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Maps Showing Lava Inundation Zones for Mauna Loa, Hawai‘i

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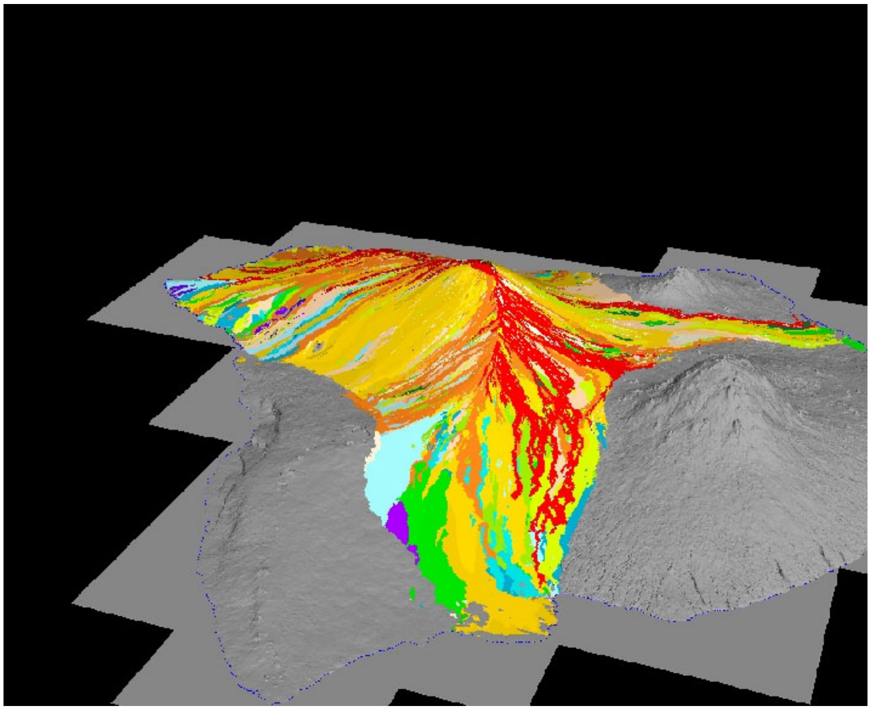
County of Hawai‘i and Federal Emergency Management Administration

Pamphlet to accompany
Miscellaneous Field Studies Map
MF-2401



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Introduction

The Island of Hawai`i is composed of five coalesced basaltic volcanoes (fig. 1). Lava flows constitute the greatest volcanic hazard from these volcanoes. This report is concerned with lava flow hazards on Mauna Loa, the largest of the island shield volcanoes. Hilo lies 58 km from the summit of Mauna Loa, the Kona coast 33 km, and the southernmost point of the island 61 km.

Hawaiian volcanoes erupt two morphologically distinct types of lava, `a`ā and pāhoehoe. The surfaces of pāhoehoe flows are rather smooth and undulating. Pāhoehoe flows are commonly fed by lava tubes, which are well-insulated, lava-filled pipes contained within the flows. The surfaces of `a`ā flows are extremely rough and composed of lava fragments. `Ā`a flows usually form lava channels rather than lava tubes.

In Hawai`i, lava flows are known to reach distances of 50 km or more. The flows usually advance slowly enough that people can escape from their paths. Anything overwhelmed by a flow will be damaged or destroyed by burial, crushing, or ignition.

Mauna Loa makes up 51 percent of the surface area of the Island of Hawai‘i. Geologic mapping shows that lava flows have covered more than 40 percent of the surface every 1,000 years. Since written descriptions of its activity began in A.D. 1832, Mauna Loa has erupted 33 times. Some eruptions begin with only brief seismic unrest, whereas others start several months to a year following increased seismic activity. Once underway, the eruptions can produce lava flows that reach the sea in less than 24 hours, severing roads and utilities. For example, the 1950 flows from the southwest rift zone reached the ocean in approximately three hours (Finch and Macdonald, 1953). The two longest flows of Mauna Loa are pāhoehoe flows from the 1859 and the 1880-81 eruptions, 50 and 48 km long, respectively.

Mauna Loa will undoubtedly erupt again. When it does, the first critical question that must be answered is: Which areas are threatened with inundation? Once the threatened areas are established, we can address the second critical question: What people, property, and facilities are at risk? These questions can be answered by estimating the areas most likely to be affected by eruptions originating on various parts of the volcano. This report contains such estimates, based on the known source vents and areas affected by past eruptions. We have divided the volcano into potential lava inundation zones and prepared maps of these zones, which are presented here on the accompanying map sheets.

Mauna Loa overview

Mauna Loa has a summit caldera and two rift zones (fig. 1). The "summit" is defined as the area above the 11,485-ft (3,500-m) elevation. A deep caldera, Moku‘aweoweo, indents the summit and keeps lava erupted within it from reaching the flanks of the volcano. The two rift zones—elongate fracture systems—extend to the northeast and southwest from the summit (fig. 1). Most of Mauna Loa's eruptive fissures and vents are located at the summit and along the rift zones.

A number of vents, however, lie outside these areas and occurs along fissures that are oriented radially to the summit area; these vents are called radial vents. Two of the 33 historical eruptions occurred from radial vents; an eruption in 1859 originated from a vent on the northwest flank, and an eruption in 1877 emerged from a vent on the west flank. Radial vents occur on the west, northwest, and north flanks at almost any elevation. Because they may occur at lower elevations, radial vents may initiate flows closer to inhabited areas than do summit and rift zone vents. Thus, because of the reduced response time, the risk from radial vent eruptions is generally greater than that from a summit or rift zone eruption.

Geologic mapping of the surface lava flows of Mauna Loa has identified more than 500 flows originating from the summit area, rift zones, or radial vents. These past flows help delineate the approximate pathways of future flows that originate in the same or similar locations.

These inundation-zone maps are part of the ongoing effort to understand the long-term eruptive history of Mauna Loa. This study is sponsored by the U.S. Geological Survey's Hawaiian Volcano Observatory and the County of Hawai‘i, with funds provided by Federal Emergency Management Administration's Project Impact[1].

Purpose

The primary goal of the U.S. Geological Survey’s Hawaiian Volcano Observatory is to provide scientific information that can be used to reduce risks due to volcanic activity. To this end, the Observatory assesses volcanic hazards and educates the public and public officials about those hazards. On the basis of detailed geologic mapping of Mauna Loa,

[1] For more information on FEMA’s Project Impact, see http://www.fema.gov/impact/

we have identified lava flow inundation zones in order to anticipate areas that could be overrun by lava from different source regions. The inundation zones are presented here to assist emergency managers and decision makers during an eruption. Accurate estimates of areas that could be affected by lava flows pouring from specific parts of Mauna Loa are critical for Hawai‘i County to quickly warn people living and working in those areas and to develop and implement plans to deal with the impending crisis. The maps presented here allow decision makers to quickly identify communities, infrastructure, and roads between the coast and possible vent locations. When an eruption starts, the maps will allow emergency managers to identify the plausible downslope areas likely to be impacted and decide how to deploy resources to cope with the event. The maps are intended to make asset allocation more efficient and effective. Although the intent of these maps is to facilitate emergency response activities, the maps can also be used by the public to educate themselves as to which segment of the rift zone or summit can erupt flows into their region and take the appropriate action if lava flow inundation becomes imminent.

Methods

Mapping

Vertical aerial photographs taken in 1977, 1978, and 1984 were used to prepare geologic maps at a scale of 1:24,000. Extensive fieldwork established the boundaries of individual lava flows, and these boundaries were then drawn on the aerial photographs. In those places where terrain and vegetation prevented us from walking along the boundaries, we created a grid and walked along the grid lines. Flow boundaries were then extrapolated from geologic and botanical information encountered along the grid lines. Boundary lines from the aerial photographs were transferred to a stable base map material (mylar) known as a “greenline” with the use of a photogrammetric stereo plotter (Kern model PG-2[2]). Finalized greenline maps were digitized with a sheet scanner, then imported into ArcInfo[2] software, which was used to produce paper maps. The maps are available online at http://geopubs.wr.usgs.gov/docs/wrgis/mf-map.html. Paper copies are available as print-on-demand maps from http://rmmcweb.cr.usgs.gov/public/mod/.

The distributions of mapped lava flows were used in constructing the 17 inundation zones presented in this report. Each inundation-zone map shows an area on the flank of Mauna Loa that could potentially be inundated by future eruptions originating from the summit, rift zones, and/or radial vents. Although any part of an

[2] The use of trade names is for descriptive purposes only and does not imply endorsement by the U. S. Geological Survey.

inundation zone could potentially be overwhelmed by a future eruption, it is more likely that only part of a zone would be buried in a single eruption.

Delineation of inundation zones

Hawaiian Ocean View Estates, Kula Kai, and Hawaiian Ranchos subdivisions are used as an example of how the inundation zones were delineated. The three communities, near the southern extremity of the southwest rift zone, naturally fall into a single risk group (fig. 2). The segment of the rift zone that sent flows in the direction of this region extends from elevations between 6,480- and 2,840-ft (1,975- to 865-m). The black lines represent lava flows that advanced in the direction of the subdivisions from that segment of the rift zone (fig. 3). Flows that originated from the rift segment directly above the target areas were selected and grouped together to form the inundation zone (gray region in fig. 4).

A second example illustrates the importance of topography in controlling lava flow distribution. An eruption between elevations of 11,400 ft and 9,600 ft (3,475 and 2,930 m) on the northeast rift zone of Mauna Loa (fig. 5) could produce two dramatically different outcomes depending on which side of the rift-zone axis the eruptive fissure is located.

(1) Scenario 1: The fissure breaks out on the north side of the rift zone. If the eruption is sufficiently voluminous, it can inundate the Kaūmana area and downtown Hilo.

(2) Scenario 2: If a fissure erupts on the south side of the rift zone axis, the lava will flow toward Hawai`i Volcanoes National Park--a sparsely populated area--and thence to Ka‘ū. The inundation zone in this area shows that Highway 11, as well as forest and pasturelands, could be covered.

Nine maps depicting 17 inundation zones were created for Mauna Loa (fig. 6) following the procedures described above. We recognize that many more homes, small communities, and facilities are scattered around the slopes of Mauna Loa than are explicitly identified in the 17 inundation zone maps. Homes, communities, and facilities that are not specifically identified by inundation zones on the maps should expect lava flow hazards at least at the same level as the communities and facilities that do appear on the maps (Wright and others, 1992).

Mauna Loa’s summit caldera provides a topographic barrier that protects an area to the southeast (fig. 6, area in dark gray) from lava flows. The summit caldera also provides a topographic barrier for an area west of the caldera, but this protection is negated by the presence of radial vents on this flank. Radial vents are absent east of the caldera.

The inundation zones identified on the nine maps are (1) Kaūmana, Waiākea and Volcano-Mountain View; (2) Kapāpala; (3) Pāhala, Punaluʻu, and Wood Valley; (4) Nāʻālehu; (5) Ka Lae; (6) Hawaiian Ocean View Estates (HOVE), Kapuʻa, and Miloliʻi; (7) Hoʻokena, Kaʻohe, and Kaʻapuna; (8) Hōnaunau and Kealakekua and (9) Puakō. The names given are descriptive and are meant to represent the larger geographic regions. The maps are at varying scales, from 1:50,000 to 1:95,000.

User Guidelines

Our intent is that these maps be used as a general guide to assist emergency managers during an eruption, to plan emergency response activities, and to identify communities and infrastructure at risk. Inundation zones do not reflect what *will* be covered by an eruption from a given segment of the rift zone but instead, only the total area that could potentially be affected or impacted.

The following explain some factors that might affect the use of these maps.

(1) Before specific, actual inundation zones can be identified, it is critically important to first identify the specific locations at which lava begins to flow down the volcano's flanks. Radial fissures are apt to send lava downslope immediately. However, the paths of lava flows from rift-zone eruptions may not be immediately apparent because of the great variation in topography within rift zones. Topographically high features include cones and spatter ramparts; topographically low features include ground cracks, old eruptive fissures, lava channels, and down-faulted areas called graben. These features can cause flows to exit the rift zones in unexpected places. Therefore, lava must leave a rift-zone buffer (areas depicted in yellow on the maps) before an actual inundation zone can be identified. This information will most likely come from scientists at the U.S. Geological Survey's Hawaiian Volcano Observatory.

(2) Inundation zones show the total area that can be potentially affected by specified source vents in future eruptions. In a single eruption it is likely that only part of a zone will be inundated.

(3) The boundaries between inundation zones should be considered approximate. The influence of local topographic features on the course of a lava flow is uncertain. The uncertainty in flow direction increases as the slope angle decreases; uncertainty is especially high in areas in which the slope is less than about 5%. Both \`a\`ā and pāhoehoe flows follow the topography, but pāhoehoe flows are more sensitive to minor topographic features. Furthermore, the topography of newly emplaced lava

flows will influence the courses of subsequent flows. Lava may flow out of one inundation zone into an adjacent inundation zone, especially if a lava flow is spreading near a boundary.

References cited

Finch, R.H., and Macdonald, G.A., 1953, Hawaiian volcanoes during 1950: U.S. Geological Survey Bulletin 996-B, p. 27-89.

Wright, T.L., Chu, J.Y., Esposo, J., Heliker, C., Hodge, J., Lockwood, J.P., and Vogt, S.M., 1992, Map showing lava-flow hazard zones, island of Hawaiʻi: U.S. Geological Survey Miscellaneous Field Studies Map MF-2193, scale 1:250,000.

Maps Sheets

Sheet 1. Index showing inundation zones on the flanks of Mauna Loa.

Sheet 2. Kaūmana, Waiākea, and Volcano-Mountain View

Sheet 3. Kapāpala

Sheet 4. Pāhala, Punaluʻu, and Wood Valley

Sheet 5. Nāʻālehu

Sheet 6. Ka Lae

Sheet 7. HOVE, Kapuʻa, and Miloliʻi

Sheet 8. Hoʻokena, Kaʻohe, and Kaʻapuna;

Sheet 9. Hōnaunau and Kealakekua

Sheet 10. Puakō.

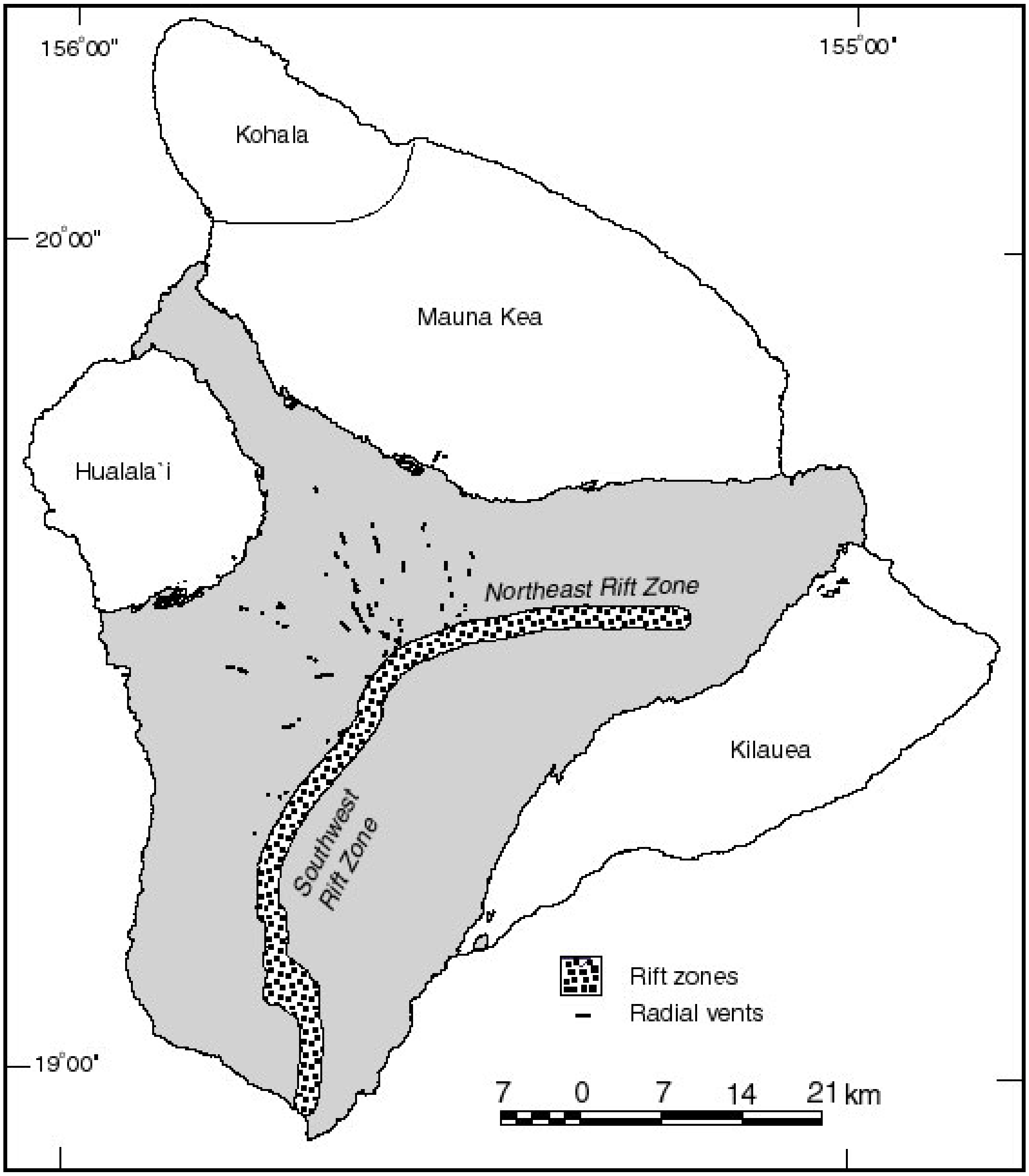

Figure 1. Subaerial volcanoes of the Island of Hawai'i. Mauna Loa shown in gray with rift zones stippled and radial vents depicted by thick black lines on Mauna Loa's north and west flanks.

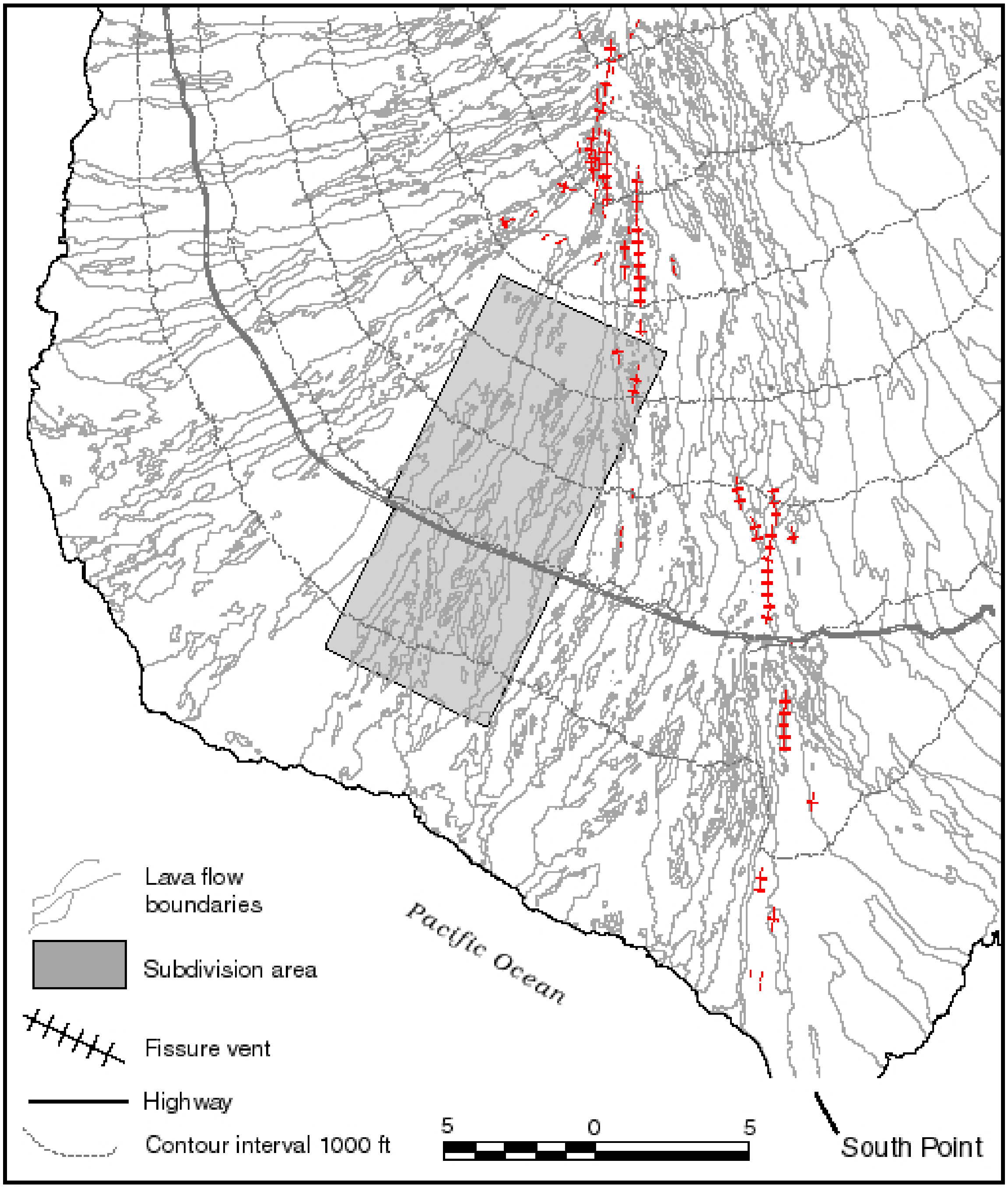

Figure 2. A target area, shown as gray rectangle, is identified in this example. Target area shown includes Hawaiian Ocean View Estates, Kula Kai, and Hawaiian Ranchos.

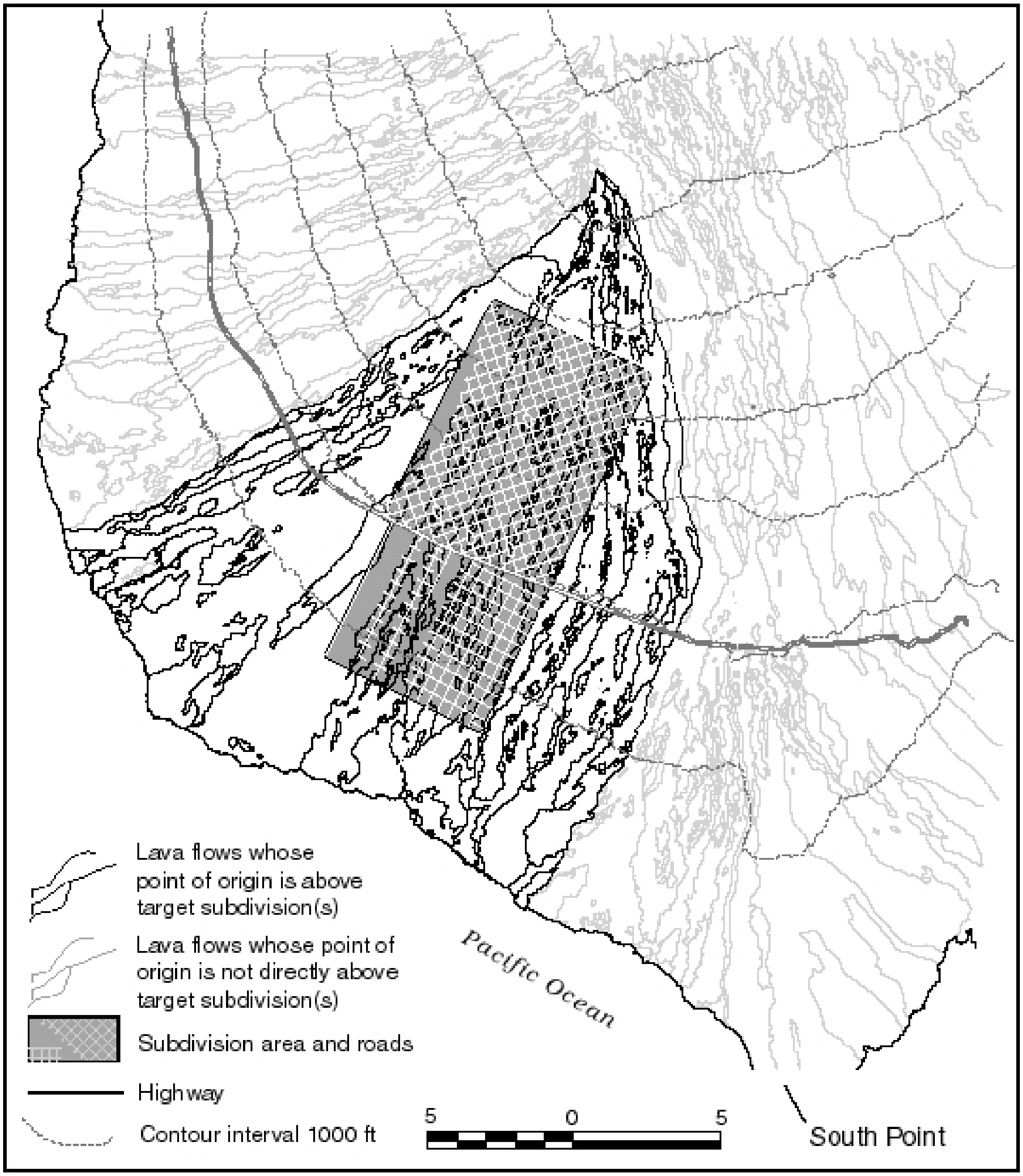

Figure 3. The rift-zone segment affecting the target area. The black lines represent lava flows that advanced in the direction of the subdivisions from that segment of rift zone.

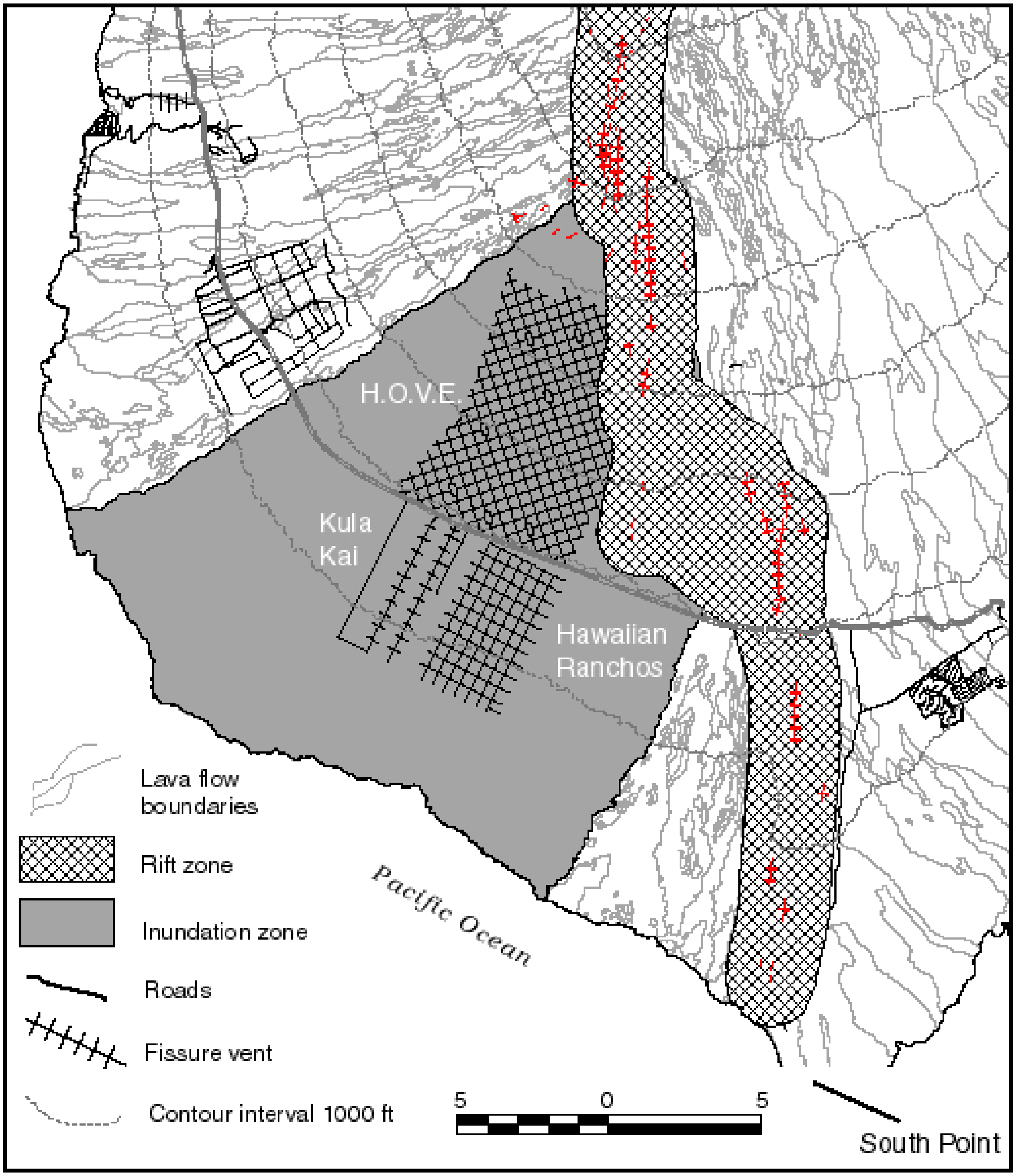

Figure 4. Flows that originated from the rift segment directly above the target area are grouped together to form the inundation zone (region in gray).

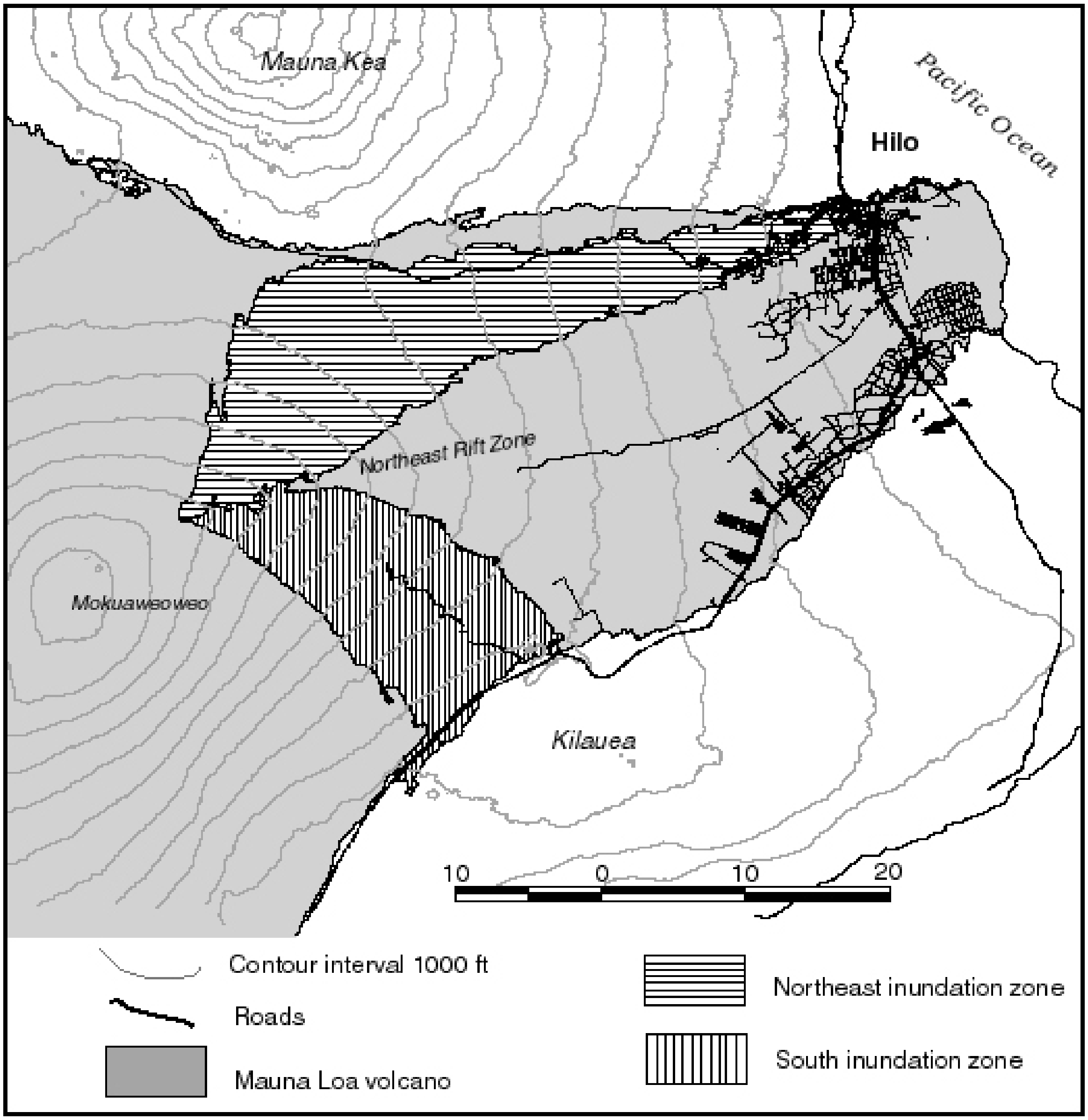

Figure 5. Lava erupting from a segment of Mauna Loa's northeast rift zone can have different impacts depending on which side of the topographic high along the rift zone the eruption occurs. Lava that erupts on the north side may impact Kaūmana and downtown Hilo. Flows on the south side, however, can cross land of Hawai‘i Volcanoes National Park and Kapāpala Ranch and eventually obstruct Highway 11.

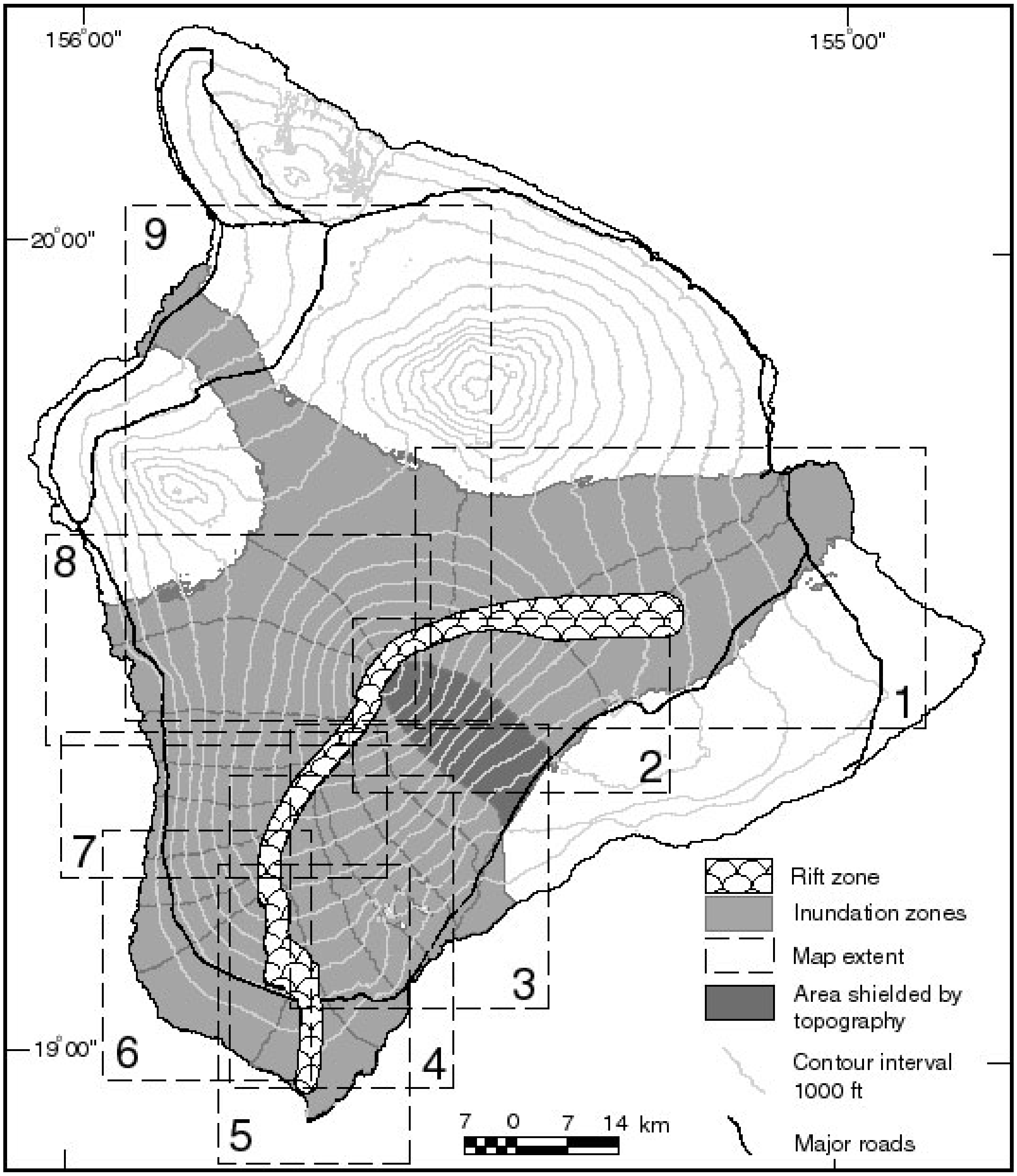

Figure 6. Inundation zones shown on map sheets. The dark gray zone is an area shielded by the caldera rim.