ranked from 1 through 9, represent a scale of increasing hazard as the numbers decrease. This means that land classified as lava zone 1 is the most susceptible to lava flow (USGS 2019).

Figure 4-8 summarizes the number of County residents living in lava zones 1 through 9. As shown, the greatest number of residents live in lava zone 3 and lava zone 4, which are considered moderate risk zones that have been inundated by historic lava flows. However, more than 2,000 residents live in lava zone 1 and an estimated 19,260 residents live in lava zones 1 and 2, combined.

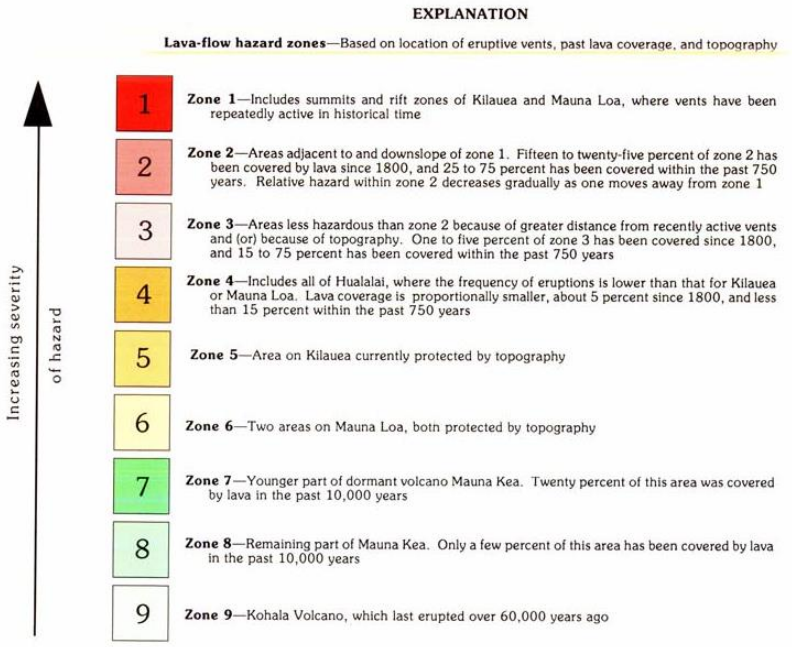


Figure 4-7. USGS-Defined Lava Zones (1-9)

Figure 4-9 and ***Figure 4-10*** illustrates the population density throughout the County relative to the Volcanic High Hazard Area. The greatest population densities are located in the Hilo region (lava zone 3), Pāhoa region (lava zone 2), and the Kailua-Kona/Keauhou region (lava zones 3 and 4) and surrounding subdivisions. Note, these resident totals do not reflect the number of undocumented residents, tourists and visitors residing in the County at any given time throughout the year, particularly the high tourist season of the winter and mid-summer months (Rizzo 2018).

In summary:

- The Puna District has the greatest number of households in the County located in the Volcanic High Hazard Area (4,417 households)
- The Puna District has the greatest number of households located in lava zone 1 (913 households)
- The Puna District has the greatest number of households located in lava zone 2 (3,504 households)
- The Hilo District has the greatest number of households located in lava zone 3 (14,984 households)
- The Ka'ū District has the greatest percent of buildings located in the Volcanic High Hazard Area (61.9%)
- At the resident level, countywide:
- Puna has the greatest number of residents living in the Volcanic High Hazard Area (11,080), lava zone 1 (2,093), and lava zone 2 (8,987). Ka'ū has the greatest percentage of their population living in lava zone 2 (51.8%)—greater than 50%.
- Puna ranks the highest for resident exposure to volcanic hazards, with the greatest number of residents living in the Volcanic High Hazard Area, lava zone 1, and lava zone 2.

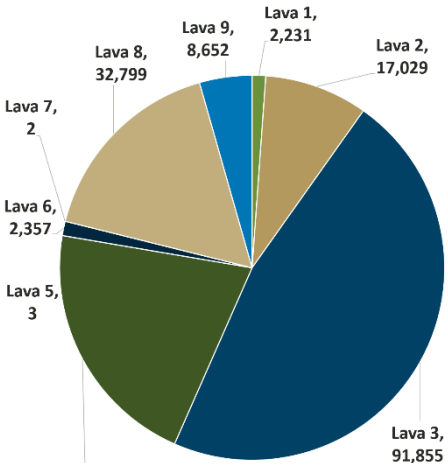


Figure 4-8. Number of County of Hawai'i Residents in Lava Zones 1 through 9

- Ka'ū has the greatest percentage of population living in lava zones 1 and 2. This represents 53.3% of total Ka'ū resident population.
- On the other end of the spectrum, North Kohala, South Kohala, and Hāmākua's resident population have a very low exposure to volcanic hazards. All of North Kohala's population lives in lava zone 9. Over 90% of South Kohala's population lives in lava zone 7, 8, or 9. In total, greater than 90% of Hāmākua's population lives in lava zone 7, 8, or 9.
- Every CDP except for North Kohala has resident population living in the Volcanic High Hazard Area (***Figure 4-9***).

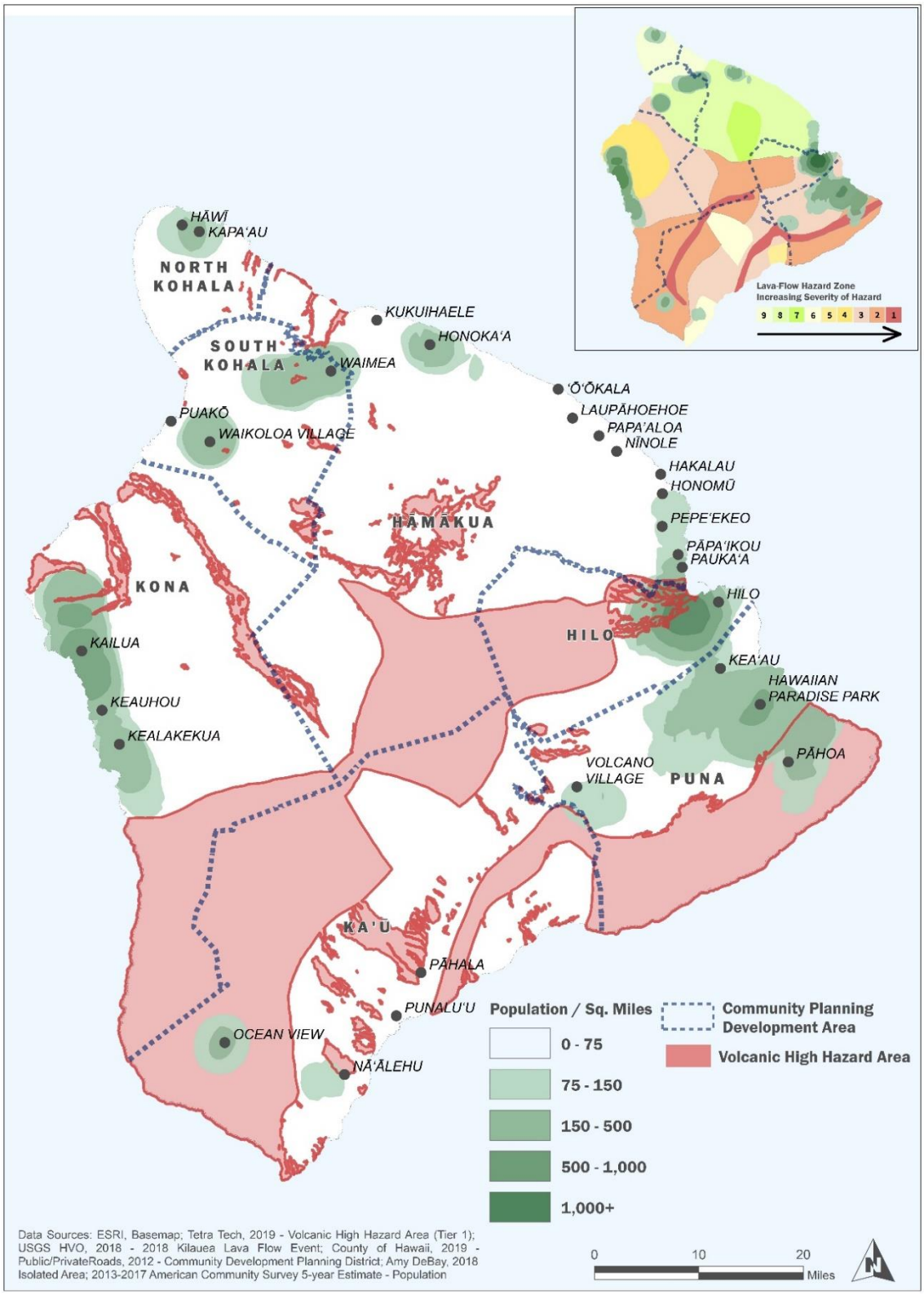


Figure 4-9. County of Hawai'i Population Density Relative to the Volcanic Hazards

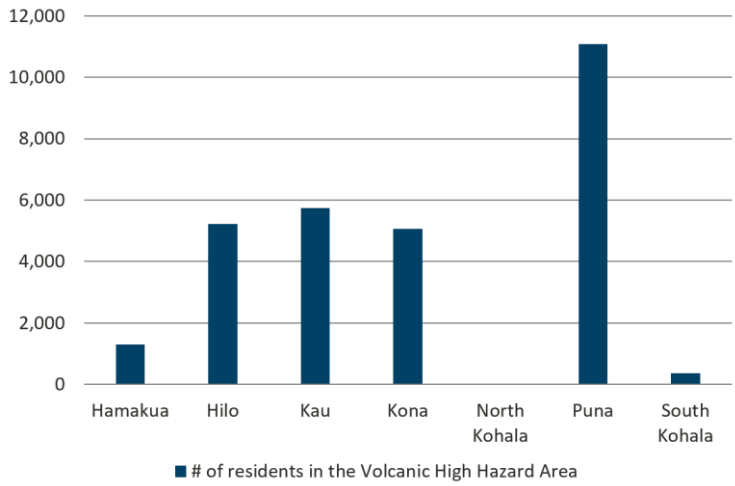


Figure 4-10. Number of County Residents in the Volcanic High Hazard Area

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This is due to many factors including their physical and financial ability to react or respond during a hazard. This population is referred to as socially vulnerable to hazard events. At the same time, County residents are unique and although may be faced with exposure to a greater number of natural hazard events, this may have increased their overall level of resilience. This is likely due to factors including, but not limited to: institutional knowledge of hazard events, intimate knowledge of the natural elements of the County (particularly for those residents who have lived in the County for an extended period of time), and varying levels of existing self-sufficiency. In 2019, the Pacific Disaster Center released the Kīlauea Eruption Risk Assessment (KERA) report that identified key social drivers of volcanic hazard vulnerability: 1. Socioeconomic status; 2. Access to information; and 3. Household composition (Pacific Disaster Center 2019). To align with the KERA report, the County examined the exposure of these vulnerable populations to the volcanic hazard.

Table 4-3 summarizes the vulnerable population statistics in the County of Hawai'i by number of residents. Ka'ū has the highest percentage of residents living below the poverty level (32%). The 2017 median annual income in Ka'ū was $43,697, which is lower than the County's median annual income of $56,395 (ACS 2017).

In terms of total number of residents, those residents with no internet, under 18, and participants in SNAP (Supplemental Nutrition Assistance Program) represent the top three vulnerable population categories in the County of Hawai'i. The County should consider the high rate and density of residents with no internet in future planning efforts, especially with specific focus on ways in which to provide alternative means of communication to those residents during an event or during awareness campaigns.

Table 4-3. County Vulnerable Population

Estimated Vulnerable Population	
No Internet	47,725
Under 18	43,114
SNAP	36,847
Single Parent	36,334
Over 65	36,232
Below Poverty Line	34,347
Disability	25,849
No Health Insurance	11,736
Non-English Speaking	11,532
No Diploma	10,643
No Vehicle	8,308
Unemployed	6,225
No Landline or Cell Phone	3,583

Over 40% of County residents that live in the Volcanic High Hazard Area are either under 18 years of age or over 65 years of age (41.3%). Additionally, 15.2% of residents living in the Volcanic High Hazard Area have no phone access so they would be limited in terms of receiving standard hazard alerts and emergency evacuation notices. Further, 14.7% of residents living in the Volcanic High Hazard Area are physically limited with a disability. The following summarizes the total County residents living in the Volcanic High Hazard Area that are considered the most vulnerable to the volcanic hazard:

- 6,476 people under 18 years of age (highest percentage in Ka'ū)
- 5,403 people over 65 years of age
- 5,257 single parents
- 3,802 people living with a disability
- 8,132 people with no internet access
- 1,382 people with no vehicle access
- 545 people with no phone access, including cell phone
- 1,418 people who are unemployed
- 6,398 people utilizing SNAP
- 6,565 people living below the poverty line (highest percentage in Ka'ū. 64.2% of the population, below the poverty level, live in a Volcanic High Hazard Area)

Many County of Hawai'i residents utilize a catchment system for water supply and many residents live "off-the-grid" and are not connected to central power (Pushard 2019). In late 1980s, studies conducted on private rainfall catchment systems in the South Kona area revealed higher than average acidity in several water samples. Drinking the acidic water does not pose a health hazard, but such water can leach lead from the lead roof flashings, lead-headed nails, and solder connections found in many plumbing systems, resulting in unsafe levels of lead in the drinking water. Extensive testing in 1988 determined that many rainfall catchment systems in the County of Hawai'i, particularly those in the districts adjacent to or downwind of the active vent, contained elevated levels of lead (HIEMA 2018). Populations at greatest risk to lead exposure are children less than 6 years old and pregnant women (Centers for Disease Control and Prevention [CDC] 2019).

Table 4-4 through ***Table 4-7*** summarize the exposure of vulnerable residents in the County of Hawai'i by socioeconomic factor to the volcanic hazard, as well as where the volcanic hazard area overlaps with another natural high hazard zone.

Table 4-4. County of Hawai'i Household Composition by Volcanic Hazard Area - A measure of households containing one or more vulnerable groups vulnerable to the negative impacts of natural disasters.

Hazard Area	Total Residents *(number / %)*	Under 18 *(number / %)*	Over 65 *(number / %)*	Single-Parent Household *(number / %)*	Persons with Disability *(number / %)*
Volcanic High Hazard Area (VHHA)	28,777 / 14.7%	6,476 / 15.0%	5,403 / 14.9%	5,257 / 14.5%	3,802 / 14.7%
VHHA with Additional Natural High Hazard Area	13,638 / 47.4%	3,249 / 50.2%	2,505 / 46.4%	2,389 / 45.4%	1,937 / 50.9%
Lava Zone 1	2,231 / 1.1%	369 / 0.9%	600 / 1.7%	330 / 0.9%	338 / 1.3%
Lava Zone 1 with Additional Natural High Hazard Area	174 / 7.8%	50 / 13.6%	31 / 5.2%	31 / 9.5%	27 / 8.0%
Lava Zone 2	17,029 / 8.7%	4,245 / 9.8%	3,086 / 8.5%	3,338 / 9.2%	2,408 / 9.3%
Lava Zone 2 with Additional Natural High Hazard Area	7,821 / 45.9%	2,077 / 48.9%	1,433 / 46.5%	1,362 / 40.8%	1,240 / 51.5%

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

Table 4-5. County of Hawai'i Household Member Health and Transportation by Volcanic Hazard Area - A measure of households with increased vulnerability due to the lack of a vehicle (i.e., evacuation). A measure of the population's access to critical services such as access to transportation routes and medical services.

Hazard Area	No Vehicle *(number / %)*	No Health Insurance *(number / %)*
Volcanic High Hazard Area (VHHA)	1,382 / 16.6%	1,901 / 16.2%
VHHA with Additional Natural High Hazard Area	785 / 56.8%	930 / 48.9%
Lava Zone 1	129 / 1.6%	194 / 1.7%
Lava Zone 1 with Additional Natural High Hazard Area	8 / 6.4%	13 / 6.8%
Lava Zone 2	700 / 8.4%	1,316 / 11.2%
Lava Zone 2 with Additional Natural High Hazard Area	330 / 47.1%	664 / 50.4%

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

Table 4-6. County of Hawai'i Resident Access to Information by Volcanic Hazard Area - A measure of the ability to receive, comprehend and appropriately act on complex messaging with regard to natural disasters.

Hazard Area	No High School Diploma, Over 25 Years Old *(number / %)*	Non-English Speaking *(number / %)*	No Internet *(number / %)*	No Phone *(number / %)*
Volcanic High Hazard Area (VHHA)	1,601 / 15.0%	1,622 / 14.1%	8,132 / 17.0%	545 / 15.2%
VHHA with Additional Natural High Hazard Area	944 / 58.9%	1,021 / 62.9%	4,020 / 49.4%	285 / 52.4%
Lava Zone 1	120 / 1.1%	72 / 0.6%	750 / 1.6%	78 / 2.2%
Lava Zone 1 with Additional Natural High Hazard Area	12 / 9.7%	15 / 20.8%	58 / 7.7%	3 / 4.3%
Lava Zone 2	934 / 8.8%	1,086 / 9.4%	5,225 / 10.9%	300 / 8.4%
Lava Zone 2 with Additional Natural High Hazard Area	505 / 54.1%	690 / 63.5%	2,360 / 45.2%	162 / 54.0%

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

Table 4-7. County of Hawai'i Resident Socioeconomic Status by Volcanic Hazard Area - A measure of the population that is less likely to have the necessary economic resources to adequately prepare for or recover from a natural disaster.

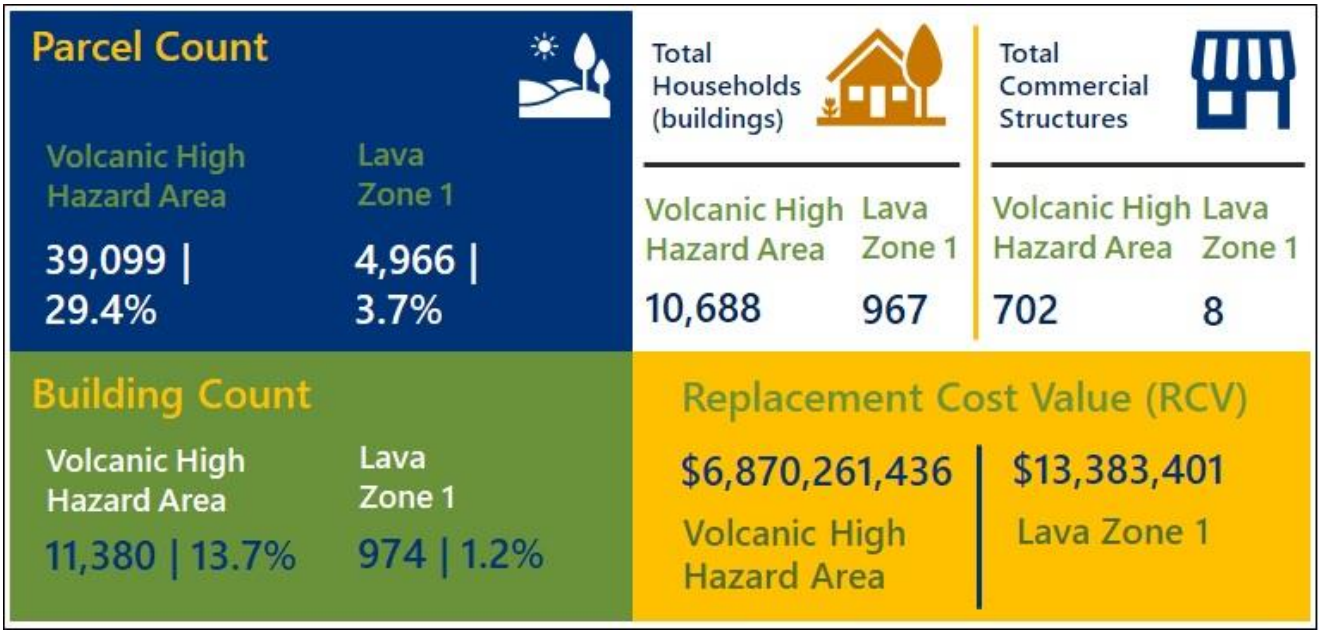
Hazard Area	Unemployed *(number / %)*	SNAP *(number / %)*	Below Poverty Line *(number / %)*
Volcanic High Hazard Area (VHHA)	1,418 / 22.8%	6,398 / 17.4%	6,565 / 19.1%
VHHA with Additional Natural High Hazard Area	507 / 35.7%	3,006 / 47.0%	3,417 / 52.1%
Lava Zone 1	133 / 2.1%	570 / 1.5%	630 / 1.8%
Lava Zone 1 with Additional Natural High Hazard Area	9 / 6.7%	46 / 8.1%	53 / 8.4%
Lava Zone 2	1,021 / 16.4%	4,150 / 11.3%	4,050 / 11.8%
Lava Zone 2 with Additional Natural High Hazard Area	311 / 30.5%	1,686 / 40.6%	1,906 / 47.1%

SNAP Supplemental Nutrition Assistance Program
Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

According to the draft County of Hawai'i General Plan, increased emphasis on evacuation route accessibility and public education is a priority and has been included in the plan as individual action items. For example, "1.51 - Establish, map, and maintain alternative and emergency evacuation routes in each high-risk hazard area" (CHPD 2019b). In some high-risk areas timely evacuation is particularly problematic because of the relative rural contexts and low densities. This is

particularly relevant for Puna's subdivisions where evacuation of residents on a short notice (in the event of a lava flow or other hazard event like tsunami or wildfire) is a significant concern and something to be factored into future planning efforts. Considering speed of evacuation, the County may consider alternative emergency messaging strategies (to mitigate for residents in Volcanic High Hazard Areas without internet access or phones, or those who will need longer to evacuate, like the elderly, folks with limited mobility and children).

4.1.4 PARCELS AND BUILDINGS



Note: All percentages are relative to the County of Hawai'i

Figure 4-11. County of Hawai'i Parcels and Buildings Located in a Volcanic High Hazard Area (VHHA)

Overall, the Puna District has the greatest building exposure to the volcanic hazard in the County. A total of 18,395 parcel acres (32%) and 4,523 buildings (23.2%) in the Puna District are located in the Volcanic High Hazard Area. At the same time, the largest percentage of Ka'ū's building stock is exposed to the Volcanic High Hazard Area (61.9%).

At greatest risk to the lava-flow hazard are those developed parcels located in lava zone 1. Countywide, there are 65,362 acres of developed parcels and 974 buildings [statistics reflecting buildings after the 2018 Kīlauea eruption] in lava zone 1. There are 257,031 acres of developed parcels and 6,555 buildings in lava zone 2. ***Figure 4-12*** illustrates the developed parcel area by lava-flow hazard zone.

Lava flow will burn structures and bury land as well as everything else in its path. For the purposes of this analysis, the total assessed value (land and building) located in the volcanic hazard areas is reported to illustrate the potential future loss to existing parcels and development. The total assessed value of parcels located in the Volcanic High Hazard Area is an estimated $5,152,642,600, which is equivalent to 12.8% of the County's total parcel assessed values. In terms of replacement cost value of buildings (estimated structure and contents), an estimated $6,870,261,436 is located in the Volcanic High Hazard Area (***Table 4-8).***

Table 4-8. County of Hawai'i Parcels and Buildings Exposed to Volcanic Hazards

Hazard Area	Total Number of Parcels *(number / %)*	Total Assessed Value *(land and structure)*	Total Number of Buildings (number */ %)*	Replacement Cost Value *(structure and contents)*	Total Households *(buildings / %)*	Total Commercial Units *(buildings / %)*
Volcanic High Hazard Area (VHHA)	39,099 / 29.4%	$5,152,642,600	11,380 / 13.7%	$6,870,261,436	10,688 / 13.7%	702 / 14.9%
VHHA with Additional Natural High Hazard Area	20,057 / 51.3%	$191,617,000	5,576 / 49.0%	$5,096,658,533	4,996 / 46.7%	589 / 83.9%
Lava Zone 1	4,966 / 3.7%	$298,598,000	974 / 1.2%	$267,135,139	967 / 1.2%	8 / 0.2%
Lava Zone 1 with Additional Natural High Hazard Area	1,706 / 34.4%	$28,174,200	67 / 6.9%	$13,383,401	67 / 6.9%	0 / 0.0%
Lava Zone 2	28,843 / 21.7%	$2,065,037,900	6,555 / 7.9%	$1,794,788,511	6,424 / 8.2%	131 / 2.8%
Lava Zone 2 with Additional Natural High Hazard Area	14,660 / 50.8%	$132,655,600	2,924 / 44.6%	$778,489,137	2,893 / 45.0%	31 / 23.7%
Lava Zone 3	61,290 / 46%	$14,535,462,200	37,882 / 45.8%	$34,117,895,504	35,488 / 45.4%	2,395 / 50.9%
Lava Zone 4	14,698 / 11%	$14,236,696,200	19,173 / 23.2%	$13,449,905,787	17,816 / 22.8%	1,358 / 28.9%
Lava Zone 5	1 / 0%	$15,000	1 / 0%	$392,046	1 / 0%	0 / 0%
Lava Zone 6	2,629 / 2%	$253,971,300	1,003 / 1.2%	$303,772,382	949 / 1.2%	54 / 1.1%
Lava Zone 7	19 / 0%	$60,370,500	10 / 0%	$10,813,860	0 / 0%	10 / 0.2%
Lava Zone 8	15,778 / 11.8%	$7,050,809,900	13,811 / 16.7%	$6,574,081,669	13,208 / 16.9%	604 / 12.8%
Lava Zone 9	4,952 / 3.7%	$1,797,209,700	3,387 / 4.1%	$1,340,004,150	3,243 / 4.2%	145 / 3.1%

Note: Data in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

Source: June 2019 Real Property Tax (RPT) database and 2019 County parcel dataset; buildings determined on parcels using the DWELDAT and COMDAT tables. Replacement cost value calculated using 2019 RS Means data.

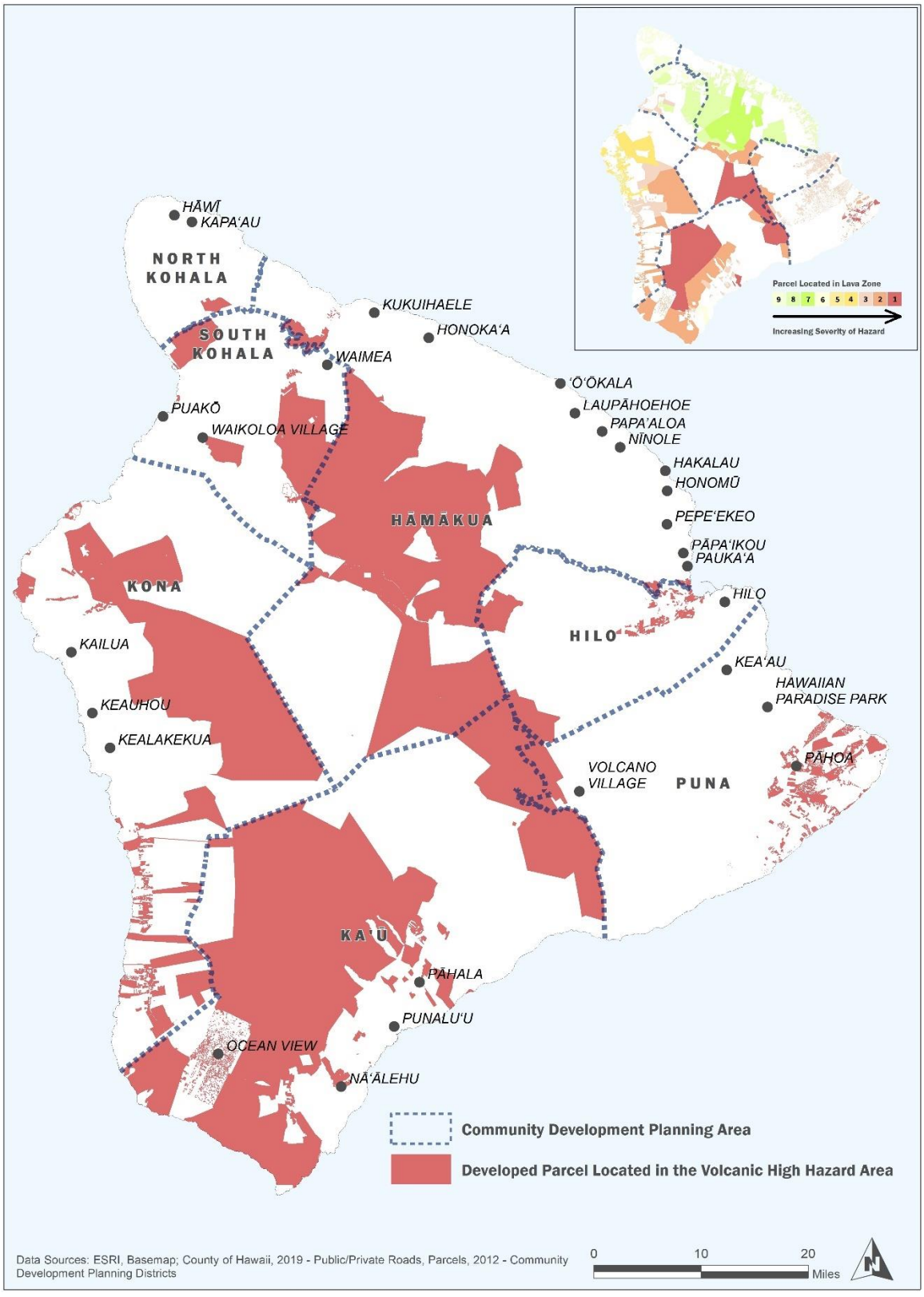


Figure 4-12. Developed Parcels in the County of Hawai'i by Lava Zone

When mitigating hazard risk, historic events and associated impacts are considered. The historic lava flow events and associated inundation extent available in GIS are included in the Volcanic High Hazard Area. This is because the lava-flow hazard zones do not have a current probability and historic lava flows have extended beyond lava zones 1 and 2. In addition, when considering policy and mitigation, it is important to understand where previous impacts have occurred to avoid future repetitive losses.

A spatial analysis was conducted intersecting the developed parcels and individual historic lava flow layers to determine the number of times a developed parcel has been impacted by a historic lava flow (***Figure 4-13*****).** The structure on the parcel may not have been present at the time of the historic lava flow (lava flow inundation is only available dating back to 1790); however, the results provide an understanding of repetitive loss to inform planning and mitigation. It is important to note that some historic lava flow GIS files are a composite of multiple events and therefore the results summarized in ***Table 4-9*** present a minimum count.

A total of 62 developed parcels have been repetitively impacted by lava-flow events. In Puna, a total of 21 developed parcels were inundated by, at minimum, three separate lava flow events. The Puna CDP has the greatest number of repetitive lava flow losses (***Table 4-9)***. A loss is assumed if the developed parcel and lava flow intersect.

Table 4-9. Lava Flow Repetitive Loss Analysis by Developed Parcel

CDP	Number of Developed Parcels	Number of Times Impacted by Historic Lava Flow
Hāmākua	4	1
	1	2
Hilo	870	1
Ka'ū	350	1
	2	2
Kona	775	1
Puna	1,729	1
	38	2
	21	3

CDP Community Development Plan

The County of Hawai'i did not adopt modern building codes contained in the 1982 Uniform Building Code (UBC) until 1985, meaning Hawai'i didn't start requiring seismic building standards until 1985. All structures built prior to 1985 are therefore considered to be unreinforced and susceptible to hurricane and earthquake damage due to the lack of uplift ties and a complete load path of connections (Martin and Chock, Inc. 2015). The frequency and location of the structures built prior to 1985 (both residential and commercial) is illustrated on ***Figure 4-14*** with many clustered very close or even overlapping with the 2018 Kīlauea flow and Ka'ū's Volcanic High Hazard Area. In total, there are 16,163 pre-1985 structures located in Peak Ground Acceleration (PGA) 120%g, or nearly 20% of structures in the County (19.5%). These structures are more vulnerable to seismic impacts when compared structures built post-1985. Refer to ***Section 3 - Methodology*** for more details on the PGA 120%g seismic zone.

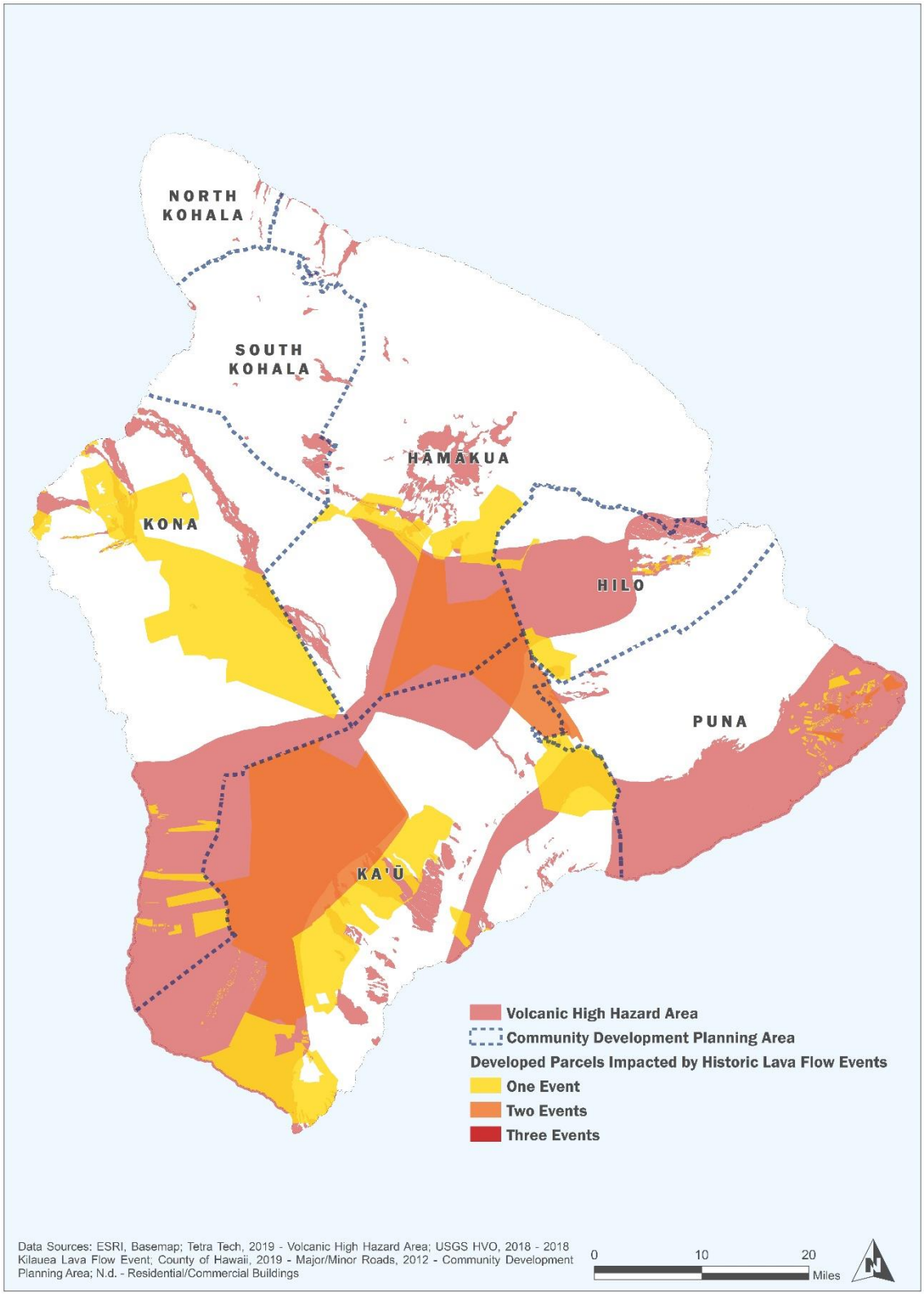


Figure 4-13. Lava Flow Repetitive Loss Analysis by Developed Parcel

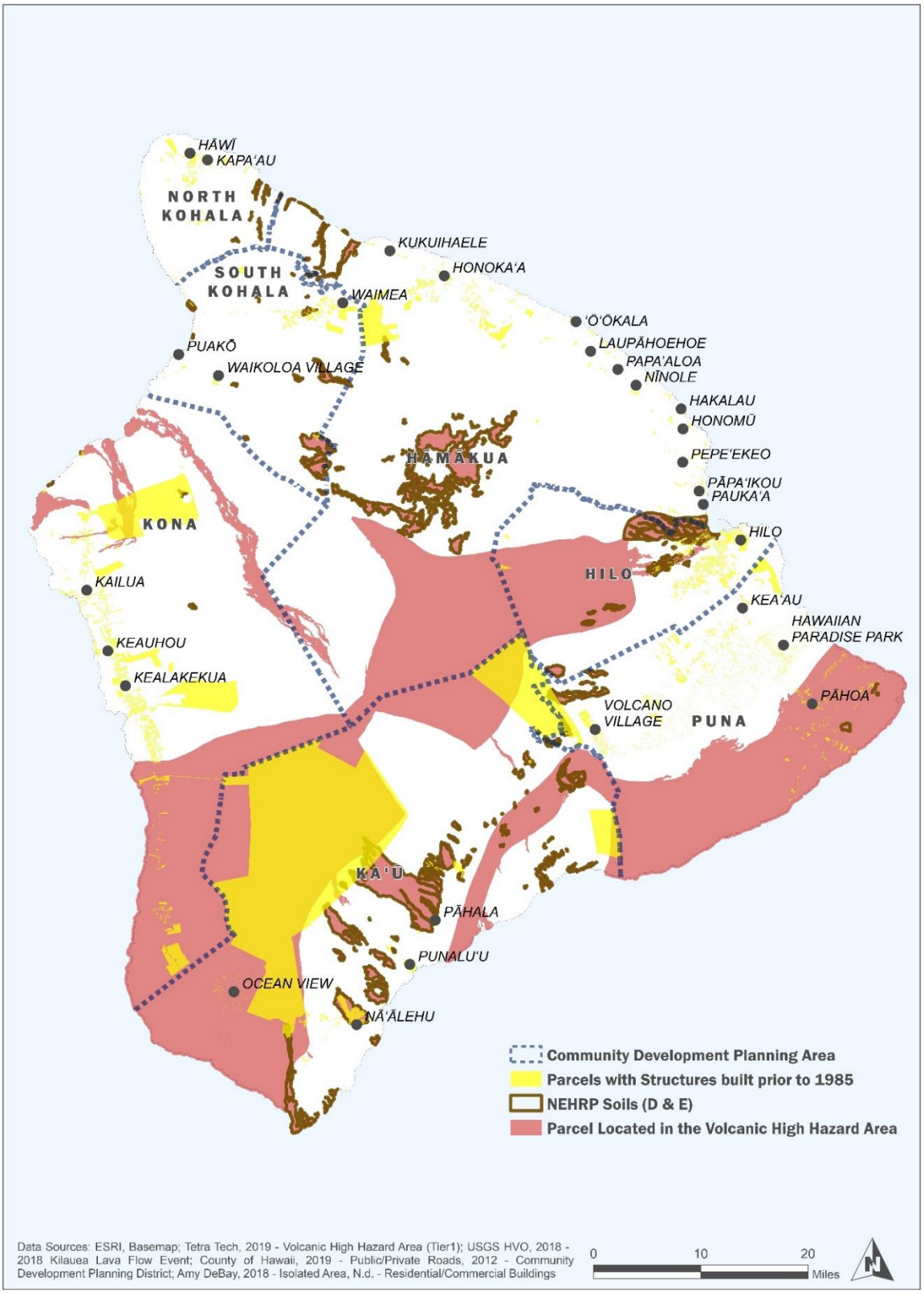
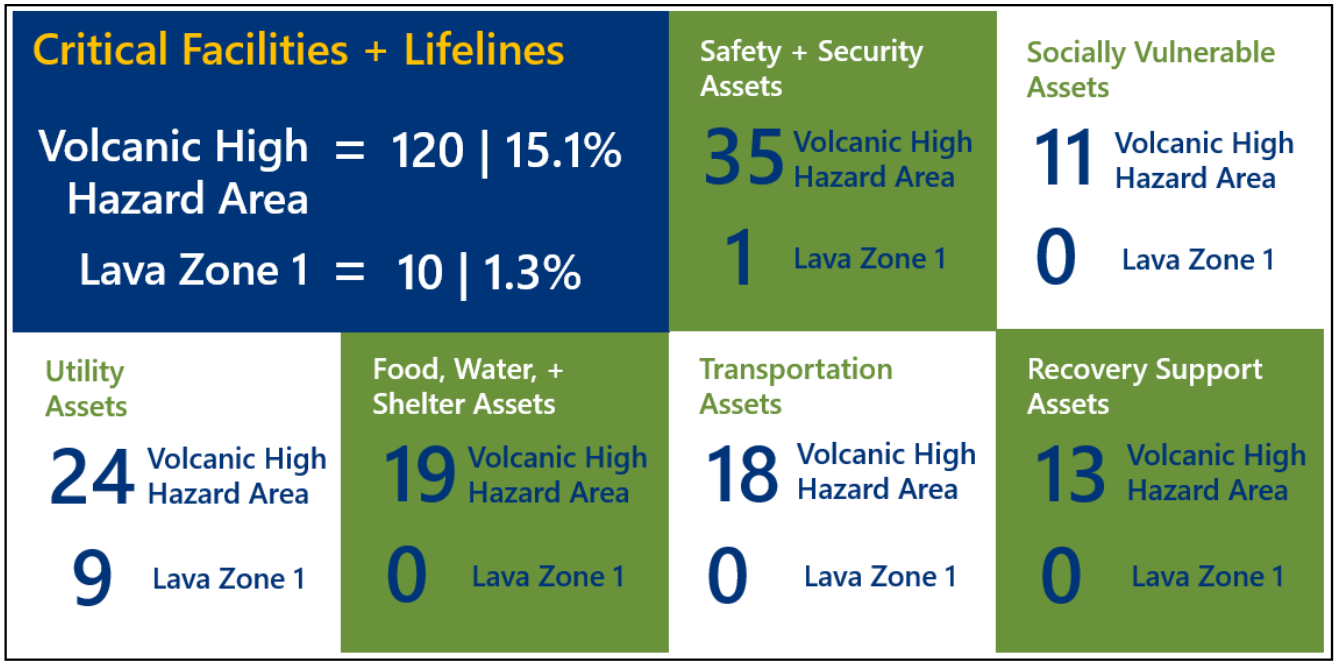


Figure 4-14. County of Hawai'i Parcels with Structures Constructed Pre-1985 in the Volcanic High Hazard Area

4.1.5 CRITICAL FACILITIES AND LIFELINES



Note: All percentages are relative to the County of Hawai'i

Figure 4-15. County of Hawai'i Critical Facilities and Lifelines Located in the Volcanic High Hazard Area and Lava Zone 1

Through this planning process, 793 critical facilities and lifelines were identified in the County of Hawai'i. The critical facilities and lifelines identified provide the following lifeline services:

- Safety and Security
- Transportation
- Utilities
- Recovery support
- House socially vulnerable populations
- Provide food, water and sheltering

The Hāmākua (23.7%) and Hilo (23.2%) Districts have the greatest number of critical facilities with a total of 188 and 184. The critical facility and lifeline categories align with the 2015 County Hazard Mitigation Plan asset categories. Many of the County's critical facilities are located along the perimeter of the island, proximate to the major road system that circulates around the island. Of all total critical facilities in the County, 15% are located in the Volcanic High Hazard Area. ***Table 4-10*** summarizes the exposure of these critical facilities to the volcanic hazards. A majority (62.5%) of the County's critical facilities located in the Volcanic High Hazard Area are also vulnerable to another hazard, and therefore susceptible to impacts from volcanic events and other hazard events. Of the 120 critical assets located in the Volcanic High Hazard Area, 10 are located in lava zone 1 (9 utility assets, and 1 safety and security asset), and 46 are located in lava zone 2. Prior to the 2018 Kīlauea event, infrastructure, critical facilities and lifelines, and essential services (i.e., water and wastewater) within Puna were already limited in their quality, capacity, and volume. The Puna District has the highest percentage of critical facilities and lifelines located in the Volcanic High Hazard Area (44.9%).

Table 4-10. County of Hawai'i Critical Facilities in the Volcanic Hazard Area

Hazard Area	Number of Critical Facilities *(number / %)*	Built Prior to 1985 *(number / %)*	Safety and Security Assets *(number / %)*	Food, Water, Shelter Assets *(number / %)*	Recovery Support Assets *(number / %)*	Socially Vulnerable Assets *(number / %)*	Utility Assets *(number / %)*
Volcanic High Hazard Area (VHHA)	120 / 15.1%	35 / 8.5%	35 / 21.7%	19 / 17.6%	13 / 25.5%	11 / 13.4%	24 / 16.4%
VHHA with Additional Natural High Hazard Area	75 / 62.5%	35 / 8.5%	26 / 74.3%	13 / 68.4%	8 / 61.5%	4 / 36.4%	11 / 45.8%
Lava Zone 1	10 / 1.3%	0	1 / 0.6%	0	0	0	9 / 6.2%
Lava Zone 1 with Additional Natural High Hazard Area	0	0	0	0	0	0	0
Lava Zone 2	46 / 5.8%	7 / 1.7%	21 / 13%	6 / 5.6%	7 / 13.7%	6 / 7.3%	6 / 4.1%
Lava Zone 2 with Additional Natural High Hazard Area	23 / 50%	3 / 0.7%	14 / 66.7%	0	4 / 57.1%	1 / 16.7%	4 / 66.7%

Note: Critical facilities in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

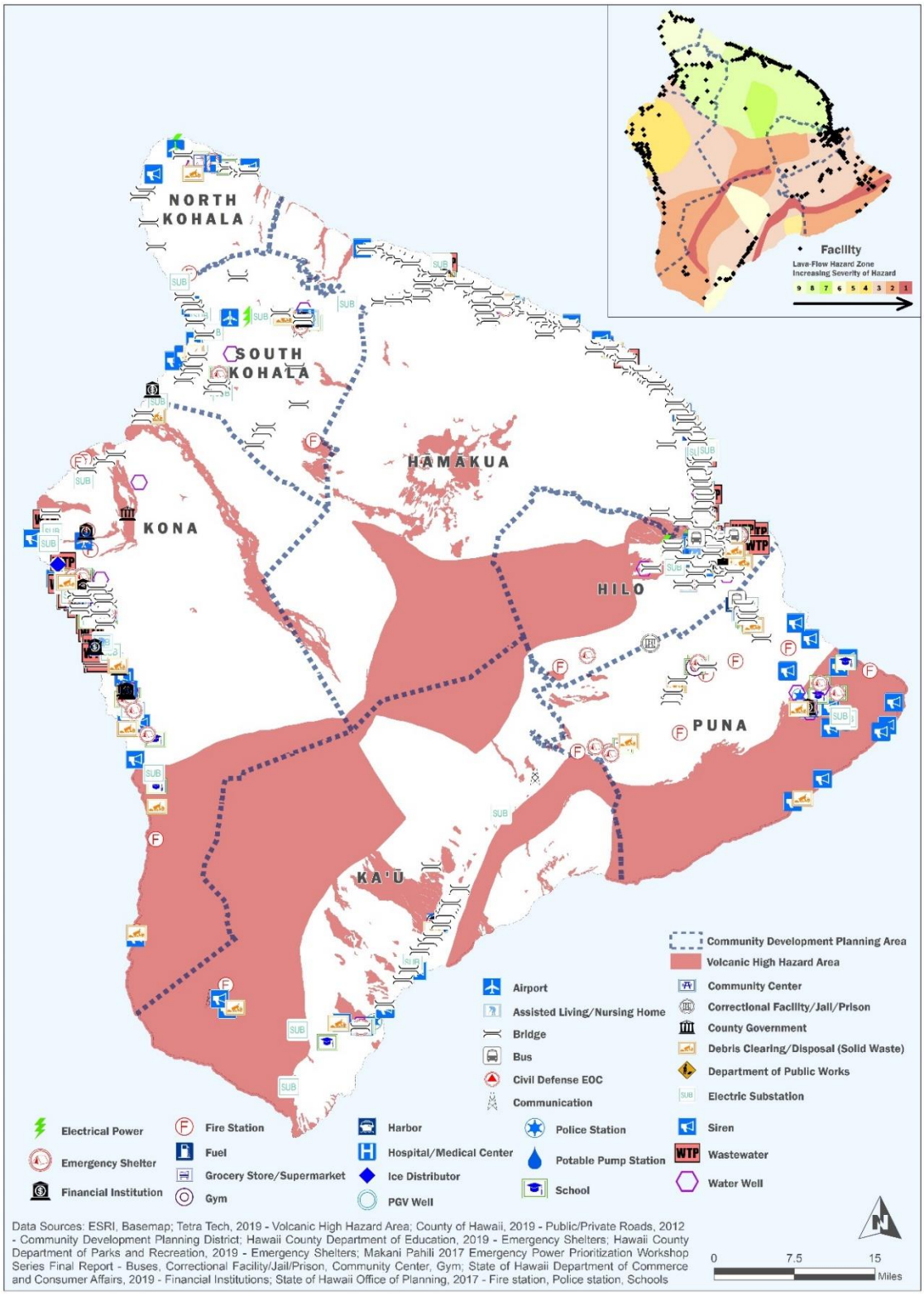


Figure 4-16. County of Hawai'i Critical Facilities Located in the Volcanic High Hazard Area

Similar to the discussion on structures constructed pre-1985, there are a number of critical facilities in the County constructed prior to 1985 and therefore more vulnerable to earthquake damage (during a volcanic eruption or occurring separately). Based on year-built data, 73.3% of the County's critical facilities and lifelines were constructed prior to 1985. Depending upon the specific facility's design and mitigation measures installed post construction, earthquake damage prior to an eruption or during an eruption could have significant implications of life safety and the resilience of infrastructure systems.

Infrastructure provides connectivity between communities and resources, as well as emergency access to keep residents safe. It is closely tied to housing providing livable spaces with services needed for communities to thrive. The miles of road that intersect the Volcanic High Hazard Area and lava zones 1 and 2 were determined in an effort to understand their exposure and where potential future losses may be incurred. The road layer used, dated May 2019, included impacted roads from Kīlauea's 2018 eruption (Kalapana Kapoho Beach Road, Leilani Ave, Pāhoa Kapoho Road, Pohoiki Road, etc.). ***Table 4-11*** summarizes these results. Additional analyses can be conducted to evaluate the connectivity of the network and to identify vulnerable roads located outside the high volcanic risk areas that may be inaccessible or isolated during a lava-flow event. Some identified routes that are at greatest risk will need to remain open because they are the singular access to critical facilities, socially vulnerable populations and essential government services.

Puna and Ka'ū are the only two CDPs with roads that intersect lava zone 1. Puna also has the greatest number of miles located in the Volcanic High Hazard Area and lava zone 1 compared to all CDPs. State highways and county roads are primary transportation routes for Puna residents (County of Hawai'i Planning Department (CHPD) 2008.). Most roads servicing Puna District subdivisions are publicly accessed, but privately-owned, and not designed for through traffic; however, residents rely on this infrastructure to travel to hospitals located outside of Puna when seeking medical assistance. Much of this critical infrastructure was impacted during the 2018 eruption and it remains for the County to decide whether to restore these access routes or explore other options.

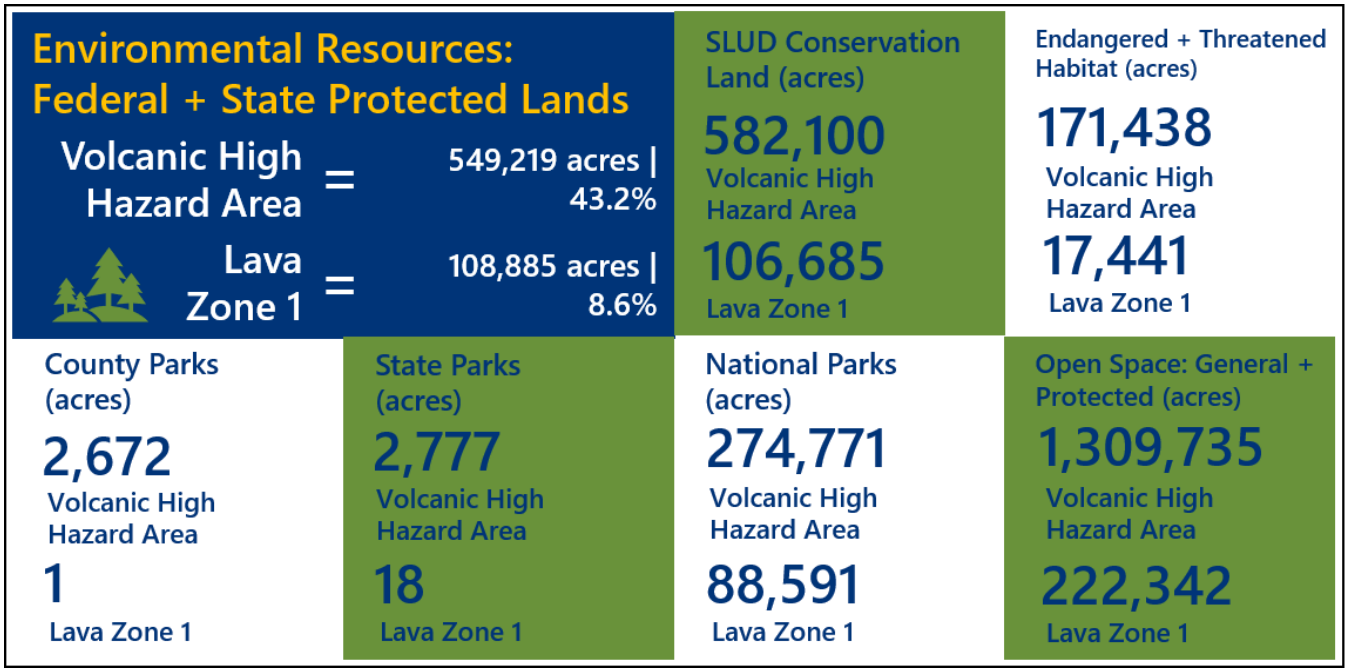
Table 4-11. Length of Roadway in the Volcanic Hazard Areas

CDP and Road Classification	Total Road Length *(miles)*	Volcanic High Hazard Area *(miles)*	Lava Zone 1 *(miles)*	Lava Zone 2 *(miles)*
Hāmākua	**489.6**	**55.0**	**0.0**	**24.2**
State	112.9	35.3	0.0	23.9
County	153.5	9.6	0.0	0.3
Other Government	0.0	0.0	0.0	0.0
Road in Limbo	85.3	2.8	0.0	0.0
Private	137.9	7.3	0.0	0.0
Hilo	**324.6**	**66.7**	**0.0**	**20.2**
State	51.9	26.4	0.0	20.2
County	244.7	32.1	0.0	0.0
Other Government	2.6	0.0	0.0	0.0
Road in Limbo	3.4	0.0	0.0	0.0
Private	22.0	8.2	0.0	0.0
Ka'ū	**404.0**	**275.1**	**33.6**	**227.7**

CDP and Road Classification	Total Road Length *(miles)*	Volcanic High Hazard Area *(miles)*	Lava Zone 1 *(miles)*	Lava Zone 2 *(miles)*
State	52.8	14.8	0.0	13.0
County	72.6	22.1	0.0	6.6
Other Government	33.2	16.3	13.8	2.1
Road in Limbo	4.6	0.0	0.0	0.0
Private	240.2	221.9	19.8	206.1
Kona	**507.0**	**87.7**	**0.0**	**68.8**
State	91.8	26.9	0.0	21.0
County	203.4	20.9	0.0	14.4
Other Government	1.5	0.0	0.0	0.0
Road in Limbo	9.9	2.7	0.0	0.0
Private	200.4	37.2	0.0	30.7
North Kohala	**138.0**	**0.3**	**0.0**	**0.0**
State	34.7	0.0	0.0	0.0
County	35.3	0.0	0.0	0.0
Other Government	0.0	0.0	0.0	0.0
Road in Limbo	8.2	0.0	0.0	0.0
Private	59.8	0.3	0.0	0.0
Puna	**976.4**	**306.8**	**74.1**	**249.1**
State	51.6	13.0	3.6	10.3
County	237.1	121.2	23.9	101.3
Other Government	25.3	21.3	0.2	20.4
Road in Limbo	32.4	11.1	5.0	6.9
Private	629.9	140.3	41.5	110.2
South Kohala	**237.1**	**8.9**	**0.0**	**0.0**
State	60.7	2.2	0.0	0.0
County	94.1	3.5	0.0	0.0
Other Government	0.0	0.0	0.0	0.0
Road in Limbo	4.5	0.0	0.0	0.0
Private	77.9	3.1	0.0	0.0

Note: A zero indicates that classification of road does exist in the CDP; however, there is no mileage in the indicated volcanic hazard area. Roads in limbo are defined as roads built or planned for by the State and are classified as either existing or paper roads.
CDP Community Development Plan

4.1.6 ENVIRONMENT



Note: All percentages are relative to the County of Hawai'i

Figure 4-17. County of Hawai'i Environmental Resources Located in the Volcanic High Hazard Area and Lava Zone 1

Natural resources are abundant on the island and include, but are not limited to, land, water, air, flora, fauna, soils, geologic features, geothermal steam, climate, wind, sunshine, ocean waters and shoreline. Many of these resources are finite and irreplaceable, while others are renewable. The island's growing population places an increased demand on limited resources (County of Hawai'i 2005). In order to conserve these resources, not only are best management practices and enforcement required, so is our understanding and consideration of their potential impacts or loss as a result of natural hazard events.

The majority of land in the County is undeveloped (58.5%) with vast acreage of intact natural area that is protected under federal and state regulations (County of Hawai'i Planning Department (CHPD) 2008.). Over one million acres in the County is publicly managed and protected (federal, state, county), which represents 49.5% of all land. Significant agricultural crops in the County includes: macadamia nuts, commercial forestry, and coffee (***Figure 4-18***).

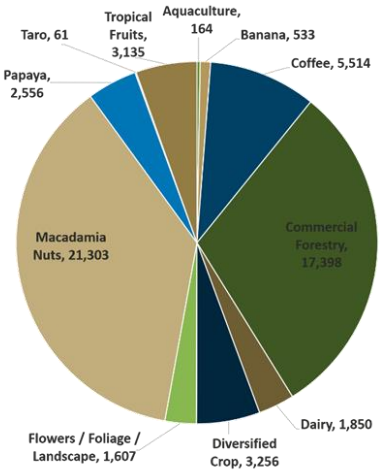


Figure 4-18. County of Hawai'i Crop Land (Acres)

Much of the land around the Kīlauea Volcano is undeveloped and protected by the Hawai'i Volcanoes National Park, which was founded on August 1, 1916, predating both the establishment of the National Park Service (August 25, 1916) and Hawaiian statehood (August 21, 1959). The Park has over 2 million visitors each year who spend approximately $166 million in communities near the park. The Park is located in the Puna CDP, Ka'ū CDP, Kona CDP, and Hāmākua CDP. This spending supports over 2,000 local jobs. The Park also protects a range of prehistoric Native Hawaiian and Euro/American historic sites and is a site of spiritual significance for Native Hawaiian communities

today (U.S. Department of the Interior Strategic Sciences Group 2018). Hawai'i Volcanoes National Park, is nearly exclusively located in lava zone 1 or 2. In addition to Hawai'i Volcanoes National Park, additional National Parks in the County include: Kaloko-Honokōhau National Historical Park (Kona CDP) and Pu'uhonua o Hōnaunau National Historical Park (Kona CDP).

As part of this risk assessment, environmental assets identified as part of the County's General Plan update (in progress) were utilized to align planning processes (***Table 4-12***). ***Figure 4-19*** and ***Figure 4-20*** illustrate the environmental resources relative to the Volcanic High Hazard Area.

Table 4-12. County of Hawai'i Environmental Resources

Agricultural Land of Importance (acres)	Crop Land (acres)	Pasture Land (acres)	Hunting Areas (acres)	Wetlands (acres)
574,536	60,983	552,982	712,315	56,384

Federal Reserves (*acres*)	State Reserves (*acres*)	Exceptional Trees	Anchialine Pools	Reservoirs	Endangered and Critical Habitats (*acres*)
503,003	628,581	160	529	227	526,532

Lava zone 1 risk is overlaid with thousands of acres of the County's environmental resource land. Over 100,000 acres (7.9%) of State Land Use District (SLUD) conservation land and over 100,000 acres of protected land (8.6%) is located in lava zone 1. Nearly 90,000 acres (24.6%) of national park land is located directly in lava zone 1, with over 75% (76.2%) located in the Volcanic High Hazard Area, in general. Over 75% (126 trees) of the County's identified exceptional trees are found in Puna's lava zone 1 or 2. All other exceptional trees in the County are found in either Hāmākua (10), Hilo (16), Ka'ū (2), and Kona (6).

Wetlands and anchialine pools are productive and biologically diverse systems that offer numerous environmental benefits. Puna has the greatest percent of the County's wetlands (50.7%) anchialine pools (52.0%) located in the Volcanic High Hazard Area. In addition, the Puna District has the County's highest percentage of federal and/or state reserve land located in the Volcanic High Hazard Area (57.3%) and lava zone 1 (17.6%).

Throughout the County's history, agriculture has played an important role in the County's economy. Nearly 20% of the County's Agricultural Land of Importance is located in the Volcanic High Hazard Area, totaling 107,149 acres. In total, the County has 60,983 acres of land used for growing crops, with 21.7% located in a Volcanic High Hazard Area. Well over half of Hilo's crop land (65.4%) and 71% of Ka'ū's tropical fruit crop land is located in a Volcanic High Hazard Area. The least vulnerable crops, countywide, to volcanic hazards are Commercial Forestry, Dairy, and Diversified Crops which are all heavily located in lava zones 7, 8, and 9 (***Table 4-13***).

Table 4-13. County of Hawai'i Acreage of Crops by Volcano Hazard Area

Crop Land	Volcanic High Hazard Area (acres)	Lava Zone 1 (acres)	Lava Zone 2 (acres)
Aquaculture	46 / 27.4%	3 / 1.8%	N/A
Banana	10 / 1.9%	N/A	1 / .2%
Coffee	862 / 14.5%	N/A	431 / 7.2%
Commercial Forestry	1,925 / 9.2%	N/A	N/A
Dairy	N/A	N/A	N/A
Diversified Crop	291 / 8.9%	3 / .01%	30 / .1%
Flowers/Foliage/Landscape	338 / 17.7%	63 / 3.3%	236 / 12.4%
Macadamia Nuts	7,573 / 28.6%	59 / .2%	5,104 / 19.3%
Papaya	1,431 / 35.9%	317 / 8%	1,114 / 27.9%
Taro	61 / 100%	N/A	N/A
Tropical Fruits	724 / 20.1%	118 / 3.3%	352 / 9.8%

N/A Not applicable

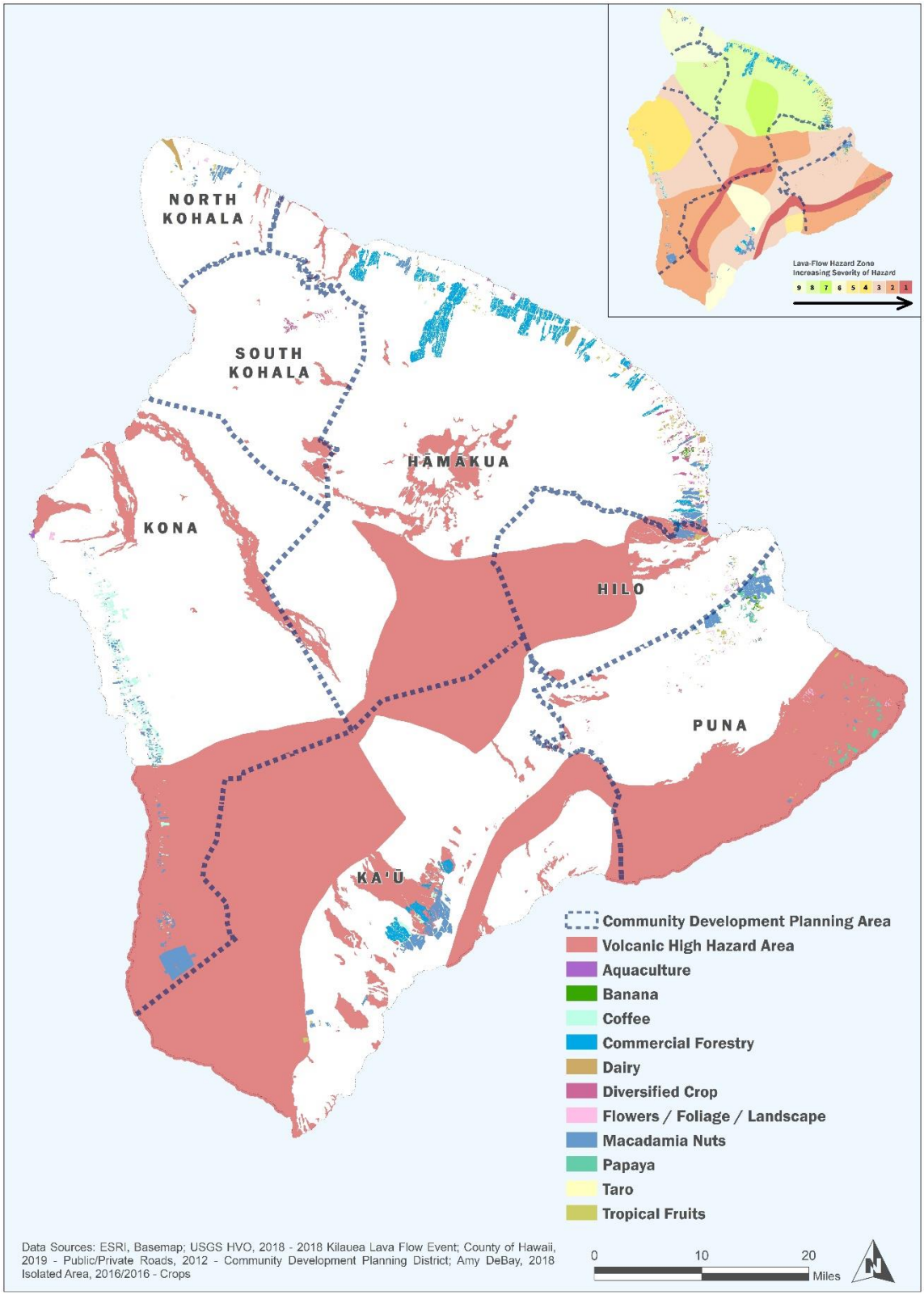


Figure 4-19. County of Hawai'i Important Agricultural Crops Located in Lava Zones and the Volcanic High Hazard Area

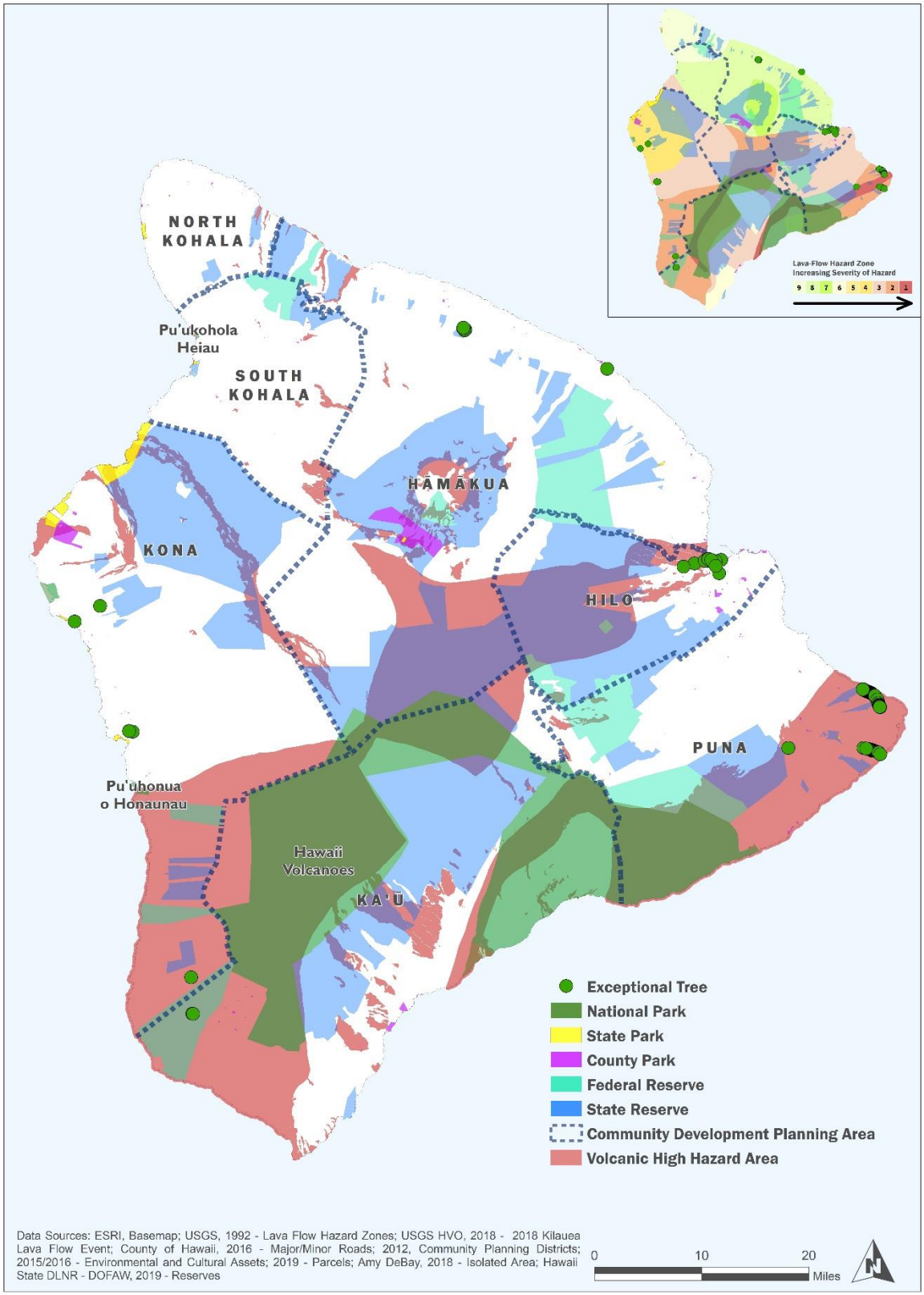


Figure 4-20. Protected Environmental Land in the County of Hawai'i Located in Lava Zones and Volcanic High Hazard Area

Table 4-14. County of Hawai'i Environmental Resources Located in Volcanic High Hazard Areas

Hazard Area	Total Protected Land *(acres / %)*	SLUD Conservation Land *(acres / %)*	Endangered and Threatened Habitat *(acres / %)*	Exceptional Trees *(number / %)*	Open Space: General and Protected *(acres / %)*	Agricultural Land of Importance *(acres / %)*
Volcanic High Hazard Area	549,219 / 43.2%	582,100 / 43.3%	171,438 / 32.6%	140 / 87.5%	1,309,735 / 37.4%	107,149 / 18.6%
Lava Zone 1	108,885 / 8.6%	106,685 / 7.9%	17,441 / 3.3%	1 / 0.6%	222,342 / 6.3%	5,442 / 0.9%
Lava Zone 2	505 / 0.0%	1,454 / 0.1%	0 / 0.0%	17 / 10.6%	7,863 / 0.2%	2,453 / 0.4%

SLUD State Land Use District
Note: Acres and total numbers of environmental resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the Volcanic High Hazard Area total.

Hazard Area	Crop Land *(acres / %)*	Pasture Land *(acres / %)*	Hunting Areas *(acres / %)*	County Park *(acres / %)*	State Park *(acres / %)*	National Park *(acres / %)*
Volcanic High Hazard Area	13,261 / 21.7%	72,365 / 13.1%	242,159 / 34.0%	2,672 / 23.1%	2,777 / 38.7%	274,771 / 76.2%
Lava Zone 1	564 / 0.9%	3,192 / 0.6%	11,420 / 1.6%	1 / 0.0%	18 / 0.2%	88,591 / 24.6%
Lava Zone 2	906 / 1.5%	25 / 0.0%	513 / 0.1%	22 / 0.2%	0 / 0.0%	0 / 0.0%

Note: Acres and total numbers of environmental resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the Volcanic High Hazard Area total.

Hazard Area	Wetlands *(acres / %)*	Reservoirs *(number / %)*	Anchialine Pools *(number / %)*
Volcanic High Hazard Area	1,947 / 3.5%	26 / 11.5%	196 / 37.1%
Lava Zone 1	15 / 0.0%	3 / 1.3%	1 / 0.2%
Lava Zone 2	92 / 0.2%	1 / 0.4%	182 / 34.4%

Note: Acres and total numbers of environmental resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the Volcanic High Hazard Area total.

In addition to lava flow impacts, other volcanic hazards may also impact environmental resources. Besides respiratory tract health effects similar to those in humans, vog can also cause the death of wildlife and livestock because of contaminated food consumption. Wildlife and livestock that graze, for example, can die after ingesting water or grass that has been heavily contaminated by falling ash and other volcanic particles. Another effect of vog on wildlife that has been noted particularly in the County of Hawai'i is the interruption of pollination by bees during heavy vog concentrations (HIEMA2018).

The deposition of fluoride salts carried by vog onto forage crops is also of great concern to wildlife and livestock. The scientific literature has documented a number of events where sheep, cattle, and horses have suffered significant losses as a result of acute exposure as well as chronic exposure and accumulation of fluoride salts by grazing animals (HIEMA 2013).

In 2010, Donald Thomas from the Center for the Study of Active Volcanoes and Trisha Macomber from the University of Hawaii's College of Tropical Agriculture produced a study on the effects of fluoride and sulfates on forage lands downwind of Kīlauea's Halema'uma'u Crater (Thomas and Macomber 2010). The study shows that forage samples contained fluoride and sulfate values higher than recommended by the World Health Organization. The study also indicates that although elevated concentrations of fluoride and sulfate do induce adverse health/nutritional effects on grazing animals, the high levels of these compounds do not impact the quality of meat from those animals that would be used for public consumption.

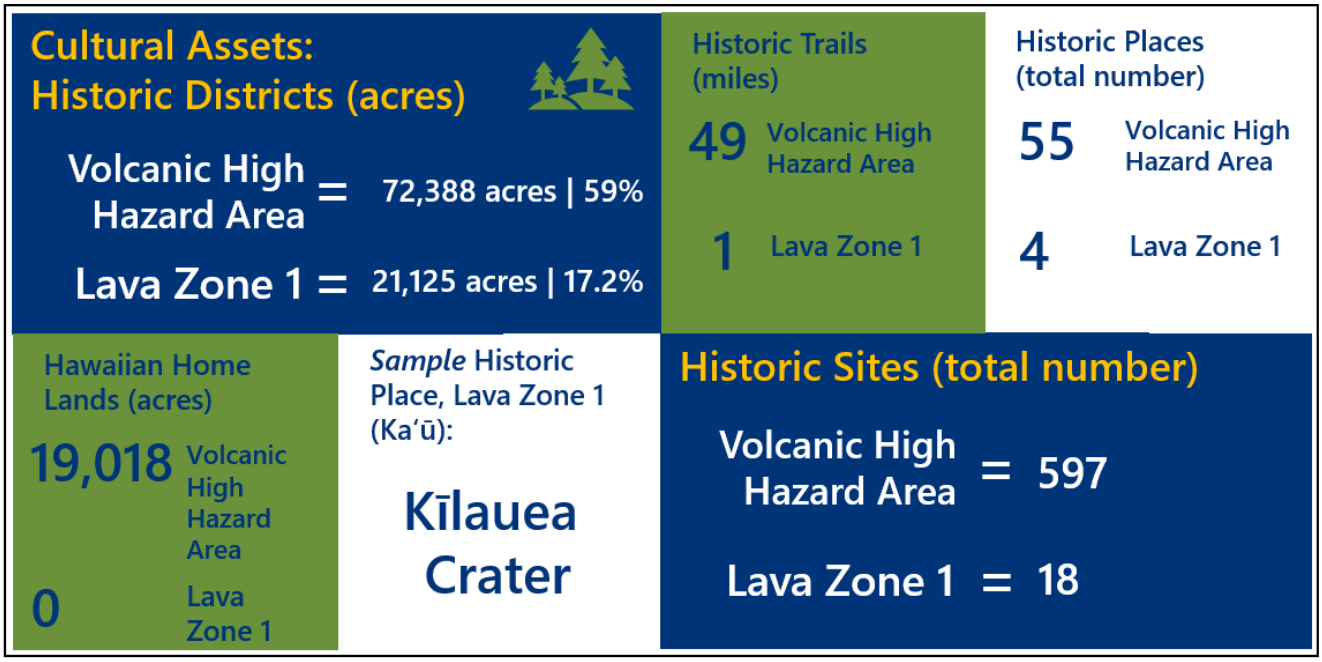
The general effects of sulfur dioxide exposure to plants varies between plant species, age, and the sulfur dioxide dosage. These effects may include:

- Reduced seed germination
- Enhanced susceptibility to other diseases
- Foliar necrosis (spots, blight)
- Epicuticular wax erosion
- Rupture of epidermis, plasmolysis
- Reduced chlorophyll content
- Increased membrane permeability of plant leaves
- Decreased plant growth (root length, shoot length, leaf numbers)
- Plant organ or entire plant death

Downwind of Kīlauea, farmers growing food crops, foliage crops, and cut flowers experienced immediate and severe losses due to damage arising from exposure to high concentrations of sulfur dioxide and sulfuric acid aerosols, following the 2018 eruption. Although downwind ranches did not experience immediate impacts, over time, they have found that horses, cattle, and goats developed serious adverse health impairment consistent with chronic fluoride exposure as well as severe mineral deficiencies. At the present time, the mediating factors in these health impacts are not well understood, although excess bone fluoride has been measured and therefore chronic exposure to and intake of fluoride is clearly one aspect of the problem. A secondary economic issue has been greatly accelerated corrosion of fencing, pipelines, and deterioration of ranching equipment. Anecdotal reports of service life losses of 60% to 70% suggest that the economic impacts of these losses could be severe (HIEMA 2018). Since August 2018, the amount of vog greatly decreased and is no longer a current hazard or impact from Kīlauea.

It should be noted, finally, that the impacts resulting from gas discharge detailed above are based on existing rates of discharge from more or less fixed locations of emissions. In the event of significant increases in the discharge rate from Kīlauea, or an eruption by Mauna Loa with ten or more times the gas production rate of Kīlauea, the impacts from the gas can be expected to increase correspondingly.

4.1.7 CULTURAL ASSETS



Note: All percentages are relative to the County of Hawai'i

Figure 4-21. County of Hawai'i Cultural Assets Located in the Volcanic High Hazard Area and Lava Zone 1

The County of Hawai'i is home to many formally designated and recognized cultural assets, historic places and sites that are important for shaping the identity of place and the people of the County of Hawai'i. A location-based database of culturally significant sites to Native Hawaiians was not available for use in this risk assessment; disclosure of the location of sacred and otherwise culturally significant sites is prohibited, in some instances, by federal law. To align with the County General Plan update, Hawaiian Home Lands, historic sites and trails were used for this analysis.

Cultural assets are non-renewable resources. Lava flows can cut off or inundate cultural sites and native land. Over half of the County's cultural asset acreage is located in a Volcanic High Hazard Area (72,388 acres; 59%). A total of 19,018 acres of Hawaiian Home Lands in the County, 55 historic places, 597 historic sites and 49 miles of historic trail are located in a Volcanic High Hazard Area (***Table 4-15***).

It is important to note that a majority of the cultural asset locations are along the coast and overlap with other hazard areas including tsunami, sea level rise, flood and coastal erosion.

Table 4-15. County of Hawai'i Cultural Resources by Volcanic Hazard Area

Hazard Area	Hawaiian Home Lands *(acres / %)*	Historic Districts *(acres / %)*	Historic Places *(number / %)*	Historic Sites *(number / %)*	Historic Trail *(miles / %)*
Volcanic High Hazard Area (VHHA)	19,018 / 15.4%	72,388 / 59%	55 / 32.0%	597 / 11.1%	49 / 19.2%
VHHA with Additional Natural High Hazard Area	6,228 / 32.7%	4,121 / 5.7%	32 / 18.6%	305 / 51.1%	10 / 3.8%
Lava Zone 1	0 / 0.0%	21,125 / 17.2%	4 / 2.3%	18 / 0.3%	1 / 0.5%
Lava Zone 2	14,030 / 11.4%	48,134 / 39.2%	24 / 14.0%	359 / 6.7%	39 / 15.3%

Note: Acres and total numbers of cultural resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

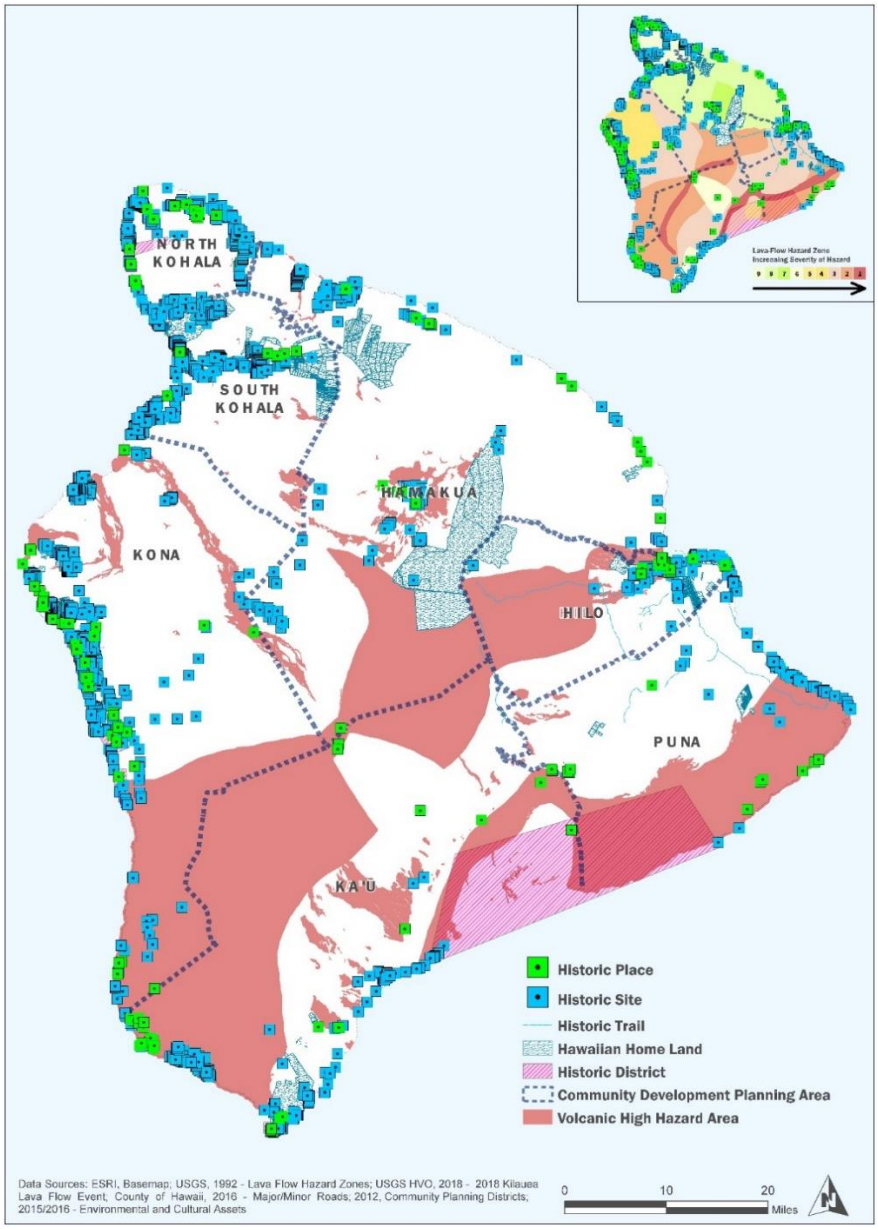


Figure 4-22. Cultural Assets in the County of Hawai'i and Volcanic Hazards

4.1.8 FUTURE LAND USE AND DEVELOPMENT

The County of Hawai'i is comprised of mixed land use classifications as categorized by the Land Use Pattern Allocation Guide (LUPAG) (***Figure 4-23***). While LUPAG designations guide decisions related to future land use, County zoning determines a parcel's current permitted land use and development entitlements (Hāmākua Community Development Plan 2016).

The majority of land in the County is either categorized as conservation (53.4%) or agricultural land (40%), either Extensive Agriculture or Important Agricultural Lands . Important Agricultural Lands are lands that are highly capable of producing significant yields of important agricultural outputs; whereas Extensive Agriculture includes lands that are not capable of producing sustained high agricultural yields without intensive application of farming methods and technologies. The remaining 6.6% of County land is classified as a mix of urban expansion, industrial, urban, rural, or open area.

Currently, 10% of the County's Volcanic High Hazard Area land is categorized for urban expansion or as another urban category (i.e., high-, medium-, or low-density urban). The land in lava zones 1 and 2 is mainly classified as conservation land, rural and extensive agriculture land; however, there is still land designated for low- and medium density urban uses that will put assets in these areas at risk to volcanic hazard impacts (***Table 4-16*** and ***Figure 4-23***).

Table 4-16. County of Hawai'i Land Use (LUPAG classification) in the Volcanic High Hazard Area and Lava Zones 1 and 2

LUPAG Classification	Total Area *(acres)*	Volcanic High Hazard Area *(acres)*	Lava Zone 1 *(acres)*	Lava Zone 2 *(acres)*
Breakwater	7	0	0	0
Conservation	1,378,357	609,742	112,986	446,161
Extensive Agriculture	641,921	168,109	19,474	134,631
High-Density Urban	1,308	177	0	0
Important Agricultural Lands	381,546	64,891	3,054	40,451
Industrial	10,916	1,770	0	0
Low-Density Urban	38,005	6,747	170	4,499
Medium-Density Urban	6,743	1,086	0	486
Open Area	35,245	7,336	331	4,602
Orchards	874	0	0	0
Ponds	18	0	0	0
Resort	178	0	0	0
Resort Node	5,654	468	0	0
Rural	47,649	15,712	4,311	11,815
University Use	1,127	52	0	0
Urban Expansion	30,757	843	0	826

LUPAG Land Use Pattern Allocation Guide

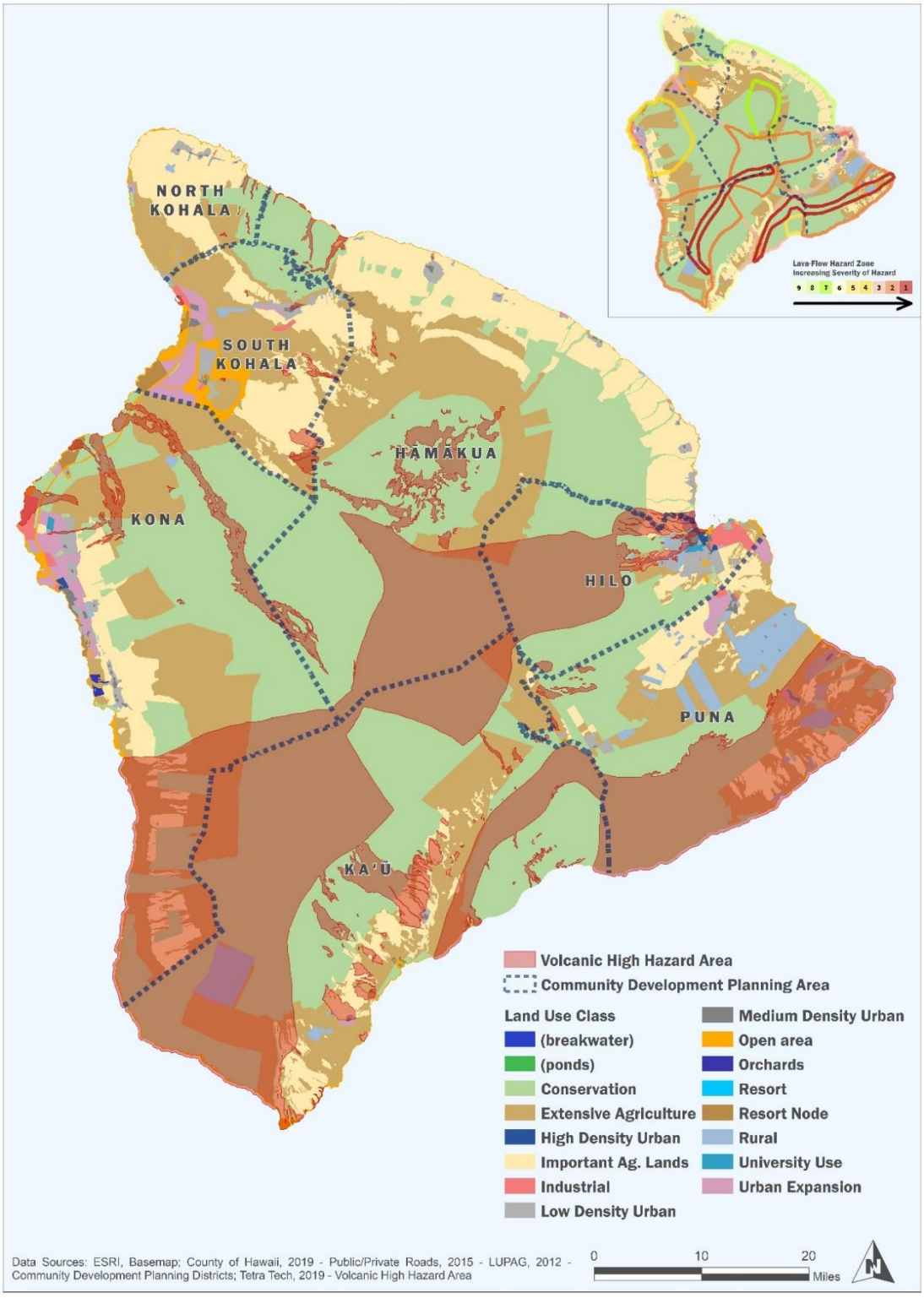


Figure 4-23. County of Hawai'i Land Use Pattern Allocation Guide (LUPAG) Classifications and Volcanic High Hazard Area

In preparation for the County's latest General Plan update (in progress), a build-out analysis was conducted to determine residential and non-residential capacity. The County has a total of 60,059 residential greenfield parcels (733,923 acres). Puna has the greatest total number of identified residential greenfield parcels in the County (35,888 parcels) illustrating the high potential for future development. Ka'ū has the greatest number of residential greenfield acres (164,711).

Future land use decisions and future policy should consider the location of the volcanic and additional natural high hazards prior as part of future development decisions. The County has a total of 25,825 residential parcels identified for potential future development located in the Volcanic High Hazard Area; of these 3,445 are located in lava zone 1, and 21,230 are located in lava zone 2. In terms of non-residential development, there are 123 non-residential parcels located in the Volcanic High Hazard Area and 192 parcels identified for potential non-residential redevelopment; refer to ***Figure 4-24*** and ***Figure 4-25***.

The exposure to other natural hazard impacts should also be taken into consideration when considering future development. Over 20% of parcels identified for residential redevelopment located in lava zone 1 also have the presence of another natural high hazard area (59 parcels). ***Table 4-17*** for additional statistics regarding parcels identified for future development and their location relative to the volcanic hazard areas and other natural high hazards.

Table 4-17.County of Hawai'i Build-out Analysis Results and Hazard Areas

Hazard Area	Residential Greenfield *(parcels / %*)*	Residential Potential Redevelopment *(parcels / %*)*	Non-Residential Greenfield *(parcels / %*)*	Non-Residential Potential Redevelopment *(parcels / %*)*
Volcanic High Hazard Area (VHHA)	25,825 / 43.0%	2,630 / 10.3%	123 / 17.3%	192 / 19.0%
VHHA with Additional Natural High Hazard Area	13,372 / 51.8%	1,429 / 54.3%	105 / 85.4%	156 / 81.3%
Lava Zone 1	3,445 / 5.7%	288 / 1.1%	0 / 0.0%	0 / 0.0%
Lava Zone 1 with Additional Natural High Hazard Area	1,484 / 43.1%	3,378 / 2.1%	0 / 0.0%	0 / 0.0%
Lava Zone 2	21,230 / 35.3%	945 / 3.7%	20 / 2.8%	35 / 3.5%
Lava Zone 2 with Additional Natural High Hazard Area	10,888 / 51.3%	504 / 53.3%	3 / 15.0%	0 / 0.0%
Lava Zone 3	26,590 / 44.3%	13,049 / 51.1%	373 / 52.4%	582 / 57.7%
Lava Zone 4	2,204 / 3.7%	3,792 / 14.9%	186 / 26.1%	156 / 15.5%
Lava Zone 5	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 6	1,608 / 2.7%	189 / .7%	2 / .3%	20 / 2%
Lava Zone 7	9 / 0%	1 / 0%	0 / 0%	0 / 0%
Lava Zone 8	3,386 / 5.6%	5,929 / 23.2%	77 / 10.8%	159 / 15.8%
Lava Zone 9	1,587 / 2.6%	1,332 / 5.2%	54 / 7.6%	56 / 5.6%

**The percentage of parcels relative to the total number in the County of Hawai'i.*
Note: Parcels in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

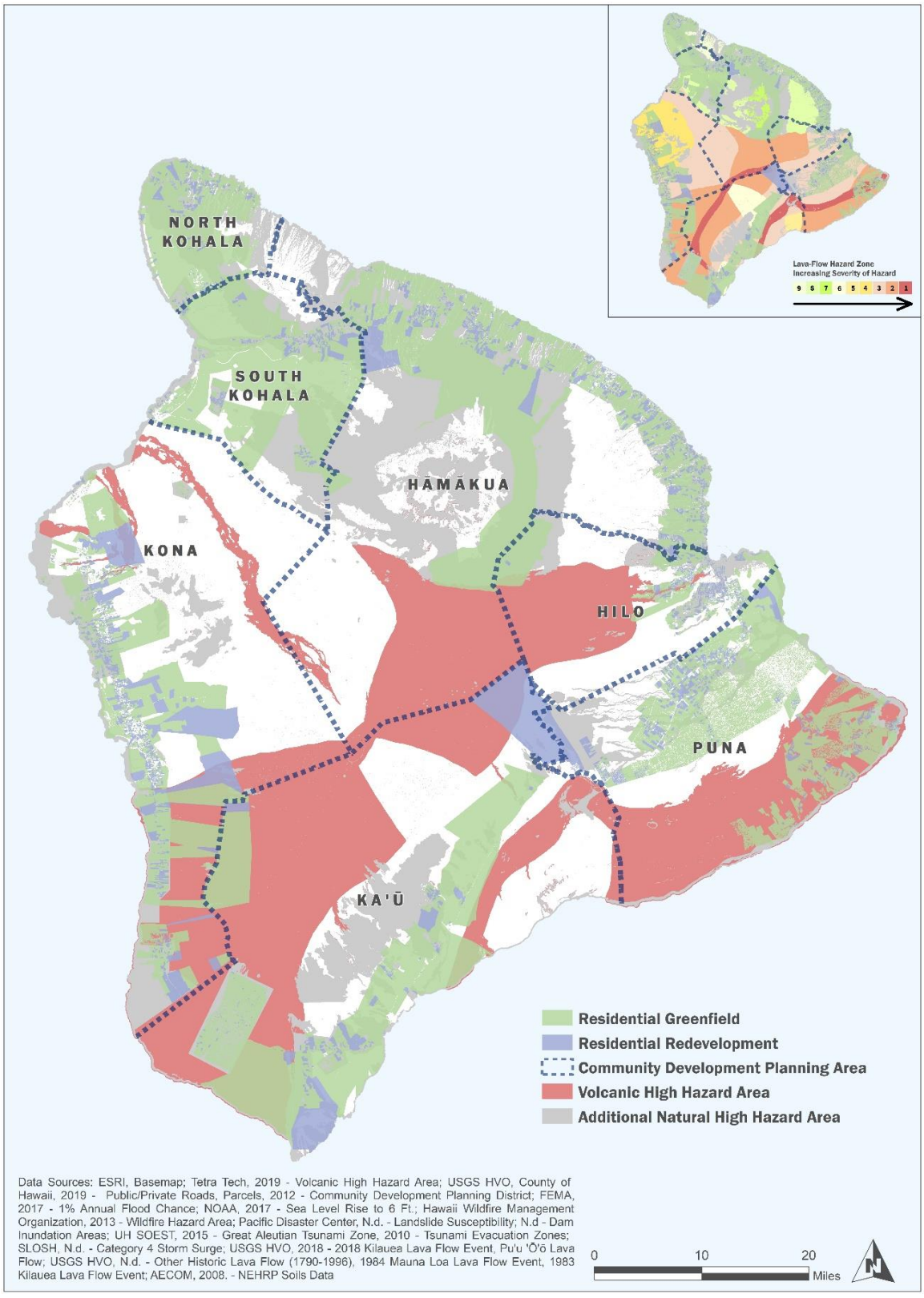


Figure 4-24. County of Hawai'i Greenfield and Redevelopment Areas and Volcanic Hazard Area

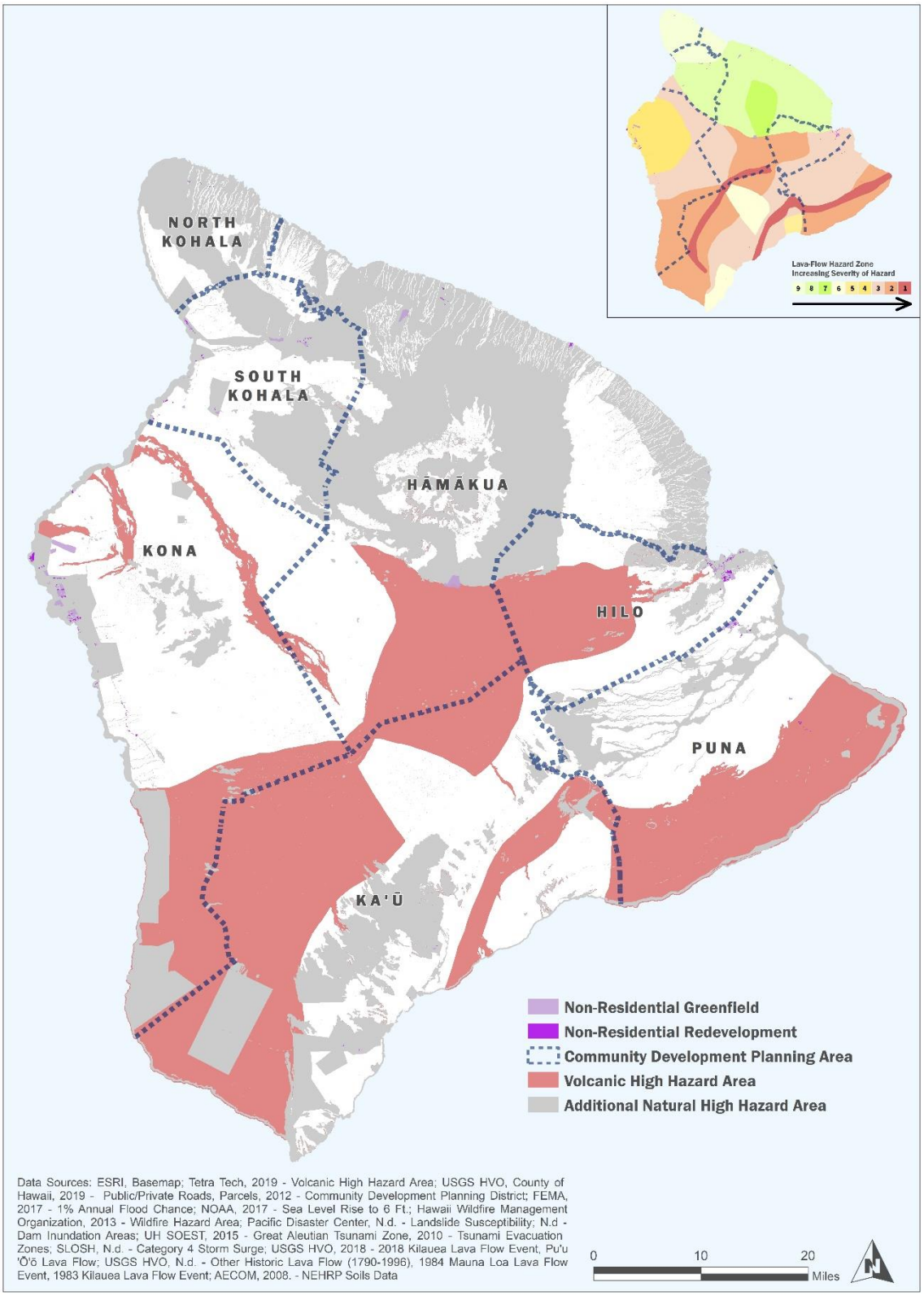


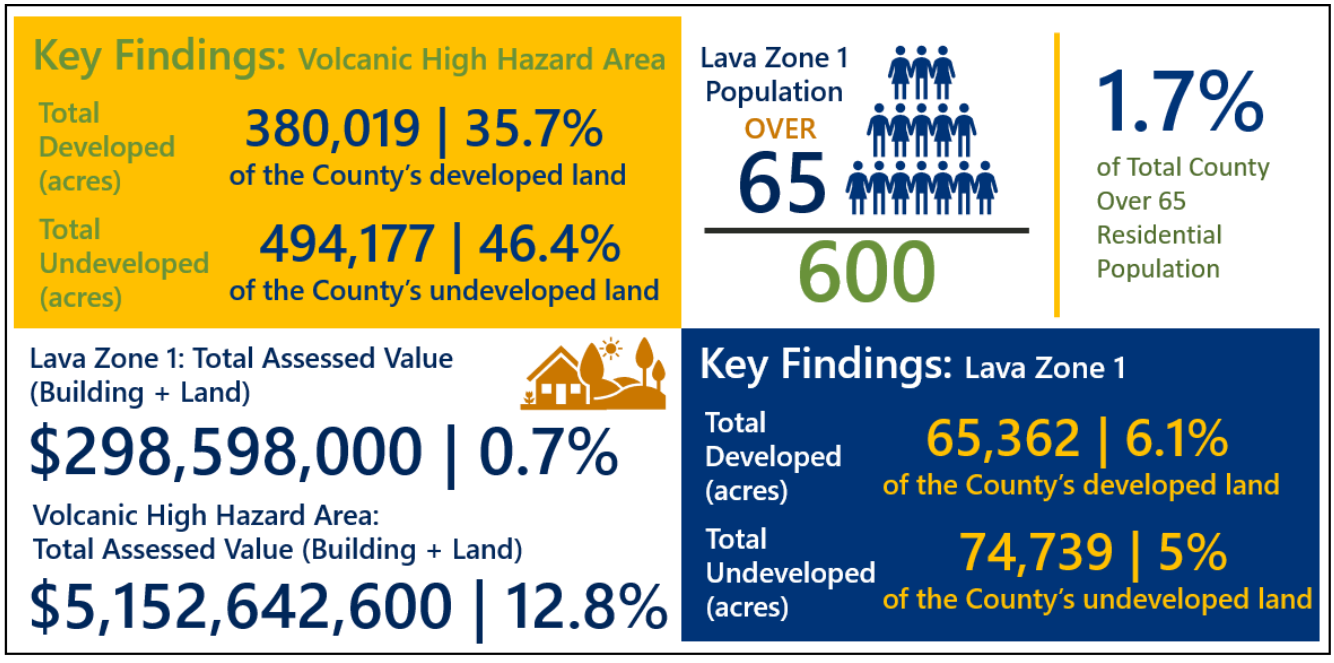
Figure 4-25. County of Hawai'i Non-Residential Greenfield Areas and Volcanic High Hazard Area

There is a significant lack of hazard insurance for many structures in the County. State of Hawai'i lawmakers created, in 1991, a nonprofit collection of insurance companies called the Hawai'i Property Insurance Association to address this gap. The State assembled the nonprofit to provide basic property insurance for people who are unable to buy coverage in the private market, due to insurers being uncomfortable with Hawai'i's significant volcano risk (ABA Journal 2018).

Looking to the future, high hazard risk combined with limited insurance is a considerable factor when planning for the County's continued growth. Who will be able to afford to live in an area that is vulnerable to lava flow and other volcanic-related risks? Will the most vulnerable be forced to move to other vulnerable areas due to availability and affordability? Or will they remain and bear the burden when the next event takes place? These questions will be critical to address moving forward with all plans for future development/re-development and decisions about future population centers in the County. Redevelopment or continued development is not always the preferred option. In fact, Hilo took an approach to some of their past damaged land to not rebuild, but rather turned the damaged land into a park—looking to other low-hazard exposure land for development and population growth.

An additional, yet related, factor is the prevalence of informal houses or settlements within some districts in the County (i.e. Puna). These settlements represent people that are often left out of traditional population surveys (i.e. U.S. Census) with homes that are not officially documented or recorded, making evacuation and emergency messages (or even evacuation teams) difficult (Jones 2019). In high-hazard areas, predominantly rural areas like Puna and Ka'ū should determine ways to account for the under-counted population and informal structures to properly understand hazard risk and identify mitigation measures.

4.1.9 KEY FINDINGS



Note: All percentages are relative to the County of Hawai'i

Figure 4-26. County of Hawai'i Key Findings

Understanding what is at risk to natural hazards and future changes that impact vulnerability can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The following summarizes the key findings for the County of Hawai'i:

- Puna has the greatest number of parcels located in lava zone 1 (3,489) in the County
- Ka'ū has the greatest total assessed value located in lava zone 1 ($146,029,900) and has the greatest number of acres in lava zone 1 (81,299) and in lava zone 2 (247,214) in the County
- Puna and Ka'ū are the only two CDPs with roads that intersect lava zone 1
- 19,242 County parcels (14.4%), 3,754 households (4.8%), and 9,476 residents (4.8%) have been inundated and impacted by historic lava flows, including the 2014-2015 Pu'u 'Ō'ō and the 2018 Kīlauea events
- A total of 62 developed parcels have been repetitively impacted by lava-flow events.

Looking to the future, the County of Hawai'i will be frequently confronted with significant decisions about life safety, development, recovery, rebuilding, and general land use, due to concentrated volcanic risk areas. The impacts from the 2018 Kīlauea event are still being felt, countywide, and many decisions still need to be made; by residents and local government. Particularly, the volcano risks associated with lava zone 1 pose the greatest risk to people, sacred places, and important crop land. Future redevelopment and greenfield development should be carefully considered with a full understanding and assessment of the implications of adding new uses and potentially new population in areas of the County with high volcano risk and exposure. Alternatively, there are locations within the County with significantly less exposure to high volcanic and other natural hazard risk providing an option for keeping up with the demand of living safely in the County (

Table 4-18 ***and Table 4-19)***. Furthermore, considerations for the County's most vulnerable populations need to made and prioritized, in support of reducing volcanic risk and exposure. Strategic policy decisions and priorities should be identified to target the County's most vulnerable, to reduce risk to future volcanic events and other natural hazard events.

Table 4-18. Volcanic High Hazard Area, CDP Ranking

Community Development Plan	Percent (%) of Volcanic High Hazard Area Land
1. Ka'ū	56%
2. Puna	45.5%
3. Hilo	41.8%
4. Kona	29.7%
5. Hāmākua	19.8%
6. South Kohala	3.3%
7. North Kohala	<1%
Community Development Plan	**Percent (%) of Volcanic High Hazard Area Land**
8. Ka'ū	56%
9. Puna	45.5%
10. Hilo	41.8%
11. Kona	29.7%
12. Hāmākua	19.8%
13. South Kohala	3.3%
14. North Kohala	<1%

Table 4-19. Additional Natural High Hazard Area, CDP Ranking

Community Development Plan	Percent (%) of Additional Natural High Hazard Area Land
1. North Kohala	69.3%
2. South Kohala	48.9%
3. Hāmākua	47.4%
4. Ka'ū	21.4%
5. Hilo	21.2%
6. Kona	16.8%
7. Puna	14.6%

4.2 Hāmākua

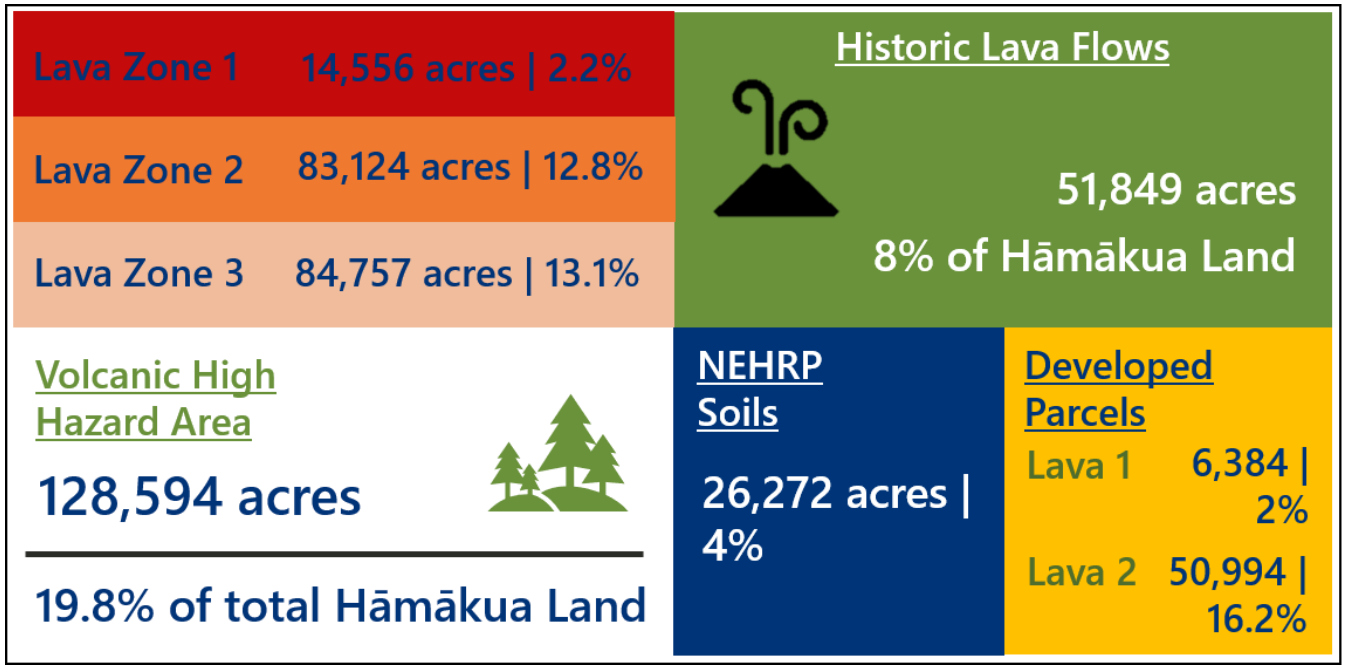
4.2.1 OVERVIEW

The Hāmākua Community Development Plan district (CDP), herein referred to as Hāmākua, is a northeastern district on the eastern coast of the Island of Hawai'i. It represents the second largest CDP in land area; and is the same size as the Ka'ū CDP. Hāmākua shares a border with all County CDPs except for Puna and includes a 50-mile long eastern coastal border with the Pacific Ocean. The Mauna Kea volcano and its tropical rainforests are defining features of Hāmākua, including a network of steep mountainous trails. The lush, steep landscape provides a dramatic backdrop to the District's famous Hāmākua Coast.

One of the six original districts of ancient Hawai'i on the island, known as moku, Hāmākua's landscape is unique, when compared to other districts in the County. Hāmākua is primarily dominated by lush rainforests because it is located on the wet or windward side of the island; it also lacks sandy beaches. Outside of several population centers, Hāmākua is primarily undeveloped or rural (51.5%), dominated by rainforests and protected land (including the northern part of Hawai'i Volcanoes National Park). Hāmākua includes waterfalls, green valleys, and receives over 80 inches of annual rainfall. Two of Hāmākua's most famous waterfalls are 'Akaka Falls (442 feet) and Kahūnā Falls (100 feet) (Hawai'i Tourism Authority 2019). Hāmākua includes the following town centers: Pauka'a, Papa'ikou, Pepe'ekeo, Honomū, Hakalau, Nīnole, Laupāhoehoe, 'Ō'ōkala, Honoka'a, and Kukuihaele (Hāmākua CDP 2018).

While Hāmākua was mostly settled beginning in the late 1800s by sugar cane farmers setting up plantations, it is one of the least populated CDPs in the County. The modern district of Hāmākua encompasses 1,011 square miles and includes the judicial districts of Hāmākua and North Hilo, and a portion of the South Hilo district commonly referred to as Rural South Hilo (Hāmākua CDP 2018). The region was historically renowned as a powerful religious, economic, and demographic center of the County and from early times, the region was known for its agriculture. Over 60% of Hāmākua's land is located in the Conservation District, less than 1% of land is classified as (low/medium/high density) urban, and the remainder is largely agricultural (37.8%). Present day, Hāmākua's character and settlement patterns remain largely rural and agricultural, with most development scattered along Highway 19 and clustered in one of the District's small town centers. Like all County Districts, Hāmākua's history runs deep with a rich context of irreplaceable cultural and environmental resources. The decline of the sugar cane industry over the last 30 years has contributed to population loss in Hāmākua. As a result, Hāmākua has been in a process of transitioning its economy away from sugar production towards tourism over the last 10 years (Hāmākua CDP Community Profile 2012).

4.2.2 VOLCANIC HAZARDS



Note: All percentages are relative to the Hāmākua CDP District

Figure 4-27. Hāmākua Volcanic Hazard Exposure Overview

Hāmākua is home to the Mauna Kea volcano, one of the five volcanoes present on the Island and highest in height. Mauna Kea is considered still active, having erupted between 6,000 and 4,500 years ago. The Mauna Loa volcano, while not located in Hāmākua, is located just outside the CDP boundaries to the southwest and therefore is the reason for the appearance of lava zones 1, 2, and 3 land in the southern half of Hāmākua. An overview of volcanic hazard exposure for Hāmākua in provided in ***Figure 4-27.***

Hāmākua is located within lava-flow hazard zones 1, 2, 3, 7, 8, and 9 (

Figure 4-28), the largest of which is lava zone 8, representing 54.7% of land area. Lava zone 8 is comprised of older land surrounding Mauna Kea; of which only a small portion has been covered by lava in the past 10,000 years (U.S. Geological Survey [USGS] 2019). Lava zone 8 extends from the slopes of Mauna Kea to the Pacific Ocean and the Hāmākua's town centers. The vast majority of Hāmākua's population lives in lava zone 8, in one of the District's several towns located along the Hawai'i Belt Road.

More than 15% of Hāmākua is located within lava-flow hazard zones 1 and 2, which includes flows surrounding Mauna Loa. Mauna Loa has a history of frequent lava flows within zone 1, or in areas adjacent to or downslope of lava zone 1 within lava zone 2. Of the nearly 50% of developed land within Hāmākua (or parcels with a building assessment value according to County assessor records), nearly 100,000 acres (97,680), is located within high-risk lava flow hazard zones 1 and 2 (***Table 4-20***). For the purposes of this assessment, developed and undeveloped land has been calculated at the parcel level, regardless of private or public ownership.

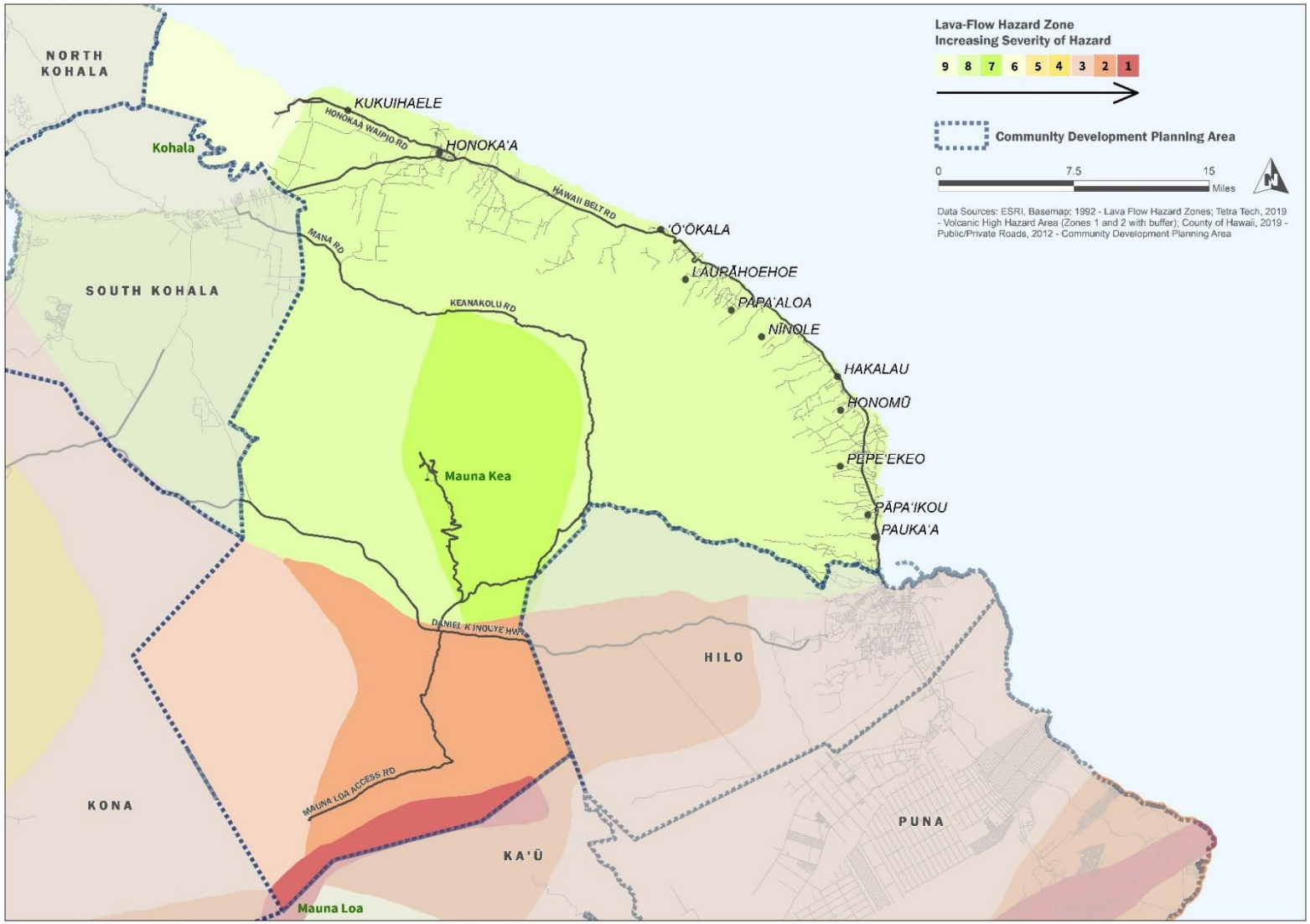


Figure 4-28. Lava Zones in Hāmākua

Table 4-20. Hāmākua Developed vs. Undeveloped Parcel Area by Lava Zone

	Total Area (acres)	Lava Zone 1 (acres)	Lava Zone 2 (acres)	Lava Zone 3 (acres)	Lava Zone 4 (acres)	Lava Zone 5 (acres)	Lava Zone 6 (acres)	Lava Zone 7 (acres)	Lava Zone 8 (acres)	Lava Zone 9 (acres)
Hāmākua	**648,934**	**14,556**	**83,124**	**84,757**	**0**	**0**	**0**	**79,650**	**354,768**	**32,019**
Developed	314,670	6,384	50,994	1,406	0	0	0	66,664	185,166	4,040
Undeveloped	334,264	8,172	32,131	83,352	0	0	0	12,986	169,602	27,979

Note: Developed parcels reflect a parcel that contains a building assessment value per the County assessor records.

Lava zone 3 represents the second highest percentage of land area within Hāmākua (13%) and is primarily located near the western border of Kona. According to the USGS, lava zone 3 is less hazardous than lava zone 2 due to its distance from recently active vents and topography. However, lava zone 3 has been inundated by past lava flows; 1 to 5% covered since 1800 and 15 to 75% covered within the past 750 years countywide (Wright et al. 1992). Lava is not the only volcanic hazard faced by Hāmākua.

Soil conditions have a profound influence on the characteristics of ground shaking during an earthquake. Of Hāmākua's parcels, 12.6% are located within peak ground acceleration (PGA) 120%g, which roughly corresponds to Seismic Design Category (SDC) E. SDC E is the seismic hazard zone capable of producing the most intense shaking (USGS 2017). Refer to ***Section 3 - Methodology*** for more details on the PGA 120%g seismic zone. Related, Hāmākua has 925 parcels (or 9.8% of total parcels) located on softer soils (National Earthquake Hazard Reduction Program [NEHRP] types D and E, such as fill, mud and sand) that amplify ground shaking.

Vog, a visible haze comprised of water vapor, carbon dioxide, sulfur dioxide (SO_2) and particulate matter produced during volcanic eruptions, can compromise air quality, especially for those areas downwind of volcanic emissions. It poses respiratory challenges for those exposed to it within the affected area. Vog impacts can be experienced hundreds, if not thousands, of miles away (Tetra Tech 2018). As was experienced during the 2018 Kīlauea eruption, regular ash emissions from the summit of Kīlauea, as well as acidic ocean entry plumes, generated by lava flows into the sea, also known as laze, also contribute to poor air quality in downwind locations (U.S. Department of the Interior Strategic Sciences Group 2018). Wind direction and speed are the two most critical factors that determine vog impacts within Hāmākua. For example, winds that emanate from the southeast, can bring SO_2 and vog from Kīlauea's summit vent to Hāmākua.

As discussed in ***Section 3 – Methodology***, geographic information system (GIS)-based volcanic hazard areas were aggregated into a single category to identify those areas throughout the County with the greatest volcanic hazard risk: Volcanic High Hazard Area. The Volcanic High Hazard Area includes: lava zones 1 and 2, historic lava flow events (1790-2018), and NEHRP D&E soils. This risk assessment focuses on Hāmākua's exposure to the Volcanic High Hazard Area and lava-flow hazard zones 1 and 2. Nearly 20% of Hāmākua is located within the Volcanic High Hazard Area (19.8%) with the remainder located in lava zones 3, 7, 8, and 9. ***Table 4-21*** provides a summary of Hāmākua's land area in each volcanic hazard area.

Table 4-21. Hāmākua Land by Volcanic High Hazard Area and Lava Zones

Hazard Area	Total Land Area *(acres)*	Developed Parcel Area *(acres)*	Undeveloped Parcel Area *(acres)*
Volcanic High Hazard Area (VHHA)	128,594 (19.8%)	78,262 (24.9%)	50,332 (15.1%)
Lava Zone 1	14,556 (2.2%)	6,384 (2%)	8,172 (2.4%)
Lava Zone 2	83,124 (12.8%)	50,994 (16.2%)	32,131 (9.6%)
Lava Zone 3	84,757 (13.1%)	1,406 (0.4%)	83,352 (24.9%)

Note: Acres in each hazard area was calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

The Hāmākua District is also prone to additional natural hazards. These hazards include tsunamis, earthquakes, floods, landslides, storm surge, coastal erosion, and sea level rise. In particular, landslides and road flooding close Highway 19, isolating communities 6 to 10 times per year. Isolation is a significant issue for many Hāmākua residents due to three gulches on the Hāmākua coast and the potential for landslides.

This area of steep mountains also impacts internet broadband and radio service. There are many areas with no service during certain times of the year, like peak tourist season which puts a strain on service. In addition to examining the assets exposed to the volcanic hazard areas, it is important to determine if those assets are located in additional natural high-hazard zones to inform the identification of recovery and mitigation strategy development. ***Figure 4-29*** illustrates the location of additional natural high-hazard areas located in Hāmākua and ***Figure 4-30*** illustrates the additional high hazard areas relative to the lava zones and Volcanic High Hazard Area. The combination of volcanic and additional natural high hazard areas is shown in ***Figure 4-31.***

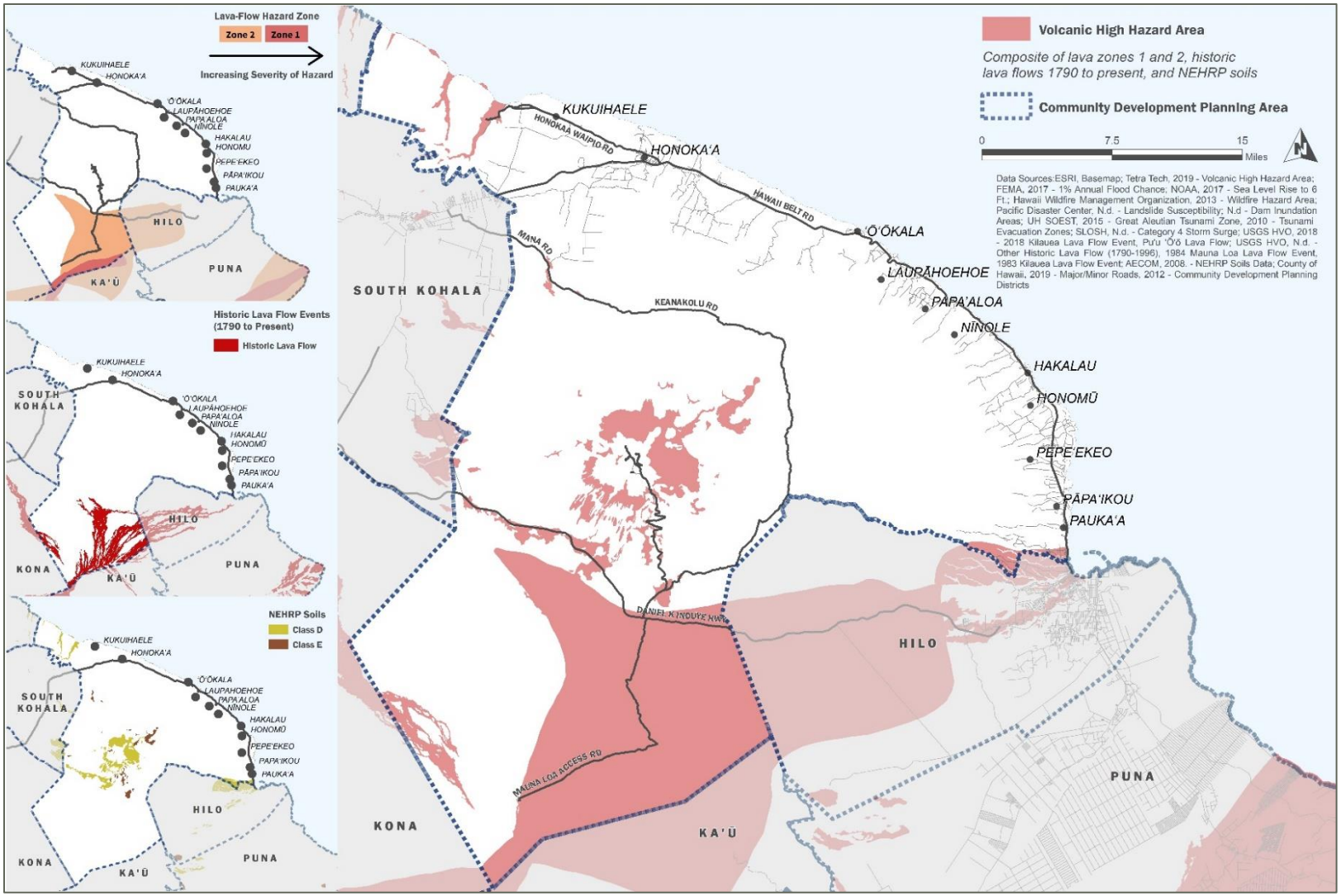


Figure 4-29. Volcanic High Hazard Areas in Hāmākua

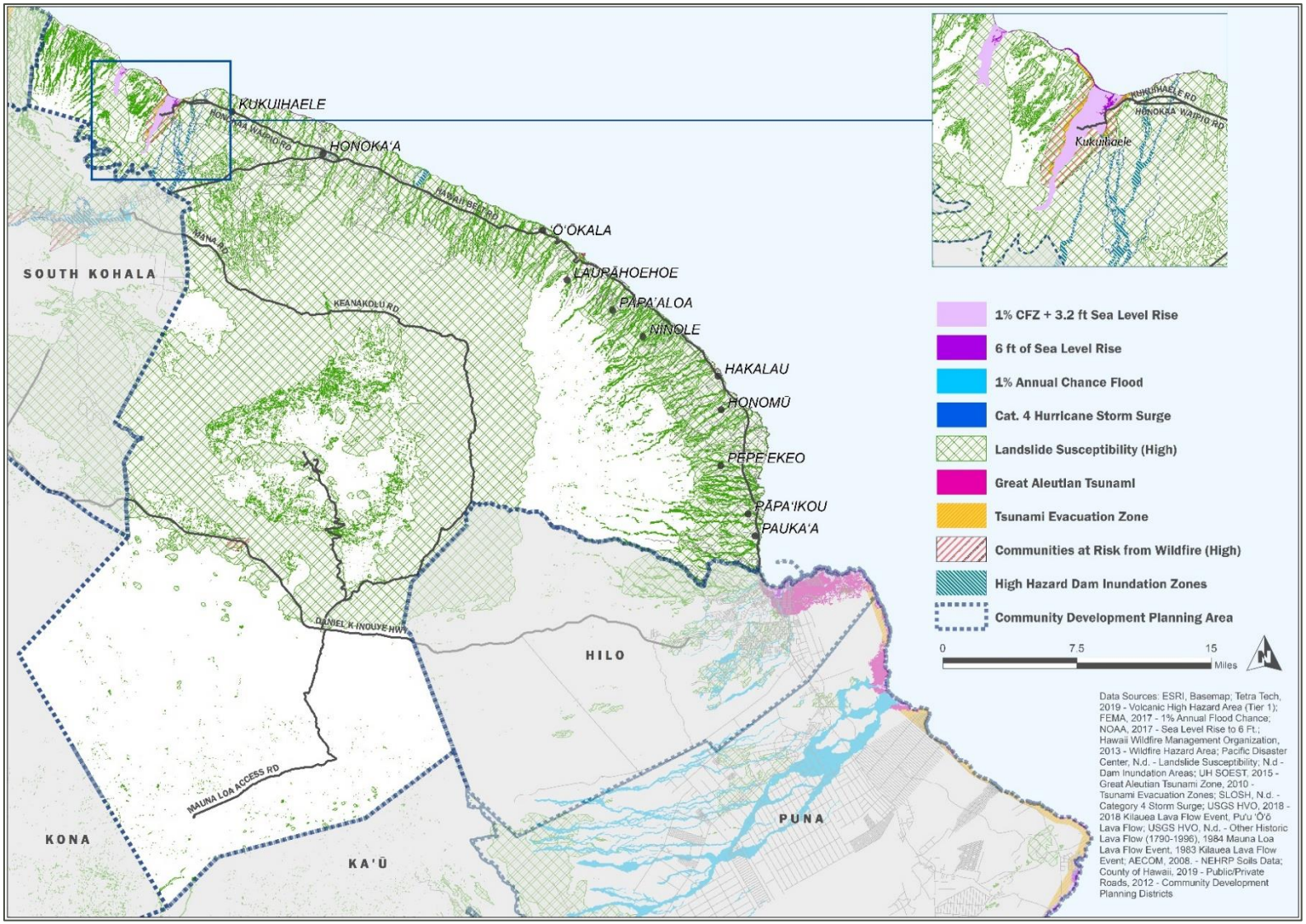


Figure 4-30. Additional Natural High Hazard Areas in Hāmākua

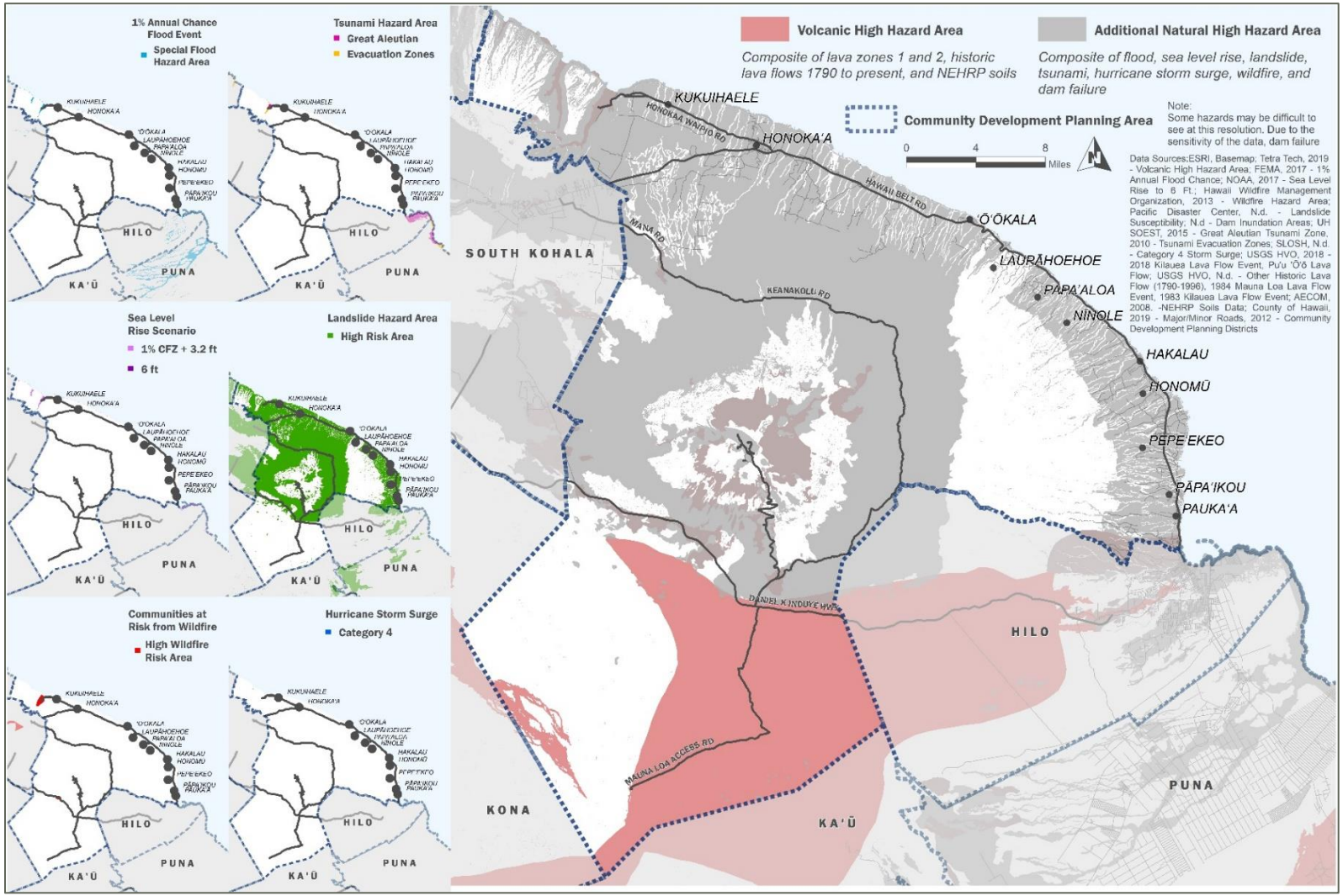
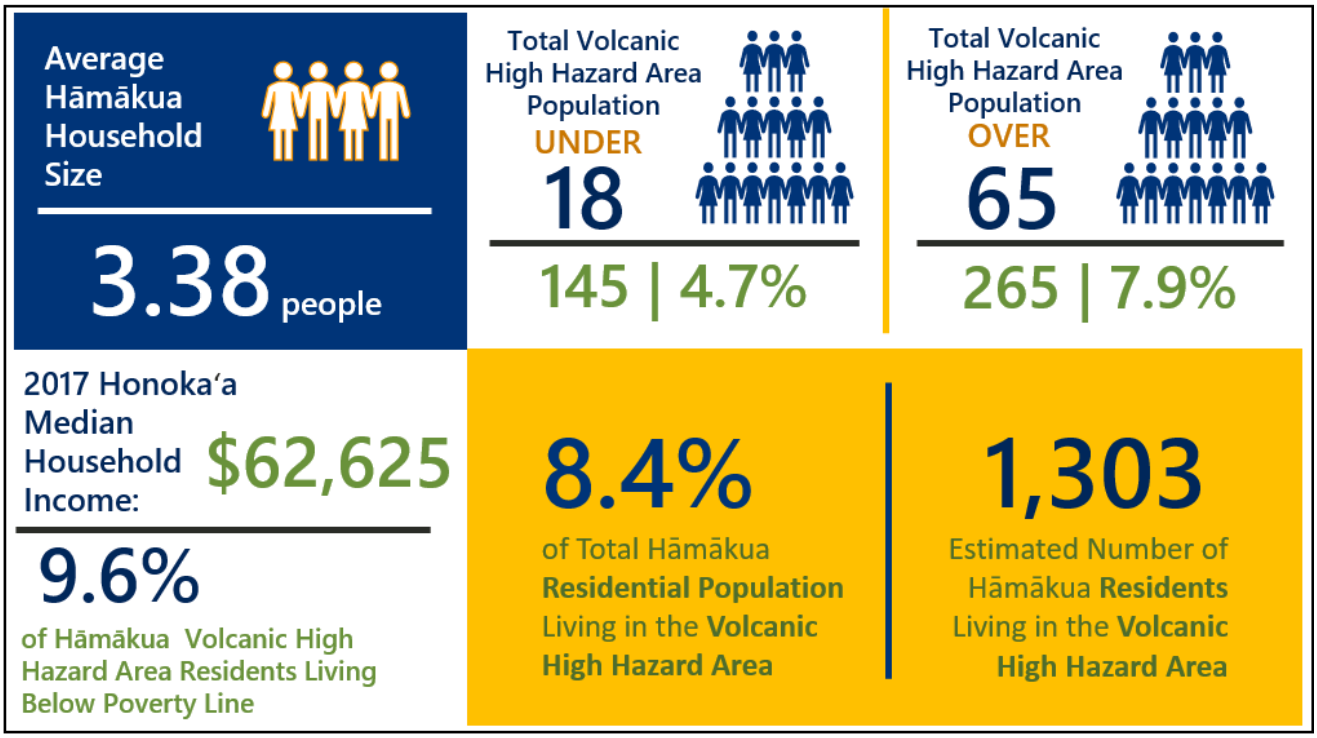


Figure 4-31. Volcanic High Hazard and Additional Natural High Hazard Areas Located in Hāmākua

4.2.3 POPULATION



Note: All percentages are relative to the Hāmākua CDP District

Figure 4-32. Hāmākua Population Exposure to the Volcanic High Hazard Areas

As of 2017, Hāmākua's total population was 15,488, which represents 4.6% of the County's total population (U.S. Census 2017). According to the 2019 draft County of Hawai'i General Plan, Hāmākua is expected to see a slowing of growth relative to other parts of the County that have, until now, been lower growth and population (i.e. Puna) (County of Hawai'i 2019). Looking forward, Hāmākua is anticipated to experience a 36% increase in growth whereas Upper Puna is expected a 101% increase (from 2010-2040). Regarding non-residential growth projections, Hāmākua is also expected to experience slow growth over the next 20 years (28%). According to the 2012 Hāmākua Community Profile, the population trend in Hāmākua over the last 20 years has been one of decline. The population decline is most likely attributable to the subsequent decline in the sugar industry, including sugar mill closures.

The Hāmākua CDP has several prominent towns (listed from south to north): Pauka'a, Papa'ikou, Pepe'ekeo, Honomū, Hakalau, Nīnole, Pāpa'aloa, Laupāhoehoe, 'Ō'ōkala, Honoka'a, and Kukuihaele (see ***Figure 4-34***). All notable towns are small in size, ranging from 300 to 2,200 people. Honoka'a is the largest in size (2,200 from 2010 U.S. Census); nearly 1,000 more people than the next largest town.

As noted in ***Section 3 – Methodology,*** examining resident and household exposure to the volcanic hazard is challenging because parcel-level demographic data is generally not available. Instead, demographic statistics from the 2017 ACS were collected for each U.S. Census tract within the County. Each tract's 2017 population count and the number of 2019 residential parcels in the tract were used to calculate the average number of persons per household. This data was then used to conduct the population exposure assessment using each parcel's estimated household size. The

results of this analysis are limited based upon the data available and should only be used for planning purposes until higher resolution data is available.

Nearly 100% of Hāmākua District residents live in lava zone 8 (99.2%), with a low exposure to the lava-flow hazard. There is no calculated probability associated with each lava-flow hazard zone. The zones, ranked from 1 through 9, represent a scale of increasing hazard as the numbers decrease, based on the probability of coverage by lava flows. Therefore, land classified as lava zone 1 is the most hazardous (USGS 2019).

Figure 4-33 summarizes the number of Hāmākua residents based on which lava zones they reside (lava zones 7, 8, and 9). Hāmākua's population lives only in lava zones 7 through 9. As shown, the greatest number of residents live in lava zone 8 (representing over 99% of Hāmākua's total population).

Figure 4-34 illustrates the population density across Hāmākua relative to the Volcanic High Hazard Area. There is minimal overlap between Volcanic High Hazard area and population densities. In total, only 8.4% of Hāmākua's population lives in a Volcanic High Hazard Area. Note, these resident totals do not reflect the number of undocumented residents, tourists and visitors residing in the District either permanently or temporarily.

In summary, the Hāmākua CDP has one of the lowest percentage of households in the County located in the Volcanic High Hazard Area (<10% of total Hāmākua households). In addition, Hāmākua has by far the greatest percentage of population living in lava zone 8 compared to the rest of the County (99.3% of total Hāmākua households).

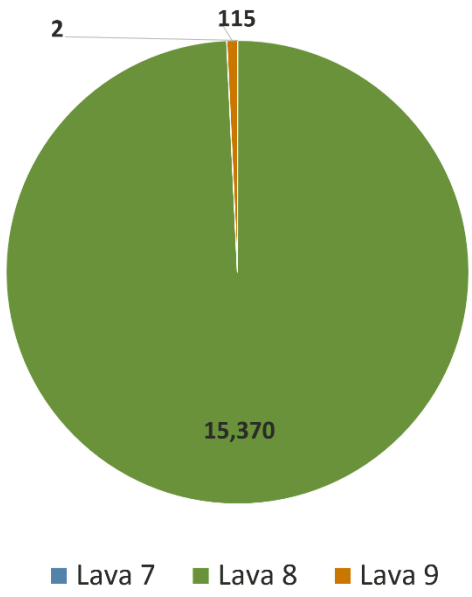


Figure 4-33. Distribution of Hāmākua Residents by Lava Zones

At the individual resident level, countywide, Hāmākua also ranks high for greatest percentage of residents living in lava zone 8 (99.2% of total Hāmākua residents).

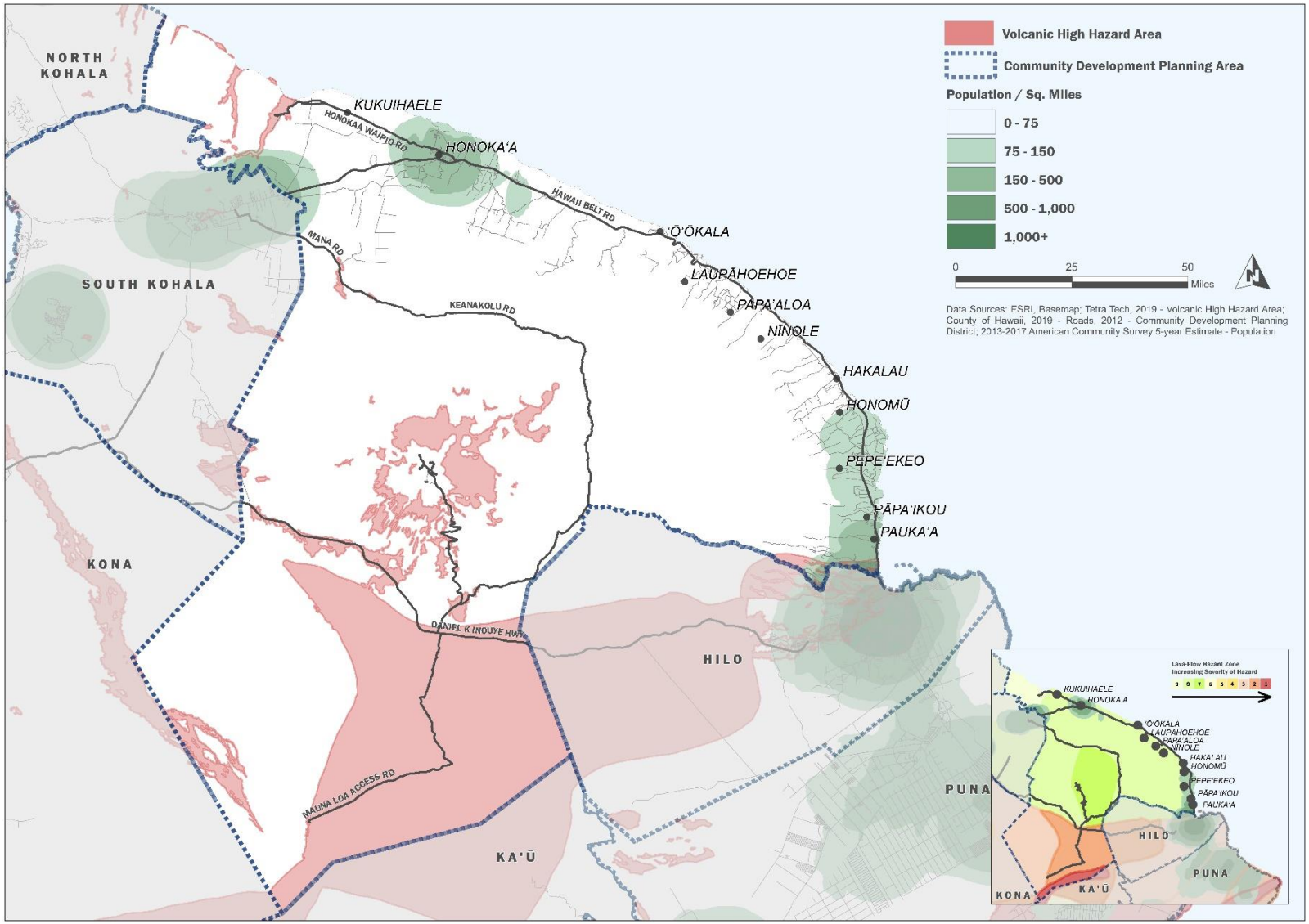


Figure 4-34. Hāmākua Population Density Relative to the Volcanic Hazards

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted (Donner 2011). This is due to many factors including their physical and financial ability to react or respond during a hazard. This population is referred to as socially vulnerable to hazard events. At the same time, County residents are unique and although may be faced with exposure to a greater number of natural hazard events, this may have increased their overall level of resilience. This is likely due to factors including, but not limited to: institutional knowledge of hazard events, intimate knowledge of the natural elements of the County (particularly for those residents who have lived in the County for an extended period of time), and varying levels of existing self-sufficiency. In 2019, the Pacific Disaster Center released the Kīlauea Eruption Risk Assessment (KERA) report that identified key social drivers of volcanic hazard vulnerability: 1. Socioeconomic status; 2. Access to information; and 3. Household composition (Pacific Disaster Center 2019). To align with the KERA report, the County examined the exposure of these vulnerable populations to the volcanic hazard.

Table 4-22 summarizes the vulnerable population statistics in Hāmākua by number of residents. The District majority is considered low-income (57.5% of total Hāmākua population). Additionally, Hāmākua has a large resident population with no access to internet (29.6% of total Hāmākua population), under 18 years old (19.9% of total Hāmākua population), and over 65 years old (21.6% of total Hāmākua population).

In terms of total number of residents, those residents with no internet, single parent household, and over 65 represent the top three vulnerable population categories within the Hāmākua District. The County may consider the high rate and density of residents with no internet in future planning efforts, especially with specific focus on ways in which to provide alternative means of communication to those residents during an event or during awareness campaigns.

Over 30% of the Hāmākua (410) residents living in the Volcanic High Hazard Area are either under 18 years of age or over 65 years of age. Additionally, it is estimated that nearly 30% of residents in Hāmākua with no phone service live within the Volcanic High Hazard Area. This means that they have limited connectivity which in turn limits their ability to receive traditional hazard alerts and emergency evacuation notices. The following summarizes the estimated number of residents living in the Volcanic High Hazard Area and considered the most vulnerable to the volcanic hazard:

- 145 people under 18 years of age
- 265 people over 65 years of age
- 203 single parents
- 157 people living with a disability
- 317 people with no internet access
- 59 people with no vehicle access
- 41 people with no phone access
- 33 people who are unemployed
- 174 people utilizing SNAP
- 263 people living below the poverty line

Table 4-22. Hāmākua Vulnerable Population

Estimated Vulnerable Populations	
No Internet	4,592
Single Parent	3,702
Over 65	3,350
Under 18	3,077
SNAP	2,745
Below Poverty Line	2,732
Disability	2,229
Non-English Speaking	1,132
No Diploma	1,122
No Health Insurance	640
No Vehicle	537
Unemployed	468
No Phone	144

As previously discussed, resident exposure to hazards is based on U.S. Census tract data because this information is not available at the parcel level. Refer to ***Section 3 - Methodology*** for more details on the methodology used to generate these estimates. The limitations of this analysis are recognized, and results should be used for planning purposes only and updated when higher resolution data is available.

Many Hāmākua residents are dependent on a rainwater catchment system for water supply (Macomber 2010). In the late 1980s, studies conducted on private rainfall catchment systems in the South Kona area revealed higher than average acidity in several water samples. Drinking the acidic water itself does not pose a health hazard, however, acidic water has the potential to cause leaching of lead from building materials such as roof flashing, nails, and plumbing solder. This may result in unsafe levels of lead in the drinking water. Extensive testing in 1988 determined that many rainfall catchment systems in the County of Hawai'i, particularly those in the districts adjacent to or downwind of the active vent, contained elevated levels of lead (Tetra Tech 2018). Populations at greatest risk to lead exposure are children less than 6 years old and pregnant women (Centers for Disease Control and Prevention [CDC] 2019).

Table 4-23 through ***Table 4-26*** summarize the exposure of vulnerable residents in Hāmākua by socioeconomic factor to the volcanic hazard, as well as where the volcanic hazard area overlaps with another natural high hazard zone.

Table 4-23. Hāmākua Household Composition by Volcanic Hazard Area - A measure of households containing one or more vulnerable groups susceptible to the negative impacts of natural disasters.

Hazard Area	Total Residents *(number / %)*	Under 18 *(number / %)*	Over 65 *(number / %)*	Single-Parent Household *(number / %)*	Persons with Disability *(number / %)*
Volcanic High Hazard Area (VHHA)	1,303 / 8.4%	145 / 4.7%	265 / 7.9%	203 / 5.5%	157 / 7.1%
VHHA with Additional Natural High Hazard Area	1,303 / 100%	145 / 100%	265 / 100%	203 / 100%	157 / 100%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

Table 4-24. Hāmākua Household Member Health and Transportation by Volcanic Hazard Area - A measure of households with increased vulnerability due to the lack of a vehicle (i.e., evacuation). A measure of the population's access to critical services such as access to transportation routes and medical services.

Hazard Area	No Vehicle *(number / %)*	No Health Insurance *(number / %)*
Volcanic High Hazard Area (VHHA)	59 / 10.9%	34 / 5.4%
VHHA with Additional Natural High Hazard Area	59 / 100%	34 / 100%
Lava Zone 1	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

Table 4-25. Hāmākua Resident Access to Information by Volcanic Hazard Area - A measure of the ability to receive, comprehend and appropriately act on complex messaging with regard to natural disasters.

Hazard Area	No High School Diploma, Over 25 Years Old *(number / %)*	Non-English Speaking *(number / %)*	No Internet *(number / %)*	No Phone *(number / %)*
Volcanic High Hazard Area (VHHA)	138 / 12.3%	61 / 5.4%	317 / 6.9%	41 / 28.4%
VHHA with Additional Natural High Hazard Area	138 / 100%	61 / 100%	317 / 100%	41 / 100%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

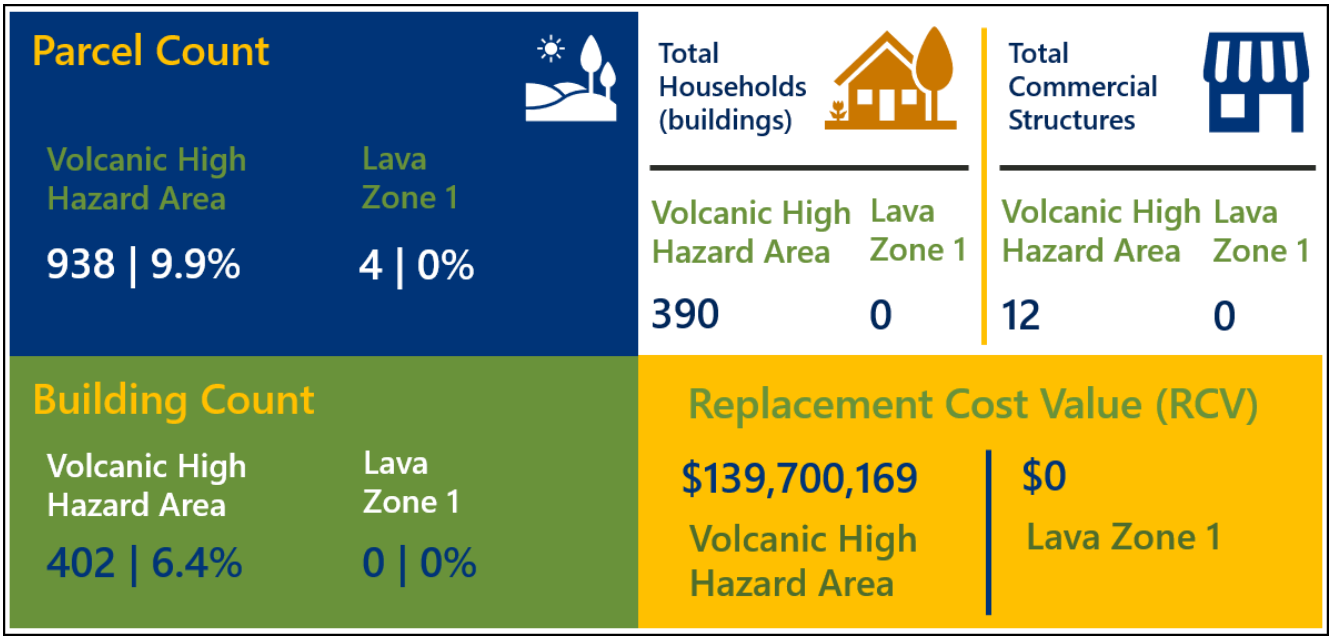
Table 4-26. Hāmākua Resident Socioeconomic Status, by Volcano Hazard Area - A measure of the population that is less likely to have the necessary economic resources to adequately prepare for or recover from a natural disaster.

Hazard Area	Unemployed *(number / %)*	Receiving SNAP *(number / %)*	Below Poverty Line *(number / %)*
Volcanic High Hazard Area (VHHA)	33 / 7.1%	174 / 6.3%	263 / 9.6%
VHHA with Additional Natural High Hazard Area	33 / 100%	174 / 100%	263 / 100%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%

SNAP Supplemental Nutrition Assistance Program

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

4.2.4 PARCELS AND BUILDINGS



Note: All percentages are relative to the Hāmākua CDP District

Figure 4-35. Hāmākua Parcels and Buildings Located in a Volcanic High Hazard Area (VHHA)

Historically, Hāmākua's settlement and development patterns have been shaped by Hawaiian homestead lands, historic plantation towns, ranch lands, mauka forests, and small diverse farms. Looking to the future, the 2018 Hāmākua CDP has identified the following as potential development considerations and activities that could undermine the existing character, natural beauty, and overall rural context:

- Open space, working agricultural lands, and the coastline are vulnerable to inappropriate development.
- The recent trend and likely future build-out potential is largely in the pre-code (and pre -Statehood) homestead lands which often lack adequate infrastructure for increased density.
- Potential for existing and new developments to build out in ways that could undermine the community's unique character and rural lifestyle (County of Hawai'i Planning Department (CHPD) 2018)

Overall, Hāmākua's building stock is minimally exposed to the volcanic high hazard. A total of 402 structures (6.4% of Hāmākua's overall building stock) is located in the Volcanic High Hazard Area. Developed parcel area, on the other hand, have greater exposure. A total of 78,262 acres of developed land (representing 24.9% of Hāmākua's total developed land) is located in the Volcanic High Hazard Area. At greatest risk to the lava-flow hazard are those developed parcels located in lava zone 1 (6,384 acres of developed parcels, yet 0 buildings); and lava zone 2 (50,994 acres of developed parcels, yet no buildings). ***Figure 4-36*** illustrates the developed parcels by lava-flow hazard zone.

Lava may burn structures and can bury land as well as everything else in its path. For the purposes of this analysis, the total assessed value (land and building) located in the volcanic hazard areas is reported to illustrate the potential future loss to existing parcels and development. The total assessed value of parcels located in Volcanic High Hazard Areas is an estimated $267,384,400 which represents 9.6% of the Hāmākua District's total assessed values (land and structure). In terms of the replacement cost value of buildings (estimated structure and contents), an estimated $139,700,169 exists in Hāmākua's Volcanic High Hazard Area (***Table 4-27***).

Table 4-27. Hāmākua Parcels and Buildings Exposed to Volcanic Hazards

Hazard Area	Total Number of Parcels *(number / %)*	Total Assessed Value *(land and structure)*	Total Number of Buildings (number / %)	Replacement Cost Value *(structure and contents)*	Total Households *(buildings / %)*	Total Commercial Units *(buildings / %)*
Volcanic High Hazard Area (VHHA)	938 / 9.9%	$267,384,400	402 / 6.4%	$139,700,169	390 / 6.4%	12 / 5.7%
VHHA with Additional Natural High Hazard Area	932 / 99.4%	$267,152,300	402 / 100%	$139,700,169	390 / 100%	12 / 100%
Lava Zone 1	4 / 0%	$9,130,000	0 / 0%	$0	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	4 / 100%	$9,130,000	0 / 0%	$0	0 / 0%	0 / 0%
Lava Zone 2	13 / 0.10%	$70,862,900	0 / 0%	$0	0 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	7 / 53.8%	$70,630,800	0 / 0%	$0	0 / 0%	0 / 0%

Notes: Data in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

Replacement cost value calculated using 2019 RS Means data.

Source: June 2019 Real Property Tax (RPT) database and 2019 County parcel dataset; buildings determined on parcels using the DWELDAT and COMDAT tables

The County of Hawai'i did not adopt the 1982 Uniform Building Code (UBC) until 1985, meaning the County did not start requiring seismic building standards until 1985 (meeting the 1982 UBC standards). Therefore, all structures built prior to 1985 are considered to be unreinforced and susceptible to earthquake and hurricane damage due to the lack of uplift ties and a complete load path of connections (Hawai'i Martin and Chock, Inc. 2015). The frequency and location of the structures built prior to 1985 (both residential and commercial) is illustrated on Figure 4-37 with a cluster of developed parcels overlapping with Hāmākua's Volcanic High Hazard Area and NEHRP Soils D&E. In total, there are 218 pre-1985 structures located in NEHRP (D&E), or 3.5% of total structures in the District, regardless of year built. These structures are more vulnerable to seismic impacts when compared to structures built post-1985.

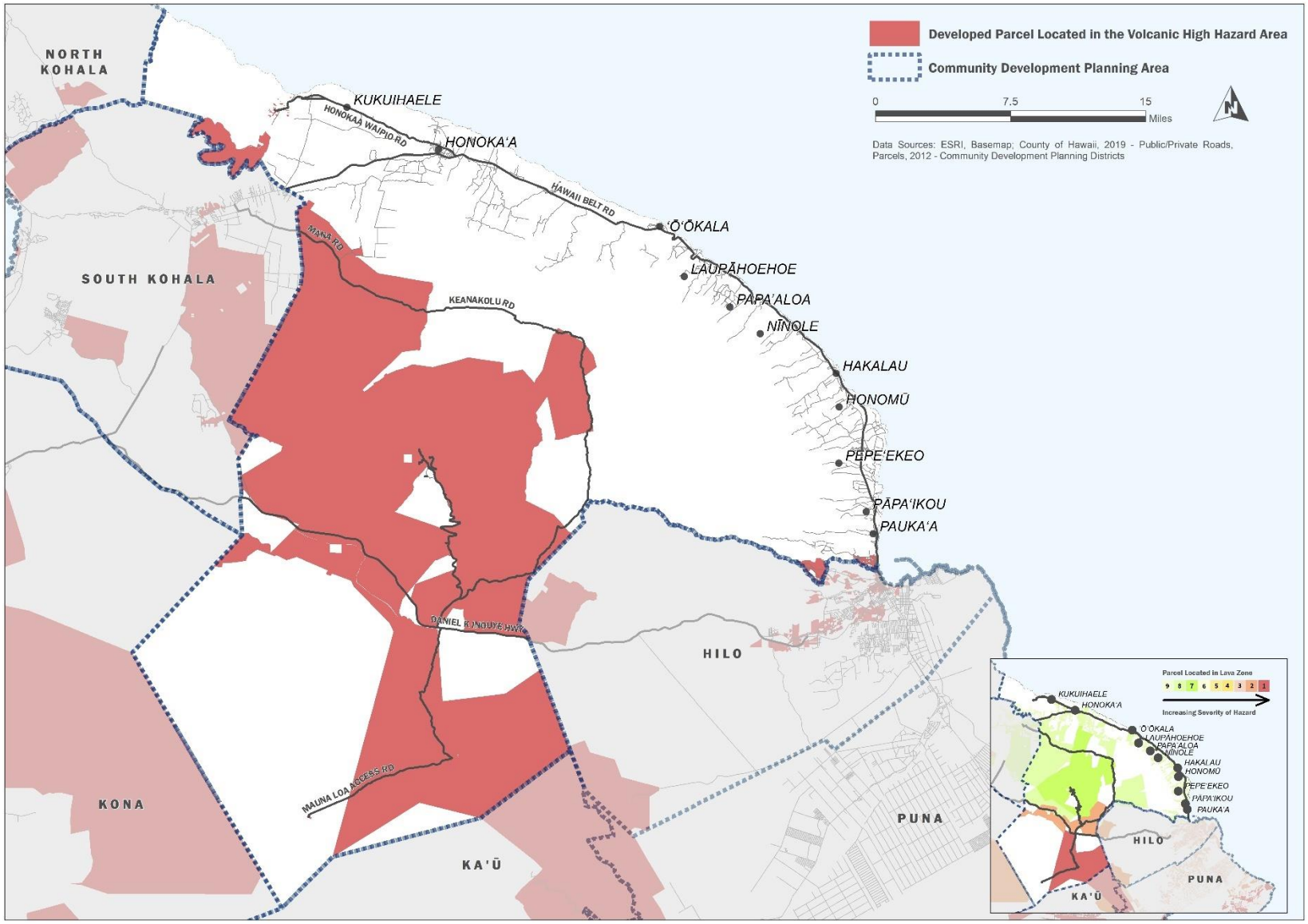


Figure 4-36. Developed Parcels in Hāmākua by Volcanic High Hazard Area and Lava Zone

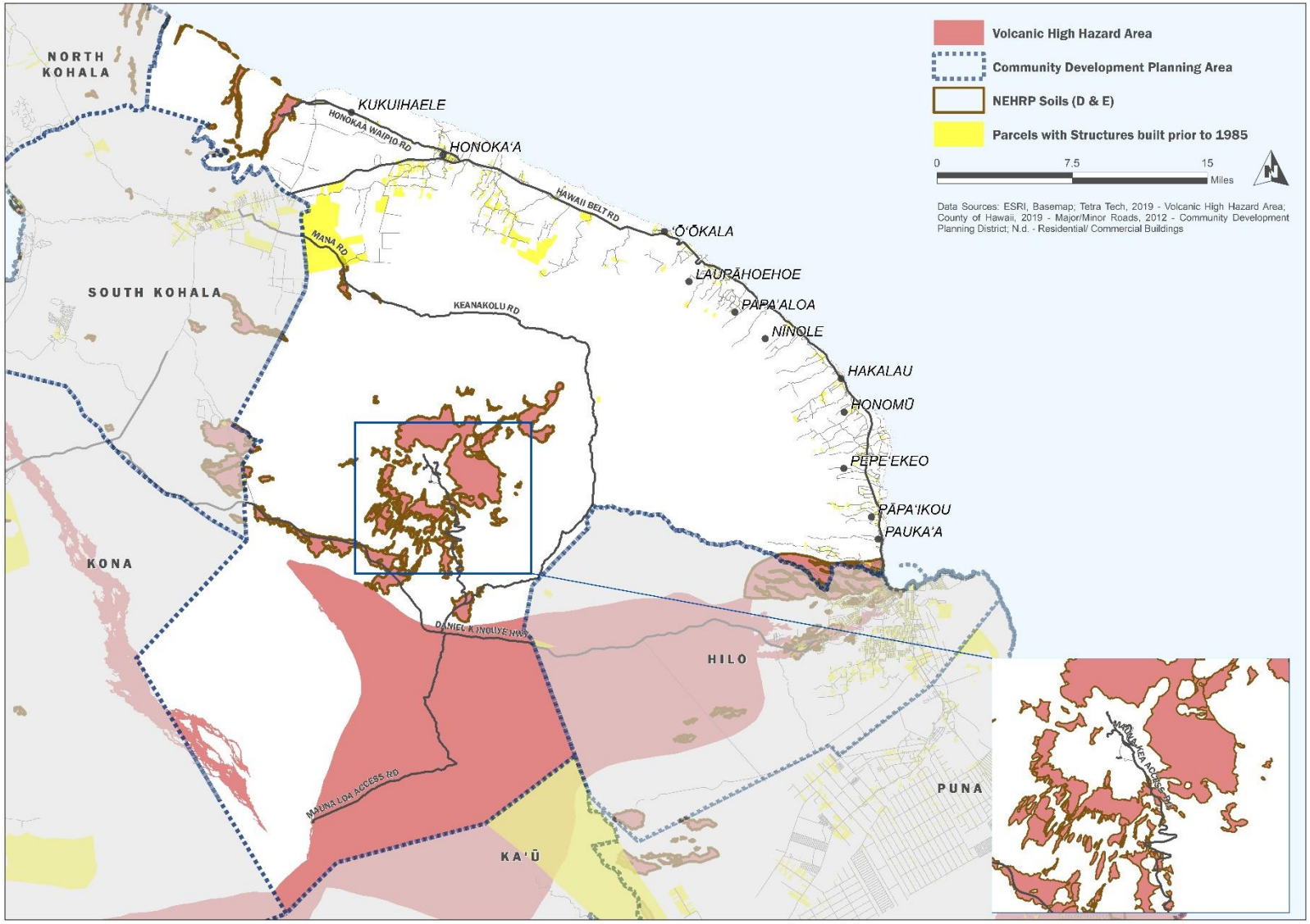
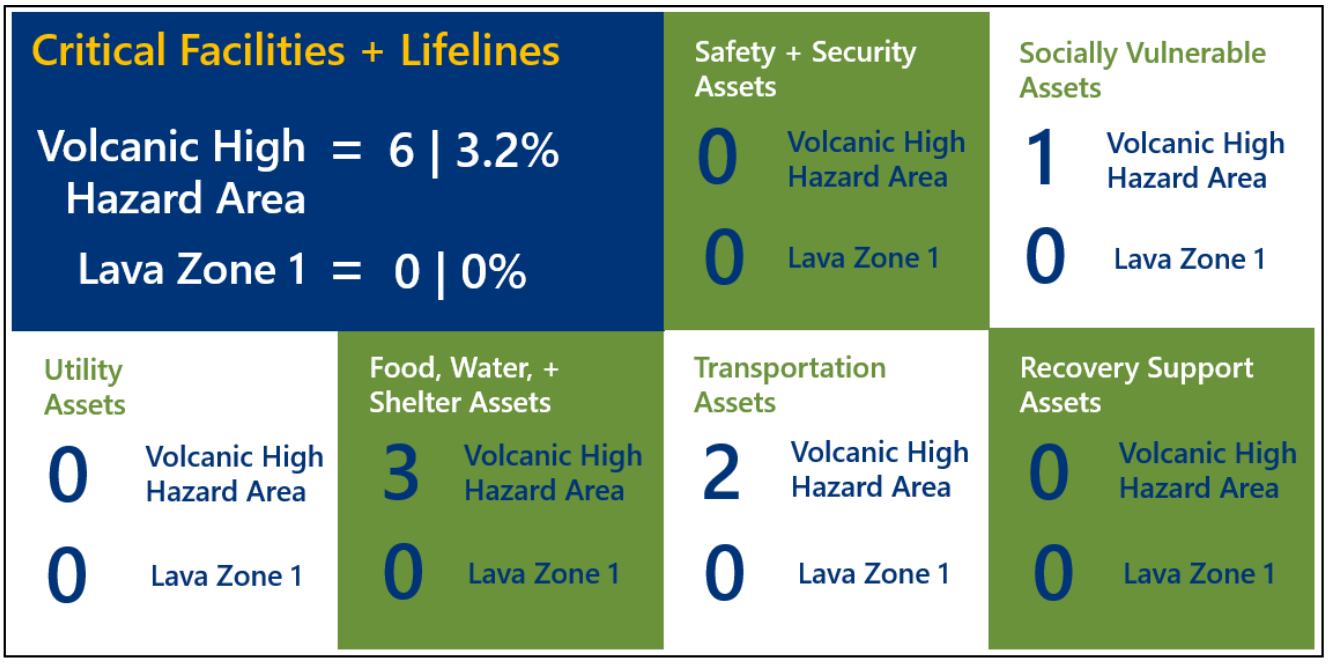


Figure 4-37. Hāmākua Parcels with Structures Constructed Pre-1985 in the Volcanic High Hazard Area

4.2.5 CRITICAL FACILITIES AND LIFELINES



Note: All percentages are relative to the Hāmākua CDP District

Figure 4-38. Hāmākua Critical Facilities and Lifelines Located in the Volcanic High Hazard Area and Lava Zone 1

Through the development of the volcanic risk assessment, 188 critical facilities and lifelines were identified in Hāmākua (the highest number in any CDP district). The critical facility and lifeline categories align with the 2015 County Hazard Mitigation Plan asset categories.

Overall, only 3.2% of Hāmākua's critical facilities are located in the Volcanic High Hazard Area, and therefore susceptible to impacts during volcanic events (***Figure 4-39***). Of the 6 critical assets located in the Volcanic High Hazard Area, all 6 are located in NEHRP D&E soil zones and thus vulnerable to seismic impacts. Hāmākua does not have any critical facilities located in lava zones 1 or 2. ***Table 4-28*** summarizes the exposure of these critical facilities to the volcanic hazards.

Infrastructure provides connectivity between communities and resources, as well as emergency access to keep residents safe. It is closely tied to housing providing livable spaces with services needed for communities to thrive. The miles of road that intersect the Volcanic High Hazard Area and lava zones 1 and 2 were determined in an effort to understand their exposure and where potential future losses may be incurred. Hāmākua has 55 miles of road that intersect the Volcanic High Hazard Area with nearly 50% located in lava zone 2.

Similar to the discussion on structures constructed pre-1985, a majority of Hāmākua's critical facilities were constructed prior to 1985 and therefore more vulnerable to earthquake damage (during a volcanic eruption or occurring separately). Based on year-built data, 90.5% of Hāmākua's critical facilities and lifelines were constructed prior to 1985 (the highest percentage in the County). However, only 2% of Hāmākua's critical facilities are pre-1985 and located in the Volcanic High Hazard Area. Depending upon the specific facility's design and mitigation measures installed post construction, earthquake damage prior to an eruption or during an eruption could have significant implications of life safety and the resilience of infrastructure systems.

Table 4-28. Hāmākua Critical Facilities by Volcanic Hazard Area

Hazard Area	Number of Critical Facilities *(number / %)*	Built Prior to 1985 *(number / %)*	Safety and Security Assets *(number / %)*	Food, Water and Shelter Assets *(number / %)*	Recovery Support Assets *(number / %)*	Socially Vulnerable Assets *(number / %)*	Utility Assets *(number / %)*
Volcanic High Hazard Area (VHHA)	6 / 3.2%	3 / 2%	0 / 0%	3 / 17.6%	0 / 0%	1 / 14.3%	0 / 0%
VHHA with Additional Natural High Hazard Area	6 / 100%	3 / 2%	0 / 0%	3 / 100%	0 / 0%	1 / 100%	0 / 0%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%

N/A Not applicable
Note: Critical facilities in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

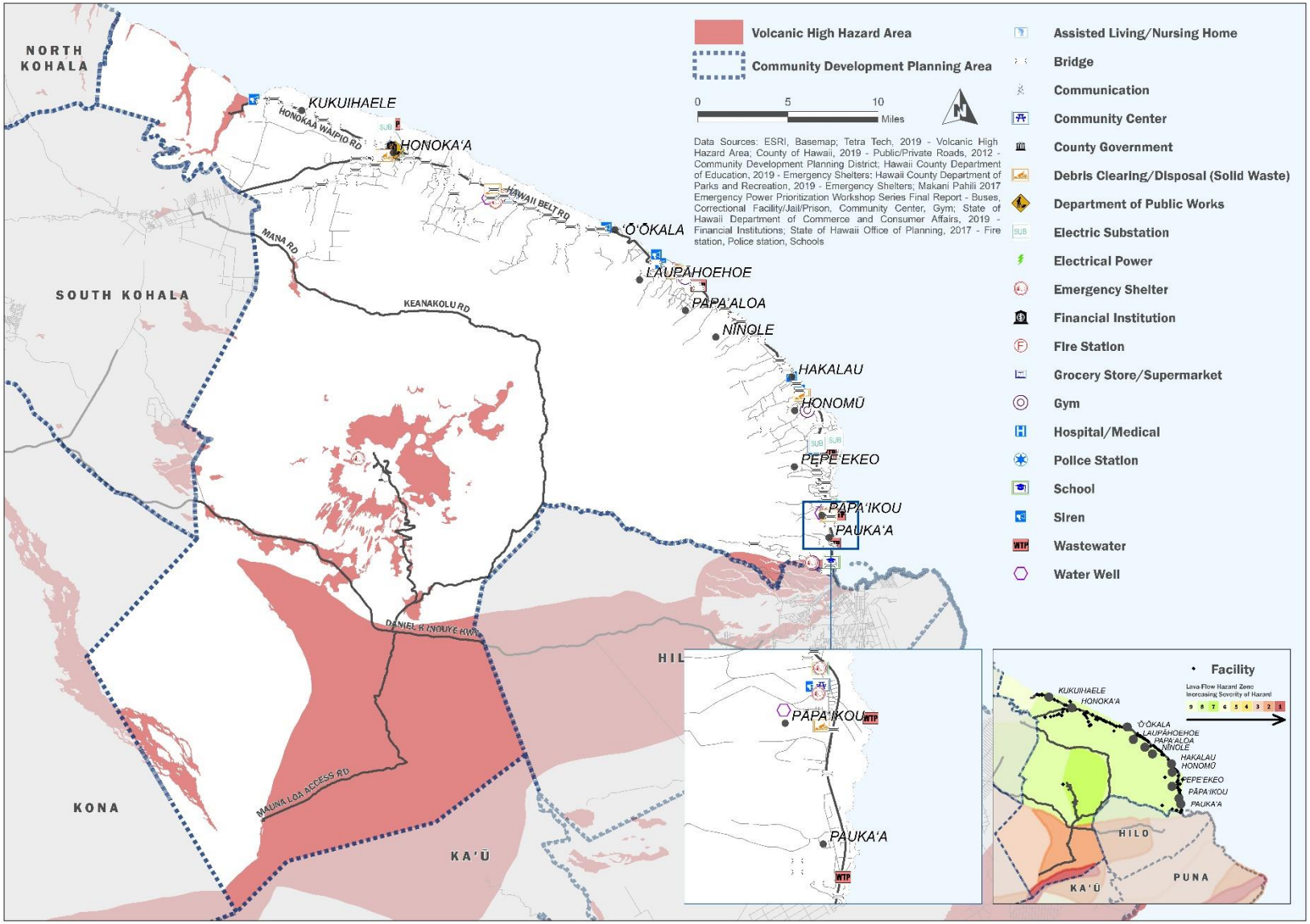
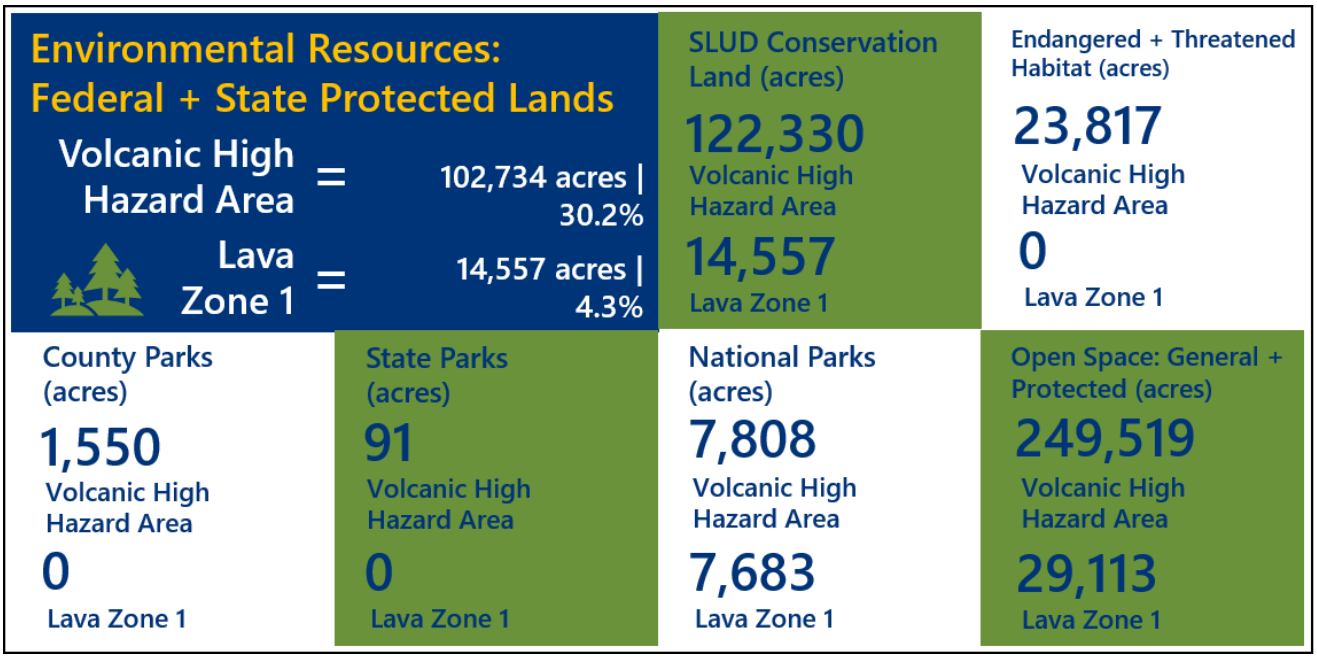


Figure 4-39. Hāmākua Critical Facilities Located in the Volcanic High Hazard Area and Lava Zones

4.2.6 ENVIRONMENT



Note: All percentages are relative to the Hāmākua CDP District

Figure 4-40. Hāmākua Environmental Resources Located in the Volcanic High Hazard Area and Lava Zone 1

Nearly half of all land (designated by parcel) in Hāmākua is developed, meaning according to the County assessor at least one structure exists on the parcel. Despite the technical designation of "developed" Hāmākua maintains a distinct rural lifestyle and way of life that is intimately connected to place and Hawaiian cultural heritage (County of Hawai'i Planning Department (CHPD) 2018). Alongside a range of developed land, however, sits the Hakalau Forest National Wildlife Refuge, the Hāmākua Forest Reserve, and other state and federally managed land. This reserve land represents over 300,000 acres of Hāmākua's entire 648,934 total acres (52.4%). Hāmākua's state and federally managed land is also protected land under federal and state regulations in Hawai'i. Agriculture in Hāmākua includes majority commercial forestry, macadamia nuts, diversified crops, and tropical fruits (***Figure 4-41*** and ***Figure 4-42***).

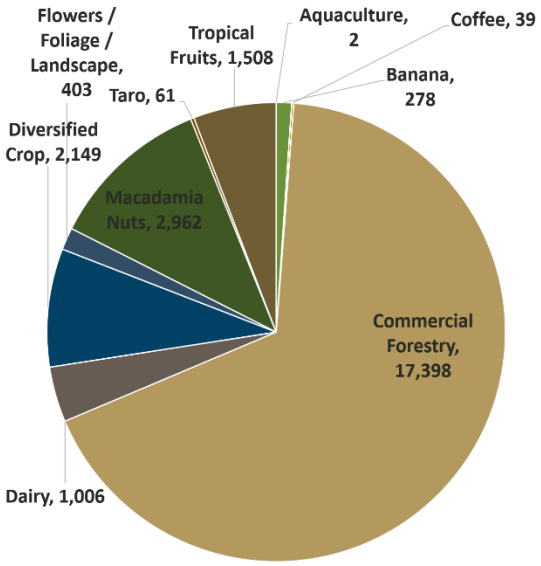


Figure 4-41. Hāmākua Crop Land (Acres)

Much of the land around the Mauna Kea and Mauna Loa Volcanoes is undeveloped or rural in context. The waterfalls and other natural beauty of the 'Akaka Falls State Park is one of the most famous natural attractions in the County (Hawai'i Tourism Authority 2019).

Environmental assets identified as part of the County of Hawai'i General Plan update (draft in progress) were used for this risk assessment (***Table 4-29***). ***Figure 4-43*** illustrates the environmental resources relative to the Volcanic High Hazard Areas.

Table 4-29. Hāmākua Environmental Resources

Agricultural Land of Importance *(acres)*	Crop Land *(acres)*	Pasture Land *(acres)*	Hunting Areas *(acres)*	Wetlands *(acres)*
205,225	25,806	154,758	264,932	38,112

Federal Reserves *(acres)*	State Reserves *(acres)*	Exceptional Trees (*number*)	Anchialine Pools (*number*)	Reservoirs (*number*)	Endangered and Critical Habitats *(acres)*
55,033	197,752	10	0	50	175,539

Over 30% of Hāmākua's federal, military, and state reserve land is located in the Volcanic High Hazard Area (30.2%). National Park land in Hāmākua's Volcanic High Hazard Area accounts for over 70% of Hāmākua's total National Park land (79.3%), one of the highest percentages for National Park Volcanic High Hazard exposure in the County (***Table 4-30***).

Only 2% of Hāmākua's Agricultural Land of Importance is in the Volcanic High Hazard Area, totaling 4,224 acres (representing one of the smaller percentages in the County). The greatest number of wetlands acres in the Volcanic High Hazard Area are found in Hāmākua (981 acres).

Hāmākua has a relatively small number of environmental resource land acres located in lava zone 1. However, of the environmental resources located in the lava 1, 78% of is National Park land (7,683 acres). This is Hāmākua's most exposed environmental asset to lava zone 1.

Only 1.6% of Hāmākua's agricultural crop land is allocated in the Volcanic High Hazard Area. However, of Hāmākua's crops, 100% of taro grown in Hāmākua is located in the Volcanic High Hazard Area. The following Hāmākua crops are located exclusively outside of the Volcanic High Hazard Area: aquaculture, banana, coffee, and dairy. Macadamia nuts have a relatively low exposure to volcano risk in Hāmākua with over 95% of macadamia crop land located outside of the Volcanic High Hazard Area.

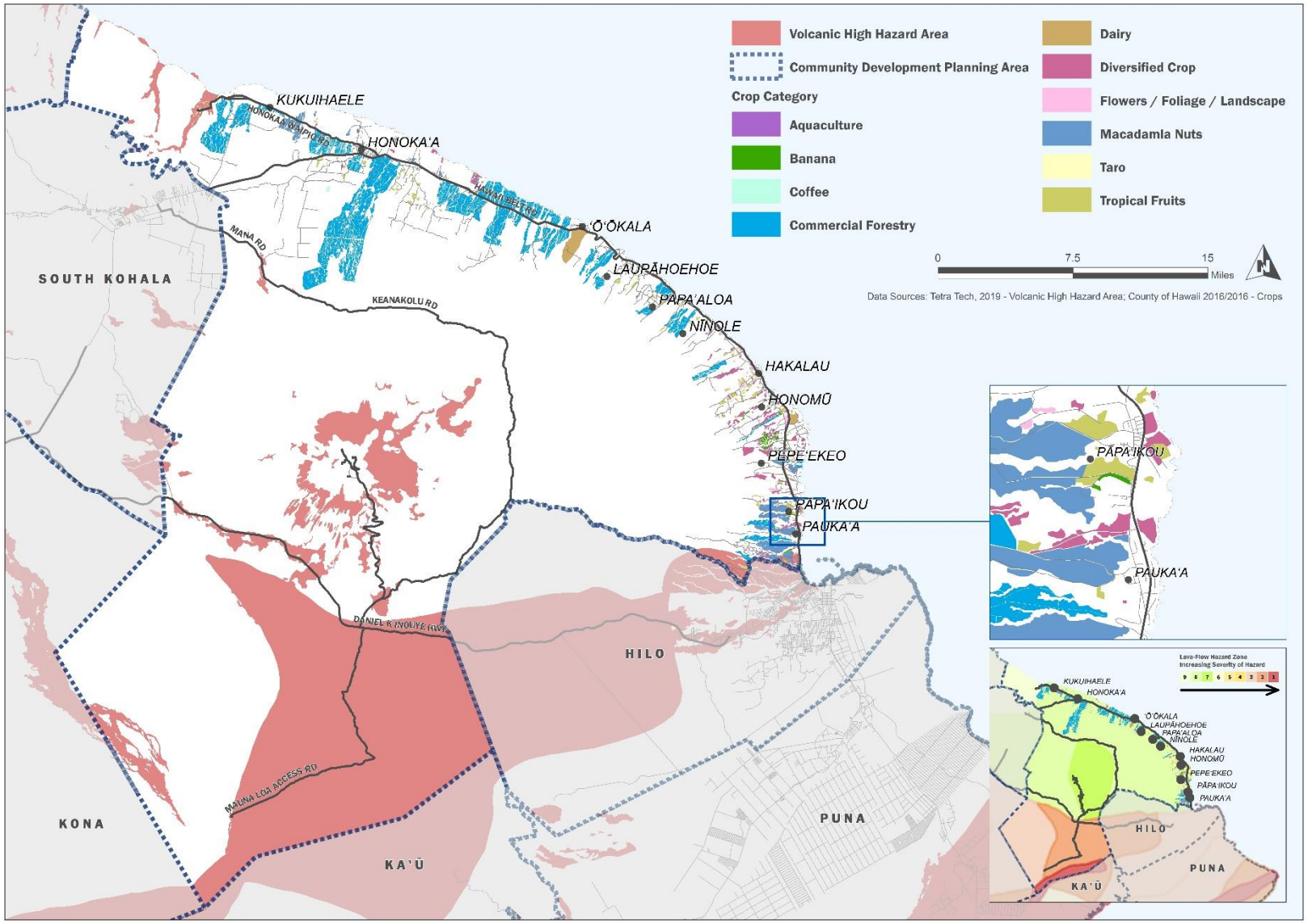


Figure 4-42. Hāmākua Important Agricultural Crops Located in Lava Zones and Volcanic High Hazard Areas

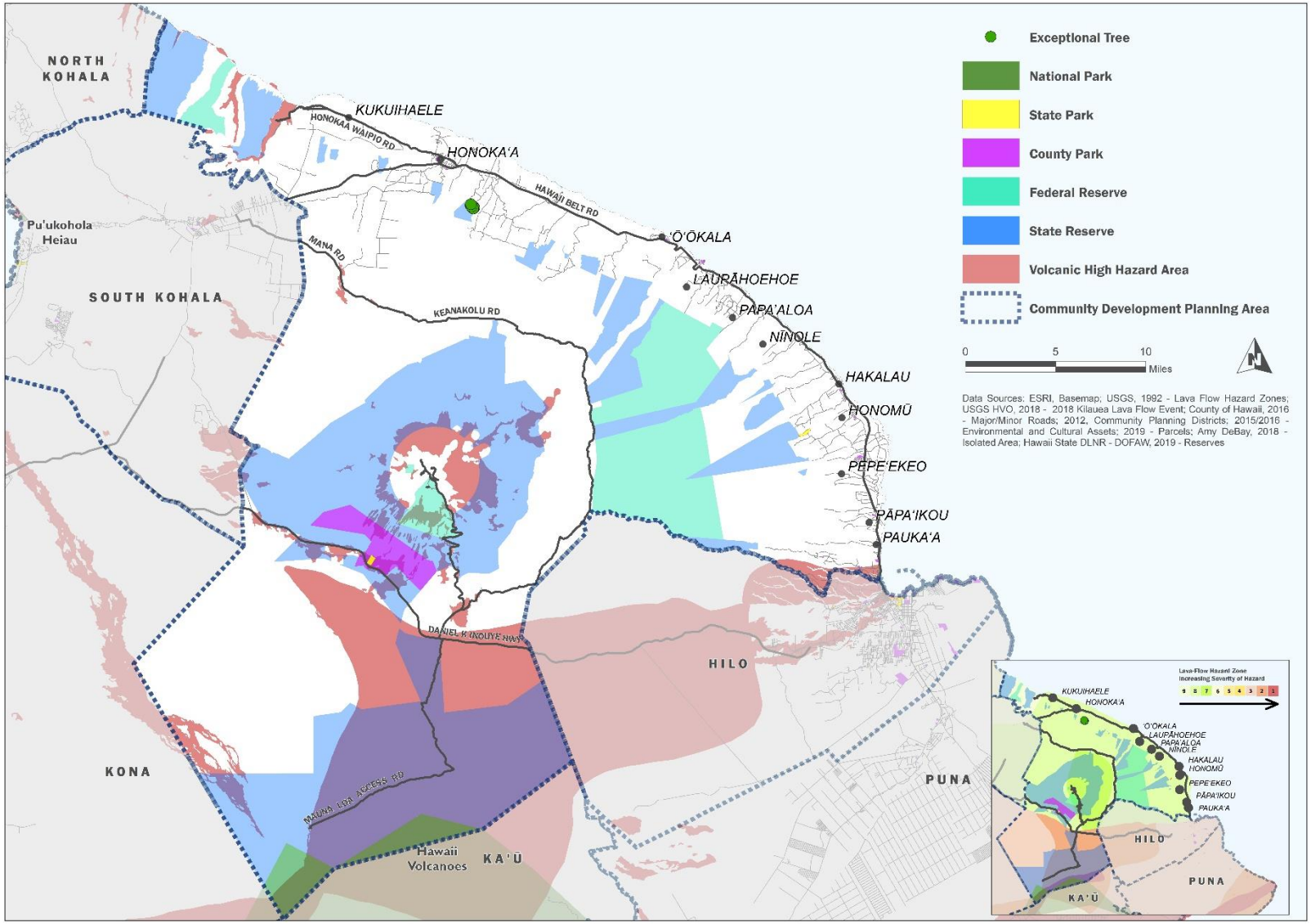


Figure 4-43. Protected Environmental Land in Hāmākua Located in Lava Zones and Volcanic High Hazard Areas

Table 4-30. Hāmākua Environmental Resources Located in Volcanic High Hazard Areas

Hazard Area	Total Protected Land *(acres / %)*	SLUD Conservation Land *(acres / %)*	Endangered and Threatened Habitat *(acres / %)*	Exceptional Trees *(number / %)*	Open Space: General and Protected *(acres / %)*	Agricultural Land of Importance *(acres / %)*
Volcanic	102,734 / 30.2%	122,330 / 30.8%	23,817 / 13.6%	0 / 0%	249,519 / 24.6%	4,224 / 2.1%
Lava	14,557 / 4.3%	14,557 / 3.7%	0 / 0%	0 / 0%	29,113 / 2.9%	0 / 0%
Lava	69,035 / 20.3%	80,606 / 20.3%	5,000 / 2.8%	0 / 0%	163,531 / 16.1%	498 / 0.2%

SLUD State Land Use District

Note: Acres and total numbers of environmental resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the Volcanic High Hazard Area total.

Hazard Area	Crop Land *(acres / %)*	Pasture Land *(acres / %)*	Hunting Areas *(acres / %)*	County Park *(acres / %)*	State Park *(acres / %)*	National Park *(acres / %)*
Volcanic High Hazard Area	410 / 1.6%	1,496 / 1%	106,229 / 40.1%	1,550 / 21.5%	91 / 44.7%	7,808 / 79.3%
Lava Zone 1	0 / 0%	0 / 0%	6,875 / 2.6%	0 / 0%	0 / 0%	7,683 / 78%
Lava Zone 2	0 / 0%	393 / 0.3%	76,337 / 28.8%	0 / 0%	0 / 0%	98 / 1%

Note: Acres and total numbers of environmental resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the Volcanic High Hazard Area total.

Hazard Area	Wetlands *(acres / %)*	Reservoirs *(number / %)*	Anchialine Pools *(number / %)*
Volcanic High Hazard Area	981 / 2.6%	1 / 2%	0 / 0%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	1 / 0%	0 / 0%	0 / 0%

Note: Acres and total numbers of environmental resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the Volcanic High Hazard Area total.

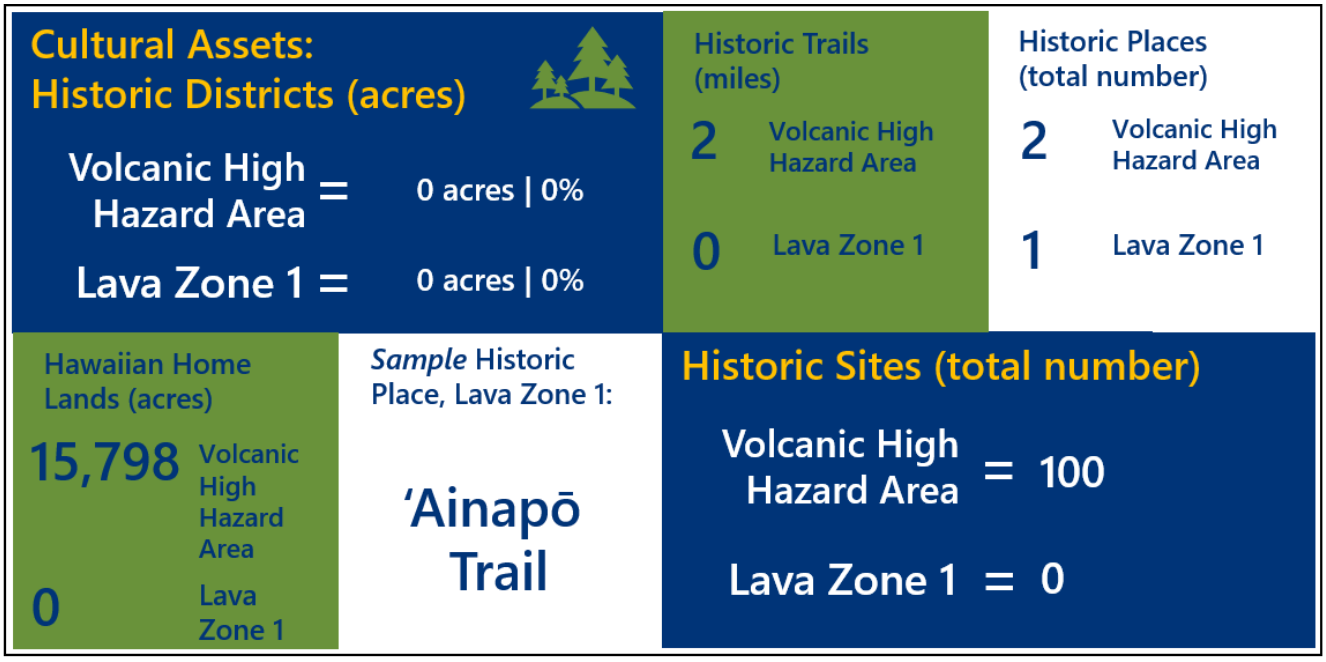
In addition to lava flow, other volcanic hazards may also impact environmental resources. In 2010, Donald Thomas from the Center for the Study of Active Volcanoes, and Trisha Macomber from the University of Hawai'i's College of Tropical Agriculture produced a study on the effects of fluoride and sulfates on forage lands downwind of Kīlauea's Halema'uma'u Crater (Thomas and Macomber 2010). The study shows that forage samples contained fluoride and sulfate values higher than recommended by the World Health Organization. Additionally, the study indicates that although elevated concentrations of fluoride and sulfate do induce adverse health/nutritional effects on grazing animals, the elevated levels of these compounds do not impact the quality of meat from those animals that would be used for public consumption.

The general effects of sulfur dioxide exposure to plants varies between plant species, age, and the sulfur dioxide dosage. These effects may include:

- Reduced seed germination
- Enhanced susceptibility to other diseases
- Foliar necrosis (spots, blight)
- Epicuticular wax erosion
- Rupture of epidermis, plasmolysis
- Reduced chlorophyll content
- Increased membrane permeability of plant leaves
- Decreased plant growth (root length, shoot length, leaf numbers)
- Plant organ or entire plant death

Farmers growing food crops, foliage crops, and cut flowers downwind of Kīlauea have experienced immediate and severe losses due to damage arising from exposure to high concentrations of sulfur dioxide and sulfuric acid aerosols. Although downwind ranches did not experience immediate impacts, over time, they have found that horses, cattle, and goats have developed serious adverse health impairment consistent with chronic fluoride exposure as well as severe mineral deficiencies.

4.2.7 CULTURAL ASSETS



Note: All percentages are relative to the Hāmākua CDP District

Figure 4-44. Hāmākua Cultural Assets Located in the Volcanic High Hazard Area and Lava Zone 1

Hāmākua is home to many formally designated and locally recognized cultural assets, historic places, and sites that are important because they help to shape the identity of the place and the people of Hāmākua, as well as the County. A location-based database of culturally significant sites to Native Hawaiians was not available for use in this risk assessment; disclosure of the location of sacred and otherwise culturally significant sites is prohibited, in some instances, by federal law. To align with the County General Plan update, Hawaiian Home Lands, historic sites and trails were used for this analysis.

Cultural assets are considered non-renewable resources. Lava flows can isolate or cover cultural sites and native land. In Hāmākua, a total of 15,798 acres of Hawaiian Home Lands (22.5% of Hāmākua's total Hawaiian Home Lands, highest percentage in the County), 2 historic places (12.5%), 100 historic sites (37.7%) and 2 miles (57.8%) of historic trail are located in the Volcanic High Hazard Area (***Table 4-31***).

It is important to note that many of the cultural assets are located along the coast and overlap with other natural hazard areas including tsunami, sea level rise, flood and coastal erosion (***Figure 4-45)***.

Table 4-31. Hāmākua Cultural Resources by Volcanic Hazard Area

Hazard Area	Hawaiian Home Lands *(acres / %)*	Historic Districts *(acres / %)*	Historic Places *(number / %)*	Historic Sites *(number / %)*	Historic Trail *(miles / %)*
Volcanic High Hazard Area	15,798 / 22.5%	0 / 0%	2 / 12.5%	100 / 37.7%	2 / 57.8%
VHHA with Additional Natural High Hazard Area	3,103 / 19.6%	0 / 0%	1 / 6.3%	92 / 92%	0 / 0%
Lava Zone 1	0 / 0%	0 / 0%	1 / 6.3%	0 / 0%	0 / 0%
Lava Zone 2	13,943 / 19.9%	0 / 0%	0 / 0%	0 / 0%	2 / 57.8%

Note: Acres and total numbers of cultural resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

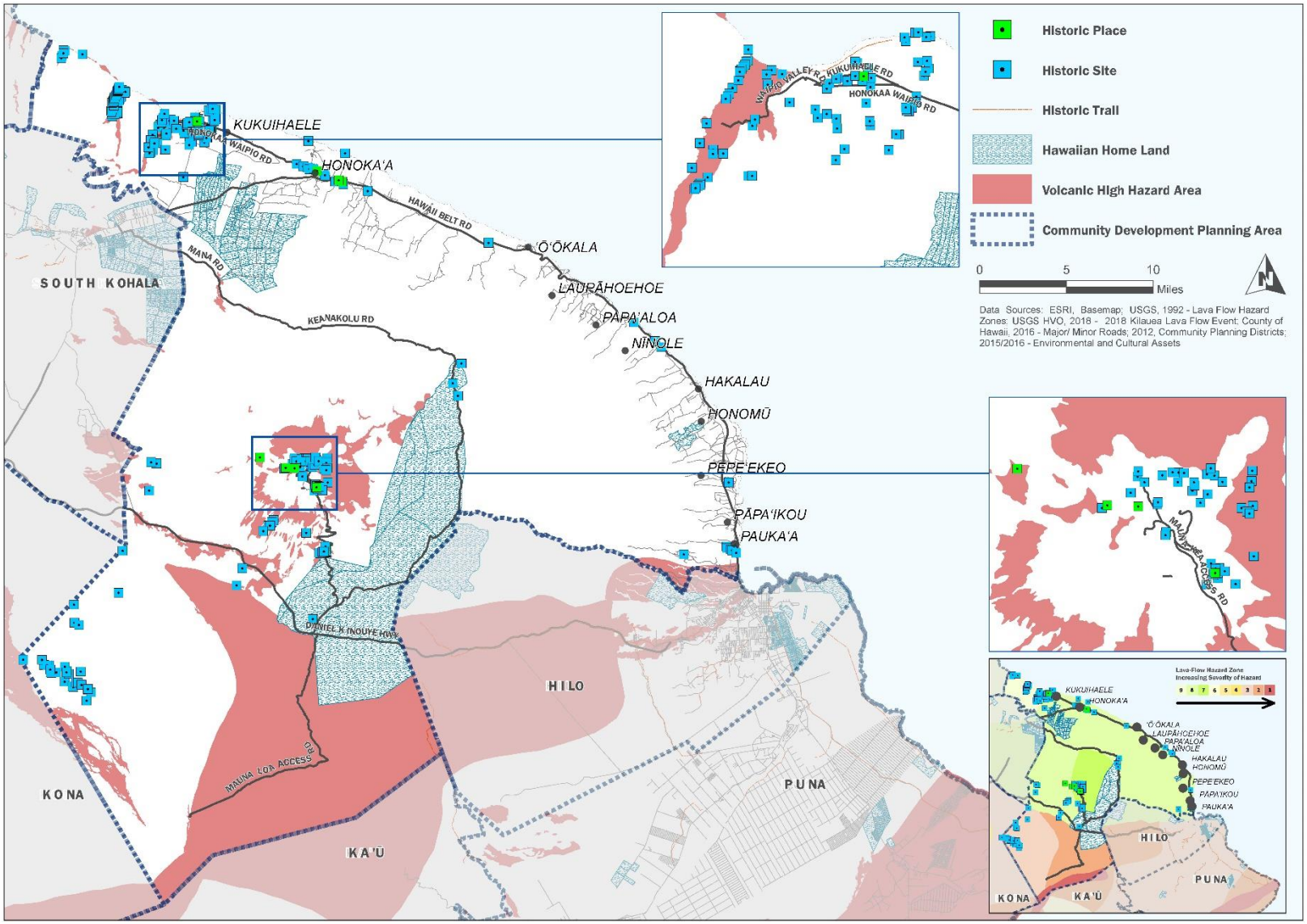


Figure 4-45. Cultural Assets in Hāmākua and Volcanic Hazards

4.2.8 FUTURE LAND USE AND DEVELOPMENT

Hāmākua is comprised of mixed land use classifications as categorized by the Land Use Pattern Allocation Guide (LUPAG) (see ***Figure 4-46***). While LUPAG designations guide decisions related to future land use, County zoning determines a parcel's current permitted land use and development entitlements.

The vast majority of Hāmākua is designated as conservation, representing a total of 394,459 acres or 61% of all Hāmākua land. Conservation land is defined as "forest and water reserves, natural and scientific preserves, areas in active management for conservation purposes, areas to be kept in a largely natural state, with minimal facilities consistent with open space uses, such as picnic pavilions and comfort stations, and lands within the State Land Use Conservation District" (CHPD 2016). Following, the second-most majority of land designation is important agricultural land (19.4%) and extensive agriculture (18.4%). Important agricultural lands are lands that are highly capable of producing significant yields of important agricultural outputs; whereas extensive agriculture includes lands that are not capable of producing sustained high agricultural yields without intensive application of farming methods and technologies. The remaining 1 to 2% of Hāmākua is classified as a mix of low-density urban, open area, medium-density urban, industrial, and rural.

Overall, Hāmākua's land in the Volcanic High Hazard Area is mainly classified as conservation land (94.6%) and extensive agriculture land (3.5%) (***Table 4-32*** and ***Figure 4-46***). According to these land use categories, Hāmākua's highest volcanic risk areas have incredibly limited urban development or residential population, in general.

Table 4-32. Hāmākua Land Use (LUPAG classification) in the Volcanic High Hazard Area and Lava Zones

LUPAG Classification	Total Area *(acres)*	Volcanic High Hazard Area *(acres)*	Lava Zone 1 *(acres)*	Lava Zone 2 *(acres)*	Lava Zone 3 *(acres)*
Conservation	394,827	122,124	14,556	84,926	84,757
Extensive Agriculture	119,247	4,545	0	2,633	0
Important Agriculture Lands	125,315	1,823	0	0	0
Industrial	193.92932	0	0	0	0
Low Density Urban	5,133	378	0	0	0
Medium Density Urban	457.95252	0	0	0	0
Open area	2,320	210	0	0	0
Resort Node	0.027273	0	0	0	0
Rural	118.03265	0	0	0	0
Urban Expansion	61.919329	0	0	0	0

LUPAG Land Use Pattern Allocation Guide

While the Volcanic High Hazard Area represents the area with the greatest volcanic risk in the County, it has not been identified for future urban development in Hāmākua. Currently, 0% of Hāmākua's Volcanic High Hazard Area land has been categorized for urban expansion. At the same time, some of the land that has been identified for future urban expansion or existing town centers may be susceptible to other hazards. For example, many of the identified communities in Hāmākua, located near the Pacific Ocean and at the base of Mauna Kea are outside of the Volcanic High Hazard Area but are at high risk to landslides. In addition, there are concentrated areas at risk to sea level rise impacts.

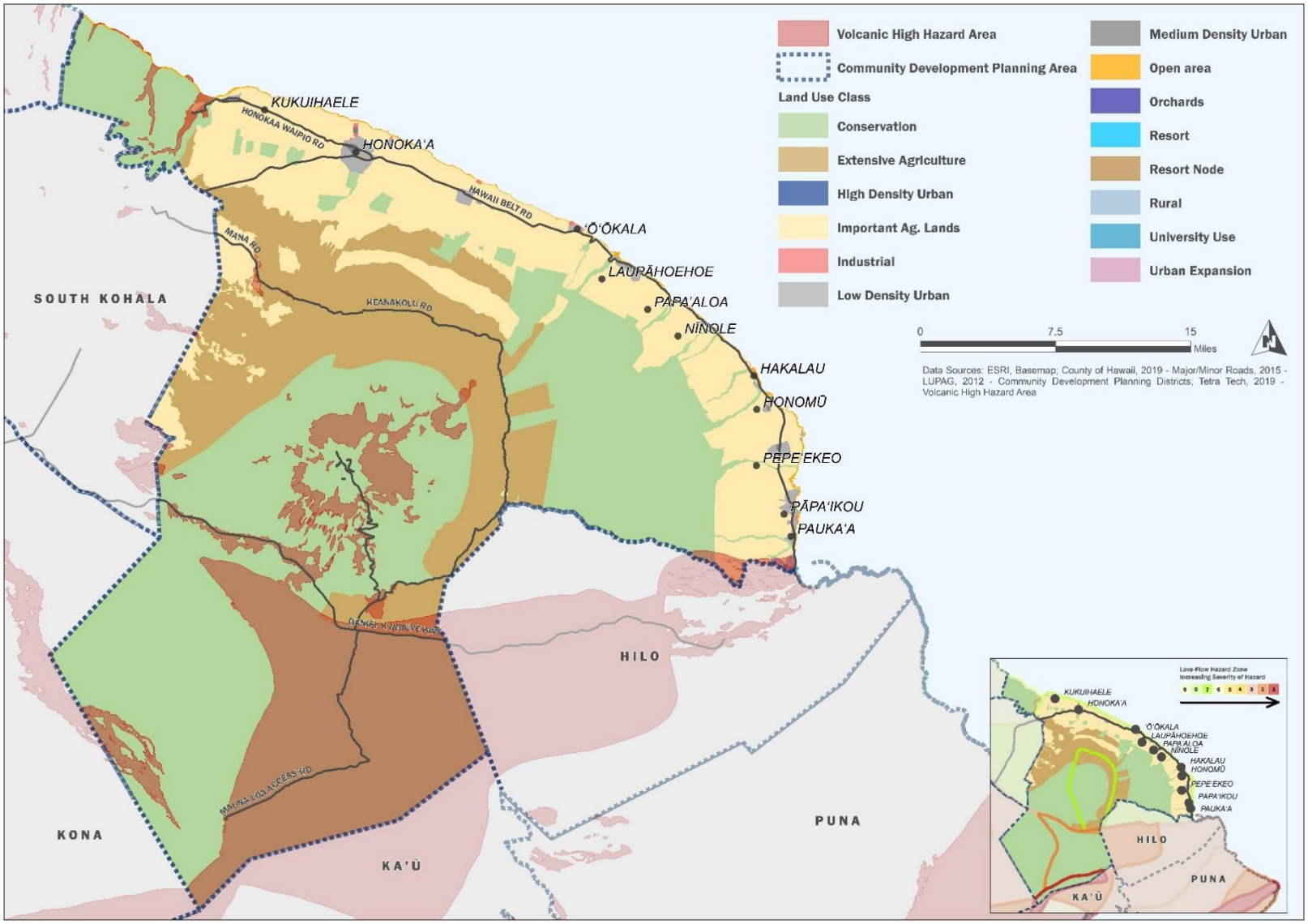


Figure 4-46. Hāmākua Land Use Pattern Allocation Guide (LUPAG) Classifications

In preparation for the County General Plan update, a build-out analysis was conducted to determine residential and non-residential capacity. Hāmākua has the second highest number of acres of identified residential greenfield area in the County (158,781 acres). This illustrates a high potential for future targeted development. Future land use decisions and future policy may consider the location of the volcanic and additional natural high hazards prior as part of future development decisions.

In Hāmākua, there are only 365 residential greenfield parcels identified for potential future development located in the Volcanic High Hazard Area; of these 0 are in lava zone 1, and only 2 parcels are located in lava zone 2 (***Figure 4-47***). In terms of non-residential development, there is only 1 non-residential greenfield parcel located in the Volcanic High Hazard Area and 0 parcels identified for potential non-residential redevelopment. 100% of all non-residential parcels identified for potential redevelopment are located in lava zone 8.

The exposure to other natural hazards should also be considered when making future development decisions. There are 100% of parcels identified for residential redevelopment located in the Volcanic High Hazard Area that also have the presence of another natural high hazard. Refer to ***Table 4-33*** for additional statistics regarding parcels identified for future development and their location relative to the volcanic hazard areas and other natural high hazards.

Table 4-33. Hāmākua Build-out Analysis Results and Hazard Areas

Hazard Area	Residential Greenfield *(parcels / %*)*	Residential Potential Redevelopment *(parcels / %*)*	Non-Residential Greenfield *(parcels %*)*	Non-Residential Potential Redevelopment *(parcels / %*)*
Volcanic High Hazard Area (VHHA)	365 / 13.6%	99 / 3.5%	1 / 4.3%	0 / 0%
VHHA with Additional Natural High Hazard Area	365 / 100%	99 / 100%	1 / 100%	0 / 0%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	2 / 0.1%	0 / 0%	1 / 4.3%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	2 / 100%	0 / 0%	1 / 100%	0 / 0%

**The percentage of parcels relative to the total number in the Hāmākua District.*

Note: Parcels in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

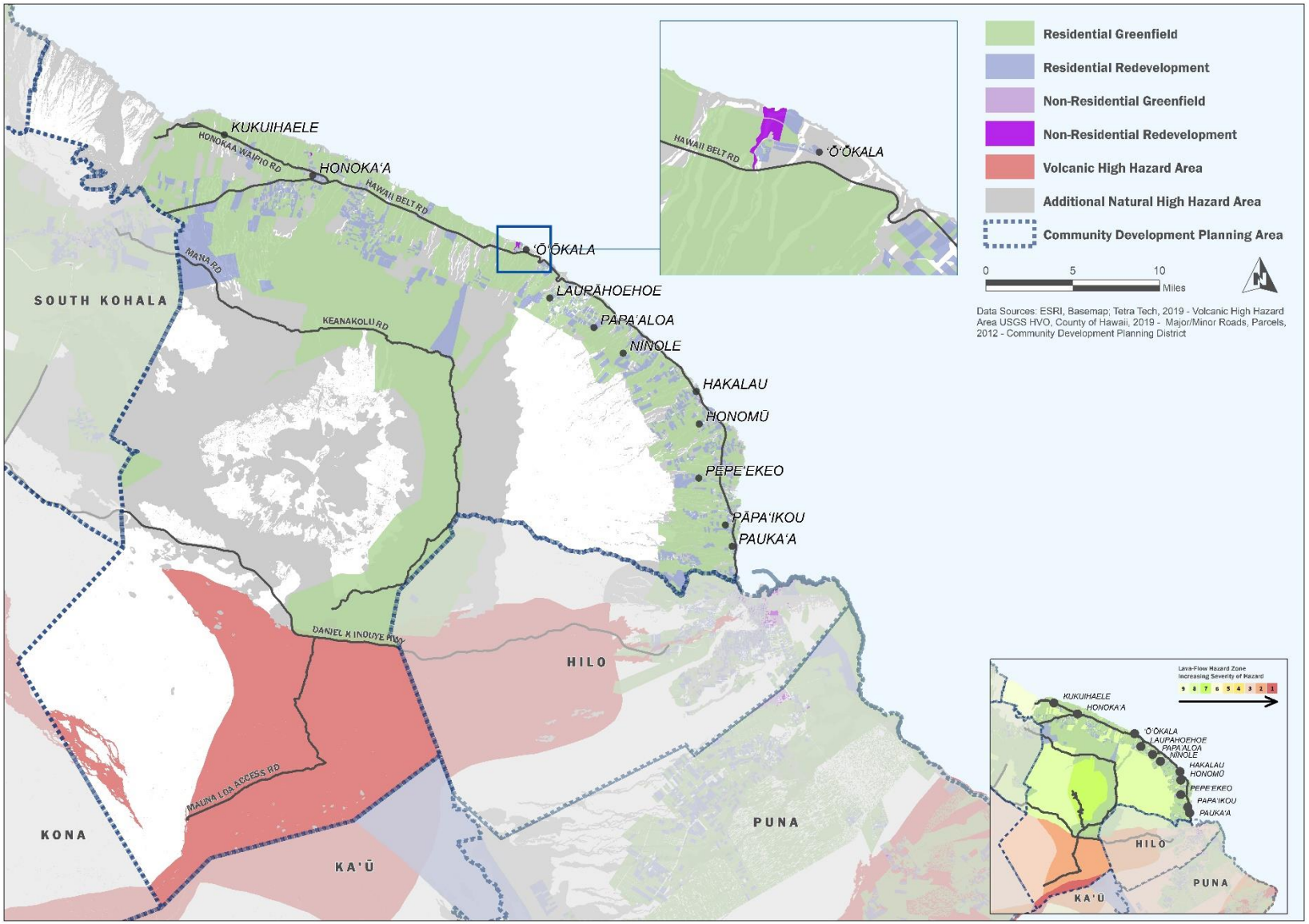


Figure 4-47. Hāmākua Greenfield and Redevelopment Areas, and Volcanic Hazard Areas

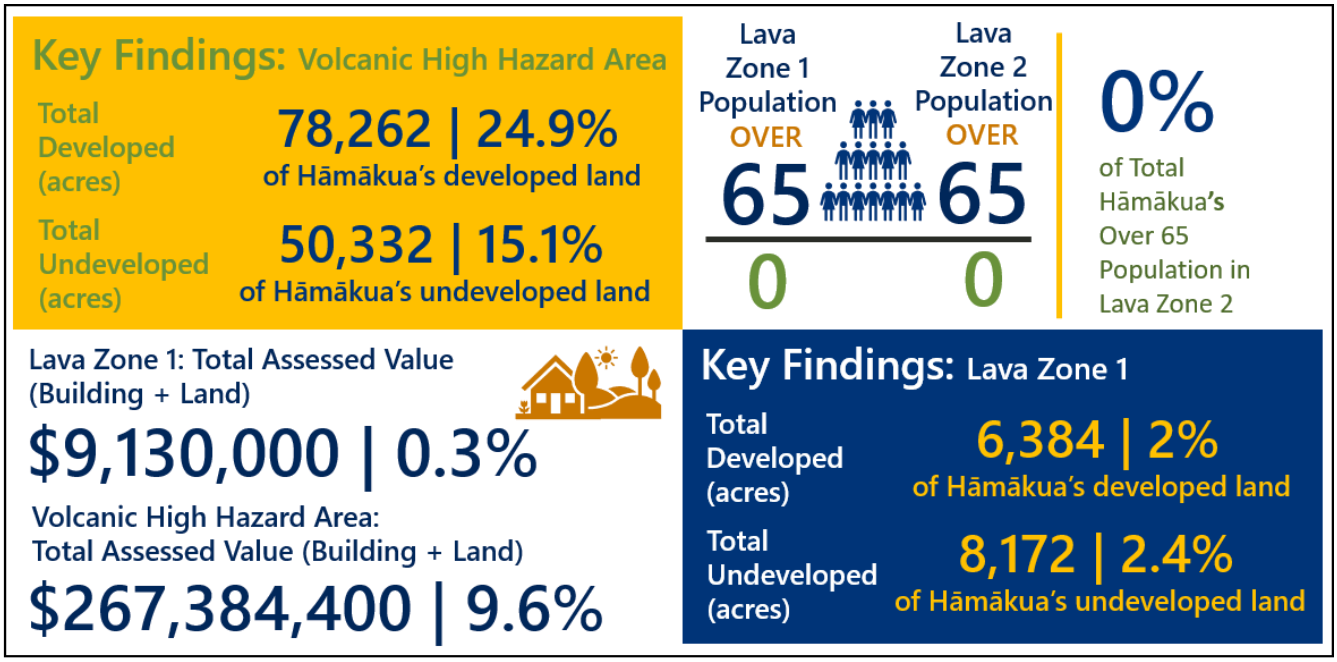
There is a significant lack of hazard insurance for many structures, across the County. In 1991, State of Hawai'i lawmakers created a nonprofit collection of insurance companies called the Hawai'i Property Insurance Association to address this gap. The State assembled the nonprofit to provide basic property insurance for people who are unable to buy coverage in the private market, due to insurers being uncomfortable with Hawai'i's significant volcano risk (Weiss 2018).

High hazard risk combined with limited or high cost insurance, when available, is a considerable factor when planning for the continued growth of Hāmākua. Critical questions that need to be addressed prior to moving forward with future plans for development/re-development and decisions about future population centers are:

- Who will be able to afford to live in an area that is vulnerable to lava flow and other volcano-related risks?
- Physical exposure to a range of hazards may make certain areas more affordable to live. What are the choices available to economically vulnerable households?
- Will the most vulnerable be forced to move to other less vulnerable districts?
- Will they remain and bear the burden when the next event takes place?
- What strategies do the County and community need to develop to manage residential development and infrastructure development relative to the expected demand on emergency services and repetitive losses in an area with high exposure to hazards?

These questions will be critical to address moving forward with all plans for future development/re-development and decisions about future population centers in Hāmākua. Development or redevelopment is not always the preferred option. In fact, Hilo took an approach to some of their past damaged land to not rebuild after the 1946 tsunami, but rather turned the damaged land into a park—looking to other low-hazard exposure land for development and population growth.

4.2.9 KEY FINDINGS



Note: All percentages are relative to the Hāmākua CDP District. According to the analysis, there are no residents located in lava zone 1 and lava zone 2.

Figure 4-48. Hāmākua Key Findings

Understanding what is at risk to natural hazards can assist in planning for Hāmākua's future, and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The following summarizes the key findings for the Hāmākua CDP District:

- Hāmākua has the greatest percentage of Hawaiian Home Land located in the Volcanic High Hazard Area (22.5%) in the County.
- Hāmākua has none of its structures exposed to high risk lava flow areas (i.e, lava zone 1 or 2). Meaning, none of Hāmākua's residential households are located in lava zone 1 or 2.
- Utilizing current data, Hāmākua's parcels, households, and residents have been untouched by historic lava flows (1790-1996).
- Overall, Hāmākua has 14,556 acres of land in lava zone 1 and 83,124 acres of land in lava zone 2.
- Over 8% of Hāmākua's population lives in the Volcanic High Hazard Area (1,303 residents).

Hāmākua is confronted with important future decisions pertaining to life safety, development, redevelopment, and general land use. Perhaps most significant is population, sacred places and agricultural land located within the Volcanic High Hazard Area and other natural high hazards, like landslides. An understanding and assessment of risk, exposure, and implications of redevelopment and/or greenfield development, which could create new land uses and potentially increased population within Hāmākua, should be carefully considered.

There are existing populated locations within Hāmākua with significantly less lava flow hazard risk, especially when compared to other CDPs in the County (i.e. Puna). All of this should be considered when weighing benefits and challenges of future development options and scenarios throughout the County of Hawai'i. At the same time,

considerations for Hāmākua's most vulnerable populations, environmental resources, and cultural resources need to made and prioritized, in support of reducing volcanic risk and exposure, and long-term sustainability. Strategic policy decisions and priorities should be identified to target the District's most vulnerable, to reduce risk to future volcanic events and other hazard events and prioritize safe evacuations when needed.

4.3 Hilo

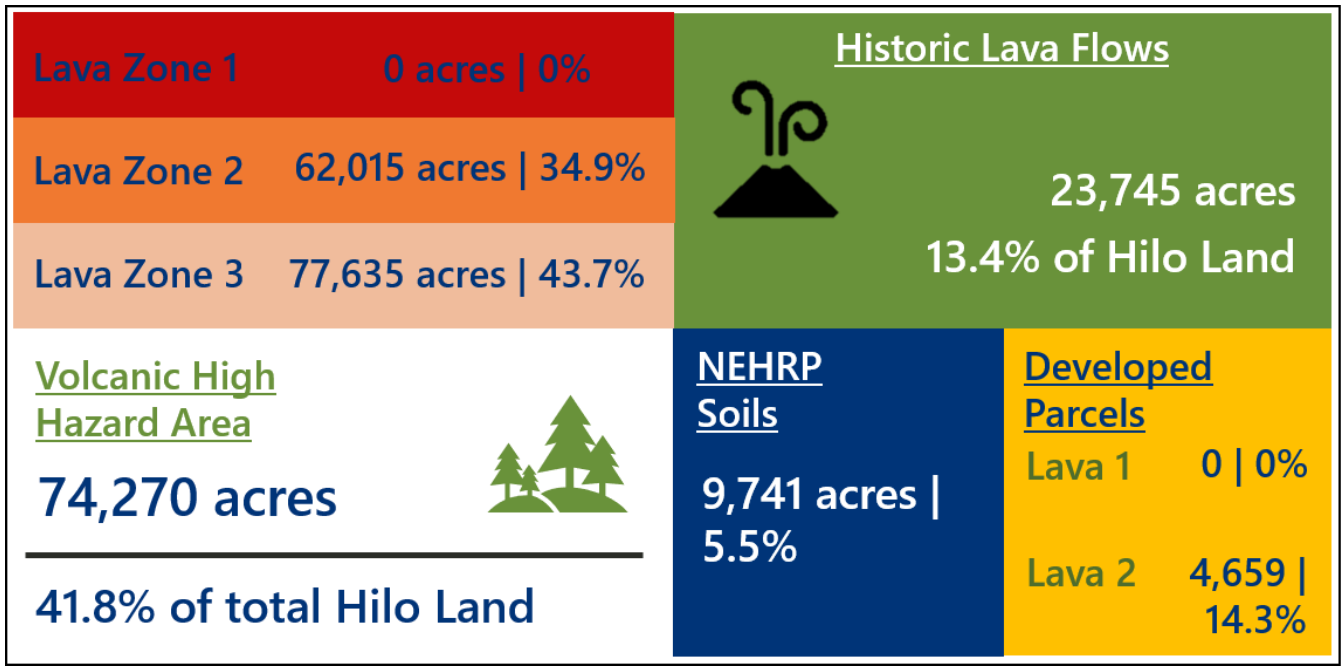
4.3.1 OVERVIEW

The Hilo Community Development Plan district (CDP), herein referred to as Hilo, is located on the eastern side of the Island of Hawai'i, just north of Puna and south of Hāmākua. Hilo is unique as its boundaries are exclusively the Hilo city boundaries (also, a census designated place), rather than a broader region like the other CDPs. Hilo has the County's largest population and holds the County seat. Hilo is also home to the Hilo International Airport (the only other airport, which is a state-owned public-use airport, on the Island is the Waimea-Kohala airport in Kona). While all CDPs are ocean-facing, Hilo's exposure to the Pacific Ocean is the most limited due to the presence of the County's largest harbor, Hilo Bay. Hilo Bay's unique shape and location is responsible for Hilo's high tsunami risk and history of recent deadly tsunamis (1946, 159 deaths and 1960, 61 deaths) (USGS 2019c). Hilo does not have a volcano contained within its boundaries but is close to Kīlauea volcano and Mauna Kea.

Hilo saw its first inhabitants, from Polynesia, starting in around 1100 AD (pre-contact). For hundreds of years that followed the Polynesian's first arrival, ancient Hawai'i grew into a system of scattered settlements with first communities settling in and near Hilo on the windward side of the Island due to its ample water resources and rich soils. In general, at the peak pre-contact era, 1700s, Hawai'i's population is estimated to have been anywhere between 100,000 and 600,000 inhabitants (Dye 1992). Post-contact, in the mid-1800s, the same landscape and climate was suitable to establish sugar plantations and factories which attracted as many as 26,000 Chinese immigrants to work in the industry. Japanese immigrants quickly followed the Chinese and eventually lead to the addition of Korean, Portuguese, Okinawan, and Filipino immigrants to work in the sugar plantations. Hilo is the most populated district in the County, but still maintains cherished natural landscapes including rainforests, waterfalls, and trails located directly west of downtown Hilo. While Hilo is the most populous community in the County, its tourist or visitor traffic is lower than other parts of the island. Hilo and its international airport routinely underperform in terms of attracting and accommodating tourists. Until 2011, the Hilo airport had been the County's only airport without a direct flight to/from North America. The passenger counts at the airport have been stagnant since the early 1970s (1.3 million people annually in 1973 and 2008) (Hawai'i Department of Transportation 2008). In 2008, the eastern coast of the County contained only 14% of the County's hotel rooms (as opposed to the 85% of rooms in Kona and Kohala) (Hawai'i County Visitor Accommodations 2008). Hilo is well-known for the following attractions: the Pacific Tsunami Museum, the Mauna Loa Macadamia Nut corporate headquarters, and its walkable, historic downtown district.

While Hilo is the most populous city in the County, it's not the most populated CDP. However, Hilo continues to experience growth: 40,759 people in 2000, 43,263 people in 2010, and to 45,703 people in 2017 (American FactFinder 2017). It maintains a mix of developed and undeveloped land, despite being the most urban cities in the County. The modern district of Hilo encompasses 277 square miles. Consistent with other County Districts, Hilo maintains a majority of land categorized as conservation (71%). Present day, Hilo's character and settlement patterns are distinct with clear urban boundaries and obvious clusters of development, mostly centered around Hilo's downtown and Hilo Bay.

4.3.2 VOLCANIC HAZARDS



Note: All percentages are relative to the Hilo CDP District

Figure 4-49. Hilo Volcanic Hazard Exposure Overview

Although one of the County's five volcanoes is not within the boundaries of Hilo, most of Hilo is located in either lava zone 2 and 3. The western half of the district is lava zone 2 and the eastern half of the district is primarily lava zone 3.

Altogether, Hilo is located within the following lava-flow hazard zones 2, 3, 7, and 8 (***Figure 4-50***), the largest of which is lava zone 3, representing 43.7% of land area. Hilo's lava zone 2 is comprised of those areas adjacent to and downslope of Mauna Loa and Kīlauea's lava zone 1. According to the USGS lava zone definitions, between 15 to 25% of lava zone 2 areas have been covered by lava since 1800, and 25 to 75% have been covered within the past 750 years. Hilo's lava zone 3 is comprised of those areas less hazardous than zone 2 because of greater distance from recently active vents and/or because of topography. Again, according to USGS, between 1 to 5% of zone 3 has been covered since 1800, and 15 to 75% has been covered within the past 750 years (USGS 2017a).

More than 30% of Hilo is located within lava-flow hazard zone 2, which includes flows surrounding Mauna Loa and Kīlauea. These volcanos have a history of frequent lava flows within zone 1, or in areas adjacent to or downslope of lava zone 1 within lava zone 2 (Wright et al. 1992). Of the 18.3% of developed land within Hilo (or parcels with a building assessment value according to County assessor records), 4,659 acres, or 14.3%, is located within the high-risk lava flow hazard zone 2 (***Table 4-34***). For the purposes of this assessment, developed and undeveloped land has been calculated at the parcel level, regardless of private or public ownership.

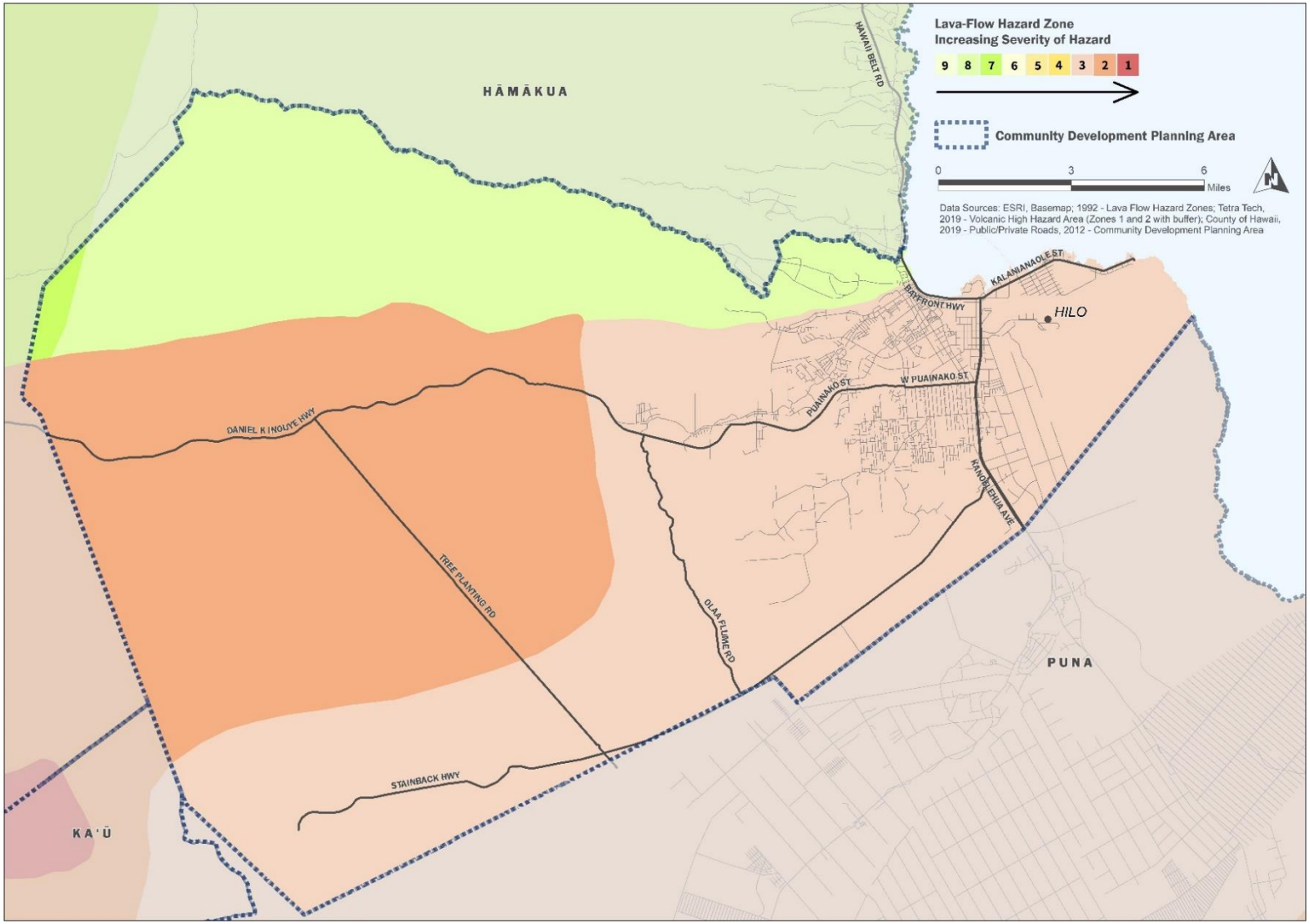


Figure 4-50. Lava Zones in Hilo

Table 4-34. Hilo Developed vs. Undeveloped Parcel Area by Lava Zone

	Total Area *(acres)*	Lava Zone 1 *(acres)*	Lava Zone 2 *(acres)*	Lava Zone 3 *(acres)*	Lava Zone 4 *(acres)*	Lava Zone 5 *(acres)*	Lava Zone 6 *(acres)*	Lava Zone 7 *(acres)*	Lava Zone 8 *(acres)*	Lava Zone 9 *(acres)*
Hilo District	**177,711**	**0**	**62,015**	**77,635**	**0**	**0**	**0**	**928**	**37,133**	**0**
Developed	32,464	0	4,659	23,994	0	0	0	211	3,600	0
Undeveloped	145,247	0	57,357	53,641	0	0	0	716	33,533	0

Note: Developed parcels reflect a parcel that contains a building assessment value per the County assessor records.

Lava is not the only volcanic hazard faced by Hilo. Soil conditions have a profound influence on the characteristics of ground shaking during an earthquake, and parcels within Hilo are exposed to seismic activity. Greater than 15% of Hilo's parcels are located within peak ground acceleration (PGA) 120%g, which roughly corresponds to Seismic Design Category (SDC) E. The SDC E is the seismic hazard zone capable of producing the most intense shaking (USGS 2017). Refer to ***Section 3 - Methodology*** for more details on the PGA 120%g seismic zone. Hilo has 1,399 parcels (or 8.3% of total parcels) located on softer soils (National Earthquake Hazard Reduction Program [NEHRP] types D and E, such as fill, mud and sand) that amplify ground shaking and can increase building and infrastructure damage and losses.

Vog, a visible haze comprised of water vapor, carbon dioxide, sulfur dioxide (SO_2) and particulate matter produced during volcanic eruptions, can compromise air quality, especially for those areas downwind of volcanic emissions. It poses respiratory challenges for those exposed to it within the affected area. Vog impacts can be experienced hundreds, if not thousands, of miles away (USGS 2019b). As was experienced during the 2018 Kīlauea eruption, regular ash emissions from the summit of Kīlauea, as well as acidic ocean entry plumes, generated by lava flows into the sea, also known as laze, also contribute to poor air quality in downwind locations (U.S. Department of the Interior Strategic Sciences Group 2018). Wind direction and speed are the two most critical factors that determine vog impacts within Hilo. For example, prevailing trade wind conditions, or winds that emanate from the southeast, could carry SO_2 and vog from Kīlauea's summit vents to Hilo (USGS 2019b).

As discussed in ***Section 3 - Methodology***, geographic information system (GIS)-based volcanic hazard areas were aggregated into a single category to identify those areas throughout the County with the greatest volcanic hazard risk: Volcanic High Hazard Area. The Volcanic High Hazard Area includes: lava zones 1 and 2, historic lava flow events (1790-2018), and NEHRP D&E soils. This risk assessment focuses on Hilo's exposure to the Volcanic High Hazard Area and lava-flow hazard zones 1 and 2. Over 40% of Hilo is located within the Volcanic High Hazard Area (41.8%) with the remainder located in lava zones 3, 7, and 8. Refer to ***Table 4-35*** and ***Figure 4-51*** for a summary of Hilo's land area in each volcanic hazard area.

Table 4-35. Hilo Land by Volcanic High Hazard Area and Lava Zones 1, 2, 3, 7, and 8

Hazard Area	Total Land Area *(acres)*	Developed Parcel Area *(acres)*	Undeveloped Parcel Area *(acres)*
Volcanic High Hazard Area (VHHA)	74,270 (41.8%)	7,481 (23%)	66,790 (46%)
Lava Zone 1	0 (0%)	0 (0%)	0 (0%)
Lava Zone 2	62,015 (34.9%)	4,659 (14.3%)	57,357 (39.5%)
Lava Zone 3	77,635 (43.7%)	23,994 (73.9%)	53,641 (37%)
Lava Zone 7	928 (.52%)	211 (.65%)	716 (.49%)
Lava Zone 8	37,133 (20.9%)	3,600 (11.1%)	33,533 (23.1%)

Note: Acres in each hazard area was calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

The Hilo District is prone to additional natural hazards. These hazards include, but are not limited to, tsunamis, landslides, coastal storm surge and floods. In addition to examining the assets exposed to the volcanic hazard areas, it is important to determine if those assets are located in additional natural high hazard zones to inform the identification of recovery and mitigation strategies.

Figure 4-52 illustrates the location of additional natural high hazard areas located in Hilo and ***Figure 4-53*** illustrates the additional natural high hazard areas relative to the lava zones and Volcanic High Hazard Area.

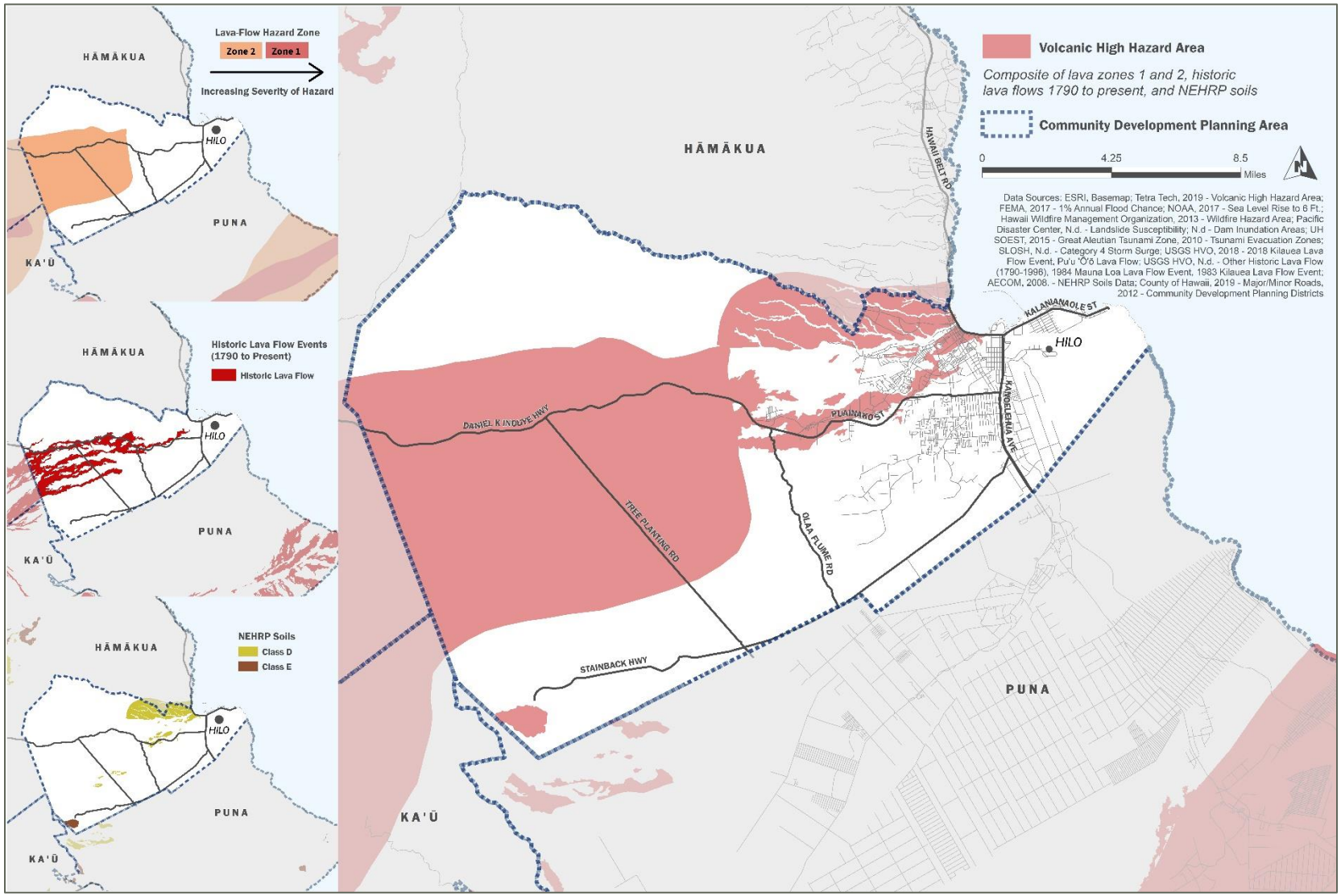


Figure 4-51. Volcanic High Hazard Area in Hilo

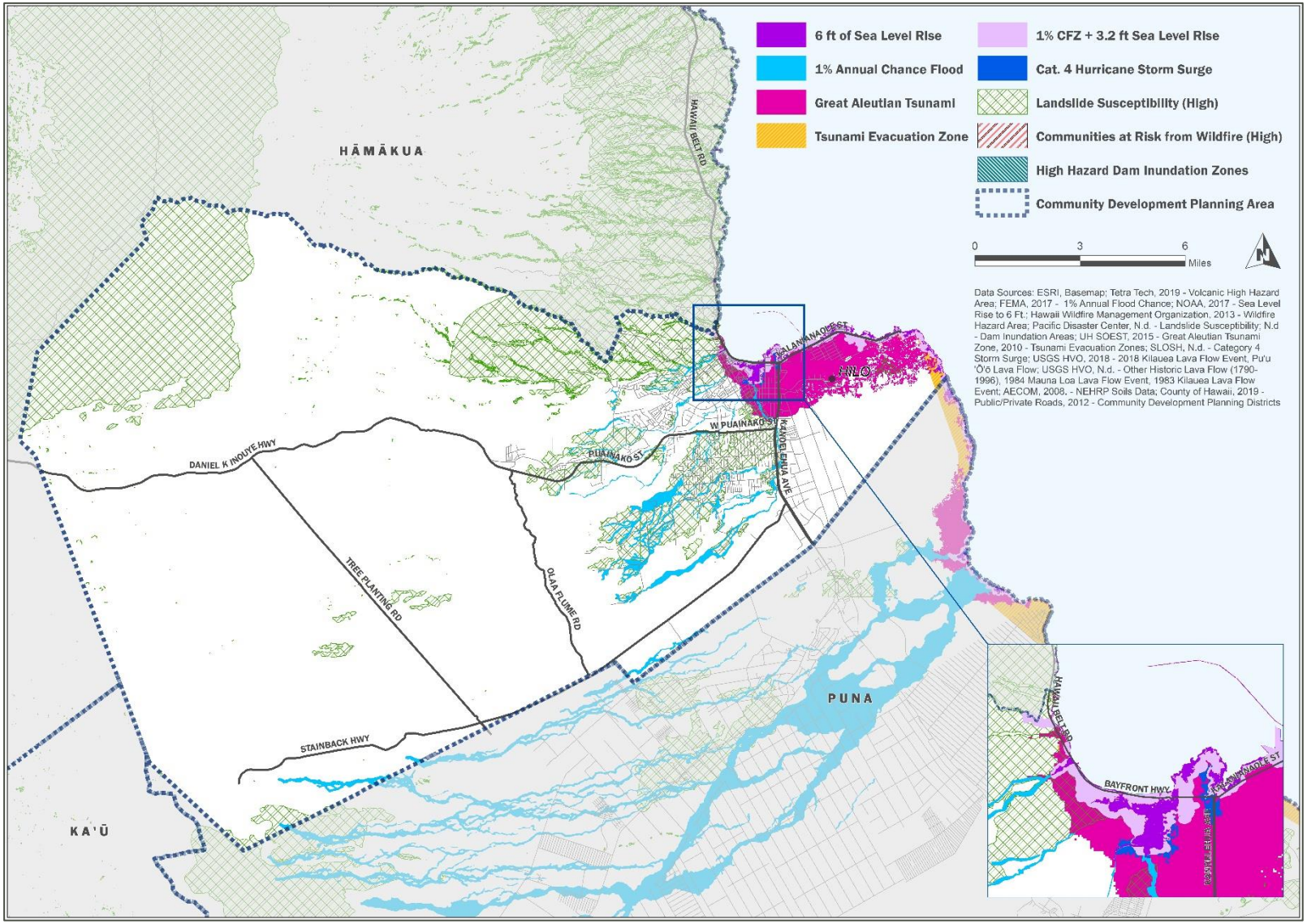


Figure 4-52. Additional Natural High Hazard Areas in Hilo

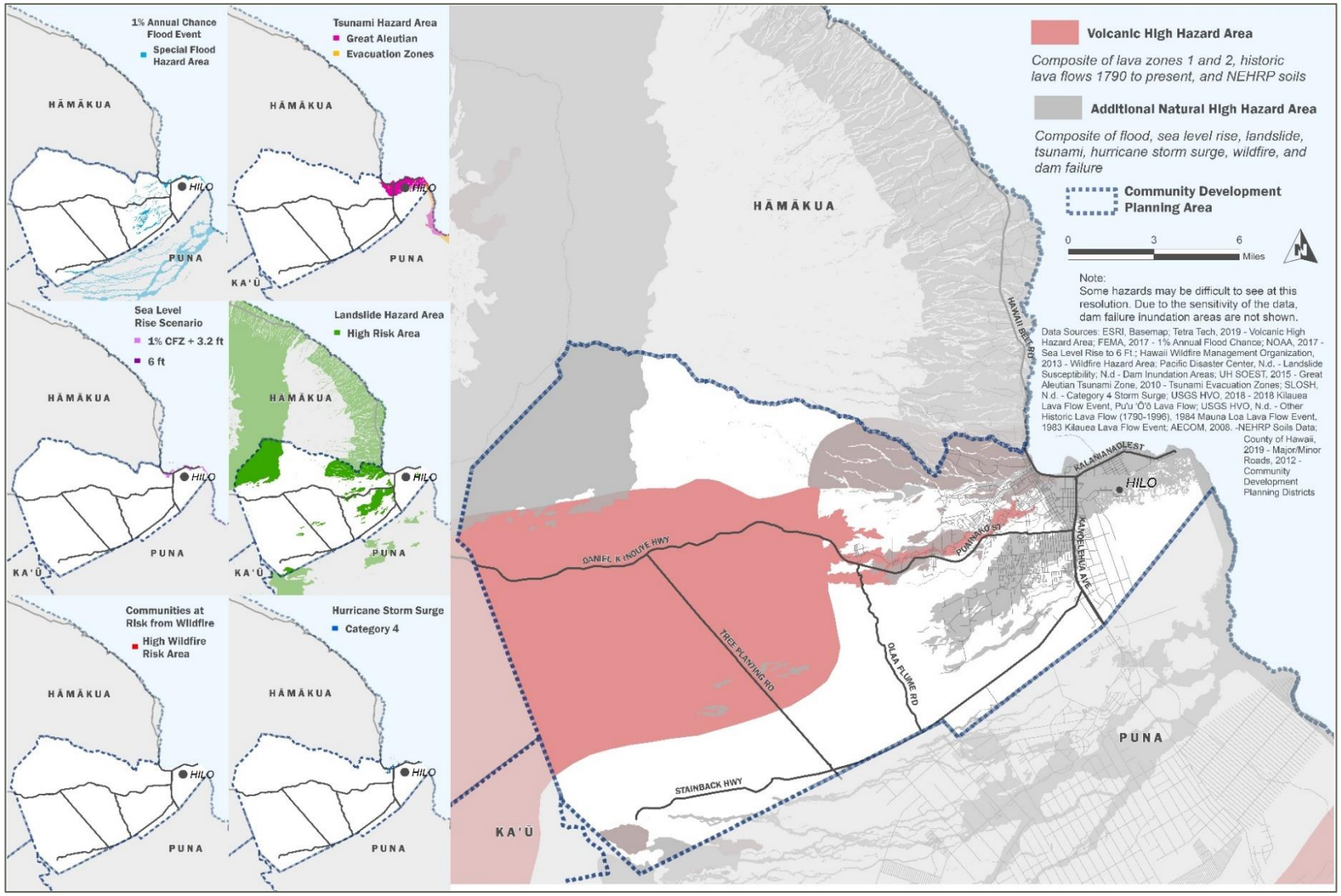
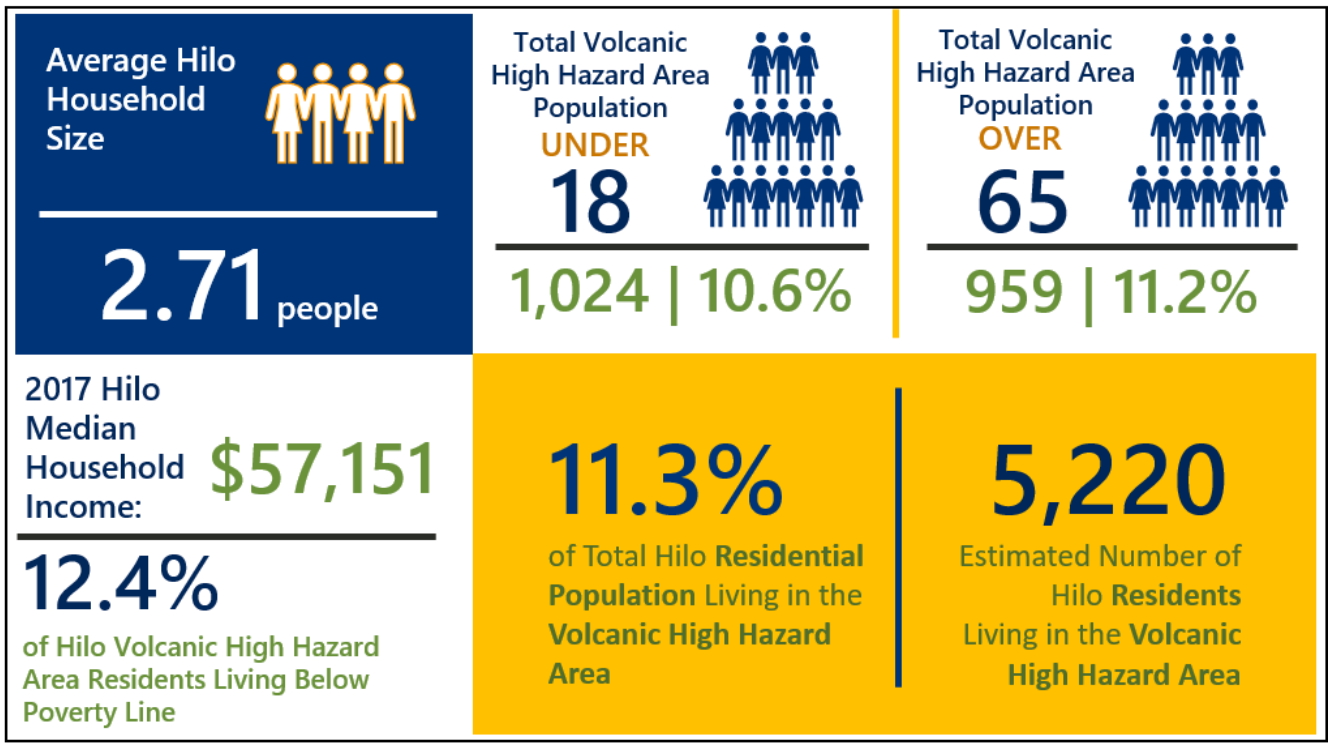


Figure 4-53. Volcanic High Hazard and Additional Natural High Hazard Areas in Hilo

4.3.3 POPULATION



Note: All percentages are relative to the Hilo CDP District

Figure 4-54. Hilo Population Exposure to the Volcanic High Hazard Areas

As of 2017, Hilo's total population was 46,003, which represents 23.4% of the County's total population (U.S. Census Bureau 2017). According to the 2019 County of Hawai'i General Plan, Hilo has been experiencing relative slow growth compared to some of the higher growth parts of the County like Ka'ū and Puna (CHPD 2019). Slow growth over the last couple of decades can be attributed to the decline of the sugar industry and stagnant tourism numbers.

Housing growth rates vary considerably by District. Hilo is expected to have one of the slowest growths between 2010 and 2040 (29%) compared to Puna's Hawaiian Paradise Park subdivision's expected 171%. The differences in growth rates, by District, are also expected to result in shifts in the relative population centers. For example, half of the housing is currently in Hilo (24%) and North Kona (25%), while only about 13% is in Upper Puna and Hawaiian Paradise Park-Orchidland. However, by 2040, only 42% of the units are forecasted to be in Hilo and North Kona, while 19% is estimated to be in Upper Puna and Hawaiian Paradise Park (CHPD2019).

Related to population growth and Hilo's economic outlook, an estimated 1/3 of jobs in Hawai'i County are located in Hilo. This is not surprising, considering Hilo is the County seat. It is useful to compare these job centers with the County's population centers. Hilo, for example, has a surplus of jobs relative to its population, reflecting the fact that residents commute there from other communities (CHPD 2019).

The Hilo CDP's population is centered around downtown Hilo (see ***Figure 4-56***), which is located in lava zone 3. Hilo's western half, on the other hand, is located in lava zone 2 with a lower population count.

As noted in ***Section 3 – Methodology,*** examining resident and household exposure to the volcanic hazard is challenging because parcel-level demographic data is generally not available. Instead, demographic statistics from the 2017 ACS were collected for each U.S. Census tract within the County (U.S. Census Bureau 2017). Each tract's 2017 population count and the number of 2019 residential parcels in the tract were used to calculate the average number of persons per household. This data was then used to conduct the population exposure assessment using each parcel's estimated household size. The results of this analysis are limited based upon the data available and should only be used for planning purposes until higher resolution data is available. The majority of Hilo District residents live within lava zone 3 (98%) and therefore, are moderately exposed to the lava-flow hazard. There is no calculated probability associated with each lava-flow hazard zone. The zones, ranked from 1 through 9, represent a scale of increasing hazard as the numbers decrease, based on the probability of coverage by lava flows. Therefore, land classified as lava zone 1 is the most hazardous (USGS 2019a).

Hilo's population lives only in lava zones 2, 3, and 8; refer to ***Figure 4-55***. As shown, the greatest number of residents live in lava zone 3, representing over 95% of Hilo's total population.

Figure 4-56 illustrates the population density across Hilo relative to the Volcanic High Hazard Area. The greatest population density is centered around historic, downtown Hilo. Note, these resident totals do not reflect the number of undocumented residents, tourists and visitors residing in the district either permanently or temporarily. In summary, the Hilo CDP has the greatest percentage of households in the County located in lava zone 3 (96.7% of total Hilo households).

At the individual resident level Hilo has over 5,000 residents living in the Volcanic High Hazard Area (11.3% of total Hilo residents). Over 50% of Hilo's Volcanic High Hazard Area residents are also exposed to another natural high hazard area (i.e. tsunami, landslide, etc.)

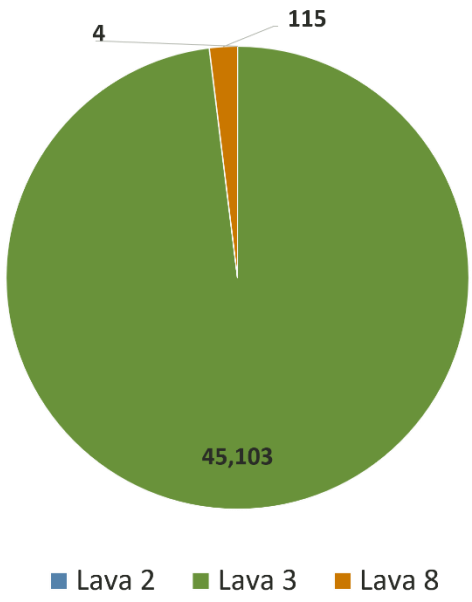


Figure 4-55. Number of Residents in Hilo's Lava Zones

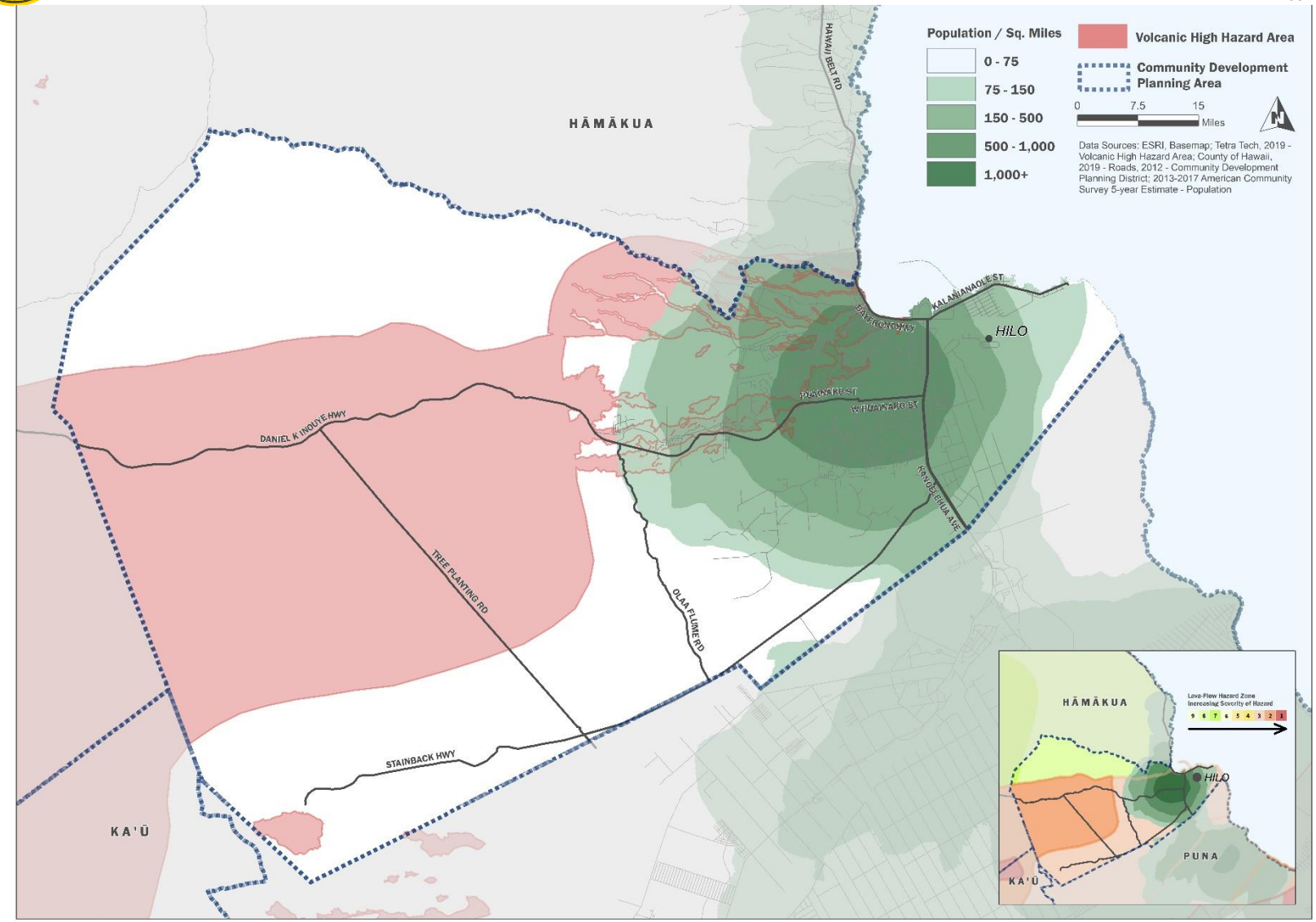


Figure 4-56. Hilo Population Density Relative to the Volcanic High Hazard Area

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted (Donner 2011). This is due to many factors including their physical and financial ability to react or respond during a hazard. This population is referred to as socially vulnerable to hazard events. At the same time, County residents are unique and although may be faced with exposure to a greater number of natural hazard events, this may have increased their overall level of resilience. This is likely due to factors including, but not limited to: institutional knowledge of hazard events, intimate knowledge of the natural elements of the County (particularly for those residents who have lived in the County for an extended period of time), and varying levels of existing self-sufficiency. In 2019, the Pacific Disaster Center released the Kīlauea Eruption Risk Assessment (KERA) report that identified key social drivers of volcanic hazard vulnerability: 1. socioeconomic status; 2. access to information; and 3. household composition (Pacific Disaster Center 2019). To align with the KERA report, the County examined the exposure of these vulnerable populations to the volcanic hazard.

Table 4-36 summarizes the vulnerable population statistics in Hilo by number of residents. Over 19% of the District's residents live below the poverty line. Hilo's 2017 median annual income of $57,151 was very similar to the County's median annual income of $56,395 (U.S. Census Bureau 2017). In order to meet some of the needs of Hilo's low-income residents, Hilo has the County's greatest share of affordable housing (23.9%), more than any other County District (County of Hawai'i 2019). This is in-part due to the availability of public infrastructure and funds to support the development of multi-family affordable housing in Hilo.

Table 4-36. Hilo Vulnerable Population

Estimated Vulnerable Populations	
No Internet	11,634
Under 18	9,617
Single Parent	9,155
Below Poverty Line	8,910
SNAP	8,671
Over 65	8,537
Disability	6,154
No Vehicle	2,807
No Diploma	2,266
No Health Insurance	1,969
Non-English Speaking	1,894
Unemployed	1,321
No Phone	1,073

In terms of total number of residents, those residents with no internet, under 18, and who live in a single-parent household represent the top three vulnerable population categories within the Hilo CDP. The County may consider the high rate and density of residents with no internet in future planning efforts, especially with specific focus on ways in which to provide alternative means of communication to those residents during an event or during awareness campaigns.

Over 37% of Hilo residents living in the Volcanic High Hazard Area are either under 18 years of age or over 65 years of age. Additionally, nearly 15% of residents in Hilo with no access to a vehicle live within the Volcanic High Hazard Area. This means that they may have limited ability to evacuate upon either a volcanic or tsunami evacuation order. The following summarizes the estimated number of residents living in the Volcanic High Hazard Area and considered the most vulnerable to the volcanic hazard:

- 1,024 people under 18 years of age
- 959 people over 65 years of age
- 904 single parents
- 569 people living with a disability
- 1,271 people with no internet access
- 405 people with no vehicle access
- 79 people with no phone access
- 142 people who are unemployed
- 984 people utilizing SNAP (Supplemental Nutrition Assistance Program)

- 1,106 people living below the poverty line

As previously discussed, resident exposure to hazards is based on U.S. Census tract data because this information is not available at the parcel level. Refer to ***Section 3 - Methodology*** for more details on the methodology used to generate these estimates. The limitations of this analysis are recognized, and results should be used for planning purposes only and updated when higher resolution data is available.

Table 4-37 through ***Table 4-40*** summarize the exposure of vulnerable residents in Hilo by socioeconomic factor to the volcanic hazard, as well as where the volcanic hazard area overlaps with another natural high hazard zone.

Table 4-37. Hilo Household Composition by Volcanic Hazard Area - A measure of households containing one or more vulnerable groups susceptible to the negative impacts of natural disasters.

Hazard Area	Total Residents *(number / %)*	Under 18 *(number / %)*	Over 65 *(number / %)*	Single-Parent Household *(number / %)*	Persons with Disability *(number / %)*
Volcanic High Hazard Area (VHHA)	5,220 / 11.3%	1,024 / 10.6%	959 / 11.2%	904 / 9.9%	569 / 9.2%
VHHA with Additional Natural High Hazard Area	2,949 / 56.5%	574 / 56%	529 / 55.2%	552 / 61.1%	307 / 53.9%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	4 / 0%	0 / 0%	1 / 0%	1 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

Table 4-38. Hilo Household Member Health and Transportation by Volcanic Hazard Area - A measure of households with increased vulnerability due to the lack of a vehicle (i.e., evacuation). A measure of the population's access to critical services such as access to transportation routes and medical services.

Hazard Area	No Vehicle *(number / %)*	No Health Insurance *(number / %)*
Volcanic High Hazard Area (VHHA)	405 / 14.4%	191 / 9.7%
VHHA with Additional Natural High Hazard Area	327 / 80.8%	122 / 63.8%
Lava Zone 1	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

Table 4-39. Hilo Resident Access to Information by Volcanic Hazard Area - A measure of the ability to receive, comprehend and appropriately act on complex messaging with regard to natural disasters.

Hazard Area	No High School Diploma, Over 25 Years Old *(number / %)*	Non-English Speaking *(number / %)*	No Internet *(number / %)*	No Phone *(number / %)*
Volcanic High Hazard Area (VHHA)	279 / 12.3%	204 / 10.8%	1,271 / 10.9%	79 / 7.4%
VHHA with Additional Natural High Hazard Area	201 / 71.8%	117 / 57.2%	902 / 70.9%	54 / 68.2%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%	1 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

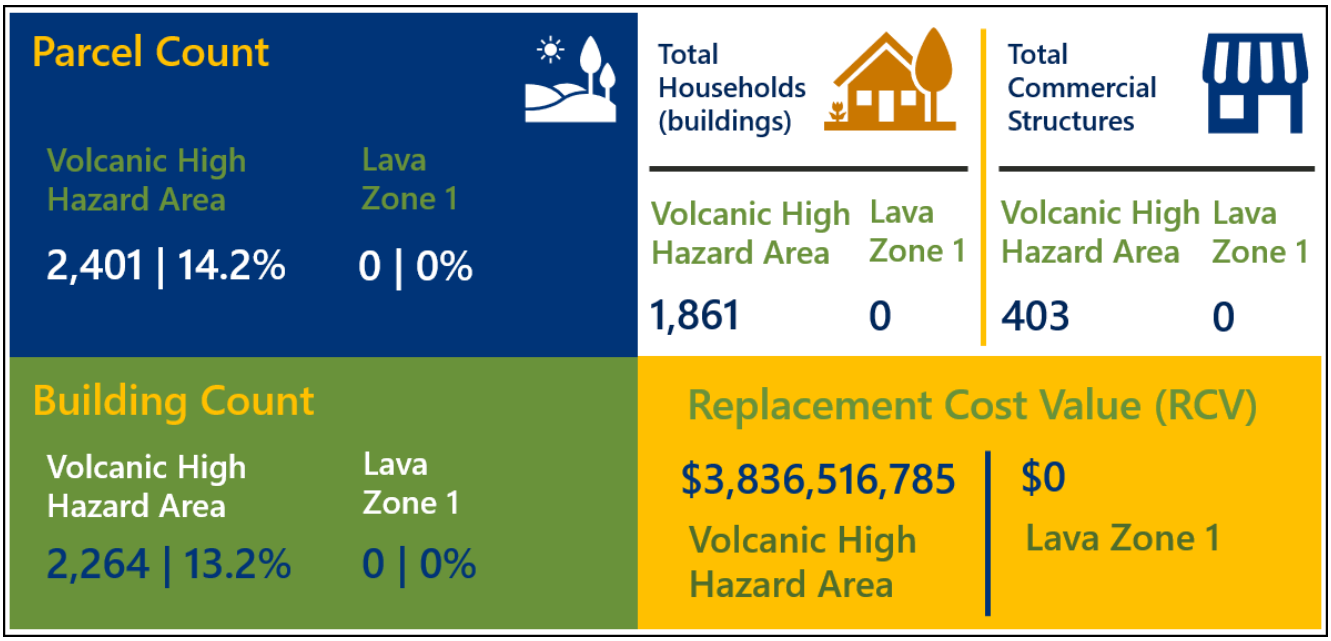
Table 4-40. Hilo Resident Socioeconomic Status, by Volcano Hazard Area - A measure of the population that is less likely to have the necessary economic resources to adequately prepare for or recover from a natural disaster.

Hazard Area	Unemployed *(number / %)*	Receiving SNAP *(number / %)*	Below Poverty Line *(number / %)*
Volcanic High Hazard Area (VHHA)	142 / 10.8%	984 / 11.3%	1,106 / 12.4%
VHHA with Additional Natural High Hazard Area	101 / 70.8%	765 / 77.8%	836 / 75.6%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%	1 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%

SNAP Supplemental Nutrition Assistance Program

Note: Total residents in each hazard area were calculated separately as distinct and separate; therefore, individual hazard area totals do not equate to the VHHA total.

4.3.4 PARCELS AND BUILDINGS



Note: All percentages are relative to the Hilo CDP District

Figure 4-57. Hilo Parcels and Buildings Located in a Volcanic High Hazard Area (VHHA)

A total of 7,481 acres of developed land (representing 23% of Hilo's total developed land) and 2,264 buildings (13.2%) in the Hilo District are located in the Volcanic High Hazard Area ***(Figure 4-57***). At greatest risk to the lava-flow hazard are those developed parcels located in lava zone 1 (no developed parcels and no buildings) and lava zone 2 (25 developed parcels and 1 building). ***Figure 4-58*** illustrates the developed parcels by lava-flow hazard zone.

Lava may burn structures and can bury land as well as everything else in its path. For the purposes of this analysis, the total assessed value (land and building) located in the volcanic hazard areas is reported to illustrate the potential future loss to existing parcels and development. The total assessed value of parcels located in the Volcanic High Hazard Area is an estimated $1,090,944,400 which represents 16.8% of the Hilo District's total assessed values (land and structure). In terms of the replacement cost value of buildings (estimated structure and contents), an estimated $3,836,516,785 exists in Hilo's Volcanic High Hazard Area. The Hilo CDP has the highest replacement cost value in the entire County's Volcanic High Hazard Area (see ***Table 4-41).***

As shown on ***Figure 4-58***, Hilo has been impacted by historic lava flows since 1790, most prominently by Mauna Loa events. Therefore, it is not unreasonable to anticipate that Hilo will be impacted by lava flows in the future.

Table 4-41. Hilo Parcels and Buildings Exposed to Volcanic Hazards

Hazard Area	Total Number of Parcels *(number / %)*	Total Assessed Value *(land and structure)*	Total Number of Buildings (number / %)	Replacement Cost Value *(structure and contents)*	Total Households *(buildings / %)*	Total Commercial Units *(buildings / %)*
Volcanic High Hazard Area (VHHA)	2,401 / 14.2%	$1,090,944,400	2,264 / 13.2%	$3,836,516,785	1,861 / 12%	403 / 23.6%
VHHA with Additional Natural High Hazard Area	1,538 / 9.1%	$771,372,900	1,541 / 68.1%	$3,541,172,787	1,142 / 61.4%	399 / 99%
Lava Zone 1	0 / 0%	$0	0 / 0%	$0	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	$0	0 / 0%	$0	0 / 0%	0 / 0%
Lava Zone 2	25 / 0.1%	$107,379,400	1 / 0%	$45,538	1 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	15 / 0.1%	$105,419,200	0 / 0%	$0	0 / 0%	0 / 0%

Notes: Data in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

Replacement cost value calculated using 2019 RS Means data

Source: June 2019 Real Property Tax (RPT) database and 2019 County parcel dataset; buildings determined on parcels using the DWELDAT and COMDAT tables

The County of Hawai'i did not adopt the 1982 Uniform Building Code (UBC) until 1985, meaning the County didn't start requiring seismic building standards until 1985 (meeting the 1982 UBC standards). Therefore, all structures built prior to 1985 are considered to be unreinforced and susceptible to earthquake and hurricane damage due to the lack of uplift ties and a complete load path of connections (Martin and Chock, Inc. 2015). The frequency and location of Hilo's structures built prior to 1985 (both residential and commercial) is illustrated on ***Figure 4-59*** with many clustered very close or even overlapping with the Volcanic High Hazard Area. In total, there are 1,481 pre-1985 structures located in Hilo, but none in the PGA 120%g zone. Overall, structures built prior to 1985 are more vulnerable to seismic impacts when compared to structures built post-1985.

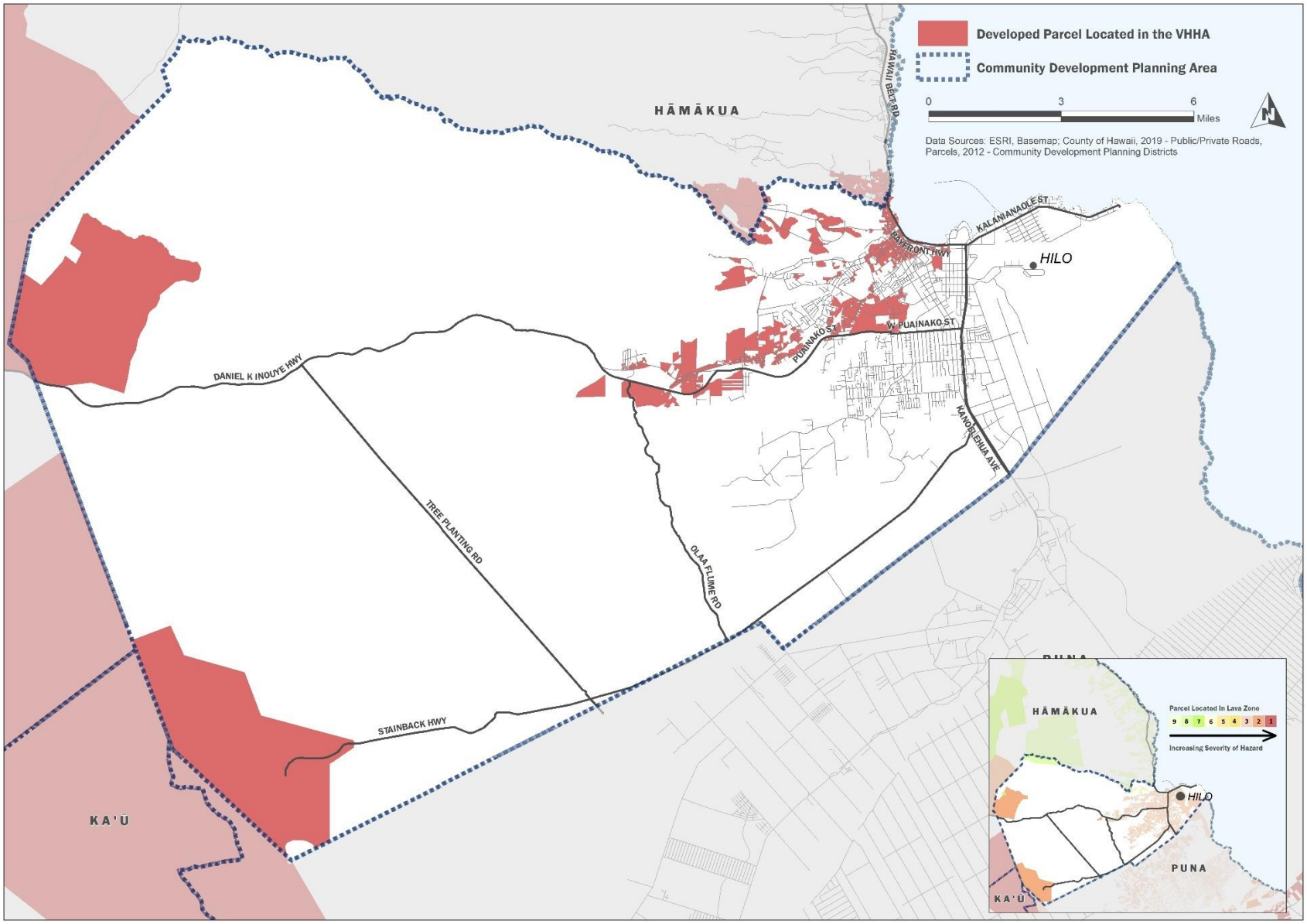


Figure 4-58. Developed Parcels in Hilo by Volcanic High Hazard Area and Lava Zone

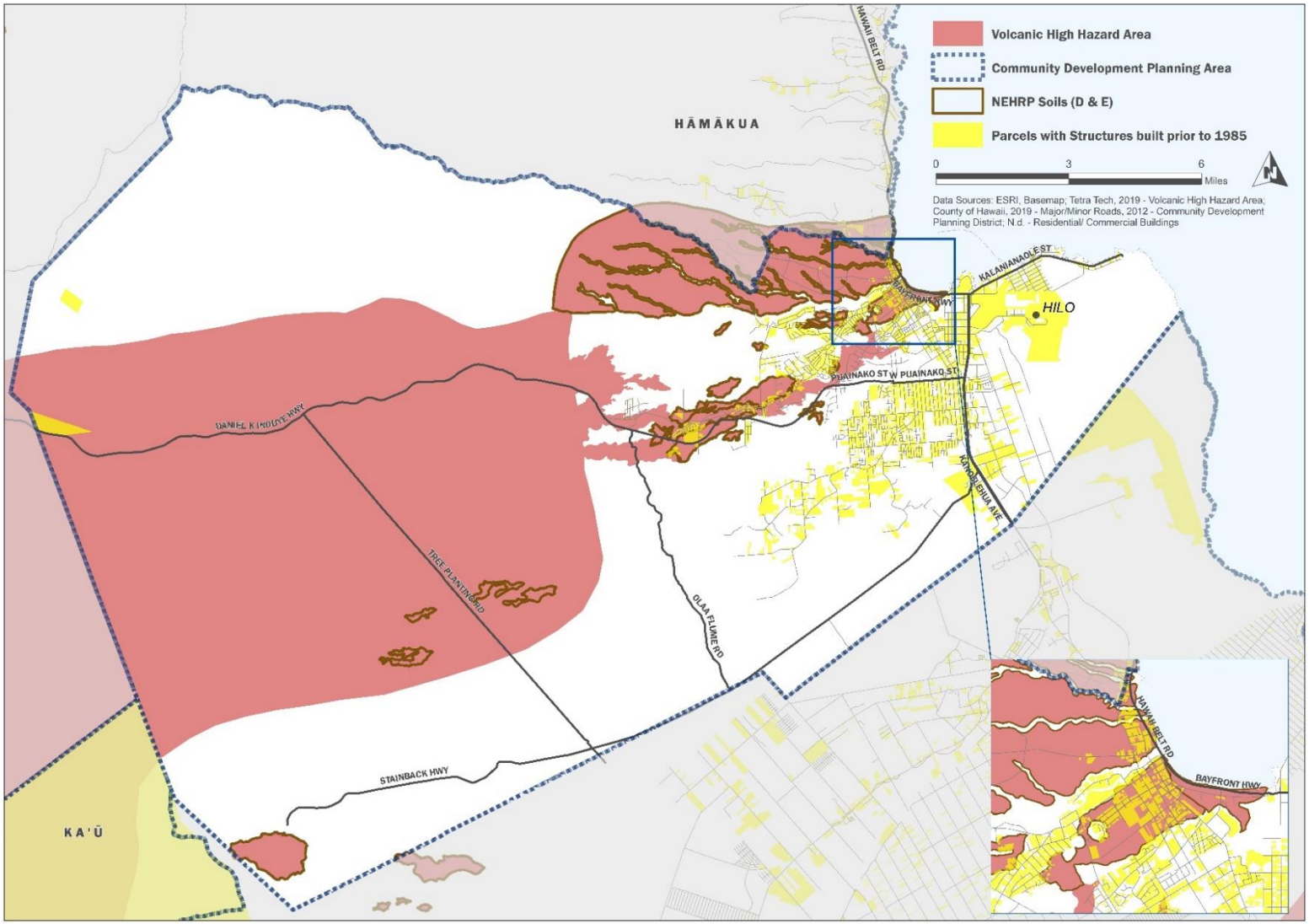
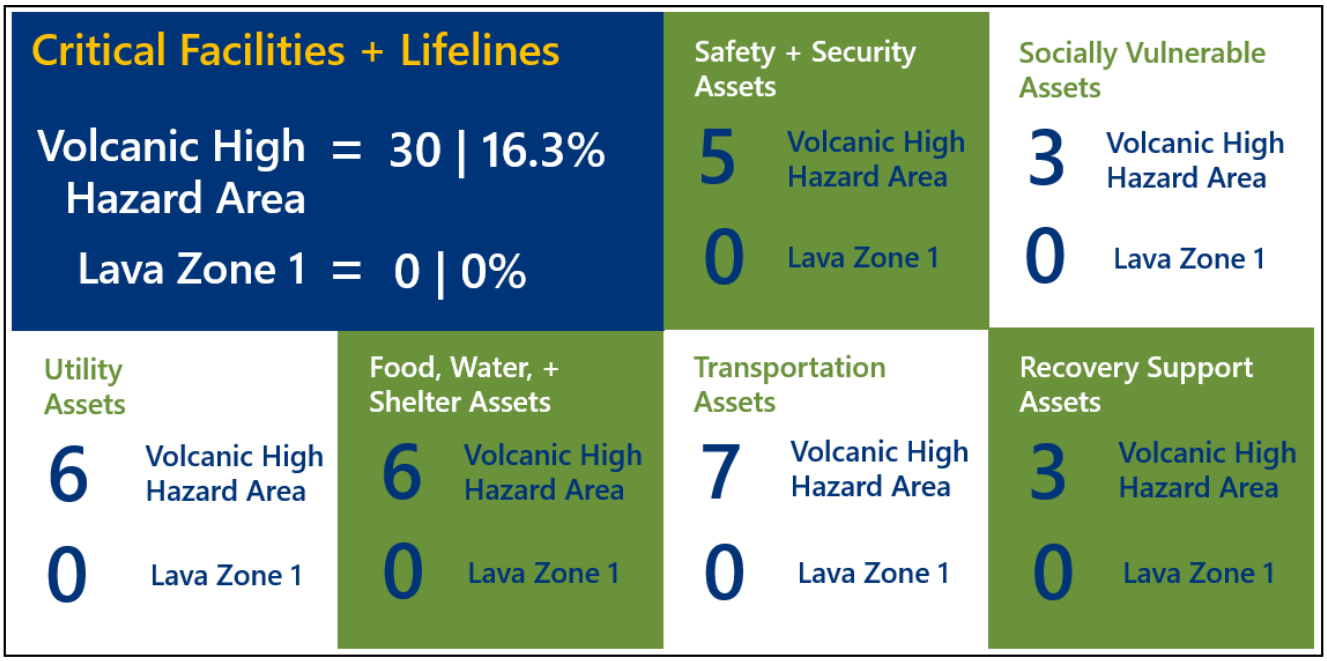


Figure 4-59. Hilo Parcels with Structures Constructed Pre-1985 in the Volcanic High Hazard Area

4.3.5 CRITICAL FACILITIES AND LIFELINES



Note: All percentages are relative to the Hilo District

Figure 4-60. Hilo Critical Facilities and Lifelines Located in the Volcanic High Hazard Area and Lava Zone 1

Through the development of the volcanic risk assessment, 184 critical facilities and lifelines were identified in Hilo. The critical facility and lifeline categories align with the 2015 County Hazard Mitigation Plan asset categories.

Table 4-42 summarizes the exposure of these critical facilities to volcanic hazards. Overall, 16.3% of Hilo's critical facilities are located in the Volcanic High Hazard Area, and therefore susceptible to impacts during volcanic events (***see Figure 4-61***). Of the 30 critical assets located in the Volcanic High Hazard Area, 5 were impacted by historic lava flow (1790-1996) and 25 are located in a NEHRP D and E area, Hilo has no critical facilities located in lava zone 1 and lava zone 2. Over 95% of Hilo's critical facilities are in lava zone 3.

Infrastructure provides connectivity between communities and resources, as well as emergency access to keep residents safe. It is closely tied to housing providing livable spaces with services needed for communities to thrive. The miles of road that intersect the Volcanic High Hazard Area and lava zones 1 and 2 were determined in an effort to understand their exposure and where potential future losses may be incurred. Hilo has 66.7 miles of roadway located in the Volcanic High Hazard Area; of which 26.4 miles are owned by the State, 32.1 miles owned by the County with the remaining being publicly accessed private roads. There are no roads that intersect lava zone 1; 20.2 miles intersect lava zone 2.

Similar to the discussion on structures constructed pre-1985, there are a number of critical facilities in Hilo constructed prior to 1985 and therefore more vulnerable to earthquake damage (during a volcanic eruption or occurring separately). Based on year-built data, 74% of Hilo's critical facilities and lifelines were constructed prior to 1985 (the second highest percentage in the County). Depending upon the specific facility's design and mitigation measures installed post construction, earthquake damage prior to an eruption or during an eruption could have significant implications of life safety and the resilience of infrastructure systems.

Table 4-42. Hilo Critical Facilities by Volcanic Hazard Area

Hazard Area	Number of Critical Facilities *(number / %)*	Built Prior to 1985 *(number / %)*	Safety and Security Assets *(number / %)*	Food, Water and Shelter Assets *(number / %)*	Recovery Support Assets *(number / %)*	Socially Vulnerable Assets *(number / %)*	Utility Assets *(number / %)*
Volcanic High Hazard Area (VHHA)	30 / 16.3%	25 / 23.5%	5 / 14.7%	6 / 18.2%	3 / 23.1%	3 / 10.3%	6 / 15%
VHHA with Additional Natural High Hazard Area	25 / 83.3%	13 / 12.2	5 / 100%	6 / 100%	3 / 100%	1 / 33.3%	4 / 66.7%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 1 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2 with Additional Natural High Hazard Area	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%

N/A Not applicable
Note: Critical facilities in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

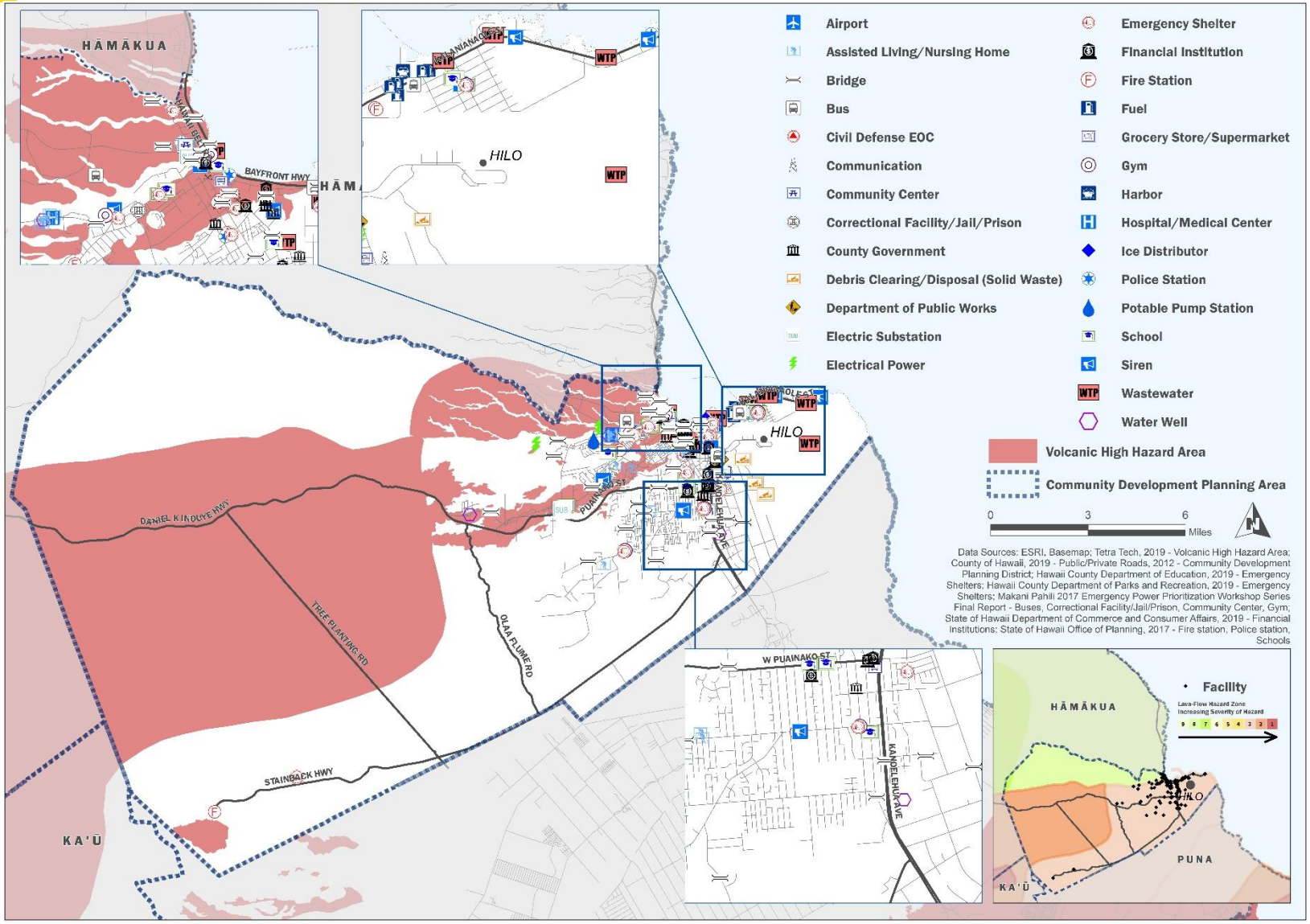
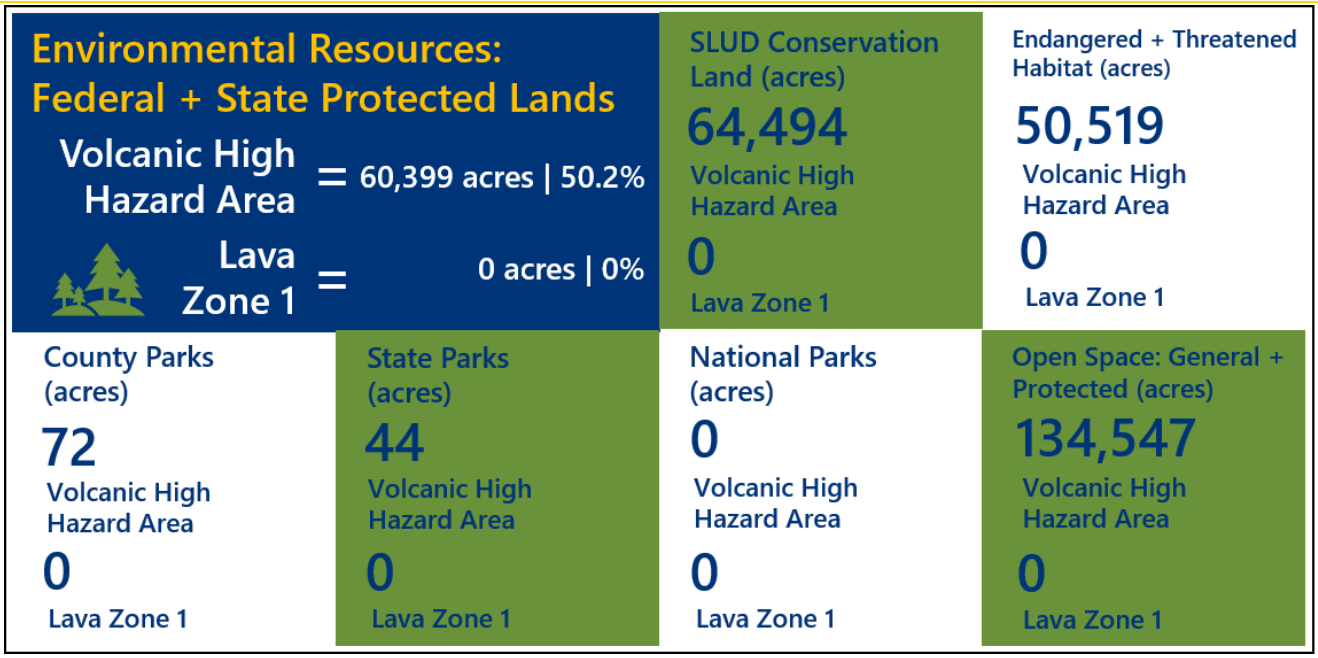


Figure 4-61. Hilo Critical Facilities Located in the Volcanic High Hazard Area and Lava Zones

4.3.6 ENVIRONMENT



Note: All percentages are relative to the Hilo District

Figure 4-62. Hilo Environmental Resources Located in the Volcanic High Hazard Area and Lava Zone 1

Well over half of land in Hilo (81.7%) is undeveloped (determined at the parcel level), meaning according to the County assessor indicates no structures on the parcel. Despite the overwhelming majority of Hilo land being that of "undeveloped," Hilo is the largest city in the County of Hawai'i. A majority of Hilo's population is contained in just a small portion of the far eastern side of the District. Outside of the developed area around downtown Hilo, Hilo maintains a distinct rural context complete with protected land, agricultural land, and a natural rainforest environment context. Some of the undeveloped land contains the following environmental resources: protected land under federal or state management (120,413 acres), hunting areas (105,845 acres), critical habitat (65,339 acres), and agricultural land of importance (33,471 acres). Fifty percent of Hilo's State Conservation District, with much of the overall land maintaining public management and ownership, is located in the Volcanic High Hazard Area. Agriculture in Hilo includes macadamia nuts, tropical fruits, flowers/foliage, and diversified crops (***Figure 4-63*** and ***Figure 4-64***).

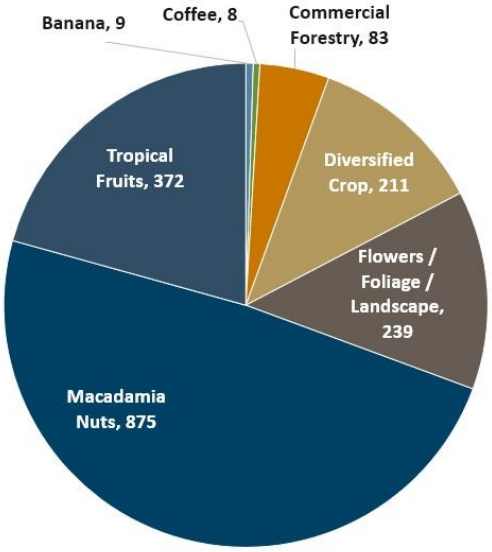


Figure 4-63. Hilo Crop Land (Acres)

Environmental assets identified as part of the County of Hawai'i General Plan update (in progress) were used for this risk assessment (see ***Table 4-43***). ***Figure 4-62*** and ***Figure 4-65*** illustrate the environmental resources relative to the Volcanic High Hazard Areas.

Table 4-43. Hilo Environmental Resources

Agricultural Land of Importance *(acres)*	Crop Land *(acres)*	Pasture Land *(acres)*	Hunting Areas *(acres)*	Wetlands *(acres)*
33,471	1,797	4,152	105,845	7,305

Federal Reserves *(acres)*	State Reserves *(acres)*	Exceptional Trees (*number*)	Anchialine Pools (*number*)	Reservoirs (*number*)	Endangered and Critical Habitats *(acres)*
11,136	108,342	16	29	25	65,339

Hilo has 16 identified exceptional trees, mostly located in and around downtown Hilo. 68.8% of Hilo's exceptional trees are located in the Volcanic High Hazard Area. Hilo has the County's third highest percentage of federal and/or state reserve land located in the Volcanic High Hazard Area (50.2%), third to Puna with 57.3% and Ka'ū with 56.3%. Hilo's remaining protected land is located in lava zones 3, 7, and 8.

Over 65% of Hilo's agricultural crop land is allocated in the Volcanic High Hazard Area, totaling 1,175 acres (the highest percentage in the County). Nearly 25% percent of Hilo's reservoirs are in a Volcanic High Hazard Area and over 50% of Hilo's hunting areas are in a Volcanic High Hazard Area.

Nearly 50% of Hilo's open space (general and protected) land is exposed to the Volcanic High Hazard Area. More than half of the following crops are grown and harvested in a Volcanic High Hazard Area: banana, coffee, commercial forestry, diversified crop, and macadamia nuts. Hilo's flowers/foliage/landscape crops have a relatively low exposure to volcanic risk with over 99% of the crop land located outside of the Volcanic High Hazard Area.

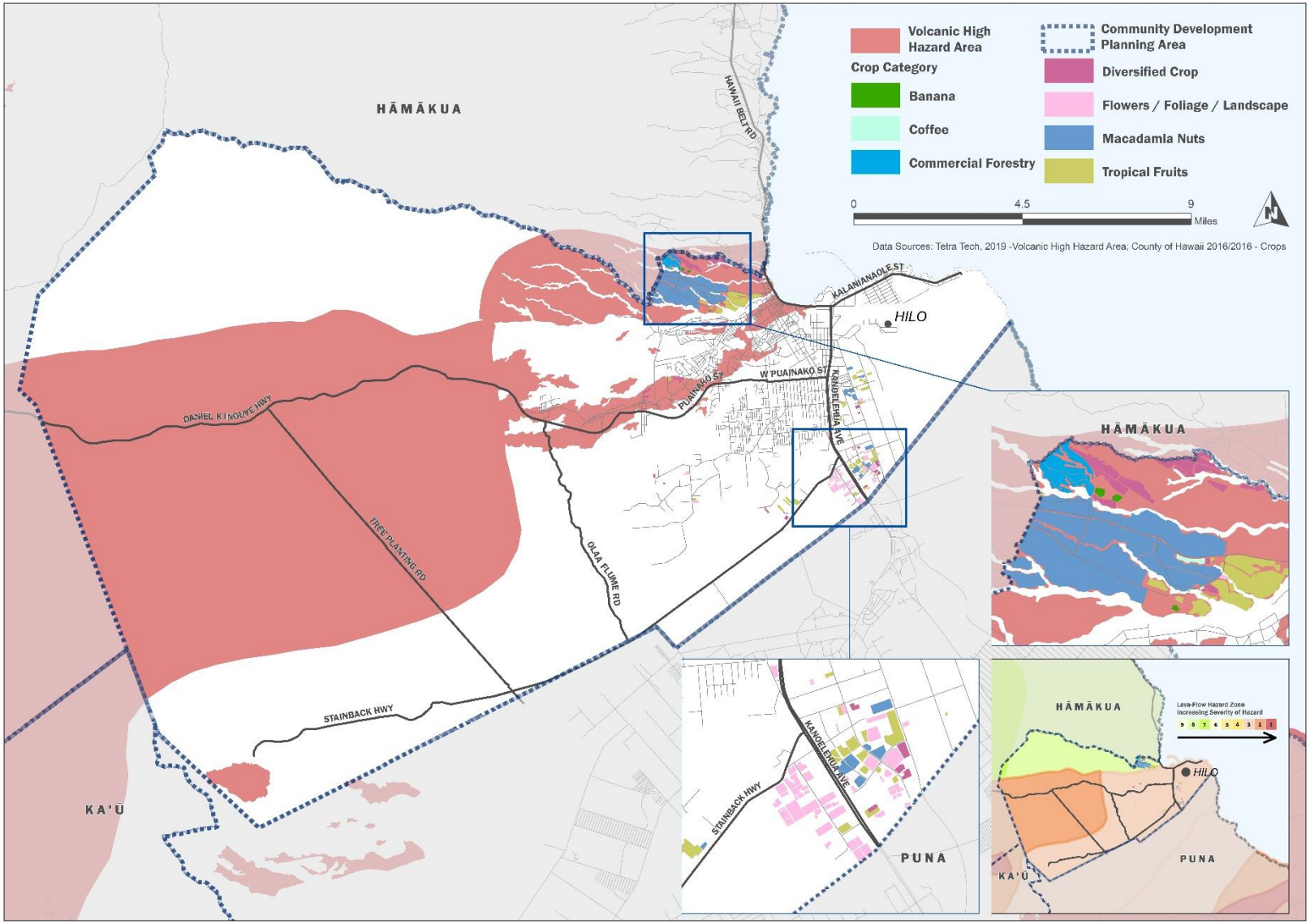


Figure 4-64. Hilo Important Agricultural Crops Located in Lava Zones and Volcanic High Hazard Area

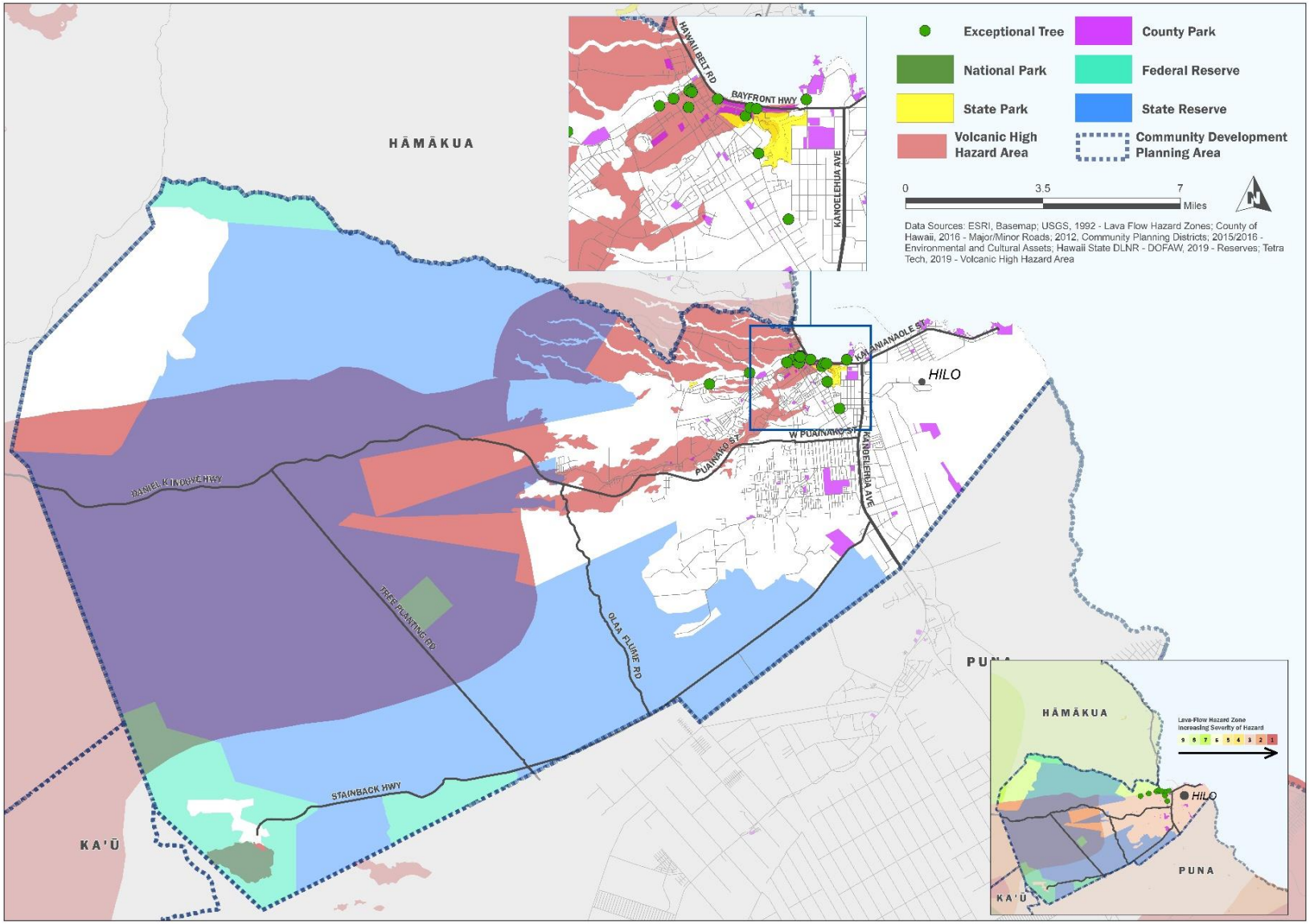


Figure 4-65. Protected Environmental Land in Hilo Located in Lava Zones and Volcanic High Hazard Area

Table 4-44. Hilo Environmental Resources

Hazard Area	Total Protected Land *(acres / %)*	SLUD Conservation Land *(acres / %)*	Endangered and Threatened Habitat *(acres / %)*	Exceptional Trees *(number / %)*	Open Space: General and Protected *(acres / %)*	Agricultural Land of Importance *(acres / %)*
Volcanic	60,399 / 50.2%	64,494 / 50.3%	50,519 / 77.3%	11 / 68.8%	134,547 / 48.8%	7,298 / 21.8%
Lava	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava	55,910 / 46.4%	59,043 / 46%	48,779 / 74.7%	0 / 0%	120,526 / 43.7%	2,674 / 8%

SLUD State Land Use District

Note: Acres and total numbers of environmental resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the Volcanic High Hazard Area total.

Hazard Area	Crop Land *(acres / %)*	Pasture Land *(acres / %)*	Hunting Areas *(acres / %)*	County Park *(acres / %)*	State Park *(acres / %)*	National Park *(acres / %)*
Volcanic	1,175 / 65.4%	114 / 2.7%	54,464 / 51.5%	72 / 8%	44 / 30.3%	213,454 / 72.6%
Lava Zone	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%	69,925 / 23.8%
Lava Zone	0 / 0%	0 / 0%	50,747 / 47.9%	0 / 0%	0 / 0%	2 / 0%

Note: Acres and total numbers of environmental resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the Volcanic High Hazard Area total.

Hazard Area	Wetlands *(acres / %)*	Reservoirs *(number / %)*	Anchialine Pools *(number / %)*
Volcanic	433 / 5.9%	6 / 24%	0 / 0%
Lava Zone	0 / 0%	0 / 0%	0 / 0%
Lava Zone	427 / 5.8%	0 / 0%	0 / 0%

Note: Acres and total numbers of environmental resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the Volcanic High Hazard Area total.

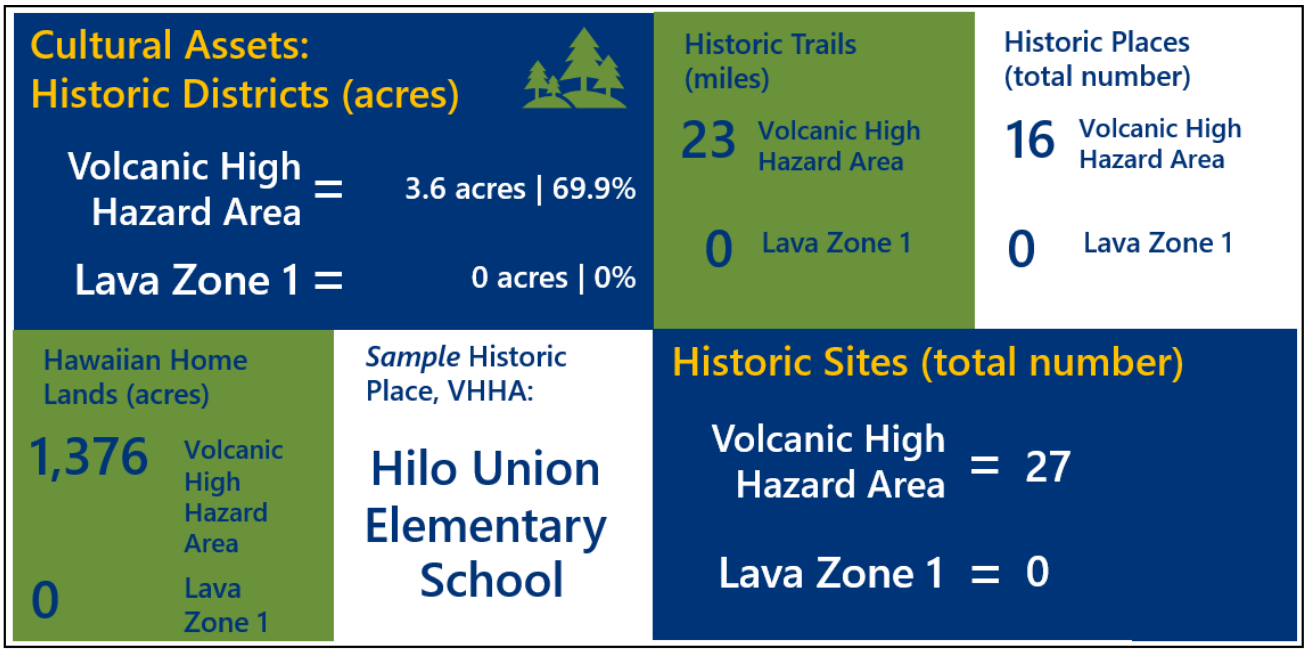
In addition to lava flow, other volcanic hazards may also impact environmental resources. In 2010, Donald Thomas from the Center for the Study of Active Volcanoes, and Trisha Macomber from the University of Hawai'i's College of Tropical Agriculture produced a study on the effects of fluoride and sulfates on forage lands downwind of Kīlauea's Halema'uma'u Crater (Thomas and Macomber 2010). The study shows that forage samples contained fluoride and sulfate values higher than recommended by the World Health Organization. Additionally, the study indicates that although elevated concentrations of fluoride and sulfate do induce adverse health/nutritional effects on grazing animals, the elevated levels of these compounds do not impact the quality of meat from those animals that would be used for public consumption.

The general effects of sulfur dioxide exposure to plants varies between plant species, age, and the sulfur dioxide dosage. These effects may include:

- Reduced seed germination
- Enhanced susceptibility to other diseases
- Foliar necrosis (spots, blight)
- Epicuticular wax erosion
- Rupture of epidermis, plasmolysis
- Reduced chlorophyll content
- Increased membrane permeability of plant leaves
- Decreased plant growth (root length, shoot length, leaf numbers)
- Plant organ or entire plant death

During Kīlauea's 2018 eruption, farmers growing food crops, foliage crops, and cut flowers downwind of Kīlauea experienced immediate and severe losses due to damage arising from exposure to high concentrations of sulfur dioxide and sulfuric acid aerosols. Although downwind ranches did not experience immediate impacts, over time, they found that horses, cattle, and goats have developed serious adverse health impairment consistent with chronic fluoride exposure as well as severe mineral deficiencies. In the event of significant increases in the discharge rate from future Kīlauea or Mauna Loa (with ten or more times the gas production rate of Kīlauea) eruptions, the impacts from the gas could be expected to increase proportionally.

4.3.7 CULTURAL ASSETS



Note: All percentages are relative to the Hilo District

Figure 4-66. Hilo Cultural Assets Located in the Volcanic High Hazard Area and Lava Zone 1

Hilo is home to many formally designated and locally recognized cultural assets, historic places, and sites that are important because they help to shape the identity of the place and the people of Hilo, as well as the County. A location-based database of culturally significant sites to Native Hawaiians was not available for use in this risk assessment; disclosure of the location of sacred and otherwise culturally significant sites is prohibited, in some instances, by federal law. To align with the County General Plan update, Hawaiian Home Lands, historic sites and trails were used for this analysis.

Cultural assets are considered non-renewable resources. Lava flows can isolate or cover cultural sites and native land. In Hilo, a total of 1,376 acres of Hawaiian Home Lands (10% of Hilo's total Hawaiian Home Lands), 16 historic places (47.1%), 27 historic sites (23.9%) and 23 miles (51.2%) of historic trail are located in the Volcanic High Hazard Area (***see Table 4-45***).

It is important to note that many of the cultural assets are located along the coast and overlap with other hazard areas including tsunami, flood, and high landslide risk areas (see ***Figure 4-67***).

Table 4-45. Hilo Cultural Resources by Volcanic Hazard Area

Hazard Area	Hawaiian Home Lands *(acres / %)*	Historic Districts *(acres / %)*	Historic Places *(number / %)*	Historic Sites *(number / %)*	Historic Trail *(miles / %)*
Volcanic High Hazard Area (VHHA)	1,376 / 10%	3.6 / 69.9%	16 / 47.1%	27 / 23.9%	23 / 51.2%
VHHA with Additional Natural High Hazard Area	1,363 / 99.1%	4 / 100%	16 / 47.1%	25 / 92.6%	0 / 0%
Lava Zone 1	0 / 0%	0 / 0%	0 / 0%	0 / 0%	0 / 0%
Lava Zone 2	0 / 0%	0 / 0%	0 / 0%	0 / 0%	16 / 35.3%

Note: Acres and total numbers of cultural resources in each hazard area were calculated separately as distinct and separate areas; therefore, individual hazard area totals do not equate to the VHHA total.

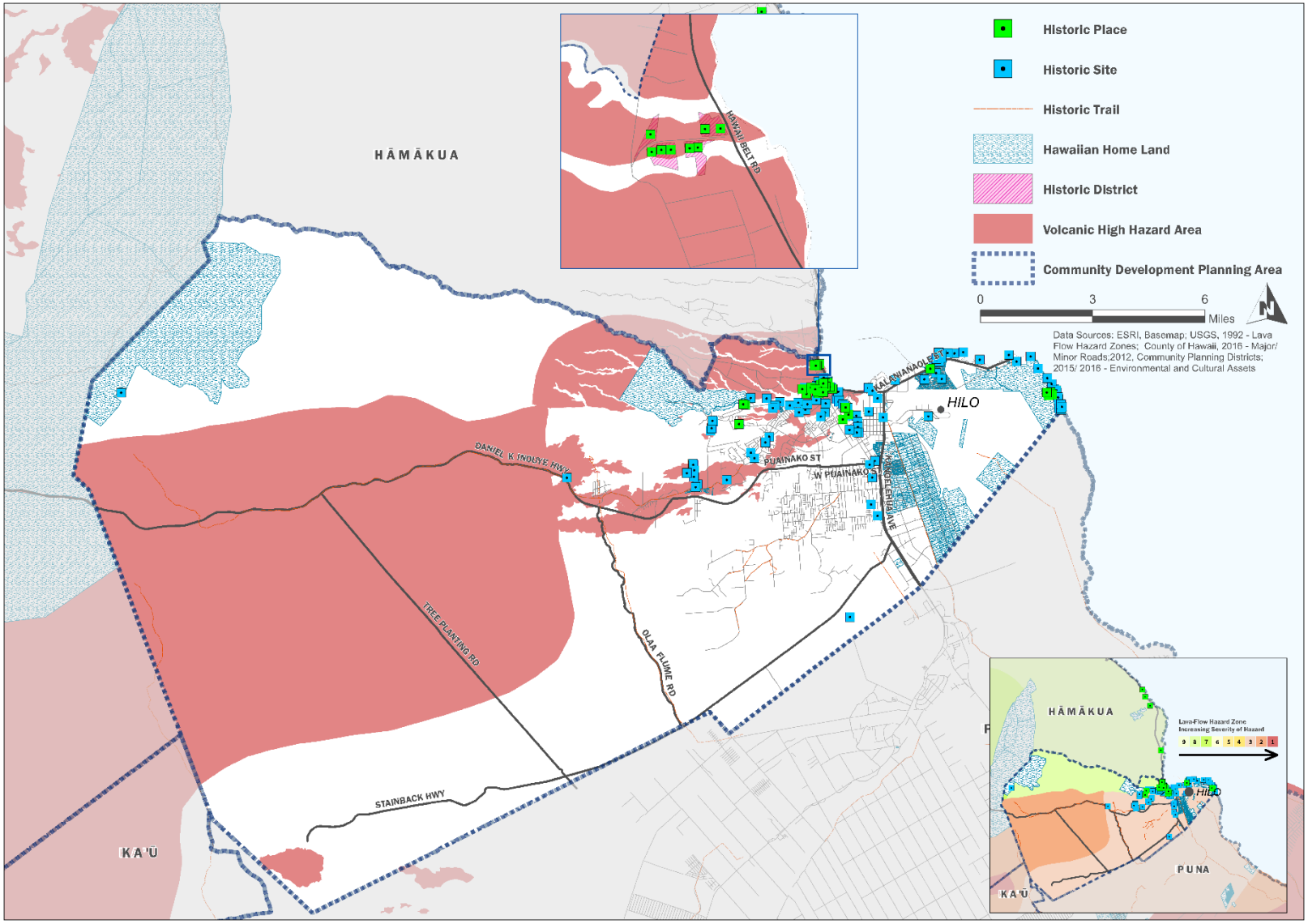


Figure 4-67. Cultural Assets in Hilo and Volcanic Hazards