Natural Hazard Research

EMERGENCY RESPONSE TO MOUNT ST. HELENS' ERUPTION: MARCH 20 TO APRIL 10, 1980

by

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Emergency Response to Mount St. Helens'
Eruption: March 20 to April 10, 1980

The situation in the weeks previous to the cataclysm of May 18th provided a rare opportunity to study the methods used by public officials and decision makers to assess the risk of eruption and potential damages, and the ways in which they warned the public. This working paper identifies the key actors and organizations in the response, traces the information flow among those actors and from them to the public, indicates persistent problems faced by emergency personnel, and analyzes how all affected parties perceived and estimated the risks from a future eruption.

Some of the study's conclusions are that the U.S. Forest Service's strong response to the impending eruption facilitated a coordinated response; most local and state agencies were poorly prepared for the eruption; rumor was not a major problem; and local efforts to respond were hampered by the lack of definitive and understandable information about the risks from the volcano.

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PREFACE

This paper is one in a series on research in progress in the field of human adjustments to natural hazards. It is intended that these papers be used as working documents by those directly involved in hazard research, as well as inform a larger circle of interested persons. The series was started with funds from the National Science Foundation to the University of Colorado and Clark University, but it is now on a self-supporting basis. Authorship of the papers is not necessarily confined to those working at these institutions.

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INTRODUCTION

Purpose and Objectives of the Study

On Friday, March 28, 1980, Mount St. Helens sent a plume of tephra and steam billowing into the skies of southwestern Washington. It was the first eruption of a Cascade volcano in many years. While this venting of materials was not dangerous, the potential risks from a major event were believed to be significant. Studies by the U.S. Geological Survey (USGS) had already outlined the possible consequences and hazards from an eruption. The situation prompted a quick emergency response by many public officials and agencies. The purpose of this study is to gain a better understanding of their actions and response in relation to the risk and uncertainties posed by what one newspaper labeled a "time bomb".

The situation provided a rare opportunity for studying the behavior of officials and decision makers faced with a low-probability, high-damage event. Most studies concerning response to a hazardous situation are done either long after a disaster occurs, making it difficult to reconstruct emergency response activities, or when there is no impending threat, when only intentions can be measured. The awakening of Mount St. Helens provided a valuable laboratory in which to study the mobilization of emergency management efforts and the process of disseminating risk information to the lay public because:

1. The consequences of an eruption had been identified and were fairly well understood by the USGS.

2. There was uncertainty over the time and magnitude of the eruption.
3. The threat was real and visible.
4. The duration of response activity made it easier to identify response processes.

In the light of these factors, the study had four broad objectives.

First, we sought to identify the key actors and organizations which were part of the response effort and to ascertain their roles and responsibilities.

Second, we wanted to discover the nature of information flow among those actors and subsequently to the public. Particular emphasis is given to technical information concerning probabilities, risks, and consequences.

Third, we wanted to discover what problems faced emergency response personnel and what activities were being pursued to alleviate them. A related objective was to gain a picture of how decisions were made about problematic issues.

Finally, we sought an understanding of how affected parties in the area perceived and estimated risks associated with the eruption and potential future events.

Previous Research

The study conducted at Mount St. Helens is based on previous work by the author (Sorensen and Gersmehl, 1980; Warrick, 1975).
The latter study, a review of research needs associated with hazard management, points out the need for a better understanding of the response to an eruption and the evaluation of volcanic hazard warning systems. In addition, Warrick stresses the need to understand how risk information and appraisals are used in managing volcano hazards.

This author's previous investigations focused on normative functions of volcanic hazard warning systems on the island of Hawaii. The research, based on semistructured interviews with key actors in the warning system, attempted to identify the factors which contributed to the success of emergency operations and warnings associated with eruptions of the Kilauea volcano.

In addition, the research is partly based on a wide range of studies conducted on hazard warning systems (Mileti, 1975), sociological investigations of disasters (Quarantelli, 1978; Mileti *et al.*, 1975a), geographical appraisals of human response to volcanoes (Murton and Shimabakuru, 1974) and to other natural hazards (Burton *et al.*, 1978).

The Research Procedure

The following section summarizes efforts to assess and analyze emergency response to the Mount St. Helens volcanic eruption. Field work began on Sunday, April 6, and ended on Sunday, April 13, 1980, and was conducted by John Sorensen and Thomas Giambelluca, University of Hawaii. The research was carried out primarily in Vancouver and Olympia, Washington, and in the vicinity of Mount St. Helens.

The research involved four modes of collecting data. First, observational techniques were used to record and assess the functions of the Emergency Operation Center located in Vancouver, Washington. Second, semi-structured interviews were conducted with representatives of most key organizations associated with the emergency response efforts. Third, short, structured questionnaires were administered to people in proximity to the volcano. Fourth, newspaper accounts form three major dailies in the Portland-Vancouver area were collected.

The study concentrates on the emergency response period, defined as the interval between the date at which the eruption became imminent (Wednesday, March 26) and the cessation of emergency activities (Friday, April 11). At the time of this writing, the emergency response is in a distinctly different phase; it is one of vigilance and low activity. It is unclear how many more distinguishable periods will be encountered if the volcano's activities continue. The remainder of this section discusses the data-collection efforts; the rest of the report presents some initial findings based upon the information gathered from the observation and informal discussions.

Observational data. A key part of the study involved having an observer in the Emergency Coordinating Center for three days. The observer was responsible for taking field notes on the interactions among the various officials and organizations participating in the response effort, having informal discussions with those participating, collecting documents and printed statements used to disseminate information and attending meetings and briefings held by the Center's staff.

In addition, the following meetings were attended:

Monday a.m.	Planning meeting over coordinating response with Federal Aviation Administration
Monday p.m.	Planning meeting to discuss draft contingency plan and road block issue
Monday p.m.	Press conference
Tuesday p.m.	Planning meeting to adopt contingency plan
Wednesday p.m.	Press conference
Thursday a.m.	Final press conference

Semi-structured interviews. All of the key organizations were interviewed following a standard interview schedule which had varying degrees of applicability for each organization. The organizations included

U.S. Forest Service
Washington State Department of Emergency Services
Pacific Power and Light
Skamania Sheriffs Department
National Guard Liaison
Clark County Amateur Radio
U.S. Forest Service Public Information
Washington State Department of Game
Washington State Department of Fisheries
Washington State Department of Agriculture
Washington State Department of Ecology
Washington State Department of Health and Social Services
Washington National Guard Command
Washington State Highway Patrol
Washington State Office of the Governor

Media. The editors of all three major newspapers in the Portland-Vancouver area were interviewed. In addition, daily copies of all three papers for the period March 24, 1980, through April 12, 1980, were obtained and were analyzed to determine the nature of the information that was being disseminated to the public. The papers are

The Columbian (Vancouver)

The Oregonian (Portland)

The Oregon Journal (Portland).

Questionnaire. To gain a better idea of how the eruption was being viewed by the public, a short questionnaire was administered to people near Mount St. Helens, including residents and sightseers. Seventy interviews were conducted outside the three major businesses in Cougar, Washington (population about 150), the settlement nearest the volcano. Fifty interviews were conducted at the Yale Reservoir public viewpoint, the closest official vantage point. No systematic sampling procedures were feasible. People were administered the questionnaire until the desired number was reached.

BACKGROUND: MOUNT ST. HELENS, VOLCANO AND ENVIRONS

Mount St. Helens: A Brief Description

Mount St. Helens is in southwestern Washington in a sparsely populated section of the Gifford Pinchot National Forest. It is 70 km northeast of Portland, Oregon, and due east of the towns of Kelso and Longview, Washington, which are near the banks of the Columbia River.

Scientists who know it best, describe Mount St. Helens as a prominent but relatively little known volcano. . .(which) has been more active and more violent during the last few thousand years than any other volcano in the conterminous United States" (Crandell, Mullineaux, and Rubin, 1975). In the last 4,000 years there have been four major eruptive phases, each spanning hundreds of years (Crandell, Mullineaux, and Rubin, 1979). The last phase began approximately 500 years ago, with the most recent eruptive sequence occurring between 1830 and 1857.

The diverse eruptions of Mount St. Helens have included lava flows, dacite dome eruptions, tephra eruptions, and pyroclastic flows. Some historic events have been of a "Plinian" nature similar to those at Vesuvius and Karkatoa. Such eruptions are extremely violent and explosive. Other eruptive sequences have been milder and continued over longer time periods.

Risks and Hazard Potential

A 1978 study by Crandell and Mullineaux outlined the hazards of potential eruptions of this volcano. It cited seven phenomena capable of causing loss of life and damage to property: lava flow, domes, tephra, gases, pyroclastic flow, mudflow, and flood. The following descriptions are brief syntheses of the hazards and are based on work by the USGS (Crandell and Mullineaux, 1978).

Lava flows have not been of large magnitudes in past eruptions and do not pose serious threats because they are slow moving and are unlikely to exceed the flanks of the volcano.

Domes, caps of rock formed over the tops of vents, are found both at the top and on the flanks of the volcano. Hazards associated with dome eruptions include lava flow, rock debris, avalanches and showers, explosions of significant force, pyroclastic flow, and mudflow.

Tephra is the term commonly used to describe the fragmented rock material ejected from a volcano, and includes large blocks of material as well as the fine matter sometimes referred to as ash. The effects of tephra fall on property include direct damage from falling fragments, burial, combustion, clogging, abrasion, and corrosion. People are affected by falling fragments, interference with respiration, heat from the materials, and darkness. Ecosystems may be affected by the acidity of the material, the suspension of solids, and by burial.

Volcanoes are capable of emitting a variety of toxic gases including carbon dioxide, carbon monoxide, and compounds of sulfur, chlorine, and nitrogen, which can threaten human life and ecosystems. The hazard of gases from Mount St. Helens is not well known.

Pyroclastic flows, sometimes called "glowing avalanches," are mixtures of hot air, tephra, debris, and gases which combine and flow downslope at high speeds. The chief hazards are the hot, coarse materials at the bottom and the hot toxic gases carried along and emitted from the flow.

Mudflows result from the combination of water and debris, which move down drainage patterns as viscous material. Mudflows have been evident in past eruptions of Mount St. Helens. Potential hazards from these flows include burial and destruction of structures, roads, and bridges; ponding, which causes flooding; the overtopping or destruction of reservoirs; and the threat to human life.

Flooding is caused by snowmelt, ponding or reservoir failure, all a result of volcanic activity. Three river systems flowing away from Mount St. Helens are subject to mudflows and floods. The Toutle River lies to the north and flows westward into the Castle. To the south are the Kalama and Lewis rivers, tributaries of the Columbia. There are three major dams and reservoirs on the Lewis used for hydroelectric power and recreation. While all three rivers are susceptible to flooding, the chief risks are along the Toutle, and from a reservoir failure on the Lewis.

Extent of Risks. Crandell *et al.*, (1979) and Crandell and Mullineaux (1978) have made efforts to estimate the extent of the various hazards and the probabilities of future eruptions. A map, based on historic tephra falls and prevailing wind conditions, has been produced to indicate tephra hazard zones. By studying geological deposits of mudflow and pyroclastic flow, a map of flowing hazards has also been produced. These maps can be found in two publications cited above. They provide the best available estimates of the areas subject to serious threat from a future eruption.

It is more difficult to estimate the likelihood or predict when Mount St. Helens will erupt. Table 1 presents some published estimates of the probability that various events will occur in a given year. Based on past behavior, however, it was predicted in 1975 that Mount St. Helens would likely erupt within the next 100 years and possibly before the end of the century (Crandell *et al.*, 1975).

TABLE 1

ESTIMATES OF PROBABILITIES:
ERUPTIONS IN THE CASCADES

(Estimates are derived from data in Crandell *et al.*, 1979)

Event	Probability
Small eruption in Cascades	.01
Eruption with volume of 2 km^3	.001
Eruption with volume of 710 km^3	.0001 to .00001
Eruption of Mount St. Helens with volume of 1-3 km^3	.0003
Eruption of Mount St. Helens that would dump 6 cm of tephra on Portland	.00001
Eruption of Mount St. Helens that would dump 10 cm of tephra on Yakima	.0001

Land Use, Human Activity and Property Risk. The permanent year-round population is very sparse around Mount St. Helens. The nearest settlement, Cougar, Washington, has a population of 150 and is located about 8 km to the southwest. Other permanent settlements in the vicinity of the volcano include the Mount St. Helens Ranger Station, housing 35 to 45 people, Spirit Lake Lodge, and an undetermined number of privately owned cabins. Farther from the mountain down the forks of the Toutle River are a number of single-family residential homes and cabins. The small town of Toutle is east of Spirit Lake. Population density increases near the town of Castle Rock. Moving from north to east to south one finds no permanent settlements until the town of Randall, 21 km to the northwest. Within the 200-km zone of tephra-fall risk there are many small towns as well as the major urban areas of Seattle-Tacoma and Yakima.

During summer months the number of people near the volcano dramatically increases. They are drawn to the area by opportunities to picnic, camp, hike, boat, fish and hunt. It is estimated that 5 to 10 thousand people engaged in recreational activities could be within the area subject to volcanic risks on any given day during the peak season. It is impossible to give greater detail on the number and locations of the recreational users during the normal time period because of variability induced by season, day of the week, and the hour of the day. Estimates of population at-risk are summarized in Table 2.

THE ERUPTION AND EMERGENCY RESPONSE

A Brief Synopsis of Physical Events

The first precursor to an eruption came on March 20th; a swarm of earthquakes, including a jolt of 4.1 on the Richter Magnitude Scale (R), was registered in the vicinity of Mount St. Helens.* During the next few days many more earthquakes were recorded, prompting additional instrumentation of the mountain and increased monitoring by the scientific community. On March 25th and 26th, a rapid increase in the number of earthquakes of significant magnitudes (3.4 to 4.0R) led volcanologists to believe an eruption was imminent, although the size and nature of it was subject to speculation. The prognosis of an eruption proved correct. On March 27th

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*See Table 3 for a detailed chronology of events.

TABLE 2

EXPOSURE TO RISK

Human use systems	Estimated population and property at risk**	Risk from* Tephra	Pyroclastic and lava flow	Flood and mudflow
Recreational use	1000-10,000			
Spirit Lake	?			
Campgrounds	125+ sites	H	H	H
Cabins	150 cabins	M	H	H
Lodges	3 lodges	M	H	H
Youth camps	4 camps	M	H	H
Day use	?	H	H	H
Swift Reservoir-Pine Creek				
Cabins	250	M	H-V	H-V
Day use	?	H	H-V	H-V
Gifford Pichot National Forest	?	V	V	V
Camping	?	V	V	V
Day use	?	V	V	V
Residential use	?			
Cougar and vicinity	200-250	L	M	M
Kalamar River Valley	250-300	L	N	M
Toutle River Valley	400-500 (?)	L	N	M
Castle Rock	2000	L	N	M
Eastern Washington***	2,000,000+	H-V	N	N
Commercial use	?			
Logging	200-300	M	H-V	L-V
Swift Reservoir	15-20	L	H	H
Hatcheries	?	M	L	H
Forest Ranger Station	35-40	M	H	H

*Relative levels: H-high, M-moderate, L-low, N-none, V-variable w/location.

**Rough estimates, subject to revision.

***Includes all or portions of Lewis, Skamania, Yakima, Kititas, Pierce, and King Counties.

at 12:36 p.m. announced by an explosive boom, steam and ash billowed from the top of the volcano. A second eruption took place the following day, sending plumes of ash 10,000 feet above the volcano. This eruption sent ash avalanches plummeting down the slopes.

The first eruption created a new crater measuring 250 feet in diameter and 150 feet deep. By March 29th a second crater was observed. Earthquake activity and mildly explosive eruptions continued through April 2nd. Strong harmonic tremors on that date signalled the probable movement of magma in the plumbing of the volcano. Such activity continued, and on April 5th three more significant eruptions occurred. The activity of the volcano slackened during the next few days. By April 8th, a single crater, 1,750 feet across and 850 feet deep, had been formed. On that day the volcano erupted for five continuous hours. Thereafter, seismic activity and eruptions diminished in size and frequency. The volcano appeared to have quieted dramatically by April 11th.

Mobilization of Emergency Response*

The earthquake of March 20 prompted the establishment of communication links between the University of Washington seismologists and USGS scientists. These groups, in turn, notified of a future eruption. The initial quake led scientists to begin mobilizing resources needed to study an eruption. The chance of an eruption loomed in the minds of Forest Service personnel, in part because of their experience with Mount Baker, which threatened an

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*This section is based on conversations with public officials and the text of the "Mount St. Helens Contingency Plan," April, 1980.

TABLE 3

THE ERUPTION: SELECTED KEY EVENTS

March 20	Initial earthquake; 4.1R
March 21-24	Increased seismic activity
March 25	10 earthquakes of magnitude 3.4 to 3.8R
March 26	14 earthquakes of magnitude 3.5 to 4.0R
March 27	Initial eruption of steam and ash at 12:36 p.m. 4.5R earthquake at 2:01 p.m. 7,000 ft. plume New crater; 250 ft. diameter, 150 ft. deep Continued seismic activity
March 28	Second eruption at 3:00 a.m. Plumes of 10,000 ft. Ash avalanches Nine earthquakes of magnitude 3.4 to 4.2R
March 29	A second crater formed 13 earthquakes of magnitude 3.3 to 4.4R
March 30	Seven explosive eruptions Mile-high plume Seven earthquakes of magnitude 3.3 to 4.4R
March 31 to April 1	Earthquake frequency declines but magnitudes increase; events of 4.7, 4.5 and 4.6R occur Harmonic tremors first recorded Ash falls in Kelso-Longview Four significant eruptions
April 2	Stronger harmonic tremor Five earthquakes of magnitude 3.5 to 4.7R Twelve more eruptions
April 3	Three earthquakes of magnitude 3.7 to 4.8R Two bursts of harmonic tremor
April 4	Harmonic tremors; two bursts Six earthquakes of magnitude 3.4 to 4.5R

April 5	Single burst of harmonic tremor Eight earthquakes of magnitude 3.4 to 4.7R Three eruptions Plumes of 6,000 ft.
April 6	Harmonic tremor 12 earthquakes of magnitude 3.4 to 4.5R
April 7	Earthquake activity declines
April 8	Single crater; 1,750 ft. across, 850 ft. Five-hour eruption
April 9	Seismic activity decreasing
April 10	Two harmonic tremors
April 11	Dismissed eruptive activity

Compiled from information bulletins issued daily by the USGS.

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eruption in 1975. During the next few days local USFS officials reviewed the Mount Baker contingency plans and reports in an effort to gain information on how to deal with the potential Mount St. Helens eruption.

The first manifestations of an emergency response came on March 25th. The USFS asserted its authority by banning the public from areas above timberline on Mount St. Helens, citing the threat from the earthquake-induced avalanches or landslides. On the same day, the USFS finishes a draft emergency evacuation plan and contacted people they decided were instrumental to the planning process.

By March 25th, the USGS was well along in its mobilization to study the behavior of the volcano. Dr. Donald Mullineaux arrived in Vancouver to meet with USFS and other officials. Other USGS personnel were meeting to plan scientific investigations of the activities. USGS scientists earlier had cited a need to monitor Mount St. Helens when it showed signs of activity, but such plans were never developed.

On Wednesday, March 26th, the seminal planning meeting was held at the U.S. Forest Service headquarters in Vancouver to plan response to what then appeared to be an imminent eruption. At this meeting, attended by about 40 people, discussions were held on air and ground traffic control, crowd control, flooding, the extent of geological hazards, how to develop communication channels, and developing a monitoring and warning procedure. An important result of the meeting was strong leadership capacity and a firm control of the situation by the U.S. Forest Service. The basic structure of the Emergency Coordination Center (ECC) emerged from this session. By this time, a fairly extensive system of informal communication had been established between scientists and key officials in federal, state, and local government.

On the morning of March 27, the USGS, with operations already established in the USFS headquarters in Vancouver, issued a formal hazard alert to state and local officials. At 12:36 p.m. the alert proved prophetic; a loud boom signalled something had happened. About ten minutes later, a news media aircraft confirmed that an eruptive outburst had occurred. This notification sent response procedures into operation. The 24-hour "hot line" communications operations was activited at U.S. Forest Service headquarters. In the field, less than an hour later, the Pine Creek Ranger Station was evacuated. Shortly thereafter, the Cowlitz County Sheriff set up a road block outside Cougar, and the Federal Aviation Administration (FAA) enacted stricter air space closure, having implemented a five-mile closure on the 26th. Residents in the vicinity of the volcano were cautioned again by forest rangers of the hazards and were advised to evacuate.

As the afternoon proceeded, response efforts increased. The Emergency Communications Center gradually took shape. The USFS organized a public information office similar to the one used for forest fires. The radio station was repaired to provide ground-to-ground and ground-to-air communication. By afternoon, the USFS and USGS had observers in a plane normally used in fire operations, transmitting data to Vancouver.

The response efforts, as outlined by key officials, were based on U.S. Forest Service experience with fire fighting. The Forest Service had the physical capability to cope with threat situations and disaster. Its people were accustomed to stress, had emergency facilities in the area, and possessed a mechanism for dealing with the media. The system apparently was transferred in a relatively smooth fashion, given the circumstances. USFS personnel, however, were quick to admit that the eruption imposed much greater pressures than the fire hazard and presented a great deal more uncertainty. Officials candidly admitted they were not well prepared for this novel set of circumstances, but qualified the admission by saying it was not their responsibility to prepare for it. This system shaped the emergency response efforts of the next several weeks.

Organizational Structure of Emergency Response

The structure of emergency response can be viewed formally, as depicted by contingency plans, or as a system defined by interactions and relationships among various organizations. This section describes the formal network and defines organizational responsibilities; a later one will assess informal networks.

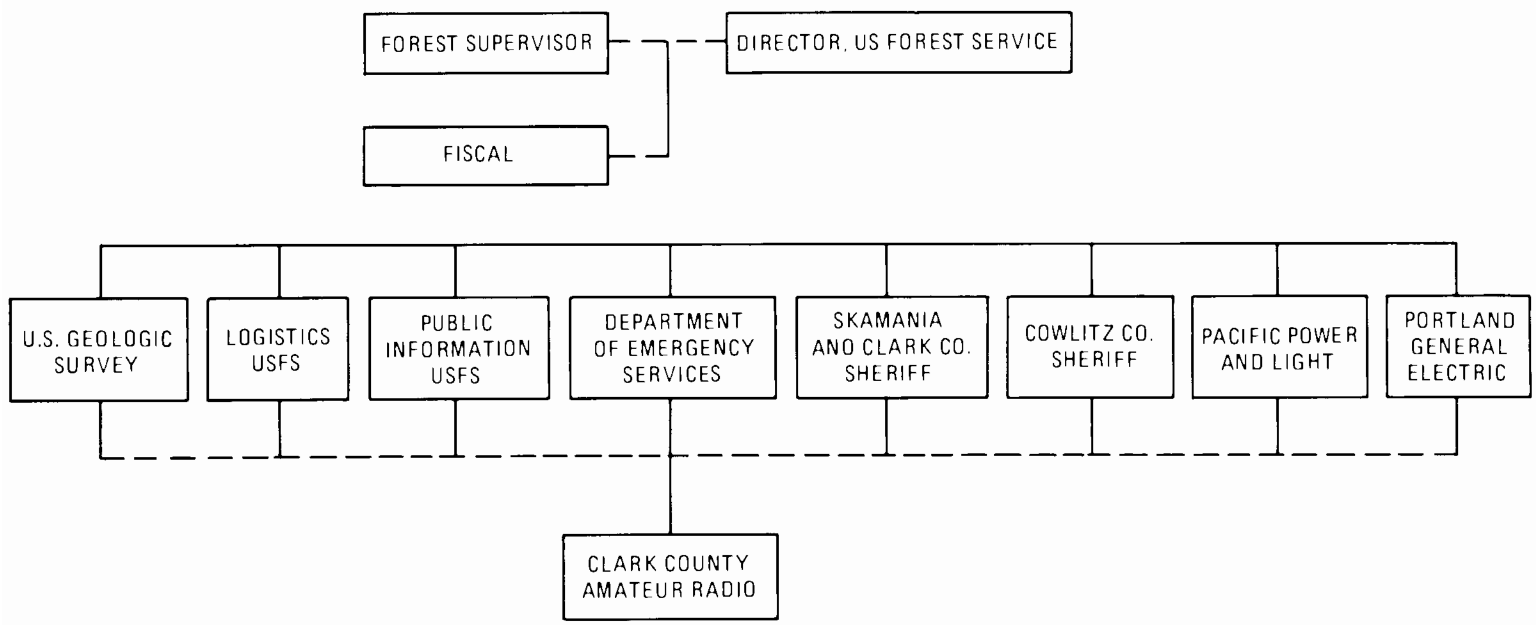
The emergency response network is composed of individuals and oraganizations charged with managing human response to the volcano and with protecting the public from the associated hazards. This covers a wide range of activities and requires participation from a diverse set of actors. Figure 2 depicts the Forest Service's concept of the organizational structure of the ECC, the hub of the response network. The characteristics of the network were decided in several planning meetings attended by representatives of a large number of government organizations and other affected parties.

Under the organizational schematic, the Forest Service was in charge of all activities, at least on a formal basis. The Forest Service also distinguished between various administrative functions and line functions. In fact, little evidence was collected to support the structure of the network described in the diagram. While the groups and organizations listed all participated, their roles and status led to different hierarchies and relationships. Prior to pursuing that idea, a brief identification of responsibilities is useful. The summaries are those used by organizational representatives to describe their functions, not those described by an emergency plan.

One problem in describing responsibilities of organizations in Figure 2 is that often there was a difference between the function of the organization's personnel in the ECC and the function of the organization as a whole in the larger emergency response. Thus, the Washington Department of Emergency Service (DES) had staff members present 24 hours a day, but their prime responsibility was to relay information to the DES office in Olympia.

FIGURE 1

OFFICIAL ORGANIZATIONAL STRUCTURE OF
EMERGENCY RESPONSE EFFORT



The responsibility of ECC organizations were summarized as follows:

U.S. Forest Service. (1) Coordinate and assist in emergency response activities, (2) collect and relay visual data about the eruption, (3) provide facilities, and (4) disseminate information to the public.

U.S. Geological Survey.* (1) Assess the hazard potential of the volcano, (2) predict major eruptions and issue warnings, and (3) disseminate information to the public.

Department of Emergency Services. (1) Act as a liaison between State Government and other parties, and (2) relay information to State agencies.

Cowlitz, Skamania, and Clark County Sheriffs. (1) Relay information between ECC and their people working in the field.

Pacific Power and Light. (1) Work with USGS to ensure safety of Swift Reservoir.

Pacific Gas and Electric. (1) Relay information about volcanic activity to its headquarters and Trojan Nuclear Power Plant.

Clark County Amateur Radio Club. (1) Act as a backup communications link to Olympia DES office, and (2) collect radio reports from people observing the volcano.

In addition, the Washington National Guard maintained personnel at the ECC to relay information to the Washington National Guard command.

Several other organizations had duties outside the ECC and were linked to the Center by communication, personal representation or decision-making authority. Some organizations within the ECC had additional duties

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*Responsibilities concerning emergency response only.

not within the purview of the Center. The duties of organizations acting outside the ECC were:

Federal Aviation Administration. (1) Regulate air traffic in vicinity of Mount St. Helens.

Washington Department of Ecology. (1) Monitor air and water quality, and (2) help assess dam safety.

Washington Department of Safety and Health Services. (1) Monitor safety of food, domestic water supplies, and health effects of air pollutants, and (2) provide assistance to evacuees.

Washington Department of Agriculture. (1) Monitor effects of ash on agricultural activities. (2) monitor dairy and food product safety, and (3) assist agricultural associations to develop emergency plans.

Washington Department of Game. (1) Regulate fishing in the areas at risk, and (2) make decisions about opening reservoirs for fishing.

Washington State Patrol. (1) Control traffic, and (2) assist with road blocks.

Governor's Office. No major responsibilities.

Governor's Watch Committee. (1) Coordinate state response.

Washington National Guard. (1) Assist with road blocks, (2) assist with evacuations, and (3) provide emergency shelter.

Washington Department of Emergency Services. (1) Assist with planning efforts, and (2) coordinate state response.

County Sheriffs. (1) Set up road blocks, (2) assist with evacuation, and (3) control rumors

A survey of these descriptions shows three distinct areas of responsibility. The first is for regulation and decision making, the second covers information transmission and communication, and the third relates to nonemergency support activities. Some organizations such as the Forest Service or the DES have dual responsibilities. Others, as in the case of the Amateur Radio Club, serve a single purpose. These are summarized in Table 4. Of course, the classification represents this author's estimation of roles, and furthermore, these roles may have changed since April 11, 1980. Excluded are the two utility companies, which were responsible for monitoring information and regulating their own facilities in the area.

Power and Decision Making

As the response structure congealed it was obvious that the Forest Service was the lead agency, and its personnel headed the ECC. No one objected; according to other agencies, most were glad the Forest Service assumed the responsibility. The USGS, while commanding great status and authority, appeared to have mainly an information-provision role and attempted to avoid decision making. While their roles differed, these two groups worked closely in making most of the emergency response decisions.

The county sheriffs also seemed to command a significant level of authority and status. In conjunction with the Forest Service, the county sheriff departments took lead roles in the field. They were responsible for carrying out warnings, setting up road blocks, and assisting in evacuation. In the planning meetings that were observed, their contributions to group

TABLE 4

THE REGULATORS AND DECISION MAKERS

U.S. Geological Survey
U.S. Forest Service
Skamania County Sheriff
Cowlitz County Sheriff

THE SUPPORT GROUPS

Washington National Guard
Washington State Patrol
State Departments of
- Ecology
- Game
- Agriculture
- Safety and Health Services
- Emergency Services
- Governor's Office

Federal Aviation Administration

COMMUNICATION GROUPS

U.S. Forest Service
Washington Department of Emergency Services
Sheriffs Offices
Washington National Guard
Clark County Amateur Radio Club

instructions regarding volcanoes. While some respondents said they had thought about developing a written document, more immediate concerns took priority. Reference was made to a "Mount Baker Contingency Plan," but the usefulness of that plan is in doubt. Only one organization, a utility company, presented evidence of a plan to cope with an eruption of Mount St. Helens. In light of the hazard assessment work done by the USGS, the lack of planning must be viewed as a serious oversight on the part of state and local officials.

A similar picture emerges from the more subjective research. To gain a fuller picture of preparedness activities, three questions were asked of response officials. First, how much effort had organizations put into preparedness activities? Second, in light of current missions and activities, how important was it to prepare for an eruption? Third, once the eruption was in progress, how unusual were an organization's responsibilities compared to its normal functions? The results of these questions are presented in Table 5. These responses suggest that:

1. Organizations admitted they had given very little attention to the possibility of a volcanic eruption. Of the two indicating "very great efforts," only one could provide evidence of preparedness planning; the other response was politically motivated or perhaps made in ignorance.
2. The lack of planning can, in part, be explained by how organizations judged the importance of preparedness. Compared to other responsibilities, volcanoes were not a high priority item. Half of the support groups responded that it was very important to prepare,

TABLE 5

PREPAREDNESS

A. Efforts to prepare

	Very great	Some	Not very much	None
Total number of organizations	2	2	2	8
Type				
Emergency response	1	1	0	3
Support	1	1	0	4
Communication	0	0	2	1

B. Importance of preparation

	Very important	Fairly important	Not very important	Not important at all
Total number of organizations	4	1	2	7
Type				
Emergency response	1	1	1	2
Support	3	0	0	3
Communication	0	0	1	2

C. Unusualness of responsibilities*

	None	Some	Alot	Total
Total number of organizations	2	5	5	12
Type				
Emergency response	0	3	1	4
Support	0	1	4	5
Communication	2	1	0	3

*Two organizations did not answer.

while only one of the emergency response groups felt the same way. In general, preparedness was not a salient topic to most who became involved.

3. An alternative explanation for low levels of preparedness is that organizations believed their responses to a volcanic eruption would closely resemble their normal activities, and that planning such a response was thus unnecessary. The results in Table 5 indicate that the duties of seven groups had either "some" or no degree ("none") of unusualness, indicating they could more readily adapt to the new environmental circumstances.

4. Table 6 reveals some correlation between effort and importance. Those who judged it important to prepare were likely to make greater efforts. No obvious relationship exists, however, between effort and the degree to which activities are unusual.

As the eruption progressed, organizations became better prepared to handle its effects. Therefore, another line of questioning was followed to discover how well organizations were prepared to deal with the "worst possible eruption event." Two said they were "very well prepared," four replied that they were "well prepared," four more were "not well prepared," and the others did not know. Thus, by the second week of volcanic activity, uncertainty still existed over how well the emergency managers could respond to a major event.

Perceived Risk

The nature of human response to a hazard is often linked to how people appraise the risks from that hazard (Kates 1962; Burton *et al.*,

TABLE 6

PREPAREDNESS EFFORT COMPARED TO IMPORTANCE OF PREPAREDNESS AND UNUSUALNESS OF RESPONSIBILITIES

Effort	Importance			
	Very	Fairly	Not very	Not at all
Very great	1	1	0	0
Some	2	0	0	0
Not very much	0	0	1	1
None	1	0	1	6
	Unusualness			
	None	Some	Alot	Total
Very great	0	1	0	0
Some	0	1	1	0
Not very much	0	1	0	0
None	1	3	4	0

1978). While risk has many meanings, it is treated here as the likelihood or probability of some specified event. Organizational representatives were asked two questions concerning risks. First, they were asked what they had felt before the eruption was the likelihood that an eruption of Mount St. Helens would take place this year. Second, we inquired about the chance of a damaging eruption now that the volcano was active.

TABLE 7

PERCEPTIONS OF RISK

Likelihood of an eruption this year *	Response	Likelihood of a damaging eruption**
5	No chance (0%)	0
4	Very small chance (1/1000)	2
1	Small chance (1/100)	0
1	Moderate chance (1/20)	1
1	50/50 chance (1/2)	2
0	Certain (100%)	2
2	Don't know	8

* Which of the following statements best reflected your feeling prior to the eruption about the likelihood of an eruption this year?

___There was no chance of an eruption (0%)
___There was a very small chance of an eruption (1/1000)
___There was a small chance of an eruption (1/100)
___There was a moderate chance of an eruption (1/20)
___There was a 50/50 chance of an eruption (1/2)
___An eruption was certain (100%)

** Given your understanding of the situation, what do you feel that the chances are of the eruption causing significant damage to property or threatening life?

___no chance (0%)
___very small chance (1/1000)
___small chance (1/100)
___moderate chance (1/20)
___50/50 chance (1/2)
___certain (100%)

In response to the first question there was a diverse set of replies. The modal belief was that there was no chance of an eruption this year, closely followed by those who believed there was a very small chance (one in one thousand). Only one emergency response official adopted the most accurate scientific response: based on recent historic behavior, the likelihood of an eruption is probably close to 1 in 100 in any given year, according to USGS reports.

When asked to estimate the chance that a damaging eruptive event would occur in the next year given the present nature of the activities, officials had more difficulty responding. The overwhelming majority replied "don't know."

Several inferences can be drawn from these responses. First, they support the idea that officials did not perceive that an eruption was likely or possible. This is not necessarily a risk-denial phenomena; it accurately reflects the recent history of volcanic activity. Second, it is interesting to note the difficulty officials had ascribing a qualitative or quantitative judgement of probability to a damaging eruption. This reflects the high level of uncertainity about future behavior of the volcano. People simply did not possess the understanding to make judgements. Furthermore, it reflects the USGS policy not to state anything unless it is confident of its accuracy. This USGS position can be attributed in,part, to recent experiences with Mount Baker and Mauna Loa, Hawaii, in which USGS predictions were misinterpreted or the predicted event did not occur.

Information Flow

The exchange of information, or the communication process, is critical to any emergency operation. Prior to the eruption, no plans specified the structure of that system: it evolved during the first week of the experience. It is important to examine information flow because it reflects aspects of status and power in the response effort and, because as a result of its structure, biases or constraints may be introduced into warning procedures or other response efforts.

The structure of the communications network is fairly complex. Figure 2 depicts the information flow among response organizations. It is based on data collected from the organizations and represents each group's view of the network. Arrows indicate the chief direction of the flow. No attempt has been made to represent the frequency of communication because it varied considerably over time.

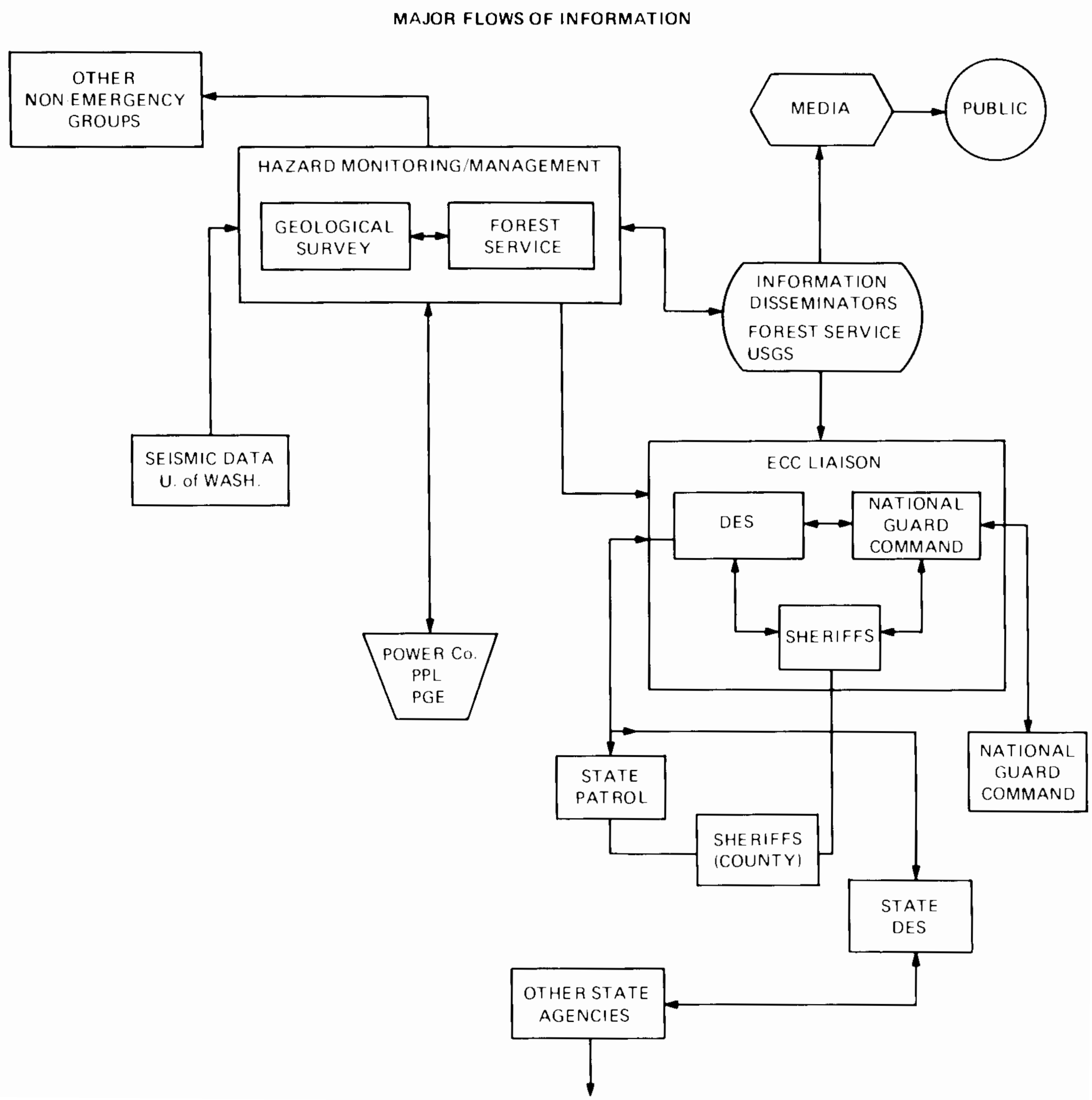
Several distinctive features characterize the network. Within it there existed a distinct segregation of federal and state/local organizations. This reflects the fact that response efforts were dominated by a federal agency. As a result, state groups such as DES were confined to a minimal role because they lacked status and important information.

Second, some organizations were as many as four links removed from the prime information generators. As a result, some respondents said they received better information sooner from media reports than through official channels. As the number of network links increase, the potential for receiving inaccurate information also rises.

Third, much of the communication was one-directional. Information was passed or received, but two-way communication was minimum in many cases.

FIGURE 2

COMMUNICATION NETWORK



For example, this author observed as a report of massive mudslides came into the DES office in Olympia. Because of the network structure, DES was unable to confirm the report's validity. This, however, is in sharp contrast to the communication between the Forest Service and the U.S. Geological Survey.

Another, perhaps more speculative, observation was that information seemed to be used as a device to maintain control over emergency management activities. Whether this was done unwittingly is unclear. One major category of information disseminated to organizations by the Forest Service was raw data, labeled "situation updates," which reported aerial observations of the volcano's behavior.

A sample of this log appears in Table 8. Response officials took it upon themselves to interpret the data and to use it to make inferences about the future behavior of the volcano. This kept people busy, it made them feel important, and it enabled the Forest Service to maintain tighter control in a situation where others were seeking to gain greater responsibilities. Thus, information was a pacifier.

This was recognized by other organizations. Many said the chief problem they faced regarding information was that they did not get much explanation about what was taking place. As one person phrased it, "We could use less information and more interpretation." Similar was the cited need for more information on the physical processes in progress and the nature of the risks.

TABLE 8

EXAMPLE OF FOREST SERVICE RAW DATA LOG

Date/title 4-8-80	Number	Who	Radio transmission
1003	1125	25G	Picking up intensity a bit--10,500: heavy with ash.
1006	1126	25G	Intensity decreasing--picking up again at summit.
1010	1127	25G	Intensity died down for about 1-1/2 minutes, then increased again.
1012	1128	25G	Heavy with ash.
1014	1129	25G	Intensity died down a bit, then picked back up.
1015	1130	25G	Back to vapor only, no ash. Going over top of mountain, still venting a little.
1016	1131	25G	Picking up intensity again. Can only see base of colum 20% of the time. Intensity increasing again. Mostly vapor but some ash mixed in.

Rumor

Most disaster or threat situations spawn rumors and Mount St. Helens proved no exception. The number of rumors and the degree to which they were problems were minor, however. Most of the organizations interviewed stated that they had to deal with rumors. A few stated that rumors were a constant problem.

The rumors which caused the most problems probably were false reports that the volcano was erupting and producing mudflows. Other rumors centered on inaccurate pictures of damage, dam cracking, and radioactive emissions.

Images of Catastrophic Events

At the time of this study there was much speculation about what would or could happen. Other studies have suggested that people's images of loss or disaster play a significant role in shaping response (National Academy of Sciences, 1979). In the case of Mount St. Helens, we felt that the images public officials had concerning the worst possible event or catastrophic event may have affected their emergency response efforts. Consequently, officials were asked to describe what they thought was the worst set of circumstances that could develop.

The nature of the eruption. Five of the fourteen organizational representatives could not describe the worst eruption that could take place. They did not possess the expertise or background to create a mental image of a catastrophic eruption. The remaining responses were, for the most part, equally vague. Eight described the eruption in terms of an associated hazard: three mentioned large ash falls, two a mudflow, one a pyroclastic flow, and two a combination of events. It was evident that emergency response officials had a poor understanding of what could happen. This, in part, can be linked with their feelings that they were not getting enough information on geological processes associated with this volcano.

Images of consequences. Officials, surprisingly, were even less adept at expressing images of the consequences of the worst eruption. Half of them did not express anything. Two said fatalities would occur. Several others thought ash fall on Portland would be the most severe consequence, and one person said the same for western Washington. Two defined consequences in light of a large population of tourists and recreational users in the area. At this time no one had developed, either mentally or on paper, alternative scenarios describing the possible impact of a major eruption.

Judged seriousness of hazard. Another method of discovering officials' images of catastrophic eruption is to measure the level of threat they ascribe to various volcanic hazards. Specifically, they were asked to judge the seriousness of the risks from floods, ash, lava flow, and mudflow. An open category allowed them to specify other hazards they felt to be significant. A distinction was made between risks to property and to human life.

Officials felt flooding created the most serious risks to property and human life, followed by mudflow hazard (Table 9). Lava flow was not viewed as a significant hazard. Ash fall was regarded as a more serious

TABLE 9

OFFICIALS' PERCEPTIONS OF RISKS FROM VOLCANIC HAZARDS

Threats	Floods	Ash	Hazard lava	Mudflow	Other Pyroclastic flow
Risk to property					
Quite serious	8	3	3	6	2
Fairly serious		3		1	
Not very serious		2	2	1	1
Not serious at all	1	1	4		
Don't know/ no mention	5	5	5	6	11
Risk to life					
Quite serious	7	5	2	5	4
Fairly serious	2	2		2	
Not very serious	1	1	3	2	
Not serious at all		1	5	1	
Don't know/ no mention	4	5	4	4	10

threat to life than property. While not specifically listed, several officials cited pyroclastic flows as a serious hazard.

Beyond the mention of floods, there was great diversity in the evaluations. Officials did not agree on the level of risk. This could be attributed to differing understanding of the hazard, receipt of varied information, or different interpretations of what constitutes a risk or threat.

A large percentage of the respondents were unable to evaluate the hazards, indicating they possessed little understanding of the volcanic activity and related threats.

Risk Evaluation Processes

The process by which emergency response officials evaluate the risks from a hazard and use that evaluation in making management decisions has been difficult to assess. In an attempt to gain insight into that process, officials were asked, "If the eruption becomes more serious, how will you know the point at which the risks justified a more intense or different emergency response?" and, "What factors of people and information will you rely on to make such an assessment of the situation?"

As suspected, most officials stated that they would rely on the USGS to tell them the point at which the risks changed to warrant a change in activities. Four officials without geological backgrounds indicated they would make their own assessments. Each cited different criteria for arriving at an evaluation of the risks. One said the frequency of earthquakes would indicate the level of risk, while a second referred to the Richter magnitude of the quakes. The third felt that an increase in the intensity or volume of ejected gases was the key factor in deciding to change response patterns. Finally, the presence of magma as measured by harmonic tremor was cited. A few officials flatly admitted they had no idea how to evaluate risks from the volcano. Response to the second question was nearly unanimous: officials would rely solely on the USGS to make assessments of the situation.

MANAGEMENT PROBLEMS AND ISSUES

Public Access and Evacuation

A problem that first surfaced before the eruption was how to decide who could go where in the vicinity of the volcano. Many people desiring access for various purposes were affected. These included permanent residents, cabin owners, reporters, loggers, sightseers, scientists and recreational users.

Initial evacuation was not a major problem, with one exception. Harry Truman, the celebrated old-timer and owner/resident of Spirit Lake Lodge, refused to move. Initially, most people within a 10-mile radius of the volcano were told to leave, but it is difficult to estimate how many this included. A current study to assess evacuation should answer many questions concerning this aspect of the response effort.

The first decisions to control public access were made on March 25th, 1980 when the Forest Service issued an order closing all lands above timber line to public use. People were still allowed near the volcano, but were required to sign a waiver to gain access to the Spirit Lake area. A day later another pre-eruption restriction was put into force when the FAA banned all unauthorized air traffic from a 5-mile radius in an attempt to limit the number of planes coming in for a close look. Since there were no visible signs of volcanic activity, however, little was done to keep people away.

The March 27th eruption changed that stance quickly. On that day the USFS suspended all logging operations near the volcano. This action suddenly deprived several hundred loggers of their jobs and represented a loss of income for the logging companies.

Stricter restrictions on the general public and potential recreationists were also imposed. The considerations on which they were based included the hazards of mudflows in the Toutle and Lewis River Basins and of pyroclastic flows in the Spirit Lake and Swift Reservoir areas.

Air traffic restrictions were tightened as well. Traffic was banned 10 miles west and 20 miles east of a line running north and south through Mount St. Helens, and to an elevation of 60,000 feet. The FAA and Forest Service coordinated the restrictions, allowing exceptions for certain approved functions. Air traffic restrictions were risk/cost tradeoffs. The Forest Service at one point wanted to expand the zone from 10 to 20 miles west. The FAA, however, felt that the costs and disruption to commercial aircraft flying in and out of Portland would be too severe, particularly if the volcanic activity persisted. Thus economic considerations took precedence over safety.

News media reporters and personnel also converged on the area, but were more a nuisance than a serious problem. Despite efforts to keep them at bay along with others with nonofficial functions, some got past road blocks.

At the time of year these events were occurring, demand for recreational access was not great and was not a major problem. Public officials, however, were cognizant of problems that could occur once the snow melted. An "airtight" seal on the area was impossible because of the extensive network of logging roads. Furthermore, trout season would begin April 20, bringing a large number of anglers to the streams, lakes, and reservoirs in the vicinity.

During the week of April 6, much attention was given to the question of opening Swift Reservoir on the Lewis River for fishing. The risks of potential mudflows and pyroclastic flows were determined to be too great to allow public use of the area, however, especially since fishing opportunity existed elsewhere.

By the second week after the initial eruption, logging access became a significant issue. Were the benefits of the logging effort worth the risks? What levels of risks were acceptable to the loggers? The logging companies answered the first question with an emphatic yes. Public officials, at first acting as though they were responsible for making this determination, gradually shifted to a position of compromise. USGS personnel outlined the various risks from the volcano to the loggers. Eventually, an agreement was reached to allow the companies access to less hazardous areas, but only after they acknowledged full responsibility for the possible consequences. Employees of the logging firms were allowed to decide whether they would risk working near the volcano. The final outcome represented a decision to balance economic considerations with the risks and uncertainties of an eruption.

Road Blocks

A concern closely tied to public access was the placement of and responsibilities for road blocks. These devices were the chief means of regulating the flow of people into hazardous areas. Three types of road blocks were used: unmanned ones which served to warn and discourage access, manned road blocks to allow selective access, and locked gates which prevented vehicular access.

During the study period both the positioning of the road blocks and their nature seemed to change rapidly in response to a variety of concerns. Table 10 and Figure 3 portray the dynamic nature of this management concern through April 10, 1980. The reasons for changing road block locations were varied. For example, on Highway 504 running from Castle Rock up to the North Toutle River Basin to Spirit Lake, a road block was established at Camp Baker prior to the eruption to advise motorists to stay away from Spirit Lake. On the 27th, it was moved to the county line, apparently so it could be staffed by personnel from both Cowlitz and Skamania County. After the eruption, because of greater risks, it was moved back to ten miles west of the county line. Pressure by loggers later forced another move to Camp Baker. Finally, because of the crowds of sightseers lining the road, it was moved west to the junction of 504 and 505.

On the south side similar movement of road blocks occurred. A major change from east of Cougar to the west side was made because of concern by residents that they would have difficulty evacuating on a crowded road. This new location angered Cougar business persons and because it was decided that Cougar was not subject to severe hazard, the road block was moved back.

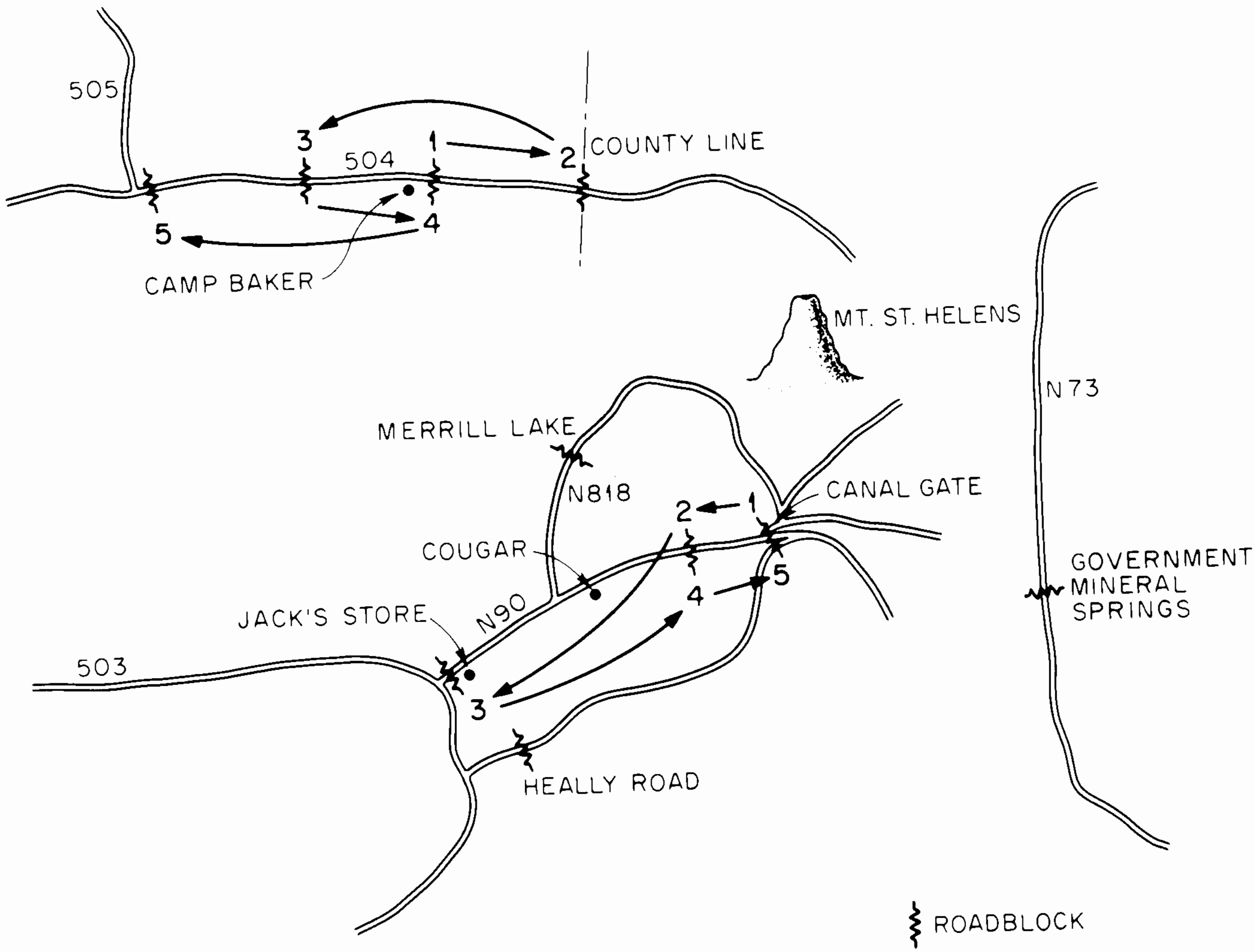
TABLE 10

ROAD BLOCKS

Road	Date	Location	Type
504/1	3/25	Camp Baker	Advisory only
2	3/27	County line	Manned by county
3	3/27	10 miles west of county line	Manned by county
4	3/28	Camp Baker	Manned by county
5	4/4	Junction W/505	Manned by state
503/1	3/25	Swift Reservoir Gate	Unmanned
N90 2	3/27	3 miles above Cougar	Manned by county
3	4/5	Jack's Stove west of Cougar	Manned by National Guard
4	3/8	3 miles above Cougar	Manned by sherif
5	3/10	Swift Reservoir Gate	
N818	3/28	Merril Lake	Manned
N73	3/28	Government Mineral Springs	Manned
Heally Road	3/28	West of Chelutchie	Manned

FIGURE 3

SCHEMATIC OF ROAD BLOCK LOCATIONS AND SHIFTS



Road blocks did not serve to keep all out; those who worked, were residents, owned cabins, or were part of the emergency response efforts in restricted areas were allowed to pass. Such individuals were required to sign waivers, although these were legally meaningless because in Washington one cannot sign away the right to litigate.

Maintenance of staffed road blocks proved to be a difficult problem. At first, sheriff's departments were providing personnel for the road blocks, and this was straining their financial resources. On April 3rd, the governor signed an emergency declaration providing National Guard and state patrol assistance for this task. However, the road blocks, and especially how to pay for them, remained a topic of debate in planning meetings.

Dams and Reservoirs

A significant management issue concerned Swift and other reservoirs on the Lewis River. Operated by Pacific Power and Light, they provide power for the Portland area and are popular recreation sites. Swift, the dam and reservoir closest to Mount St. Helens, is subject to mudflows and pyroclastic flows. Such flows into the reservoir could result in dam failure or overflow. The failure of Swift could result in the failures of the other two reservoirs, and catastrophic flooding would occur. These risks and consequences were well known to company officials prior to the eruption.

From a geological viewpoint, scientists had earlier estimated that the largest possible mudflow into the reservoir would have a volume of 100,000 acre feet (Crandall and Mullineaux, 1978). Swift has a storage capacity of 756,000 acre feet, with a nonuseable base of 310 acre feet. Scientists suggested that a 100,000 acre feet drawdown would "provide reasonable assurance against overtopping and failure" (Crandall and Mullineaux, 1978). At the time of the eruption, the reservoir was already down 125,000 acre feet, and further lowering was not needed. However, with spring runoff starting, the amount of water to be retained was a problem. Once passed through the system, it could not be recovered. Water not stored in the spring means less electrical power in the winter. Thus, a tradeoff existed between the value of the electricity plus the potential costs of a brownout induced by the shortage, and the risk and costs of a dam failure. At the time this study was done, Pacific Power and Light officials had decided to allocate 100,000 acre feet of storage in Swift to the volcano and fill the other two to capacity. As far as is known, no formal studies were undertaken to determine from a social and economic view the optimal solution.

Government Responsibility and Liability

Much of the uncertainty which shrouded emergency response efforts can be attributed to three factors. First, due to the lack of pre-eruption planning and experience, no agency had a clear idea about which aspects of emergency response were its responsibility. New mechanisms had to be created to cope with new and different environmental threats. Second, public officials were unsure, at times, of their legal authority. Did they have police powers to restrict access? To whom should they turn for authority to spend money or permission to act? The state emergency declaration was delayed because local entities did not know the proper procedures to set that mechanism in motion. Third, confusion resulted from the question of legal responsibility of the government to safeguard public welfare. Officials were uncertain if they could be held responsible for losses, injuries, or deaths resulting from their decisions to allow public access. This was manifest in the liberal use of waivers to allow people with legitimate reasons into restricted areas.

Financing. Perhaps the foremost issue during the initial period of emergency action was money. Disaster-response mechanisms are not designed for volcanic situations. They are honed to provide relief from damages, not potential but uncertain risks spread over time and a large geographic area. This meant that organizations could rely only on their existing financial resources, which were not adequate to fund the necessary response activities. Furthermore, there were few avenues open to obtain additional financing or assistance.

At the local level, the county sheriffs quickly spent their emergency funds for overtime pay to staff the road blocks. A rough estimate was that the road blocks were costing Cowlitz and Skamania County governments a total of $3,500 a day to operate. Each had only $10,000 to $12,000 allocated for such emergencies.

The financial strain on the other organizations was less severe, although significant. The USGS was rapidly expending its field study budget. The Forest Service estimated the eruption was costing it roughly $20,000 per day. In addition, other normal work activities were abandoned, resulting in nonquantifiable costs. While it is nearly impossible to sort out the total value of the efforts and expenses associated with the eruption, an estimate of $50,000 to $70,000 a day over this period is reasonable.

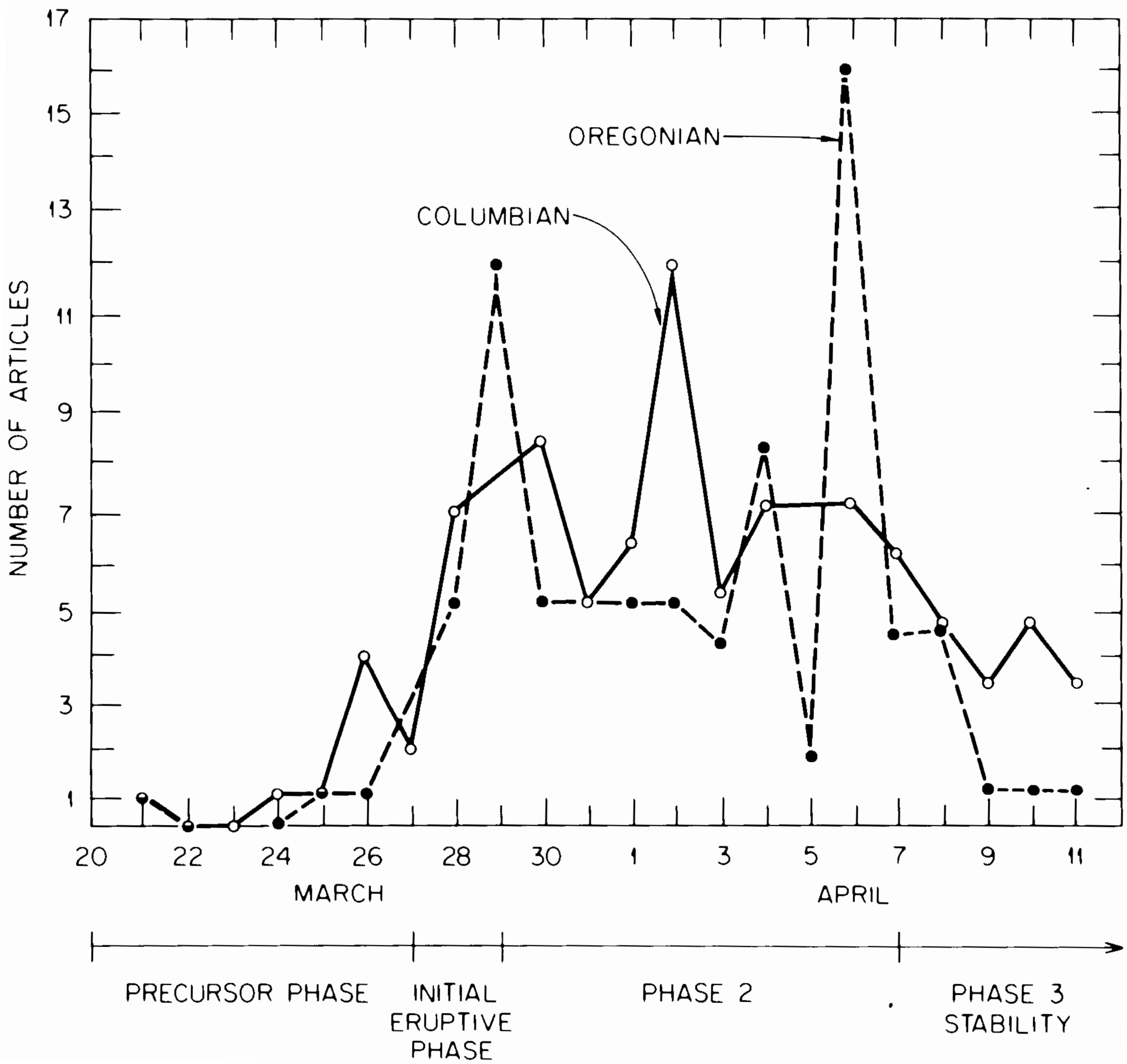
Media coverage and information flow. A newspaper headline that stated, "We're pulling for Mt. St. Helens," typifies the basic problems with media coverage. Many of the officials we talked to felt the newspapers and radio and television stations, while not deliberately warping the facts, portrayed the situation in a manner which did not facilitate emergency response efforts. As another article stated, the eruption was the biggest media event in the history of the area. The initial coverage was intensive and informative. As the activity persisted, coverage increased. One indicator of the level of media attention given to the eruption is the number of articles which appeared in newspapers (Figure 4). There was a rapid increase in attention following the eruption, with a quick drop after April 6th. It is interesting to note that the level of coverage varied with the physical phases of the eruption demarcated by the USGS.

However, many officials felt the media were dwelling on the sensational aspects of the event and not the important ones. Several officials complained that the media were irresponsible in their failure to publish preparedness information. Indeed, when the USGS published a list of "how to respond" items, the media treated it with sarcasm and ridicule.

Further complaints were that the media, by emphasizing certain aspects of the situation, were distorting scientific and social realities. For example, it appears that if reports did not get colorful or speculative responses from sources such as the Geological Survey, they turned to scientists less cautious in offering explanations. Some of the media

FIGURE 4

LEVEL OF COVERAGE IN TWO AREA NEWSPAPERS



played certain experts against others in seeking predictions when forecasts were impossible and uncertainties associated with the volcano too great to make definitive statements.

These contentions by officials are supported by an examination of newspaper coverage of the situation. A general analysis of 90 articles printed between March 21st and April 11th in one of the major papers in the area reveals little attention given to warning, preparedness or precautionary measures (Figure 5). People converging on the area to watch or those staying despite the risk received much attention. Not shown in the figure, but important to note, was that many of the other articles were straightforward accounts of the events taking place and the potential hazards associated with an eruption.

An attempt was made to assess how the risks from various hazards were portrayed. It was found that some articles emphasized the risks and discussed the potential impacts, while others stressed safety or deemphasized risk (Figure 6). Tephra and mudflow received the most attention, although three of the eight articles with significant discussion of ash or tephra stressed it would not be harmful. Based on the information in this figure, tephra, pyroclastic flow, flood, mudflow, and avalanche were portrayed as significant hazards. Earthquakes, lava, and a major eruption were deemphasized in the coverage.

Newspaper coverage concerning the future behavior of the volcano was also examined. Lead articles were classified according to whether they stated or implied that eruptions were more likely or likely to increase in frequency and magnitude or less likely or decreasing in frequency and magnitude. Second, an assessment was made of the portrayal at the uncertainty of the behavior (Figure 7). Here, published information varied

FIGURE 5

NEWSPAPER COVERAGE OF HUMAN RESPONSE THEMES
(Source: Columbian and Oregonian, March 21 to April 11, 1980)

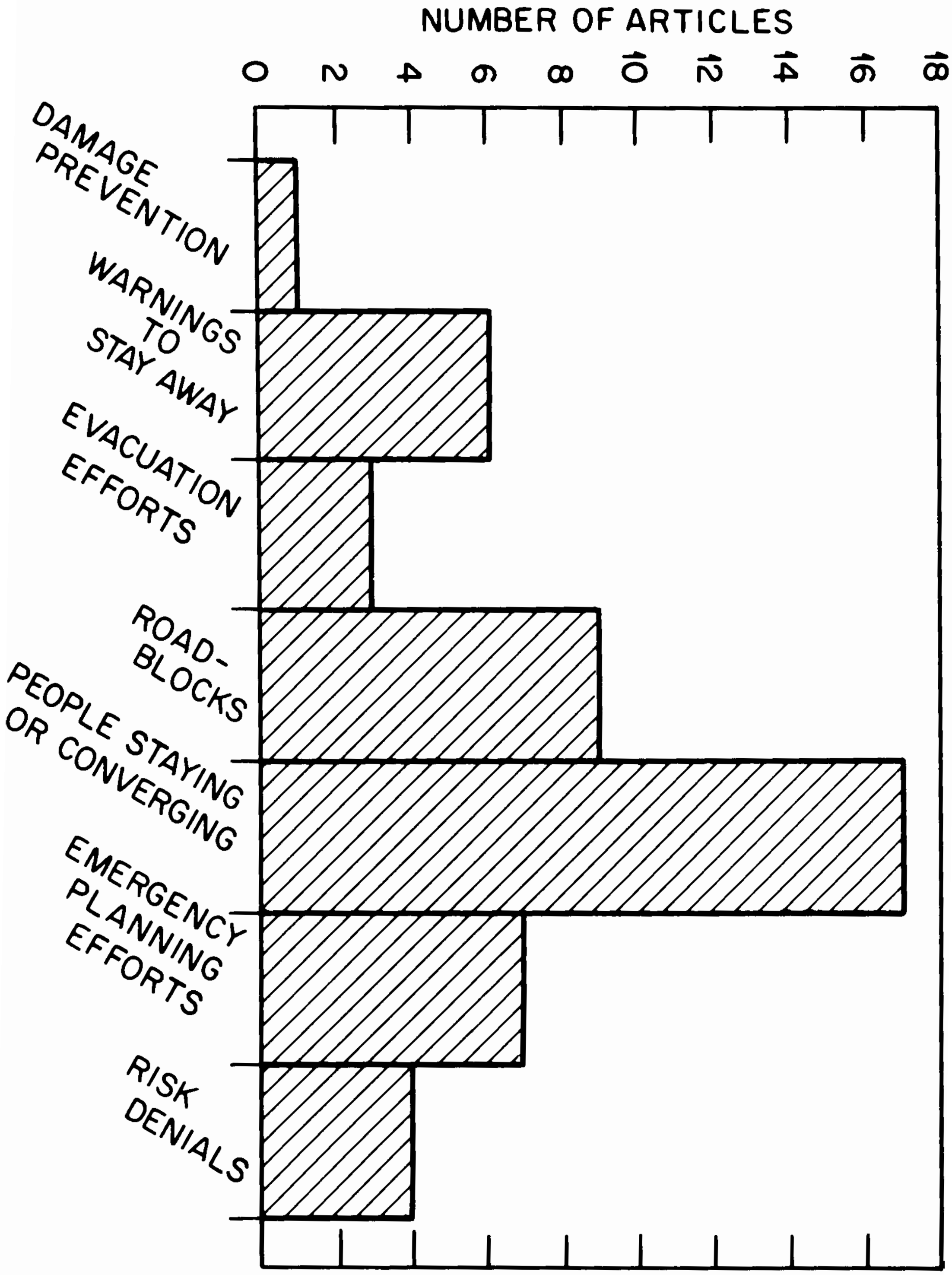


FIGURE 6

NEWSPAPER PORTRAYAL OF VOLCANIC HAZARDS
(Source: Columbian and Oregonian, March 21 to April 11, 1980)

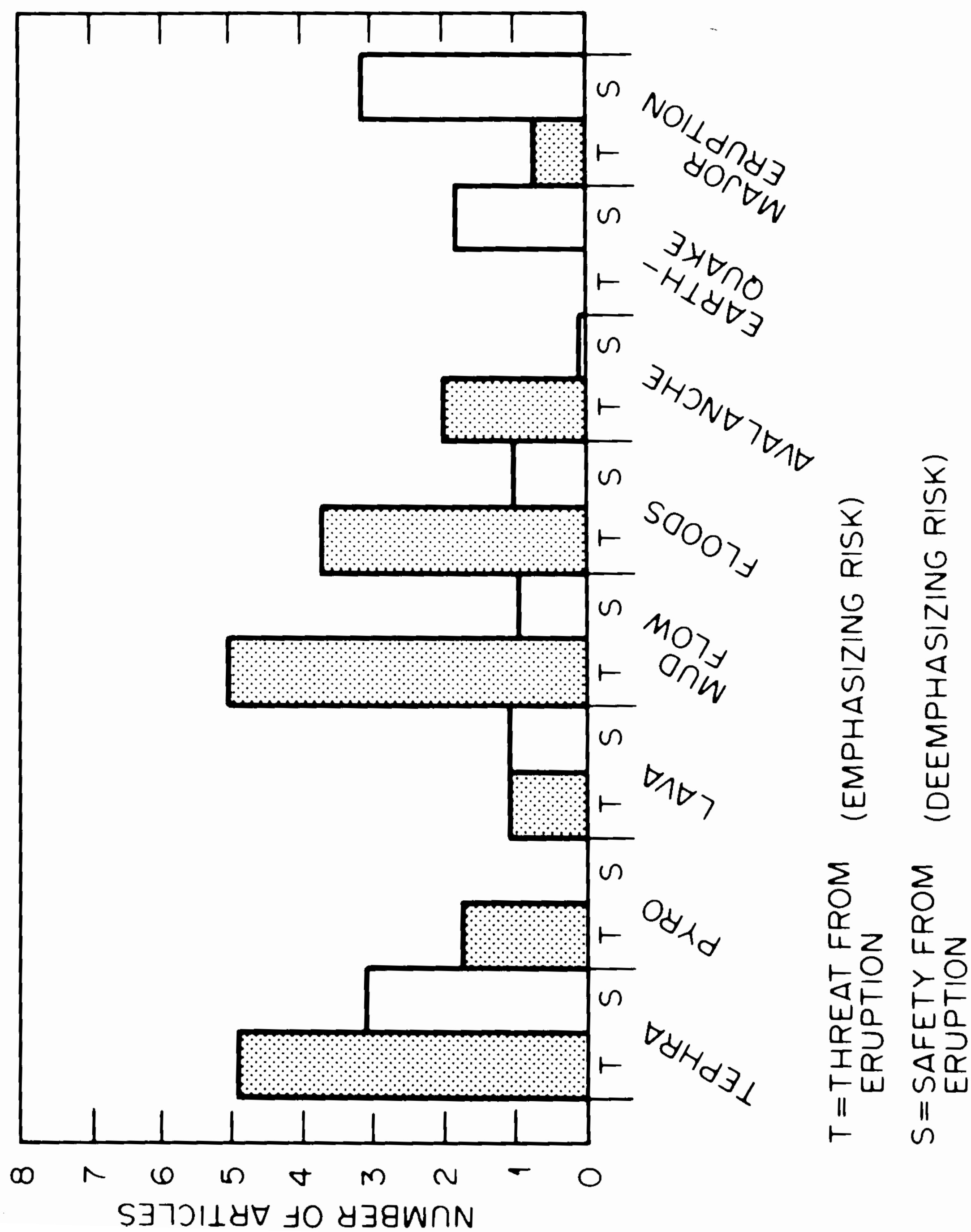
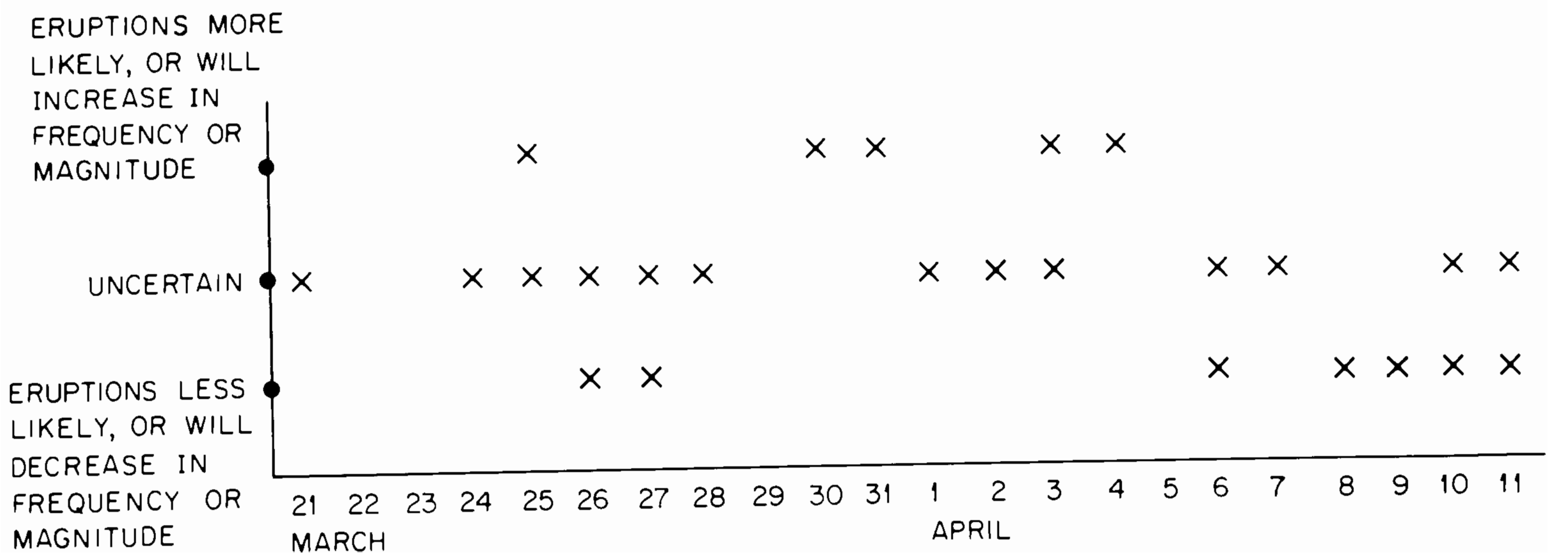


FIGURE 7

NEWSPAPER PORTRAYAL OF FUTURE BEHAVIOR OF THE VOLCANO
(Source: Columbian and Oregonian)



over what was going to happen and how certain the experts were that the volcano would behave as predicted. This helps to illustrate the lack of consistency in the warning efforts and the confusion over future events that come from changing views of the eruption potential.

PERCEPTIONS AND ATTITUDES OF PEOPLE IN COUGAR AND VICINITY

A quick assessment of public perceptions and attitudes was desirable. Since a systematic telephone survey of residents of towns on the Lewis River and in the Longview/Kelso area was already underway (Greene et al., 1980), an attempt was made to interview people who had converged near the mountain to assess public perceptions and attitudes. One hundred twenty interviews were administered on April 12, 70 in Cougar and 50 at the public view point at Yale Reservoir. In Cougar, the questionnaires were used outside three major businesses which served as focal points of social interaction for residents and visitors. Since a random sampling procedure was impossible, every person in the area was interviewed (given the constraints of time and personnel) until a quota was reached. At Yale Reservoir, one person from approximately every fifth vehicle was interviewed. Thus, the sample is felt to be a reasonable representation of the population visible and accessible in that area at that time.

Of the 70 people interviewed in Cougar, 25 were residents, property owners, or workers in the vicinity. The rest were visitors. All of the 50 subjects at the Yale site were visitors. Thus, there is some basis for comparing people with ties to the area with those converging for other reasons. In the course of interviewing only three potential subjects refused to respond to the questionnaire, yielding a completion rate of 98%.

Questions were posed in three subject areas: perception of risks, evaluation of emergency response, and individual risk taking.

Perception of Risk

A primary interest was to gain a better understanding of how people viewed the volcano as a potential hazard. We asked respondents whether they wanted the volcano to have a major eruption, or a continuing series of small eruptions, or a ceasing of eruptive activity. Almost half (49%) indicated they wished to see the volcano undergo a major eruption. An additional 34% expressed a desire for more minor activity. When transients are compared to those with ties to the area (locals) a notable difference is observed (Table 11). Over half the locals desired the volcano to return to dormancy versus 6% of the other population. This reflects the glorification of the volcano as a media event or form of entertainment. It also indicates that many people have weak or inaccurate cognitive images of the consequences of a major eruption.

TABLE 11

PUBLIC PREFERENCES FOR ALTERNATIVE ERUPTION STATES

	Major eruption	More small eruptions	Stop erupting	Totals
Local ties (% of subgroup)	16%	28%	56%	100% (n=25)
Non-local (% of subgroup)	58%	36%	6%	100% (n=95)
Total (% of sample)	49%	34%	17%	100% (n=120)

Another method of measuring perception of risk was to ask people to judge the relative levels of threat to which they were exposed (Table 12). Results show that local and nonlocal people expressed their cognition of risk levels in similar terms. Both groups were skewed toward believing the threat was relatively low at their location when interviewed.

TABLE 12

PERCEIVED THREAT TO PERSONAL SAFETY

	Very high risk	High risk	Moderate risk	Low risk	Very low risk	Total
Local	4%	8%	16%	44%	28%	n=25
Non-local	3%	12%	22%	27%	37%	n=95
Total	3%	11%	21%	31%	35%	n=120

Finally, treating risk as probability, people were asked to make subjective estimates of the likelihood of a damaging eruption. As shown in Table 13, people avoided extremes. Only a few said it would not happen, and no one said it was certain. Many (33%) indicated that a damaging eruption had a moderate or a 50/50 (32%) chance of occurring, while fewer sided with the estimates of lower probabilities. No significant trend in differences between the two groups can be detected.

Evaluation of Emergency Response

The survey also attempted to measure attitudes toward and evaluations

TABLE 13

LIKELIHOOD OF A DAMAGING ERUPTION

	No chance 0	Very small chance 1/1,000	Small chance 1/100	Moderate chance 1/20	50/50 chance 1/2	Certain 1/1
Local	0%	20%	12%	36%	32%	0
Non-local	2%	12%	22%	32%	32%	0
Totals	2%	14%	20%	33%	32%	0

of emergency response efforts and issues. Four items on the questionnaire sought information on this subject. First, people were asked to appraise the overall performance of public officials in handling the situation. Second, evaluations of the amount and perceived accuracy of news media coverage were elicited. Third, in response to an alleged problem, people were asked if they felt scientists were releasing all their information on the eruption to the public. Finally, people were asked their opinions on public access to the volcano and their willingness to enter restricted areas if road blocks were removed.

In general, the evaluation of the performance by public officials was favorable (Table 14). Over 60% felt the officials were doing a "good" or "very good" job. Few evaluated their performance as poor. The local group made a slightly more favorable evaluation than the visitors.

Scientists also fared well in the valuations. People interviewed were not skeptical about release of information by the scientific community (Table 15). Only a few (16%) felt that scientists were withholding information about Mount St. Helens.

TABLE 14

EVALUATION OF PERFORMANCE BY PUBLIC OFFICIALS

	Very good job	Good job	Average job	Poor job	Very poor job
Local	24%	48%	20%	8%	0%
Non-local	27%	30%	30%	9%	4%
Total	27%	34%	28%	9%	3%

TABLE 15

FREQUENCY OF SCIENTISTS MAKING ALL INFORMATION PUBLIC

	Always	Most of the time	Sometimes	Rarely
Local	20%	56%	16%	8%
Non-local	23%	62%	13%	2%
Total	23%	61%	13%	3%

The media also received high marks on quantity and quality of coverage (Table 16). The vast amount of coverage was welcomed by an information-hungry public. Most also believed what they heard or read.

Finally, it was apparent that a sizeable portion of the sample (58%) disagreed with the government policy of road blocks and restricted access. Many of them (45%) also expressed a willingness to go nearer the volcano if given the chance (Table 17). Field observations confirmed that some

TABLE 16

NEWSPAPER COVERAGE: AMOUNT AND ACCURACY

	Too much	About right	Too little	Totals
Very accurate	3%	29%	1%	33%
Somewhat accurate	9%	35%	5%	49%
Somewhat inaccurate	7%	8%	2%	17%
Very inaccurate	0	0	1%	1%
Totals	19%	72%	9%	100%

did. Road blocks were circumvented by those willing to explore the network of logging roads which laced the countryside.

TABLE 17

PUBLIC RIGHTS TO ACCESS

Willing to go beyond road blocks	Yes	No	Total
Yes	45%	13%	59%
No	13%	29%	41%
Total	58%	42%	100%

CONCLUSIONS

Initial analysis of the data leads to the following conclusions and observations.

1. The U.S. Forest Service's strong response to the impending eruption facilitated a coordinated response and reduced confusion.
2. Most local and state agencies and organizations were poorly prepared to respond to the eruption despite USGS hazard studies which had suggested an eruption was likely.
3. The State of Washington Department of Emergency Services did not play a major role in the initial response effort.
4. Since the volcano threatened many political divisions, coordinated response was hampered by jurisdictional problems and conflicts.
5. As the situation developed, more organizations attempted to become involved and competition for authority became more pronounced.
6. Much of the communication was unidirectional.
7. Many public officials felt that they were not getting enough interpretive analysis of what was taking place with respect to the eruption.
8. Local efforts to respond were hampered by the lack of definitive and understandable risk information.
9. Rumor was not a major problem.
10. Response officials had weakly defined images of the nature of a catastrophic eruption and its consequences.
11. Decisions over emergency response issues were made by a rough benefit/risk analysis. Risks were balanced against the costs of an action.

12. Major issues at the time included public and commercial access, road block placement, financing response activities, dam and reservoir safety, government responsibility and liability, media coverage, and information flow and warning.

The response to the volcanic activity of Mount St. Helens illustrates the difficulty of managing rare events which are not certain to occur and which have uncertain potential impacts. Social mechanisms were slow to respond, even after the initial seismic activity and subsequent eruption signalled higher probabilities of activity, and despite the fact that the public became aware that scientists were not surprised by the awakening of the volcano. In time, however, emergency management mechanisms developed and were, for the most part, effective in minimizing public risks of damage or death. The experience gained in the non-disaster phase of the eruption was instrumental in preparing officials and some of the public for the major eruption on May 18, 1980. Had that same eruption taken place earlier much greater damage and more deaths probably would have occurred. Whether the eruption of Mount St. Helens will be a unique event in the annals of hazard management in the United States remains unclear. Its lessons should prove valuable in the management of other hazards.

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