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CDC--MOUNT ST. HELENS VOLCANO HEALTH REPORT #23 February 23, 1981

Mount St. Helens: Effects and Implications

With the reawakening of Mount St. Helens, volcanic activity has become recognized as a major public health hazard in the western United States. Before May 18, 1980, when Mount St. Helens erupted with such force, the danger was perceived as remote, despite warnings by some geologists and others. Local planning is now necessary not only for future activity of Mount St. Helens but also for other volcanoes in the Cascade Range.

In this report, we attempt to provide an update on some recent public health issues as a background for consideration in future planning at the regional and local level. Some agencies, states, counties, and cities now have written plans for emergency response, but there is a need for health aspects to be fully incorporated into these plans in the future.

Future Volcanic Hazards at Mount St. Helens

The following account has been prepared from recent discussions with members of the U.S. Geological Survey (USGS) and abstracted from a USGS news release (November 15, 1980) by Dr. Christopher G. Newhall, Mount St. Helens Volcanic Hazards Coordinator, USGS. All items in the list of hazards with the obvious exception of mud flows and floods are regarded as aspects of "eruptions":

Ashfall: Periodic explosive eruptions can be expected to continue to project ash as high as 20,000-70,000 feet. Ash volumes will most likely range from 1/10th to 10 times those of post-May 18 eruptions. However, there is a lower but continuing possibility that a much larger volume of ash could be erupted, which could lead to deposits up to 3 feet deep 20 miles from the volcano, 1 foot deep 50 miles from the volcano, and lesser amounts at greater distances. Historically, only a few eruptions of the volcano produced such large ash deposits, but since we do not know details of the events leading up to those eruptions, we cannot rule out the possibility that similarly large, vertically directed columns of ash could recur during the current activity. It is anticipated but not assured that an influx of fresh magma leading to a major vertically directed eruption of this sort would be reflected in seismic precursors.

Explosive Ejection of Rock Fragments: During explosive eruptions, some dense rock fragments, such as from disrupted stones, can be thrown on ballistic trajectories across or against the prevailing

winds. (In the July 22 eruption, dense rocks up to 1 inch in diameter were blown by the wind as far as 12 miles from the volcano and reached an estimated terminal velocity of 80 to 100 miles per hour. Theoretically, much larger fragments could be hurled up to 10 miles away.)

Lateral Blasts: In terms of their effects, lateral blasts may be thought of as a combination of large, laterally directed explosions and major pyroclastic flows. A lateral blast such as the one that occurred on May 18 is not likely to occur without warning--i.e., increased seismic activity accompanied by extensive deformation of the volcano. However, smaller, laterally directed explosions may occur without seismic precursors if the dome should grow to sufficient size.

Pyroclastic Flows: Pyroclastic flows are hot mixtures of gas, ash, and pebble-to-boulder-sized pumice and dense rock. They can be recognized as billowing clouds moving laterally across the land's surface at speeds from 30 to over 100 miles per hour and will usually destroy or char everything in their path. While small, short flows (i.e., less than 5 miles long) into the North Toutle area are the most likely, larger flows up to 15 miles long in the same direction or down other slopes are also possible. (The small flows could occur without warning, but larger flows are more likely to be accompanied by a vertical eruption, so that in general the ability to predict these devastating flows is the same as for major eruptions.)

Pyroclastic Surges: Pyroclastic surges are multiple hurricane-like pulses of hot ash and gas. Some are related to lateral blasts; others occur at the start of large, vertically directed eruptions. Such surges travel as sheets rather than as discrete channel flows; they can cover anywhere from a few tenths of degrees to 360 degrees around a volcano. A few very large surges have been known to travel 6-10 miles from their vents, but no prehistoric pyroclastic surge deposits have been identified from Mount St. Helens. (The May 18th lateral blast was a type of pyroclastic surge.)

Lava Flows: Lava could move down the north flank of the cone, but Mount St. Helens lava flows would move so slowly that people would have time to get out of the way. (However, lava flows would melt snow and so could conceivably cause mud flows and floods.)

Mud Flows and Floods: Future eruptions may cause melting of snow from steam blasts, pyroclastic flows or lava. The resulting meltwater will tend to mix with material from the pyroclastic flows, May 18 deposits, and older deposits to form mud flows. The USGS Water Resources Division is studying probable volumes, ranges in velocities of resulting mud flows, and increased stream flows.

(NOTE: USGS assessment of Mount St. Helens has not radically changed. Mount St. Helens is still a dangerous and unpredictable volcano and could stay in its present eruptive phase for perhaps 1 or 2 decades to come. Geologic studies of previous eruptions have been used to predict the future behavior of Mount St. Helens and other volcanoes in the Cascade Range. Perhaps the main use of such studies is to help categorize the volcano and its hazards in general terms, but a

large element of doubt is associated with attempts to make any long-term interpretations from the available evidence. No radical change in the USGS overall appraisal is likely in the near future. The ability to predict major eruptions may improve over time, but there is at present no guarantee of that. Thus, despite day-to-day fluctuations in the volcano's behavior, the assessment of the underlying risk to people working close to the volcano or living further away could remain unchanged for the foreseeable future.)

Current Volcano Monitoring Program

Twenty-four-hour monitoring of the volcano's activity is being undertaken at the USGS Center in Vancouver, which also comprises US Forest Service staff. Information on the status of the volcano is received from 6 main sources: 1) seismographs operated 24 hours a day in Vancouver and also the Department of Geophysics, University of Washington, Seattle. (There is a 24-hour telephone hot-line between the 2 locations); 2) deformation studies involving measurements of the size of the crater and the volcano's flanks; 3) direct geologic observations (e.g., rock falls and changes in the dome); 4) measurement of type and quantity of gaseous emissions; 5) observations from a fixed-wing US Forest Service plane that is kept in the air throughout daylight hours and can also be scrambled at night; 6) other studies, e.g., geologic studies of previous eruptions of Mount St. Helens, to provide background information.

At least once a day the volcano's status is assessed by the Hazards Coordinator in collaboration with the Director of the USGS Center. Should there be a change in the volcano's status, the Hazards Coordinator, who is on 24-hour call, is contacted immediately for his opinion. Depending on his findings and interpretation, he can release an alert or warning that an eruption may be forthcoming or an advisory stating that increased seismic activity is occurring. The US Forest Service will transmit this information to the appropriate emergency groups through a call-down system that, in an emergency, takes about 10 minutes to complete. During the day, people working in danger zones are also notified by radio so that they can evacuate.

The most important tool for providing warning of an impending eruption is the seismic trace. However, seismic readings have to be interpreted along with other sources of information, such as increasing deformation of the dome over a period of days preceding an increase in seismic activity. It may take several hours before a seismic trace develops sufficiently for a warning to be given with assurance. So far, it appears possible to give about 4 hours' warning, but this is based on the experience from 3 of the last 4 eruptions of Mount St. Helens since May 18. Not enough is known to be certain that sufficient warning can be given before all eruptions to allow time to evacuate people from hazardous areas around the mountain.

Within about 10 minutes of the beginning of a major eruption, it should be possible to advise that the eruption is actually occurring.

At night or when visibility is otherwise poor, this information comes from the seismograph and from radar stations in Portland and Seattle. The size and direction of the plume can be inferred from radar observations, which would be used to warn aircraft in the area. The height, density, and breadth of the plume can be distinguished to warn at least of a massive eruption capable of producing disruptive heavy ashfalls. Such a warning can theoretically be transmitted to cities 50 or more miles away before the plume reaches them; meteorologists on call can rapidly make predictions from wind and jetstream directions for cities further away.

Restricted Zones

At present, there are the Washington State red zone and the US Forest Service red and blue zones. The US Forest Service zones were established to restrict access to hazardous areas in the Gifford Pinchot National Forest, whereas the Washington State red zone includes the same area and also a wider area to the west of Mount St. Helens that encompasses the limits of mud flows and destruction caused by the May 18 eruption. Apart from access to the town of Cougar, this zone corresponds roughly to a 20-mile radius around the mountain. Permits are issued by Washington State and the US Forest Service separately under certain restrictions.

In addition to scientific activities, logging is the main reason that people routinely enter the zones. The Weyerhaeuser Company is currently logging within 10 miles of the volcano, to the west and south, and has developed emergency procedures and site-specific risk assessments in collaboration with the USGS and consulting volcanologists. In 3 evacuations so far, in response to USGS warnings, all the workers were out of the red zone in about 45 minutes, most in about 20 minutes.

Modifications to Zones

The Washington State red zone was established by special order of the Governor as part of an emergency proclamation. We do not yet know what the long-term arrangements will be. At present, the limits of the zones are discussed at ad hoc meetings set up separately by the State Department of Emergency Services or the US Forest Service. At the state meeting, representatives from different groups interested in having access to Mount St. Helens (e.g., major industries and members of the public) and law enforcement officers discuss limits of the red zone with representatives of the USGS. A recommendation goes to the Governor, who makes the final decision with input from his own staff. The US Forest Service zones are set by the Forest Supervisor and his staff in consultation with the USGS; they take into account the threat of heavy ashfall in the northeast part of the forest. The usual duties of the US Forest Service in the now restricted area are to facilitate access for the timber companies; logging is the main reason for obtaining access to the blue zone. Since May 18, the main

US Forest Service activity has been extinguishing fires around Mount St. Helens; some are still burning.

There is room for debate on how to maintain restricted access in the future. Some people think that 1 zoning system should be established by a single body or that all access to an area up to 10 miles around the volcano should be prohibited. However, rigid restrictions are unlikely to be universally accepted. The principal local industries are logging and tourism, so there are strong economic reasons for gaining access closer to the mountain. The blown-down trees are of considerable value, and Mount St. Helens itself is now a unique tourist attraction.

There is a need in the future for decision making on the zone limits to be made in an accountable and comprehensible manner. It is worth noting that the zoning system in effect before May 18, while based on the best available information, was imperfect, as most of the bodies recovered were either found outside the zones or were those of persons authorized to enter the zones. Furthermore, study of the deaths, missing persons, and survivors shows that the outcome correlated strongly with location and distance from the volcano. Another factor to be taken into account is that if increasing numbers of people are allowed to enter potentially hazardous areas, the task of the USGS and the University of Washington group of predicting dangerous volcanic activity accurately becomes all the more onerous. It is not known at present whether the USGS forecasting, still at an early stage of development, can be improved in the foreseeable future. In addition, deformation studies for prediction purposes require geologists to enter the very hazardous areas of the crater to make observations. Thus, geologists are already taking considerable personal risks in providing predictions for the safety of people permitted to enter the restricted zones.

With the present lack of knowledge for predicting volcanic activity accurately, the utmost caution must be used before current zone restrictions are altered if further loss of life is to be avoided. Similarly, all persons seeking permits to enter the zones should be aware of the USGS hazard evaluation as summarized above.

Public Health Implications of a Heavy Ashfall

A massive eruption causing heavier ashfall than that following the May 18 upheaval could still occur. If it occurred without warning, people in the red zone could be marooned until visibility improved so that they could be rescued. The potential impact of a foot of ash on cities such as Portland and Yakima, as well as on smaller communities, warrants close study by public health officials, city planners, and other agencies. Some groups were attempting to study the problem before May 18, but since then interest has waned--partly because the later eruptions of Mount St. Helens have been diminishing in size and have led to the belief that the volcano is entering a quiescent phase. Some geologists have also tended to paint an optimistic picture of events while at the same time admitting the inherent unpredictability

of the volcano. Also, there is the human propensity to underestimate the seriousness of rare, threatening events when there is little that can be done to avoid them. Further attention should at least be given to possible preventive measures to reduce the public health impact of very heavy ashfalls:

1) An ashfall of 1 foot depth would be accompanied by impenetrable darkness which could last for several days. As a result, virtually all transport and movement in cities would come to a halt (headlights and windshield wipers, e.g., are only minimally effective in a major ashfall). Emergency services, e.g., ambulance and fire, would be seriously restricted or stopped because of poor visibility. An ashfall occurring during a working day would leave workers stranded in their offices.

2) Increases in numbers of cases of asthma and bronchitis were observed after each of the 3 earlier major eruptions (May 18 and 24, and June 12) in areas with the heaviest ashfall. (See Mount St. Helens Volcano Health Reports #5,8,14,17,19.) The consequences of a much heavier ashfall might be considerably more serious, particularly for the old and the very young, especially if it occurred during a seasonal increase of influenza or respiratory disease. On the other hand, the grain size of the ash 50 miles from Mount St. Helens in such an eruption could be larger than that found after the May 18 eruption, so that the proportion of respirable particles of ash might be lower. Houses need to be well weatherproofed and caulked to reduce ash infiltration. (See CDC--Mount St. Helens Volcano Report #20.)

3) Power outages could occur in many parts of Portland if district substations failed. Rain frequently accompanies heavy ashfalls, and moist ash has sufficient conductivity to cause shorting of exposed electrical insulators--particularly the horizontal type used in substations, that permit ash to accumulate along the insulator's length. Maintenance men could not travel to substations to remove the ash and repair equipment because visibility would be severely reduced. The lack of visibility inside houses as well as outside would pose serious problems to the aged living alone and to families with small children unless adequate emergency lighting were available. Similarly, food preservation, cooking, and home heating would be adversely affected, and the poor visibility would prevent people from leaving their homes to seek help.

4) Experience with the May 18 eruption indicates that lightning would probably accompany the ash plume at least as far as 50 miles away from the volcano. Lightning strikes might pose an additional threat to life and electricity supplies. Personal protection measures against lightning should be more widely known. The risk of fire from lightning is virtually eliminated in dwellings made from modern materials, but wooden buildings can be ignited unless fitted with lightning protection. In thunderstorms, residents should keep to the middle of rooms as a precaution, and avoid large metal objects, electrical appliances, and open fireplaces (lightning striking a chimney can be discharged through a layer of soot). This advice

should also be heeded when making a telephone call, even though telephones are routinely protected against lightning.

5) About 20% of Portland's water supply is dependent on electrical pumping and not gravity flow. Thus, a power outage would stop water supplies to a substantial segment of the population. Portland's supply comes from the Bull Run watershed, and it is not known whether gravitational supplies would be seriously affected by a very heavy ashfall, e.g., if a filtration plant were overwhelmed. Toxic constituents of the ash or ash of a low pH could pose further health problems. The Portland Bureau of Water Works has an emergency ashfall plan that includes water-monitoring procedures. Also, as in the May 18 eruption, sewage disposal systems could be put out of action by the volume and abrasiveness of the ash.

6) Portland building codes required that roofs of houses be able to withstand weights of 20 pounds per square foot before mid-1974, and have required that they be able to withstand 25 pounds per square foot since mid-1974. Reputable builders usually construct homes to withstand about twice this load. In certain areas, e.g., in the Hood River area, houses are built to withstand as much as 500 pounds per square foot because of potential heavy snowfalls. Accumulations of ash from the May 18 eruption to a depth of 1 foot on a roof could create stresses of up to 100 pounds per square foot, especially if the ash became wet. Such build ups would be most likely on flat-roofed buildings such as meeting halls or auditoriums where people might seek refuge, and gymnasiums, bowling alleys, warehouses, etc., which might only meet minimum building code requirements. Regular removal of accumulated ash from a roof during a heavy ashfall would be made difficult by poor visibility and the irritative effects of the ash on the eyes and respiratory system. Thus the roofs of certain dwellings and other buildings, particularly those that might otherwise be used for evacuation centers, could undergo catastrophic collapse.

7) Telephone communications would probably remain intact for the most part (at least for 2 days) if the central telephone offices were left unattended. In the event of a power failure, batteries in the central offices would automatically provide electricity for 2 days. Beyond that, emergency auxiliary diesel engines are kept ready but would have to be started by operators. Telephone wires themselves are well insulated and should not be affected by an ashfall unless damaged by other objects falling under the weight of ash. Computerized switchgear can be damaged by dust and ash, but improvements in air filtration have been made since May 18 and are said to have obviated this problem. However, in the May 18 eruption the telephone system overloaded in many areas for up to 4 days later, and many calls could not get through.

This doomsday list (by no means complete) of the more obvious sequelae of a severe ashfall does not pose insuperable health problems if there is sufficient preplanning--especially for such vulnerable groups as the very young, the elderly, and the sick. Hospitals, in particular, should consider how they would best function during such

an emergency. Planning for lighter ashfalls may be done in light of this extreme case.

Emergency Response Procedures Around Mount St. Helens

A revised Mount St. Helens search and rescue plan, prepared by officials from the Washington counties of Clark, Cowlitz, Lewis, and Skamania, the Washington State Department of Emergency Services, and the US Forest Service, was issued in June 1980. This plan would be activated in the event of a disaster involving a large number of casualties at Mount St. Helens and would be initially coordinated by the Sheriff of Skamania County. For an incident involving a few casualties or people marooned (e.g., because of helicopter failure) inside the restricted zones, including on Mount St. Helens itself, only part of the plan would be activated. For example, stranded individuals belonging to the US Forest Service or a logging company might be easily removed by their own agency/company helicopter. However, should special rescue operators or expertise be required, the 304th Air Force Reserve in Portland is on standby; it takes 45 to 60 minutes to dispatch helicopters and reach the volcano. Coordination of such a rescue operation is the responsibility of the sheriff of the county in which the rescue is taking place. Emergency communication would be initiated through the USGS/US Forest Service office in Vancouver.

The US Forest Service and USGS have an agreement with the Yacolt Fire Department to receive air-lifted casualties who, after being seen by paramedics, can be sent by ambulance to St. Joseph's Hospital, Vancouver, all within about 45 minutes. Patients with severe burns will be flown directly to the helipad at Emanuel Hospital, Portland, where there is a regional burn unit. The usual capacity of the burn unit allows up to 6-8 emergency cases to be accepted, and additional cases can be diverted to the regional burn unit in Seattle/Tacoma.

If the search and rescue plan were activated, casualties would also be airlifted directly to St. John's Hospital, Kelso, and to Toledo High School. After the May 18 eruption, many survivors were evacuated by helicopter to Toutle School, where they were debriefed and seen by paramedics. However, it appears that not all survivors received a clinical examination, and adequate records on the clinical status of the survivors were not kept.

An emergency morgue would also be set up at Toledo. Retrieval of the dead from the May 18 eruption was begun on May 22. In the event of another catastrophe, epidemiologic data relating to the state of the bodies when found, their location, and information on damaged and nearby vehicles, tents, trees, etc., should be carefully collected to facilitate medical studies.

Medical aspects of emergency response tend to be overlooked by rescue planners. For example, it seems appropriate that an experienced physician rather than a paramedic should be placed in charge of the triage center planned for Toledo High School, and that all survivors should have a careful examination with full documentation

before being released. Of course, survivors may be scattered over a wide area, so not all would necessarily pass through Toledo. Other aspects, for example the most appropriate hospitals to send different types of casualties and the adequacy of hospital disaster plans in the light of Mount St. Helens continuing eruptive activity, should also be reviewed. Helicopter crew foremen, together with first aiders and paramedics who may staff rescue helicopters, should benefit from additional instruction on, for example, the handling of cases of severe burns and inhalational injuries from hot ash.

Flooding and Related Health Problems

Mud flows ran down the north and south forks of the Toutle River in the May 18 eruption and sent an immense flow of debris down the Toutle and Cowlitz into the Columbia River. About 250 homes were flooded, but no one was drowned. As a result of this flow, the Cowlitz River was estimated to have lost 80% of its normal capacity. The US Army Corps of Engineers has been dredging the river and building levees to protect the communities of Lexington, Castle Rock, Kelso, and Longview from flooding during the winter rains. The old stream bed of the Toutle is being reformed by the Corps, but some homesteads are still at risk of being flooded by the Toutle.

These urgent repairs have been impeded by increased wear of machinery from the abrasive ash and also because the ash compacts more densely than ordinary mud and can be excavated at only half the usual rate. Also, dredged areas have rapidly refilled with debris continuing to come down from the Toutle, and dredging has to be continued to keep the capacity of the Cowlitz at a safe level.

Records of floods in the area have been kept since the beginning of this century, and in the past severe flooding of the Toutle and Cowlitz has only occurred in December and January--caused by heavy rainfalls rather than melting snow. There is now optimism that, with the mild, dry weather the region has been experiencing (apart from some heavy rain over Christmas), the period of greatest risk may be over for the winter of 1980-81. However, the possibility of eruptions with hot pyroclastic flows that would cause snow to rapidly melt on Mount St. Helens and upset this optimistic view must be remembered, though the below-average snowfall this winter has reduced this risk. Next winter may once again pose serious problems depending upon the quantities of debris that continue to flow down the Toutle from the devastated land upstream.

Emergency response to a flood warning is being coordinated at the office of the Sheriff of Cowlitz County. A warning system involving a network of rain gauges is designed to give about 4 hours' warning of a rise in water level large enough to necessitate evacuation of residents in high-risk areas. About 4,000-5,000 people in Lexington, Castle Rock, and nearby small communities are at highest risk. These residents have been advised to leave their homes and go to designated evacuation centers when warned by a siren to do so; a system by which

neighbors in a block will go door to door to provide assistance has also been implemented.

According to USGS, phenols are being released as decay products from trees killed by the May 18 eruption. They can be smelled in ponds and still-water in the area of destruction. So far, phenol levels measured in the Toutle River have not been elevated. In 2 wells at Toutle, raised levels of phenol have been found, but it is not known whether this groundwater contamination was caused by the May 18 eruption or predated it. Another effect of the destruction of the May 18 eruption was an increase in fecal coliform counts (perhaps from decaying animal and vegetable matter) in the Toutle and Cowlitz rivers; these counts have gradually fallen over time. Routine chlorination procedures have been regarded as adequate to safeguard water supplies. Trace metal concentrations in the rivers are not elevated.

In addition, water intakes on the bed of the Cowlitz have been partially or totally obstructed by debris on the riverbed. The building of alternative water supplies is under active consideration. At Toutle, new wells have been drilled because the surface tap in the Toutle River was destroyed and there were continuing turbidity problems.

Summary

This report was prepared from discussions with members of the USGS, US Forest Service, US Army Corps of Engineers, state and county officials, representatives of public utilities and local physicians, some of whom kindly reviewed an earlier draft for accuracy. We are most grateful to them all for their assistance.

Hazard evaluations by geologists need to be translated into effective preventive health measures for people living and working near Mount St. Helens, especially for those whose livelihood depends on the beneficial aspects of past volcanic activity, e.g., logging, tourism, and agriculture. Nine months have now passed since the destructive May 18 eruption, but eruptive activity of Mount St. Helens may continue for 1-2 decades, with the unlikely but ever-present possibility of a massive eruption. The public health implications of a heavy ashfall, especially on modern cities, require careful planning. In the vicinity of the volcano itself, zone restrictions, with their implications for occupational and recreational groups, need to be maintained or modified with the utmost regard for human safety.

CDC--Mount St. Helens Volcano Health Reports will be published on an ad hoc basis. Information in these reports represents the latest data reported to CDC; much of the information is preliminary in nature and subject to confirmation and change. It is distributed for the purpose of providing up-to-date health data from CDC and the many other groups involved in public health assessment. We hope to continue to receive relevant reports and data from others working on this problem.

The current mailing list will be retained for any future issues. Anyone who desires back copies or to be put on the mailing lists should contact the Centers for Disease Control, ATTN: Ms. Carolyn Forrester, Center for Environmental Health, Chronic Diseases Division, Atlanta, GA 30333.

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