DEVELOPING EFFECTIVE LAHAR WARNING SYSTEMS FOR RUAPEHU

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Ruapehu is an active volcano with a history of eruptive activity spanning at least the last 250,000 years. Lahars represent one of the greatest risks to life and property.

Ruapehu poses a variety of risks to life and property depending on the location of an individual or structure, the size of eruption, and seasonal and weather conditions. One of the greatest risks is from lahars – volcanic mudflows containing abundant rocks and ash, and often snow at Ruapehu. This risk is addressed and managed in two different settings – the three Ruapehu ski areas (where lahars are only generated during eruptions) and in the Whangaehu River (where lahars may be generated from both eruptions and from non-eruptive break-out of part of Crater Lake).

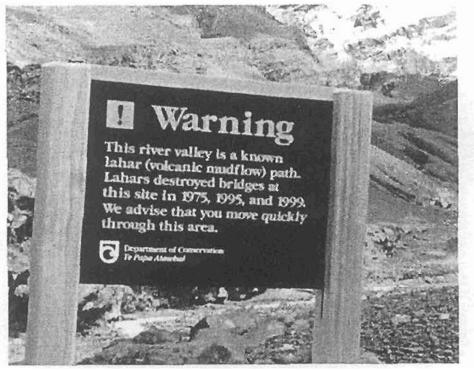
Since 1995 research has been undertaken by the Institute of Geological and Nuclear Sciences (GNS), the Department of Conservation (DoC) and associates at Ruapehu as part of a multi-disciplinary programme, directed at determining factors which enhance public and organisational response to warning systems. This research involves hazard analysis, developing and evaluating public education, reviewing training amongst responding agencies, undertaking gap analysis of existing and desired training (for both warning and evacuation) and undertaking on-site analysis of warning system simulations.

Warning Systems for Ruapehu Ski Areas

The risk from volcanic hazards appears to be much greater at Whakapapa and Turoa ski areas, than at Tukino ski area. The Tukino area receives ash from eruptions but has been protected from historic lahars because of its distance from Crater Lake and the effects of local topography. It may receive lahars in extremely large eruptions, but the risk is low. The upper lifts at Turoa are within the range of bombs ejected from Crater Lake and the area may also be susceptible to lahars in moderate-sized eruptions. Whakapapa ski area is further from the lake and is less likely to be affected by bombs, but it has received historic lahars in three different eruptions, two of which damaged buildings and lifts. Because of the experience of lahars at Whakapapa an early warning system has been installed in the area and steps to develop an effective response to the system initiated there first.

Surveys conducted around the last four annual tests of the Eruption Detection System (EDS) at Whakapapa indicate a need for increased awareness of what to do when the alarm sounds both by staff and public. The EDS automatically triggers a siren and loud-speaker announcement across the ski area in an eruption. Three eruptions in the last 35 years have created potentially deadly lahars down several ski runs. On hearing the alarm skiers have as little as 90 seconds to clear the lahars' paths on the highest runs. Three additional studies of public perceptions of (a) Ruapehu's volcanic hazard, and (b) the EDS, have also been conducted and these indicate a significant drop in awareness of the EDS prior to 2004. While awareness of volcanic hazards remained consistently high, the proportion of skiers aware of the EDS, who knew that the correct action on hearing the alarm was to'move out of the valleys', decreased from 2000 to 2003.

A public education program involving posters and brochures, was carried out in conjunction with Ruapehu Alpine Lifts (RAL) in 2004 as a product of this ongoing research. Public awareness of what to do after a warning is given increased in 2004, following implementation of the program. Staff training has also been modified, including increasing testing to twice annually – once at the beginning of the season, with a planned test (staff aware), to act as a training exercise, and once late in the season (unannounced) to test



LEFT:: Skiers at Whakapapa ski area being directed to higher ground by a lift operator, in a lahar warning system exercise.
ABOVE:: A Department of Conservation lahar warning sign for the Whangaehu River valley.

the EDS's effectiveness and to evaluate staff and public response. Ongoing cooperative research continues to feed back into the education process and the EDS itself.

Audibility of the siren in the last three tests seems to have been continuous across the ski area, but the announcement is not always understandable due to environmental conditions, skier noise or hearing impairment. Therefore, promoting correct response in skiers when the EDS is activated involves public lahar education. The annual EDS tests themselves appear to be acting as an effective educational tool for annually returning customers. Feedback from skiers also countered concerns that a public warning system would have a detrimental economic effect to the ski area. On the contrary, regular visitors felt reassured and would continue to ski. Staff receive lahar hazard training each year, but the tests give them hands-on training in the correct actions to take in an alarm. In the two tests in which staff were alerted prior to the test their actions were more effective at moving people to safety and keeping them calm than in the years when the' test was 'unannounced'. This has been attributed to staff choosing to learn critical information in the hours between being informed and conducting the test.

Turoa ski area was connected into the EDS in 2004 via a pager. An initial public education programme involving posters has been released in 2005, and a mini-map of both ski areas' hazards has been mailed out to all season pass holders. GNS and DoC are working with RAL to improve staff training and response planning at Turoa as well at Whakapapa.

Warning Systems for the Crater Lake Breakout Lahar

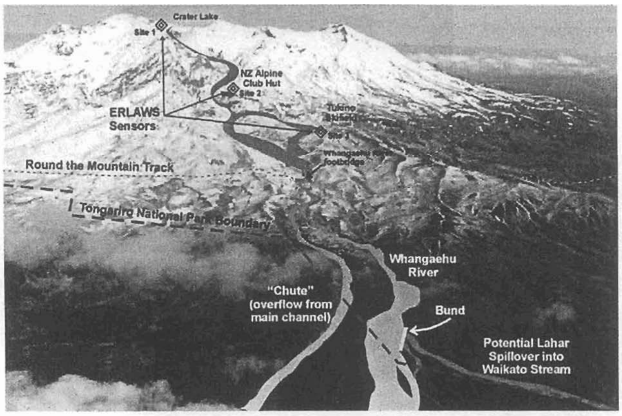
The largest historical eruption of Ruapehu took place in 1995 (September-November) and 1996 (June-August). The early eruptions were through Crater Lake and generated lahars down four rivers, with over 90% of the volume of the lahar material flowing in 35 lahars down the Whangaehu River. Later eruptions were drier, more sustained and deposited ash up to 250 km from the crater. A key result of the 1995-96 activity was the build up of a tephra layer over the natural lake overflow channel at the head of the Whangaehu valley. Studies of the changes to the Crater Lake area caused by the 1995-96 eruptions were carried out to assess the stability of the crater. These studies concluded that a potentially hazardous situation existed, similar to that of 1953 after the 1945 eruptions. There was a clear possibility of another tephra-barrier collapse lahar when the lake refilled. Because glacial recession had removed the restriction of the Crater Basin glacier (and tunnel under the glacier), the potential lahar could be much larger (50 – 75 %) at Tangiwai where the rail bridge was destroyed in 1953. Warning system development is more complicated under these circumstances. In addition to ensuring an effective warning, it is essential to ensure that diverse agencies can respond effectively and in a coordinated manner within a short time of receiving the warning/alarm.

Response Plan Development

Response plans have been prepared by local government (Ruapehu District Council and Taupo District Council) for the southern and northern areas likely to be affected by the lahar. Separate response plans were necessary because the nature of the hazard, and the probability of its occurrence, differ in the two areas.

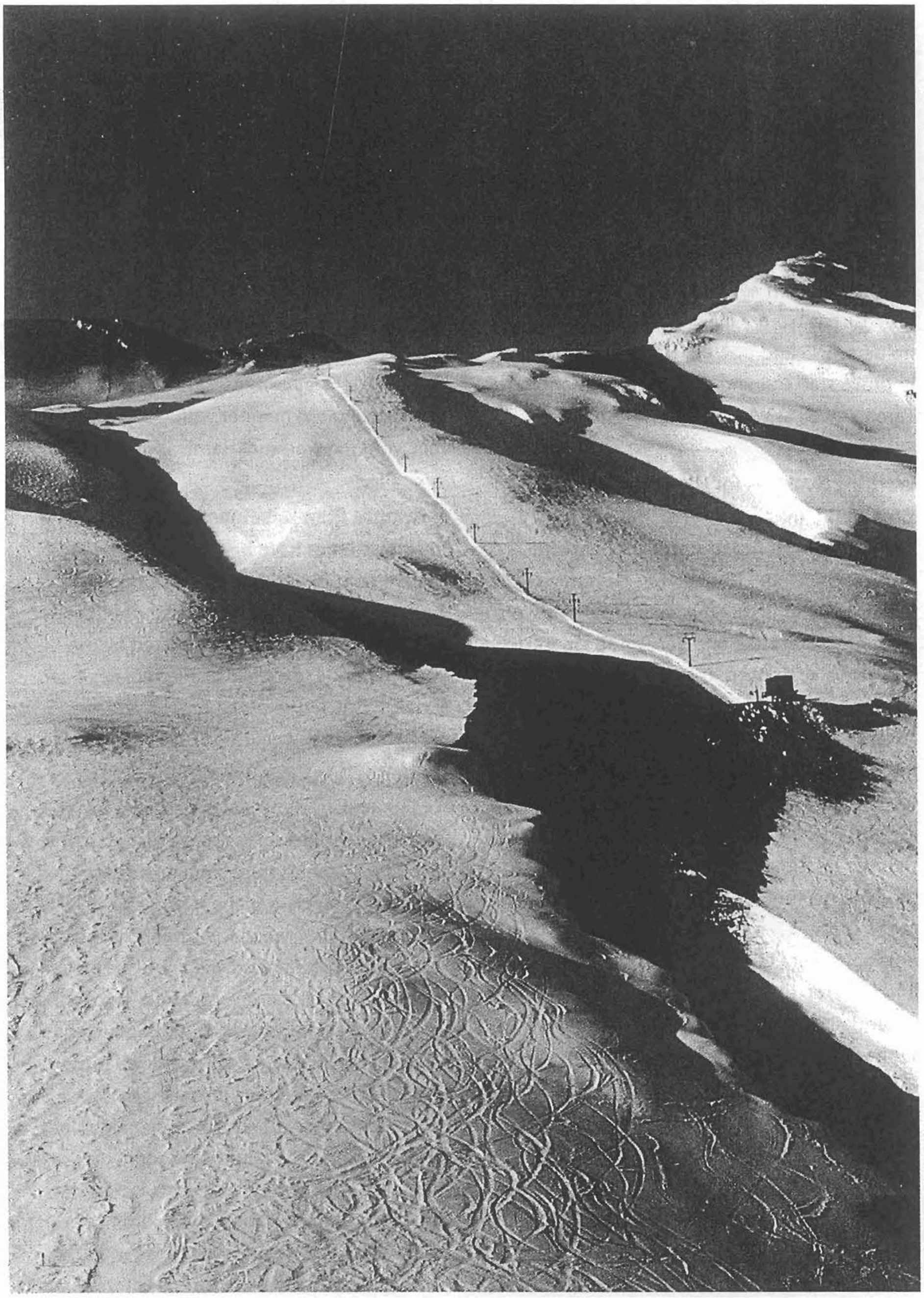
The organisations are developing an "all-hazards" approach to response planning, with many components applicable to a range of hazards, rather than planning specifically for the barrier-break lahar. This enhances future response capability, and will allow the actual break out to act as a case study for integrated emergency management. In addition to the response agencies and other organisations (including GNS and universities), several community groups, such as kayakers, anglers, trampers and local communities, whose members may be affected by the event are involved. Communication and coordination needs to be maintained with these groups.

The lahar response process is complicated



LEFT:: A lahar in 1995 narrowly missed the For West T-bar.

BELOW:: Aerial photo of the upper Whangaehu catchment on Mt Ruapehu showing the location of the bund and ERLAWS sensors. From www.doc.govt.nz/.



by the geographic extent of the affected area. This is reflected in the diversity of organisations involved in the response. The affected area includes four district councils, two regional councils and crosses the functional boundaries of a number of the organisations involved. In addition to raising problems associated with multi-jurisdictional management and coordination, geographical factors raise several operational issues. For example (a) high levels of inter-agency and inter-jurisdictional planning, (b) the development of distributed decision making procedures (defining geographic and hierarchical locations within and between agencies) and (c) the capabilities to utilise these procedures effectively during operational implementation of the plan.

The communications issues raised is made more complex by the functional boundaries between agencies (e.g. Police and DoC). This diversity creates challenging communication and coordination issues (e.g., sorting terminological issues, lead agencies etc.). These issues have to be resolved in ways that allow collective action so that each can achieve its goals and objectives. Consequently, planning must be a multi-agency activity. Adopting this approach has resulted in significant progress towards an effective management strategy for this event. An ongoing state of readiness has been in effect since spring 2004, as the Crater Lake nears it's old outflow level. Maintaining this state for an uncertain period has created some planning issues in itself. For example, civic agencies have to allocate resources to maintaining readiness, including re-training for staff fulfilling response roles. As time passes, the more likely it is that key people move on. Succession planning thus becomes important.

The installation of a permanent lahar

warning system was partly in response to a decision to not physically remove the tephra barrier. The system now provides long-term early warning for both Crater Lake break-out and eruption-triggered lahars in the Whangaehu River valley.

Conclusions

The lahar risk at Ruapehu provides the entire New Zealand emergency management sector with an ideal opportunity to learn about the complexities of emergency response planning The response to the barrier-collapse lahar hazard involves a wide range of organisations, has relatively well constrained parameters and a short predicted window of occurrence.

Best practice recommendations for developing the correct and an effective response to hazard warnings in New Zealand can be grouped into five elements, based on the results of our research, other empirical studies, observations from the public response to past events and common sense. These are:

1) Reliable Early Warning System (EWS)

An early warning system comprises hardware, electronics and communication required to effectively initiate a warning message in a hazard event. To ensure that the system will be reliable in an event, there must be built-in redundancy and regular, ongoing testing and maintenance. The best practice for alert systems includes both warning sirens and loudspeaker announcements.

2) Research and Monitoring

An effective lahar warning systems must be underpinned by good (a) event research (for example identifying the source and nature of the lahar risk that effect a specific area); (b) impact research (for example hazard maps); and (c) monitoring and improvement of warning effectiveness, including observing simulation drills, researching public awareness and monitoring the effectiveness of education initiatives. These types of research must be done in a measured way and be regularly and continuously updated.

3) Cooperation, Discussion and Communication

It is essential to have pre-planned and exercised communication between central government agencies, local emergency management agency staff, scientists and community representatives. Renewal of contacts must be regular and permanently sustained, to overcome common high staff turnover,

4) Public Education, Staff Training and Signage

Pre-event public education should not be confused with event-imminent warning messages. Public education through hazard/ evacuation maps, media releases, brochures/ posters, meetings, internet resources etc. are critical to understanding of warning system details and the range of suitable responses. Training for emergency management, response, media and staff must be regular and continuously repeated to overcome ongoing staff turnover. The actions of staff are a key determinant on the effective response of the public to an early warning system.

Signage has been shown to be critical for maximum effectiveness of early warnings. Signs showing hazard zones, evacuation routes and safe zones should have permanently scheduled checks for replacement/maintenance.

5) Simulation Drills and Exercises

These should be undertaken regularly, preferably annually. However, the frequency is a balance between positive maintained readiness and awareness, and negative social disruption. Simulations test planned emergency management group members' training, communication and information sharing with one-another and, most importantly, effective removal of public from harms way. ::

Selected References and Further Reading

Galley, I., Leonard, G, Johnston, D, Balm, R and *Paton, D*, 2004. The Ruapehu *lahar* emergency response plan development process: An analysis. The Australasian Journal of Disaster and Trauma *Studies, 2004(1):* 1-33.

Leonard, G, Johnston, D, *Paton, D.* and Kelman, *I., 2004.* Mitigating the lahar risk at Whakapapa Ski Area, Mt Ruapehu: Public perceptions and the effectiveness of the new warning system. *2004/02,* Institute of Geological and Nuclear Sciences science report, Lower *Hutt.*

Mileti, D, Nathe, *S.,* Gori, t?, Greene, M. and Lemersal, E, 2004. Public Hazards Communication and Education: The State of the Art, Natural Hazards Center Natural Hazards Informer issue 2, Boulder.

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