Early Warning for All in Volcanology: Case Study Series

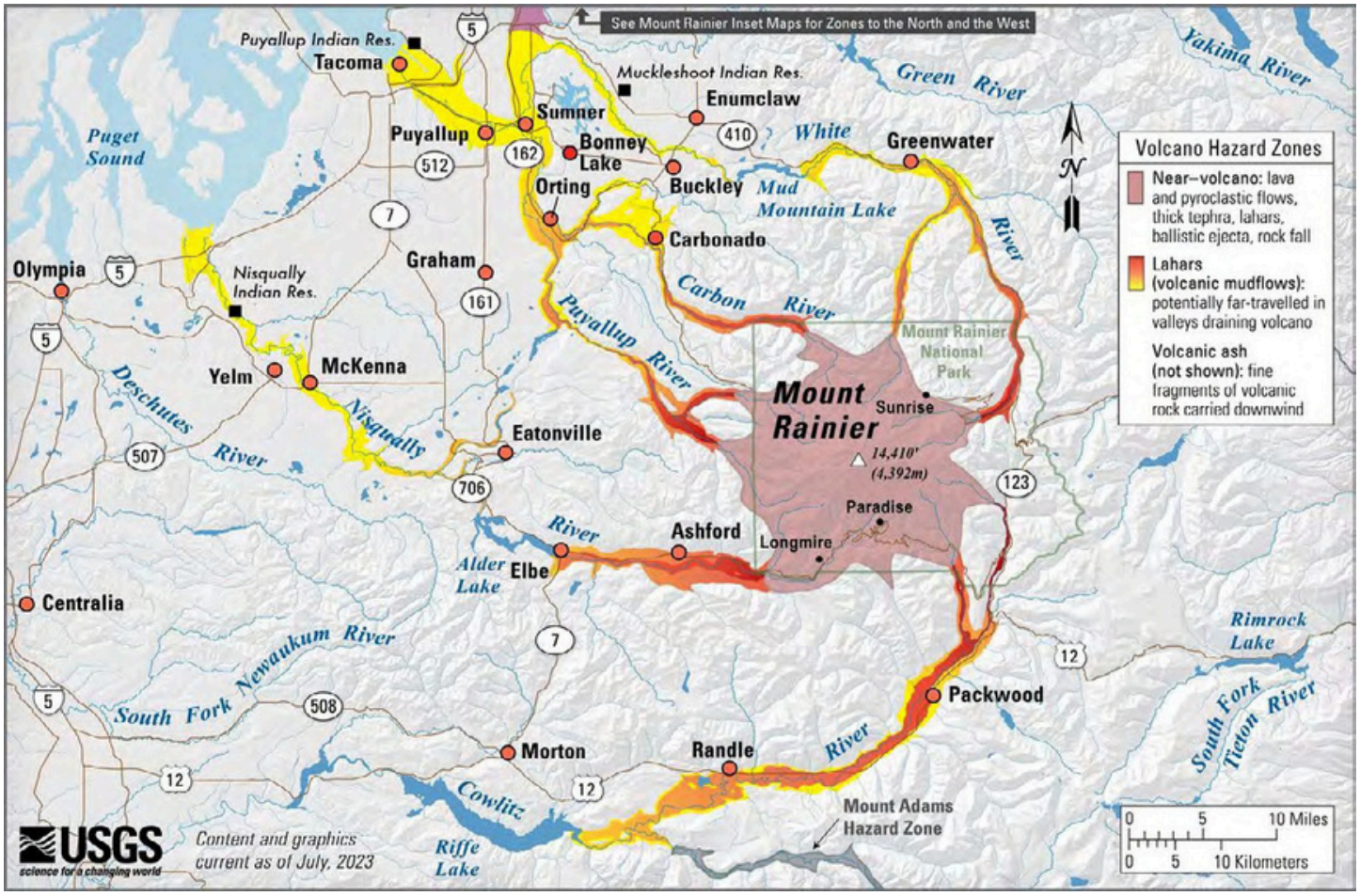

Figure 1. This simplified hazard map shows colored zones (pink and red are higher and more frequent hazard than yellow) that could be affected by lahars, lava flows, and pyroclastic flows from Mount Rainier if events similar in size to those of the past occurred today. USGS figure in public domain

As a follow-up to the *"Advancing Volcanic Hazards in EW4All"* workshop that took place in Geneva between 7–9 July 2025 in association with the IAVCEI Scientific Assembly (See §2.2 of IAVCEI Newsletter No. 3, October 2025), *we are pleased to introduce a dedicated series of case-study contributions that highlight practical examples of cross-pillar collaboration in volcanic early warning*.

EW4All (Early Warning for All) is a global initiative as launched by UN Secretary-General António Guterres in 2022 to strengthen early warning systems and ensure communities at risk receive timely information (https://www.un.org/en/climatechange/early-warnings- for-all). The EW4All approach is structured around four pillars:

1. Disaster risk knowledge and management (led by UNDRR)
2. Detection, observation, monitoring, analysis, and forecasting (led by WMO)
3. Warning, dissemination and communication (led by ITU)
4. Preparedness and response capabilities (led by IFRC)

We will begin by featuring case studies contributed by participants of "*Advancing Volcanic Hazards in EW4All*" in July (https://www.unige.ch/sciences/terre/CERG-C/international-conferences/EW4ALL), and we warmly encourage broader engagement from the IAVCEI community. If additional members are interested in sharing their own experiences or initiatives, they are invited to contact IAVCEI for inclusion in future newsletters (please contact Costanza.Bonadonna@unige.ch).

Each case study provides key elements of the EW4All pillars, such as:

- Examples of a project, activity;
- Initiatives demonstrating inter-pillar integration;
- Reflections on how EW4All pillars have been addressed and interconnected; and
- Insights into challenges, lessons learned, and successes in implementation

The goal of this series is to enhance awareness, stimulate discussion, and encourage exchange of best practices across the EW4All and volcanological communities. We hope these contributions will inspire further collaboration and help bridge scientific expertise, operational needs, and societal preparedness. *We warmly thank all contributors for sharing their*

perspectives and experiences, and we look forward to expanding this collection over time.

EW4All in volcanology – Case Study 1: Hazards information and models inspire community-wide mitigation and preparation near Mount Rainier, Washington (USA)

Author: Cascades Volcano Observatory
https://www.usgs.gov/cascades-volcano-observatory

The U.S. Geological Survey (USGS) addresses volcanic risk in the United States largely through its five volcano observatories, including the Cascades Colcano Observatory (CVO) in Vancouver, Washington. Research at the observatory is closely tied to operational activities that inform local communities and are integrated into emergency readiness. An outstanding example is the use of computer models to understand how volcanic landslides and lahars (mudflows composed of a slurry of pyroclastic material, rocky debris, and water) travel downstream, and endanger communities in their path.

Large lahars pose substantial threats to people and property downstream from Mount Rainier volcano in Washington State. Geologists have found evidence that at least 11 large lahars from Mount Rainier have reached into the surrounding area, known as the Puget Sound lowlands, in the last 6000 years. A recent USGS study estimated that over 90 000 people as far as 70 km away from the summit live within Mount Rainier lahar hazard zones (Figure 1). Infrastructure damage within these zones could affect millions of people in the region; however, the precise character of these threats can be difficult to anticipate. To estimate potential lahar depths, inundation areas, and travel times in the area, USGS scientists developed and used an open-source software package, D-Claw, to simulate hypothetical future lahars that originate as landslides high on the west side of Mount Rainier (Figure 2).

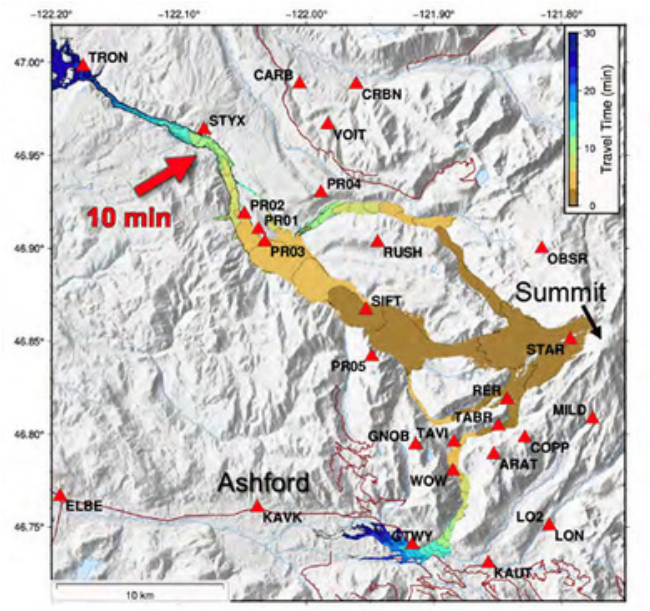

Figure 2. The travel time for a hypothetical 260 million cubic meter lahar (shown as colored areas in the western drainages off Mount Rainier) are estimated using the D-Claw flow-modeling package, providing communities with insights they can use to mitigate risks from volcanic mudflows. Red triangles are monitoring stations. USGS figure based on George et al. (2022)

In an extreme-case scenario (though one that has happened before), a 260-million-cubic-meter, high-mobility lahar. The lahar originates from a landslide high on the west flank of Mount Rainier, has a flow front approximately 4 m deep, travels about 4 m/s (~14 km/hr), and reaches the outskirts of the community of Orting (Figure 1) about 1 hour after the onset of slope failure. This model, and the underlying geologic fieldwork that reveals evidence for past lahars at Mount Rainier, represent *Disaster Risk Knowledge*, part of Pillar 1 within the framework of Early Warnings for All (EW4All). Armed with this information, communities in the Puyallup River lowlands now organize evacuation drills to explore schools' response capabilities to the lahar threat. Over 45,000 students from multiple school districts in the region participate in biannual lahar evacuation drills (Figure 3). These evacuation drills prompt critical emergency preparedness conversations among key agencies, including the USGS and emergency management authorities, within and outside the lahar hazard zones, and enable the sort of *Preparedness and Response Capability* envisioned by Pillar 4 of EW4All.

Figure 3. During a 2024 drill, thousands of students from schools in the Puyallup River valley walked to the Washington State Fairgrounds in Puyallup, Washington to practice evacuating from a lahar generated by Mount Rainier. USGS staff welcome students with high-fives as they arrive at the fairgrounds. USGS figure in public domain

Hazard information and response capability are integral parts of the design of a lahar monitoring (Pillar 2) system designed by CVO that permits warnings by the State of Washington and local emergency response agencies (Pillar 3) to vulnerable communities around Mount Rainier. An important result of intense community outreach is that providing communities with tangible evidence of past events and visual illustrations of hazards can motivate vulnerable populations to plan mitigative activities that generate discussion and promote safe practices. Moreover, communities are involved in co-developing the outreach products that serve their citizens. This long-term, multiagency approach enables lessons from science to directly impact warnings, mitigation, and responses that are intended to protect people living near dangerous volcanoes.