecta to nuclear reactors in the Pacific Northwest: U.S. Geological Survey Miscellaneous Field Studies Map MF-1435, 27 p., 1 plate, scale 1:2,500,000.

- Hoblitt, R. P., Miller, C. D., and Scott, W. E., 1987, Volcanic hazards with regard to siting nuclear-power plants in the Pacific Northwest: U.S. Geological Survey Open-File Report 87-297, 196 p., 5 plates, scale 1:2,000,000. (Selected items on CVO website at http://vulcan.wr.usgs.gov/Hazards/NRC_Report/framework.html and scanned version of report at http://pubs.er.usgs.gov/usgspubs/ofr/ofr87297)

ALASKA

Alaska volcano-hazard assessment reports are available as PDF on the AVO website. A dynamically generated list can be created on AVO's website via Library/Introduction/Hazard Reports; see http://www.avo.alaska.edu/downloads/classresults.php?pregen=haz

Akutan

- Waythomas, C. F., Power, J. A., Richter, D. H., and McGimsey, R. G., 1998, Preliminary volcano-hazard assessment for Akutan Volcano east-central Aleutian Islands, Alaska: U.S. Geological Survey Open-File Report 98-360, 36 p., 1 plate.

Aniakchak

- Neal, C. A., McGimsey, R. G., Miller, T. P., Riehle, J. R., and Waythomas, C. F., 2001, Preliminary volcano-hazard assessment for Aniakchak Volcano, Alaska: U.S. Geological Survey Open-File Report 00-519, 35 p., 1 plate.

Augustine

- Waythomas, C. F., and Waitt, R. B., 1998, Preliminary volcano-hazard assessment for Augustine Volcano, Alaska: U.S. Geological Survey Open-File Report 98-106, 39 p., 1 plate.

Emmons Lake Volcanic Center

- Waythomas, C.F., Miller, T.P., and Mangan, M.T., 2006, Preliminary Volcano Hazard Assessment for the Emmons Lake Volcanic Center, Alaska: Anchorage, Alaska, U.S. Geological Survey, Scientific Investigations Report 2006-5248, 33 p., 1 plate.,

Great Sitkin

- Waythomas, C. F., Miller, T. P., and Nye, C. J., 2003, Preliminary volcano-hazard assessment for Great Sitkin Volcano, Alaska: U.S. Geological Survey Open-File Report 03-112, 25 p., 1 plate,

Hayes

- Waythomas, C. F., and Miller, T. P., 2002, Preliminary volcano-hazard assessment for Hayes Volcano, Alaska: U.S. Geological Survey Open-File Report 02-072, 27 p., 1 plate.

Iliamna

- Waythomas, C. F., and Miller, T. P., 1999, Preliminary volcano-hazard assessment for Iliamna Volcano, Alaska: U.S. Geological Survey Open-File Report 99-373, 31 p., 1 plate.

Kanaga

- Waythomas, C. F., Miller, T. P., and Nye, C. J., 2002, Preliminary volcano-hazard assessment for Kanaga Volcano, Alaska: U.S. Geological Survey Open-File Report OF 02-0397, 27 p., 1 plate,

Katmai Volcanic Cluster

- Fierstein, Judy, and Hildreth, Wes, 2001, Preliminary volcano-hazard assessment for the Katmai volcanic cluster, Alaska: U.S. Geological Survey Open-File Report 00-489, 50 p., 1 plate.

Makushin

- Begét, J. E., Nye, C. J., and Bean, K. W., 2000, Preliminary volcano-hazard assessment for Makushin Volcano, Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigations 2000-4, 22 p., 1 plate, scale 1:100,000.

Mount Spurr

- Waythomas, C. F., and Nye, C. J., 2002, Preliminary volcano-hazard assessment for Mount Spurr Volcano, Alaska: U.S. Geological Survey Open-File Report 01-482, 40 p., 1 plate, available at

Okmok

- Beget, J.E., Larsen, J.F., Neal, C.A., Nye, C.J., and Schaefer, J.R., 2005, Preliminary volcano-hazard assessment for Okmok Volcano, Unmak Island, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2004-3, 32 p., 1 sheet, scale 1:150,000,

Pavlof

- Waythomas, C. F., Miller, T. P., McGimsey, R. G., and Neal, C. A., 1997, Preliminary volcano-hazard assessment for Pavlof Volcano, Alaska: U.S. Geological Survey Open-File Report 97-135, 1 plate.

Redoubt

- Waythomas, C. F., Dorava, J. M., Miller, T. P., Neal, C. A., and McGimsey, R. G., 1998, Preliminary volcano-hazard assessment for Redoubt Volcano, Alaska: U.S. Geological Survey Open-File Report 97-857, 40 p., 1 plate.

Shishaldin

- Begét, J. E., Nye, C. J., Schaefer, J. R., and Stelling, P. L., 2003, Preliminary volcano-hazard assessment for Shishaldin Volcano, Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigations 2002-4, 28 p., 1 plate, scale 1:500,000.

Tanaga

- Coombs, M. L., McGimsey, R. G., and Browne, B. L., 2007, Preliminary volcano-hazard assessment for the Tanaga volcanic cluster, Tanaga Island, Alaska: U.S. Geological Survey Scientific Investigations Report 2007-5094, 41 p., 1 plate, available at http://pubs.usgs.gov/sir/2007/5094/

WASHINGTON

Recent hazard-assessment reports for Cascade volcanoes in Washington and Oregon are available on the CVO website at http://vulcan.wr.usgs.gov/Publications/hazards_reports.html (CVO homepage menu offers "Hazard Assessment Reports and Maps).

In addition, 20 GIS data sets have been created that represent hazard information from the assessments of the 5 Washington volcanoes; see http://vulcan.wr.usgs.gov/Hazards/DataSets/Washington/framework.html

State-wide

- Crandell, D. R., 1976, Preliminary assessment of potential hazards from future volcanic eruptions in Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-774, 1 plate, scale 1:1,000,000.

Glacier Peak

- Waitt, R. B., Mastin, L. G., and Begét, J. E., 1995, Volcanic-hazard zonation for Glacier Peak Volcano, Washington: U.S. Geological Survey Open-File Report 95-499, 9 p., 2 plates, scale 1:100,000.

Mt. Adams

- Scott, W. E., Iverson, R. M., Vallance, J. W., and Hildreth, Wes, 1995, Volcano hazards in the Mount Adams region, Washington: U.S. Geological Survey Open-File Report 95-492, 11 p., 2 plates, scale 1:500,000, 1:100,000.

Mt. Baker

- Gardner, C. A., Scott, K. M., Miller, C. D., Myers, Bobbie, Hildreth, Wes, and Pringle, P. T., 1995, Potential volcanic hazards from future activity of Mount Baker, Washington: U.S. Geological Survey Open-File Report 95-498, 16p., 1 plate, scale 1:100,000.

Mt. Rainier

- Hoblitt, R. P., Walder, J. S., Driedger, C. L., Scott, K. M., Pringle, P. T., and Vallance, J. W., 1998, Volcano hazards from Mount Rainier, Washington, Revised 1998: U.S. Geological Survey Open-File Report 98-428, 11 p., 2 plates, scale 1:100,000, 1:400,000.
- U.S. Geological Survey, 1996, Perilous Beauty, The Hidden Dangers of Mount Rainier: VHS video, 29 min.

Mt. St. Helens

- Wolfe, E. W., and Pierson, T. C., 1995, Volcanic-hazard zonation for Mount St. Helens, Washington, 1995: U.S. Geological Survey Open-File Report 95-497, 12 p., 1 plate, scale 1:100,000.

OREGON

Recent hazard assessement reports for Cascade volcanoes in Washington and Oregon are available on the CVO website at http://vulcan.wr.usgs.gov/Publications/hazards_reports.html (CVO homepage menu offers "Hazard Assessment Reports and Maps)

Crater Lake

- Bacon, C. R., Mastin, L. G., Scott, K. M., and Nathenson, Manuel, 1997, Volcano and earthquake hazards in the Crater Lake region, Oregon: U.S. Geological Survey Open-File Report 97-487, 32 p, 1 plate, scale 1:100,000.

Mt. Hood

- Scott, W. E., Pierson, T. C., Schilling, S. P., Costa, J. E., Gardner, C. A., Vallance, J. W., and Major, J. J., 1997, Volcano hazards in the Mount Hood region, Oregon: U.S. Geological Survey Open-File Report 97-89, 14 p., 1 plate, scale 1:100,000.
- Wessells, Steve, 1998, At risk: Volcano Hazards from Mount Hood, Oregon: U.S. Geological Survey Open-File Report 98-492, VHS video, 14 min.

Three Sisters

- Scott, W. E., Iverson, R. M., Schilling, S. P., and Fisher, B. J., 2000, Volcano hazards in the Three Sisters region, Oregon: U.S. Geological Survey Open-File Report 99-437, 14 p., 1 plate, scale 1:150,000.

Newberry

- Sherrod, D. R., Mastin, L. G., Scott, W. E., and Schilling, S. P., 1997, Volcano hazards at Newberry Volcano, Oregon: U.S. Geological Survey Open-File Report 97-513, 14 p., 1 plate, scale 1:100,000.

Jefferson

- Walder, J. S., Gardner, C. A., Conrey, R. M., Fisher, B. J., and Schilling, S. P., 1999, Volcano hazards in the Mount Jefferson region, Oregon: U.S. Geological Survey Open-File Report 99-24, 14 p., 2 plates, scale 1:100,000.

CALIFORNIA

Selected maps and summaries (but not full reports) from the Shasta and State-wide hazard reports are online at various pages on the CVO website (see below). Link to Lassen fact sheet on VHP website via Selected Products page (see below).

State-wide

- Miller, C. D., 1989, Potential hazards from future volcanic eruptions in California: U.S. Geological Survey Bulletin, 1847, 17 p., 2 plates, scale 1:500,000. (Selected parts at: http://vulcan.wr.usgs.gov/Volcanoes/California/Hazards/Bulletin1847/framework.html)

Lassen

- Clynne, M. A., Christiansen, R. L., Miller, C. D., Stauffer, P. H., and Hendley, J. W. II, 2000, Volcano Hazards of the Lassen Volcanic National Park Area, California: U.S. Geological Survey Fact Sheet 022-00, 4 p. Online via VHP website at http://pubs.usgs.gov/fs/2000/fs022-00/

Medicine Lake

- Donnelly-Nolan, J. M., Nathenson, Manuel, Champion, D. E., Ramsey, D. W., Lowenstern, J. B., and Ewert, J. W., 2007, Volcano hazards assessment for Medicine Lake volcano, northern California: U.S. Geological Survey Scientific Investigations Report 2007-5174-A, 26 p., 1 plate.

Shasta

- Miller, C. D., 1980, Potential hazards from future eruptions in the vicinity of Mount Shasta volcano, northern California: U.S. Geological Survey Bulletin 1503, 43 p., 3 plates, scale 1:62,500. Selected items online at:http://vulcan.wr.usgs.gov/Volcanoes/Shasta/Hazards/Bulletin1503/framework.html
- Crandell, D. R., and Nichols, D. R., 1987, Volcanic hazards at Mount Shasta, California: U.S. Geological Survey General Interest Publication, 21 p.
- Crandell, D. R. 1989, Gigantic debris avalanche of Pleistocene age from ancestral Mount Shasta Volcano, California, and debris-avalanche hazard zonation: U.S. Geological Survey Bulletin 1861, 32 p. Selected items online at: http://vulcan.wr.usgs.gov/Volcanoes/Shasta/Publications/Bulletin1861/framework.html

- Blakely, R., Christiansen, R., Ramsey D., Robinson, J., and Smith, J.G., 2001, Digital Shasta: Applying GIS Technology to Volcano Hazards: Online at: http://www.esri.com/mapmuseum/mapbook_gallery/volume16/geology4.html

Long Valley

- Miller, C. D., Mullineaux, D. R., Crandell, D. R., and Bailey, R. A., 1982, Potential hazards from future eruptions in the Long Valley–Mono Lake area, east-central California and southwest Nevada – a preliminary assessment: U.S. Geological Survey Circular 877, 10 p.

HAWAII

Island of Hawaii

- Mullineaux, D. R., Peterson, D. W., and Crandell, D. R., 1987, Volcanic hazards in the Hawaiian Islands, in Decker, R. W., Wright, T. L., and Stauffer, P. H., eds., Volcanism in Hawaii: U.S. Geological Survey Professional Paper 1350, v. 1, p. 599-621.
- Heliker, Christina, 1990, Volcanic and seismic hazards on the Island of Hawaii: U.S. Geological Survey General Interest Publication, 48 p. Online via HVO website at http://pubs.usgs.gov/gip/hazards/
- Wright, T. L., Chun, J. Y. F., Esposo, Joan, Heliker, Christina, Hodge, Jon, Lockwood, J. P., and Vogt, S. M., 1992, Map showing lava-flow hazard zones, Island of Hawaii: U.S. Geological Survey Miscellaneous Field Studies Map MF-2193, 1 plate, scale 1:250,000.

Island of Maui

- Crandell, D. R., 1983, Potential hazards from future volcanic eruptions on the Island of Maui, Hawaii: U.S. Geological Survey Miscellaneous Investigations Map I-1442, scale 1:100,000.

Island of Oahu

- Crandell, D. R., 1975, Assessment of volcanic risk on the Island of Oahu, Hawaii: U.S. Geological Survey Open-File Report 75-287, 18 p.

Mauna Loa

- Trusdell, F. A., Graves, P., and Tincher, C. R., 2002, Maps showing inundation zones for Mauna Loa, Hawai'i: U.S. Geological Survey Miscellaneous Field Studies Map MF-2401, 14 p., 10 plates, various scales. Online at http://geopubs.wr.usgs.gov/map-mf/mf2401/
- Trusdell, F., A., 1995, Lava flow hazards and risk assessment on Mauna Loa Volcano, Hawai`i, in Rhodes, J.M., and Lockwood, J. P. (eds.), Mauna Loa revealed: structure, composition, history, and hazards: Washington D.C., American Geophysical Union Monograph 92, p. 327-336.
- Kauahikaua, J., Trusdell, F., and Heliker, C., 1998, The probability of lava inundation at the proposed and existing Kulani Prison sites: U.S. Geological Survey Open-File Report 98-794, 21 p. On HVO website at http://hvo.wr.usgs.gov/products/OF98794/OF98794toc.html

Haleakala

- Mullineaux, D. R., Peterson, D. W., and Crandell, D. R., 1987, Volcanic hazards in the Hawaiian Islands, in Decker, R. W., Wright, T. L., and Stauffer, P. H., eds., Volcanism in Hawaii: U.S. Geological Survey Professional Paper 1350, v. 1, p. 599-621.

WYOMING

Yellowstone

- Christiansen, R.L., Lowenstern, J.B.,Smith, R.B., Heasler, H., Morgan, L.A., Nathenson, M., Mastin, L.G., Muffler, L.J.P., and Robinson, J.E., 2007, Preliminary Assessment of Volcanic and Hydrothermal Hazards in Yellowstone National Park and Vicinity: U.S. Geological Survey Open-File Report 2007-1071, version 1.1, 98 p. Online at http://pubs.usgs.gov/of/2007/1071/

Appendix 2.

INTERAGENCY RESPONSE PLANS FOR VOLCANIC ACTIVITY

Mt. Rainier Volcanic Hazards Response Plan
1999. Involves National Park Service, Pierce County Department of Emergency Management, King County Emergency Management, Washington State Emergency Management, Washington Division of Veterans Affairs, University of Washington, U.S. Forest Service, National Weather Service, U.S. Army at Fort Lewis, Federal Emergency Management Agency, cities of Tacoma, Puyallup, Sumner, Orting, and others.
Online at http://www.co.pierce.wa.us/pc/abtus/ourorg/dem/EMDiv/Mt%20Rainier%20VHRP.htm

Mount Baker-Glacier Peak Coordination Plan
2001, signed by Washington State Military Department, Snohomish County Department of Emergency Management, Skagit County Department of Emergency Management, Whatcom County Emergency Management Council, British Columbia Provincial Emergency Program, U.S. Forest Service (Mt. Baker-Snoqualmie National Forest), and U.S. Geological Survey (Cascade Volcano Observatory). This is a combined response plan for Baker and Glacier Peak that replaces the 1982 Baker plan.

Mount St. Helens Volcanic Activity Response Plan
2006, signed by U.S. Forest Service. Other participating cooperators are USGS Cascades Volcano Observatory, Clark County, Cowlitz County, Skamania County, Lewis County, Washington Emergency Management Division, Federal Emergency Management Agency, U.S. Army Corps of Engineers, PacifiCorp, Portland General Electric, Portland Office of Emergency Management.
Online at http://www.fs.fed.gov.us/gpnf/mshnvm/documents/Volcano-Respnse-Plan-Oct-2006-current.pdf

Mt. Hood Coordination Plan
2005, signed by Oregon Emergency Management, Washington State Military Department, Oregon Department of Geology and Mineral Industries, Clark County, Hood River County, Wasco County, Clackamas County, Multnomah County, Confederated Tribes of the Warm Springs Reservation, USGS Cascades Volcano Observatory, Mount Hood National Forest, and FEMA Region 10.
Online at http://www.oregongeology.com/sub/earthquakes/mthoodplanfinal0905.pdf

Alaska Interagency Operating Plan for Volcanic Ash Episodes
Last updated 1 April 2004, signed by Alaska Division of Homeland Security and Emergency Management, USGS, U.S. Air Force, Federal Aviation Administration, U.S. Coast Guard, and NOAA/National Weather Service. Online at http://aawu.arh.noaa.gov/interagency/interagency_plan.pdf

Interagency Operating Plan for Volcanic-Ash Hazards to Aviation in the Pacific Region of the Northern Mariana Islands
2006, involves Federal Aviation Administration, USGS, National Oceanic and Atmospheric Administration, U.S. Air Force, and Emergency Management Office of the Commonwealth of the Northern Mariana Islands.

National Volcanic Ash Operating Plan for Aviation
2007, signed by Federal Aviation Administration, USGS, National Oceanic and Atmospheric Administration, U.S. Air Force, NASA, and Smithsonian Institution. Online at http://www.ofcm.gov/p35-nvaopa/pdf/FCM-P35-2007-NVAOPA.pdf

Appendix 3.

LIST OF DATA BASE FIELDS USED IN CONSTRUCTING VOLCANIC ACTIVITY NOTICES

Notice Name (e.g., USGS Volcanic Activity Notice, USGS Volcanic Observatory Notice for Aviation)
Volcano Name
CAVW#
Current Alert Level
Previous Alert Level
Current Aviation Color Code
Previous Aviation Color Code
UTC Date and Time Issued (YYYYMMDD/HHMMZ)
Local Date and Time Issued (Month Day, Year Time Zone)
Source (Observatory)
Notice Number
Location, latitude
    Specify aviation format (e.g., Cardinal point DDMM) or regular format (Cardinal point DD deg MM min)
Location, longitude
    Specify aviation format (e.g. Cardinal point DDDMM) or regular format (Cardinal point DDD deg MM min)
Area (regional descriptor)
Summit Elevation (always given in feet and meters)
Volcanic Activity Summary
Recent Observations
    Monitoring report (instrumental, remote-sensing, visual, web cam, etc.)
    Observed volcanic cloud height
    Other volcanic cloud information
    Observed paths of lava flow(s)
    Observed distribution of mudflow(s)
    Observed extent of pyroclastic flow(s)
    Observed tsunami runup(s)
Hazard Analysis
    General
    Ash cloud(s)
    Ash fall (or, Tephra fall)
    Lava flow(s)
    Mudflow(s)
    Tsunami
    Gas emission(s)
Remarks
Contacts
Next Notice