



SECTION 4. RISK ASSESSMENT

4.7 Event-Based Flood

2018 HMP UPDATE CHANGES

- ❖ The flood hazard profile is divided into several separate hazards. This profile explains the event-based flooding hazard in the State of Hawai'i and includes event-based coastal and inland flooding.
- ❖ The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, and probability of future occurrence (including climate change).
- ❖ Flood events that occurred in the State of Hawai'i from January 1, 2012, through December 31, 2017, were researched for this 2018 HMP Update. Due to the severity of recent events, the April 2018 event is discussed; however, details regarding monetized impacts are not available at the time of this plan update.
- ❖ New and updated figures from federal and state agencies are incorporated.
- ❖ The 1% annual chance flood or special flood hazard area (SFHA) served as the basis for the exposure analysis for State assets, critical facilities, population, general building stock, environmental resources and cultural assets.
- ❖ Hazus was used to generate estimated potential losses for State buildings, critical facilities and general building stock located in the special flood hazard area.

4.7.1 Hazard Profile

The State of Hawai'i is a mountainous tropical archipelago, making floods a frequent occurrence (National Science Foundation 2018). Flooding in the state is caused by numerous sources, including: rainfall from storms, storm surge, tsunamis, dam failures, and tidal flooding. Event-based flooding as defined in the 2018 HMP Update includes coastal flooding and rainfall flooding in the special flood hazard area, which is the 1% annual chance flood depicted on counties' Flood Insurance Rate Maps (FIRM). Flooding caused by dam failure is discussed in Section 4.3 (Dam Failure); passive inundation, annual high waves, coastal erosion, and tidal flooding/King tides are discussed in Section 4.2 (Chronic Coastal Flood); storm surge is discussed in Section 4.10 (Hurricane); and chronic coastal flooding from sea level rise is discussed in Section 4.1 (Climate Change and Sea Level Rise).

Summary of Key Terms

Event-Based Flood – The 1% annual chance flood as depicted on the FEMA Flood Insurance Rate Maps, also known as the Special Flood Hazard Area (inclusive of V- and A-zones).

A-Zones – Special flood hazard areas that are not subject to wave heights of 3 feet or greater; includes A-, AE-, AO-, and AH-zones.

LiMWA – The inland limit of the area expected to receive 1.5-foot or greater breaking waves during the 1% annual chance flood event.

V-Zones – Areas subject to coastal flooding with velocity hazard (wave action of 3 feet or greater); includes V- and VE-zones.



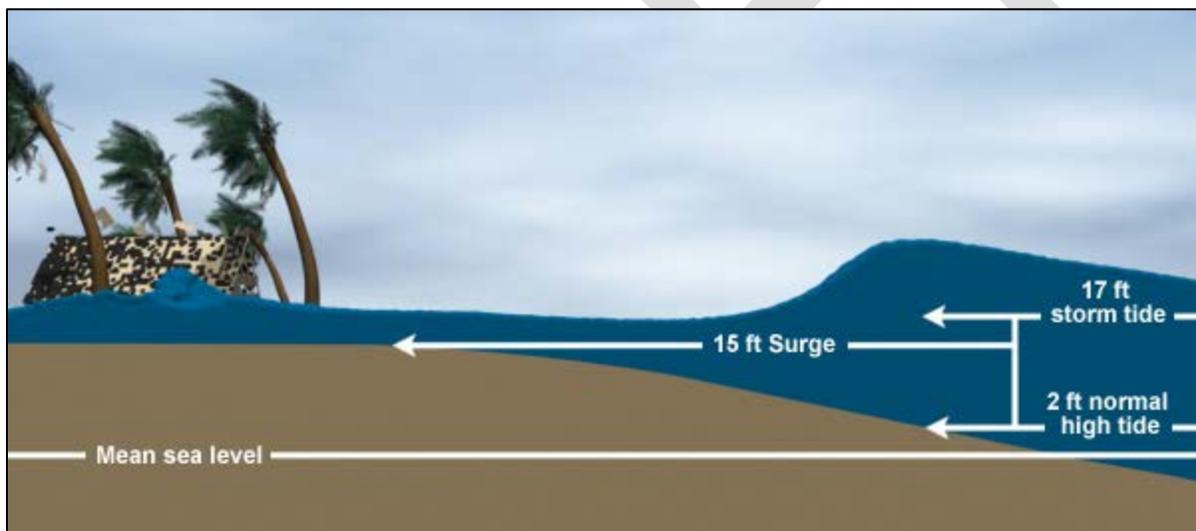
HAZARD DESCRIPTION

Event-based floods are the result of storms that cause temporary inundation of land from excessive rainfall or wave action. Flooding also occurs as a result of other event-types such as storm events which are discussed in other sections of the risk assessment. For the purposes of the 2018 HMP Update, event-based flood include both coastal and inland flooding as depicted on Flood Insurance Rate Maps (FIRMs).

Event-Based Coastal Flooding

Coastal flooding in the State of Hawai'i generally occurs along the coasts of oceans, bays, and estuaries and is caused by seawater over and above normal tide action as a result of the storm surge (see Figure 4.7-1.) Hurricanes and severe storms cause most coastal flooding (National Hurricane Center [NHC] 2018a; NHC 2018b). During these events, high winds and surf can push water several feet and even hundreds of yards inland. Conditions can be exacerbated by large waves that form on top of rising water (Hawai'i State HMP 2013). Event-based coastal flooding is limited to discussion of such flooding from a 1% annual chance storm. Refer to Section 4.10 (Hurricanes) for additional discussion on hurricanes and storm surge from less frequent and more severe events.

Figure 4.7-1. Storm Surge



Source: National Hurricane Center 2018

Inland Flooding

Inland flooding is a general term used to describe non-coastal flooding. In the State Hawai'i, inland flooding is caused by rainfall events, which cause three types of inland flooding:

- Channel overflow— Channel overflow occurs when the carrying capacity of the channel is exceeded, which can be exacerbated by development changes within the drainage basin or clogging by debris or overgrown streambed vegetation. Channels are defined, ground features that carry water through and out of a watershed. They may be called rivers, creeks, streams, or ditches (FEMA 2008). Flooding from channel overflow is sometimes referred to as riverine flooding.



- Overland sheet flow—Overland sheet flow occurs primarily in areas with undefined drainage ways and flood waters simply flow over land.
- Ponding of standing water in poorly drained low-lying areas—Poorly drained low-lying areas are a problem when flooding occurs even when rainfall is not heavy (Hawai'i State HMP 2013). Such drainage issues can be naturally occurring or human-caused. When human-caused such flooding is sometimes referred to as urban flooding.

LOCATION

The Federal Emergency Management Agency (FEMA) conducts flood studies that use historical records to determine the probability of occurrence for different flood levels in a community. Flood Insurance Rate Maps (FIRMs) show the location of these flood hazard areas. This mapping reflects risk from both coastal and major inland flooding, but does not generally reflect risk from urban flooding as it has been defined in the 2018 HMP Update. There is no statewide system for mapping risk from urban flooding. As a result, the location, extent, and vulnerability of the event-based flood hazard is analyzed using the special flood hazard areas (SFHA) depicted on each county's FIRM, which shows flood zones for rainfall flooding, coastal flooding, shallow flooding, and distinguishes areas where detailed studies have been conducted to determine flood elevations.

The special flood hazard area serves as the regulatory boundary in which each county's flood damage prevention ordinance is enforced. The flood damage prevention ordinance requires that development in the community's special flood hazard areas meet certain standards to reduce damage from flooding, such as being elevated above the base flood elevation. The SFHA shows the horizontal extent of a flood that has a 1% chance of being equaled or exceeded in any given year (e.g. a 1% annual chance flood), while the base flood elevation shows the vertical height of flooding from a 1% annual chance flood at any given location within the SFHA.

It should be noted that the source of flooding used to determine base flood elevations within the SFHA for each county may include a combination of tsunami inundation, freshwater flooding from rain events, and storm surge as FIRMs differentiate flood zones based on flooding characteristics with a 1% annual chance of occurrence and do not differentiate based on flood source (e.g. tsunami, hurricane). Refer to the individual county's Flood Insurance Study for details on the hydrologic analyses performed.

Table 4.7-1 displays the total area of each county that is located in the SFHA. Approximately 1.4% of the entire state is located within the mapped SFHA. The City and County of Honolulu has the largest SFHA area, with 4.6% of its land located in the SFHA. Figure 4.7-2 through Figure 4.7-5 illustrate the SFHAs throughout the State of Hawai'i.

Table 4.7-1. Area Located in the Special Flood Hazard Area by County

County	Area (square miles)		
	Total Area	SFHA	SFHA as Percent (%) of Total Area
County of Kaua'i	620.0	20.4	3.3%
City and County of Honolulu	600.7	27.8	4.6%
County of Maui	1,173.5	22.8	1.9%
County of Hawai'i	4,028.4	20.8	0.5%
Total	6,422.6	91.8	1.4%

Source: FEMA National Flood Hazard Layer 2017; State of Hawai'i GIS layer Trust Land, State of Hawai'i GIS Program Geospatial Data Portal 2017

Notes: GIS Geographic Information System SFHA Special Flood Hazard Area



Figure 4.7-2. Special Flood Hazard Areas in the County of Kaua'i

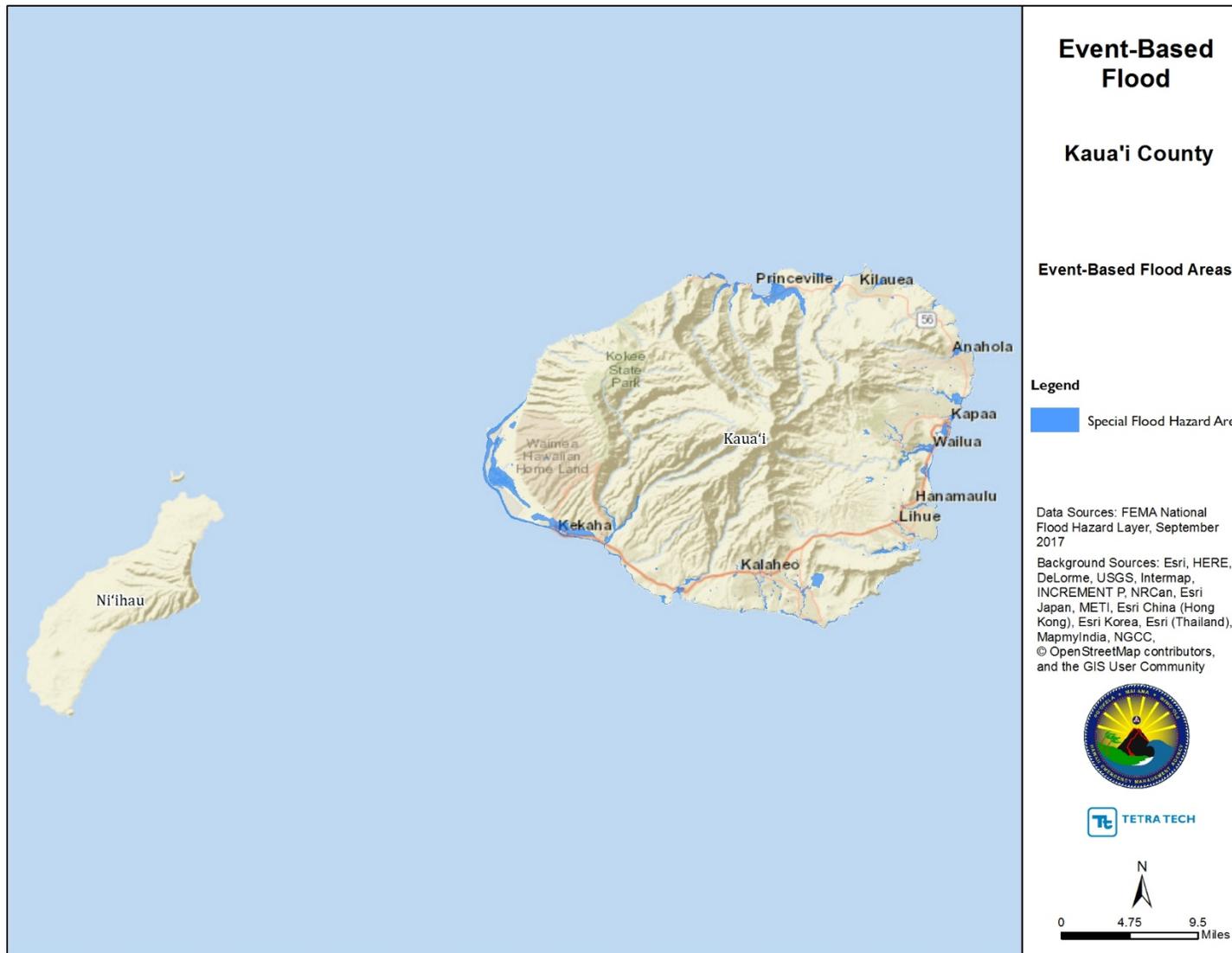




Figure 4.7-3. Special Flood Hazard Areas in the City and County of Honolulu





Figure 4.7-4. Special Flood Hazard Areas in the County of Maui

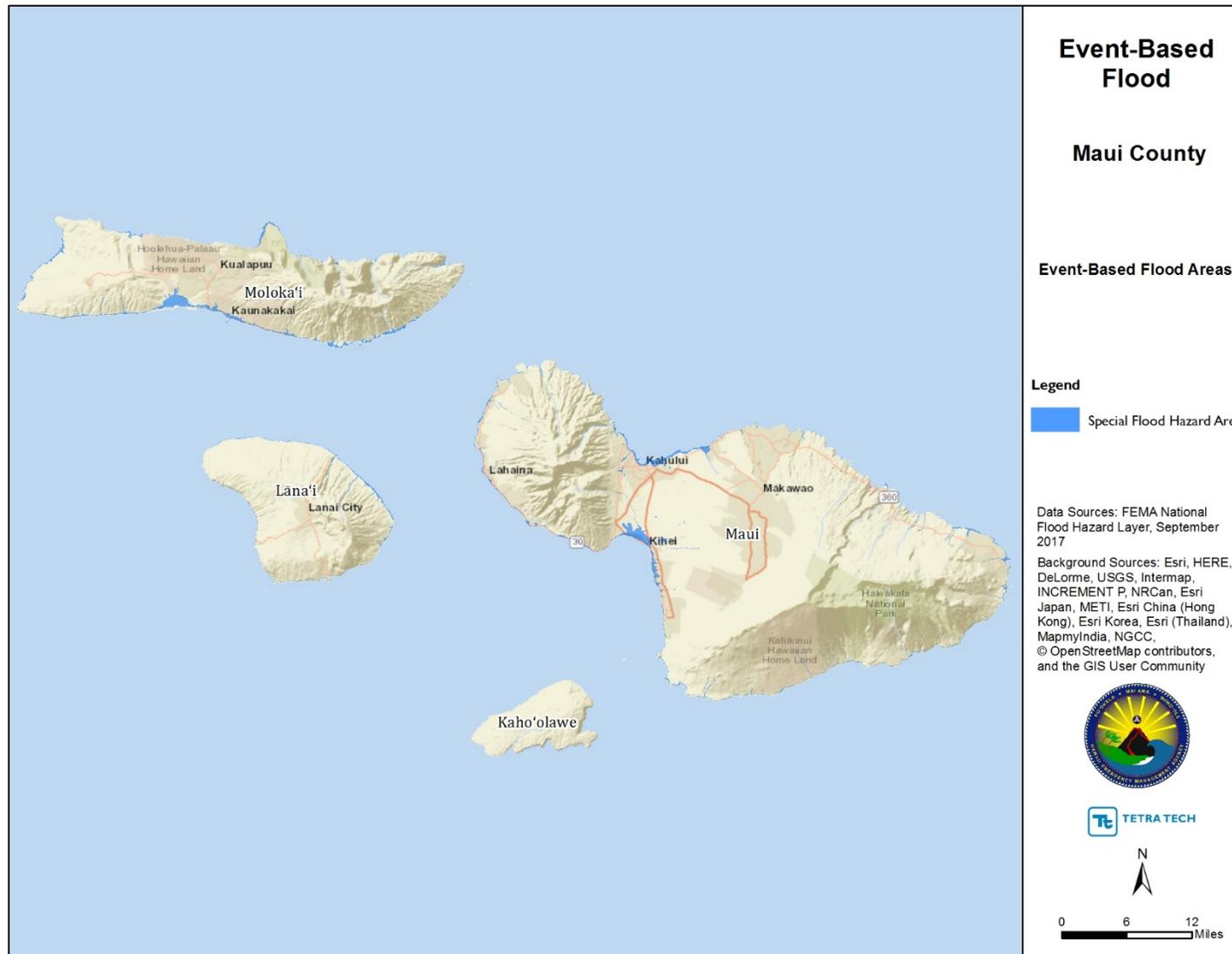
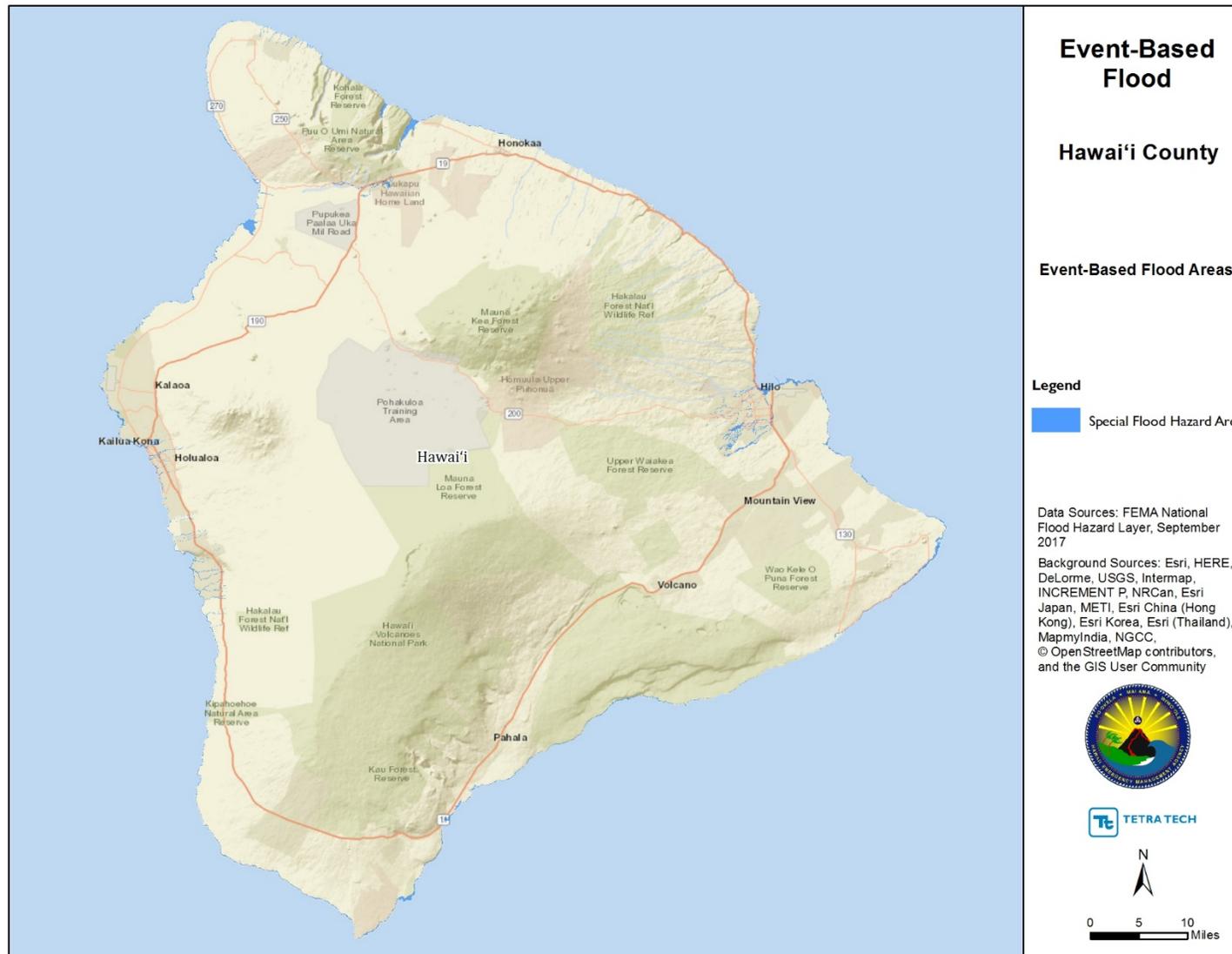




Figure 4.7-5. Special Flood Hazard Areas in the County of Hawai'i





EXTENT

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. The special flood hazard area on a community's FIRM is divided into different zones generally referred to as A-zones and V-zones. These zones represent characteristics of flooding pertaining largely to depth and velocity.

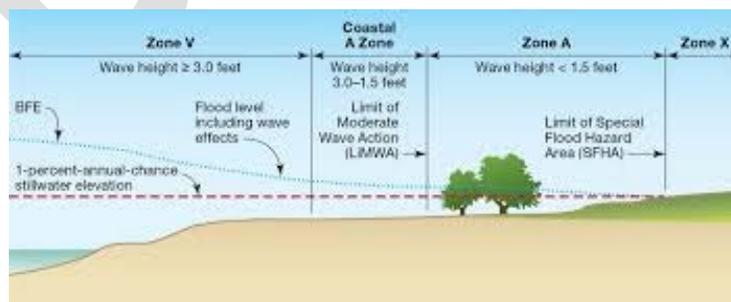
Event-Based Coastal Flooding

Flood severity from coastal flooding is generally determined by wave runup and setup. The degree of damage caused depends on the tidal cycle occurring at the time of the event. During high tides, water levels can be significantly higher than low tide and can inundate further inland causing more extensive damage. The area of impact of storm surge floods is confined to regions along the immediate coastlines and typically extends to a few hundred feet inland (Hawai'i State HMP 2013).

On each county's FIRM, areas that have a 1% annual chance of experiencing wave heights of 3 feet or greater are shown as V-zones. These areas have been traditionally known as coastal high hazard areas and there are stringent requirements in place to ensure that buildings constructed in these areas can withstand the velocities associated with this degree of wave action. Recent studies conducted after large scale flood events, such as following Hurricane Katrina, have shown that wave heights as small as 1.5 feet can cause considerable damage to structures and other development. This means that V-zones depicted on FIRMs do not include all areas with a 1% annual chance of experiencing wave action velocities significant enough to cause serious structural damage. Some A-zones, commonly referred to as Coastal A-zones, may also be subject to these velocities. Requirements to withstand these wave impacts are not part of required building codes in the Coastal A-zones.

Because of this new information on structure vulnerability, FEMA now delineates an area known as the Limit of Moderate Wave Action (LiMWA) that can be shown on a FIRM when the Flood Insurance Study that provides the basis for the FIRM is updated. The LiMWA generally bisects an A-zone, which shows areas that have a 1% annual chance of flooding and less than 3 feet of expected wave heights. Areas seaward of the LiMWA may experience wave heights of 1.5 feet or greater. Areas landward of the LiMWA may still be flooded by ocean waves or other sources; however, the height of waves will be less than 1.5 feet in a 1% annual chance storm (see Figure 4.7-6). At the time of the 2018 HMP Update, none of the county's FIRMs show the LiMWA.

Figure 4.7-6. Coastal Flooding on Flood Insurance Rate Maps



Source: FEMA, 2015



Inland Flooding

Factors influencing inland flooding conditions include rainfall intensity and duration; rain shed area, topography and steepness, soil type, soil moisture before an event, and ground cover (State of Hawai'i HMP 2013). The frequency and severity of inland flooding that occurs along a stream or river is measured using a discharge probability, which is the probability that a certain discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels, which are then used to determine the extent of flooding. Inland flooding that has a 1% annual chance of exceedance is shown on FIRMs as A-zones. Because the county FIRMs do not show LiMWAs as described above, there is no simple way to differentiate between coastal and riverine A-zones besides making an educated guess based on location.

In the case of flooding along a river or stream, once a river reaches flood stage, the flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category has a definition based on property damage and public threat:

- **Minor Flooding**—minimal or no property damage, but possibly some public threat or inconvenience.
- **Moderate Flooding**—some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- **Major Flooding**—extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations (NWS 2011).

Prolonged rainfall may result in an accumulation of water creating flooding conditions that last several days, or even weeks. Alternatively, flooding can occur very quickly in instances of high rainfall intensity. When flooding emerges quickly over a matter of hours, it is known as flash flooding. Flash floods are characterized by rapid rise in water level, high velocity, large amounts of debris, and concentration in stream beds that are often normally small or even dry (Hawai'i State HMP 2013).

Warning Time

It is unusual for a flood to occur without warning. Warning time for floods are typically between 24 and 48 hours. Flood warnings and watches are issued by the local NWS office. The NWS will update the watches and warnings and will notify the public when they are no longer in effect. Watches and warnings for flooding in the State of Hawai'i are as follows (NWS 2016).

The NWS issues coastal flood advisories, warnings, and watches:

- **Coastal Flood Advisory** is issued when minor or nuisance coastal flooding is occurring or imminent.

Figure 4.7-7. Flooding in Kona Area in the County of Hawai'i



Source: West Hawai'i Today 2015



- **Coastal Flood Watch** is issued when moderate to major coastal flooding is possible. Such flooding could potentially pose a serious risk to life and property.
- **Coastal Flood Warning** is issued when moderate to major coastal flooding is occurring or imminent. This flooding will pose a serious risk to life and property.

The NWS issues inland flood advisories, watches, and warnings:

- **Flood Advisory**—A Flood Advisory means nuisance flooding is occurring or imminent. A Flood Advisory may be upgraded to a Flash Flood Warning if flooding worsens and poses a threat to life and property
- **Flash Flood Watch**—A Flash Flood Watch means heavy rain leading to flash flooding is possible. People in the area of a flash flood watch should be prepared for heavy rains and potential flooding. Flash Flood Watches may be issued up to 12 hours before flash flooding is expected.
- **Flash Flood Warning**—A Flash Flood Warning means that flooding is occurring or will develop quickly. If a Flash Flood Warning is issued for an area, the population needs to take shelter and/or move to high ground as necessary. Never drive or walk across a flooded roadway.

Duration of a flood event means the time between the start and end of the flood or the event that caused the flood. This can be difficult to define for floods, particularly inland floods, as they recede slowly and do not vanish completely; flood water moves from one area to another (M&E Studies 2018). Additionally, the duration of a flood depends on the type of flood. Flash flooding occurs within six hours of a rain event, while other types of flooding are a longer-term event and may last a week or more (NWS 2018).

Flood Control Structures

Flood control structures can significantly alter the extent of flooding in an area. Major flood control structures in the State include dams and levees. For details regarding dams, refer to Section 4.3 (Dam Failure). The following provides information regarding levees located in the State.

Levees are usually earthen embankments or concrete floodwalls, which have been designed and constructed to contain, control, or divert the flow of water to reduce the risk of temporary flooding. Vertical concrete floodwalls may be erected in urban areas where there is insufficient land for an earthen levee. They are designed to provide a specific level of protection and can be overtopped in larger flood events. Levees require regular maintenance to retain their level of protection. Over time, levees decay and require maintenance. When levees fail or overtop, they can cause catastrophic impacts and lead to major flooding and impacts. Areas protected from flooding by levees certified to the 1% annual chance event are not located in special flood hazard areas.

According to the U.S. Army Corps of Engineers (USACE), there are 25 levees (12 federal flood control projects and 13 non-federal flood control projects) in the State that are approximately 13 miles in total length. These 13 miles are located across the State with: 2.3 miles in the County of Hawai'i, 3.8 miles in the City and County of Honolulu, 2.7 miles in the County of Kaua'i, and 4.1 miles in the County of Maui. Of the 25 levees, 12 have an inspection rating of minimally acceptable, 9 are unacceptable, and 4 are unknown. For more detailed information on these levees, please refer to the Flood Insurance Studies for each county.



Table 4.7-2. Levees in the State of Hawai'i

County	System Name (and Acronym)	Length (in miles)	Construction Date	Date of Last Inspection	Inspection Rating
Kaua'i	Waimea River—RB, All Levees (WRR1)	1.44	January 1, 1950	July 17, 2012	Minimally Acceptable
Kaua'i	Hanapēpē Stream—RB Levee (HRRB)	0.85	January 11, 1966	May 24, 2011	Unacceptable
Kaua'i	Hanapēpē Stream—LB Levee (HRLB)	0.41	January 11, 1966	May 24, 2011	Unacceptable
Honolulu	Waimalu Stream—NF Debris Basin and Channel (WSNB)	0.54	Unknown	Unknown	Unknown
Honolulu	Kalauao Stream—RB (NOKA)	0.2	April 12, 1966	Unknown	Unknown
Honolulu	Kuli'ou'ou Stream—RB & Channel (KIBR)	0.83	January 2, 1970	November 1, 2011	Minimally Acceptable
Honolulu	Kuli'ou'ou Stream—LB & Channel (KIBL)	0.26	January 2, 1970	November 1, 2011	Minimally Acceptable
Honolulu	Kawainui Marsh—6850 If Levee, Floodwall and Oneawa Channel (KMFL)	1.5	January 8, 1966	February 21, 2012	Unacceptable
Honolulu	Kahawainui Stream—RB Levee (KSLR)	0.5	January 1, 1990	August 10, 2010	Unacceptable
Maui	Īao Stream—Channel at Bottom and LB (ISAL)	0.28	January 10, 1981	Unknown	Unknown
Maui	Kaunakakai Stream—RB Levee (KSRB)	0.21	January 1, 1950	April 11, 2012	Minimally Acceptable
Maui	Kaunakakai Stream—LB Levee (KSUL)	0.72	January 1, 1950	April 11, 2012	Minimally Acceptable
Maui	Kahoma Stream—RB, Channel and Levee (KORB)	0.09	January 4, 1990	June 11, 2011	Minimally Acceptable
Maui	Kahoma Stream—LB, Channel and Levee (KOLB)	0.3	January 4, 1990	June 11, 2011	Minimally Acceptable
Maui	Īao Stream—Levee I, H, Channel at Bottom—LB (ISIL)	0.76	January 10, 1981	September 22, 2011	Unacceptable
Maui	Īao Stream—Levee G, LB (ISLG)	0.27	January 10, 1981	September 22, 2011	Unacceptable
Maui	Īao Stream—Levee F, LB (ISLF)	0.2	January 10, 1981	September 22, 2011	Unacceptable
Maui	Īao Stream—Levee A, B, C, D, E, H, I, Channel and Rev X, RB (ISLE)	1.31	January 10, 1981	September 22, 2011	Unacceptable
Hawai'i	Keōpū Drainageway*	0.11	Unknown	Unknown	Unknown
Hawai'i	Wailoa Stream RB—Diversion Levee 1, 2, 3, 4 & Channel (WSRB)	0.99	January 8, 1965	October 30, 2012	Minimally Acceptable
Hawai'i	Wailoa Stream LB (WALB)	0.23	January 8, 1965	October 30, 2012	Minimally Acceptable
Hawai'i	Wailoa Stream—Diversion Levee LB 5 (WSL5)	0.07	January 8, 1965	October 30, 2014	Minimally Acceptable
Hawai'i	Pā'au'au Stream—All (PALV)	0.4	January 10, 1984	August 28, 2013	Minimally Acceptable
Hawai'i	Alenaio Stream LB—Levee, Floodwall C & Lined Channel (ASFC)	0.32	January 11, 1997	August 26, 2013	Minimally Acceptable
Hawai'i	Alenaio Stream—Floodwall A, B—RB & Lined Channel (ASFA)	0.20	January 11, 1997	August 26, 2013	Unacceptable



Source: USACE 2018

Note: The length, construction date, date of last inspection, and inspection rating is for levee structure.

- N/A Not Applicable
- * Inactive levee
- LB Left Bank
- LF Linear feet
- RB Right Bank

PREVIOUS OCCURRENCES AND LOSSES

Many sources provided flooding information regarding previous occurrences and losses associated with flooding events throughout the State of Hawai'i. The 2013 HMP discussed specific flooding events that occurred in the State of Hawai'i through 2012. For this 2018 HMP Update, event-based flood events were summarized between January 1, 2012, and December 31, 2017. However, due to the heavy rains and flooding that caused damages and losses to areas in the City and County of Honolulu and the County of Kaua'i during the time of the 2018 HMP Update, this event was included.

Table 4.7-3 includes details of major flooding events that occurred in the State between 2012 and 2017, with the addition of the April 2018 flood event. These events do not include tropical storms or hurricanes that may also cause flooding; refer to Section 4.11 (Hurricane) for a listing of these events. Major events include those that resulted in losses or fatalities, as reported by the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI), events that resulted in the activation of the State and/or County Emergency Operations Center (EOC), and/or events that led to a FEMA disaster declaration. For events prior to 2012, please refer to Appendix X.

According to the NOAA NCEI storm events database, the State of Hawai'i experienced 170 flooding events between 2012 and 2017. Total property or crop damage was not estimated. However, it was reported these events led to five fatalities. These events included flash floods and floods.



Table 4.7-3. Event-Based Flood Events in the State of Hawai'i, 2012 to 2017

Date(s) of Event	Event Type and Federal Disaster Declaration (if applicable)	Counties Affected	Description
January 17, 2012	Heavy Rain and Flash Flooding	Kaua'i and Hawai'i	Heavy showers fell over the Counties of Hawai'i and Kaua'i. The rain was intense enough in the County of Kaua'i to cause flash flooding. In Princeville (Kaua'i), the Kūhiō Highway was closed at the Hanalei Bridge due to flooding in the area of the Hanalei River. In Kapa'a, there were road closures due to flooding of Keālia Stream. A flash flood warning was issued for the County of Kaua'i, which led to the activation of County's EOC.
February 26, 2012	Flash Flood Warning	Kaua'i and Honolulu	Surface and upper troughs generated heavy rain across the City and County of Honolulu, as well as the County of Kaua'i, with flash flooding occurring over northern parts of Kaua'i. In the County of Kaua'i, Kūhiō Highway was closed at the Hanalei Bridge due to flooding. In Kōloa, Weliweli Road, Hapa Road and Ala Kinoki were closed due to flooding. A flash flood warning was issued for the County of Kaua'i which led the partial activation of the County's EOC.
March 3 to 11, 2012	Severe Weather, Flooding and Tornado (FEMA-DR-4062)	Kaua'i, Honolulu, and Maui	On March 3 and 4, an upper trough in the vicinity of the Hawaiian Islands brought heavy rain and flash flooding to the County of Kaua'i and the City and County of Honolulu. Numerous roads and bridges were closed throughout the impacted counties due to flooding. The City and County of Honolulu EOC was activated. This event resulted in a FEMA declaration for the counties of Kaua'i and Maui. A total of \$3.6 million in public assistance was approved for the impacted counties.
December 19, 2012	Heavy Rain and Flash Flooding	Hawai'i	Heavy showers fell over the windward side of the County of Hawai'i near Pāpa'aloa. A motorist tried to cross the swollen Pāhale Stream but was swept away by the current; the motorist died.
January 26 to 27, 2013	Severe Weather and Flooding	Kaua'i, Honolulu, and Maui	A winter storm triggered heavy rain and flash flooding over the Hawaiian Islands from the County of Kaua'i and the City and County of Honolulu, to the County of Maui. Roadway and property flooding was reported in the impacted counties. The EOCs for these the counties of Kaua'i, Honolulu, and Maui were activated as a result of this event.
February 21, 2013	Severe Weather and Flooding	Kaua'i, Honolulu, Maui, and Hawai'i	Heavy rain brought flash flooding, mainly to the County of Maui. In the County of Kaua'i, approximately 50 hikers were stranded on the Nā Pali Coast on Kaua'i. One hiker died when swept away into the swollen Hanakāpi'ai Stream. Numerous roads were closed due to flooding throughout the area. The County of Kaua'i activated its EOC. In the County of Honolulu, heavy rain was observed. In the County of Maui, flash flooding was reported which resulted in road closures. In the County of Hawai'i, heavy rain was observed.
March 26 to 27, 2013	Severe Weather and Flooding	Kaua'i	A strong upper trough brought heavy rain to the County of Kaua'i, causing flash floods. Many roads were closed throughout due to flooding. Emergency managers reported that 12 hikers were airlifted out of Hanakāpi'ai because they could not pass Hanakāpi'ai Stream due to rising waters. The County of Kaua'i activated its EOC.
April 4, 2013	Severe Weather and Flooding	Kaua'i, Honolulu	The County of Kaua'i and the City and County of Honolulu EOCs were activated.



Date(s) of Event	Event Type and Federal Disaster Declaration (if applicable)	Counties Affected	Description
May 4 to 5, 2013	Flood	Hawai'i	Heavy rain produced small stream and drainage ditch flooding, and ponding on roadways near Hawi, Waikoloa Village, Māhukona, and Kawahae in the County of Hawai'i. The County of Hawai'i EOC was activated as a result of this event.
May 18, 2013	Flood	Hawai'i	Heavy rain fell over the County of Hawai'i. The precipitation led to small stream and drainage ditch flooding and ponding on roadways. Heavy rain led to the activation of the County of Hawai'i EOC.
May 28 to 29, 2013	Flood	Kaua'i, Honolulu, Maui, and Hawai'i	A surface trough and upper low brought heavy rain to the State of Hawai'i. The showers caused ponding on roadways and small stream and drainage ditch flooding. On May 28, in the City and County of Honolulu, the rainfall was intense enough to overflow the banks of the Kalihi Stream due to clogged culverts. Four people were caught in the swollen stream but were able to make it to safety. The City and County of Honolulu EOC was activated as a result of this event.
September 30 to October 1, 2013	Severe Weather and Flooding	Kaua'i	An upper low just north of the State of Hawai'i induced heavy rain and thunderstorms over the County of Kaua'i. The rain caused ponding on roadways and small stream and drainage ditch flooding. The County of Kaua'i EOC was activated as a result of this event.
October 11, 2013	Severe Weather and Flooding	Kaua'i, Honolulu, and Maui	Heavy rain fell over the Counties of Kaua'i, Maui and the City and County of Honolulu. The City and County of Honolulu EOC was activated as a result of this event.
October 14, 2013	Severe Weather and Flooding	Kaua'i, Honolulu, Maui, and Hawai'i	An upper low moving over the State of Hawai'i produced heavy showers and thunderstorms, and the occasional funnel cloud and waterspout. There was small hail reported in central O'ahu. The rainfall led to small stream and drainage ditch flooding, minor debris flows, and ponding on roadways. The City and County of Honolulu EOC was activated as a result of this event.
October 27, 2013	Severe Weather and Flooding	Hawai'i and Maui	An upper trough produced heavy rain and thunderstorms over much of the State of Hawai'i. The rain caused ponding on roadways, small stream and drainage ditch flooding, and minor debris flows. The County of Maui EOC was activated as a result of this event.
November 9 to 10, 2013	Severe Weather and Flooding	Kaua'i, Honolulu, and Maui	An upper level low, north of the Hawaiian Islands, combined with a surface trough and shear line produced heavy rain and flash flooding over parts of the State of Hawai'i. In the County of Kaua'i, heavy rain caused the Hanalei River to overflow its banks along Kūhiō Highway. Homes flooded and roadways were inundated with water as a result of the heavy rains. The County of Kaua'i activated its EOC as a result of this event.
December 1, 2013	Severe Weather and Flooding	Kaua'i	An advancing cold front and upper trough brought heavy rain, thunderstorms, and flash flooding to portions of the County of Kaua'i, the Island of Moloka'i (located in the County of Maui), and the City and County of Honolulu. Multiple roadways were closed due to flooding. The County of Kaua'i activated its EOC as a result of this event.
December 30, 2013	Severe Weather and Flooding	Hawai'i	Heavy rain and thunderstorms impacted a large portion of the County of Hawai'i. There were reports of flash flooding, hail and microbursts. Roads were closed throughout the county due to flooding. Several roadways washed out. The County of Hawai'i activated its EOC as a result of this event.



Date(s) of Event	Event Type and Federal Disaster Declaration (if applicable)	Counties Affected	Description
January 11 to 12, 2014	Severe Weather and Flooding	Honolulu, Maui, and Hawai'i	Heavy downpours and isolated thunderstorms impacted parts of the State of Hawai'i (counties of Honolulu, Maui, and Hawai'i). Ponding on roadways, and small stream and drainage ditch flooding occurred in several areas. The County of Maui EOC activated.
February 16, 2014	Severe Weather and Flooding	Kaua'i	A surface low and upper trough west of the Hawaiian Islands caused instability over the western parts of the State of Hawai'i. Heavy rain and flash flooding occurred over the County of Kaua'i. Roadways were closed due to flooding. The County of Kaua'i activated its EOC as a result of this event.
May 24 to 26, 2014	Heavy Rain and Flash Flooding	Kaua'i and Honolulu	The combination of abundant low-level moisture and an upper trough northwest of the State of Hawai'i generated heavy showers and isolated thunderstorms across the County of Kaua'i and the City and County of Honolulu. The heavy rain caused ponding on roadways, and small stream and drainage ditch flooding. The City and County of Honolulu EOC was activated as a result of this event.
July 19 to 20, 2014	Severe Weather and Flooding (remnants of Tropical Storm Wali)	Honolulu and Maui	An upper trough near the Hawaiian Islands acted on remnant moisture from former Tropical Storm Wali to generate heavy showers and thunderstorms. The rain was intense enough to produce flash flooding in windward parts of the Island O'ahu and in windward West Maui. Strong winds accompanied the precipitation, and blew down trees and damaged homes. Also, a man, snorkeling with a group, died when he succumbed to high waves that battered the area off the County of Maui on July 20. Flooding inundated roads in the impacted areas. The City and County of Honolulu activated its EOC as a result of this event.
July 22, 2015	Heavy Rain and Flash Flooding	Kaua'i	Heavy showers and isolated thunderstorms impacted the western portion of the State. The heavy rain led to flash flooding in the County of Kaua'i near Hanalei as the Hanalei River overflowed its banks and inundated Kūhiō Highway near Hanalei Bridge. The County of Kaua'i EOC was activated as a result of this event.
August 17, 2015	Flooding	Honolulu, Maui, and Hawai'i	Heavy showers and isolated thunderstorms developed over parts of the State of Hawai'i, causing small stream and drainage ditch flooding, ponding on roadways, and flash flooding. In the County of Hawai'i, 14 hikers were rescued by the fire department after the trail they were on was blocked by high water after flash flooding. Many roads were closed throughout the County of Hawai'i as a result of flooding. In the City and County of Honolulu, officials reported between 8 and 12 inches of water on the Kamehameha Highway near Waikane Valley Road in windward O'ahu. In the County of Maui, water over the road forced the closure of Pi'ilani Highway at Mile Marker 29 in the Nu'u area. As a result of this event, the County of Maui and County of Hawai'i EOCs were activated.
August 25, 2015	Flash Flood and Severe Weather	Kaua'i and Maui	Heavy rain, thunderstorms and flash flooding impacts parts of the State. In the County of Maui, lower Honoapi'ilani Highway was flooded by excessive rainfall near Kahana and Honokōwai. The County of Kaua'i EOC was partially activated as a result of this event.
September 3, 2015	Flash Flood and Severe Weather	Honolulu	With a moist air mass over the islands, warm ocean temperatures, and low-level instability; heavy showers and thunderstorms brought flooding to parts of the State of Hawai'i (City and County of Honolulu). In the City and



Date(s) of Event	Event Type and Federal Disaster Declaration (if applicable)	Counties Affected	Description
			County of Honolulu, one foot of water flooded Liliha Street, Dillingham Boulevard, and North King Street in Honolulu. More flash flooding was reported at the intersection of Dillingham Boulevard and Alakawa Street. Liliha Street was closed in both directions from North King Street to Vineyard Boulevard because of excessive ponding on the roadway. In the Iwilei section of Honolulu, Dole Cannery and surrounding offices had to be evacuated due to flooding on the first floor, including rooms with electrical equipment. The City and County of Honolulu EOCs were activated as a result of this event.
September 11, 2015	Flash Flood and Severe Weather (remnants of Hurricane Jimena)	Honolulu	Another round of heavy rain and flooding developed over parts of the State of Hawai'i (City and County of Honolulu) as the remnants of former Hurricane Jimena passed north of the islands. Warm ocean temperatures and the added instability from the tropical disturbance helped generate deep convection over the area. In the City and County of Honolulu, Waikane Bridge along Kamehameha Highway was closed due to flooding from Waikane Stream in windward O'ahu. The City and County of Honolulu activated its EOC as a result of this event.
September 14, 2015	Heavy Rain and Flash Flooding	Hawai'i	High running water at Wailuku River's Boiling Pots in the County of Hawai'i resulted in one drowning fatality after the swimmer was pulled downstream.
November 20, 2015	Flash Flooding	Honolulu	An area of deep tropical moisture moving from the southeast brought heavy showers to most of the Hawaiian Islands, with a majority of impacts in the City and County of Honolulu. The rainfall was intense enough to cause flash flooding over a portion of windward O'ahu. Most of the showers, however, produced mainly small stream and drainage ditch flooding, and ponding on roadways. The City and County of Honolulu EOC was activated as a result of this event.
May 26, 2016	Flash Flooding and Landslide	Kaua'i and Honolulu	Heavy rain fell in the County of Kaua'i and the City and County of Honolulu. The City and County of Honolulu EOC was activated as a result of this event.
September 11 to 14, 2016	Severe Storms, Flooding, Landslides and Mudslides (FEMA-DR-4282)	Maui and Hawai'i	As a weak tropical disturbance with abundant low-level moisture moved through the Hawaiian Islands, an upper low moved in from the northwest. This combination generated heavy showers and thunderstorms, which then resulted in flash flooding over the County of Maui. In the County of Hawai'i, flash flooding was reported closing roadways in the Mountain View area of the county. Other parts of the State received heavy rainfall as well. Overall damages were estimated at \$15 million. On September 27, 2016, Governor Ige requested a major disaster declaration due to this event. On October 6, 2016, President Obama declared that a major disaster existed in the State of Hawai'i. The County of Maui was included in the declaration.
December 3, 2016	Heavy Rain and Flash Flooding	Statewide	An upper low and a separate upper trough produced heavy rain and showers, isolated thunderstorms, and flash flooding over much of the State. The system also produced snow in the upper elevations of the County of Hawai'i. A woman was swept away and killed during flash flooding on the County of Kaua'i during a kayak and hiking tour near the Wailua River.



Date(s) of Event	Event Type and Federal Disaster Declaration (if applicable)	Counties Affected	Description
January 21, 2017	Heavy Rain and Flash Flooding	Hawai'i	Strong wind and heavy rains impacted the County of Hawai'i, downing trees and power lines, causing power outages, and bringing flash flooding. A woman attempted to cross fast-moving water in Ahumoa but was swept away and died.
February 28 to March 1, 2017	Heavy Rain and Flash Flooding	Kaua'i, Honolulu, and Maui	Heavy showers and thunderstorms impacted parts of the State of Hawai'i, mainly the Counties of Kaua'i and Maui, and the City and County of Honolulu. Some of the rainfall led to flash flooding. In the City and County of Honolulu, an elementary school and church were damaged. Police closed Kamehameha Highway in the area because of deep water on the roadway. Waimea Valley Park and a home were also damaged due to flooding. The Counties of Maui and Kaua'i, and the City and County of Honolulu EOCs were partially activated as a result of this event.
March 7, 2017	Heavy Rain and Flooding	Maui	An upper trough near the Hawaiian Islands induced heavy downpours and thunderstorms over the County of Maui, particularly the leeward Haleakalā area. Intense rainfall inundated Kūlanihāko'i Gulch, which then led to South Kihei Road being flooded. Seven individuals trapped by the deluge had to be rescued by fire crews. The flood waters damaged several vehicles and condominiums. The storm system also produced heavy rain and thunderstorms over the County of Hawai'i and the City and County of Honolulu. In the County of Maui, several roads were closed due to flash flooding and individuals were evacuated from their homes. The County of Maui EOC was activated as a result of this event.
August 21, 2017	Flash Flood	Kaua'i and Maui	An upper trough brought heavy showers and thunderstorms over the Counties of Kaua'i and Hawai'i. Most of the rain caused ponding on roadways and small stream and drainage ditch flooding. In the County of Kaua'i, the rain caused flash flooding. The Kūhiō Highway in Hanalei (Kaua'i) became impassable, and county officials were forced to close the Hanalei Bridge. The County of Kaua'i and the County of Maui activated their EOCs as a result of this event.
October 23 to 24, 2017	Severe Weather and Flooding	Maui and Hawai'i	Periods of strong winds, heavy rain, thunderstorms, and flash flooding impacted the counties of Maui and Hawai'i. Lightning strikes led to power outages, and gusty winds downed trees and power lines. In the County of Maui, the strong winds led to island-wide power outages after lightning hit the electrical system. The storm downed trees and power lines in multiple areas; and flash flooding occurred as well. The County of Maui EOC was partially activated. In the County of Hawai'i, the storms brought strong winds, lightning strikes, and heavy rain. The County of Hawai'i EOC was fully activated.
October 31 to November 1, 2017	Severe Weather and Flooding	Kaua'i	Flooding conditions in the County of Kaua'i resulted in several road closures, including Kūhiō Highway in the vicinity of the Hanalei Bridge. County officials were warning motorists of ponding, low visibility, and other hazardous driving conditions. The County of Kaua'i EOC was partially activated as a result of this event.
November 11 to 12, 2017	Severe Weather and Flooding	Honolulu	Rainfall totals ranged from 3.74 inches to 4.37 inches. Multiple car accidents were reported due to water on the roadways. Water rescues were performed near the intersection of Waiālae Avenue and Koali Road, where two



Date(s) of Event	Event Type and Federal Disaster Declaration (if applicable)	Counties Affected	Description
			people were in need of assistance amid rain-swollen stream conditions. The City and County of Honolulu EOC was partially activated.
December 20, 2017	Flash Flood	Honolulu and Maui	Heavy rain, flash flooding, and isolated thunderstorms impacted the counties of Honolulu and Maui. In the City and County of Honolulu, the intersection at Pu'unēnē and Wakea Avenues near Christ the King Church were closed in all directions due to flooding. In the County of Maui, on Kahekili Highway in the area of Mile Marker 7, the road was impassable due to flooding.
December 26, 2017	Flash Flood	Honolulu	An area of showers formed over the County of Honolulu, becoming intense and isolated thunderstorms developed. The storm led to flash flooding conditions in the county; however, no significant injuries were reported. Water was flowing into stores at Market City between Kapiolani Boulevard and Kapahulu Avenue.
April 2018	Heavy Rains, Flooding, and Mud and Rock Slides	Kaua'i and Honolulu	<p>Heavy rains and flooding caused damages and losses to areas in the City and County of Honolulu and the County of Kaua'i. According to the NWS, 27.52 inches of rain fell in two days in the Town of Hanalei. In the County of Kaua'i, heavy rain caused extensive damage to the slopes adjacent to Kūhiō Highway and impacted the communities of Wainiha and Hā'ena. Multiple landslides led to the closure of the road. Numerous road closures reported in the impacted areas. Many homes were damaged or destroyed. American Red Cross conducted damage assessments and distributed clean up kits to residents in Aina Haina, Niu Valley, Kuli'ou'ou, Waimānalo, and Kailua. In the County of Kaua'i, the American Red Cross opened five shelters. Ten residents from Wainiha were airlifted to be taken to a shelter. Between April 13 and 19, the American Red Cross provided shelter to 110 individuals on the County of Kaua'i.</p> <p>Governor Ige declared the District of Hanalei in the County of Kaua'i a disaster area. This declaration provided relief for damage caused by the event. Details regarding monetized impacts are not available at the time of this 2018 HMP Update.</p>

Sources: FEMA 2017, NOAA-NCEI 2017, Storm Prediction Center 2017, State of Hawai'i 2017; State of Hawai'i Emergency Management Agency 2018

Notes: With flood documentation for the State of Hawai'i being so extensive, not all sources have been identified or researched. Additionally, loss and impact information for many events could vary depending on the source. Therefore, this table may not include all events that have occurred in the State and the accuracy of monetary figures discussed is based only on the available information identified during research for this 2018 HMP Update.

The State did experience flooding as a result of Tropical Storm Iselle (DR-4194); this is discussed further in Section 4.11 (Hurricane).

- EOC Emergency Operations Center
- FEMA Federal Emergency Management Agency
- HMP Hazard Mitigation Plan
- NCEI National Centers for Environmental Information
- NOAA National Oceanic and Atmospheric Administration
- NWS National Weather Service



FEMA Disaster Declarations

Between 1954 and 2018, FEMA included the State of Hawai‘i in 17 flood-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: flooding, heavy rains, high surf, mudslides, landslides, or severe storms. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2017).

Table 4.7-4 summarizes the flood-related FEMA disaster declarations between 2012 and 2018. This list does not include tropical storm or hurricane disaster declarations that may have resulted in flooding; refer to Section 4.11 (Hurricane) for a listing of these events. For details regarding all declared disasters, refer to Section 4.0 (Risk Assessment Overview). Refer to **Appendix X** which includes a figure that illustrates the number of flood-related FEMA-declared disasters by county.

Table 4.7-4. Flood-Related Federal Declarations (2012 to 2018)

Year	Event Type	Date Declared	Federal Designation	Counties Affected
2012	Severe Storms, Flooding and Landslides	April 18, 2012	DR-4062	Kaua‘i, Maui
2016	Severe Storms, Flooding, Landslides and Mudslides	October 6, 2016	DR-4282	Maui
2018	Severe Storms, Flooding, Landslides, and Mudslides	May 8, 2018	DR-4364	Honolulu and Kaua‘i

Source: FEMA 2018

Notes: FEMA Federal Emergency Management Agency
Tropical Storm Iselle (DR-4194) is in Section 4.11 (Hurricane).

Repetitive Loss Properties

Properties that are located within the SFHA and have federally backed mortgages or were constructed using federal or federally-related financial assistance are required to purchase flood insurance. When an insured property is damaged by flooding, they typically file a claim. If the insured property has had at least two paid flood losses of more than \$1,000 each in any 10-year period since 1978, they are referred to as a Repetitive Loss (RL) property. An insured property is known as a Severe Repetitive Loss (SRL) property if: (1) the insured property has had four or more paid flood losses of \$5,000 (amount of each claim) and a total amount of claims payments of \$20,000; or (2) the insured property filed at least two separate claims that have been paid with the cumulative amount of claim payments exceeding the fair market value of the insured building on the day before each loss (FEMA 2017).

PROBABILITY OF FUTURE HAZARD EVENTS

Flooding is common in the State of Hawai‘i and can take place any time of the year; however, flooding is more frequent during the rainy season which runs from October through April. Based on the history of flood events and the evidence of climate change and sea level rise, flood events may become more frequent throughout the State of Hawai‘i.

The recurrence interval of a flood, or flood frequency, is the average number of years between floods of a certain size. The actual number of years between floods of any given size varies because of the natural variations in



climate and weather events (USGS 2016). As discussed previously, FIRM maps identify a flood hazard area as the area that would be inundated by a flood with a 1% chance of occurring annually (State of Hawai'i HMP 2013). These measurements reflect statistical averages only; it is possible for two or more floods with a 1% annual or greater chance to occur in a short time period. Table 4.7-5 describes the recurrence intervals and probabilities of occurrence for flood events.

Table 4.7-5. Recurrence Intervals and Probabilities of Occurrence

Recurrence Interval (in years)	Probability of Occurrence in Any Given Year	Percent Chance of Occurrence in Any Given Year
100	1 in 100	1
50	1 in 50	2%
25	1 in 25	4%
10	1 in 10	10%
5	1 in 5	20%
2	1 in 2	50%

Source: USGS 2016

Note: USGS U.S. Geological Survey

For the 2018 HMP Update, the most up-to-date information was collected to calculate the probability of future occurrence of event-based flood events, of all magnitudes, in the State of Hawai'i. Information from the 2013 State HMP, FEMA, and NOAA-NCEI were used to identify the number of event-based flood events that occurred between 1879 and 2017. Using these resources ensures the most accurate probability estimates possible. Based on these historic statistics, the State of Hawai'i has a 100% chance of an event-based flood, of any magnitude, occurring any given year and can experience approximately five to six event-based flood events each year. The State has a 26% chance (or one declaration every four years) of receiving a FEMA declaration for event-based floods in any given year. However, some areas in the State are more flood prone than others and the frequency and size of flood events varies.

Potential Impacts of Climate Change on Probability of Future Events

Climate projections for the State of Hawai'i indicate an overall decline in rainfall; however, the State will experience an increase in heavy rain events causing more frequent or intense flash flooding, infrastructure damage, runoff, and sedimentation. Sea level is also projected to rise, increasing the risk of coastal flooding from hurricanes and tropical storms. Event-based coastal flooding with sea level rise would alter the extent of the area subject to flooding from storm events. Beach and wetland systems may not be able to adapt to rising sea levels and could be lost if not able to migrate inland. Their loss reduces the coast's ability to buffer impacts from storms and flooding (University of Hawai'i 2014). Overall, it is highly likely that changing future conditions will exacerbate current conditions and increase future event-based flood risk.

For additional climate change and sea level rise details, refer to Section 4.1 (Climate Change); Section 4.2 (Chronic Coastal Flooding); and Section 4.10 (Hurricane).

4.7.2 Vulnerability Assessment

To assess the State's risk to the flood hazard, a spatial analysis was conducted using the best available spatially-delineated flood hazard areas. In summary, to determine exposure, the hazard areas were overlaid with the assets



to determine the total number and replacement cost value located in the hazard areas. If the asset is in the hazard area, it is deemed exposed to the hazard and potentially vulnerable to loss. FEMA's Hazus flood model was used to estimate potential losses to structures from event-based flooding by looking at the depth of flooding at each structure location.

To evaluate vulnerability to event-based flooding, the SFHA was used. Estimated 1% annual chance flood depth grids were generated utilizing 3D Analyst tools in ArcGIS for A-zones and V-zones.

The depth grids were integrated into Hazus version 4.2 and the flood model was run to estimate potential losses to state buildings and critical facilities as user-defined facilities and the default dasymetric general building stock in Hazus.

According to DLNR, the flood maps need to be updated due to new development. In addition, there are large sections in the City and County of Honolulu and the County of Hawai'i that have not been studied. Therefore, the estimated results below may be underestimating vulnerability.

As discussed previously, structures located in coastal high hazard areas (V-zones) are at considerable risk of structural damage due to wave action velocities. In order to highlight this added degree of risk, as well as the additional construction requirements in these areas, exposure and vulnerability estimates presented in the following sections show both V-zone risks and the combined risk (A-zone and V-zone) for the special flood hazard area.

When interpreting the information presented, it is important to remember that the entire state is unlikely to experience impacts from a 1% annual chance flood event in all SFHAs at the same time.

ASSESSMENT OF STATE VULNERABILITY AND POTENTIAL LOSSES

This section discusses statewide vulnerability of areas susceptible to event-based flooding and potential losses to state assets (state buildings and state roads) and critical facilities.

The exposure analysis for the event-based flooding hazard determined there are 486 state buildings (7.3%) located in the SFHA; of which 98 are located in the V-zone. As noted earlier, buildings located in the V-zone are at considerable risk of structural damage due to wave velocity. The City and County of Honolulu has the greatest total replacement cost value exposed to the SFHA (\$598.2 million). The Department of Education has the greatest total replacement cost value exposed (\$440 million). Table 4.7-6 summarizes the state buildings located in the SFHA by county. Table 4.7-7 summarizes state buildings exposure and potential loss to event-based flooding by agency.

Event-Based Flood Hazard Area Definition

Special Flood Hazard Area (SFHA) – The 1% annual chance flood as depicted on the FEMA Flood Insurance Rate Maps (inclusive of V- and A-zones). The hazard area is called the SFHA.

Exposure represents assets located in the SFHA.

Estimated potential losses are calculated for the 1% annual chance flood event for assets located in the SFHA.



Table 4.7-6. State Buildings Located in the SFHA by County

County	State Buildings in the SFHA (A- and V-Zones)			State Buildings in the V-Zone
	Number	Total Replacement Cost Value	Number	Total Replacement Cost Value
County of Kaua'i	79	\$113,527,762	9	\$5,004,551
City and County of Honolulu	320	\$598,229,038	69	\$32,866,631
County of Maui	50	\$141,073,152	2	\$112,450
County of Hawai'i	37	\$42,609,275	18	\$31,608,663
Total	486	\$895,439,226	98	\$69,592,294

Source: Hawai'i State Risk Management Office 2017; Hazus v4.2

Note: SFHA Special Flood Hazard Area

Table 4.7-7. State Buildings Exposure and Potential Loss to the 1% Annual Chance Flood Event by Agency

Agency	Total Number of State Buildings	Total Replacement Cost Value	State Buildings Located in the SFHA				Potential Loss to the 1% Annual Chance Flood Event	
			Number	Percent (%) of Total Buildings	Replacement Cost Value	Percent (%) of Total Value	Estimated Potential Loss	Percent (%) of Total
Dept of Accounting & General Services	66	\$946,504,656	6	9.1%	\$50,613,018	5.3%	\$1,284,901	2.5%
Dept of Agriculture	70	\$133,065,375	5	7.1%	\$4,998,715	3.8%	\$0	0.0%
Dept of Attorney General	15	\$95,151,863	1	6.7%	\$1,953,251	2.1%	\$0	0.0%
Dept of Budget & Finance	16	\$26,624,294	1	6.3%	\$121,540	0.5%	\$0	0.0%
Dept of Business, Economic Development and Tourism	25	\$612,574,032	2	8.0%	\$26,786,125	4.4%	\$9,104,816	34.0%
Dept of Commerce & Consumer Affairs	2	\$35,611,360	0	0.0%	\$0	0.0%	\$0	0%
Dept of Defense	69	\$246,099,477	17	24.6%	\$62,162,658	25.3%	\$20,579,115	33.1%
Dept of Education	4,090	\$9,604,111,443	266	6.5%	\$439,963,050	4.6%	\$21,835,704	5.0%
Dept of Hawaiian Home Lands	12	\$100,471,477	1	8.3%	\$4,748,597	4.7%	\$2,172,881	45.8%
Dept of Health	44	\$387,068,440	1	2.3%	\$429,251	0.1%	\$0	0.0%
Dept of Human Resources Development	1	\$5,523,320	0	0.0%	\$0	0.0%	\$0	0%
Dept of Human Services	130	\$420,004,555	8	6.2%	\$9,995,739	2.4%	\$1,868,356	18.7%



Agency	Total Number of State Buildings	Total Replacement Cost Value	State Buildings Located in the SFHA				Potential Loss to the 1% Annual Chance Flood Event	
			Number	Percent (%) of Total Buildings	Replacement Cost Value	Percent (%) of Total Value	Estimated Potential Loss	Percent (%) of Total
Dept of Labor and Industrial Relations	22	\$79,322,626	2	9.1%	\$2,251,107	2.8%	\$0	0.0%
Dept of Land and Natural Resources	90	\$98,666,185	28	31.1%	\$12,682,661	12.9%	\$1,349,360	10.6%
Dept of Public Safety	154	\$427,884,909	14	9.1%	\$30,496,180	7.1%	\$2,827,053	9.3%
Dept of Taxation	1	\$6,864,408	0	0.0%	\$0	0.0%	\$0	0%
Dept of Transportation	68	\$2,912,510,888	25	36.8%	\$84,824,357	2.9%	\$1,140,185	1.3%
Hawai'i State Ethics Commission	1	\$891,212	0	0.0%	\$0	0.0%	\$0	0%
Hawai'i Health Systems Corporation	106	\$1,223,962,810	1	0.9%	\$829,553	0.1%	\$0	0.0%
Hawai'i Housing Finance & Development Corporation	86	\$333,526,064	1	1.2%	\$39,460,800	11.8%	\$6,092,283	15.4%
Hawai'i Public Housing Authority	273	\$933,255,767	40	14.7%	\$47,266,236	5.1%	\$166,090	0.4%
Hawai'i State Legislature	2	\$43,024,855	0	0.0%	\$0	0.0%	\$0	0%
Hawai'i State Public Library System	53	\$525,584,082	7	13.2%	\$14,566,099	2.8%	\$95,348	0.7%
Judiciary	41	\$511,093,204	1	2.4%	\$1,983,075	0.4%	\$0	0.0%
Legislative Reference Bureau	1	\$2,686,408	0	0.0%	\$0	0.0%	\$0	0%
Office of Hawaiian Affairs	11	\$53,991,251	5	45.5%	\$17,078,644	31.6%	\$3,114,166	18.2%
Office of the Auditor	2	\$1,789,788	0	0.0%	\$0	0.0%	\$0	0%
Office of the Governor	1	\$2,686,408	0	0.0%	\$0	0.0%	\$0	0%
Office of the Lieutenant Governor	2	\$3,977,640	0	0.0%	\$0	0.0%	\$0	0%
Office of the Ombudsman	1	\$1,620,944	0	0.0%	\$0	0.0%	\$0	0%
Research Corporation of the	3	\$3,713,497	1	33.3%	\$412,021	11.1%	\$164,585	39.9%



Agency	Total Number of State Buildings	Total Replacement Cost Value	State Buildings Located in the SFHA				Potential Loss to the 1% Annual Chance Flood Event	
			Number	Percent (%) of Total Buildings	Replacement Cost Value	Percent (%) of Total Value	Estimated Potential Loss	Percent (%) of Total
University of Hawai'i								
University of Hawai'i	637	\$5,000,692,783	53	8.3%	\$41,816,547	0.8%	\$7,061,523	16.9%
Total	6,095	\$24,780,556,017	486	8.0%	\$895,439,226	3.6%	\$78,856,366	8.8%

Source: Hawai'i State Risk Management Office 2017;

The Hazus flood model estimates \$78.8 million in damages to state buildings as a result of the 1% annual chance flood event. This figure does not include the cost of damage to roads or utilities which could be considerable. The City and County of Honolulu is estimated to experience the greatest loss (\$72 million, or 12% of the county's total building replacement cost value), with more than \$8 million of the total loss located in the V-zone. Table 4.7-8 summarizes the state building loss by county; estimated potential loss by state agency is summarized in Table 4.6-6. The Department of Education and the Department of Defense occupy buildings with the greatest potential loss; \$21.8 billion and \$20.5 billion in damages, respectively which nearly equate to half of the state building estimated loss.

Table 4.7-8. State Building Estimated Potential Loss to the 1% Annual Chance Flood Event by County

County	Estimated Potential Loss to the 1% Annual Chance Flood Event (A- and V-Zones)		Estimated Potential Loss in the V-Zone Only	
	Replacement Cost Value	Percent (%) of Total	Replacement Cost Value	Percent (%) of Total
County of Kaua'i	\$5,635,238	5.0%	\$0	0.0%
City and County of Honolulu	\$72,423,675	12.1%	\$8,230,618	25.0%
County of Maui	\$0	0.0%	\$16,990	15.1%
County of Hawai'i	\$797,453	1.9%	\$0	0.0%
Total	\$78,856,366	8.8%	\$8,247,644	11.9%

Source: Hawai'i State Risk Management Office 2017; Hazus v4.2

Note: SFHA Special Flood Hazard Area

Statewide, there are 84.4 miles of state roads exposed to event-based flooding. There is a major public safety hazard when residents attempt to drive on flooded roadways. Many state roads serve as evacuation routes to higher ground. Not only will these roads be closed during a flood event and potentially isolate communities, the flood waters may accelerate the degradation of these roads leading to increased repair and replacement costs. Bridges exposed to flood events can be extremely vulnerable due to the forces transmitted by the velocity and by the impact of debris carried by the water. Table 4.7-9 shows the length of state roads in the SFHA by county. The City and County of Honolulu has the greatest number of miles (44.7 miles) exposed, followed by the County of Maui (20.6 miles). A complete list of state roads is included in [Appendix X](#).



Table 4.7-9. State Road Exposure to the 1% Annual Chance Flood Event by County

County	Length (in miles)		
	Total Length	Length in the SFHA	Percent (%) of Total Length
County of Kaua'i	104.0	14.7	14.2%
City and County of Honolulu	375.3	44.7	11.9%
County of Maui	238.6	20.6	8.6%
County of Hawai'i	378.7	4.4	1.2%
Total	1,096.5	84.4	7.7%

Source: State of Hawai'i SDOT State Routes GIS layer 2017

Notes: GIS Geographic Information System

SDOT State Department of Transportation

Critical Facilities

Critical transportation hubs and critical infrastructure located are exposed to the event-based flood hazard. Utility lines commonly follow roads and those located underground may be impacted resulting in disruption of services.

Table 4.7-10 summarizes the total number of critical facilities by core category located in the SFHA by county. The cost to repair or replace flooded critical facilities is an estimated \$306 million. The City and County of Honolulu has the greatest number of critical facilities (68) exposed, followed by the County of Maui (42). Table 4.7-11 summaries the critical facilities exposure and potential losses by core category. Water, waste and wastewater systems have the greatest estimated potential loss at \$161.8 million, followed by the Energy core category with greater than \$75 million.

Table 4.7-10. Critical Facilities Located in the SFHA by County

County	Core Category of Critical Facilities										Total in the SFHA
	Commercial Facilities	Communications	Emergency Services	Energy	Food and Agriculture	Government Facilities	Healthcare and Public Health	Mass Care Support Services	Transportation Services	Water, Waste, and Wastewater Systems	
County of Kaua'i	1	1	3	1	0	1	0	4	0	2	13
City and County of Honolulu	4	8	7	14	1	6	2	5	2	19	68
County of Maui	0	2	3	1	0	5	4	4	8	15	42
County of Hawai'i	0	0	0	2	5	1	0	1	5	9	23
Total	5	11	13	18	6	13	6	14	15	45	146

Source: Makani Pahili 2017 Emergency Power Prioritization Workshop Series final report; Hazus v4.2



Table 4.7-11. Critical Facilities Exposure and Potential Losses by Core Category to the 1% Annual Chance Flood Event

Core Category	Critical Facilities Located in the SFHA				Estimated Potential Loss to the 1% Annual Chance Flood Event (A- and V-Zones)	
	Number of Critical Facilities	Percent (%) of Total Facilities	Replacement Cost Value	Percent (%) of Total Value	Replacement Cost Value	Percent (%) of Total
Commercial Facilities	5	8.3%	\$12,446,395	6.0%	\$2,723,081	21.9%
Communications	11	8.5%	\$32,035,980	6.1%	\$4,301,718	13.4%
Emergency Services	13	8.7%	\$77,684,370	7.6%	\$676,487	0.9%
Energy	18	20.0%	\$533,553,615	20.6%	\$75,907,789	14.2%
Food & Agriculture	6	15.4%	\$84,920,890	10.2%	\$11,067,313	13.0%
Government Facilities	13	13.0%	\$50,945,510	12.7%	\$4,078,617	<1%
Healthcare & Public Health	6	3.1%	\$95,015,433	2.8%	\$2,368,394	2.5%
Mass Care Support Services	14	4.0%	\$160,107,435	1.4%	\$2,812,375	1.8%
Transportation Services	15	26.8%	\$465,972,480	26.8%	\$40,546,219	8.7%
Water, Waste, & Wastewater Systems	45	14.8%	\$1,401,120,000	14.8%	\$161,840,359	11.6%
Total	146	9.9%	\$2,913,802,107	9.2%	\$306,322,351	10.5%

Source: Makani Pahili 2017 Emergency Power Prioritization Workshop Series final report; Hazus v4.2

ASSESSMENT OF LOCAL VULNERABILITY AND POTENTIAL LOSSES

This section provides a summary of vulnerability and potential losses to population, general building stock, and environmental resources and cultural assets by county. A spatial exposure analysis was conducted using the SFHA and estimate potential losses were estimated using Hazus. These results are summarized below.

Population

Over 95,000 residents statewide are located in the SFHA; refer to Table 4.7-12. These residents may be displaced by the flooding of their homes, requiring them to seek temporary shelter with friends and family or in emergency shelters. The City and County of Honolulu has the greatest number of people (74,931) and the County of Kaua'i has the greatest percent of people (9.9%) located in the SFHA. This analysis does not include the number of tourists and visitors in the state; therefore this estimate may be underestimating exposure and vulnerability.

While all people located in SFHA are considered exposed and potentially vulnerable, populations considered most vulnerable include the elderly (persons over the age of 65) and individuals living below the U.S. Census poverty threshold. The City and County of Honolulu has the largest population over 65, with 1.2% exposed and 2.7% of the low-income population exposed to the SFHA. Appendix X summarizes the population exposure to the A-Zone and V-Zone areas.



Table 4.7-12. 2010 U.S. Census Population Located in the SFHA by County

County	Population						
	Total Population	Population in the SFHA	Population Exposed as % of Total Population	Population Over 65 in the SFHA	Population Over 65 Exposed as % of Total	Population with Income <\$30K/yr in the SFHA	Population with Income <\$30K/year as Percent (%) of Total
County of Kaua'i	67,091	6,656	9.9%	946	1.4%	1,995	3.0%
City and County of Honolulu	953,207	74,931	7.9%	10,970	1.2%	25,827	2.7%
County of Maui	154,924	8,173	5.3%	1,106	0.7%	2,361	1.5%
County of Hawai'i	185,079	5,456	2.9%	877	0.5%	2,088	1.1%
Total	1,360,301	95,216	7.0%	13,899	1.0%	32,271	2.4%

Source: U.S. Census 2010; Hazus 4.2

The poverty threshold for the State is \$24,000/year (Federal Register 2017). Utilizing the demographic layer in Hazus, the total households with an income of \$30,000 or less was calculated. Per the U.S. Census Bureau QuickFacts, the average number of persons per household (2012-2016) is 3.03 for the State of Hawai'i. To convert households to residents, three people per household was used.

Floods and their aftermath present numerous threats to public health and safety:

- **Vehicles in Flood Waters**— Flood waters can carry large amounts of debris potentially increasing the damage they do.
- **Unsafe food**—Floodwaters can contain disease-causing bacteria, dirt, oil, human and animal waste, and farm and industrial chemicals. Their contact with food items, including food crops in agricultural lands, can make that food unsafe to eat.
- **Contaminated drinking and washing water and poor sanitation**—Flooding impairs clean water sources with pollutants; pollutants also infiltrate into the groundwater contaminating potable water. Flooded wastewater treatment plants and private sewage disposal systems can be overloaded, resulting in backflows of raw sewage becoming a cause of disease.
- **Mosquitoes and animals**—Floods provide new breeding grounds for mosquitoes in wet areas and stagnant pools; deceased animals can carry viruses and diseases if not disposed of timely and properly.
- **Mold and mildew**—Excessive exposure to mold and mildew can cause flood victims, especially those with allergies and asthma, to contract upper respiratory diseases, triggering cold-like symptoms. Infants, children, elderly people and pregnant women are considered most vulnerable to mold-induced health problems.
- **Carbon monoxide poisoning**—In the event of power outages the use alternative fuels in enclosed or partially enclosed spaces can lead to carbon monoxide poisoning.
- **Hazards when reentering and cleaning flooded homes and buildings**—Flooded buildings can pose significant health and physical hazards to people entering them including live electrical wires, gas leaks, flood debris, and hazardous materials.
- **Mental stress and fatigue**—People who live through a devastating flood can experience long-term psychological impact.



General Building Stock

Economic losses to the State of Hawai'i from event-based flooding include but are not limited to: general building stock damage, agricultural losses and business interruption. These losses will negatively affect the tax base. Damage to general building stock can be quantified using Hazus. Other economic components such as loss of facility use, functional downtime, and social economic factors are less quantifiable. For the purposes of this analysis, the general building stock damage is discussed further.

Low-lying urban areas have the greatest vulnerability to a flood event. To estimate the potential losses by county, the Hazus flood model and default general building stock provided by the model were used. This analysis has been refined since the 2013 HMP due to the updated and improved flood hazard areas and flood depth grids across the state. Table 4.7-13 summarizes the estimated potential losses to the general building stock by county.

Hazus estimates \$2.5 billion in statewide potential damages to the general building stock inventory associated with the 1% annual chance flood event. Although this loss represents only 1% of the State's total building replacement cost value, the area flooded comprises of some of the most valued in the state. The City and County of Honolulu is estimated to experience the greatest loss; nearly \$2 billion in building damages (repair or replacement costs), of which \$1.5 billion of the damages are in the V-zone. The cost to repair or replace buildings in the County of Kaua'i is estimated an estimated \$282 million; and an estimated \$204 million in the County of Maui. Hazus estimates \$93 million in building loss for the County of Hawai'i. Appendix X summarizes the exposure and potential losses to the 1% Annual Chance Flood A-Zone and V-Zone areas.

Table 4.7-13. General Building Stock Exposure and Potential Losses to the 1% Annual Chance Flood Event

County	Total Replacement Cost Value	Replacement Cost Value in the SFHA	% of Total in the SFHA	Estimated Potential Loss to the 1% Annual Chance Flood Event (A-and V-Zones)		Estimated Potential Loss to Buildings in the V-Zones	
				Replacement Cost Value	Percent (%) of Total	Replacement Cost Value	Percent (%) of Total
County of Kaua'i	\$13,287,882,000	\$1,510,657,000	11.4%	\$282,379,000	2.1%	\$146,778,000	1.1%
City and County of Honolulu	\$164,787,212,000	\$18,295,042,000	11.1%	\$1,944,614,000	1.2%	\$1,533,898,000	0.9%
County of Maui	\$31,320,693,000	\$2,233,402,000	7.1%	\$204,455,000	0.7%	\$102,798,000	0.3%
County of Hawai'i	\$33,326,392,000	\$1,673,237,000	5.0%	\$93,133,000	0.3%	\$35,91,000	0.1%
Total	\$242,722,179,000	\$23,712,338,000	9.8%	\$2,524,581,000	1.0%	\$1,819,391,000	0.7%

Source: Hazus v4.2; State of Hawai'i GIS layer Trust Land, State of Hawai'i GIS Program Geospatial Data Portal 2017

Notes: GIS Geographic Information System
SFHA Special Flood Hazard Area

The NFIP data are also a useful tool to determine areas vulnerable to flood. Table 4.7-14 summarizes the NFIP policies, claims, and repetitive loss buildings in each county. Severe repetitive loss statistics were not provided



for the 2018 HMP Update. The City and County of Honolulu has the highest number of repetitive loss properties (107), followed by the County of Hawai'i (45). The County of Kaua'i has the greatest total losses paid as of 2017. These statistics do not include the April 2018 flood event.

Table 4.7-14. NFIP Statistics for the State of Hawai'i

County	Number of Policies	Insurance In Force	Number of Paid Losses	Total Losses Paid	Repetitive Loss Buildings				
					2013	2018			
					Total	Total	A-Zone	V-Zone	Outside the Floodplain
County of Kaua'i	5,365	\$1,115,241,400	652	\$37,093,919	19	19	12	2	5
City and County of Honolulu	38,077	\$8,815,199,700	1,500	\$29,733,112	97	107	53	13	31
County of Maui	12,240	\$2,658,756,600	301	\$6,319,516	36	35	20	5	10
County of Hawai'i	4,363	\$1,035,377,300	501	\$18,240,427	45	45	13	25	4
Total	60,045	\$13,624,575,000	2,954	\$91,386,974	197	206	98	45	50

Source: FEMA Region IX, NFIP Regulations and Compliance, 2/19/2018; State of Hawai'i HMP 2013

Over the performance period of the 2013 HMP, the number of repetitive loss properties has increased from 197 to 206 (an approximate 5% increase). The City and County of Honolulu is the only county to experience an increase in repetitive loss properties; 10 properties over the last five years. The County of Maui experienced a decrease of one property. The number of repetitive loss properties in the Counties of Kaua'i and Hawai'i have remained the same since 2013. However, as noted above, these statistics do not include the April 2018 flood event (DR-4365).

Land Use Districts

Table 4.7-15 shows the square miles of special flood hazard areas in each State Land Use District statewide; refer to Appendix X for results by county. Agricultural District lands and Urban District lands have the greatest area exposed to A-zone flooding in the State, 34.2 and 20.6 square miles, respectively. This is not surprising for two reasons 1) productive agricultural lands tend to be located along streams as rivers as sediment build up and accumulation from prior flood events results in fertile soil and 2) floodplain mapping is generally conducted in areas that are developed or are likely to be developed in the future. Conservation District lands and Urban District lands have the greatest area exposed to V-zone flooding in the State, 14.4 and 8 square miles respectively. This is also not surprising as urban development in the State tends to be situated along the coast and Conservation District lands contain valuable environmental resources, which are often located in coastal areas. Additional discussion of exposure and vulnerability of Conservation District lands and their exposure and vulnerability to Event Based Floods can be found in the Environmental Resources section below.

Table 4.7-15. State Land Use Districts Located in the Special Flood Hazard Area

Land Use District	Total (square miles)	Square Miles in the SFHA	Percent (%) of Total Area
Agricultural	2,942.8	36.9	1.3%
Conservation	3,156.3	23.9	0.8%
Rural	16.1	1.9	12.0%
Urban	319.7	28.6	8.9%
Total	6,434.9	91.4	1.4%

Source: FEMA



Notes: Total area was calculated from the State of Hawai'i State Land Use District GIS layer
 Hazard area clipped to coastline were downloaded from State of Hawai'i GIS Program Geospatial Data Portal
 Total area may differ slightly between this and other calculations due to slight differences in the shoreline geography.

FEMA Federal Emergency Management Agency
 GIS Geographic Information System
 SFHA Special Flood Hazard Area

Environmental Resources

Environmental resources are valuable assets to the environment and overall economy in the State. Coral reefs and wetlands provide a coastal buffer and protect from wave and flood impacts. However, flooding may adversely impact the natural environment including: beach erosion; loss or submergence of wetlands and other coastal ecosystems; saltwater intrusion; high water tables; loss of coastal recreation areas, beaches, protective sand dunes, parks and open space; and loss of coastal structures (sea walls, piers, bulkheads, bridges, or buildings) (FEMA 2007). Flash floods often result in increased sediment deposited in the nearshore environment negatively impacting coral reefs from sedimentation and stormwater runoff (University of Hawai'i 2014).

Environmental resource areas, including critical habitat (or habitats that are known to be essential for an endangered or threatened species), wetlands and parks and reserves are vulnerable to event-based flooding. The area of each environmental resource located in the SFHA was calculated and is summarized in Table 4.7-16.

Table 4.7-16. Environmental Resources Located in the SFHA

Environmental Resource	Total Square Miles of Resource	Resource Area in the SFHA (square miles)	Percent (%) of the Total Resource Area
Critical Habitat ^a	915.2	2.6	0.3%
Wetlands	260.0	24.4	9.4%
Parks and Reserves	2,607.7	15.1	0.6%
Total^b	3,837.6	42.1	1.1%

Source: State of Hawai'i GIS Program Geospatial Data Portal; HWMO 2013
 a. Critical area mileage includes the combined area of coverage of individual critical habitat areas
 b. Total square miles may be over reported as some environmental asset areas may overlap.
 Sq. Mi. = Square miles.

Reefs were excluded from the analysis because they are under water and thus 100% exposed to a flood hazard.

Cultural Assets

Many Native Hawaiian cultural resources are located near the shoreline and may be impacted by event-based flooding. Structures that experience damage would result in displaced residents in need of shelter or new homes. Less than 3% of the Hawaiian Home Lands is in the 1% Annual Chance Flood areas (this includes the A-Zone, V-Zone and SFHA) in all four counties (see Table 4.7-17).

Table 4.7-17. Hawaiian Home Lands Located in the SFHA

County	Area (in square miles)		
	Total Area	Land in the SFHA	Percent (%) of Total Area
County of Kaua'i	32.0	0.3	1.0%
City and County of Honolulu	10.9	0.2	1.9%
County of Maui	92.6	2.3	2.5%



County	Area (in square miles)		
	Total Area	Land in the SFHA	Percent (%) of Total Area
County of Hawai'i	190.3	1.1	0.6%
Total	325.8	3.9	1.2%

Source: State of Hawai'i GIS layer Trust Land, State of Hawai'i GIS Program Geospatial Data Portal 2017

Notes: GIS Geographic Information System

SFHA Special Flood Hazard Area

FUTURE CHANGES THAT MAY IMPACT STATE VULNERABILITY

Understanding future changes that impact vulnerability in the State can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Potential or Projected Development

The special flood hazard areas were overlain on areas that may experience significant changes in development or redevelopment in future years (see Table 4.7-19 below; refer to Section 3 for more information on projected development areas). The results of this assessment indicate none of the HCDA Community Development Districts and only a very small amount of the Maui Development Projects areas are located in special flood hazard areas. Approximately 68.8% of the Enterprise Zones statewide are located in special flood hazard areas. Most of the exposed area, 50.4 square miles, is located in A-zone special flood hazard areas. Each county participates in the National Flood Insurance Program and has a flood damage prevention regulations in place that regulates how development can occur in mapped special flood hazard areas. Future development in these areas will be required to adhere to flood damage prevention standards. If new development occurs in areas that currently support natural and beneficial floodplain functions, such as in upland conservation areas, impacts to event based flooding may be seen throughout the associated watershed.

Other Factors of Change

Climate change is certain to alter flood dynamics in the State. Changes in the timing and intensity of rainfall may impact inland and stormwater flooding, changes in wind and storm patterns may impact coastal flooding, and sea level rise will increase the areas exposed to coastal and some inland flooding as well as flood heights in some areas. For more information on how climate change will impact event based flooding, please refer to Section 4.2 (Climate Change and Sea Level Rise).



Table 4.7-18. HCDA Community Development Districts, Maui Development Projects, and Enterprise Zones Located in Special Flood Hazard Areas

County	Area (in square miles)								
	HCDA Community Development Districts (Total Area)	Total Area Exposed to Hazard	Hazard Area as % of Total Area	Maui Development Projects (Total Area)	Total Area Exposed to Hazard	Hazard Area as % of Total Area	Enterprise Zones (Total Area)	Total Area Exposed to Hazard	Hazard Area as % of Total Area
A-Zone									
County of Kaua'i	-	-	-	-	-	-	252.3	14.1	5.6%
City and County of Honolulu	7.4	0.0	0.0%	-	-	-	288.3	14.5	5.0%
County of Maui	-	-	-	27.6	0.0	0.0%	1,016.7	13.7	1.4%
County of Hawai'i	-	-	-	-	-	-	1,286.6	8.0	0.6%
Total	7.4	0.0	0.0%	27.6	0.0	0.0%	2,843.9	50.4	1.8%
V-Zone									
County of Kaua'i	-	-	-	-	-	-	252.3	1.4	0.6%
City and County of Honolulu	-	-	-	-	-	-	288.3	3.3	1.1%
County of Maui	-	-	-	27.6	0.02	0.1%	1,016.7	6.7	0.7%
County of Hawai'i	7.4	0.0	0.0%	-	-	-	1,286.6	7.0	0.5%
Total	7.4	0.0	0.0%	27.6	0.02	0.1%	2,843.9	18.4	0.6%
Special Flood Hazard Area									
County of Kaua'i	-	-	-	-	-	-	252.3	15.5	6.2%
City and County of Honolulu	-	-	-	-	-	-	288.3	17.8	6.2%
County of Maui	-	-	-	27.6	0.02	0.1%	1,016.7	20.4	2.0%
County of Hawai'i	7.4	0.0	0.0%	-	-	-	1,286.6	15.1	1.2%
Total	7.4	0.0	0.0%	27.6	0.02	0.1%	2,843.9	68.8	2.4%

Notes: Total area calculated from: (1) HCDA Community Development District GIS layer from Hawai'i Community Development Authority
 (2) Maui Development Projects GIS layer from Maui County Planning Department (3) Enterprise Zones from Community Economic Development Program, DBEDTS
 Hazard area clipped to coastline downloaded from State of Hawai'i GIS Program Geospatial Data Portal
 HCDA Hawai'i Community Development Authority
 SFHA Special Flood Hazard Area