SECTION 4. RISK ASSESSMENT

4.3 Chronic Coastal Flood

2018 HMP Update Changes

- The flood hazard profile is now divided into two separate hazards: chronic coastal flood and event-based flood. This profile describes the chronic coastal flooding hazard in the State of Hawai‘i and includes passive inundation, annual high waves, coastal erosion, and tidal flooding/King tides with sea level rise.
- 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).
- Chronic flooding events that occurred in the State of Hawai‘i from January 1, 2012, through December 31, 2017, were researched for this 2018 HMP Update.
- New and updated figures from federal and state agencies are incorporated.
- Included analysis on chronic coastal flood per county for exposure to geocoded State assets, critical facilities, population, general building stock, and environmental/cultural assets.

4.3.1 Hazard Profile

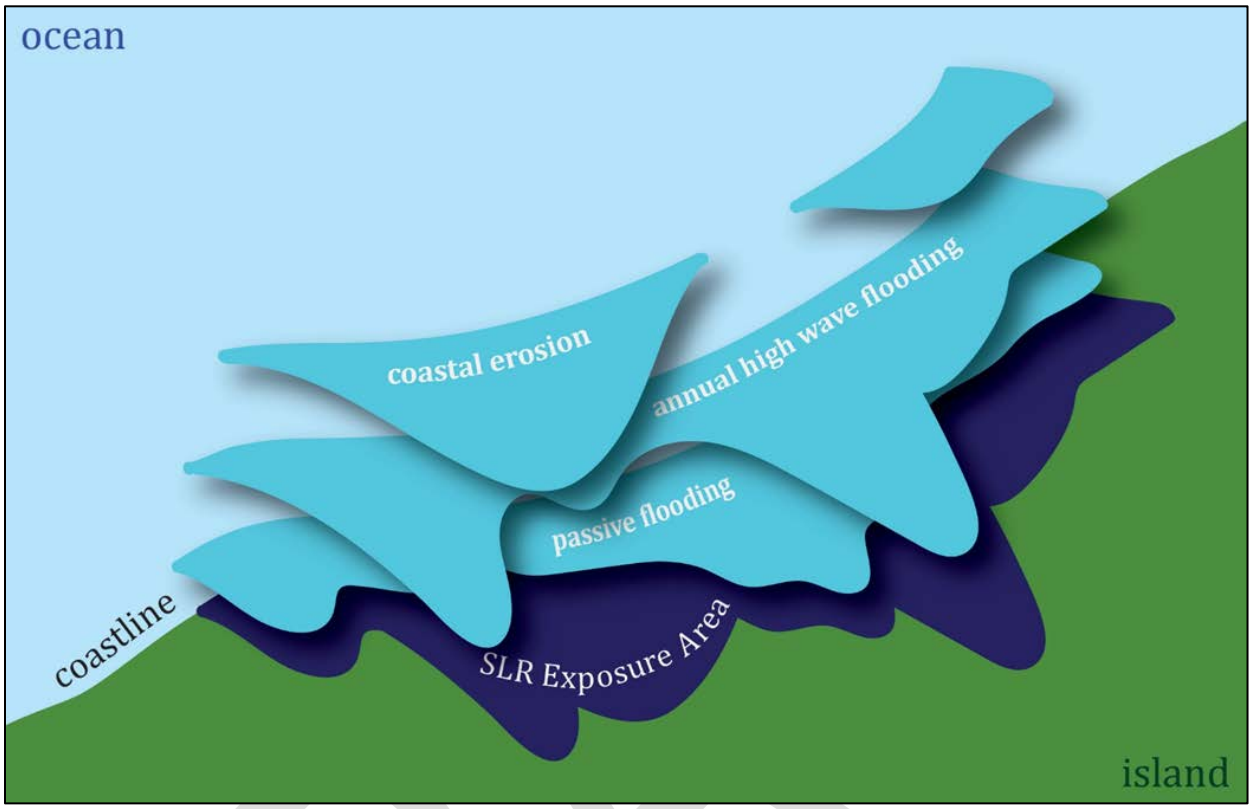
Chronic coastal flooding is occurring in the State of Hawai‘i now and will continue to worsen as sea level continues to rise. The 2017 *Hawai‘i Sea Level Rise Vulnerability and Adaptation Report* defines chronic coastal flooding as the Sea Level Rise Exposure Area (SLR-XA), or the area exposed to potential chronic (e.g., permanent) coastal flooding and land loss based on modeling passive flooding, annual high wave flooding, and coastal erosion (Hawai‘i Climate Change Mitigation and Adaptation Commission 2017). Refer to Figure 4.3-1 for a schematic diagram of the SLR-XA.

How is Chronic Coastal Flooding Defined for the 2018 HMP Update?

Chronic coastal flooding is defined as the combined effects of annual high wave flooding, passive flooding, and coastal erosion that are being exacerbated by sea level rise. The SLR-XA with 1.1 feet of sea level rise (SLR-XA-1.1), as defined in the 2017 Hawai‘i Sea Level Rise Vulnerability and Adaptation Report, approximates current or near-term exposure to chronic coastal flooding in the State of Hawai‘i.

The individual components of chronic coastal flooding were modeled with 1.1 feet of sea level rise using the Intergovernmental Panel on Climate Change (IPCC) projection for the year 2050 and are depicted as the sea level rise exposure area (SLR-XA) (see detailed methodology in *Hawai‘i Sea Level Rise Vulnerability and Adaptation Report* (Hawai‘i Climate Mitigation and Adaptation Commission 2017). For the 2018 HMP Update, chronic coastal flooding is assessed using the SLR-XA with 1.1 feet of sea level (SLR-XA-1.1) which represents both the current and near-term exposure area to chronic coastal flooding. It should be noted that chronic coastal flooding represented by the SLR-XA-1.1 for the Islands of Moloka‘i and Hawai‘i is based on modeling passive flooding only due to limitations in data (Hawai‘i Climate Mitigation and Adaptation Commission 2017).

Figure 4.3-1. Chronic Coastal Flooding as the Cumulative Impact of Passive Flooding, Annual High Wave Flooding, and Coastal Erosion



Source: Hawai'i Climate Mitigation and Adaptation Commission 2017

This section provides general information on the chronic coastal flood hazard which includes passive flooding, annual high waves, coastal erosion, and tidal flooding/King tides. Flooding caused by dam failure is discussed in Section 4.4 (Dam Failure), event based flooding is discussed in Section 4.7 (Event-Based Flood), and storm surge is discussed in Section 4.11 (Hurricane). The assessment of mid- to late century sea level rise on chronic coastal flooding is discussed in Section 4.2 (Climate Change and Sea Level Rise).

Hazard Description

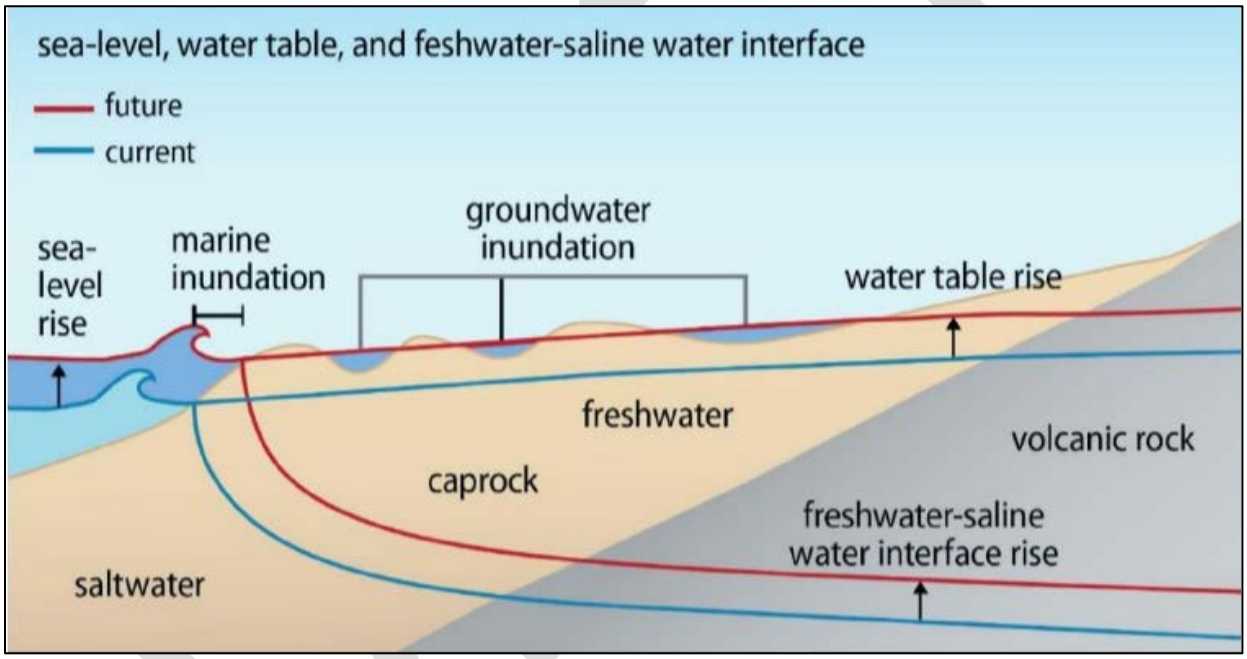
The SLR-XA-1.1 represents the present-day or near-term exposure to chronic coastal flooding, defining the State's vulnerability to chronic coastal flooding (Hawai'i Climate Mitigation and Adaptation Commission 2017). The latest scientific literature suggests that 1.1 feet of sea level rise could be reached intermittently in the State of Hawai'i over the next couple of decades, and sustained before mid-century. Long-term records from tide stations around the State of Hawai'i are already showing that the sea level is rising around the islands (refer to Figure 4.2-6 in the Climate

Change section). Coastal areas are already experiencing an increase in frequency of chronic coastal flooding components (passive inundation, high wave flooding, coastal erosion, and tidal/King tide flooding).

Passive Flooding

Passive flooding, also known as hydrostatic flooding, is depicted by bathtub modeling. Passive flooding includes marine flooding over the shoreline by stillwater flow into the lands that lie below the water level. The model also depicts low-lying areas indirectly flooded by sea level rise through water table rise. Passive flooding is exacerbated by rainfall as it prevents drainage and as such, runoff and marine waters combine to produce larger impacts. Passive flooding represents the simplest projection and provides an initial assessment of low-lying areas susceptible to flooding by sea level rise. Passive flooding includes areas that are hydrologically connected to the ocean (marine flooding) and low-lying areas that are not hydrologically connected to the ocean (groundwater) (Figure 4.3-2) (Hawai'i Climate Change Mitigation and Adaptation Commission 2017).

Figure 4.3-2. Schematic Diagram Showing Passive Marine and Groundwater Flooding



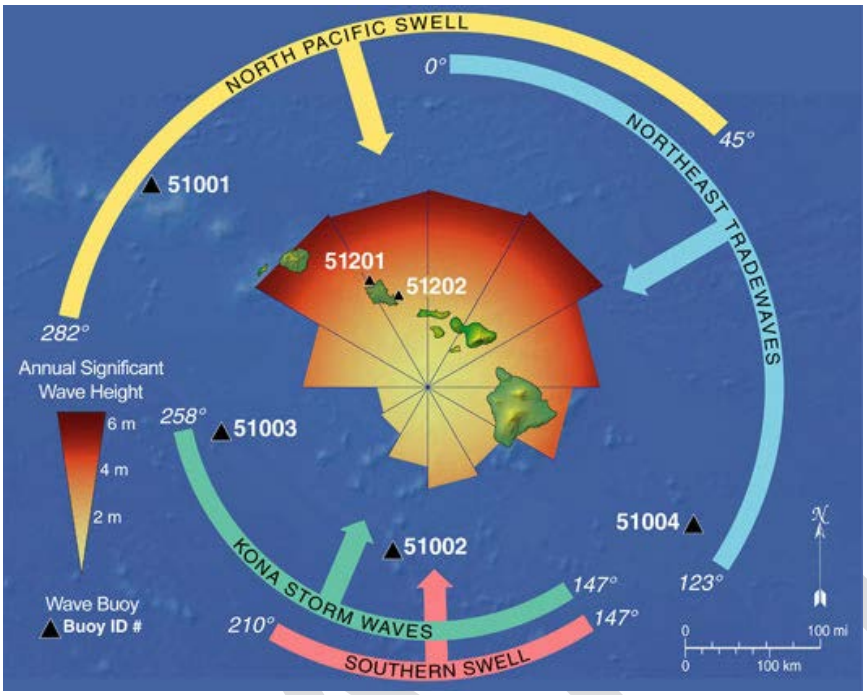
Source: Hawai'i Climate Change Mitigation and Adaptation Commission 2017

Annual High Wave Flooding

Storms or high winds over the open ocean can generate large waves that trigger high surf in coastal areas. High surf typically impacts the shore in "sets" of three to five waves between lulls. Any wave can be significantly larger than the previous one and can catch beachgoers off guard. Although general forecasts can be made about surf conditions, the timing of individual waves can never be predicted (Pacific Disaster Center [PDC] 2017).

Each year, waves that reach Hawaii's shorelines originate from four primary sources: north Pacific swell, trade wind swell, south swell, and Kona storms. Figure 4.3-3 illustrates the regions of influence and a wave rose depicting annual swell heights and direction.

Figure 4.3-3. State of Hawai'i Dominant Swell Regimes



Source: Vitousek et al. 2009

Hazards associated with high waves include debris overwash, flooding, erosion, high wave energy and turbulence in the nearshore zone, and strong currents. Because the contact between deep water and the shallow margins around the Hawaiian Islands is abrupt, surface waves can grow very tall, very quickly (USGS 2002). High waves in Hawai'i are also generated by approaching storms, including tropical storms and hurricanes in the summer and fall, as well as winter Kona storms. These types of wave events are discussed in Section 4.7 (Event-Based Flood) and Section 4.11 (Hurricanes).

Coastal Erosion

Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a period of time. It is generally associated with storm surges, hurricanes, windstorms, and flooding hazards. Coastal erosion may be exacerbated by human activities such as boat wakes, shoreline hardening, and dredging. Coastal erosion describes the landward movement and loss of the abutting land in the process. Natural recovery after erosive episodes can take months or years. If a dune or beach does not recover quickly enough via natural processes, coastal and upland properties may be exposed to further damage in subsequent events.

Beach erosion occurs when waves and currents remove sand from a beach system. The loss of sand causes the beach to become narrower and lower in elevation. Storm waves carry the sand offshore, depositing and storing the sediment in large sandbars. In weeks and months following the storm, the sand is returned to the beach by calm-weather waves. Beach erosion threatens coastal properties and infrastructure. A series of storms can cause significant shoreline retreat, leaving coastal properties more vulnerable to future storms (USGS 2016).

Seasonal coastal erosion (or episodic coastal erosion) occurs when beaches and other coastal areas are exposed to seasonally high waves. In the State of Hawai‘i, seasonal erosion is more severe on beaches that lack fringing reefs. On these beaches a single, unusually large wave event or high wave season can cause severe coastal erosion. The vegetation line may retreat as much as 60 or more feet, but if the erosive event is followed by a long period of normal wave conditions, the shoreline can recover, often accreting back to its pre-event location (Hawai‘i State HMP 2013).

Sources of Erosion

The following provides details regarding the different sources of coastal erosion that may impact the State of Hawai‘i.

High Waves and Strong Currents

High waves and strong currents will cause a beach to change shape. To absorb the additional wave energy, beaches and dunes give up sand to the waves which carry it seaward and drop it on the bottom. This raises the seafloor and flattens the overall beach profile. Waves then shoal and break further offshore, minimizing their erosive effects. Beaches recover from these changes when smaller waves move the sand back onto the beach and winds blow it into the dunes (Hawai‘i Institute of Geophysics and Planetology 2005).

Coastal Armoring

Coastal managers and property owners often attempt to stabilize coastal land and protect infrastructure along the coast by building shoreline armoring structures to hold back the ocean and prevent the loss of sediment. These structures include seawalls and breakwaters.

- Seawalls are vertical or near vertical shore-parallel structures designed to prevent upland erosion and storm surge flooding. They are generally massive concrete structures placed along a stretch of shoreline.
- Breakwaters are common along the shorelines of Hawai‘i. They are constructed to protect harbors, marinas and boat basins from the effects of weather and longshore drift. They reduce the intensity of wave action in inshore waters and reduce coastal erosion. However, they have the potential to cause sediment deficiencies along adjacent beaches because they interfere with patterns of sand flow and accumulation.

Coastal armoring is both beneficial and detrimental. Armored shorelines can prevent sandy beaches, wetlands, and other intertidal areas from moving inland as the land erodes or sea levels rise, but they also have the potential to eliminate habitat for marine organisms and beach front for the public by restricting the natural movement of sediments. If coastal armoring is being used, it is important to use a site-specific stabilization method that balances the needs of the public and the needs of the natural system (NOAA 2017).

Dune Leveling and Grading

Coastal dunes are critical to beach survival and provide protection from high waves, rising sea levels and strong storms. Dunes are one of the most important storage sites for sand. However, in the State of Hawai‘i, many dunes have been flattened and mined. Grading of dunes with soil to support short-grass lawns is a source of silt accumulation in coastal waters during erosion events, and acts to compact and trap dune sands such that the adjacent beach experiences deflation, or a lowering of elevation due to sand removal by waves without replacement by dune sand. Deflated beaches fronting filled dunes provide poor erosion buffering capabilities and

are themselves a degraded environment with little to offer the normal coastal ecosystem and its host of organisms with beach-dependent life stages (including turtles, various marine larvae, and certain reef fishes) (Hawai‘i State HMP 2013).

Sand Mining

Sand mining is a presently outlawed, historic practice that refers to the process of collecting large amounts of coastal sands to produce building materials. The beaches in the State of Hawai‘i, especially the beaches on the Island of Maui, were subjected to sand mining for lime processing which was then baked to produce lime for use as a building material. Sand mining is in large part responsible for the retreat of both the vegetation line and the beach foreshore over recent decades along these beaches. Besides loss of vegetation and beach foreshore, sand mining impacts beaches negatively by decreasing sand volumes, steepening the morphology of the shoreline, and reducing the ability of beach profiles to respond to seasonal wave stresses (Hawai‘i State HMP 2013).

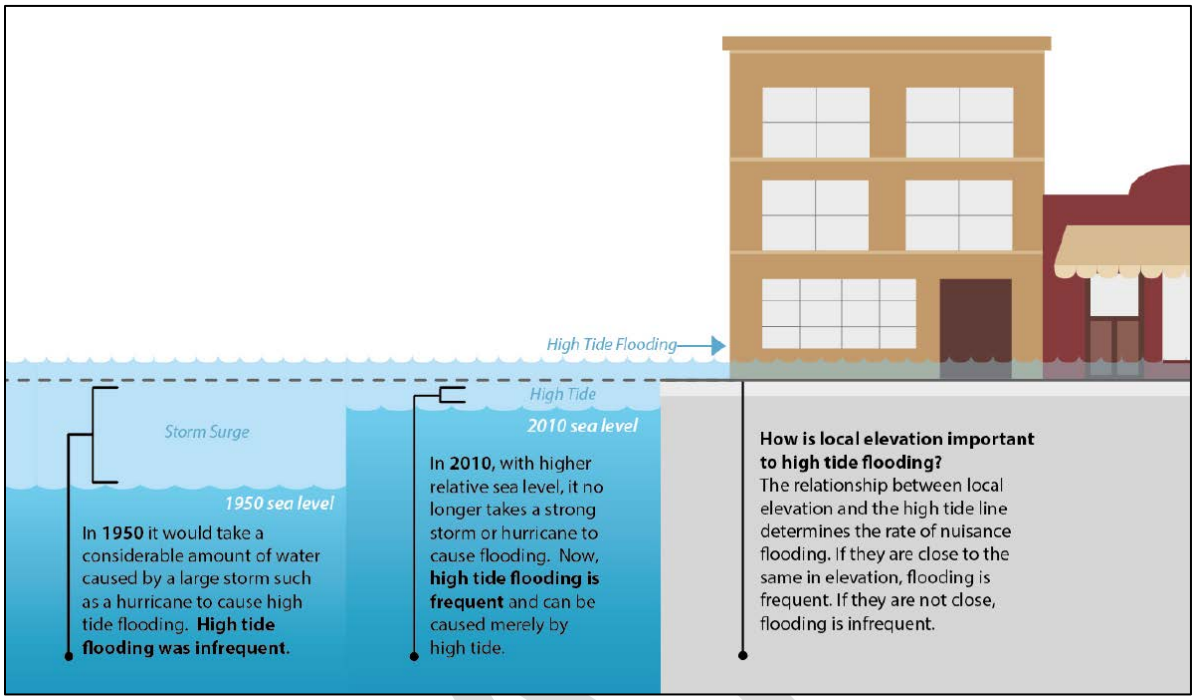
Canalization

Many streams that flow intermittently from Hawaiian mountain ranges to the coast are subject to flash flooding during heavy rainfall events. To prevent coastal zone flooding, the most hazardous of these streams have been canalized into concrete canals or gutters so that flooding is contained. Where canals and similar infrastructure open onto the coastal zone, the channel mouths tend to trap sand that is moving along the shoreline. The buildup of sand within the channel mouths increases the upstream flood hazard and creates a sand deficiency on the adjacent beach. Public works departments often clear these accumulations and dispose of the sand in various ways, including trucking it off-site to be used elsewhere (i.e. golf courses). Unless these sands are returned to the immediate beach area, the long-term dredging and clearing is nothing less than a sand mining effort and it will have a similar detrimental impact on the adjacent beach. This process has the potential to reduce available sand volumes and create chronic erosion where none previously existed. By placing cleared sands onto adjacent beaches, it is important to be aware of prevailing sediment transport patterns so that returned sand can function in a manner that will provide nourishment. To ensure proper adjacent beach replenishment, it is necessary to conduct reviews of the ambient littoral processes and develop schedules of transport direction around each channel mouth, with guidelines on the placement of returned sand (Hawai‘i State HMP 2013).

Tidal Flooding/King Tides

Tidal flooding, also known as sunny day flooding or high tide flooding, is the temporary inundation of low-lying areas during exceptionally high tide events, and causes public inconvenience (Figure 4.3-4). King tides is a non-scientific term used to describe exceptionally high tides, when high tides are higher than normal. In the State of Hawai‘i, higher-than-normal king tides occur during a full moon. These alignments in space and time are fairly predictable, and so are King tides (NOAA 2015; University of Hawai‘i Sea Grant 2018).

Figure 4.3-4. High Tide Flooding



Source: *NOAA 2018*
Notes: *National Oceanic and Atmospheric Administration*

Location

Chronic coastal flooding is occurring throughout the Hawaiian Archipelago in the main Hawaiian Islands and Northwestern Hawaiian Islands. Maps showing the location of chronic coastal flooding in the main Hawaiian Islands, depicted as the SLR-XA-1.1, as well as the individual component hazards, can be found on the Hawai'i Sea Level Rise Viewer located at: http://www.pacioos.hawaii.edu/shoreline/slr-hawaii/.

Areas that are more susceptible to chronic coastal flooding include low-lying areas along the coast as well as inland areas which are susceptible to groundwater flooding with sea level rise. Inland areas are also flooded because storm drains, that typically flow to the ocean, are backed up during high tides. The north and south shores of all the islands are subject to annual high wave events. The north shores of all islands are subject to extraordinary wave heights each winter, ranging between 20 and 40 feet due to north and northwestern swells. The south shore, on average, sees waves of 4 to 8 feet each summer from south and southwestern swells. High waves in Hawai'i are also generated by approaching storms, including tropical storms and hurricanes in the summer and fall, as well as winter Kona storms. Strong trade wind events also stir up high waves that influence the east-facing shorelines. Annual high waves from both north and south swells are common in the Hawaiian coastal zone and pose a significant hazard, especially where they break at the shoreline (USGS 2002).

The extent of chronic coastal flooding varies by county. Table 4.3-1 shows the hazard area in square miles and the percent of the total area located in the chronic coastal flood hazard area based on the SLR-XA-1.1. The City and County of Honolulu have the largest percent (1.4%) of land in the chronic coastal flood hazard area.

Table 4.3-1. Chronic Coastal Flood Hazard Area (SLR-XA-1.1) by County

County	Area		
	Total Area (square miles)	Chronic Coastal Flood Area (square miles)	Hazard Area as % of Total Area
County of Kaua‘i	630.3	4.6	0.7%
City and County of Honolulu	600.2	5.7	0.9%
County of Maui	1,174.6	4.7	0.4%
County of Hawai‘i	4,027.8	3.4	0.1%
Total	**6,432.9**	**18.3**	**0.3%**

Source: Hawai‘i Climate Change Mitigation and Adaptation Commission 2017
Note: Total area for each County calculated using coastline spatial layer downloaded from State of Hawai‘i GIS Program Geospatial Data Portal

EXTENT

The severity of any flood depends upon the type, cause, duration, and existing conditions (i.e., drainage design and pathways for water to exit). Flooding from severe rain events coupled with high tide flooding increases the severity chronic coastal flooding.

Warning Time

As defined, chronic coastal flooding is a continuum of daily, monthly, and annual occurrences. Warning times for high wave and tide events are available as high surf advisories and high tide advisories.

The National Weather Service (NWS) Honolulu Forecast Office uses the criteria for the issuance of high surf advisories and warnings in coordination with civil defense agencies and water safety organizations in the State of Hawai‘i (Table 4.3-2). Offshore wave sensors help provide adequate warning to approaching high waves with damaging potential throughout the State of Hawai‘i. The NWS Honolulu Forecast Office issues a surf forecast for the State of Hawai‘i. Surf heights are forecast heights of the face, or front, of waves. It is based on the significant wave height, the average height of the one-third largest waves, at the locations of the largest breakers. Some waves may be more than twice as high as the significant wave height.

Table 4.3-2. High Surf Advisory/Warning Criteria

Location	Advisory	Warning
North-Facing Shores	15 feet	25 feet
West-Facing Shores - Island of Hawai‘i	8 Feet	12 Feet
West-Facing Shores - Remaining Islands	12 Feet	20 Feet
South-Facing Shores	8 Feet	15 Feet
East-Facing Shores	8 Feet	15 Feet

Source: NWS 2016
Notes: All surf height observations and forecasts are for the full-face surf height, from the trough to the crest of the wave.
NWS National Weather Service

High tide flooding and King tides are fairly predictable due to their occurrence during new or full moons. NOAA’s tide predictions for the State of Hawai‘i, are based on the astronomical tide calendar and takes into account the

gravitational pull of the moon and sun on the Earth’s oceans. Using this information helps provide predictions as to when high tide flooding and King tides may occur and impact low-lying and coastal areas (NOAA 2015).

Previous Occurrences and Losses

The 2013 HMP discussed specific coastal erosion and high wave flooding events that occurred in the State of Hawai‘i through 2012. For this 2018 HMP Update, high wave flooding, coastal erosion, and tidal flooding/King tides were summarized between January 1, 2012, and December 31, 2017. For events prior to 2012, please refer to Appendix X. Table 4.3-3 includes details regarding major chronic coastal flooding that occurred in the State between 2012 and 2017. Major events include those that resulted in losses or fatalities, as reported by NOAA 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.

With flood documentation for the State of Hawai‘i being extensive, not all sources have been identified or researched. Additionally, loss and impact information for many events could vary depending on the source. Therefore, Table 4.3-3 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.

Table 4.3-3. Chronic Coastal Flooding Events in Hawai‘i, 2012 to 2017

Date(s) of Event	Event Type	Counties Affected	Description
January 3, 2012	High Surf	Honolulu	The County and City of Honolulu partially activated their EOC and opened shelters due to high surf.
November 4 to 7, 2012	High Surf	Kaua‘i, Maui, Hawai‘i, and Honolulu	A combination of swells generated surf of 15 to 25 feet along the north-facing shores of the Islands of Ni‘ihau, Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i; 8 to 14 feet along the west-facing shores of the Islands of Ni‘ihau, Kaua‘i, and Moloka‘i; and 6 to 10 feet along the east-facing shores of the Islands of O‘ahu and Hawai‘i. Lifeguards rescued several individuals who were overwhelmed by the dangerous surf.
December 24 to 26, 2012	High Surf	Kaua‘i, Maui, Hawai‘i, and Honolulu	A swell from a powerful low, far northwest of the islands generated surf of 15 to 25 feet along the north- and west-facing shores of the Islands of Ni‘ihau, Kaua‘i, and Moloka‘i; and the north-facing shores of the Islands of O‘ahu and Maui; and 10 to 15 feet along the west-facing shores of the Island of O‘ahu and north-facing shores of the Island of Hawai‘i. At least three people required assistance by paramedics after getting caught in the surf. Lifeguards performed numerous rescues and provided warnings to beach goers to stay away from the water.
January 17 to 22, 2013	High Surf	Kaua‘i, Maui, Hawai‘i, and Honolulu	A swell from a powerful low, far northwest of the islands generated surf of 15 to 30 feet along the north- and west-facing shores of the Islands of Ni‘ihau and Kaua‘i, and the north-facing shores of the Islands of O‘ahu, Moloka‘i, and Maui; 10 to 20 feet along the west-facing shores of the Islands of O‘ahu, Moloka‘i, and Maui; 10 to 15 feet along the west-facing shores of the Island of Hawai‘i; and 8 to 12 feet along the west-facing shores of the Islands of Lāna‘i and Kaho‘olawe. On the Island of Kaua‘i, there were two fatalities associated with this high surf event. Two men were swept away by the large waves on the north shore of the Island of Kaua‘i on January 18. On the Island of O‘ahu alone, lifeguards reported more than 2,000 safety actions as a result of this high surf event. Many beaches were closed for a time because of the rough conditions, and several roadways near the shoreline on the individual isles became covered with debris from waves breaking beyond the beach areas.
April 4 to 6, 2013	High Surf	Kaua‘i, Maui, Hawai‘i, and Honolulu	A swell from a powerful low, far northwest of the islands produced surf of 15 to 25 feet along the north- and west-facing shores of the Islands of Ni‘ihau and Kaua‘i, and the north-facing shores of the Islands of O‘ahu, Moloka‘i, and Maui; and 10 to 20 feet along the west-facing shores of the Islands of O‘ahu, Moloka‘i and Maui, and the north-facing shores of the Island of Hawai‘i. Lifeguards issued more than 1,000 warnings during the episode, and conducted several rescues of individuals overwhelmed by the pounding surf.
May 16 to 22, 2013	High Surf	Kaua‘i, Maui and Hawai‘i	A series of swells from the southern hemisphere generated surf of 6 to 10 feet along the south shores of all islands. Lifeguards were busy throughout the high surf episode. They provided many rescues, and warnings to inexperienced swimmers and surfers. On the Island of Maui, with the high surf, three sailing vessels broke free from their moorings and washed aground near Mala Wharf in Lahaina.

Date(s) of Event	Event Type	Counties Affected	Description
June 4 to 6, 2013	High Surf	Kaua‘i, Maui, Hawai‘i, and Honolulu	A long period swell from the southern hemisphere generated surf of 6 to 12 feet along the south-facing shores of all the main Hawaiian Islands. In a few instances, water from the high surf flowed over adjacent roads and deposited sand and other debris. Lifeguards rescued more than 100 surfers and swimmers and issued hundreds of warnings. One surfer died from injuries suffered at Ala Moana Bowls on the Island of O‘ahu on June 6. Another surfer sustained serious injuries while surfing at Sandy Beach.
October 20 to 21, 2013	High Surf	Kaua‘i, Honolulu, and Maui	A swell from a strong low, far northwest of the islands generated surf of 15 to 20 feet along the north- and west-facing shores of the Islands of Ni‘ihau and Kaua‘i; and 10 to 15 feet along the north-facing shores of the Islands of O‘ahu, Moloka‘i, and Maui. On October 21, three individuals were injured when they were swept away on a wave from the Shark’s Cove reef area on the Island of O‘ahu’s north shore. Ocean safety officials performed rescues, assists and preventative actions.
October 28 to 29, 2013	High Surf	Kaua‘i, Honolulu, and Maui	A swell from a strong low generated surf of 15 to 20 feet along the north- and west-facing shores of the Islands of Ni‘ihau and Kaua‘i; and 10 to 15 feet along the north-facing shores of the Islands of O‘ahu, Moloka‘i, and Maui. Ocean safety officials were busy with rescues, assists and preventative actions.
November 13 to 15, 2013	High Surf	Hawai‘i, Kaua‘i, and Honolulu	A swell from a powerful low north of the islands, in combination with a strong high far to the northwest, generated surf of 20 to 30 feet along the north-facing shores, and 10 to 20 feet along the east-facing shores of the Islands of Ni‘ihau, Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i. On November 13, a surfer was lost in the churning waters on the north shore of the Island of O‘ahu at Chun’s Reef. On the Island of Maui, the parking and pavilion areas of Baldwin Park in Pā‘ia were closed due to flooding from high surf wash up. Bayfront Highway on the Island of Hawai‘i was closed due to the high surf.
December 19 to 22, 2013	High Surf	Kaua‘i, Honolulu, Maui, and Hawai‘i	A swell from powerful low, far northwest of the islands produced surf of 20 to 30 feet along the north- and west-facing shores of the Islands of Ni‘ihau and Kaua‘i, and the north-facing shores of the Islands of O‘ahu, Moloka‘i, and Maui; 15 to 25 feet along the west-facing shores of the Island of Hawai‘i; and 10 to 15 feet along the west-facing shores of the Islands of O‘ahu, Moloka‘i, Lāna‘i, and Kaho‘olawe. Lifeguards issued over 4,800 warnings and rescued or assisted more than 50 people on the Island of O‘ahu. Two people were injured by the high surf. Additionally, on the Island of Hawai‘i, two boating facilities were damaged by high waves.
October 9 to 11, 2014	High Surf	Kaua‘i, Honolulu and Maui	A swell from a strong low, far northwest of the islands generated surf of 10 to 20 feet along the north- and west-facing shores of the Islands of Ni‘ihau and Kaua‘i; the north-facing shores of the Islands of O‘ahu, Moloka‘i, and Maui; and 8 to 14 feet along the west-facing shores of the Islands of O‘ahu and Moloka‘i. One person was injured when they were caught in the shore-break at Waimea Bay on the Island of O‘ahu’s North Shore. Ocean safety personnel performed 1,120 preventative actions, just on North Shore beaches alone.
July 25 to 28, 2015	High Surf	Honolulu	A swell from the southern hemisphere generated surf of 8 to 15 feet along the south-facing shores of all the islands. This was unusually high surf that led to lifeguards performing 3,000 preventative actions and 39 rescues on south and west shores of just the Island of O‘ahu alone. There were two deaths associated with this event.

Date(s) of Event	Event Type	Counties Affected	Description
October 27 to 31, 2015	High Surf	Maui, Honolulu, and Hawai‘i	A swell from a powerful low far northwest of the State of Hawai‘i generated surf of 15 to 25 feet along the north-facing shores of all the islands except Lāna‘i; 10 to 20 feet along the west-facing shores of the Islands of Ni‘ihau, Kaua‘i, O‘ahu, Moloka‘i, and Maui; and 8 to 12 feet along the west-facing shores of the Island of Hawai‘i. A large wave near Ka‘ena Point on the Island of O‘ahu swept three men into the water on October 27. One man died and the other two were injured. On the Island of Kaua‘i on the same day, a 33-foot sailing vessel ran aground in the high surf after its motor failed. The vessel beached on the west side of Hanalei Bay at Waipā. The boat's owner injured himself trying to leave the boat.
December 5 to 7, 2015	High Surf	Kaua‘i, Honolulu, and Maui	A swell from a powerful low, far northwest of the islands generated surf of 20 to 35 feet along the north-facing, and 10 to 20 feet along the west-facing, shores of the Islands of Ni‘ihau, Kaua‘i, O‘ahu, and Moloka‘i. Surf reached 20 to 35 feet along the north-facing shores of the Island of Maui as well. Lifeguards and other ocean safety officials provided assistance to surfers and other beachgoers in the rough conditions. One surfer nearly drowned at the Banzai Pipeline on the Island of O‘ahu’s North Shore due to dangerous surf.
February 21 to 29, 2016	High Surf and Coastal Erosion	Kaua‘i, Honolulu, Maui, and Hawai‘i	Large swells from the northwest generated surf of 20 to 40 feet, with sets as high as 55 feet, on the north- and west-facing shores of the Islands of Ni‘ihau and Kaua‘i, and the north-facing shores of the Islands of O‘ahu, Moloka‘i, and Maui; and 15 to 25 feet, with sets as high as 35 feet, on the west-facing shores of the Islands of O‘ahu and Moloka‘i, and the north-facing shores of the Island of Hawai‘i; and 8 to 12 feet along the west-facing shores of the Islands of Maui and Hawai‘i. The large surf also caused beach erosion and damaged roadways, inundated parking areas of coastal recreation areas, and closed beaches. One person was swept out to sea as a large wave broke where the person was taking pictures on the Island of Kaua‘i.
November 6 to 12, 2016	High Surf	Kaua‘i, Honolulu, Maui, and Hawai‘i	A swell from a powerful low far northwest of the islands produced surf of 25 to 40 feet along the north- and west-facing shores of the Islands of Ni‘ihau, Kaua‘i, and Moloka‘i; and the north-facing shores of the Islands of O‘ahu and Maui; and 20 to 30 feet along the west-facing shores of the Island of O‘ahu and the north-facing shores of the Island of Hawai‘i. One man drowned on November 8 on the north shore of the Island of Kaua‘i.
January 28 to 31, 2017	High Surf	Kaua‘i, Maui and Honolulu	Swells from powerful lows far northwest of the islands produced surf of 15 to 30 feet along the north- and west-facing shores of the Islands of Ni‘ihau and Kaua‘i, and the north-facing shores of the Islands of O‘ahu, Moloka‘i, and Maui; and 10 to 20 feet along the west-facing shores of the Islands of O‘ahu and Moloka‘i. A young woman drowned in the high surf on the Island of Kaua‘i on January 30.
May 5 to 26, 2017	King Tide / High Surf	Kaua‘i, Maui, Hawai‘i, and Honolulu	The State of Hawai‘i EOC was partially activated due to King tides and high surf.

Sources: FEMA 2017, NOAA-NCEI 2017, Storm Prediction Center 2017, State of Hawai‘i 2017
EOCEmergency Operations Center
FEMA Federal Emergency Management Agency
Mph Miles Per Hour

NCEI	*National Centers for Environmental Information*
NOAA	*National Oceanic and Atmospheric Administration*

FEMA Disaster Declarations

Between 1954 and 2017, FEMA included the State of Hawai‘i in five chronic coastal-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe storms, high wave flooding, flooding, heavy rains, and land/mudslides. 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). During the 2018 HMP Update performance period, the State has not had any declared disasters or emergencies related to the chronic coastal flood hazard. For details regarding all declared disasters, refer to Section 4.0 (Risk Assessment).

Probability of Future Hazard Events

Over time, recurring flooding at the highest tides in low-lying areas leads to chronic flooding and then to permanent flooding and permanent loss. Overall, the probability of future chronic coastal flooding will increase with increasing sea level rise and punctuated by severe flood events.

Coastal erosion exacerbates flooding and inundation resulting in the permanent loss of beaches and dry land which will become submerged at increasing rates due to sea level rise. Shoreline recession and beach loss due to coastal erosion is already a severe problem along the State of Hawaii’s coastline, threatening shorefront development and infrastructure. Statewide, 70% of the State of Hawaii’s shorelines have retreated over years to decades (Hawai‘i Climate Adaptation Portal 2017). The return period of an episodic erosion event is directly related to the return period of a coastal storm, hurricane or tropical storm.

High wave flooding events occur frequently on the coasts of all islands in the State of Hawai‘i. Events that actually cause damage to property or loss of human life are far less common. During the time period from January 1, 2012, to December 31, 2017, high surf conditions and impacts existed continuously in the State of Hawai‘i. Based on the history of high wave flooding in the State, the State of Hawai‘i can expect high wave flooding events on an ongoing basis, with an increase in events during coastal storms.

The probability of tidal flooding/King tides is linked to both the lunar cycle and proximity to a tidal area. Low-lying areas in the State of Hawai‘i have the highest probability of experiencing regular flooding from tides and King tides. As the sea level rises, these areas will become more vulnerable to regular flooding from daily and monthly high tides and King tides. The greatest potential for flooding from King tides occurs for a couple of days around the new moons (University of Hawai‘i Sea Grant 2018).

Potential Impacts of Climate Change on Probability of Future Events

The frequency, extent and severity of chronic coastal flooding will increase with sea level rise. The sea level rise is expected to increase over 3 feet within the 21st Century. For the 2018 HMP update, mid- to late century sea level rise on chronic coastal flooding was assessed using the SLR-XA with 3.2 feet of sea level rise (SLR-XA-3.2). Statewide impacts are discussed further in Section 4.2 (Climate Change and Sea Level Rise). Overall, the loss of land and structures will take the form of incrementally eroding beaches, waterfront property inundated by increasingly high tides and by seasonal waves that reach farther inland, and low-lying areas becoming wetlands because of rising water tables and reduced drainage. The estimated total amount of land loss is less than 1% of the State’s total land area; however, much of this land is located in high density urban, commercial, and industrial

districts leading to great potential economic loss for the State (Hawai'i Climate Change Mitigation and Adaptation Commission 2017).

4.3.2 Vulnerability Assessment

To assess the State's risk to the chronic coastal flood hazard, the SLR-XA-1. 1, developed for the *Hawai'i Sea Level Rise Vulnerability and Adaptation Report,* was used. Overall, vulnerability to chronic coastal flooding is assessed as chronic flooding with the potential permanent loss of assets and displacement of population located in the SLR-XA-1.1 hazard area.

Chronic Coastal Flood Hazard Area Definition

SLR-XA 1.1 – *To assess vulnerability to chronic coastal flooding the area generated by modeling of passive flooding, annual high wave flooding and coastal erosion (known as the SLR-XA) with 1.1 feet of sea level rise was used. The hazard area is called SLR-XA-1.1.*

Assessment of State Vulnerability and Potential Losses

This section discusses statewide vulnerability of exposed state assets (state buildings and state roads) and critical facilities to the chronic coastal flooding hazard.

State Assets

The exposure analysis determined there are 8 state buildings located in the chronic coastal hazard area; of which the greatest number are in the City and County of Honolulu (6 buildings with a replacement cost value of $30 million). The majority of these buildings (six) are occupied by the Department of Human Services and Department of Land and Natural Resources. Over time, recurring flooding at these locations may lead to the permanent loss of these structures. Only replacement cost value was available for state buildings; this was the best available data and therefore, this value is reported as the estimated total loss. However, a more accurate reflection of loss to the chronic coastal flood hazard would be the combine value of the land and structure. Table 4.3-4 summarizes the state buildings located in the chronic coastal flood area by county. Table 4.2-5 summarizes the state buildings by state agency.

Table 4.3-4. State Buildings Loss to the SLR-XA-1.1 by County

County	Total Number of State Buildings	Total Value	Located in the SLR-XA-1.1			
			Number	% of Total	Total Value	% of Total
County of Kaua'i	531	$957,679,537	0	0%	$0	0%
City and County of Honolulu	3,472	$16,750,785,426	6	<1%	$30,412,601	<1%
County of Maui	831	$2,862,316,819	2	<1%	$370,372	<1%
County of Hawai'i	1,261	$4,209,774,236	0	0%	$0	0%
Total	**6,095**	**$24,780,556,017**	**8**	**<1%**	**$30,782,973**	**<1%**

Source: Hawai'i State Risk Management Office 2017
Value = Replacement Cost of the building; does not include land value which may be underestimating the loss due to the SLR-XA-1.1

Table 4.3-5. State Building Loss to the SLR-XA-1.1 by Agency

Agency	Total Number of State Buildings	Total Value	Number of State Buildings in SLR-XA-1.1	Percent (%) of Total Buildings	Value in the SLR-XA-1.1	Percent (%) of Total Value
Dept of Accounting & General Services	66	$946,504,656	0	0.00%	$0	0.00%
Dept of Agriculture	70	$133,065,375	1	1.43%	$2,040,456	1.53%
Dept of Attorney General	15	$95,151,863	0	0.00%	$0	0.00%
Dept of Budget & Finance	16	$26,624,294	0	0.00%	$0	0.00%
Dept of Business, Economic Development and Tourism	25	$612,574,032	0	0.00%	$0	0.00%
Dept of Commerce & Consumer Affairs	2	$35,611,360	0	0.00%	$0	0.00%
Dept of Defense	69	$246,099,477	0	0.00%	$0	0.00%
Dept of Education	4,090	$9,604,111,443	0	0.00%	$0	0.00%
Dept of Hawaiian Home Lands	12	$100,471,477	0	0.00%	$0	0.00%
Dept of Health	44	$387,068,440	0	0.00%	$0	0.00%
Dept of Human Resources Development	1	$5,523,320	0	0.00%	$0	0.00%
Dept of Human Services	130	$420,004,555	2	1.54%	$2,839,820	0.68%
Dept of Labor and Industrial Relations	22	$79,322,626	0	0.00%	$0	0.00%
Dept of Land and Natural Resources	90	$98,666,185	2	2.22%	$370,372	0.38%
Dept of Public Safety	154	$427,884,909	0	0.00%	$0	0.00%
Dept of Taxation	1	$6,864,408	0	0.00%	$0	0.00%
Dept of Transportation	68	$2,912,510,888	1	1.47%	$3,368,912	0.12%
Hawai'i State Ethics Commission	1	$891,212	0	0.00%	$0	0.00%
Hawai‘i Health Systems Corporation	106	$1,223,962,810	0	0.00%	$0	0.00%
Hawai‘i Housing Finance & Development Corporation	86	$333,526,064	0	0.00%	$0	0.00%
Hawai‘i Public Housing Authority	273	$933,255,767	1	0.37%	$5,340,000	0.57%
Hawai‘i State Legislature	2	$43,024,855	0	0.00%	$0	0.00%
Hawai‘i State Public Library System	53	$525,584,082	0	0.00%	$0	0.00%
Judiciary	41	$511,093,204	0	0.00%	$0	0.00%

Agency	Total Number of State Buildings	Total Value	Number of State Buildings in SLR-XA-1.1	Percent (%) of Total Buildings	Value in the SLR-XA-1.1	Percent (%) of Total Value
Legislative Reference Bureau	1	$2,686,408	0	0.00%	$0	0.00%
Office of Hawaiian Affairs	11	$53,991,251	0	0.00%	$0	0.00%
Office of the Auditor	2	$1,789,788	0	0.00%	$0	0.00%
Office of the Governor	1	$2,686,408	0	0.00%	$0	0.00%
Office of the Lieutenant Governor	2	$3,977,640	0	0.00%	$0	0.00%
Office of the Ombudsman	1	$1,620,944	0	0.00%	$0	0.00%
Research Corporation of the University of Hawai'i	3	$3,713,497	0	0.00%	$0	0.00%
University of Hawai'i	637	$5,000,692,783	1	0.16%	$16,823,413	0.34%
Total	**6,095**	**$24,780,556,017**	**8**	**0.13%**	**$30,782,973**	**0.12%**

Source: Hawai‘i State Risk Management Office 2017
Value = Replacement Cost of facility; does not include land value which may be underestimating the loss due to the SLR-XA-1.1

Roads provide a vital transportation link between populated areas on the Hawaiian Islands. Approximately 15 miles of state roads are located within the SLR-XA-1.1 hazard area. These state roads will become potentially impassable, jeopardize critical access and isolate communities. Loss of road use may result in regional issues such as loss of commerce and increased traffic on other roads and highways. Utility lines commonly follow roads and those located underground may be impacted resulting in disruption of services.

Table 4.3-6 shows the length of state roads in the hazard area by county. The City and County of Honolulu has the greatest length of roads (6.4 miles) exposed, followed by the County of Maui (4.8 miles) and County of Kauai (3.8 miles). A complete list of state roads exposed to the chronic coastal flood hazard is included in Appendix X.

Table 4.3-6. State Road Exposure to the SLR-XA-1.1 by County

County	Length (in miles)		
	Total Length	Length of Road in the SLR-XA-1.1	Percentage (%) of Total Length
County of Kaua‘i	104.0	3.8	3.6%
City and County of Honolulu	375.3	6.4	1.7%
County of Maui	238.6	4.8	2.0%
County of Hawai‘i	378.7	0.2	0.1%
Total	**1,096.5**	**15.2**	**1.4%**

Source: State of Hawai‘i SDOT State Routes GIS layer 2017
Notes: GIS Geographic Information System
SDOT State Department of Transportation

Critical Facilities

Table 4.3-7 summarizes the total number by core category of critical facilities located in the chronic coastal flooding by county. The County of Maui has 5 critical facilities located in the chronic coastal flood hazard area; three facilities are categorized as water, waste and wastewater system facilities; one is a communication facility and one is an emergency service critical facility. Table 4.3-8 summaries the critical facilities exposure by core category. Overall, the emergency services category has the greatest exposure (2.4% of total value) to the chronic coastal flood hazard. Similar to state buildings, only replacement cost value of the facility was available for critical facilities and does not include the value of the land; therefore, this value is reported as the total loss. However, a more accurate reflection of loss to the chronic coastal flood hazard would be the combine value of the land and structure using tax-assessed data. Further, the loss of service of that critical facility would increase the total loss from the hazard.

Table 4.3-7. Critical Facilities by County Located in the SLR-XA-1.1

County	Number of Critical Facilities by Core Category										Total in the SLR-XA-1.1
	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	0	0	0	0	0	0	0	0	0	0	0
City and County of Honolulu	0	0	2	0	0	0	0	0	0	1	3
County of Maui	0	1	1	0	0	0	0	0	0	3	5
County of Hawai'i	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**1**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**8**

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

Table 4.3-8. Critical Facilities by Core Category Located in the SLR-XA-1.1

Category	Total Number of Critical Facilities	Total Value	Number of Critical Facilities in SLR-XA-1.1	Percent (%) of Total Facilities	Value in the SLR-XA-1.1	Percent (%) of Total Value
Commercial Facilities	60	$206,894,206	0	0.0%	$0	0.0%
Communications	130	$523,848,060	1	0.8%	$8,332,280	1.6%
Emergency Services	149	$1,017,628,710	3	2.0%	$24,455,750	2.4%
Energy	90	$2,591,975,628	0	0.0%	$0	0.0%
Food & Agriculture	39	$829,869,410	0	0.0%	$0	0.0%
Government Facilities	100	$399,781,575	0	0.0%	$0	0.0%
Healthcare & Public Health	193	$3,399,521,375	0	0.0%	$0	0.0%
Mass Care Support Services	353	$11,497,547,155	0	0.0%	$0	0.0%
Transportation Services	56	$1,739,256,960	0	0.0%	$0	0.0%

Category	Total Number of Critical Facilities	Total Value	Number of Critical Facilities in SLR-XA-1.1	Percent (%) of Total Facilities	Value in the SLR-XA-1.1	Percent (%) of Total Value
Water, Waste, & Wastewater Systems	305	$9,481,445,760	4	1.3%	$123,832,320	1.3%
Total	**1,475**	**$31,687,768,838**	**8**	**0.5%**	**$156,620,350**	**0.5%**

Source: Makani Pahili 2017 Emergency Power Prioritization Workshop Series final report; Hazus v4.2
Value = Replacement Cost of the facility; does not include land value which may be underestimating the loss due to the SLR-XA-1.1

Critical transportation hubs and critical infrastructure located on the coast are exposed to chronic coastal flooding. As summarized in Section 4.2 (Climate Change), the primary transportation arteries for the entry of people and goods to the State is the Daniel K. Inouye International Airport and Honolulu Harbor. In addition, each island has critical points of entry for people and goods which are considered vulnerable to chronic coastal flooding if located along the coast. Interruption of interisland and transoceanic shipping and travel would impact residents, visitors and all forms of economic activity (Hawai'i Climate Mitigation and Adaptation Commission 2017).

Assessment of Local Vulnerability and Potential Losses

This section provides a summary of vulnerability and potential losses to population, general building stock, and environmental assets and cultural resources by county. Similar to the analysis for state assets, a spatial exposure analysis was conducted. As noted above, vulnerability to chronic coastal flooding is assessed as chronic flooding with the potential permanent loss of assets and displacement of population located in the SLR-XA-1.1 hazard area.

Population

People living and working in the chronic coastal flood hazard area may be displaced as homes and businesses become flooded and permanently lost. According to the 2017 *Hawai'i Sea Level Rise Vulnerability and Adaptation Report*, statewide, an estimated 4,160 people may be displaced as a result of the potential permanent loss to structures and land in the SLR-XA-1.1 hazard area (Table 4.2-9). The analysis indicates that the City and County of Honolulu has the greatest number of people that may be displaced, and County of Kaua'i has the greatest percent population that may be displaced (1.5%).

Table 4.3-9. Estimated Population Displaced by the Chronic Coastal Flood Hazard

County	Total Population	Displaced Population	Percent (%) of Total Population
County of Kaua'i	67,091	1,000	1.5%
City and County of Honolulu	953,207	2,000	<1%
County of Maui	154,924	710	<1%
County of Hawai'i	185,079	450	<1%
Total	**1,360,301**	**4,160**	**<1%**

Source: Hawai'i Climate Mitigation and Adaptation Commission 2017

According to the 2013 HMP, the greatest number of deaths, injuries and rescues in the Hawaiian Islands are from high waves breaking at the shoreline. High surf, resulting from dangerous and damaging waves, is typically described as waves ranging in height from 10 feet to 20 feet or more. These waves result from storms passing

across the higher latitudes of the Northern and Southern Hemispheres in addition to storms passing across the Central Pacific in proximity to the Hawaiian Islands.

Land Use Districts

Table 4.3-10 shows the number of square miles in each State Land Use District statewide exposed to the chronic coastal flood hazard areas; refer to Appendix X for results by County. Conservation District lands will experience the greatest total loss of area from chronic coastal flooding in the near-term. Conservation District Lands contain valuable environmental resources. Additional discussion of exposure and vulnerability of these resource areas can be found in the subsection below. Urban District areas, where populations and development are concentrated, will lose the greatest percentage of total land area to chronic coastal flooding in the near-term. The loss of land will be greatest in the City and County of Honolulu where 2.8 square miles or 1.7% of the Urban District lands will be lost if no adaptation measures are taken. In the County of Maui 1.2 square miles or 2.8% of Urban District lands will be lost.

Table 4.3-10. State Land Use Districts Located in the SLR-XA-1.1

Land Use District	Total (square miles)	Square Miles in the SLR-XA-1.1	% of Total Area
Agricultural	2,942.8	3.0	0.1%
Conservation	3,156.3	9.9	0.3%
Rural	16.1	0.2	1.4%
Urban	319.7	5.3	1.7%
Total	**6,434.9**	**18.4**	**0.3%**

Source: Hawai'i Climate Mitigation and Adaptation Commission 2017; State Land Use Commission, 2016
Notes: Total area calculated from the State of Hawai'i State Land Use District GIS layer
Hazard area clipped to coastline 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.
GIS Geographic Information System

General Building Stock

The 2017 *Hawai'i Sea Level Rise Vulnerability and Adaptation Report* calculated the estimated potential loss to both structure and land by island; as both the structures and land may become permanently inundated due to the chronic coastal flood hazard over time. These calculations were totaled by county with an estimated economic loss of $6.9 billion statewide.

Table 4.3-6. Estimated Structure and Property Value (Structure and Land) Loss from SLR-XA-1.1 by County

County	Number of Structures in the SLR-XA-1.1	Estimated Structure and Land Value Located in the SLR-XA-1.1
County of Kaua'i	170	$763,000,000
City and County of Honolulu	650	$4,100,000,000
County of Maui	732	$1,839,000,000
County of Hawai'i	30	$195,000,000
Total	**1,582**	**$6,897,000,000**

Source: Hawai'i Sea Level Rise Vulnerability and Adaptation Report, 2017

Environmental Resources

The loss of natural resources statewide is difficult to quantify; however, their loss would deeply cost the State. Parks and beaches play a critical role in recreation, employment and the local economy. In addition, wetland areas and coastal habitats are vital to the environment and may be altered through chronic coastal flood conditions. As discussed in Section 4.2 (Climate Change and Sea Level Rise), chronic coastal flooding has the potential to impact facilities that could release wastewater or hazardous materials and waste to nearshore waters and coastal habitats. Septic tanks, cesspools, and other on-site sewage disposal systems (OSDS) as well as other hazard materials/waste storage and disposal sites are located along the coast.

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 chronic coastal flooding. The area of each environmental asset located in the SLR-XA-1.1 hazard area was calculated and summarized by county (Table 4.3-7).

Table 4.3-7. Environmental Resources Located in the SLR-XA-1.1

Environmental Asset	Total Square Miles of Asset	Asset Area in the SLR-XA-1.1	Percent (%) of the Total Asset Area
Critical Habitat[a]	915.2	1.2	0.1%
Wetlands	260.0	9.8	3.8%
Parks and Reserves	2,607.7	4.3	0.2%
Total[b]	**3,837.6**	**70.1**	**1.8%**

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

Coastal portions of the Hawaiian Home Lands are vulnerable to chronic coastal flooding which may displace Native Hawaiian families that live in this area. Table 4.3-8 summarizes the area of the Hawaiian Home Lands located in the chronic coastal flood hazard area. In addition, many Native Hawaiian cultural and historical resources are located near the shoreline and threatened by flooding and beach erosion. This includes fishing and cultural practices that take place along the shore. The 2017 *Hawai'i Sea Level Rise Vulnerability and Adaptation Report* summarizes cultural sites located in the SLR-XA-1.1 hazard area.

Table 4.3-8. Hawaiian Home Lands Located in the SLR-XA-1.1

County	Area (in square miles)		
	Total Area	Asset Area in the SLR-XA-1.1	Percent (%) of Total Area
County of Kaua'i	32.0	< 1	< 1%
City and County of Honolulu	10.9	< 1	< 1%

County	Area (in square miles)		
	Total Area	Asset Area in the SLR-XA-1.1	Percent (%) of Total Area
County of Maui	92.6	< 1	< 1%
County of Hawai'i	190.3	< 1	< 1%
Total	**325.8**	**< 1**	**< 1%**

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

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.

Chronic coastal flood areas were overlain on areas that may experience significant changes in development or redevelopment in future years (see Table 4.3-9 below; refer to Section 3 for more information on projected development areas). Only very small amounts of the HCDA Community District Areas and Maui Development Projects intersect with these areas. Larger portions of the Enterprise Zone areas in each county are exposed; however, exposure is still less than 1% of the total area of these zones. Care should be taken to not increase development in these Chronic Coastal Flood Areas as the incidence of flooding and/or erosion will increase over time. It is likely; however, that existing rules and regulations in the State, such as shoreline setback regulations (see Section 5 for more information) already prohibit or strictly regulate most new development in these areas. It is possible that chronic flooding conditions may exist outside of existing regulated areas if chronic flooding is a result of stormwater system failure due to higher than design level tidal flooding or in very flat areas where chronic flooding may extent further inland. Potential or projected development exposed to risk from long-term coastal flooding as it will be further exacerbated by climate change is discussed in Section 4.2 (Climate Change and Sea Level Rise).

Table 4.3-9. HCDA Community Development Districts, Maui Development Projects, and Enterprise Zones Located the SLR-XA-1.1

County	Area (in square miles)								
	HCDA Community Development Districts	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
County of Kaua'i	-	-	-	-	-	-	252.3	2.7	1.1%
City and County of Honolulu	7.4	0.1	1.7%	-	-	-	288.3	2.4	0.8%
County of Maui	-	-	-	27.6	0.0	0.1%	1,016.7	4.0	0.4%

County	Area (in square miles)								
	HCDA Community Development Districts	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
County of Hawai‘i	-	-	-	-	-	-	1,286.6	2.5	0.2%
Total	**7.4**	**0.1**	**1.7%**	**27.6**	**0.0**	**0.1%**	**2,844**	**12**	**0.4%**

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