Introduction to Simplified Volcano Hazard Zone Maps for California

Geologists produce hazard zone maps to convey the types of hazards that may occur during future eruptions and to identify the areas of potential impact. Hazard zones are derived from detailed geologic studies that identify the type and extent of volcanic deposits created in past eruptions and on isotopic and paleomagnetic dating of the age and frequency of eruptions. Users of the information in this report should be aware that volcanic areas in California are the subject of continuing research and that refinement of volcano hazard zones are sure to come in subsequent years.

The volcano hazard zones provided in this report reflect a simplified compilation of the following peer-reviewed U.S. Geological Survey reports:

1) **For Lassen Volcanic Center:** Clynne, M.A., Robinson, J.E., Nathenson, M., and Muffler, L.J.P., 2012, Volcano hazards assessment for the Lassen region, northern California: U.S. Geological Survey Scientific Investigations Report 2012–5176–A, 47 p., 1 plate, scale 1:200,000, [Available at <http://pubs.usgs.gov/sir/2012/5176/a>], and, Robinson, J.E., Clynne, M.A., 2012, Lahar hazard zones for eruption-generated lahars in the Lassen Volcanic Center, California: U.S. Geological Survey Scientific Investigations Report 2012–5176–C, [Available at <http://pubs.usgs.gov/sir/2012/5176/c>].

2) **For Medicine Lake Volcano:** Donnelly-Nolan, J.M, Nathenson, M., Champion, D.E., Ramsey, D.W., Lowenstern, J.B., and Ewert, J.W., 2007, Volcano hazards assessment for Medicine Lake volcano, northern California: U.S. Geological Scientific Investigations Report 2007–5174–A, 33 p., 1 plate, [Available at <https://pubs.usgs.gov/sir/2007/5174/a>, and, subsequent GIS compilation in Ramsey, D.W., Donnelly-Nolan, J.M., and Robinson, J.E., 2019, Hazard boundaries for the volcanic hazard assessment of Medicine Lake volcano, California: U.S. Geological Survey data release, available at <https://doi.org/10.5066/P9SDH8E6>.]

3) **For Mount Shasta, Clear Lake volcanic field, Long Valley volcanic field, Ubehebe Craters, Salton Buttes:** Miller, C.D., 1989, Potential hazards from future volcanic eruptions in California: U.S. Geological Survey Bulletin 1847, 17 p., 2 tables, 1 plate, scale 1:500,000. [Available at <https://pubs.usgs.gov/bul/1847>, and, subsequent GIS compilation in White, M.N., Ramsey, D.W., and Miller, C.D., 2011, Database for potential hazards from future volcanic eruptions in California: U.S. Geological Survey Data Series 661 (database for Bulletin 1847), available at <http://pubs.usgs.gov/ds/661>].

The studies above represent the work of numerous researchers occurring over a collective span of almost three decades. As a result, methodology, nomenclature, and level of geologic detail vary from one report to the next. The simplified hazard zone maps presented in this report maintain the scientific integrity of the reports listed above, while simplifying nomenclature and amalgamating information to provide a consistent, statewide portrayal of California’s volcano hazard zones.

It is important to note that volcanic hazard zone boundaries are gradational in nature, with the severity of the hazard diminishing outward from the eruption site (vent), or, for the various flowage hazards, with increasing height above valley floors or basins. The simplified hazard zone maps in this report portray hazard boundaries as diffuse bands rather than as sharp lines. Diffuse boundaries give a qualitative sense of the level of uncertainty in the original data, and account for differences in geologic resolution (map scales) across the various published reports listed above.

It is unlikely that all parts of a volcanic area will be impacted during an eruption. As a volcano reawakens, real-time monitoring of earthquakes, ground deformation, and gas emissions will provide the information needed to anticipate the vent location and geographic sectors most likely to be impacted. Specific hazards to people and property will depend on the eruption style, the volume of lava erupted, the location of the eruptive vent, and the eruption duration, as well as local meteorological and hydrological conditions.

Specific Points of Simplification

1) This report focuses only on those volcanic regions ranked as moderate, high, or very high threat in the U.S. Geological Survey national volcanic threat assessment (Ewert and others, 2018, available [at https://doi.org/10.3133/sir20185140](https://doi.org/10.3133/sir20185140.)). As such, zones delineated in Clynne and others (2012) for “regional volcanism” surrounding Lassen Volcanic Center are not included. Hazard zones for the Lavic Lake and Amboy Crater areas in Miller (1989) are likewise omitted.

2) Although Coso volcanic field is ranked as a moderate threat in the Ewert and others (2018) threat assessment, it is not included in this report because additional geologic research is needed before hazard zones can be defined.

3) Hazards in the eruption source regions (vents) are compiled as “near-vent” hazard zones in this report. Within near-vent zones, one or more hazards may occur, including pyroclastic flows, unstable lava domes, lava flows, tephra (heavy ash fall), ballistics, lahars, and/or floods. See glossary of terms below.

4) The simplified hazard zones are constrained to those based on past eruptive events, and thus do not include zones delineated in Miller (1989) based on the “unprecedented” events—events which are typical of certain types of volcanoes worldwide, but are not known to have occurred locally. Likewise, “inferred” zones in Miller (1989) were omitted.

5) Various sub-types of ash hazards are delineated in Clynne and others (2012) and Miller (1989). In this report, the sub-types are merged into composite “ash fall” hazard zones. An ash fall hazard zone is not delineated for Medicine Lake Volcano in Donnelly-Nolan and others (2007), thus, this report uses that provided in Miller (1989). New research is needed to identify ash fall hazard zones for Clear Lake volcanic field, Ubehebe Craters, and Salton Buttes.

The Appropriate use of Simplified Hazard Zone Maps

1) Users of the information in this report should be aware that volcanic areas in California are the subject of continuing research and that refinement of volcano hazard zones are sure to come in subsequent years. Hazard zones are meant solely for general awareness and as broad guidance for emergency planning purposes. The simplified hazard zones have insufficient geospatial resolution for use in real estate transactions or for any regulatory purpose.

2) Within a single hazard zone, the severity of hazard from one location to the next can vary on a scale too fine for hazard mapping. Geospatial rendering of hazard zone boundaries provided in this report are of insufficient resolution to definitively determine in all cases whether a particular parcel of land or property lies within or outside a particular zone.

3) Uses of the digital data in this report should not violate the spatial resolution of the data. Although digital data removes the constraint imposed by the scale of paper maps, the level of detail and accuracy inherent in the original map scales are also present in the digital data. Data from the original reports were edited at a scale of 1:500,000 to create simplified hazard zones. Plotting at a higher resolution (zooming in) will not yield greater real detail. Similarly, if this database is overlain with other data of higher resolution, the resolution of the combined output will be limited by the lower resolution of these data.

4) This report provides a digital database for the simplified volcano hazard zones used in the USGS publication SIR 2018-5159 entitled “California’s Exposure to Volcanic Hazards California” (<https://pubs.er.usgs.gov/publication/sir20185159>). The digital database herein features 3500 meter uncertainty bands instead of the sharp lines bounding hazard zones in the exposure analysis.

5) Acknowledgment of the U.S. Geological Survey would be appreciated in products derived from these data. It is suggested that citations should include this report and the original scientific publications from which this report was derived (listed as 1 through 3 above).

Glossary of Hazard Zone Terms

**Ash** Fine fragments (size of a sand grain or smaller) of volcanic rock formed by a volcanic explosion or ejection from a volcanic vent.

**Ballistic** Rock or blobs of molten lava larger in size than volcanic ash that are hurled from the vent like cannonballs during an eruption; usually land within a few miles of the vent.

**Lahar** A mixture of water and volcanic debris that moves rapidly downstream. Consistency can range from that of muddy water to that of wet cement, depending on the ratio of water to debris. Also referred to as volcanic mudflow or debris flow.

**Lava** General term for molten or partly molten rock that has been erupted onto the surface of the Earth.

**Lava dome** A steep-sided, unstable mound of viscous, partially-molten lava extruded from a vent but too viscous to flow far; builds up around the vent.

**Lava flow** Lava flows are fluid rivers of molten rock that travel away from the vent during an eruption. Lava flows can spread across the landscape for many miles, generally at speeds of 30 miles per hour or less.

**Pyroclastic flow** A hot, chaotic mixture of lava fragments, gas, and ash that rush outward from a volcanic vent or collapsing lava dome at speeds of 60 miles per hour or greater. Also referred to as a pyroclastic density current, surge, ignimbrite, or block and ash flow.

**Tephra** A general term for any type and size of rock fragment that is forcibly ejected from the volcano and travels an airborne path during an eruption (including ash and ballistics).

**Vent** Any opening at the Earth’s surface from which lava erupts.

**Volcanic flood** Sudden melting of snow and ice by volcanic heat, sudden release of impounded water, and (or) diversion of water by blocked drainages or breached embankments can cause volcanic floods, with characteristics similar to nonvolcanic flooding.