

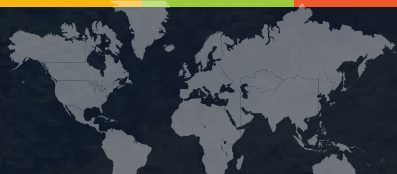
# RISK ASSESSMENT

## KĪLAUEA ERUPTION RISK ASSESSMENT 2018 BIG ISLAND, HAWAII

(VERSION 1.0, 2019)



 **PDC** | GLOBAL





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# AN **INTRODUCTION** TO THE **KĪLAUEA ERUPTION RISK ASSESSMENT ASSESSMENT (KERA)**

In late April of 2018, the collapse of Kīlauea Volcano's Pu'u O'o vent initiated a series of eruptive events in the lower East Rift Zone of the Puna District of Hawaii. On May 3rd lava erupted in the Leilani Estates subdivision, and over a two-week period, 24 fissures opened along a 4.2 mile stretch of Lava Zone 1, the part of the volcano most frequently affected by volcanic activity. On May 4, 2018, amid swarms of smaller earthquakes, a larger magnitude 6.9 earthquake centered 19 kilometers SSW of Leilani Estates occurred, adding to the stress and disruption already experienced by Hawai'i residents. A major disaster declaration was announced May 11, 2018.<sup>1</sup>

Since the eruption, Hawai'i County disaster managers, planners and other stakeholders have worked to assess damage and advance recovery efforts, grappling with the numerous challenges facing communities living on the slopes of an active volcano. In support of the county's efforts, Pacific Disaster Center conducted a Risk and Vulnerability Assessment (RVA) that examines the county's exposure to volcanic hazards and the socio-economic conditions that contribute to vulnerability. The goal of the assessment is to provide Hawai'i County and vested stakeholders data and information for decision-support focused on volcanic disaster risk and vulnerability identification.





# KĪLAUEA ERUPTION EVENT SUMMARY

## LAVA ZONE 1



# 24

FISSURES OPENED



# M6.9

EARTHQUAKE 19 KM SSW OF LEILANI ESTATES

# 8,000+

 ACRES OF LAND

CONSUMED BY LAVA



# 3,000+

RESIDENTS  
DISPLACED



# 700+

STRUCTURES  
DESTROYED



# 58 MILES

OF ROADWAYS ENGULFED  
BY LAVA



**CLOSED**

GEOTHERMAL  
POWER PLANT  
PROVIDING 22% OF  
POWER SUPPLY



## ECONOMIC IMPACT

# \$236.5 MILLION

IN DAMAGES TO CRITICAL INFRASTRUCTURE  
AND FACILITIES

In just over three months, the equivalent of eight years of Kīlauea's magma supply engulfed over 13.7 square miles, creating 875 acres of new land.

Entire neighborhoods and more than 700 structures were completely destroyed, displacing over 3,000 residents. Lava engulfed 58 miles of roadways and closed the Puna Geothermal Venture power plant which had been providing 22% of the island's power supply prior to the event. Damages to roads, waterlines and facilities totaled \$236.5 million.<sup>2</sup>

Volcanic gases and airborne particulates resulting from the eruption were severe, elevating health concerns and significantly impacting agricultural crops. Damage assessments conducted after the event estimated farm losses at \$27.9 million.<sup>3</sup>

Tourism to the island also suffered, partly due to the 4-month closure of Hawai'i Volcanoes National Park. Economic impacts to the county exceeded \$100 million. By September 2018, all surface volcanic activity had ceased.

<sup>1</sup> <http://www.hawaiicounty.gov/kilauea-eruption-recovery> Accessed 7 May 2019.

<sup>2</sup> County of Hawaii. Kīlauea Eruption: Recovery Fact Sheet. May 2019.

<sup>3</sup> Ibid.

# APPLYING RESULTS

## KĪLAUEA ERUPTION RISK ASSESSMENT

Results from this assessment provide Hawai'i County stakeholders with a repeatable, data-driven approach for assessing and communicating risk. Results can be used to help anticipate challenges before, during, and after a disaster; as well as prioritize actions and identify potential leverage points to support sustainability.



### COMMUNICATE RISK & EMPOWER COMMUNITIES

- + Inform residents and property owners at greatest risk about the potential impacts of volcanic hazards.
- + Strengthen the capacity of communities to prepare for and respond to future events.



### INFORM LAND USE AND DEVELOPMENT PLANS & POLICIES

- + Inform new plans/policies for areas where repeated impacts due to volcanic activity may be expected.



### STRENGTHEN DISASTER MANAGEMENT

- + Anticipate where alternative evacuation routes may be needed.
- + Identify communities that may require additional time or assistance to evacuate.
- + Tailor hazard messaging and warning information.
- + Stage disaster supplies for populations with special needs.
- + Prioritize community outreach efforts.



### PRIORITIZE ACTIONS FOR MITIGATION & RECOVERY

- + Identify mitigation measures aimed at reducing risk to volcanic hazards.
- + Develop strategies to speed recovery in economically disadvantaged communities.
- + Restore/upgrade infrastructure to improve access to communications and critical services (e.g., medical care).



# HAWAI'I COUNTY BACKGROUND

## 1 MITIGATE RISK ASSOCIATED WITH VOLCANIC HAZARDS

One of the county's long-term recovery strategies is to mitigate risk associated with volcanic hazards. An update of the county's Hazard Mitigation Plan is underway and will be completed by 2020. One of the goals expressed by stakeholders is to identify volcanic hazard mitigation strategies that could include modifications to land use policies and/or buy-outs of properties at greatest risk. Assessment results can assist the county by providing the justification and rationale for the selection and prioritization of mitigation measures for volcanic hazards.

## 2 INFORM LONG-RANGE AND COMMUNITY PLANS

Hawai'i County is in the process of updating its General Plan, including long-range planning, and will subsequently be updating community plans. In addition to supporting recovery efforts, assessment results may be used to inform existing and future plans and policies for land use and development.

## 3 SUPPORT COMMUNITY OUTREACH ABOUT RISKS

Over the course of the assessment, stakeholders stressed the importance of community outreach efforts, and from experience recognize that while some communities are well-prepared for volcanic hazards, others are not. The assessment can serve as a tool to inform residents and property owners of their risk to the impacts of volcanic hazards and support awareness and preparedness campaigns in Hawai'i's communities.

## 4 IDENTIFY VULNERABLE COMMUNITIES AND THEIR SPECIFIC NEEDS

The county has had the foresight to establish access to unimproved or government-owned roads that can be used for the purposes of evacuation during an eruption, but recognize that due to the remoteness of, and limited infrastructure serving some communities, challenges remain with regard to the penetration of warning messages and the ability of residents to evacuate in a timely manner. The Vulnerability component of the assessment, in particular, provides disaster managers, decision makers and service providers with additional insight into those communities that have special needs, limited economic resources, or are non-English speaking, and the implications for preparedness, evacuation, warning, and recovery assistance.



**KERA**

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# **METHODOLOGY & OBJECTIVES**

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**OVERVIEW**



# METHODOLOGY

## MEASURING RISK



**Volcanic  
Multi-hazard Exposure**



**Vulnerability**



**Volcanic  
Multi-hazard Risk**

The KERA risk model is an adaptation of the Pressure and Release Model (PAR) of disaster risk which characterizes disasters as a function of socioeconomic conditions and physical hazard exposure. The PAR proved useful for this assessment because it was designed to demonstrate the potential consequences of exposure to populations who are socially vulnerable. The model allows for the examination of root causes of vulnerability that lead to conditions that would make hazard exposure unsafe for the population and, by extension, lead to a disaster.<sup>4</sup>

### OBJECTIVE

Reliably assess risk associated with volcanic hazards and identify factors that may adversely affect the ability of communities to adapt to or respond to volcanic hazard exposure. Inform long-range planning, community plans, and support effective disaster management decision making and communication strategies.

The Kīlauea Eruption Risk Assessment (KERA) is based on a composite index approach. It is a scaled version of PDC's Risk and Vulnerability Assessment that investigates the underlying conditions that lead to increased risk. The assessment combines several components of risk which include multi-hazard volcanic exposure and vulnerability to determine an area's relative likelihood of experiencing lasting disruption (e.g., enhanced impacts, inability to recover) due to exposure to hazards associated with volcanic activity on the island of Hawaii. A composite index takes measurable data and combines it into subcomponents that represent distinct areas of hazard exposure

and disaster vulnerability. The resulting index provides a score representing the ranking of each area relative to others by disaster risk. This approach allows users to examine the data representing underlying conditions that contribute to overall scores.

<sup>4</sup> PAR model developed by Blaikie, et al. (1994)

# METHODOLOGY

## RISK ASSESSMENT SUBCOMPONENTS

### VOLCANIC MULTI-HAZARD EXPOSURE



**Lava Flows**



**Cinder Cones**



**Eruptive Fissures**



**Pit Craters**



**Volcanic Gases**



**Graben and Caldera Faults**



**Earthquakes**

### AVERAGE SCORE

The assessment measures exposure to the hazards above. All hazards directly associated with volcanic activity were assessed, and the geographic extent of these hazards fell completely within Lava-flow Hazard Zones 1 and 2 as established by the U.S. Geological Survey.<sup>5</sup> (Reference Lava and Seismic Zone Maps, pages 9 and 10.)

### VULNERABILITY



The assessment measures vulnerability using an adaptation of the Center for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry’s (CDC/ATSDR) Social Vulnerability Index.<sup>6</sup> The assessment leverages the CDC/ATSDR methods for US Census data aggregation along with PDC’s approach for assessing relative disaster risk of communities.

The geometric mean was used to calculate the Vulnerability Index to ensure that a high score in one area was not counteracted by a lower score in another. This gives the end-user a clearer picture of vulnerability not obscured by the total number of subcomponents included, and accurately represents the multiplicative relationship.

<sup>5</sup> Wright, T.L., Chun, J.Y.F., Exposito, Jean, Heliker, Christina, Hodge, Jon, Lockwood, J.P., and Vogt, S.M., 1992, Map showing lava-flow hazard zones, Island of Hawaii: U.S. Geological Survey Miscellaneous Field Studies Map MF-2193, scale 1:250,000.

<sup>6</sup> Flanagan, Barry E.; Gregory, Edward W.; Hallisey, Elaine J.; Heitgerd, Janet L.; and Lewis, Brian (2011) “A Social Vulnerability Index for Disaster Management,” Journal of Homeland Security and Emergency Management: Vol. 8: Iss. 1, Article 3.



# METHODOLOGY

## KEY CONCEPTS

### CONCEPTS AND DEFINITIONS



**VOLCANIC MULTI-HAZARD EXPOSURE:** A volcanic multi-hazard exposure analysis plots the geographic extent of major volcanic hazards and inventories the people, property, and other elements subject to potential losses within those corresponding zones. The assessment considers both raw and relative multi-hazard exposure. Raw multi-hazard exposure estimates the number of people exposed per census unit, while relative multi-hazard exposure represents the number of people exposed divided by the total population of the census unit. The average of both raw and relative exposure scores results in the overall volcanic Multi-hazard Exposure Index.



**VULNERABILITY:** Vulnerability provides visibility into the underlying socioeconomic and societal factors that predispose a population to disasters. Unique aspects of vulnerability are represented by five sub-components:

**Household Composition:** A measure of households containing one or more groups identified as more vulnerable to the negative impacts of natural disasters.

**Socioeconomic Status:** A measure of the proportion of the population that is less likely to have the necessary economic resources to adequately prepare for or recover from a natural disaster.

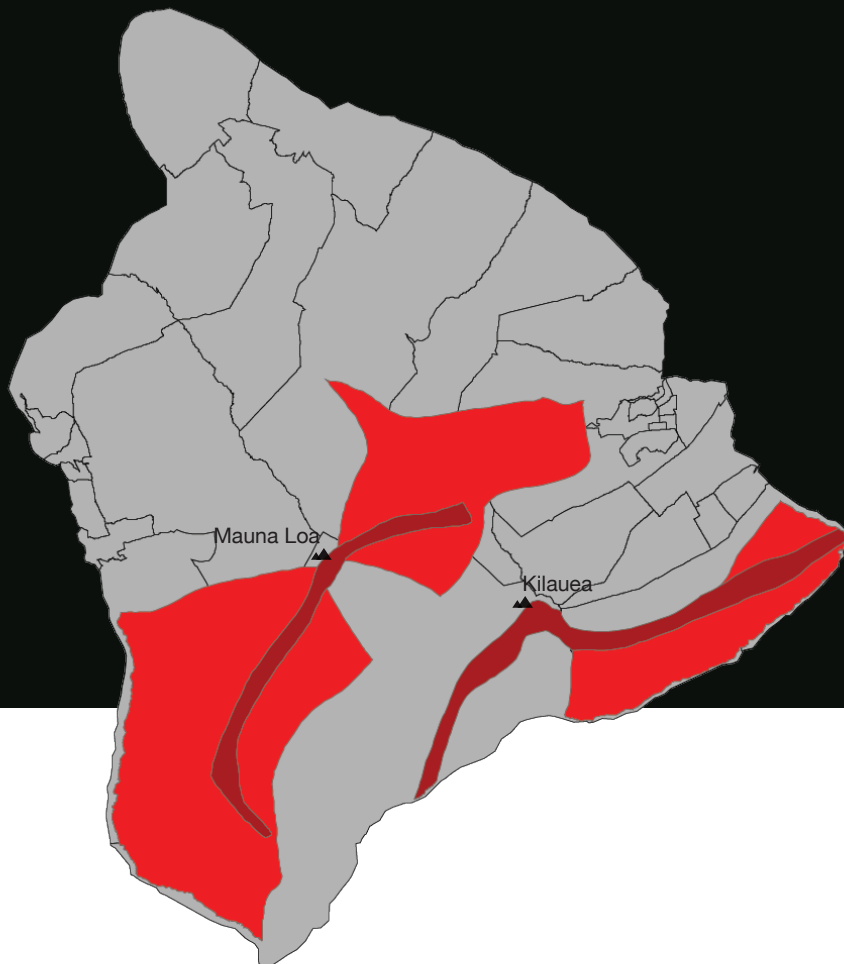
**Access to Information:** A measure of the population's ability to receive, comprehend and appropriately act on complex messaging with regard to natural disasters.

**Housing and Transportation:** A measure of the proportion of the population who may experience housing and transportation issues that increase potential natural disaster vulnerability.

**Access to Lifelines:** A measure of the population's access to critical services such as access to transportation routes and medical services.

## MAP

# LAVA ZONES ASSESSED



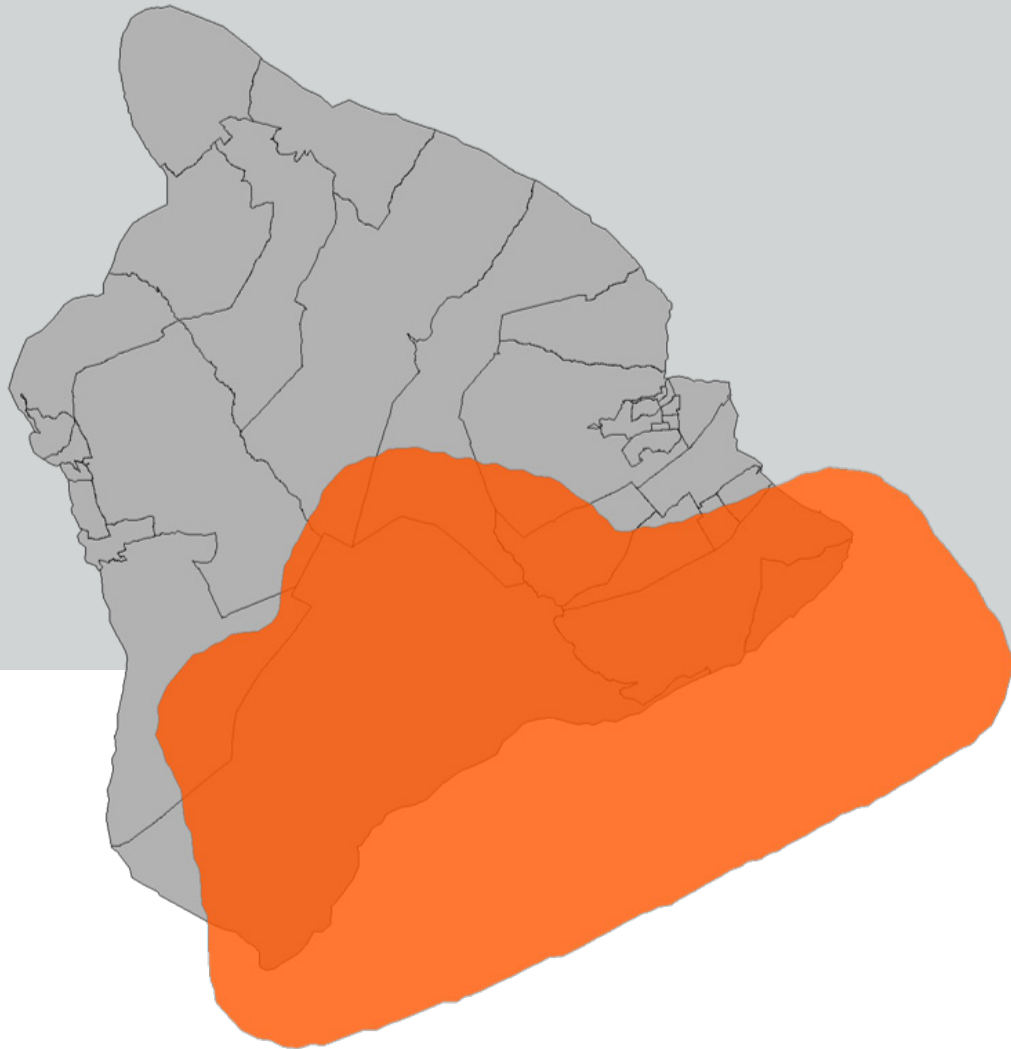
- **ZONE 1:** Includes summits and rift zones of Kilauea and Mauna Loa, where vents have been repeatedly active in historical time.
- **ZONE 2:** Areas adjacent to and downslope of Zone 1. Fifteen to twenty-five percent of Zone 2 has been covered by lava since 1800, and 25 to 75 percent has been covered within the past 750 years. Relative hazard within Zone 2 decreases gradually as one moves away from Zone 1.<sup>7</sup> [Lava Zones 1 and 2 were deemed adequate proxies for all volcanic hazards with the exception of earthquakes.](#)

<sup>7</sup> Klein, F.W., Frankel, A.D., Mueller, C.S., Wesson, R.L., and Okubo, P.G., 2000, Seismic-Hazard Maps for Hawaii: U.S. Geological Survey Geologic Investigations Series I-27724, Version 1.0.



# MAP

## SEISMIC ZONE ASSESSED



Seismic exposure zone represents areas with Peak Ground Acceleration (PGA) greater than or equal to 120%g. This threshold roughly corresponds to Seismic Design Code E (~125%g). PGA is a measure of ground shaking at a given location.

Exposure was estimated using 2017 American Community Survey 5-year population estimates at the block group level, in combination with building locations supplied by Hawaii County (2018). Block group populations were equally distributed to all buildings. Buildings within the hazard zones were considered exposed. Populations are estimated using the total number of buildings exposed and the average persons per building in each block group. Exposures were aggregated to the census tract level for tract analysis.





**KERA**

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# **RISK AND VULNERABILITY**

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## **ASSESSMENT RESULTS**

The KERA assessment seeks to describe those areas where populations exposed to volcanic hazards experience conditions that may adversely affect their ability to adjust, respond, and/or adapt to the effects of the exposure.



# MULTI-HAZARD RISK CENSUS TRACT RESULTS

Multi-hazard risk was assessed by combining components of volcanic multi-hazard exposure and vulnerability—focusing on 11 census tracts and 25 block groups.

## COMPONENTS OF RISK



Volcanic  
Multi-hazard  
Exposure



Vulnerability



**61,320**

PEOPLE EXPOSED

**26,084**

BUILDINGS EXPOSED

**41%** **25,325**

PEOPLE LIVING IN HIGH OR VERY HIGH RISK ZONES

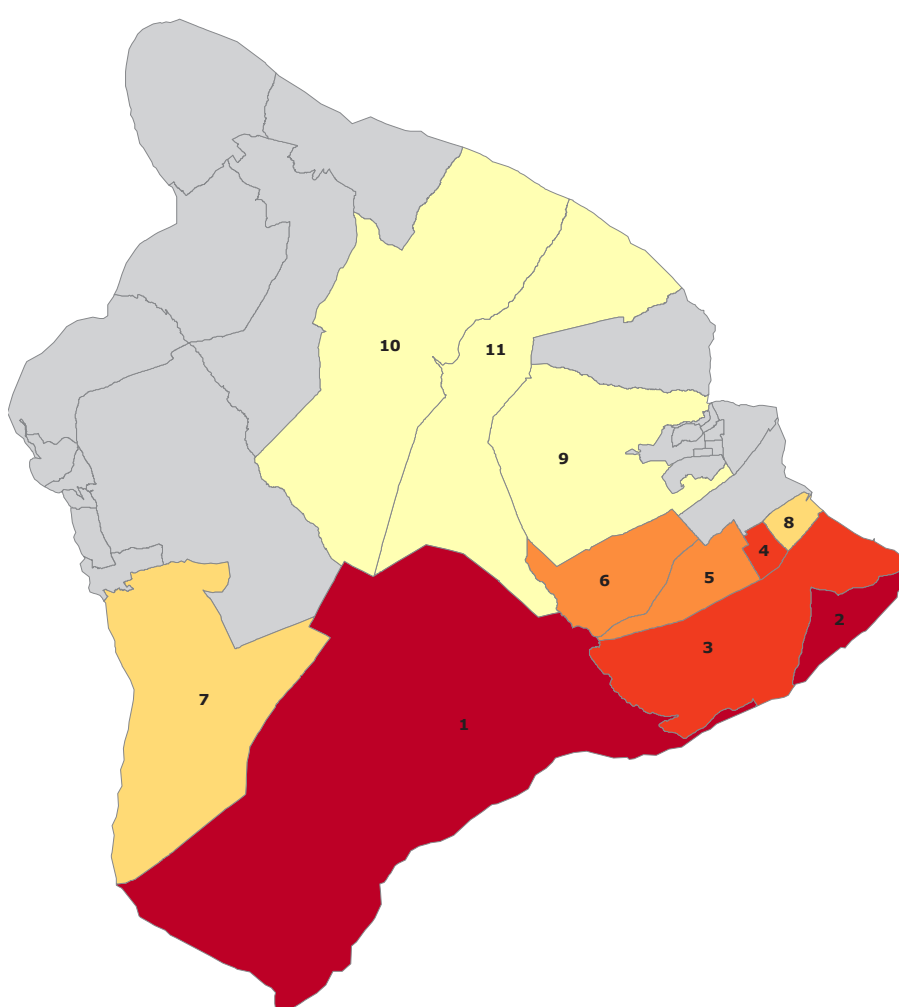


**42%** **10,989**

BUILDINGS IN HIGH OR VERY HIGH RISK ZONES

## MULTI-HAZARD RISK BY CENSUS TRACT

Lava associated with the 2018 eruption occurred primarily within census tract 211.01, with some flow within tract 211.06 (ranked as the 3rd highest risk). Census tracts 212.02 and 211.01 have the highest risk to volcanic hazards, scoring 'very high' on the Multi-Hazard Risk Index.



- Very High
- High
- Moderate
- Low
- Very Low

VMHE RANK	CENSUS TRACT	VMHE INDEX
1	Census Tract 212.02	0.708
2	Census Tract 211.01	0.688
3	Census Tract 211.06	0.663
4	Census Tract 210.03	0.593
5	Census Tract 210.10	0.549
6	Census Tract 210.11	0.462
7	Census Tract 213	0.439
8	Census Tract 210.05	0.430
9	Census Tract 202.02	0.303
10	Census Tract 220	0.226
11	Census Tract 221.02	0.189

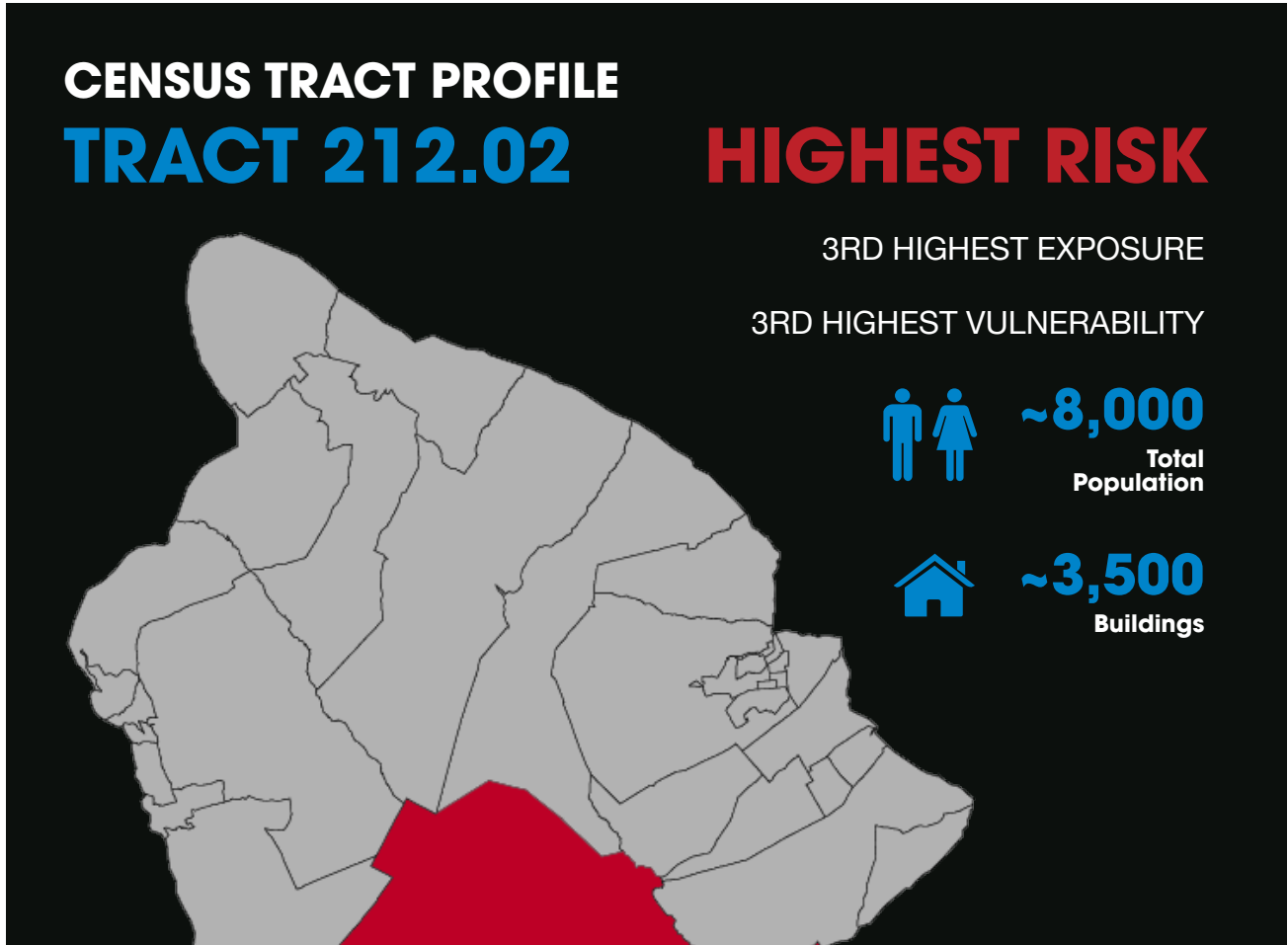
# CENSUS TRACT PROFILE

## TRACT 212.02

# HIGHEST RISK

3RD HIGHEST EXPOSURE

3RD HIGHEST VULNERABILITY



**~8,000**  
Total  
Population



**~3,500**  
Buildings

212.02



- 30% of population is under 18 yrs of age
- 18% of population is over 65 yrs of age
- 16% of population are disabled



- 12% unemployment rate
- 32% of population under poverty line
- 30% of population are receiving food assistance



- 5% of population are non-English speakers
- 33% of population has no internet access
- 3% of population has no phone

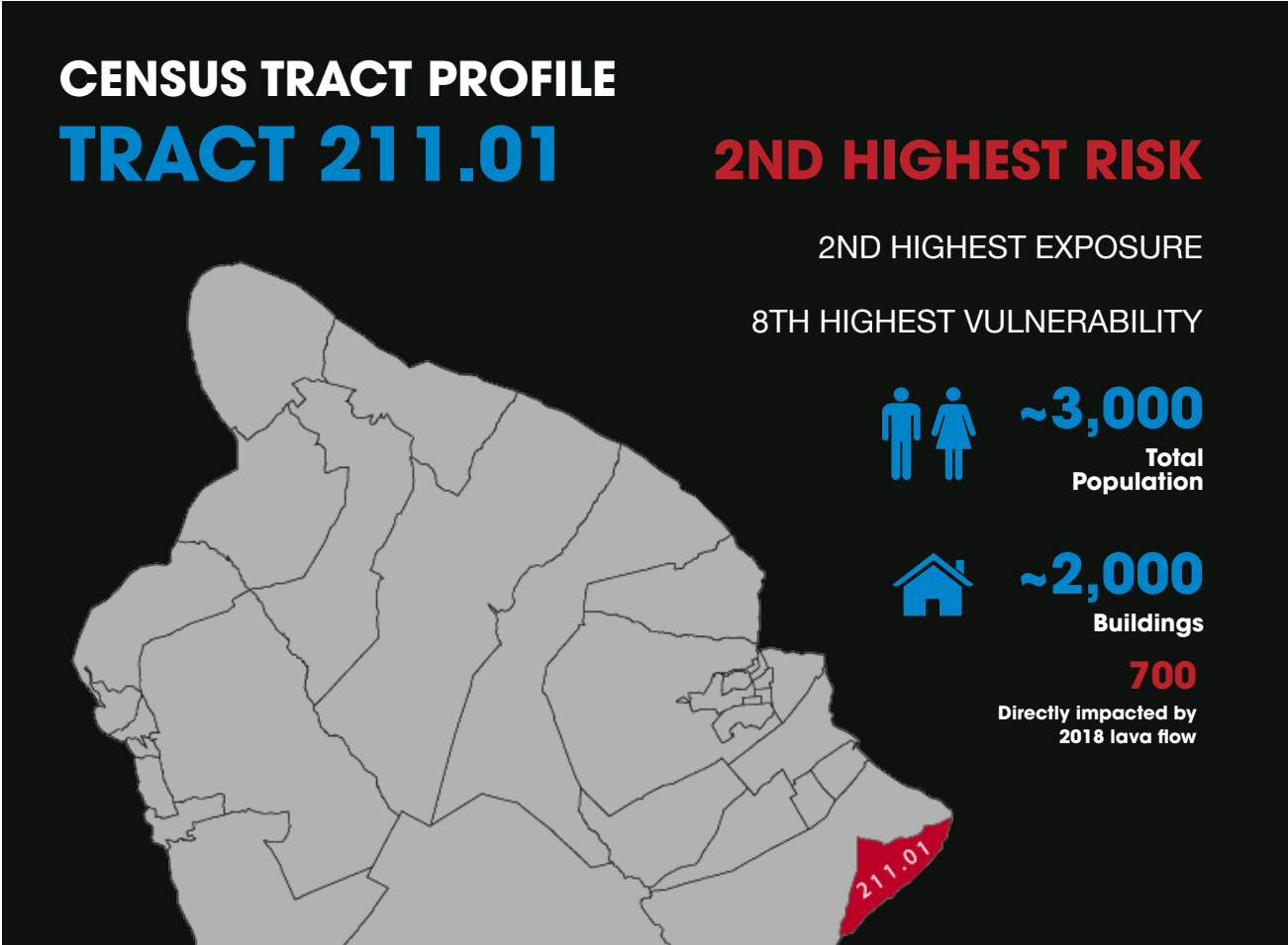


# CENSUS TRACT PROFILE TRACT 211.01

## 2ND HIGHEST RISK

2ND HIGHEST EXPOSURE

8TH HIGHEST VULNERABILITY



**~3,000**  
Total  
Population



**~2,000**  
Buildings

**700**  
Directly impacted by  
2018 lava flow



- 14% of population is under 18 yrs of age
- 30% of population is over 65 yrs of age
- 16% of population are disabled



- 14% unemployment rate
- 29% of population under poverty line
- 25% of population are receiving food assistance



- 29% of households have no internet access
- 4% of households have no phone







# MULTI-HAZARD RISK BLOCK GROUP RESULTS



**52,722**

PEOPLE EXPOSED

**22,236**

BUILDINGS EXPOSED

**42%**

**22,101**

PEOPLE LIVING IN HIGH OR VERY HIGH RISK ZONES



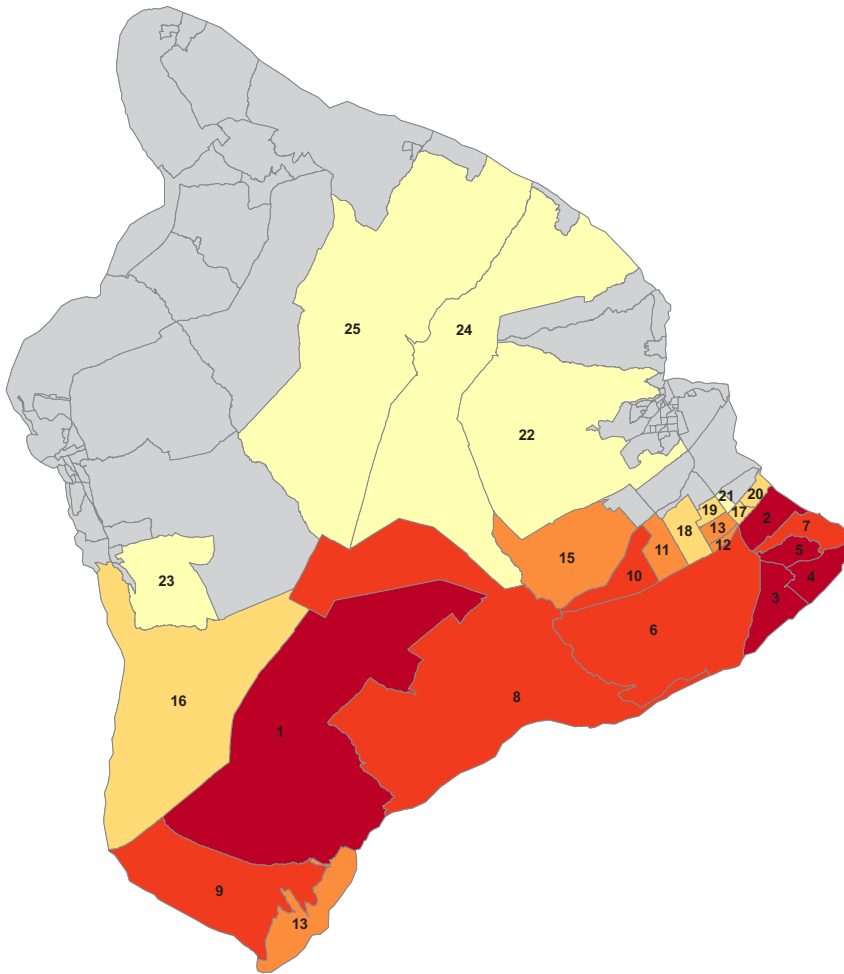
**42%** **9,349**

BUILDINGS IN HIGH OR VERY HIGH RISK ZONES

## MULTI-HAZARD RISK BY BLOCK GROUP

Five block groups were assessed as having 'very high' risk. Demographic information for the two highest ranking block groups follows.

- Very High
- High
- Moderate
- Low
- Very Low



VMHE RANK	BLOCK GROUP	CENSUS TRACT	VMHE INDEX
1	Block Group 2	Census Tract 212.02	0.788
2	Block Group 3	Census Tract 211.06	0.741
3	Block Group 1	Census Tract 211.01	0.653
4	Block Group 2	Census Tract 211.01	0.617
5	Block Group 4	Census Tract 211.06	0.609
6	Block Group 1	Census Tract 211.06	0.594
7	Block Group 2	Census Tract 211.06	0.550
8	Block Group 1	Census Tract 212.02	0.472
9	Block Group 3	Census Tract 212.02	0.471
10	Block Group 1	Census Tract 210.10	0.456
11	Block Group 2	Census Tract 210.10	0.444
12	Block Group 3	Census Tract 210.03	0.432
13	Block Group 1	Census Tract 210.03	0.423
13	Block Group 4	Census Tract 212.02	0.423
15	Block Group 1	Census Tract 210.11	0.419

# BLOCK GROUP PROFILE

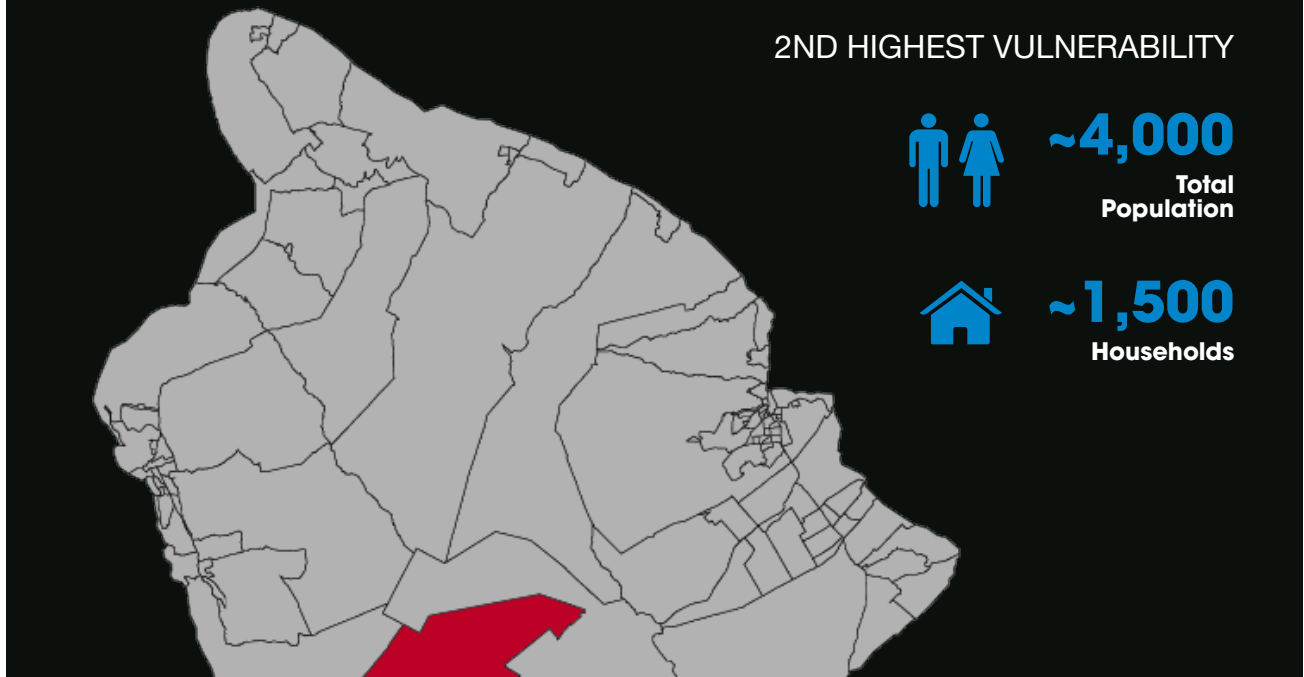
## BLOCK GROUP 2

## HIGHEST RISK

CENSUS TRACT 212.02

HIGHEST EXPOSURE

2ND HIGHEST VULNERABILITY



**~4,000**  
Total  
Population



**~1,500**  
Households



- 33% of population is under 18 yrs of age
- 15% of population is over 65 yrs of age
- 14% of population live in conditions classified as 'crowded housing' by US Census



- 15% unemployment rate
- 3rd lowest per capita income in the county



- 33% of households have no internet access
- 4% of households have no phone access



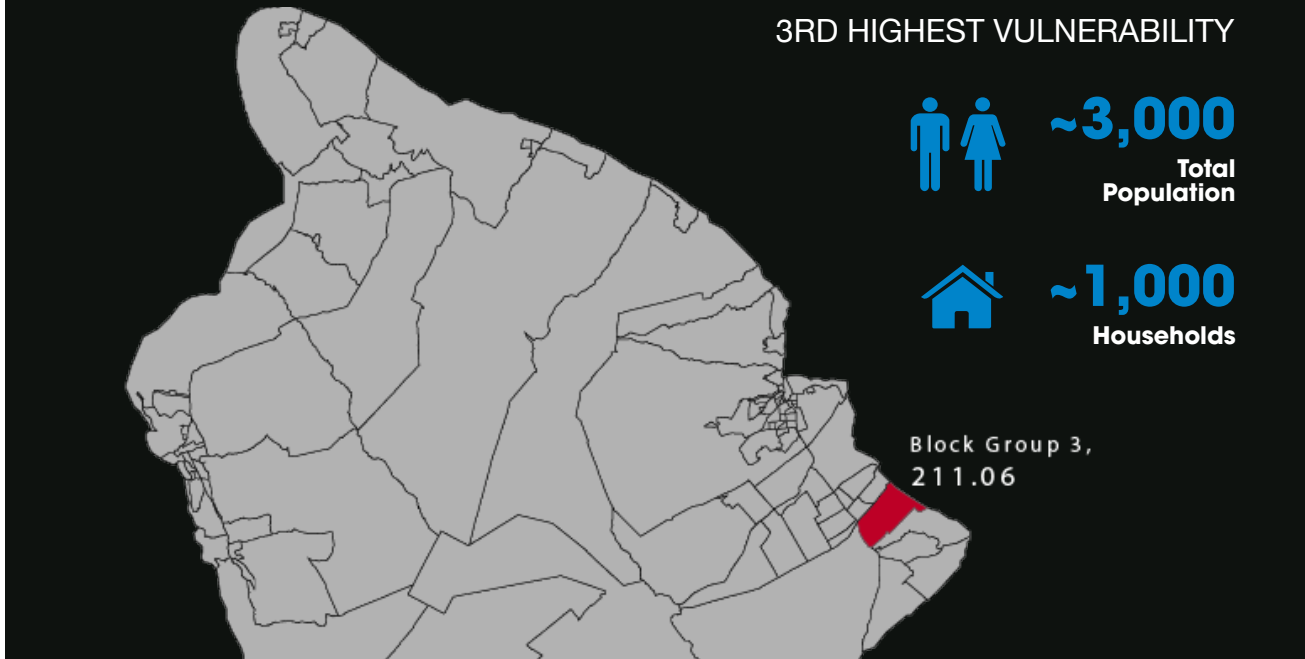
# BLOCK GROUP PROFILE

## BLOCK GROUP 3 2ND HIGHEST RISK

CENSUS TRACT 211.06

2ND HIGHEST EXPOSURE

3RD HIGHEST VULNERABILITY



 **~3,000**  
Total Population

 **~1,000**  
Households

Block Group 3,  
211.06



- 27% of population is under 18 yrs of age
- 15% of population is over 65 yrs of age
- 12% of population live in conditions classified as 'crowded housing' by US Census



- 25% unemployment rate
- 8th lowest per capita income in the county



- 41% of households have no internet access
- 2% of households have no phone



**KERA**

# **VULNERABILITY INDICATORS**

**RESULTS BREAKDOWN**

# VULNERABILITY CENSUS TRACT RESULTS






The vulnerability assessment was performed at both the census tract and census block group levels using 2017 U.S. Census American Community Survey (ACS) data. However, not all demographic data collected at the census tract level are published at the census block group level in order to protect the privacy of those surveyed. While analyses differ somewhat, results show that the main drivers of vulnerability remained consistent.

Examining the drivers of vulnerability offer opportunities to more effectively target mitigation activities and social development initiatives to benefit at-risk communities.

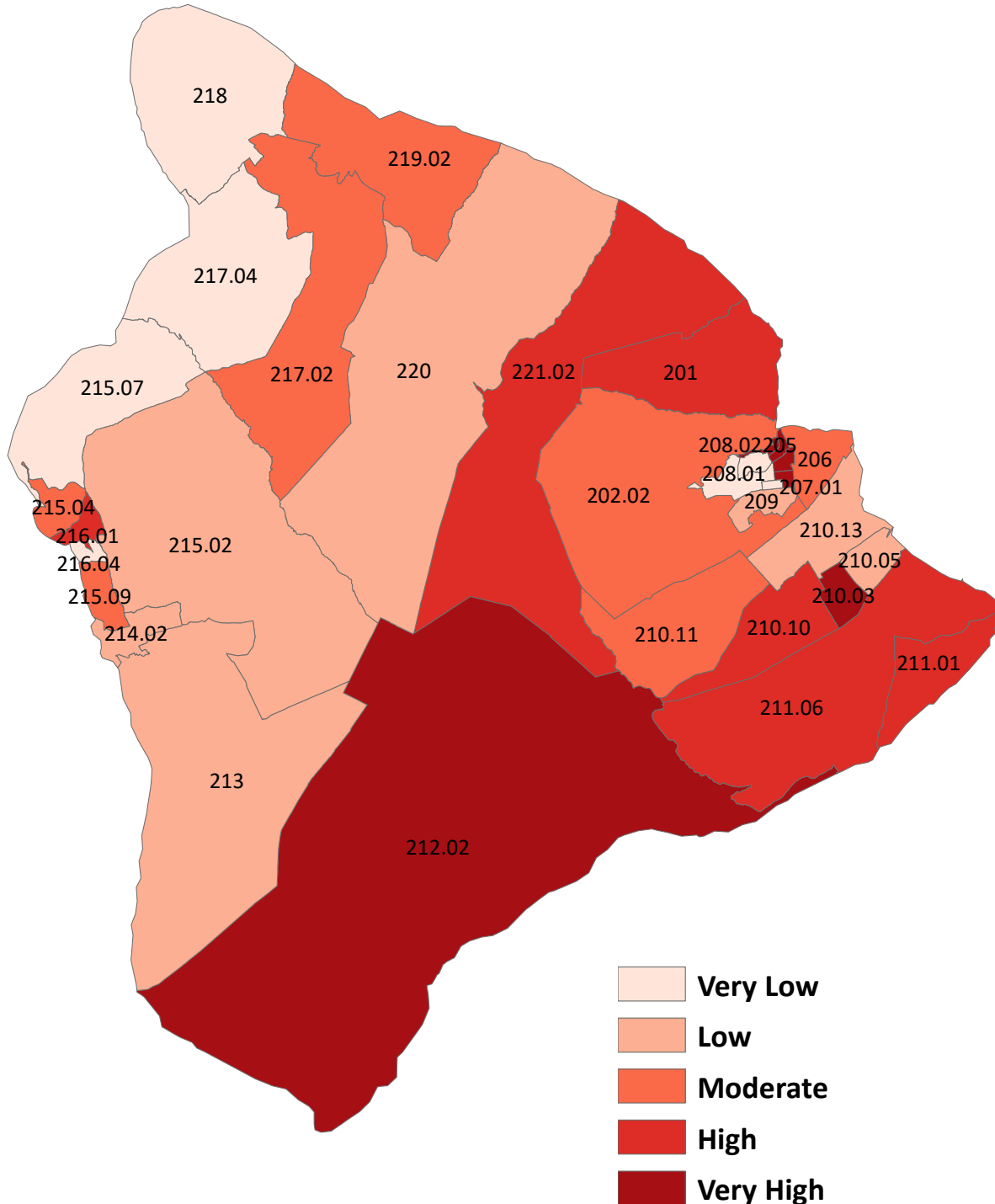
## VULNERABILITY SUBCOMPONENTS



## Indicators

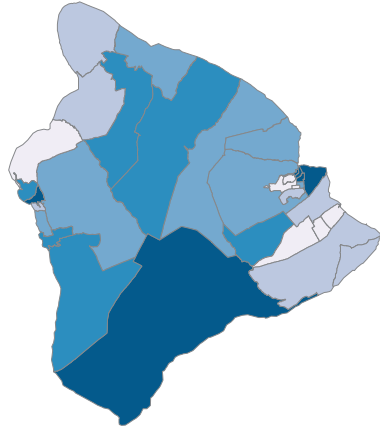
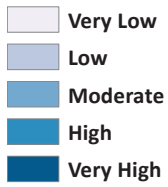
 Percent of Population Older than 65  Percent of Population younger than 18  Percent of Population that is Disabled  Percent Single Parent Households	 Percent Household Crowding  Percent of Structures with 10 or More Units  Percent of Houses Built before 1950  Percent of Households without a Vehicle	 Percent of Households w/out Telephone  Percent Non-English Speakers  Percent of Households without Internet	 Percent of Population without HS Diploma  Unemployment Rate  Percent Receiving Food Stamps/SNAP  Percent below Poverty Line  Per Capita Income	 Percent of Population without Health Insurance  Road Network Density
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# VULNERABILITY CENSUS TRACT RESULTS

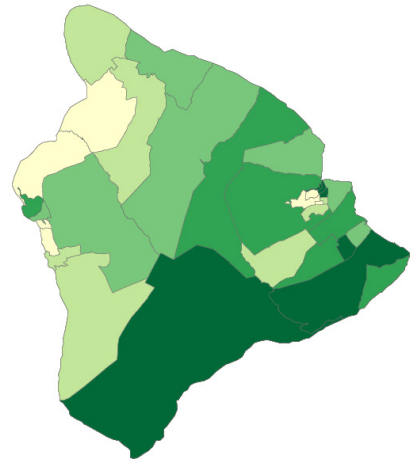
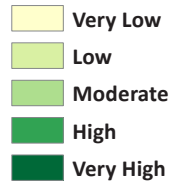




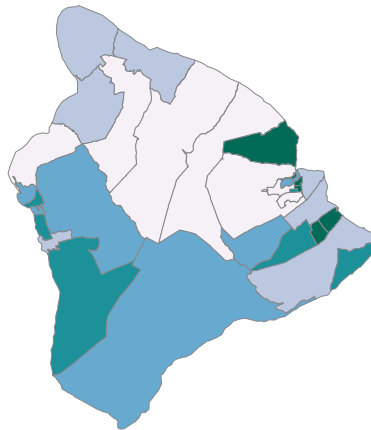
**Vulnerable Housing and Transportation Index**



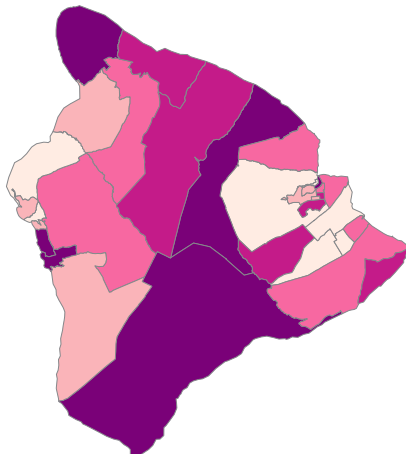
**Vulnerable Socioeconomic Status index**



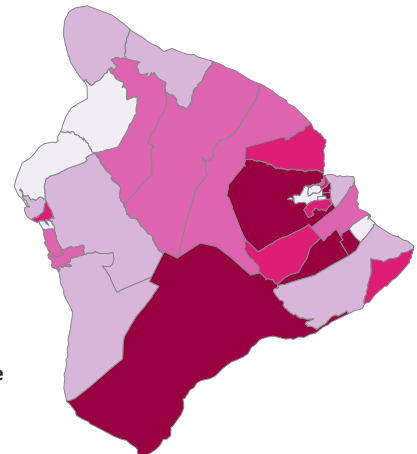
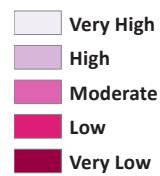
**Lifeline Access Index**



**Vulnerable Household Composition Index**



**Access to Information Index**



# VULNERABILITY

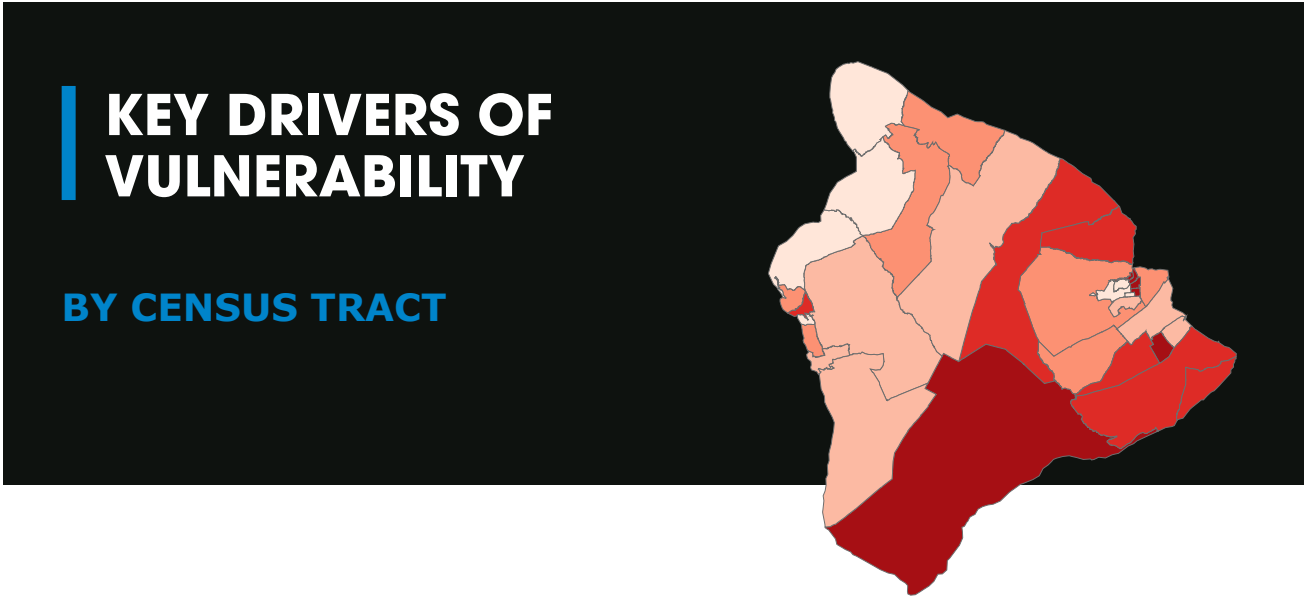
## CENSUS TRACT RESULTS

Vulnerability describes the conditions that may influence the extent to which the population is adversely affected by volcanic hazards.

INDEX RANK	CENSUS TRACT	VULNERABILITY INDEX
1	Census Tract 205	0.67
2	Census Tract 203	0.594
3	Census Tract 212.02*	0.585
4	Census Tract 204	0.573
5	Census Tract 210.03	0.524
6	Census Tract 207.01	0.507
7	Census Tract 201	0.506
8	Census Tract 211.01*	0.497
9	Census Tract 216.01	0.474
10	Census Tract 210.10	0.456
11	Census Tract 211.06*	0.444
12	Census Tract 221.02	0.426
13	Census Tract 215.04	0.424
14	Census Tract 210.11	0.421
14	Census Tract 215.09	0.421
16	Census Tract 206	0.417
17	Census Tract 202.02	0.413
18	Census Tract 219.02	0.406
19	Census Tract 217.02	0.397
20	Census Tract 220	0.395
21	Census Tract 213	0.394
22	Census Tract 210.13	0.39
23	Census Tract 214.02	0.389
23	Census Tract 215.02	0.389
25	Census Tract 210.05	0.376
26	Census Tract 209	0.37
27	Census Tract 218	0.369
28	Census Tract 207.02	0.322
29	Census Tract 216.04	0.313
30	Census Tract 208.02	0.281
31	Census Tract 217.04	0.273
32	Census Tract 208.01	0.219
33	Census Tract 215.07	0.189

- Very High
- High
- Moderate
- Low
- Very Low

\* Census tracts that scored in the 90th percentile or above for key drivers of vulnerability.



### SOCIOECONOMIC STATUS

Proportion of population that is considered economically disadvantaged. This includes the proportion of the population experiencing unemployment, poverty, food assistance, and low income.



### ACCESS TO INFORMATION

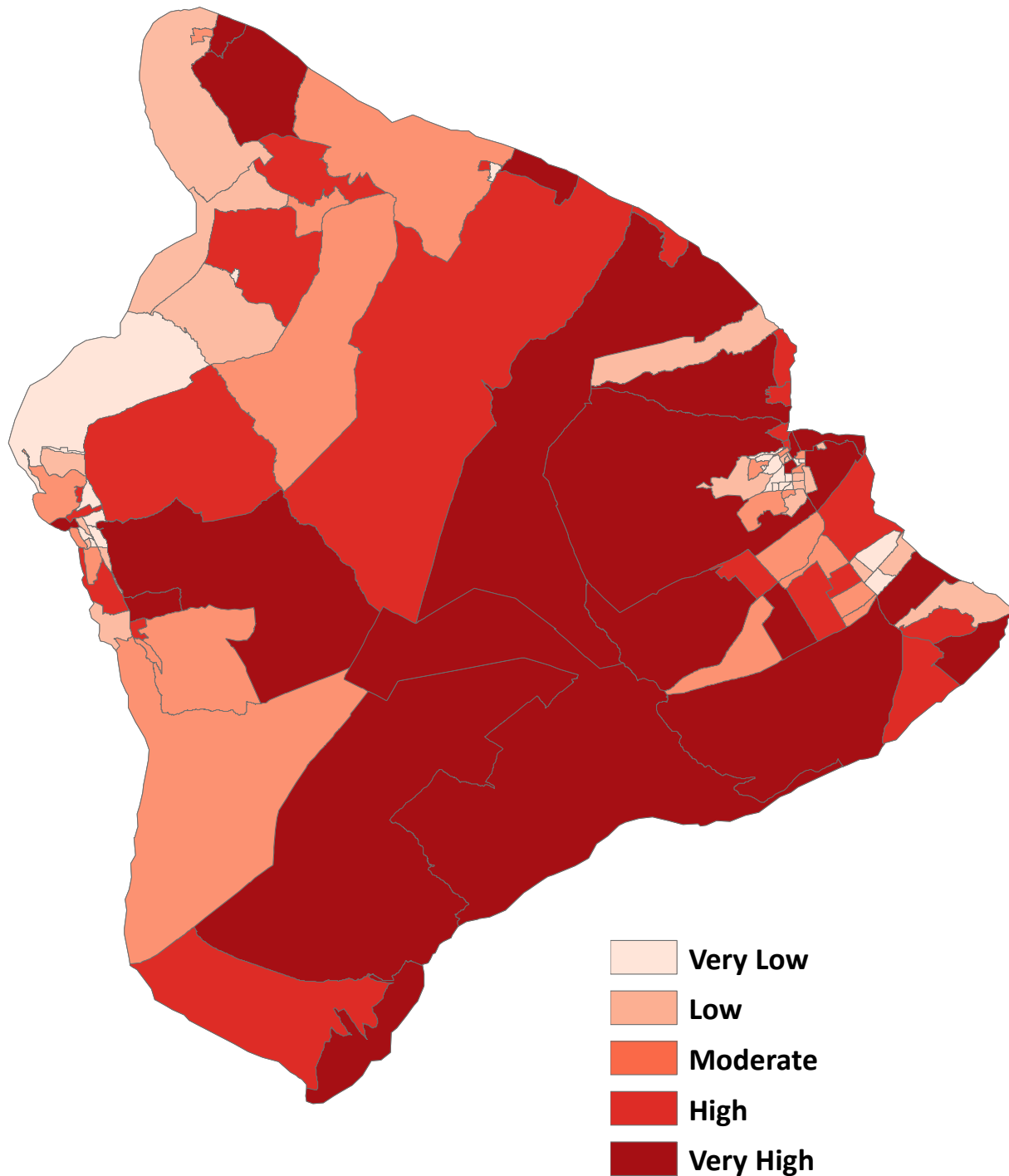
Proportion of the population with potential difficulty receiving and comprehending complex disaster messaging. This includes internet access, telephone access, and non-English speakers.



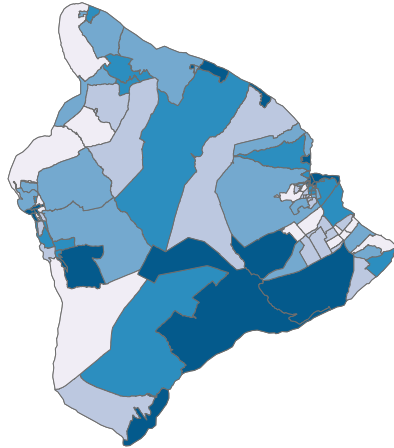
### HOUSEHOLD COMPOSITION

Proportion of households with vulnerable groups. Includes over age 65, under 18, the disabled and single- parent households.

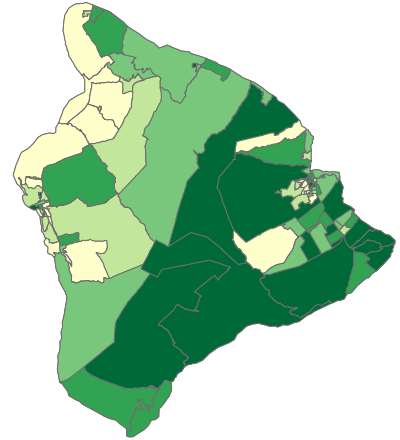
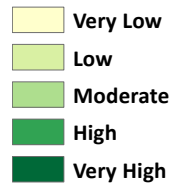
# VULNERABILITY BLOCK GROUP RESULTS



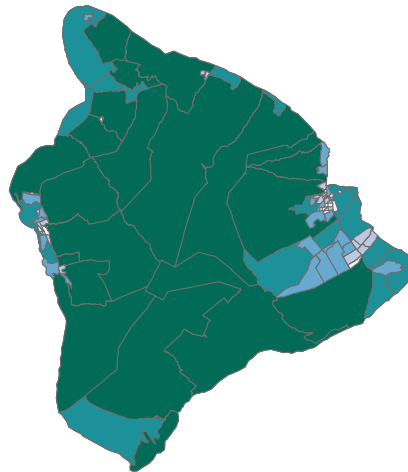
**Vulnerable Housing and Transportation Index**



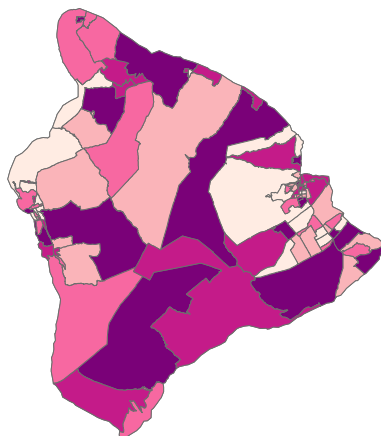
**Vulnerable Socioeconomic Status index**



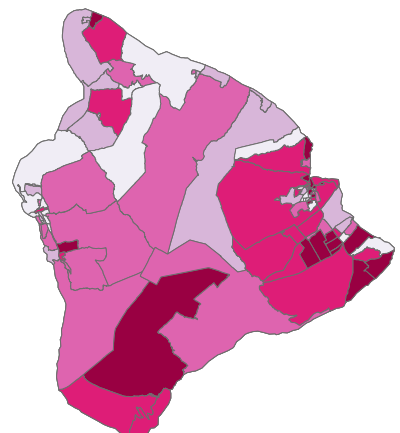
**Lifeline Access Index**



**Vulnerable Household Composition Index**



**Access to Information Index**





# VULNERABILITY

## CENSUS BLOCK GROUP RESULTS

Vulnerability describes the conditions that may influence the extent to which the population is adversely affected by volcanic hazards.

VULNERABILITY INDEX RANK	BLOCK GROUP	CENSUS TRACT	VULNERABILITY INDEX
1	Block Group 2*	Census Tract 211.01	0.683
2	Block Group 2*	Census Tract 212.02	0.644
3	Block Group 3*	Census Tract 211.06	0.618
4	Block Group 1	Census Tract 211.06	0.607
5	Block Group 1	Census Tract 204	0.582
5	Block Group 1*	Census Tract 221.02	0.582
7	Block Group 5*	Census Tract 205	0.577
8	Block Group 2*	Census Tract 210.10	0.573
9	Block Group 1	Census Tract 212.02	0.57
10	Block Group 4	Census Tract 212.02	0.565
11	Block Group 3	Census Tract 218	0.56
12	Block Group 1	Census Tract 206	0.552
13	Block Group 2	Census Tract 214.02	0.547
13	Block Group 4	Census Tract 218	0.547
15	Block Group 1	Census Tract 202.02	0.544
16	Block Group 1	Census Tract 201	0.541
17	Block Group 2	Census Tract 215.02	0.535
18	Block Group 4	Census Tract 216.01	0.533
18	Block Group 2	Census Tract 220	0.533
20	Block Group 2	Census Tract 206	0.527

- Very High
- High
- Moderate
- Low
- Very Low

\* Census tracts that scored in the 90th percentile or above for key drivers of vulnerability.



### **SOCIOECONOMIC STATUS**

Proportion of population that is considered economically disadvantaged. This includes the proportion of the population experiencing unemployment and low income.



### **ACCESS TO INFORMATION**

Proportion of the population with potential difficulty receiving and comprehending complex disaster messaging. This includes internet access and telephone access.



### **HOUSEHOLD COMPOSITION**

Proportion of households with vulnerable groups. Includes over age 65, under 18, and single- parent households.





**KERA**

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# **VOLCANIC MULTI-HAZARD EXPOSURE**

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**RESULTS BREAKDOWN**



# MULTI-HAZARD EXPOSURE CENSUS TRACT RESULTS

Exposure represents the presence of people and property located in hazard zones. Volcanic multi-hazard zones used to calculate exposure resulted from the intersection of census areas with Lava Zones 1 and 2 and Earthquake Zone (PGA 120%) mentioned above.

The assessment considers both raw and relative multi-hazard exposure. The average of both raw and relative exposure scores results in the overall volcanic Multi-hazard Exposure Index.

## VOLCANIC MULTI-HAZARD EXPOSURE

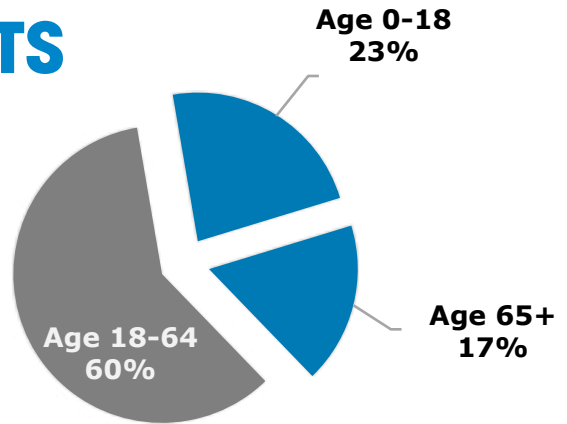


### AVERAGE SCORE

# VOLCANIC MULTI-HAZARD EXPOSURE CENSUS TRACT RESULTS

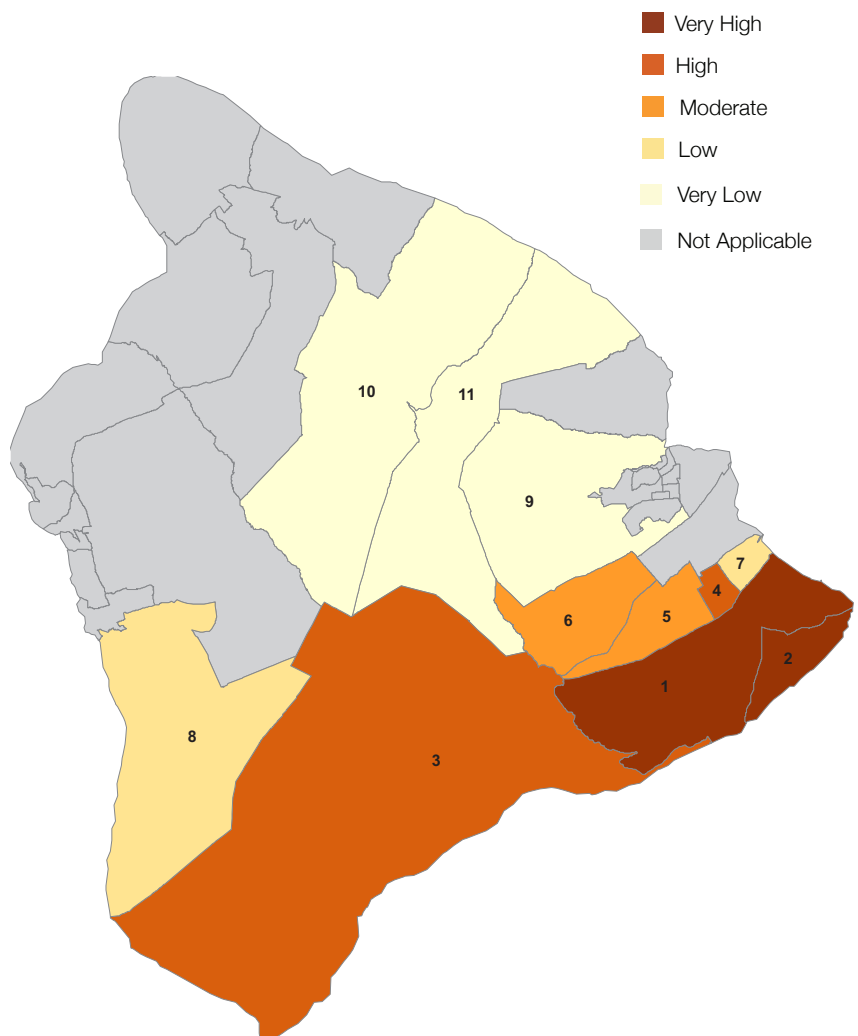
 **61,320**  
TOTAL POPULATION  
EXPOSED

 **21,518**  
TOTAL HOUSEHOLDS  
EXPOSED

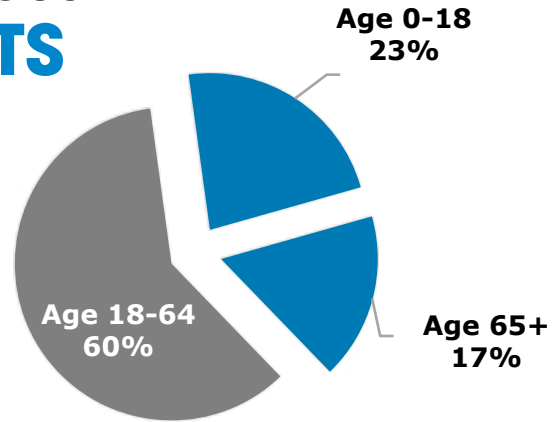


## VOLCANIC MULTI-HAZARD EXPOSURE BY CENSUS TRACT

VMHE RANK	CENSUS TRACT	VMHE INDEX
1	Census Tract 211.06	0.99
2	Census Tract 211.01	0.953
3	Census Tract 212.02	0.858
4	Census Tract 210.03	0.67
5	Census Tract 210.10	0.66
6	Census Tract 210.11	0.507
7	Census Tract 210.05	0.492
8	Census Tract 213	0.49
9	Census Tract 202.02	0.222
10	Census Tract 220	0.129
11	Census Tract 221.02	0.084



# VOLCANIC MULTI-HAZARD EXPOSURE BLOCK GROUP RESULTS

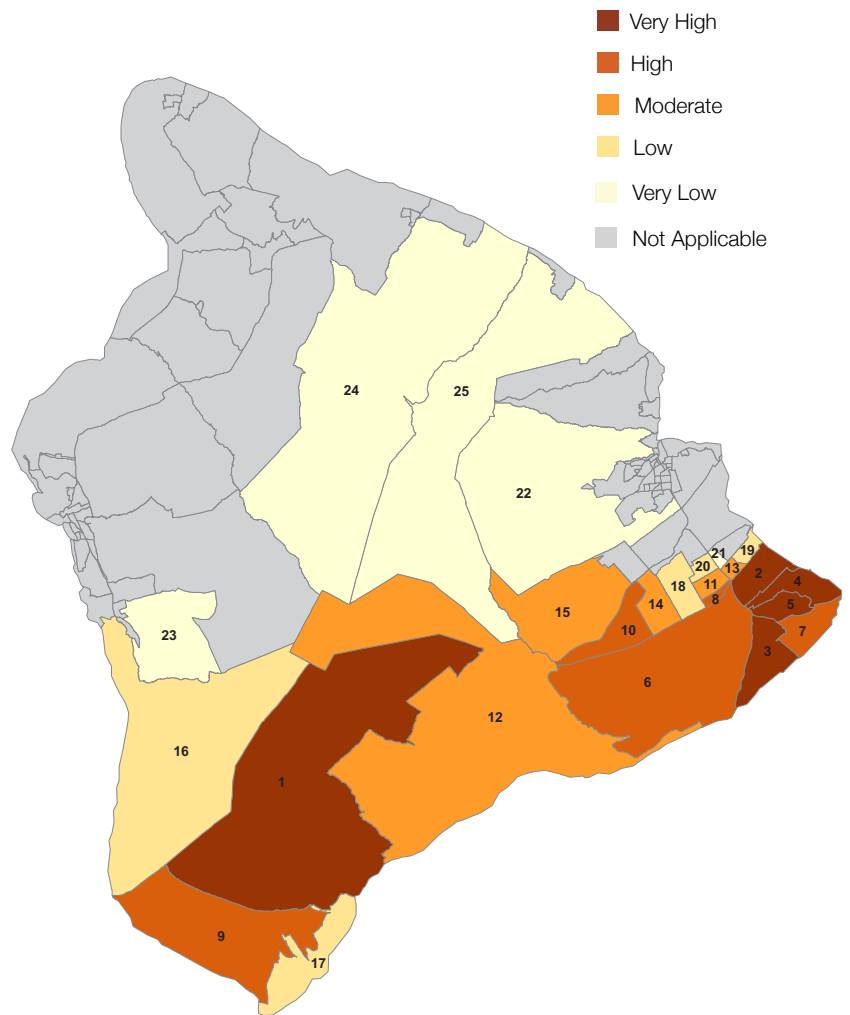


**52,722**  
TOTAL POPULATION EXPOSED

**17,457**  
TOTAL HOUSEHOLDS EXPOSED

## VOLCANIC MULTI-HAZARD EXPOSURE BY BLOCK GROUP

VMHE RANK	BLOCK GROUP	CENSUS TRACT	VMHE INDEX
1	Block Group 2	Census Tract 212.02	0.964
2	Block Group 3	Census Tract 211.06	0.889
3	Block Group 1	Census Tract 211.01	0.843
4	Block Group 2	Census Tract 211.06	0.763
5	Block Group 4	Census Tract 211.06	0.725
6	Block Group 1	Census Tract 211.06	0.581
7	Block Group 2	Census Tract 211.01	0.558
8	Block Group 3	Census Tract 210.03	0.445
9	Block Group 3	Census Tract 212.02	0.442
10	Block Group 1	Census Tract 210.10	0.438
11	Block Group 1	Census Tract 210.03	0.402
12	Block Group 1	Census Tract 212.02	0.391
13	Block Group 4	Census Tract 210.05	0.357
14	Block Group 2	Census Tract 210.10	0.344





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