Multi-Hazard Pre-Disaster Mitigation Plan
For The
City & County of Honolulu

January 31, 2020

Prepared For

Department of Emergency Management
City & County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

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Multi-Hazard Pre-Disaster Mitigation Plan
City & County of Honolulu
2020
Executive Summary

Prepared For

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EXECUTIVE SUMMARY
Multi-Hazard Pre-Disaster Mitigation Plan of the City & County of Honolulu

The Purpose of Hazard Mitigation

The amount of damage during major disasters as a consequence of natural hazards in the State of Hawaii is tending to rise as evidenced by the cost of recent disasters. As the direct and indirect costs of disasters continue to rise, it becomes particularly critical that preparing for these events include actions and policies to reduce the amount of damage. Hazard mitigation is action taken to permanently reduce long-term risk to people and their property. The purpose of multi-hazard mitigation is twofold: 1) to protect people and structures from harm and destruction; and 2) to minimize the costs of disaster response and recovery. Hazard mitigation planning is the process that analyzes a community's risk from natural hazards, coordinates available resources, and implements actions to reduce risks. The purpose of this multi-hazard mitigation plan is to provide a strategy to reduce loss of property or life caused by natural hazard events for the City and County of Honolulu (City). A multi-hazard strategy presented in this plan addresses the relationship among various types of hazards, evaluates the effects of climate change, and prioritizes mitigation policies, actions, and projects.

Mitigation Goals

The goals of the hazard mitigation plan are to eliminate or reduce risk through the following:

1. Continually strive to improve the state of the art for the identification of hazard areas, risk assessment capabilities, warning systems, and effective response and recovery.
2. Plan, design, and construct future development and retrofit existing structures within hazard areas to become resilient and minimize losses.
3. Ensure that all emergency response critical facilities, communication systems, information technology data networks, and broadband internet connectivity remain operational during and after hazard events.
4. Ensure that all lifeline and information technology infrastructures are able to withstand hazard events or have contingency plans to quickly recover after a disaster.
5. Develop public guidance for the need to shelter in residences that are strengthened as necessary and outside of areas that are subject to flooding, or in alternative resilient structures. Provide pre- and post-disaster emergency shelters to accommodate residents and visitors that are not able to shelter in place.
6. Develop a high level of awareness among the general public and businesses, particularly the visitor industry, that results in calm and efficient evacuations, self-sufficient survival skills, and willingness to abide by preventive or property protection requirements.
7. Minimize post-disaster recovery disruption by developing systems for efficient clean-up, documentation of damage and injury, and processing of appropriate aid to rebuild businesses and the economy.
8. Protect natural and cultural resources that buffer hazard effects to the extent practicable.

Hazard Mitigation Planning and Plan Development

Hazard mitigation planning is the process that analyzes a community's risk from natural hazards, evaluates existing measure and identifies gaps, and implements actions to further reduce risks. Since November 1, 2003, local governments seeking Pre-Disaster Mitigation (PDM) funds through a State application must have an approved local mitigation plan prior to the approval of local mitigation project grants. Since November 1, 2004, States must also have an approved Standard State Mitigation Plan in order to receive PDM funds for State or local mitigation projects. The Standard State Mitigation Plan will also be required for non-emergency assistance provided, including Public Assistance restoration of damaged facilities and Hazard Mitigation Grant Program (HMGP) funding. Therefore, State and local multi-hazard mitigation plans are keys to maintaining eligibility for future Federal Emergency Management Agency (FEMA) mitigation and disaster recovery funding. County plans must be updated every five years to continuously maintain funding eligibility.

Initiated by Department of Emergency Management (DEM), the development of the Multi-Hazard Pre-Disaster Mitigation Plan (Plan) for Honolulu involved a significant broad-based participation to include the Mayor, the City Council, the City's Office of Climate Change, Sustainability and Resiliency (CCSR), the Honolulu Climate Change Commission, other City department representatives, the Plan's Advisory Committee, community organizations such as the Cross Island Communities Resilience Network (CICRN), Hawaii Emergency Management Agency (HI-EMA), the Department of Land and Natural Resources (DLNR), the State Hazard Mitigation Forum, Hawaiian Electric Company (HECO) and National Oceanic and Atmospheric Administration (NOAA) Central Pacific Hurricane Center (CPHC).

Land Use Planning and Development in the City & County of Honolulu

The City guides and directs land use and growth through a three-tier system of objectives, policies, planning principles, guidelines and regulations. The General Plan forms the first tier of this system, consisting primarily of statements of objectives and policies. The second tier of the system is formed by regional development plans or sustainable communities plans, the titles of which are determined by the extent of planned development in the regions These plans address eight geographic regions of the island: the Primary Urban Center, Central Oahu, Ewa, Waianae, North Shore, Koolauloa, Koolaupoko and East Honolulu. The third tier of the system is composed of the implementing ordinances, including the Land Use Ordinance (Honolulu's zoning code) and the City's Capital Improvement Program. Mandated by the City Charter, these ordinances constitute the principal means for implementing the City's plans. The tiers are supplemented with functional plans for the countywide water and wastewater systems and transportation. There is a high priority need to integrate natural hazard policies into the General Plan & Community Development Plans.

Identifying and Profiling Hazard Events

Hazards are physical conditions or events that have the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of losses. The intent of this document is to present the current state of knowledge of natural hazards significant within the City & County of Honolulu. Hazards assessed in this plan include:

Climate Change Effects	Chapter 4
Coastal Erosion	Chapter 5
Strong Winds (Non tropical cyclonic)	Chapter 6
Tropical Cyclones (including Hurricanes)	Chapter 7
Floods	Chapter 8
Tsunamis	Chapter 9
Earthquakes	Chapter 10
Landslides and Rock Falls	Chapter 11
Droughts	Chapter 12
Wildfire	Chapter 13
Hazardous Materials	Chapter 14
Dam Failures	Chapter 15
VOG (Volcanic Gases)	Chapter 16

Note: Chapter 14, 15, and 16 are provided in addition to the hazards required by FEMA.
In addition, there is a nonmandatory Chapter 17 summarizing the status of emergency shelters.

Detailed information is given in these chapters on previous occurrences of natural hazard events and analysis of probable future losses where possible. A very brief synopsis of each follows:

Climate Change Effects

Climate variability and climate change can each result in hazards, or they can exacerbate and facilitate impacts from other hazards included in this Plan. Changes in Sea Surface Temperatures (SST) and climatic circulation patterns may affect a northward shift in the distribution of storm tracks; thus, the hazard for hurricanes and storm surge/wave setup inundation is not stationary over time. Simulations indicate that the hurricane inundations of the south shore would be significantly increased in extent due to climate change effects on hurricane intensities and sea level rise. Rainfall during tropical cyclones is also anticipated to intensify. Sea level rise (combined with land subsidence) can result in higher apparent sea level (relative to a point on land), and this can exacerbate inundation, especially for low-lying areas subject to hurricanes and high surf. The intent of this chapter is to enable a basic understanding of the characteristics of climate variability and change that better inform risk management decisions discussed in the other chapters. Adaptive design should be incorporated into policy for all infrastructure projects to accommodate climate change effects. This plan includes a number of other regulatory measures to implement. Some of these measures require the development of design maps that would show the expected future shoreline, the expected future hurricane inundations. The methodology for how to develop the expected future probabilistic hurricane inundation maps has been established in a pilot study sponsored by the State Office

of Planning. This chapter has been specifically reviewed by the CCSR for compatibility with the Resilient Oahu Strategy. It has also been reviewed by members of the Honolulu Climate Change Commission.

Coastal Erosion

The beaches of Hawaii are vital economic, environmental, and cultural resources. A healthy, wide sandy beach provides some mitigation of the effects of storm surge, flooding, and high surf. Coastal erosion and beach loss are chronic problems on Oahu. Typical erosion rates in Hawaii are in the range of 15-30 cm/yr. Studies on Oahu have shown that nearly 24% or 17 miles of an original 72 miles of sandy shoreline (1940s) has been either significantly narrowed or lost. The cost of the beach loss at Waikiki has been estimated to be about $1 million per year, in order to maintain the beach in its current state. Island-wide annual losses are estimated at the equivalent of $2 million to $3 million per year. It is recommended that setbacks should incorporate each area's rate of shoreline erosion, with due diligence consideration of each area's geology and local soil conditions inland.

Strong Winds

Most wind storms are either from trade-winds (70% of the time) or Kona winds (30% of the time). Trade-winds predominate from the northeast and generally range from 10 – 25 miles per hour, although occasional extreme events reach 40 - 50 miles per hour when the sub-tropical high pressure cell north of the islands intensifies. Damaging Kona winds have reached velocities of 50 miles per hour for several days on end. Topographic wind speed-ups exacerbate the risk.

Tropical Cyclones (and Hurricanes)

The most severe source of damaging winds are tropical cyclones, large circulating windstorms that form over warm tropical ocean water. Tropical cyclones generally occur during the season between June 1 and November 30. Depending on sustained windspeeds, they are categorized as tropical depressions, tropical storms or hurricanes; during Hurricane Iwa in 1982, Oahu did experience tropical storm winds. To be classified as a hurricane, the sustained wind speeds must exceed 74 miles per hour. Potential hurricane landfalls would be the most damaging events on Oahu and result in the greatest losses from a natural disaster. In August 2018, Oahu was at risk to Hurricane Lane but narrowly escaped its damaging winds due to vertical wind shear effects. Based on regional simulations, the average annual odds of hurricanes of different intensity categories affecting Oahu are given in Table 1. Under these odds, Oahu had about an even chance of receiving hurricane windspeeds over the last 60 years. Thus, it is not considered unusual that Oahu has not yet experienced hurricane-force winds from a tropical cyclone in recent decades. However, the risk is high due to the large numbers of vulnerable structures on Oahu.

Most of the existing residential structures in Hawaii are under-designed for high winds, depending on their construction type, age and location. Terrain or topographic amplification of wind speed has been a significant additional contributing factor in the past hurricane loss experiences of Hawaii. The equivalent average annual hurricane losses due to wind damage on Oahu are projected to be $410 million per year, making tropical cyclones to be the more severe risk to Oahu. Timely periodic updates of the Honolulu

Building Code would be the most effective means over time of improving overall community resilience against hurricanes. Incentives for retrofitting of older vulnerable housing would also be beneficial.

Table 1. Hurricane Annual Odds of Occurrence by Saffir Simpson Category Incorporating NASA and HHRF Sponsored Research

Hurricane Category	Sustained Wind	3-sec. Peak Gust	Oahu-Affected Annual Odds
1	74 to 94 mph	81 to 105 mph	1 in 133
2	94 to 110 mph	106 to 121 mph	1 in 200
3 or greater	110 to 155 mph	122 to 171 mph	1 in 400
Any Hurricane	Greater than 74 mph	Greater than 81 mph	1 in 80

Floods

The major flooding events in Hawaii are caused by storms, storm surge, high surf and tsunamis. High waves from hurricanes most often hit the eastern shores as hurricanes approach the islands from the east, and south- and west-facing shorelines as the storm passes to the south and west. In the City, from about 1915, floods caused by rainstorms, including tsunamis and hurricanes, have claimed more than 140 lives and inflicted more than $225 million dollars of direct and indirect damage. Some of the largest rainfall counts and most severe flooding events have occurred in the last several years, with the Kauai and East Oahu floods in April 2018 alone causing an estimated $20 million in damage to public infrastructure on Oahu. In the long-term, floods, from either rainfall or tropical cyclone storm surge and waves, have an estimated average risk equivalent to $41 million in damage losses per year. Design of essential and critical facilities should incorporate a 500-year flood level. The electrical code should incorporate special requirements to keep electrical equipment of essential and critical facilities protected from flooding. Homeowners in the flood zones could benefit from reduced insurance premiums if the City participated in FEMA's Community Rating System (CRS).

Tsunamis

The Hawaiian Islands have a long history of destruction due to tsunamis and are amongst the most vulnerable places in the world. Twenty-six tsunamis with flood elevations greater than 3.3 ft. (1 m) have inundated the Hawaiian Islands during recorded history, and 10 of these had significant damaging effects on Oahu. Oahu receives a potentially damaging tsunami (that is, runup greater than 1 meter) about every 20-25 years. Hawaii is most vulnerable to subduction earthquake events in the Alaska Aleutian island chain, the worst case of which has been used to determine the State's Extreme Tsunami Evacuation Zones. Average Annualized tsunami losses are estimated at $81 million. Essential and Critical Facilities are especially vulnerable to tsunamis which would affect the entire state simultaneously. A major tsunami would also become a statewide disaster affecting nearly all ports and harbors and most airport runways. The Port of Honolulu, the hub of Hawaii's supply chain, would suffer a significant loss of cargo capacity. Essential and

critical facilities and taller structures can be designed to lessen the effects of tsunami using the methodology of the American Society of Civil Engineers (ASCE) 7-16 national standard. Planning and design of critical facilities and the supply chain, particularly Honolulu Harbor improvements, should be undertaken to mitigate future tsunami damage. The approximate annual odds of various levels of inundation are given in Table 2.

Table 2. Tsunami Annual Odds of Inundation

Inundation	Oahu-Affected Annual Odds
Tsunami Evacuation Zone	1 in 400
Tsunamis overtopping Port of Honolulu piers and wharves and adjacent areas	1 in 800
Extreme Tsunami Evacuation Zone	1 in 1500
ASCE 7-16 Geodatabase Tsunami Design Zone	1 in 3500

Earthquakes

Seismic hazard on Oahu was historically underestimated. In the late 1980's, Oahu was recognized to be in a region of moderate seismic hazard, and building standards were improved beginning in 1990. The most current seismic design code available is in the 2018 International Building Code (IBC). The risk is now estimated to account for the fourth largest amount of annualized financial losses behind flood losses. Based on an analysis of Hawaii construction cost data, projected earthquake average annual loss is about $41 million on Oahu which is related to the older building inventory that was not designed to the appropriate level of ground shaking. United States Geological Survey (USGS) intends to complete an update of the Hawaii seismic hazard maps in 2020.

Landslides and Rockfalls

The City combines several of the essential components for landslide and rockfall hazards: steep hillsides, heavy rainfall, highways near steep slopes, and residential development in upland areas. They are dangerous because they occur suddenly and can move rapidly by flowing or avalanching down hillslopes and channels. They generally occur during or immediately after severe rainfall of more than 3 inches in a peak 6-hour period. The State identified a number of highway sites on Oahu that have a high risk of rockfall or landslide, many of which have been mitigated or are soon to be mitigated, such as the ongoing 2019 mitigation work on the Pali Highway after a rockfall and landslide. Buffer zones as a condition for residential development near hillsides would mitigate this hazard.

Droughts

Drought hazard considers three sectors impacted by drought: the water supply sector, agriculture and commerce sector, and the environment, public health and safety sector. Drought monitoring, prediction, communication, and mitigation is managed through the Hawaii Drought Plan steered by the Hawaii Drought Council. The integrated water system on Oahu effectively minimizes water supply risks to any particular

area on Oahu. The commercial agricultural sector is affected by drought and the uncertainty of water supply. The primary environmental safety concern from drought is the wildfire hazard which is exacerbated during drought conditions, particularly at the urban wildland interfaces in Mililani/Waipio and the Waianae range valleys. Fire access maintenance is a vital task.

Wildfires

The wildfire risk is increasing as development encroaches on wildlands without sufficient defensible space at the wildland/urban interface. To date, property damage on Oahu due to wildfires is minimal although many acres of wildlands have been burnt in recent years. The Honolulu Fire Department (HFD) is responsible for mitigation and control of urban fires, while the DNLR Division of Forestry and Wildlife (DOFAW) is responsible for forest reserves, with a co-response in intermediate area.

Hazardous Materials

A major Superfund Amendments and Reauthorization Act (SARA) provision is Title III, also referred to as Emergency Planning and Community Right-to-Know Act (EPCRA). EPCRA established guidelines for Federal, State and local governments, and industry regarding emergency planning and providing communities with information on hazardous chemicals within their jurisdiction. The Hawaii Emergency Planning and Community Right-to-Know Act became law in 1993 (Hawaii Revised Statutes (HRS 128E). A Hawaii State Emergency Response Commission (HSERC) was formed and Local Emergency Planning Committee (LEPC) was established in each county. Functions of the LEPC include preparing a hazardous material emergency response plan, reviewing the plan annually, evaluating resources to mitigate an emergency, receiving emergency response notifications, and receiving and processing requests for information from the general public.

Dam Failures

The majority of Oahu's 13 existing dams were built by private plantation owners in the early 1900's for irrigation and not flood control; there were no standards at that time. Two factors influence the potential severity of a full or partial dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream. Visual dam safety inspections happen on a two-year schedule and all dams on Oahu now have Emergency Action Plans and evacuation zones. The State DLNR Engineering Division oversees the State Dam Safety Program.

VOG

VOG is a term used for the volcanic gaseous emissions. VOG occurs when volcanic gases react with sunlight, oxygen and moisture creating a variety of compounds, at varying concentrations, that could have adverse impacts on the downwind communities and environment. Despite even the recent 2018 Lower East Rift Zone eruption on the Big Island, the elevated sulfur dioxide (SO_2) levels that cause major environmental concerns chemically dissipate to a large extent prior to reaching Oahu. Therefore, VOG is not currently considered a relatively severe health hazard to Oahu; VOG production on the Big Island are historically low

since the end of the 2018 Lower East Rift Zone eruption. Since the source of VOG cannot be controlled, there is a reliance on personal precautions and public information advisories.

Status of Shelters

An analysis of shelters on Oahu for tropical cyclones and refuge areas for tsunamis is provided in Chapter 17. Hurricanes are the hazard with the greatest need for sheltering. There is an estimated capacity of just over 200,000 shelter spaces at the designated shelters in public schools, which excludes the potential for spaces in the Hawaii Convention Center, Neal S. Blaisdell Center and Brigham Young University-Hawaii. This could meet the projected needs for sheltering during a "strong" storm; however, very few are rated for resistance to hurricane windspeeds. In 2018, DEM advises that shelters are "a safer option than remaining in areas prone to flooding or storm surge inundation, on exposed ridge lines or in older homes with wood frames or single wall construction". More all-hazard shelter safety evaluations and retrofit strengthening are proposed, along with starting a private sector shelter screening system.

Risk Assessment

Risk considers both the likelihoods and the consequences of the range of possible events. Risk is defined as the expected losses over time associated with a hazard, defined in terms of expected annual loss, resulting from the probabilities of occurrence of events of various severities, asset exposure and vulnerability, and resulting economic loss consequences. Losses linked directly to a hazard event include the physical destruction of buildings and transportation and utility systems. Average Annualized Loss (AAL) is an objective measure of future losses averaged on an annual basis, calculated as the sum of the expected loss for each event (i.e., sum of the products of the estimated loss from each event and that event's rate of occurrence). In cases where there is insufficient confidence in the probability estimates of rare events and where sufficient past data is available, the average annualized loss is based on historical losses. Annualized loss estimates were used to establish a measure of relative economic importance of particular natural hazards and to determine the priorities for hazard mitigation measures. The comparative average annual direct losses for the most severe hazards are listed in Table 3.

Table 3. Relative Hazard Severity to the City & County of Honolulu
Based on Average Annual Loss Estimates or Historical Experience

Hurricane Winds	$410 Million / Year
Tsunamis	$81 Million / Year
Floods	$41 Million / Year
Earthquakes	$21 Million / Year
Debris Flows and Rockfalls	$1 to $5 Million / Year
Coastal Erosion	$3 Million / Year
Wildfire	$1 Million / Year
Dam Failure	less than $1 Million / Year
High Surf	less than $0.5 Million / Year
HAZMAT	less than $0.10 Million / Year

Highest Priority Hazard Mitigation Actions

A summary of the 45-highest priority mitigation actions is provided in Table 4 below. How the priorities were developed in a process involving multiple public agencies, private entities, and the general public over multiple meetings/workshops and online, these are discussed in Chapter 2 of the Plan. The complete listing of 55 hazard mitigation actions are given in Chapter 19. Some of these actions require further planning and engineering work as a part of implementation.

Table 4. Highest Priority Hazard Mitigation Actions for the City & County of Honolulu

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
1	Policies and Processes	2	Plan and determine how to execute public works to protect or defend existing critical facilities, infrastructure and utility services, supply chain, and vital economic assets at risk to climate change effects.	High
2	Flooding	15	Plan for flood control public works for the defense of critical facilities and major economic assets. Harden critical facilities, utilities, power and communication networks, and port facilities.	High
3	Policies and Processes	1	Integrate natural hazard policies into the General Plan & Community Development Plans.	High
4	Building Facilities	29	Establish regulatory policy to identify critical facilities during planning and design, which are buildings and structures that provide services essential for the implementation of the response and recovery management plan or for the continued functioning of a community.	High
5	Public Information	53	Enhance the public availability of disaster resilience information that can be quickly understood, especially regarding hurricane awareness, hurricane retrofits, hurricanes, tsunamis and flooding.	High
6	Policies and Processes	6	Develop strategic master plans for implementation of new resilient and sustainable designs for communities that may need to be rebuilt post-disaster. Update the Land Use Ordinance.	High
7	Infrastructure Facilities	19	Relocate or locally defend/reinforce vital infrastructure such as roads in coastal eroding regions. Improve the materials and construction practices of roadways for greater resiliency.	High
8	Infrastructure Facilities	18	Evaluate the risks and prioritize protective measures for existing infrastructure facilities.	High

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
9	Building Facilities	28	Start hazard mitigation retrofits for the protection of essential facilities on Oahu.	High
10	Tsunami	43	Evaluate fuel storage tank farm containment walls in Honolulu Harbor for the capability to withstand tsunami and hurricane flooding.	High
11	Tsunami	44	Continue to identify and retrofit critical pumping stations in the tsunami inundation zone.	High
12	Flooding	10	Revise and update the Flood Hazard Area, Revised Ordinances of Honolulu (ROH) Chapter 21A to enable the use of the ASCE 24-14 Standard, Flood Resistant Design and Construction, and revise regulations to require explicit building design for climate change adaptation. For Critical and Essential Facilities, this standard would require 500-year flood elevations be used for design. Incorporate climate change effects on the storm-generating environment, per the methodology as detailed in *Probabilistic mapping of storm-induced coastal inundation for climate change adaptation* (Li, N., et al., 2017).	High
13	Flooding	11	Revise the Honolulu Electrical Code, ROH Chapter 17: For Essential and Critical Facilities, the Electrical Code should require placement of electrical transformers, switchgear, and emergency generators above the 500-year flood elevation, or alternatively, protected by dry floodproofing.	High
14	Policies and Processes	3	Utilize an adaptive engineering approach to all current and future projects near the shoreline. Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly the Ala Wai Watershed Flood Control project.	High
15	Policies and Processes	4	HRS 205A Certified Shoreline For planning purposes, include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years. ROH Chapter 23 Establish the setback line about 25 feet from the certified shoreline plus 50 times the average annual coastal erosion rate, or to a minimum of 40 feet. The local geology and soil conditions should be taken in to account.	Medium-High

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
16	Infrastructure Facilities	24	Improve the resiliency of fuel supplies during and after disasters through the Hawaii State Energy Council and the Hawaii Emergency Preparedness Executive Consortium.	Medium-High
17	Tropical Cyclones and Hurricanes	34	Perform all-hazard structural safety assessments of hurricane shelters.	Medium-High
18	Flooding	16	Pursue the Ala Wai Watershed Flood Mitigation project with the United States Army Corps of Engineers (USACE); include resilience, visual appeal, water quality, and infrastructure improvements; create a watershed district to coordinate infrastructure projects, resilience planning and regulations, watershed data collection, and community engagement.	Medium-High
19	Tropical Cyclones and Hurricanes	36	Create incentives for homeowners, landlords, and businesses to retrofit their buildings.	Medium-High
20	Tsunami	39	Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects to enable their use as refuges of safety during extreme tsunamis. Produce a workshop seminar on this procedure for the visitor industry.	Medium-High
21	Tropical Cyclones and Hurricanes	35	Retrofit public shelter buildings to increase capacity, refine actual evacuation demand, and update City policies on evacuation to decrease sheltering deficit.	Medium-High
22	Flooding	14	Develop Honolulu flood maps that go beyond FEMA requirements to consider concurrent rainfall and coastal surge flooding, concentrating on areas with critical infrastructure and the potentially affected communities.	Medium-High
23	Infrastructure Facilities	20	State Public Utilities Commission (PUC) should adopt the 2017 National Electric Safety Code (NESC) for power transmission and distribution, to include an amendment with the ASCE topographic windspeed maps. The PUC should update the NESC requirements periodically. Strategically plan with HECO to achieve a disaster-resilient network.	Medium-High
24	Public Education and Outreach	55	Investigate financial incentives for business and individuals to invest in building resiliency.	Medium
25	Tsunami	40	Perform preliminary engineering of tsunami and coastal flood mitigation defense of critical infrastructure.	Medium

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
26	Tropical Cyclones and Hurricanes	33	Identify the types of buildings more suitable for self-sheltering as alternatives to public shelters	Medium
27	Climate Change Adaptation	7	ROH Chapter 25 SMA: Amend the Special Management Area (SMA) permit requirements to include consideration of climate change effects for major developments. Adopt coastal flooding maps that account for future climate change.	Medium-High
28	Building Facilities	26	ROH Chapter 16 Building-Code - Adopt 2012 and 2018 IBC and related codes per HRS 107 Part II. (Honolulu is presently using the 2006 IBC, which is obsolete by four editions of the national model code.)	Medium-High
29	Drought and Wildfire	48	Fire Break and Fire Road Maintenance by DOFAW to stop advancing fire and provide access to firefighters.	Medium
30	Climate Change Adaptation	8	Produce regulatory (100-year and 500-year) coastal flooding maps that account for future climate change effects on storm intensities and sea level rise.	Medium-High
31	Infrastructure Facilities	25	Rockfall buffer zones should be defined and incorporated into new developments between high-hazard rock fall areas and homes and critical facilities; this requires regulatory mapping.	Medium
32	Flooding	13	Participate in the National Flood Insurance Program (NFIP) CRS to reduce flood losses and lower flood insurance premiums for homeowners.	Medium
33	Climate Change Adaptation	9	Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities. Re-evaluate storm water flood control practices that address requirements for storm runoff quantities for flood control for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs.	Medium
34	Public Information	54	Provide culturally appropriate disaster preparedness education and outreach for immigrant minority groups, limited English proficiency individuals, individuals with access and functional needs, etc.	Medium
35	Infrastructure Facilities	21	Update the design and construction standards of the City for utility lifelines to improve the disaster resilience of essential services.	Medium

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
36	Tsunami	42	Adopt the ASCE national standard for tsunami design of new construction for critical, essential, and certain occupancy types of multi-story buildings in ROH Chapter 16 Building-Code.	Medium
37	Drought and Wildfire	49	Assist Oahu communities to become Firewise Communities.	Medium
38	Tropical Cyclones and Hurricanes	38	Establish a policy for strengthening of critical public facility enclosure integrity for wind and windborne debris.	Medium
39	Drought and Wildfire	50	Establish water tanks at the fringes of threatened communities that can serve as dip tanks.	Medium
40	Building Facilities	31	Harden City base yards such as the Department of Facility Maintenance (DFM) Division of Road Maintenance (DRM) base yards in Wahiawa and Kaneohe to provide viable pre-hurricane staging of debris clearing equipment and personnel.	Medium
41	Flooding	12	Re-evaluate critical inland and stream flooding Standard Digital Flood Insurance Rate Maps (DFIRMs) to account for a) watershed details and the floodway, its extent of urbanization, and b) assess from a policy standpoint whether the frequency of flood overtopping in heavily developed areas is really acceptable. Include rainfall intensification.	Medium
42	Infrastructure Facilities	23	Replace weathered wood poles with National Electric Safety Code conforming poles, upgrading them rather than replacing them with the same type as existing.	Medium
43	Policies and Processes	5	HRS Chapter 484:- Uniform Land Sales Practices Act: Require disclosure of an explicitly defined list of hazards. HRS Chapter 508D: Mandatory Seller Disclosures in Real Estate Transactions: Make disclosure apply to vacant lots.	Medium
44	Infrastructure Facilities	22	Increase resiliency of post-disaster power plant capacity and achieve greater redundancy/reliability of the supply network.	Medium
45	Tsunami	41	ROH Chapter 16 Building-Code Produce higher resolution probabilistic tsunami hazard maps (of run-up) for use with the ASCE-2016 and IBC-2018 building code design provisions.	Medium

Plan Monitoring, Evaluation, Maintenance, and Update Procedures

The plan should be updated incrementally to stay current, regardless of FEMA requirements; a subgroup of the Plan's Advisory Committee, supported by subject matter experts, should meet annually to monitor ongoing and new mitigation actions. The updates may be necessary following any of the actions or events listed below:

- Anticipated update of the Honolulu Building Code by City Council Ordinance
- Progress in ongoing mitigation actions within the City
- Development of new mitigation recommendations
- Changes necessary because of Federal, State, or County legislative acts and mandates
- Public involvement in mitigation and other existing planning activities
- New data, analysis, or scientific and hazard modeling capabilities
- Events or new information on environmental conditions that indicate new mitigation needs or requirements
- Major federally declared disasters on Oahu and subsequent hazard mitigation grant funding
- Identification of risk to city structures with emphasis on critical facilities
- Incorporation of hazard analysis in the city's general plan process to include the impact on land use, zoning, etc.
- CCSR development of a Long-term Disaster Recovery Plan
- The new Oahu Resilience Strategy implementation starting in 2019
- The new set of high-resolution Tsunami Design Zone maps for use in the Honolulu Building Code to become available at the end of 2019
- The USGS preparation of updated seismic hazard maps for Hawaii

The Program Coordinator for the City Hazard Mitigation Program is the Office of Climate Change, Sustainability and Resiliency (CCSR). CCSR initiates and facilitates appropriate and regular hazard mitigation stakeholder engagement. CCSR also supports all City Departments and Offices with hazard mitigation projects to ensure that investment in resilience is maximized. CCSR works closely with the Department of Emergency Management in fulfilling this role, as Hazard Mitigation is one of the five mission areas defined in the National Preparedness Goal. At the next update, the City Office of Climate Change Sustainability and Resilience will be the lead agency.

Ongoing monitoring and coordination of the Hazard Mitigation Program will occur through a Core Planning Team designated by CCSR that would meet annually in the second quarter. The Program Coordinator will facilitate an annual review to evaluate effectiveness of the program and update the program and plan, as needed.

The City & County of Honolulu will continue to hold interagency meetings and public workshops. For more grassroots involvement, the County has mentored a community outreach network, the Cross-Island Community Resilience Network, that serves two functions: 1) to prepare communities to respond to emergencies and 2) to serve as a two- way communication conduit between the community and County officials.

U.S. Department of Homeland Security
1111 Broadway, Suite 1200
Oakland, CA. 94607-4052

FEMA

August 7, 2019

Crystal Van Beelen
Disaster Preparedness Officer
City & County of Honolulu
650 South King Street
Honolulu, HI 96813

Dear Ms. Van Beelen:

We have completed our review of the *Multi-Hazard Pre-Disaster Mitigation Plan for the City & County of Honolulu* and have determined that this plan is eligible for final approval pending its adoption by the City & County of Honolulu.

Formal adoption documentation must be submitted to the FEMA Region IX office by the jurisdiction within one calendar year of the date of this letter, or the entire plan must be updated and resubmitted for review. We will approve the plan upon receipt of the documentation of formal adoption.

If you have any questions regarding the planning or review processes, please contact the FEMA Region IX Hazard Mitigation Planning Team at fema-r9-mitigation-planning@fema.dhs.gov.

Sincerely,

Juliette Hayes
Director
Mitigation Division
FEMA, Region IX

cc: Savanna Holloway-Ledo, Grant Coordinator, Hawai'i Emergency Management Agency
Larry Kanda, State Hazard Mitigation Officer, Hawai'i Emergency Management Agency

REGION IX LOCAL HAZARD MITIGATION PLAN REVIEW TOOL

Updated 9/6/2018

The *Local Hazard Mitigation Plan Review Tool* demonstrates how the Local Hazard Mitigation Plan meets the regulation in 44 CFR §201.6 and offers State and FEMA Mitigation Planners an opportunity to provide feedback to the community.

- The **Regulation Checklist** provides a summary of FEMA's evaluation of whether the plan has addressed all requirements.
- The **Plan Assessment** identifies the plan's strengths as well as documents areas for future improvement. This section also includes a list of resources for implementation of the plan.
- The **Multi-Jurisdiction Summary Sheet** is a mandatory worksheet for multi-jurisdictional plans that is used to document which jurisdictions are eligible to adopt the plan.
- The **Hazard Identification and Risk Assessment Matrix** is a tool for plan reviewers to identify if all components of Element B are met.

Jurisdiction: City & County of Honolulu	**Title of Plan:** Multi-Hazard Pre-Disaster Mitigation Plan for the City & County of Honolulu	**Date of Plan:** May 20, 2019
Local Point of Contact: Crystal Van Beelen		**Address:** 650 S King St, Honolulu, HI 96813
Title: Disaster Preparedness Officer		
Agency: Department of Emergency Management		
Phone Number: 808-723-8956		**E-Mail:** cvanbeelan@honolulu.gov

State Reviewer: Larry Kanda	**Title:** State Hazard Mitigation Officer	**Date:** May 31, 2019
Date Received at State Agency		
Date Sent to FEMA	June 4, 2019	

FEMA Reviewer: JoAnn Scordino Xing Liu	**Title:** Community Planner	**Date:** June 10, 2019 August 7, 2019
Date Received in FEMA Region IX	June 4, 2019 July 26, 2019	
Date Not Approved	July 11, 2019	
Date Approvable Pending Adoption	August 7, 2019	
Date Approved		

SECTION 1:
REGULATION CHECKLIST

INSTRUCTIONS: The Regulation Checklist must be completed by FEMA. The purpose of the Checklist is to identify the location of relevant or applicable content in the plan by element/sub-element and to determine if each requirement has been 'Met' or 'Not Met.' The 'Required Revisions' summary at the bottom of each element must be completed by FEMA to provide a clear explanation of the revisions that are required for plan approval. Required revisions must be explained for each plan sub-element that is 'Not Met.' Sub-elements should be referenced in each summary by using the appropriate numbers (A1, B3, etc.), where applicable. Requirements for each Element and sub-element are described in detail in the *Local Plan Review Guide* in Section 4, Regulation Checklist.

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)		**Location in Plan** (section and/or page number)	**Met**	**Not Met**
ELEMENT A. PLANNING PROCESS				
A1. Does the plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement §201.6(c)(1))	a. Does the plan provide documentation of how the plan was prepared? This documentation must include the schedule or timeframe and activities that made up the plan's development as well as who was involved.	Chapter 2, Mitigation Planning Process, from Page 2-2 to -8 onward, is entirely devoted to this documentation. Planning Process starts pg. 61	X	
	b. Does the plan list the jurisdiction(s) participating in the plan that are seeking approval?		X	
	c. Does the plan identify who represented each jurisdiction? (At a minimum, it must identify the jurisdiction represented and the person's position or title and agency within the jurisdiction.)		X	

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)		**Location in Plan** (section and/or page number)	**Met**	**Not Met**
A2. Does the plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development as well as other interests to be involved in the planning process? (Requirement §201.6(b)(2))	a. Does the plan document an opportunity for neighboring communities, local, and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development, as well as other interested parties to be involved in the planning process?	Chapter 2, Mitigation Planning Process, from Pages 2-24 to 2-67	X	
	b. Does the plan identify how the stakeholders were invited to participate in the process?	Sec 2-11 but very vague & unclear if Stakeholders or Plan Cmte	X	
A3. Does the plan document how the public was involved in the planning process during the drafting stage? (Requirement §201.6(b)(1))	a. Does the plan document how the public was given the opportunity to be involved in the planning process?	Chapter 2, Mitigation Planning Process, from Pages 2-14 to 2-45	X	
	b. Does the plan document how the public's feedback was incorporated into the plan?	Section 2-14 to 2-15	X	
A4. Does the plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement §201.6(b)(3))		Every hazard chapter from 4 through 16, describes the evaluation of technical information. Chapter 1, Introduction, page 1-11 through 1-16, gives a digest of significant technical changes Sec 3	X	
A5. Is there discussion of how the community(ies) will continue public participation in the plan maintenance process? (Requirement §201.6(c)(4)(iii))		Chapter 20, Plan Maintenance and Update Procedures, Pages 20-2 and 20-4 to 20-5	X	

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)		Location in Plan (section and/or page number)	Met	Not Met
A6. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a 5-year cycle)? (Requirement §201.6(c)(4)(i))	a. Does the plan identify how, when, and by whom the plan will be **monitored** (how will implementation be tracked) over time?	Chapter 20, Plan Maintenance and Update Procedures, Pages 20.2.2, 20.2.3	X	
	b. Does the plan identify how, when, and by whom the plan will be **evaluated** (assessing the effectiveness of the plan at achieving stated purpose and goals) over time?	Chapter 20, Plan Maintenance and Update Procedures, Pages 20.2.2, 20.2.3	X	
	c. Does the plan identify how, when, and by whom the plan will be **updated** during the 5-year cycle?	Chapter 20, Plan Maintenance and Update Procedures, Pages 20.2.3	X	
ELEMENT A: REQUIRED REVISIONS				
ELEMENT B. HAZARD IDENTIFICATION AND RISK ASSESSMENT (Reviewer: See Section 4 for assistance with Element B)				
B1. Does the plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction(s)? (Requirement §201.6(c)(2)(i))	a. Does the plan include a general description of all natural hazards that can affect each jurisdiction?	Chapters 4 through 16; every hazard has a full chapter. also Chapter 1, Introduction, page 1-6.	X	
	b. Does the plan provide rationale for the omission of any natural hazards that are commonly recognized to affect the jurisdiction(s) in the planning area?		X	
	c. Does the plan include a description of the **type** of all natural hazards that can affect each jurisdiction?		X	
	d. Does the plan include a description of the **location** for all natural hazards that can affect each jurisdiction?		X	

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)		**Location in Plan** (section and/or page number)	**Met**	**Not Met**
	e. Does the plan include a description of the **extent** for all natural hazards that can affect each jurisdiction?		X	
B2. Does the plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6(c)(2)(i))	a. Does the plan include information on **previous occurrences** of hazard events for each jurisdiction?	Chapters 4 through 16 are organized to have sections on historical occurrences and the expected probabilities of future hazards (where they can be estimated)	X	
	b. Does the plan include information on the **probability** of future hazard events for each jurisdiction?		X	
B3. Is there a description of each identified hazard's impact on the community as well as an overall summary of the community's vulnerability for each jurisdiction? (Requirement §201.6(c)(2)(ii))	a. Is there a description of each hazard's **impacts** on each jurisdiction (what happens to structures, infrastructure, people, environment, etc.)?	Chapter 18, Risk Assessment, summarizes the detailed vulnerability assessments. Also, Chapter 1, Introduction, Page 1-6.	X	
	b. Is there a description of each identified hazard's overall **vulnerability** (structures, systems, populations, or other community assets defined by the community that are identified as being susceptible to damage and loss from hazard events) for each jurisdiction?		X	
B4. Does the plan address NFIP insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii))		Chapter 8, Floods, pages 8-16 through 8-24	X	
ELEMENT B: REQUIRED REVISIONS				
ELEMENT C. MITIGATION STRATEGY				

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)		**Location in Plan** (section and/or page number)	**Met**	**Not Met**
C1. Does the plan document each jurisdiction's existing authorities, policies, programs and resources and its ability to expand on and improve these existing policies and programs? (Requirement §201.6(c)(3))	a. Does the plan document each jurisdiction's existing authorities, policies, programs and resources?	Chapter 20, Plan Maintenance and Update Procedures, Pages 20-3 and 20-4 to 20-5. Also, Chapter 3, Pages 3-8 through 3-22.	X	
	b. Does the plan document each jurisdiction's ability to expand on and improve these existing policies and programs?		X	
C2. Does the plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement §201.6(c)(3)(ii))		Chapter 8, Floods, Pages 8-16 through 8-31	X	
C3. Does the plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))		Chapter 19, Mitigation Strategy and Actions, Pages 19-8 to 19-9	X	
C4. Does the plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement §201.6(c)(3)(ii))	a. Does the plan identify and analyze a comprehensive range of specific mitigation actions and projects to reduce the impacts from hazards?	Chapter 19, Mitigation Strategy and Actions, Pages 19-13 through 19-20	X	
	b. Does the plan identify mitigation actions for every hazard posing a threat to each participating jurisdiction?		X	
	c. Do the identified mitigation actions and projects have an emphasis on new and existing buildings and infrastructure?		X	
C5. Does the plan contain an action plan that describes how the actions identified will be prioritized (including cost benefit review), implemented, and administered by each jurisdiction? (Requirement §201.6(c)(3)(iv)); (Requirement §201.6(c)(3)(iii))	a. Does the plan explain how the mitigation actions will be prioritized (including cost benefit review)?	Chapter 19, Mitigation Strategy and Actions, Pages 19-13 through 19-39	X	

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)		Location in Plan (section and/or page number)	Met	Not Met
	b. Does the plan identify the position, office, department, or agency responsible for implementing and administering the action, potential funding sources and expected timeframes for completion?	Table 19-4	X	
C6. Does the plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement §201.6(c)(4)(ii))	a. Does the plan identify the local planning mechanisms where hazard mitigation information and/or actions may be incorporated?	Chapter 3, Land Use and Development, Pages 3-26 to 3-40	X	
	b. Does the plan describe each community's process to integrate the data, information, and hazard mitigation goals and actions into other planning mechanisms?		X	
	c. The updated plan must explain how the jurisdiction(s) incorporated the mitigation plan, when appropriate, into other planning mechanisms as a demonstration of progress in local hazard mitigation efforts.		X	
ELEMENT C: REQUIRED REVISIONS				
ELEMENT D. PLAN REVIEW, EVALUATION, AND IMPLEMENTATION (Applicable to plan updates only)				
D1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3))		Chapter 3, Pages 3-3 through 3-7, and 3-12 through	X	
D2. Was the plan revised to reflect progress in local mitigation efforts? (Requirement §201.6(d)(3))		Chapter 19, Pages 19-1 through 19-6	X	
D3. Was the plan revised to reflect changes in priorities? (Requirement §201.6(d)(3))		Chapter 19, Pages 19-21 through 19-39	X	
ELEMENT D: REQUIRED REVISIONS				
ELEMENT E. PLAN ADOPTION				

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)	**Location in Plan** (section and/or page number)	**Met**	**Not Met**
E1. Does the plan include documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval? (Requirement §201.6(c)(5))	Chapter 2, pages 2-68 through 2-72. Council adoption resolution pending		X
E2. For multi-jurisdictional plans, has each jurisdiction requesting approval of the plan documented formal plan adoption? (Requirement §201.6(c)(5))	N/A	N/A	
ELEMENT E: REQUIRED REVISIONS			
ELEMENT F. ADDITIONAL STATE REQUIREMENTS (Optional for State Reviewers only; not to be completed by FEMA)			
F1.			
F2.			
ELEMENT F: REQUIRED REVISIONS			

SECTION 2:
PLAN ASSESSMENT

INSTRUCTIONS: The purpose of this Plan Assessment is to offer the local community more comprehensive feedback to the community on the quality and utility of the plan in a narrative format. The Plan Assessment **must** be completed by FEMA.

The Assessment is an opportunity for FEMA to provide feedback and information to the community on: 1) suggested improvements to the plan; 2) specific sections in the plan where the community has gone above and beyond minimum requirements; 3) recommendations for plan implementation; and 4) ongoing partnership(s) and information on other FEMA programs, specifically Risk MAP and Hazard Mitigation Assistance programs.

The Plan Assessment is divided into two sections:

1) Plan Strengths and Opportunities for Improvement
2) Resources for Implementing Your Approved Plan

Plan Strengths and Opportunities for Improvement is organized according to the plan elements listed in the Regulation Checklist. Each element includes a series of italicized bulleted items that are suggested topics for consideration while evaluating plans, but it is not intended to be a comprehensive list. FEMA Mitigation Planners are not required to answer each bullet item, and should use them as a guide to paraphrase their own written assessment (2-3 sentences) of each element.

The Plan Assessment must not reiterate the required revisions from the Regulation Checklist or be regulatory in nature, and should be open-ended and to provide the community with suggestions for improvements or recommended revisions. The recommended revisions are suggestions for improvement and are not required to be made for the plan to meet Federal regulatory requirements. The italicized text should be deleted once FEMA has added comments regarding strengths of the plan and potential improvements for future plan revisions. It is recommended that the Plan Assessment be a short synopsis of the overall strengths and weaknesses of the Plan (no longer than two pages), rather than a complete recap section by section.

Resources for Implementing Your Approved Plan provides a place for FEMA to offer information, data sources and general suggestions on the overall plan implementation and maintenance process. Information on other possible sources of assistance including, but not limited to, existing publications, grant funding or training opportunities, can be provided. States may add state and local resources, if available.

A. Plan Strengths and Opportunities for Improvement

This section provides a discussion of the strengths of the plan document and identifies areas where these could be improved beyond minimum requirements.

Element A: Planning Process

Strengths:

1) The Executive Summary is a great addition to your plan. It is an excellent way to engage your political and community leaders, funders, stakeholders, and general public!
2) The full version of your plan is so detailed and comprehensive – excellent for your partners who need to get hands on with you.
3) Excellent documentation and summary of public participation and surveys.

Opportunities for Improvement:

1) Please use your Executive Summary in working with your politicians, leadership, stakeholders and public. It is a much easier version to digest vs. the whole plan.
2) You could make this section a bit simpler and more streamlined by
3) Add more documentation to validate planning team and stakeholder meetings – agendas, sign in sheets, pictures, etc. These help the reviewers see your process and participants.
4) While the plan discusses opportunities for public outreach events over the next five years, they seem to be primarily focused on pushing information "out" rather than listening to the public to make sure the plan's priorities are still accurate. Sending out mitigation and hazard information is great but be sure to ask the public's opinion as well for the plan's maintenance.

Element B: Hazard Identification and Risk Assessment

Strengths:

1) Very thorough assessment and updates from your last plan to this update.
2) Your combining climate change throughout made this a very robust section.
3) The layout of your hazards and risk assessment really build a framework for your mitigation strategies and actions going forward!

Opportunities for Improvement:

1)
2)
3)

Element C: Mitigation Strategy

Strengths:

1) Very thorough assessment of your strategies and actions for this current plan.
2) You outlined very clearly what was accomplished in the last plan and where you are going forward with mitigation actions this update period.
3)

Opportunities for Improvement:

1)
2)
3)

Element D: Plan Update, Evaluation, and Implementation (*Plan Updates Only*)

Strengths:

1) Excellent, thorough work. You've made an incredible case for what needs to happen in the City and County of Honolulu for a more safe and resilient future for all residents, visitors and the environment!
2)
3)

Opportunities for Improvement:

1)
2)
3)

B. Resources for Implementing and Updating Your Approved Plan

This resource section is organized into three categories:

1) Guidance and Resources
2) Training Topics and Courses
3) Funding Sources

Guidance and Resources

Local Mitigation Planning Handbook
https://www.fema.gov/media-library/assets/documents/31598
Beyond the Basics
http://mitigationguide.org/
Mitigation Ideas
https://www.fema.gov/media-library/assets/documents/30627
Plan Integration: Linking Local Planning Efforts
https://www.fema.gov/media-library/assets/documents/108893
Integrating Disaster Data into Hazard Mitigation Planning
https://www.fema.gov/media-library/assets/documents/103486
Integrating Historic Property and Cultural Resource Considerations into Hazard Mitigation Planning
https://www.fema.gov/ar/media-library/assets/documents/4317
Community Rating System User Manual
https://www.fema.gov/media-library/assets/documents/8768
U.S. Climate Resilient Toolkit
https://toolkit.climate.gov/
2014 National Climate Assessment
http://nca2014.globalchange.gov/
Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
http://ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf
FY15 Hazard Mitigation Assistance Unified Guidance
https://www.fema.gov/media-library/assets/documents/103279
Climate Resilient Mitigation Activities for Hazard Mitigation Assistance
https://www.fema.gov/media-library/assets/documents/110202

Training

More information at https://training.fema.gov/emi.aspx or through your State Training Officer

Mitigation Planning

IS-318 Mitigation Planning for Local and Tribal Communities
https://training.fema.gov/is/courseoverview.aspx?code=is-318
IS-393 Introduction to Hazard Mitigation
https://training.fema.gov/is/courseoverview.aspx?code=is-393.a
G-318 Preparing and Reviewing Local Plans
G-393 Mitigation for Emergency Managers

Hazard Mitigation Assistance (HMA) Grant Programs

IS-212.b Introduction to Unified HMA
http://www.training.fema.gov/is/courseoverview.aspx?code=IS-212.b

IS-277 Benefit Cost Analysis Entry Level
http://www.training.fema.gov/is/courseoverview.aspx?code=IS-277

E-212 HMA: Developing Quality Application Elements

E-213 HMA: Application Review and Evaluation

E-214 HMA: Project Implementation and Programmatic Closeout

E-276 Benefit-Cost Analysis Entry Level

GIS and Hazus-MH

IS-922 Application of GIS for Emergency Management
http://www.training.fema.gov/is/courseoverview.aspx?code=IS-922

E-190 ArcGIS for Emergency Managers

E-296 Application of Hazus-MH for Risk Assessment

E-313 Basic Hazus-MH

Floodplain Management

E-273 Managing Floodplain Development through the NFIP

E-278 National Flood Insurance Program/ Community Rating System

Potential Funding Sources

Hazard Mitigation Grant Program

POC: FEMA Region IX and State Hazard Mitigation Officer

Website: https://www.fema.gov/hazard-mitigation-grant-program

Pre-Disaster Mitigation Grant Program

POC: FEMA Region IX and State Hazard Mitigation Officer

Website: https://www.fema.gov/pre-disaster-mitigation-grant-program

Flood Mitigation Assistance Grant Program

POC: FEMA Region IX and State Hazard Mitigation Officer

Website: https://www.fema.gov/flood-mitigation-assistance-grant-program

Emergency Management Performance Grant Program

POC: FEMA Region IX

Website: https://www.fema.gov/emergency-management-performance-grant-program

SECTION 4:
HAZARD IDENTIFICATION AND RISK ASSESSMENT MATRIX (OPTIONAL)

INSTRUCTIONS: This matrix can be used by the plan reviewer to help identify if all of the components of Element B have been met. List out natural hazard names that are identified in the plan in the column labeled "Hazards" and put a "Y" or "N" for each component of Element B.

HAZARD IDENTIFICATION AND RISK ASSESSMENT MATRIX								
Hazard	Requirement Met? (Y/N)							
	Type	Location	Extent	Previous Occurrences	Probability	Impacts	Vulnerability	Mitigation Action
Coastal Erosion-Sec 5	X	X	X	X	X	X	X	X
Strong Wind – Sec 6	X	X	X	X	X	X	X	X
Floods – Sec 8	X	X	X	X	X	X	X	X
Tropical Cyclones – Sec 7	X	X	X	X	X	X	X	X
Tsunami – Sec 9	X	X	X	X	X	X	X	X
Earthquakes – Sec 10	X	X	X	X	X	X	X	X
Landslides – Sec 11	X	X	X	X	X	X	X	X
Drought – Sec 12	X	X	X	X	X	X	X	X
Wildfire – Sec 13	X	X	X	X	X	X	X	X
Haz Mat – Sec 14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dams – Sec 15	X	X	X	X	X	X	X	X
Vog – Sec 16	X	X	X	X	X	X	X	X



1. Introduction

1. INTRODUCTION

1.1 Overview

A hazard is an event or physical circumstance that has the potential to cause impacts that include:

- Loss of life and injury
- Property destruction and/or damage
- Economic disruption, including interruption of business, essential services, and the supply chain.
- Loss of culturally and historically important items and natural resources.
- Expenditure on disaster response by both governments and private organizations.

"Disasters" are distinguished from "emergencies" by the degree of response required. An emergency is where local resources are adequate to respond. A disaster means any situation, usually catastrophic in nature, and the governor of the State or the mayor of the County have declared a state of disaster or emergency. A disaster requires the marshaling of broader resources such as State and/or national resources to assist with response and recovery. Since 1946, the State of Hawaii has experienced 36 Presidential declared disasters (seventeen storms causing floods, wind damage and/or debris flow; three hurricanes; five earthquakes; five volcanic events, and; four tsunamis) as listed in Table 1-1. Many of these events have directly affected Oahu.

As the direct and indirect costs of disasters continue to rise, it becomes particularly critical that preparing for these events include actions and policies to reduce the amount of damage. Hazard mitigation is action taken to permanently reduce long-term risk to people and their property. The purpose of multi-hazard mitigation is twofold: 1) to protect people and structures from harm and destruction; and 2) to minimize the costs of disaster response and recovery. Hazard mitigation planning is the process that analyzes a community's risk from natural hazards, coordinates available resources, and implements actions to reduce risks. Mitigation planning for the City and County of Honolulu is the purpose of this document.

There is a difference between disaster preparedness/response planning and hazard mitigation. Both are important but constitute different activities. Response planning occurs in preparation, but the actual implementation usually occur after a natural hazard. The City and County of Honolulu plan for response during and after an emergency is outlined in its Emergency Operations Plan. Mitigation, however, should be implemented prior to the occurrence of a disaster. The purpose of mitigation is to reduce the impact of future hazard events on life, property, and the economy, thereby enhancing community resilience.

In addition to its primary emphasis on response and recovery, FEMA's focus has broadened to incorporate mitigation as a foundation of community resilience. Each state and county is now required to have a mitigation plan that identifies steps to reduce the impact from hazards. If a state and its counties do not have approved plans in place and a disaster occurs, they would not be entitled to public assistance and other FEMA funding. Federal Emergency Management Agency (FEMA) provides funds to communities, counties, and states to reduce impacts from natural hazards through hazard mitigation planning and grants.

Table 1-1. Federally Declared Disasters in the Hawaiian Islands (1946 – 2018)

Year	Date	Disaster	Island	Damage ($ Millions)
2018	08/23	Hurricane Lane	Hawai'i, Maui, Lanai, Oahu, Kauai	$250 Statewide
2018	05/03	Kilauea Volcanic Eruption, Lower East Rift Zone and assorted Earthquakes	Hawai‘i	N/A (Ongoing)
2018	04/13-04/16	Severe Storms, Floods, Landslides, Mudslides	Kaua‘i, O‘ahu	N/A
2016	09/11-09/14	Severe Storms, Floods, Landslides, Mudslides	Moloka‘i, Maui	$3.37
2014-2015	09/04/14-03/26/15	Pu‘u ‘Ō‘ō Volcanic Eruption, Lava Flow	Hawai‘i	$11.36
2014	08/07-08/10	Tropical Storm Iselle	Moloka‘i, Maui, Hawai‘i	$4.98
2012	03/03-03/11	Severe Storms, Floods, Landslides	Kaua‘i, Moloka‘i, Maui	$3.66
2011	03/11	Tsunami	O‘ahu, Moloka‘i, Maui, Hawai‘i	$6.37
2010	06/09	Maalaea Fire	Maui	$0.243
2009	08/31	Kaunakakai Fire	Maui	$0.601
2008	12/10-12/16	Severe Storm, Floods	O‘ahu primarily, Kaua‘i	$1.1
2007	12/04-12/07	Severe Storm, High Surf, Floods, Mudslides	Kaua‘i, Moloka‘i, Maui, Hawai‘i	N/A
2006	10/15	Kiholo Bay Earthquake	Hawa‘i primarily, Maui, O‘ahu	$200.0+
2006	02/20-04/02	Severe Storm, Floods, Landslides, Mudslides	Kaua‘i, O‘ahu	N/A
2004	10/30	Severe Strom, Flash Floods	O‘ahu	$85.0
2000	10/28-11/02	Severe Storm, Floods	Hawai‘i	N/A
1996	11/26	Severe Storm, Floods	N/A	N/A
1992	09/12	Hurricane Iniki	Kaua‘i primarily, all islands	$1,600.0
1990	05/18	Lava Flow	Hawai‘i	N/A
1987-1988	12/11-01/21	Severe Storm, Flash Floods, Mudslides	East O‘ahu	$35.0
1982	11/23	Hurricane Iwa	Kaua‘i primarily, O‘ahu	$239.0
1982	04/22	Heavy Rains, Floods	N/A	N/A
1980	01/07-01/16	High Surf, Wind, Floods	All islands	$27.6
1980	01/08-01/10	Kona Storm	Maui	$12.9
1979	03/07	Severe Storm, Floods	N/A	N/A
1975	12/07	Kalapana Earthquake	Hawai‘i	N/A
1974	04/19	Heavy Rains, Floods	Kauai, Oahu, Maui	$3.8

1973	05/16	Earthquake		N/A
1968	01/05	Heavy Rains, Floods	Oahu	$1.2
1963	04/24	Heavy Rains, Floods		N/A
1960	05/23	Tsunami	Hawai‘i (Hilo)	$23.0
1960	01/21	Earthquake/Volcanic Disturbances		N/A
1959	08/04-08/06	Hurricane Dot	Kaua‘i, O‘ahu, Hawai‘i	$6.0
1957	03/16	Tsunami		N/A
1955	04/01	Volcano Disturbances	Hawai‘i	N/A
1946	04	Tsunami	Hawai‘i (Hilo)	$2.6

1.2 The City and County of Honolulu

The State of Hawaii consists of eight major islands (Kauai, Niihau, Oahu, Maui, Molokai, Lanai, Kahoolawe, and Hawaii) and 124 small islands, reefs, and shoals (referred to as the Northwest Hawaiian Islands) (Figure 1-1). The City and County of Honolulu consists primarily of the Island of Oahu but also includes the Northwest Hawaiian Islands, with the exception of Midway Atoll, which is administered by the U.S. Fish and Wildlife Service. The Northwest Hawaiian Islands and surrounding waters are also part of the Papahanaumokuakea Marine National Monument, which was established in 2006 and expanded in 2016, forming the largest marine wildlife reserve in the world. Its National Monument status also provides federal administration and protection. Consequently, this planning document focuses on the Island of Oahu.

Each of the islands in the Hawaiian archipelago are formed by volcanic activity understood to originate deep below the earths crust resulting in islands formed in the middle of the Pacific tectonic plate, as illustrated by the 3D topographic and bathymetric rendering of the island chain in Figure 1-2. The island of Oahu is formed by the parallel Koolau and Waianae mountain ranges, the eroded remnants of two shield volcanoes that last erupted 1.3 and 2.2 million years ago (Juvik, 1998). The mountains are oriented perpendicular to the tradewinds creating distinct windward and leeward climate conditions with 250 inches of rain per year on the crest of the Koolau mountains but only 20 inches per year on the leeward coastal areas. Oahu accounts for about 70% of the state’s population of 1.43 million.

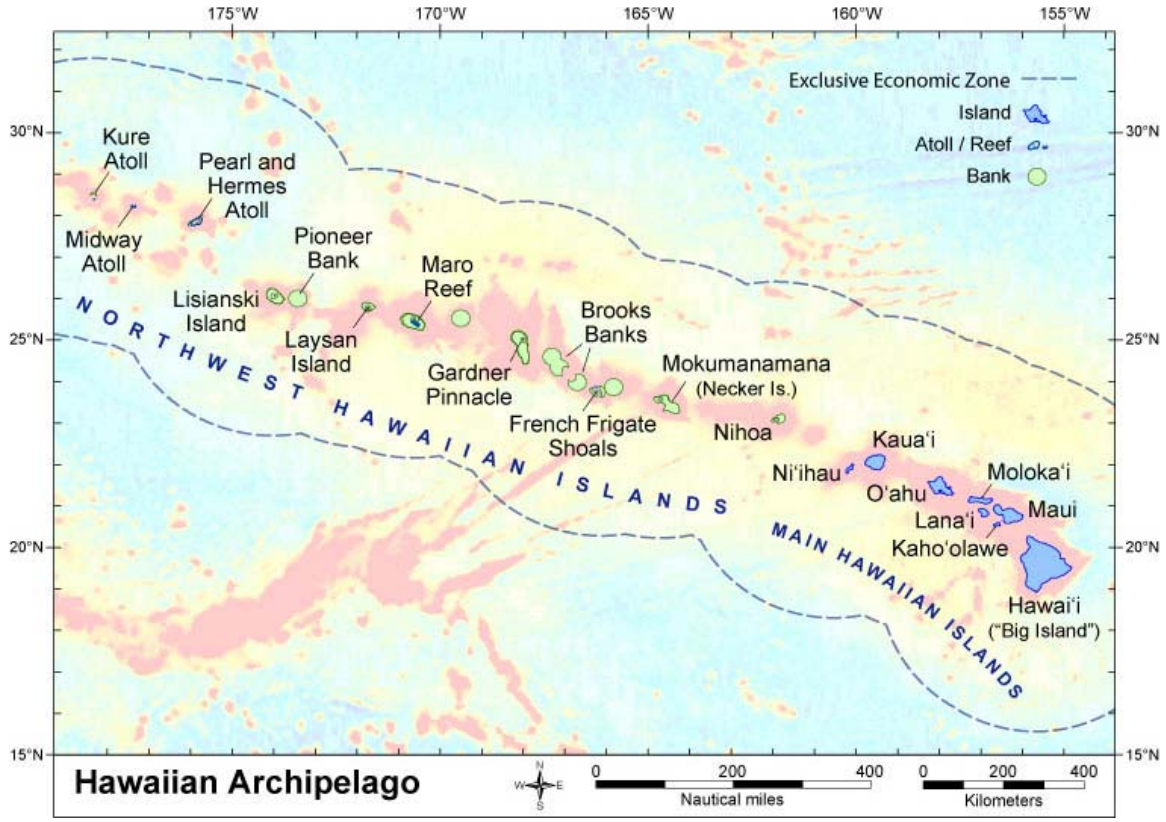


Figure 1-1. Map of the Hawaiian Archipelago

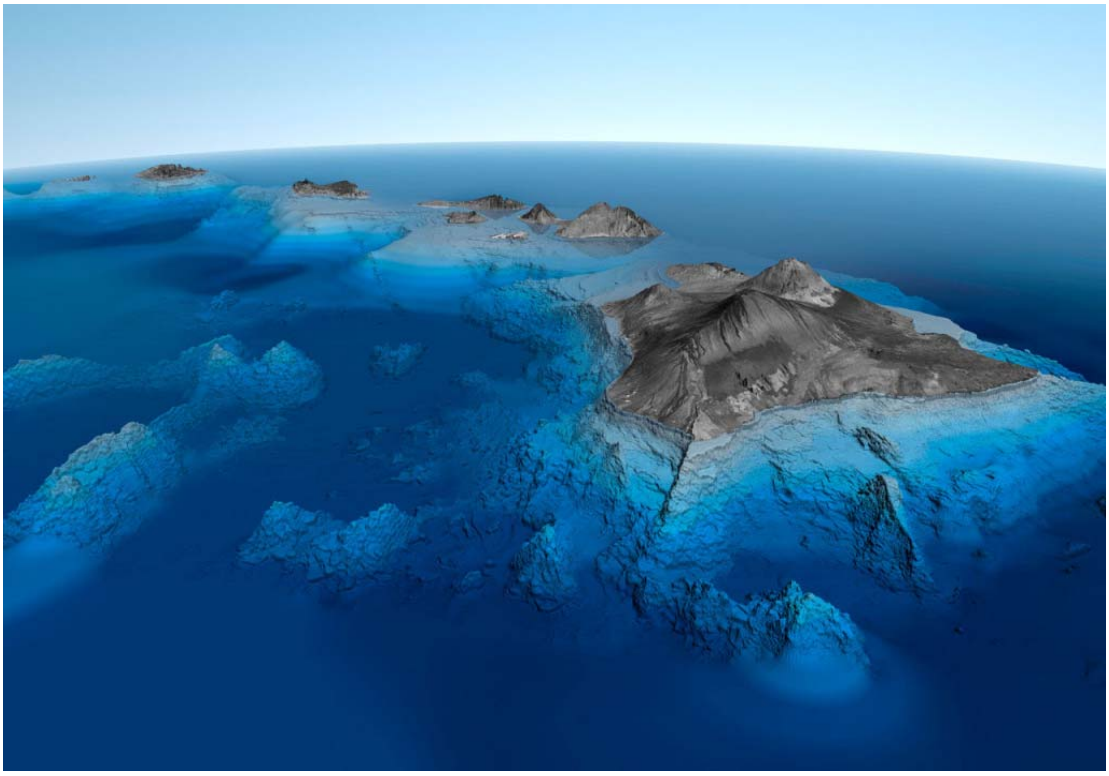


Figure 1-2 Three Dimensional Rendering of the Main Hawaiian Islands

1.3 Hazards, Losses and Risk Management

The first steps in hazard mitigation planning are to identify the hazards that affect a community, to assess the risk of disaster losses and evaluate the social, economic, and environmental vulnerability of a community. A summary of the hazards relevant to Oahu is provided in Table 1-3.

Losses linked directly to a hazard event include all damages, deaths and injuries, loss of habitation, and employment losses due to the closure of damaged facilities. This includes physical destruction of buildings and contents, transportation and utility systems, crops, and natural resources and employment losses due directly to the closure of damaged facilities, including the cost of post-disaster cleanup. Indirect losses include economic losses due to dislocations in the industrial or commercial sectors, banking and insurance, temporary unemployment and business interruption, loss of economic productivity and downtime in tourism, loss of tax revenues from business relocation, and long-term health expenses incurred from a permanent injury. Recovery from disasters also requires resources to be diverted from other public and private programs, adversely affecting the productivity of the economy.

Average Annualized Loss (AAL) is an objective measure of future losses averaged on an annual basis, calculated as the sum of the expected loss for each event (i.e., sum of the products of the estimated loss from each event and that event's rate of occurrence). In cases where there is insufficient confidence in the probability estimates of rare events and where sufficient past data is available, the average annualized loss is based on historical losses. Annualized loss estimates were used to establish a measure of relative economic importance of particular natural hazards and to determine and prioritize potentially effective mitigation actions insofar as benefits from reduced annual loss costs. This information is used in assessing the relative contributors to total natural hazard losses and determining the priorities for hazard mitigation measures. The comparative average annual losses for the most severe hazards are listed in Table 1-2. Other unquantifiable losses include environmental consequences, non-financial losses such as loss of historical resources, and psychological-social effects suffered by persons involved in a disaster.

Risk management is the process by which the results of an assessment are integrated with political, economic, and engineering information to establish programs, projects and policies for reducing future losses and dealing with the damage after it occurs. Managing risks involves selecting various approaches that will reduce the vulnerability when applied to the risk area. In order to effectively evaluate the expected costs associated with natural hazards, the vulnerability of the built environment, public, health and safety, and business and natural resource vulnerabilities must be estimated. Vulnerable asset groups on Oahu, along with the hazards to which they are most vulnerable, are listed in Table 1-4.

When vulnerable assets are identified, choosing whether to mitigate the potential hazards is based on whether proposed mitigation actions can significantly reduce the particular hazards or potential loss. Selection of specific mitigation projects can be prioritized based on some form of cost-benefit analysis.

Table 1-2. Relative Hazard Severity to the City & County of Honolulu Based on Average Annual Loss Estimates

Hurricane Winds	**$410 Million / Year**
Tsunamis	**$81 Million / Year**
Floods	**$41 Million / Year**
Earthquakes	**$21 Million / Year**
Debris Flows and Rockfalls	**$1 to $5 Million / Year**
Coastal Erosion	**$3 Million / Year**
Wildfire	**$1 Million / Year**
Dam Failure	**less than $1 Million / Year**
High Surf	**less than $0.5 Million / Year**
HAZMAT	**less than $0.10 Million / Year**

Table 1-3. Summary of Hazards Relevant to Oahu

Hazard	Siting Issues	Building Issues	Locations	Plan Chapters	Hazard/Loss Analysis Method
Climate Change Effects	Yes	Climate change affects other hazards	Primarily coastlines, also heavier rainfall	4	Modifying hazard analysis methods to account for climate change effects
Coastal Erosion and High Surf	Yes - Establish erosion zone setbacks	Location of structure on lot – its setback, and its elevation	Sandy coastlines.	5	Historical Rates
Hurricane Wind	Yes	Higher standards for particular topographic conditions.	Coastal areas may have high winds due to open exposure, but inland areas are affected by topography	6 7	Probabilistic Windspeed Analysis and Loss Estimation
Tsunamis	Avoid inundation zone, if possible, for critical facilities	Higher design standards for critical and essential facilities and taller buildings.	All coastal areas	9	Probabilistic Tsunami Hazard Analysis and Loss Estimation
Hurricane Storm Surge / Flooding	V, VE zones – avoid for critical facilities Flood zones A, AE – elevate critical facilities	Lowest horizontal structural member above Base Flood Elevation (BFE)	Along coastal areas and adjacent to stream floodways. West, East and South shores at higher risk	7 8	Probabilistic 100-yr. and 500-yr. per Flood Insurance Rate Maps
Earthquakes	Yes	Adopt an updated building code	Moderate seismic hazard throughout Oahu	10	Probabilistic ground motion hazard basis for loss estimation
Landslides/ Debris Flow	Yes	Residential development in upland areas	Steep hillsides, and heavy rainfall	11	Historical Losses and Mitigation Costs
Droughts and Wildfire	Yes	No	Primarily the central region between the Koolau and Waianae mountains	12 13	Standardized Precipitation Index (SPI)
Dams and HAZMAT	Yes	No	Existing older dams Hazardous Material Facility Locations	14 15	Deterministic Scenarios
Volcanic Gas Emissions	No	No	Distant Source – Big Island	16	VOG Chemistry and Public Input

Table 1-4. Areas of Vulnerabilities

Vulnerable Area	Ownership	Natural Hazards	Primary Problems/Effects	Mitigation Benefits
Power lines, traffic signals, power substations	HECO	High winds, Kona storms Hurricanes	Utility and transportation disruption, navigation impeded, business interruption; social stress	Public safety, minimize power outages, economic recovery
Residential homes	Private	High winds, Kona storms Hurricanes, erosion	Damage, loss of property	Public safety, reduce costs of recovery, rebuilding
Schools	Public/private	High winds, hurricane	Loss of life, damage to building and contents, disruption of social well-being, shelter facilities at risk	Public safety, protection of use of structure
Coastal hotels/resorts	Private	Coastal erosion, storm surge, high wind & surf	Erosion removes sand and compromises structural integrity, damage to lower floors, economic disruption	Prevent costly damage, prevent impact of erosion on beaches/dune systems
Public beaches and facilities	Federal, County State	Coastal erosion, storm surge, high wind & surf	Coastal erosion	Protect beaches and dunes
Port/harbor damage	Public/private	Storm surge, tsunami overwash	Facility flood inundation, hazardous materials released, foundation / structural damage, waterborne debris, interrupted intermodal commerce, loss of supplies to Island, business interruption	Minimize business disruption, prevent costly damage, protect the supply chain for goods
Coastal roads	County, State	Overwash, erosion, storm surge, high surf	Evacuation difficulties, access difficulties	Prevent costly road repair, business interruption
Downed trees	County, private	High winds, hurricanes, Kona Storms	Damage to buildings, cars, power outages, business interruption, transportation disruption, debris cleanup	Public safety, prevent costly debris cleanup, business interruption
Historical buildings	County, state, Private	High winds, storm surge	Loss of cultural resources	Protect cultural resources
Sewage Treatment Plants	County	Storm surge, high surf	Environmental damage, economic & social hardship	Public safety, avoid environmental damage

This plan focuses on natural hazards, with a priority on disaster-potential hazards. Rather than create separate plans for each type of natural hazard, this plan is a multi-hazard plan. A multi-hazard plan has several advantages:

1. Certain hazards cause cascading hazard effects (e.g., earthquakes may cause landslides, rockfalls; hurricanes cause wind damage and flooding or dam break flooding; etc.).
2. Priorities can be established to allocate limited resources to areas susceptible to the most severe or frequent hazards.
3. Areas identified as susceptible to multiple types of risks may require special attention.
4. Common responses often apply to different hazards.
5. Resources or mitigation measures can be leveraged where they could benefit multiple hazards; for example proposed changes to building design standards could consider both wind effects (hurricane) and ground-shaking (earthquake), flooding, and shoreline erosion / climate change.

1.4 State Hazard Mitigation Goals

The following hazard mitigation goals were established in coordination with the 2018 State of Hawaii Hazard Mitigation Plan, which is based on input from its State Hazard Mitigation Forum:

- **Goal 1**— Reduce the long-term vulnerability of Hawaii's people, property and jurisdictions, including state-owned or operated buildings, infrastructure and critical facilities, to natural hazards while conserving the State's natural, historical, and cultural assets. This includes high risk properties such as repetitive loss (RL) and severe repetitive loss (SRL) properties.
- **Goal 2**— Promote actions designed to ensure long-term resiliency
- **Goal 3**— Strengthen partnerships and leverage existing resources and capabilities to identify, assess and reduce the impact of natural hazards
- **Goal 4**— Utilize state-of-the-art methods and technology and local knowledge to identify and analyze natural hazards and assess State capabilities to reduce the impact of those hazards
- **Goal 5**— Promote public awareness of natural hazard risks and public action to reduce the long-term risks
- **Goal 6**— Provide a framework for robust local hazard mitigation planning and mitigation strategy implementation in alignment with this plan.

1.5 Organization of the Plan

The plan is organized into the following subject areas, following an organization similar to the 2012 plan last approved by FEMA. However stakeholder feedback incited a change in the order of the hazards. Climate Change was indicated as a long term effect that could possibly affect many other hazards and was therefore placed towards the beginning. FEMA required chapters (5-13) were then placed next in relevant order, followed by the additional chapters (14-10) not required by FEMA:

- **Mitigation Planning** (Chapter 2).
- **Land Use and Development** (Chapter 3).
- **Hazards Analysis** (Chapters 4-16). All natural hazards that pose a potential threat to the City and County of Honolulu were analyzed to determine the degree of threat posed by each. The analysis provides a description of the hazard, significant historical events, probability of occurrence, risk assessment techniques, and mitigation strategies. All chapters have been updated from the 2012 Plan:
  - Climate Change Effects (Chapter 4); new chapter added to address the exacerbating effects of climate change on other hazards
  - Coastal Erosion (Chapter 5); formerly Chapter 13; High Surf (formerly Chapter 12) has been consolidated into Coastal Erosion due to the nature of the hazards
  - High Wind Storms (Chapter 6); formerly Chapter 4
  - Tropical Cyclones (Chapter 7); formerly Chapter 5
  - Floods (Chapter 8); formerly Chapter 10

- Tsunamis (Chapter 9)
- Earthquakes (Chapter 10); formerly Chapter 7
- Landslides and Rock Falls (Chapter 11); formerly Chapter 6
- Droughts (Chapter 12); formerly Chapter 14
- Wildfire (Chapter 13); formerly Chapter 15
- HAZMAT (Chapter 14); formerly Chapter 16
- Dam Failures (Chapter 15); formerly Chapter 11
- Vog (Chapter 16); formerly Chapter 8

- **Shelters** (Chapter 17). Facilities used for the purposes of sheltering residents in the event of a hazard are presented in this updated chapter.
- **Risk Assessment** (Chapter 18). Those hazards determined to be of sufficient threat to Oahu were further examined to determine the degree to which the population, structures and land areas are vulnerable to the hazards. The analysis examined location of population concentrations, critical facilities, community resources, major transportation routes and infrastructure lines.
- **Mitigation Strategy and Implementation Action** (Chapter 19). By overlaying the hazard areas and community assets, problems and issues were identified. The strategy to address these problems and issues consisted of clarifying mitigation goals and objectives, identifying alternative mitigation actions, selecting and prioritizing the actions to be implemented, and developing an action plan. Mitigation actions include "hardening" critical facilities to withstand hurricane, tsunami and earthquake forces; structural and land treatment measures that contain or redirect natural hazards; planning and regulatory measures to guide development adaptative to hazards and establishing standards for managing risk to hazards; and incentive and educational measures to encourage practices which are consistent with the disaster resistant community goals.
- **Planning Maintenance and Update Procedures** (Chapter 20). The last chapter documents the extent of public participation and methodology used to develop the plan, as well as the methods and frequency to keep the plan updated.

1.6 Accomplishments from the 2012 Priority Mitigation Projects

A list of accomplishments based on completed and ongoing projects mostly identified as priority mitigation activities from the 2012 City and County of Honolulu Multi-hazard Pre-disaster Mitigation Plan are as follows:

- Adopted tsunami design provisions for buildings for new design and construction in the State Building Code amendment to the 2012 IBC, SECTION 1615 TSUNAMI LOADS. (However, this section needs to be further refined for adoption in the Honolulu Building Code.)
- State Building Code includes Enhanced Hurricane Protective Area requirements for all new State- and County-owned public assembly buildings.

- Developed a Hawaii certification program for residential safe room assemblies that is embodied in the State Building Code local amendment to the 2012 IBC, Section 425.5.4 Approved Debris Impact Resistant Wall Assemblies.
- Formulated a proposed comprehensive set of climate change adaptation measures for Honolulu, *Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability To Coastal Hazards and Climate Impacts* (State Office of Planning, 2018)
    - Developed a pilot study south coast inundation analysis for hurricane and high wind events to include climate change effects, to quantify flood hazards from hurricanes for Honolulu on the south shore of Oahu, Hawai`i. Probabilistic inundation maps, which take into account increasing hurricane activity and sea level change, will be a useful tool for planning and regulation of coastal development. This pilot study of coastal storm inundation including climate change was performed as a proof-of-methodology for implementation.
- Conservation land setback rules established the setback line about 40 feet from the certified shoreline, plus 70 times the average annual coastal erosion rate. Conservation Land Use Rules, Chapter 13-5 of the Hawaii Administrative Rules have established that for DLNR Conservation land, the previously suggested policy is now law.
- Tsunami evacuation maps have been updated based on state-of-the-art inundation modeling of an Extreme Tsunami from the Aleutian Islands.
- At the port of Honolulu, the effects of tsunami scenarios having greater risk were analyzed to determine: 1) damages to the ports, cargo, and vessels, 2) port functionalities and trade disruptions. Damage assessment was based on harbor currents, inundation depth onland, and flow velocity onland. Important facilities significantly impacted were identified.
- A post & pier/single wall hurricane retrofit online guide was developed by DCCA.
- In 2018, enhanced Honolulu building inventory updates included new site-specific building inventory, and additionally including site-specific essential City and State buildings and all the buildings in the University of Hawaii system on Oahu. This enhanced data was incorporated into the HAZUS model of PDC
- Inspection of all Oahu dams has been completed including development of evacuation maps that are now publically available.
- The Hawaii Rainfall Atlas was updated.

1.7 Digest of Significant Changes from 2012 to 2018 Multi-Hazard Mitigation Plan

Overall Reorganization and Reformatting of the 2018 Plan	
As an improvement to make the plan easier to read for users, the second Volume from the 2012 Plan has been removed, and links are included to view necessary information online. The ordering of the individual hazards has also been changed, as noted in Section 1.5. The number of hazards individually included in the plan has remained the same, due to the consolidation of High Surf into Coastal Erosion due to their paired nature and a new chapter now included on the effects of Climate Change on Oahu. Although not a hazard itself, climate change may cause an increase in the severity of most other hazards and has thus been given its own chapter.	
The number of graphic and photographic exhibits has decreased, and examples are included with links to full maps. This was done in order to reduce the size of the document and promote the City's shift towards online, interactive maps.	
Each hazard-specific chapter discusses previous/current mitigation efforts and future mitigation plan activities, so that specific recommendations focused on each hazard are more readily identified.	
Chapter	**Description of Updates / Revisions in the 2018 Plan**
Executive Summary	
The 2012 plan plan developed a concise executive summary leading more definitively to the plan's hazard mitigation measures. Tables were added providing the results from the Risk Assessment chapter on the Relative Hazard Severity to the City & County of Honolulu based on Average Annual Loss Estimates and the listing of projects.	The table has been updated providing the results from Chapter 18 on the Relative Hazard Severity to the City & County of Honolulu based on Average Annual Loss Estimates. The table of specific hazard mitigation measures and their priorities has also been updated. County Council and Mayoral approval documents are located at the end of the Executive Summary.
1. Introduction	
In the 2012 plan, a more comprehensive summary of historic disasters, general information about the County and State, mitigation goals and objectives, plan organization, and an included summary of what recommended major mitigation measures have been achieved.	The table listing the Federally Declared Disasters has been updated. The organization of the plan has been significantly updated. The table listing the AAL estimates has also been updated. This table providing a summary of most significant changes from the prior plan has been updated as well.
2. Mitigation Planning	
The 2012 plan discussed the planning effort for this document and various organizations involved. Hazard mitigation is defined and the range of hazard mitigation activities and examples are presented.	The plan includes a broader discussion of the mitigation planning process at the Federal, State and local levels. National goals and programs are explained. The City and County General Plan public safety objectives are discussed. The Honolulu Planning Process to develop this document is discussed, chronologized, and lists of individuals from the various organizations participating in planning meetings are given, leading to the All Department workshop to finalize the mitigation project priorities documented in this plan. The results of a widely disseminated survey on public concerns regarding hazards are summarized. City Council hearings are documented leading up to final City Council approval of the plan. Mayoral approval is to be after FEMA review.

Chapter	Description of Updates / Revisions in the 2018 Plan
3. Land Use and Development	
The 2012 plan included general population and economic demographics. It then discusses the county planning process including details of each development plan region.	In the 2018 Plan, population and economic demographics and development trends have been updated. The land use and the general and development planning regulations of the City of Honolulu are described and updated. The status of the eight regional development plans are reported. A link to the DPP's website for the development plan regions has been included, with more concise summaries provided in this chapter. The environmental assessment process is described, which now must include the effects of sea level rise. Relevant information previously found in other sections of the 2012 Plan have been relocated to this chapter. Future development mitigation projects have been summarized and referenced to Chapter 19, Mitigation Strategy and implementation Actions.
4. Climate Change Effects	
The 2012 plan did not include a chapter on Climate Change, however the effects of it were discussed in other chapters. Due to the significance of its effects and new research, a new chapter was created.	Climate change itself is not an immediate issue for the City and County of Honolulu, it is the impending exacerbating effects that climate change will have on all other hazards that may greatly affect Oahu. Includes explanations of climate change effects that could occur on Oahu. Oahu is projected to have the most significant losses due to climate change, both economically and in terms of structures. The current attempts at reducing Oahu's carbon footprint are recognized. Suggested projects and policy changes to secure Oahu's adaptation to climate change are included.
5. Coastal Erosion	
The 2012 plan described the causes of coastal erosion and exacerbating factors. It described research that had been done to quantify the amount of coastal erosion and the cost to fix it. Proposed legislation to increase setbacks is discussed.	The coastal erosion rate maps (now published) developed by the University of Hawaii are highlighted to document coastal erosion; an example and link to the rest are included. Updated shoreline setback regulations based on these values and Maui County's strategy are suggested. Recent wave run-up simulations, beach nourishment programs, and projects to relocate or reinforce vital infrastructure in coastal regions are described.
6. Strong Winds	
The 2012 plan included detailed descriptions of wind hazards. It gave a history of high wind events and mentioned work on quantifying the topographic effects on windspeed due to Oahu's unique geography.	A more clear distinction is made between non-tropical cyclonic winds (Trade winds and Kona winds as discussed in this chapter) and tropical cyclones. A previous discussion of wind and wind effects nomenclature has been refined. Wind roses to show the annual wind patterns are also refined. Redundant information and tables are removed from this chapter and placed exclusively in the next chapter. An updated chronology of high wind events on Oahu not related to hurricanes is given, which have historically reached to over 100 mph gusts. This is important to distinguish extreme events of synoptic winds of the regular climatology from tropical cyclone activity in the Central Pacific region. Topographic effects due to Oahu's mountainous terrain are quantified using information now adopted in the Honolulu Building Code and awarded the Outstanding Civil Engineering Achievement of 2010 by the Hawaii Chapter of the American Society of Civil Engineers. The 2012 plan had many of these maps included, now an example and a link of where to find them is included. The chapter is updated to reflect changes in building codes. The different hazard curves of tropical cyclones and all other wind events are clearly distinguished and discussed.

Chapter	Description of Updates / Revisions in the 2018 Plan
7. Tropical Cyclones	
In the 2012 plan, this chapter included hurricanes, discussing the hurricane hazard, risks, and vulnerabilities. Tropical cyclone winds present a distinctly different level of wind hazard episode to Oahu compared to its annual climatology. The scope of this chapter includes all tropical cyclones (tropical depressions, tropical storms and hurricanes) as these are all contributors to the wind hazard curve (the probabilities of windspeed) It included many figures and historical events. Some shelter information was included.	Cyclonic storm activity in the Central Pacific region near Hawaii is described. Several figures were outdated and were either updated or removed. Historical data was also updated. The FEMA flood insurance study of the south and west coasts of Oahu based on tropical cyclones is summarized. An analysis of hurricane hazard for the climate at the end of the century was performed. This is discussed in Chapter 4. State Building Code: Wind speed maps have been completed and incorporated for each of the major islands. The maps of effective wind speed can be interpreted as reflecting a higher risk. Incorporation into State Building Code. For new buildings, shelter criteria have been incorporated into the State building code for new buildings having an occupancy that could function as shelters. The chapter discusses changes to the recent building codes. HAZUS MH includes a hurricane loss estimation module. The hazard assessment using average annualized losses has been updated using HAZUS MH and an updated profile of housing construction on Oahu. This is the highest rated hazard in terms of average annualized losses anticipated. Hurricane hazard mitigation projects have been revised. All hurricane shelter information has been moved to Chapter 17.
8. Floods	
The 2012 plan describes historic floods, the NFIP and its local implementation, high risk areas, FIRM maps, flood ordinances, and planning.	The major flooding events in Hawaii are caused by storms, storm surge, high surf and tsunamis. The effect of coastal erosion on coastal flood hazard increase is described. Historic flood data has been updated, particularly considering the 2018 Kauai and east Oahu floods. A rainfall intensity map is provided with discussion of flash floods. NFIP flood insurance study maps for the coastal zone are described and exhibited. The City of Honolulu revised floodplain ordinance is described. Flood ordinances are updated. All repetitive loss properties have been updated and mapped. The repetitive flood loss analysis is also performed on properties only within flood zones. For Oahu, the number of Severe Repetitive Flood Loss properties is relatively few. The hazards considered of high importance by most people for personal planning and preparation were hurricanes, high winds/storms, tsunami, earthquake and flooding. The FHAT tool is discussed as a decision support tool to enable better compliance with flood regulations. Planning and zoning regulatory measures are detailed. New flood hazard mitigation activities are recommended. Recent and future mitigation activities are discussed.
9. Tsunamis	
The 2012 plan discussed causes of tsunamis, historic tsunamis, the tsunami hazard, and evacuation maps. It also included a community vulnerability study for Oahu.	Additional general discussion of tsunamis, a more complete treatment of their various source mechanisms and damaging effects. Recent damage from the Samoa and Japan tsunamis is included. A discussion of a recent update to the community vulnerability study is provided. New tsunami inundation and evacuation map products are discussed, now including the Extreme Tsunami events. The previous inventory of all maps has been removed and replaced with an example and a link to the maps. Historical sections have been refined to only include the most relevant information. An estimate of tsunami average annualized losses is calculated based on these maps and property values in a GIS-geocoded database. New tsunami hazard mitigation projects are presented; a recently completed project towards implementation of the new ASCE tsunami design standard in Hawaii is discussed. A recent study of the effects of tsunamis impacting Honolulu Harbor functionality is presented.

Chapter	Description of Updates / Revisions in the 2018 Plan
10. Earthquakes	
The 2012 plan provided a basic description of seismicity for Hawaii effects and distribution of soil types and risk assessment. It added a discussion on the 2006 Kiholo Bay earthquake.	More information is provided on the fundamental seismological mechanisms for earthquakes in Hawaii, which is unlike continental seismology. Oahu is subject to deep earthquakes resulting from the plate flexural stresses in the lithosphere generated by the emplaced weight of the superimposed volcanic island mass on top of the oceanic crust. The most recent example of this was the M6.7 October 15, 2006 Kiholo Bay earthquake; it is described and its effects on Oahu in regards to island-wide electricity failures. This section is shortened from the 2012 report. Outdated figures have been updated or removed if unnecessary. The 2018 lower Puna eruption has not seismically affected Oahu in any significant way but is mentioned. The most current seismic design code available is the International Building Code (IBC). These provisions incorporate seismic hazard mapping of Hawaii developed by the U.S. Geological Survey (USGS) and the Hawaii State Earthquake Advisory Committee. Seismic hazard for Oahu based on the International Building Code is explained. The average annualized risk analysis is updated per HAZUS MH along with related mitigation activities. The risk is now estimated to account for the fourth largest amount of annualized financial losses behind flood losses. The continuation of bridge seismic retrofits are described. Seismic hazard mitigation project recommendations are updated.
11. Landslides and Rock Falls	
The 2012 plan discusses the various mechanisms for landslides and rockfalls in Hawaii and high hazard areas. It contains a detailed history of rockfalls on Oahu.	This chapter is slightly reorganized and then significantly modernized. Information on rockfalls due to seismic activity is removed due to it being unlikely to occur on Oahu. More data on historic debris flows has been added, and unnecessary historical details have been removed. Mudslides on Kauai and Oahu in April 2018 are discussed. The 2012 update to the Rockfall Hazard Rating System is discussed. There have recently been a number of other mitigation measures funded by various organizations. A significant amount of such rockfall mitigation has been accomplished. A description of recently completed mitigation activities by the state and other organizations has been added. Different rockfalls mitigation techniques are discussed.
12. Droughts	
Droughts, drought impacts for the various sectors, drought management, and advancements in drought monitoring are described.	The status of recent drought mitigation is discussed and new drought mitigation activities are included. The Hawaii Drought Plan (HDP) has been updated in 2017 for use by the Hawaii Drought Council to improve coordination and implementation of drought management strategies for the State of Hawaii. The Oahu Drought Committee produced an update to their report in 2012. Several new drought studies are included in the chapter.
13. Wildfires	
The 2012 plan established wildfire as its own chapter for the first time. It focused upon the threat of developing near wildlands without sufficient defensible space.	Added further discussion of the hazard and example statistics of acres burned and accounts of recent wildfire events are now included. A map of fire response zones for HFD and DOFAW is provided. The status of ongoing projects is updated and a new list of future mitigation projects are proposed.

Chapter	Description of Updates / Revisions in the 2018 Plan
14. HAZMAT	
The HAZMAT hazard is described in the 2012 plan along with the HSERC and LEPC. HAZMAT sites are listed and HAZMAT team equipment is inventoried.	Further background for the legislative structure and organizations that govern the management of hazardous materials is provided along with their roles and responsibilities. The CLEAN local emergency action network is included. An Oahu Response Program Site List and the HAZMAT sites are mapped and discussed.
15. Dam Failures	
A general description of the dam failure hazard and dam locations was given in the 2012 plan. A description of the seismic evaluation of dams was provided.	Emergency Action Plans are now in place for all 13 dams on Oahu.
16. VOG (Volcanic Gas)	
The 2012 Plan described VOG, its effect on the population on Oahu, and declared that no mitigation projects are currently necessary on Oahu.	VOG is used to describe hazy conditions caused by gaseous emissions from three primary sources from Kilauea volcano. The direct volcanic hazard from gaseous emission is minimal on Oahu that is 200 miles away. The 2018 Lower East Rift Zone eruptions on the island of Hawai‘i have renewed concerns of VOG on Oahu. The effects are discussed and the chapter is updated accordingly. However, no mitigation projects are currently considered necessary on Oahu.
12. High Surf	
The 2012 plan described the high surf hazard, historical occurrences, high wave hazard zones, and mitigation strategies.	The example maps have been updated. The 2012 Plan mentioned several resources that were more about hazard response rather than hazard mitigation, and thus have been removed. This chapter has been merged into the costal erosion chapter
17. Emergency Shelters	
The 2012 plan described a list of hurricane shelters and an analysis of the shelter needs. Shelter information was consolidated in this chapter.	There is a lack of shelter space people on Oahu, and many of those buildings have never been inspected to see if they can actually survive a hurricane. An updated list of shelters on Oahu for all hazards is provided. Structural inspections of all hurricane shelters were deemed necessary and have been underway for several years. SEAOH created a catalog of shelters on Oahu of the shelters that engineers have inspected. Vertical evacuation plans for tall buildings are now in place to ease the strain of shelters in high population density areas such as Waikiki.
18. Risk Assessment	
The 2012 Plan describes what Risk Assessment is and presents findings from studies done for the plan.	This chapter updates a summary of risk assessments for all hazards. Results from new risk analyses of all critical facility buildings in the County and expected losses for earthquakes and hurricanes is described with the most vulnerability facilities identified. A risk analysis of the University of Hawaii System campus buildings is given with facility vulnerability rankings. Risk assessment AAL's are updated for Hurricane, Earthquake, Floods, Tsunamis, and the other significant hazards. The relative hazard severity of the hazards treated in this plan based on average annualized losses is determined. The completed and ongoing projects that are expected to reduce vulnerability to the different hazards are discussed. Critical facilities are identified and listed. The most vulnerable facilities are identified.

Chapter	Description of Updates / Revisions in the 2018 Plan
19. Mitigation Strategy and Implementation Actions	
The 2012 Plan discusses mitigation strategy, goals and the planning process. It also describes the benefit-cost analysis process and provides a list of prioritized proposed mitigation projects.	The planning information was moved into the mitigation planning chapter. The status of the past prioritized list of mitigation projects from the 2012 plan is reported with most of these completed. This chapter then focuses on the prioritized mitigation projects recommended moving forward as determined through stakeholder workshops. Since the individual mitigation projects proposed were developed in each hazard section previously, this chapter can be succinct in a compilation and prioritization of those projects. An updated list of proposed projects is included and categorized by type of mitigation activity. Honolulu's Mitigation Goals and Objectives are revised and updated.
Chapter	**Description of Updates / Revisions in the 2018 Plan**
20. Plan Maintenance	
The 2012 planning plan maintenance and implementation process was described.	This chapter has been revised with specific monitoring, evaluation and update procedures. A check list of hazard mitigation projects to monitor for future inclusion in this plan is given, so that any ongoing or anticipated activities are specifically identified for the next plan update. Examples of recent activities to promote hazard mitigation in other plans is detailed. Guidelines for grant eligible types of projects are given.
21. & 22. Glossary and References	
	These chapters have been updated to reference new material.
FEMA Review	
	Any FEMA review comments and responses are to be documented.



2. Mitigation Planning Process

2. MITIGATION PLANNING PROCESS

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan discussed the planning effort and the various organizations involved. Hazard mitigation was defined and the range of hazard mitigation activities and examples are presented. It included a broader discussion of the mitigation planning process at the Federal, State and local levels. National goals and programs were explained.	• The City and County General Plan public safety objectives are updated. • The Honolulu Planning Process to develop this document is discussed, chronologized, and detailed lists of individuals from the various organizations participating in planning meetings are given, leading to an All Department workshop in February 2019 to finalize the mitigation project priorities documented in this plan. • The results of a widely disseminated survey on public concerns regarding hazards are summarized. • Records of hazard mitigation planning meetings are provided. • City Council hearings are documented leading up to final City Council approval of the plan. • Mayoral approval is still required, signed after FEMA review.

2.1 National Hazard Mitigation Planning Background Information

2.1.1 The Stafford Act

The Stafford Act was first passed into law in 1988 and created the system in place today that allows the President to make disaster declarations triggering financial and physical assistant through FEMA. 44 CFR Part 201, Hazard Mitigation Planning, establishes criteria for State and local hazard mitigation planning authorized by §322 of the Stafford Act, as amended by §104 of the Disaster Mitigation Act 2000 (DMA). After November 1, 2003, local governments seeking Pre-Disaster Mitigation (PDM) funds through a State application had to have an approved local mitigation plan prior to the approval of local mitigation project grants. States also were required to have an approved Standard State Mitigation Plan in order to receive PDM funds for State or local mitigation projects after November 1, 2004. The Standard State Mitigation Plan is required for non-emergency assistance provided under the Stafford Act, including Public Assistance restoration of damaged facilities and Hazard Mitigation Grant Program funding. Currently, any State with a FEMA-approved Enhanced State Mitigation Plan at the time of a disaster declaration is eligible to receive increased funds under the Hazard Mitigation Grant Program, based on 20 percent of the total estimated eligible Stafford Act assistance. Therefore, the maintenance of State and local multi-hazard mitigation plans is key to maintaining eligibility for future FEMA mitigation and disaster recovery funding. Elements of the Disaster Mitigation Act of 2000 and 44CFR Part201.6 which relates local hazard mitigation planning are provided below (recent amendments effective October 16, 2009 are shown in underlined italics):

2.1.2 The Disaster Mitigation Act of 2000

The Disaster Mitigation Act of 2000 authorizes spending each year and encourages a broad accounting of benefits. Section 101 (b)(2) of Act states that the intent is:

(1) to reduce the lots of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters; and

(2) to provide a source of pre-disaster hazard mitigation funding that will assist States and local governments (including Indian tribes) in implementing effective hazard mitigation measures that are designed to ensure the continued functionality of <u>critical services</u> after a natural disaster.

Section 203(b) indicates that:

> . . . The President may establish a program to provide technical and financial assistance to States and local governments to assist in the implementation of pre-disaster hazard mitigation measures that are cost-effective and are designed to reduce injuries, loss of life, and damage and destruction of property, including damage to critical services and facilities under the jurisdiction of the States or local governments.

2.1.3 44 CFR Part § 201.6 Local Mitigation Plans

The local mitigation plan is the representative of the jurisdiction's commitment to reduce risks from natural hazards, serving as a guide for decision makers as they commit resources to reducing the effects of natural hazards. Local plans will also serve as the basis for the State to provide technical assistance and to prioritize project funding.

(a) *Plan requirements.*

(1) For disasters declared after November 1, 2004, a local government must have a mitigation plan approved pursuant to this section in order to receive HMGP project grants. Until November 1, 2004, local mitigation plans may be developed concurrent with the implementation of the HMGP project grant.

(2) By November 1, 2003, local governments must have a mitigation plan approved pursuant to this section in order to receive a project grant through the Pre-Disaster Mitigation (PDM) program, authorized under '203 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. 5133. PDM planning grants will continue to be made available to all local governments after this time to enable them to meet the requirements of this section.

(3) Regional Directors may grant an exception to the plan requirement in extraordinary circumstances, such as in a small and impoverished community, when justification is provided. In these cases, a plan will be completed within 12 months of the award of the project grant. If a plan is not provided within this timeframe, the project grant will be terminated, and any costs incurred after notice of grant's termination will not be reimbursed by FEMA.

(4) Multi-jurisdictional plans (e.g. watershed plans) may be accepted, as appropriate, as long as each jurisdiction has participated in the process and has officially adopted the plan. State-wide plans will not be accepted as multi- jurisdictional plans.

(b) *Planning process.* An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include:

(1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;

(2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and

(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

(c) *Plan content.* The plan shall include the following:

(1) Documentation of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

(2) A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient

information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards. The risk assessment shall include:

(i) A description of the type, location, and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

(ii) A description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community. The plan should describe vulnerability in terms of:

(A) The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;

(B) An estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)*(ii)*(A) of this section and a description of the methodology used to prepare the estimate;

(C) Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

(iii) For multi-jurisdictional plans, the risk assessment section must assess each jurisdiction's risks where they vary from the risks facing the entire planning area.

(3) A mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools. This section shall include:

(i) A description of mitigation goals to reduce or avoid long- term vulnerabilities to the identified hazards.

(ii) A section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

(iii) An action plan describing how the actions identified in paragraph (c)*(3)(ii)* of this section will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

(iv) For multi-jurisdictional plans, there must be identifiable action items specific to the jurisdiction requesting FEMA approval or credit of the plan.

(4) A plan maintenance process that includes:

(i) A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five- year cycle.

(ii) A process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.

(iii) Discussion on how the community will continue public participation in the plan maintenance process.

(5) Documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commissioner,

Tribal Council). For multi-jurisdictional plans, each jurisdiction requesting approval of the plan must document that it has been formally adopted.

(d) *Plan review.*

(1) Plans must be submitted to the State Hazard Mitigation Officer for initial review and coordination. The State will then send the plan to the appropriate FEMA Regional Office for formal review and approval.

(2) The Regional review will be completed within 45 days after receipt from the State, whenever possible.

(3) Plans must be reviewed, revised if appropriate, and resubmitted for approval within five years in order to continue to be eligible for HMGP project grant funding.

(4) Managing States that have been approved under the criteria established by FEMA pursuant to 42 U.S.C. 5170c(c) will be delegated approval authority for local mitigation plans, and the review will be based on the criteria in this part. Managing States will review the plans within 45 days of receipt of the plans, whenever possible, and provide a copy of the approved plans to the Regional Office.

Table 2-1. Examples of Pre-Disaster Hazard Mitigation Activities

Type		Types of Activity
I	Education/Training	Offering workshops and seminars for public officials and employees, personnel of state agencies, and the general public
		Developing videos, pamphlets, brochures, and other literature
II	Commitment and Capacity Building	Organizing community groups and conducting team-building exercises
		Recruiting partners to promote mitigation
		Forming teams or committees for planning and conducting preparedness, response, and recovery planning
		Encouraging interagency cooperation and planning
III	Risk Assessment, Planning, and Plan Implementation	Conducting hazard, vulnerability, and risk analyses; mapping hazards; preparing inventories of threatened facilities; and carrying out other studies
		Preparing plans (e.g., risk mitigation plans, land improvements plans, harbor management plans, and beach management plans)
		Supporting planning, administrative, and legislative activities
		Forming planning and hazard management districts
		Developing and/or strengthening zoning and building code ordinances
		Enacting new risk mitigation regulations and legislation
		Conducting engineering studies and designing projects
		Developing mitigation incentives such as loan subsidy and/or grant programs
		Providing technical assistance
		Implementing risk mitigation plan
		Coordinating risk mitigation activities
IV	Drainage Projects	Replacing and improving culverts, pipes, mains, storm water lines, drainage ditches, channels, sewer pipes, and backup valves
		Constructing and stabilizing detention ponds and basins, dams, dikes, levees, barriers, berms, floodgates, and flood walls
		Stabilizing riverbanks and shorelines (retaining walls, riprap)
		Dredging and maintaining channels
		Removing debris and vegetation

V	Acquisition and Relocation Projects	Acquiring, demolishing, and/or relocating structures in flood zones
		Purchasing land and development rights in flood and erosion zones
VI	Structural Improvement Projects	Improving and retrofitting buildings and structures to resist earthquakes, wind, hail, water, and waves
		Floodproofing buildings and infrastructure in flood zones
		Elevating buildings and other structures
		Installing storm shutters and upgrading roofs to resist wind, rain, and fire
		Constructing hurricane walls, barriers, gates, and tidal valves
		Constructing new buildings, lifelines, and other structures to meet appropriate codes
		Repairing damaged buildings in ways to reduce repeated losses
		Constructing and upgrading emergency shelters
		Installing roll-up doors, special windows, and impact-resisting film
VII	Lifeline Improvement Projects	Upgrading piers and wharves
		Upgrading fuel storage tanks
		Anchoring and bracing equipment
		Improving utilities such as storm water, wastewater, and water treatment facilities and pumping stations; and electric, gas, communications systems
		Improving transportation systems (roads, bridges, etc.)
VIII	Land Improvement Projects	Replenishing beaches
		Stabilizing and restoring sand dunes and roadway banks
		Constructing and/or strengthening bulkheads and head walls
		Managing vegetation
		Controlling erosion (grading and vegetation)
		Stabilizing slopes (grading, drainage and vegetation)
		Remediating soil to reduce liquefaction potential
		Clearing brush, doing controlled bums, and building fuel breaks

2.1.4 FEMA National Pre-Disaster Mitigation Plan

2.1.4.1 Mission

The mission of the National Pre-disaster Mitigation Program is to reduce fatalities and injuries and to minimize the social, economic, and other negative economic effects of natural hazards by developing and promoting knowledge, practices and regulations.

2.1.4.2 Goals and Objectives

The main goals are:

1. Implement natural hazard loss reduction practices and policies.
2. Improve the performance of facilities and systems in natural hazard events.

The principles for program decision-making and prioritization are:

1. The proposed project will reduce losses effectively, including life, economic, social, and environmental losses;
2. The proposed project is consistent with the mission and approaches of the National Plan;
3. The proposed project, when considered with other projects, contributes to an integrated and comprehensive approach to hazard mitigation;
4. The proposed project is funded and assigned to an agency with the requisite authority and expertise; and
5. The proposed project will produce meaningful, definable, and measurable outcomes in terms of Principle 1.

The expanded objectives under the two main goals are:

Goal 1: Implement natural hazard loss reduction practices and policies:

Objective A: Encourage and support the development of disaster resistant communities

Objective B: Identify and implement means to effectively motivate the public to take actions to mitigate natural hazard risks

Objective C: Create and leverage incentives for public and private sector loss reductions actions.

Objective D: Develop and provide information to decision-makers and professionals on natural hazards and loss reduction measures

Objective E: Provide technical assistance to local and State governments for implementing loss reduction measures.

Objective F: Support mitigation training and education for professionals and practitioners (design professionals, land use planners, emergency management personnel, and facilities managers).

Objective G: Discourage social and economic activities that create vulnerability to natural hazards.

Objective H: Advocate public and private decision-making based on the use of hazard identification and risk assessment methods and technologies.

Objective I: Implement policies and practices that reduce the vulnerability of Federally-owned, financed, and leased facilities and infrastructure.

Objective J: Encourage policies and practices that reduce the vulnerability of State-owned, financed, and leased facilities and infrastructure.

Goal 2: Improve the performance of facilities and systems in natural hazard events.

Objective K: Encourage the transfer of mitigation technology to the end user.

Objective L: Improve the quality of planning, design, and construction practice.
Objective M: Support efforts to improve the development, adoption and enforcement of building and planning codes and standards that relate to natural hazards.
Objective N: Support and encourage the validation of mitigation technologies.
Objective O: Advance the understanding of naturals hazards phenomena and their effects.
Objective P: Advocate research based on user needs.

2.2 City and County of Honolulu Mitigation Planning

2.2.1 Development of Pre-Disaster Mitigation Plan

The prior plan had been approved in 2012 and thus had expired on August 2, 2017. An FY16 FEMA Predisaster Mitigation Program grant to fund the update process had not been obligated by the federal government. An interim partial plan with content that was essentially a five-page mitigation project status update, had been approved in August 2017 as an interim plan to be effective until this full update was accomplished and approved by August 30, 2019. Accordingly, per a Memorandum of Understanding between the City and County of Honolulu, the State of Hawaii, and FEMA Region IX, an extension anticipated a relationship of an abbreviated interim plan and the expected level of effort for this full update was indicated schematically as follows:

Level of Effort		
Existing Chapters	Abbreviated Update	Full Update
Introduction	Low or N/A	Low
Planning Process	Medium	Medium
Land Use and Development	Medium	Medium
Strong Winds	Low	Medium
Tropical Cyclones	Low	Medium
Landslides, Debris Flows, and Rockfalls	Low	Medium
Earthquakes	Low	Medium
VOG	Low	Medium
Tsunamis	Low	Medium
Floods	Low	Medium
Dam Failure	Low	Medium
High Surf	Low	Medium
Coastal Erosion	Low	Medium
Drought	Low	Medium
Wildfire	Low	Medium
Hazardous Material	Low	Medium
Emergency Shelters	Low	Medium
Risk Assessment	Low	High
Mitigation Projects	High	Low
Plan Maintenance	Medium	Low
Addtional		
- Inclusion of Ports	N/A	Medium

The development of the full update of the Pre-Disaster Hazard Mitigation Plan for Honolulu involved a significant broad-based participation of the Mayor, the City Council, Department of Emergency Management (DEM), a multi-agency Multi-Hazard Pre-Disaster Mitigation Plan Update Advisory Committee and its public and private partners, many State agencies, such as Hawaii Emergency Management Agency, the Dept. of Land and Natural Resources, HECO (electric utility) and federal partners such as NOAA. DEM determined that a specialty consultant should be utilized to do background research and studies of available update material and resources, present proposed update material and knowledge to the planning committee and stakeholder participants in periodic workshops, and document the workshops and incorporate the updates, and document hazard mitigation projects proposed. The full update of the Pre-Disaster Hazard Mitigation Plan began on June 7, 2018.

The project planning consultant team consisted of: **Martin & Chock**, which has established multi-faceted expertise in the fields of engineering research and development, planning for natural, man-made, and technological hazards, structural performance reliability analysis, risk analysis, structural engineering and antiterrorism blast analysis, as well as geospatial analysis using Geographic Information Systems; **HHF Planners (HHF)**, a Honolulu-based professional consulting firm, established in 1980, that is internationally recognized in disaster mitigation planning, community-based planning, policy and strategic planning, and environmental planning; and the **Pacific Disaster Center (PDC)**, which uses computer-based models to translate complex hazard information into actionable visualizations of potential disaster impacts. Model results are combined with GIS mapping tools to highlight scenario and to provide information about infrastructure, populations, and critical facilities in at-risk areas.

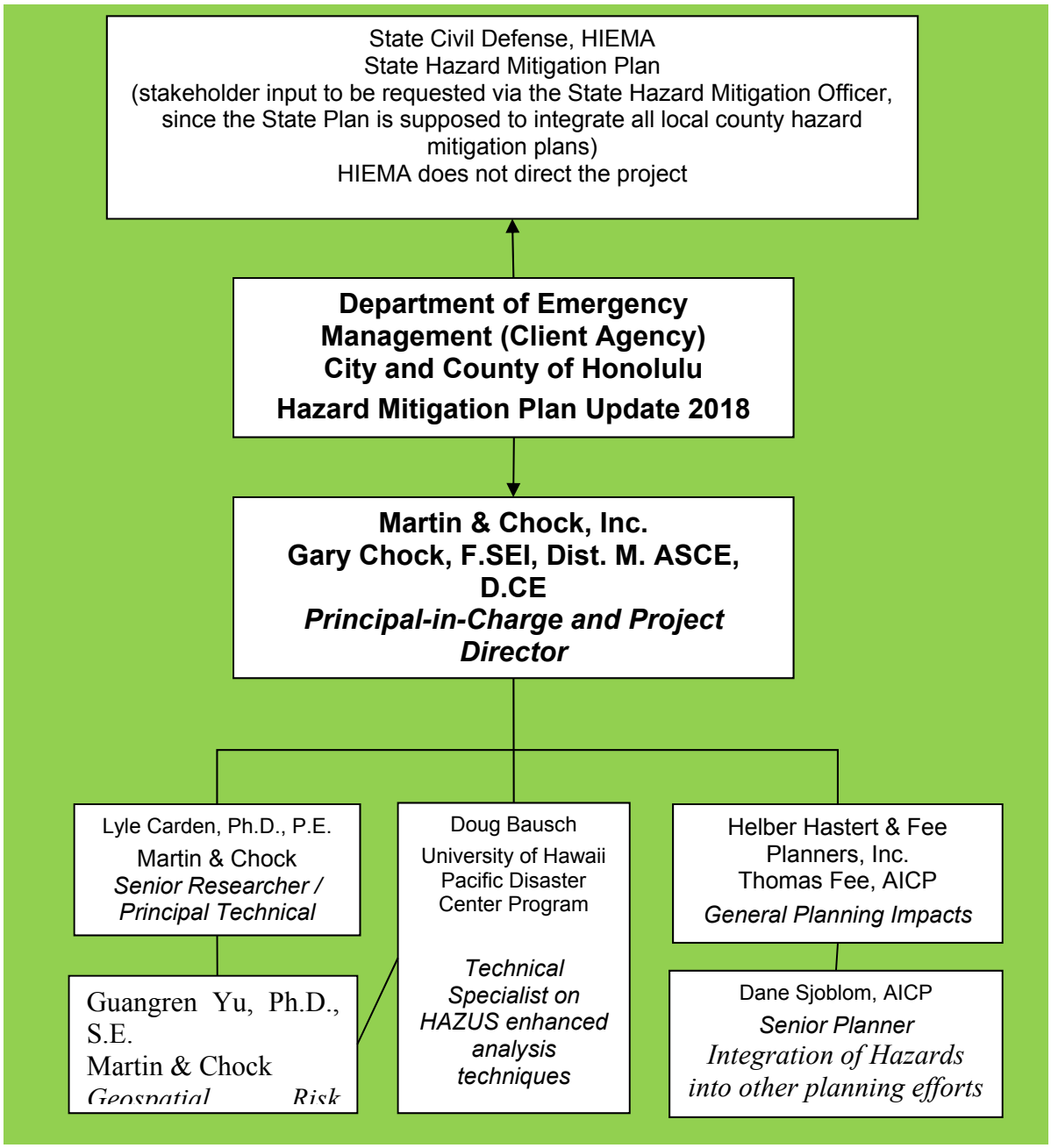


Figure 2-1 Project Planning Organization

The primary steering committee for the planning process was the Multi-Hazard Pre-Disaster Mitigation Plan Update Advisory Committee, comprised of representatives from the Department of Emergency Management, Hawaii Emergency Management Agency, City Office of Climate Change, Sustainability and Resiliency, Department of Planning & Permitting, Department of Design and Construction, Hawaiian Electric Company, the Board of Water Supply, Public Utilities Commission, State Department of Land and Natural Resources, State Office of Planning – Department of Business, Economic Development, and Tourism, State Department of Accounting and General Services, Department of Forestry and Wildlife, National Weather Service, as stakeholders in disaster mitigation. This committee was the core group for vetting of mitigation planning and development of proposed mitigation projects, which provided further detailed review of the mitigation planning process and reviewed electronic drafts of the plan.

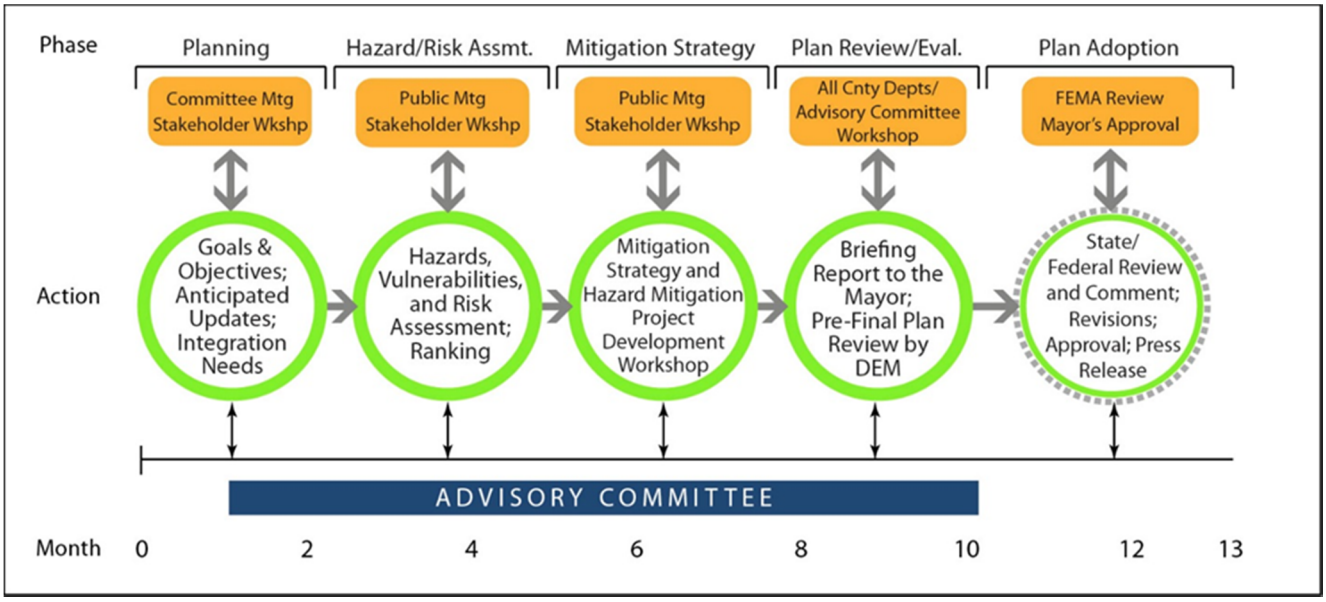


Figure 2-2 Mitigation Planning Phases

<u>The plan development process consisted of the following steps</u>:

Data Collection. The data collection and analysis was synthesized in this Hazard Mitigation Plan. In the process of preparing the plan, the Honolulu Hazard Mitigation Plan utilizes a significant increase in GIS spatial analysis and engineering risk analysis to develop probabilistic loss estimates to compile, analyze, and illustrate available data in maps, developing needed additional data, and identifying the gaps to focus future efforts. At the project kick-off meeting, the following data needs to be furnished were identified:

- 2012 IBC Adoption Ordinance (DPP) - Chock met with DPP on Wednesday December 19th 2018
- NFIP flood loss data (Flood Chapter) - including the April 2018 flood data, received NFIP Repetitive Loss (RL) and Severe Repetitive Loss (SRL) Detail Report Data as of July 31, 2018 from Carol Tyau-Beam, DLNR NFIP
- DOFAW Wildfire Annual Report – the published summary of 2017 was used

- Rockfall & Landslide Mitigation Projects completed/ongoing by DLNR, HDOT, City DDC - from (2010/2011-up those currently ongoing / planned)
- DLNR and PDC Dam Inundation/Evacuation GIS data DLNR GIS data were used for dam location, but the evacuation maps are not presented in the Hazard Mitigation Plan
- DLNR Dam inspection status - DLNR verified all regulated dams inspected;
- LEPC / DOH Hazard Evaluation and Emergency Response Office website publicly provides its annual reports, and provided review
- Hurricane Shelter Lists (SEAOH, HIEMA) - the most updated Oahu Shelter Listings were provided from HIEMA; SEAOH also had a listing of the status of those evaluated for structural integrity under wind load.
- Hurrevac/MMS access privileges DEM arranged Hurrevac download; the MMS module with topographic effects is no longer operational; therefore, this data was not used and topographic effects on the windfield of probabilistic hurricane scenarios were directly computed.
- High-Resolution Tsunami Design Zone GIS data (Office of Planning within State DBEDT) To be available in late 2019; this is an ongoing project to be incorporated as a part of plan maintenance
- Tsunami Evacuation Refuges and Routes – Phase 2 (DEM) this is an ongoing project; Phase 1 data incorporated into this paln
- Honolulu Infrastructure GIS data - DPP GIS provided this data
- Hawaii Drought Council updates (Neal Fujii and Kevin Kodama) The updated Hawaii Drought Plan (May 2017) was provided by the Hawaii Drought Council

*2.2.2 **Analysis**.*

- Hazard Identification and Analysis. The working committee researched available documents and consulted with pertinent agencies and experts to synthesize the state of knowledge of the various natural hazards. The sources are referenced throughout the document in footnotes and listed in Chapter 21-References.
- Risk and Vulnerability Analysis. Critical facilities and infrastructure were mapped in the GIS. Hazard zones were then overlaid on the critical facilities/infrastructure maps to highlight the assets at risk. An engineering-based risk analysis utilized HAZUS MH was performed to accurately determine the facility structural characteristics, calculate the risk, and identify the measures needed to mitigate the risk.
- Mitigation Strategies. The mitigation actions were derived from the hazard analysis and the risk and vulnerability analysis. Implementation of these actions required assignment of priorities.

*2.2.3 **Plan Development.***

Key stakeholder groups that have been involved in the continuous hazard mitigation planning include: 1) frontline agencies involved in emergency and disaster response and recovery; 2) regulatory and planning agencies responsible for certain mitigation actions; 3) key sectors that are involved with disaster preparedness or recovery; and 4) the general public.

The first meeting of the Multi-Hazard Pre-Disaster Mitigation Plan Update Advisory Committee was on June 22, 2018. This meeting and discussion covered the primary goals of the update, schedule of the planning process, the role of the Advisory Committee, the proposed editorial organization of the plan document, information needed and the primary sources of information, anticipated focus areas based on the FEMA review of the 2017 Interim Hazard Mitigation Plan, anticipated improvements in the plan, public input and other Oahu stakeholder groups.

Initial Meeting of the Oahu Multi-Hazard Pre-Disaster Mitigation Plan Update Advisory Committee

Date: Friday, June 22, 2018, 9:00AM-11:00AM

Facilitators: Crystal van Beelen (DEM) & Gary Chock (Martin & Chock, Inc.)

Location: DEM EOC, 650 S. King St., Honolulu, HI 96813

Attendees:

Name:	Department:
Crystal van Beelen	DEM
Gary Chock	Martin & Chock
Dane Sjoblom	HHF Planners
Luke Withy-Berry	Martin & Chock
Scott Ojiri	DAGS
Gerard Fryer	UH Manoa
Clifford Lau	DDC
Lydia Mertyris	HECO
Robert Harter	DEM, LEPC
Ashley Norman	PUC
Edwin Matsuda	DLNR
Carol Tyau-Beam	DLNR
Brian Chang	DLNR Engineering
Kaanoi Clemente	HECO
Justin Gruenstein	CCSR
Melvin Kaku	DEM
Hirokazu Toiya	DEM
Andrew Tang	DPP
Lisa Imata	DPP – Planning
Perry Tamayo	DPP – Permitting
Tom Fee	HHF
John Bravender	NWS
Robert Morita	BWS

Other members unable to attend:

Ian Robertson	UHM
Larry Kanda	HIEMA
Kristen E Martin	CCSR Intern
Timothy F. T. Hiu	DPP Building Division
Sandy Ma	DBEDT Office of Planning
Meoh-Leng Silliman	DAGS
Christine Kinimaka	DAGS Planning Branch Chief

S. Marigold, D. Myers-Trembley or Michael Walker) DOFAW

A presentation with discussion was organized into the following sections:

Briefing on Hazard Mitigation Plan Update Work Plan
Introductions
The Purpose of Mitigation Planning
Update goals for the new plan
Schedule
The Advisory Committee
Organization of the Hazard Mitigation Plan
Updating the Plan
Review of past plan FEMA comments and projects
Corrections to the 2017 Interim Plan update projects
Anticipated Improvements to the Plan
The Need for Stakeholder and Public Input
What is a Hazard Mitigation Strategy?

Corrections to the 2017 Interim Plan update summary of projects were identified:

- Building Facility Retrofits were described as being implemented for essential facilities; that was NOT correct. It was confused with the funded program for hurricane shelter retrofits.
- Incorporation of detailed bridge inventory in the HAZUS loss model is NOT in progress. This was confused with periodic bridge condition inspections.
- NFIP Community Rating System – Honolulu does NOT presently participate
- Policy for strengthening the enclosures of critical public facilities – there is NOT any language in the building code for strengthening existing critical facilities (or any other existing structures).
- Detailed HAZUS loss modeling with enhanced detail of building inventory- this was NOT in progress; the modeling of the Big Island inventory does not cover Oahu.
- Many projects listed as ongoing were not active.

At this meeting it was recognized that a new separate chapter on climate change adaptation should be included in the hazard mitigation plan, since there had been a public referendum to change the City Charter to create the Office of Climate Change, Sustainability, and Resilience (CCSR), which was supported by a wide margin of the voting public in 2016. As mandated by the revised Charter, the Office is tasked with tracking climate change science and potential impacts on City facilities, coordinating actions and policies of departments within the City to increase community preparedness, developing resilient infrastructure in response to the effects from climate change, and integrating sustainable and environmental values into City plans, programs, and policies.

On **July 12, 2018**, the consultant team met with DEM to discuss the meeting with the Multi-Hazard Pre-Disaster Mitigation Plan Update Advisory Committee, discuss the collection of public input through surveys, workshops and related events, use of the DEM website for hazard mitigation planning events and announcements, and schedule future briefings and meetings with focus groups DEM had already engaged in disaster preparedness, the Cross Island Communities Resilience Network (CICRN).

Subsequently, **on July 16, 2018**, Mayor Caldwell issued a directive on climate change and sea level rise, in which each department and agency shall

> *"…take a proactive approach in both reducing greenhouse gas emissions and adapting to impacts caused by sea level rise, and to align programs wherever possible to help protect and prepare the infrastructure, assets, and citizens of the City for the physical and economic impacts of climate change."*

Accordingly, it was agreed by the Department of Emergency Management that the organization of the new hazard mitigation plan would be as follows, which was presented to the Honolulu City Council Committee on Public Health, Safety and Welfare on **July 26, 2018**:

Executive Summary	
1. Introduction	14. Hazardous Material
2. Mitigation Planning	15. Dam Failures
3. Land Use and Development	16. VOG
4. Climate Change	17. Hurricane Shelters
5. Coastal Erosion	**18. Risk Assessment**
6. High Wind Storms	**19. Mitigation Strategy**
7. Tropical Cyclones	**20. Planning Process Update Procedure**
8. Floods	
9. Tsunamis	
10. Earthquakes	Note that chapters 14 – 17 are optional and those chapters are not required to be reviewed by FEMA.
11. Landslides and Rockfalls	
12. Droughts	
13. Wildfires	

2.2.4 Public Input.

An initial draft of this hazard mitigation plan was available for public review and comment on the State's hazard mitigation website since July 10, 2018. In addition, public meetings have been held on hazard preparedness and mitigation. A public survey of disaster preparedness was formulated and distributed at public meetings and on the County government's website homepage.

In order to get further community involvement, a survey was developed and distributed through various community gatherings, seminars, workshops, and was made publicly available online on the City's website from **July 10, 2018 to December 30, 2018**. The purpose of the survey was to gauge the public's understanding of natural hazards, determine the hazards to which they believe they are most vulnerable and provide an opportunity for public recommendations on disaster preparation. The 2018 updated survey included questions on climate change adaptation and further refined questions. The two sided form or online survey was designed to take only a few minutes to complete. A copy of the survey is provided on the page 2-15 and 2-16.

The results from the survey are presented in the figures below. The results of the survey were presented and discussed by the Planning Advisory Committee prior to an All-Departmental Workshop convened to prioritize mitigation project recommendations. The survey from about

900 respondents indicates a high awareness of and strong desire to mitigate against hurricanes, high winds/storms, and flooding:

- While almost 60% of respondents had not been affected by natural hazards, among the others the hazards that have most affected people were high wind storms (27%), followed by flooding (15%).
- The highest perceived risk from natural hazards on Oahu is from high wind storms (76%) hurricanes (82%), and flooding (39%).
- About 40% to 45% of the respondents felt the need for more public information on tsunami, flooding, high winds/storms, hurricanes, and sea level rise.
- The hazards considered of high importance by most people for personal planning and preparation were hurricanes, high winds/storms, tsunami, and flooding.
- The publicly funded projects considered most important by the respondents were power and communication retrofits, infrastructure retrofits, supply chain infrastructure retrofits, essential facility retrofits, and maintenance of streams to clear debris to mitigate flooding, and improving standards for storm drainage and flood control.
- Of respondents, 47% sited cost as one reason they would not strengthen their homes for the next disaster, with 26% to 32% not knowing what to do or believing there is nothing that can be done.
- The most popular assistance for homeowners was videos and guidebooks that showed them how to install home retrofits with public briefings and workshops also popular.
- During a hurricane landfall event, only about 1 in 4 would go to a hurricane shelter; 3 out of 4 would stay at home.
- 82% percent of Oahu respondents found VOG tolerable with no significant health impact while 18% have sought medical attention.
- With respect to future climate change, over two-thirds felt that both government of property owners should bear the costs, and that funding for climate change adaptation should begin now.
- 66% of respondents were married.
  77% of respondents owned their own homes.
  75% lived in a single family house.

Honolulu Department of Emergency Management
650 South King Street Honolulu, Hawaii 96813
723-8960 Phone 524-3439 Fax
Email: cvanbeelen@honolulu.gov

Oahu Resident Survey on Disaster Preparedness

Honolulu has experienced many severe natural disasters throughout history. Some of these rarely occur but can be catastrophic. The City & County has a multi-hazard mitigation plan that has two main objectives: 1) to protect people and structures from harm and destruction; and 2) to reduce or mitigate losses and disruption of services during disasters. Hazard mitigation planning is the process that analyzes the risk from natural hazards and implements actions to reduce those risks.

Besides consulting the best available scientific and engineering studies, we would like to find out more about your understanding of natural hazards and what recommendations you have that we should consider in preparing for disasters. We are seeking your input on this two-sided form that should take only a few minutes to complete. It can help us improve our hazard planning and preparedness strategy, and will additionally help us seek federal funding for mitigation actions with priority.

Thank you, we really appreciate your thoughts and input!

1. Which of the following natural hazards have adversely affected/damaged your present home or property?

☐ None ☐ High winds / storm damage ☐ Rockfalls & landslides ☐ Wildfire
☐ Earthquake ☐ Hurricane ☐ Coastal erosion ☐ Drought
☐ Tsunami ☐ Flooding ☐ Sea level rise ☐ Vog

2. Select the natural hazards that you think may affect you and your family or property most adversely in the future.

☐ None ☐ High winds / storm damage ☐ Rockfalls & landslides ☐ Wildfire
☐ Earthquake ☐ Hurricane ☐ Coastal erosion ☐ Drought
☐ Tsunami ☐ Flooding ☐ Sea level rise ☐ Vog

3. If any of these hazards were important factors in selecting the location of your home or job, which were they?

☐ None ☐ High winds / storm damage ☐ Rockfalls & landslides ☐ Wildfire
☐ Earthquake ☐ Hurricane ☐ Coastal erosion ☐ Drought
☐ Tsunami ☐ Flooding ☐ Sea level rise ☐ Vog

4. If none of the above hazards were a factor in your home selection decision, why not?

☐ I did not have enough information at the time, but I would have probably considered it if I knew
☐ I was generally aware of the hazards, but they were just not significant enough compared to other more immediate factors
☐ My home is a long-term property under the ownership of my family, and I did not choose its location

5. From what sources do you get information on natural hazards and the amount of risk associated with them?

☐ Television ☐ Social media ☐ Smartphone/push alerts ☐ Radio ☐ Family/friends ☐ Other:_____

6. Which of these hazards need to have more information available to the public?

☐ None ☐ High winds / storm damage ☐ Rockfalls & landslides ☐ Wildfire
☐ Earthquake ☐ Hurricane ☐ Coastal erosion ☐ Drought
☐ Tsunami ☐ Flooding ☐ Sea level rise ☐ Vog

7. On an importance scale of H (high), M (medium), or L (low), which of these hazards are the most important for your personal planning/preparation?

___ None ___ High winds / storm damage ___ Rockfalls & landslides ___ Wildfire
___ Earthquake ___ Hurricane ___ Coastal erosion ___ Drought
___ Tsunami ___ Flooding ___ Sea level rise ___ Vog

8. Check if any of the following describe why you would not be able to strengthen your home for the next disaster:

☐ I don't really know what to do or how to do it
☐ I can't find a contractor to do the work
☐ It costs too much
☐ The odds of being impacted are too remote to justify the cost
☐ I'm too busy; I'll just prepare when there's any warning
☐ There isn't any way to stop the hazard and damage

Please fill out the reverse side of this page! Then, return the form to Honolulu Dept. of Emergency Management

Side - A

Honolulu Department of Emergency Management
Oahu Resident Survey on Disaster Preparedness

9. **Let us know if you would like the State or City to assist you in any of the following ways:**
   - ☐ Public briefings in my area on the hazards that are the most important for local residents to understand
   - ☐ A workshop to learn how you can strengthen your home against earthquakes, hurricanes, or sea level rise
   - ☐ Have contractors trained on how to strengthen homes and post a list of the contractors willing to do the work
   - ☐ Prepare videos and guidebooks on how to install home retrofits and make them available to the public
   - ☐ We need some other assistance, like: _____

10. **What projects do you believe the government should try to fund in order to reduce the damage and disruption caused by natural hazards? (Rate each of these by an importance scale of H (high), M (medium), or L (low)):**
   - ___ Retrofit our infrastructure, such as the harbors, airports, highways and bridges, to make them more reliable
   - ___ Work on improving the reliability of power and communications against outages
   - ___ Work on improving the reliability of the supply infrastructure for essential goods and fuel after a disaster, such as Honolulu and Kalaeloa (Barber's Point) Harbors
   - ___ Strengthen essential facilities such as hospitals, so they are better able to remain functional after a disaster
   - ___ Improve safety in the schools and emergency (hurricane) shelters
   - ___ Improve the way government facilities are built or located to resist tsunamis and storms
   - ___ Improve public works standards for storm drainage and flood control construction projects
   - ___ Work on protecting or upgrading infrastructure against the effects of future sea level rise
   - ___ Work on highways and city roadways to reduce the amount of rockfalls, landslides, and coastal erosion
   - ___ Improve the building code used for the construction of new homes to prevent or lessen damage
   - ___ Allow grants or tax credits in addition to insurance discounts for strengthening my home or place of business
   - ___ Provide more public information on how to reduce damage and property losses
   - ___ Cut back trees that may topple on roadways or powerlines
   - ___ Perform regular maintenance to clear streams of debris to prevent flooding

11. **A recent referendum vote established the Office of Climate Change, Sustainability and Resiliency (CCSR) that has proposed many changes to account for the effects of climate change, such as: creating a statewide sea level rise vulnerability zone for planning and government policies, retreating from coastal urban areas, and more stringent flood zone requirements. Who should be subject to making these changes and bearing the additional costs?**
   ☐ Property owners first ☐ Government first ☐ Both, together ☐ Don't make any changes

12. **When do you believe the government should reallocate your tax money to mitigate the effects of climate change?**
   ☐ Beginning now ☐ 10-20 years ☐ 20-30 years ☐ 30+ years ☐ Never

13. **In the event of a hurricane making landfall on Oahu, where would you take shelter?**
   ☐ My house ☐ Friend/family's home that's sturdier ☐ A workplace that's sturdier ☐ An official shelter

14. **Has your health been affected by vog?**
   ☐ Not significantly; I have not required medical attention ☐ Yes, and I have sought medical attention

15. **We need information to better understand your concerns: How many years have you lived on Oahu?** _____

16. **Where do you live? Area:** _____ **Zip Code:** _____

17. **Are you** ☐ **Married** ☐ **Single**

18. **Do you** ☐ **Own your home** ☐ **Rent your home**

19. **Is your residence a** ☐ **Single–family house** ☐ **Apartment** ☐ **Condominium/townhouse**

20. **Do you plan on doing anything that could most help you prepare your family and home for the next disaster?**
   ☐ **Create a Disaster Plan** ☐ **Make a 14-Day Disaster Supply Kit** ☐ **Nothing for now**
   ☐ **Locate my area's Emergency Shelter or my alternative** ☐ **I already have a Disaster Plan and Supply Kit**
   ☐ **Plan a Home Retrofit** ☐ **Get a landline phone that does not require a separate power outlet for it to work**

Mahalo for your time. Please return the form to Honolulu Department of Emergency Management

Side - B

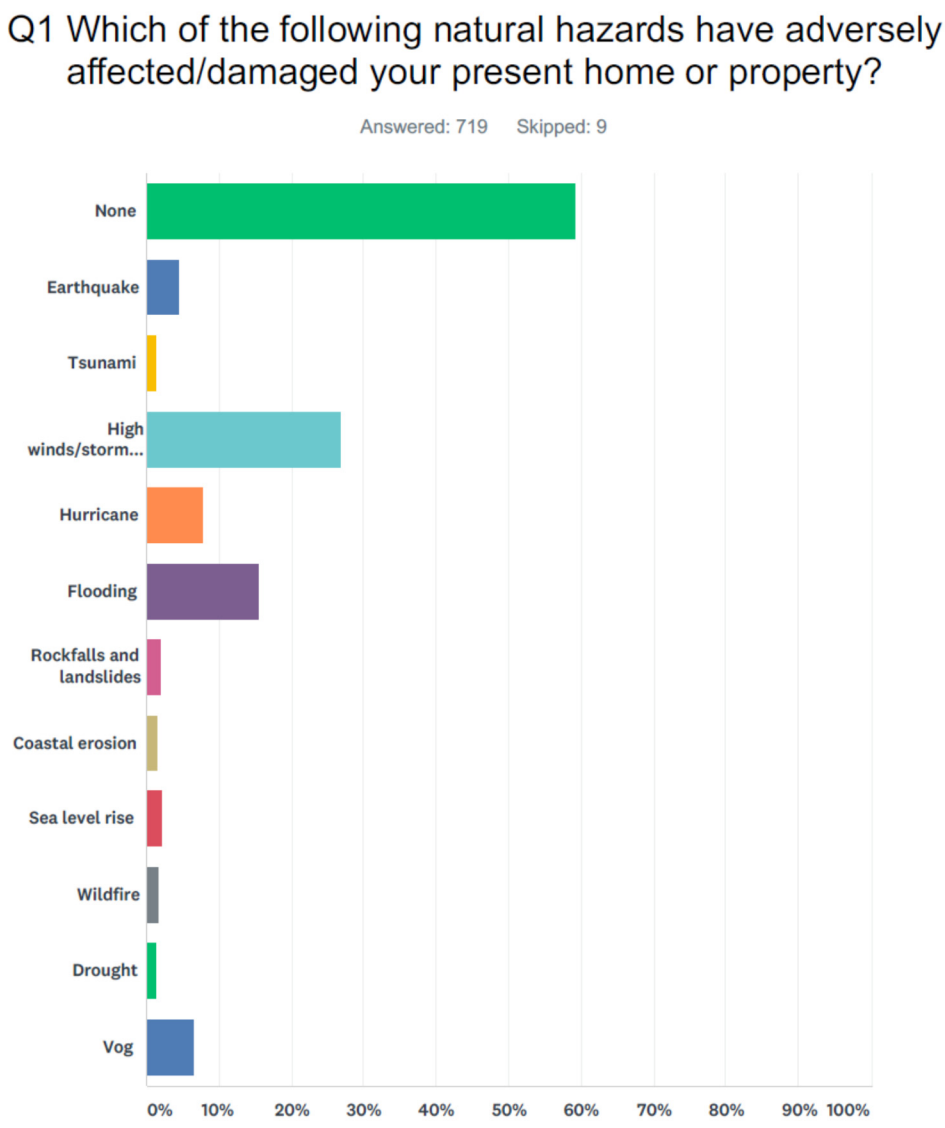


Figure 2-3 Hazards that have affected individual's homes

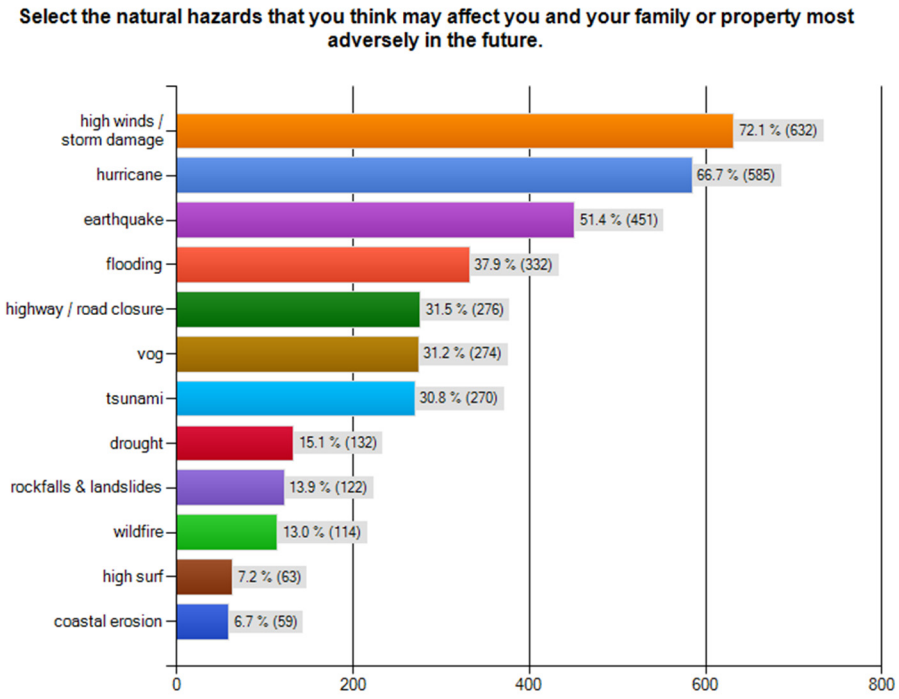


Figure 2-4 2012 Perceptions of most risky natural hazards (for comparison to 2018)

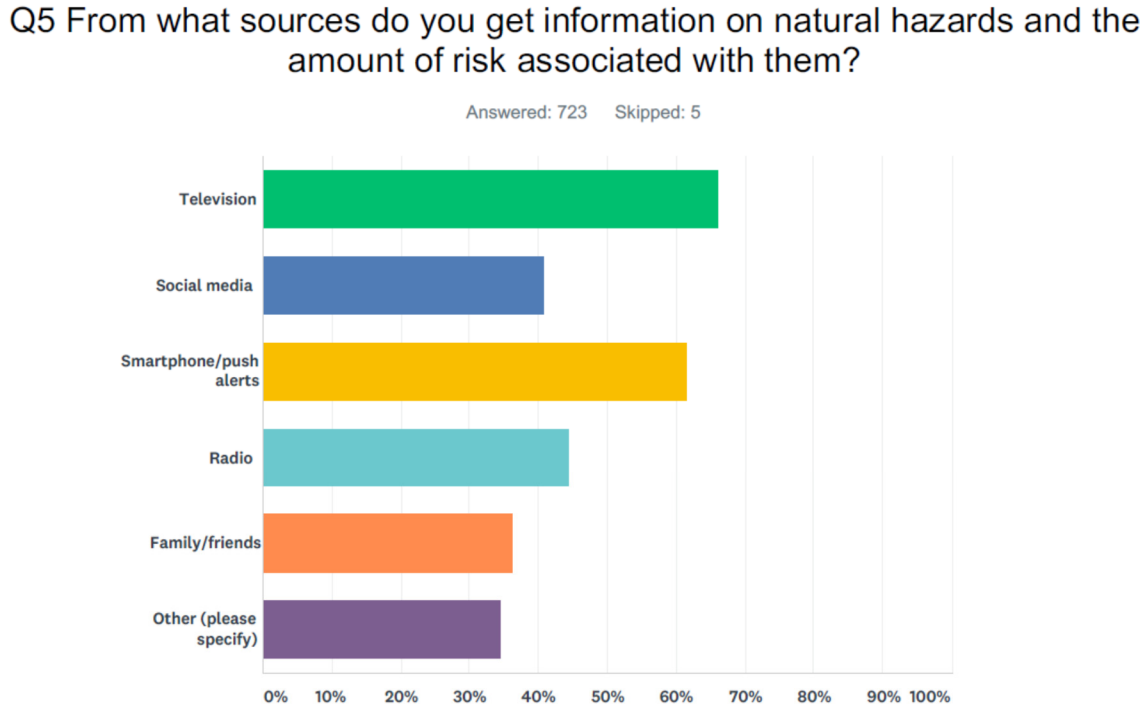


Figure 2-5 Sources of Information

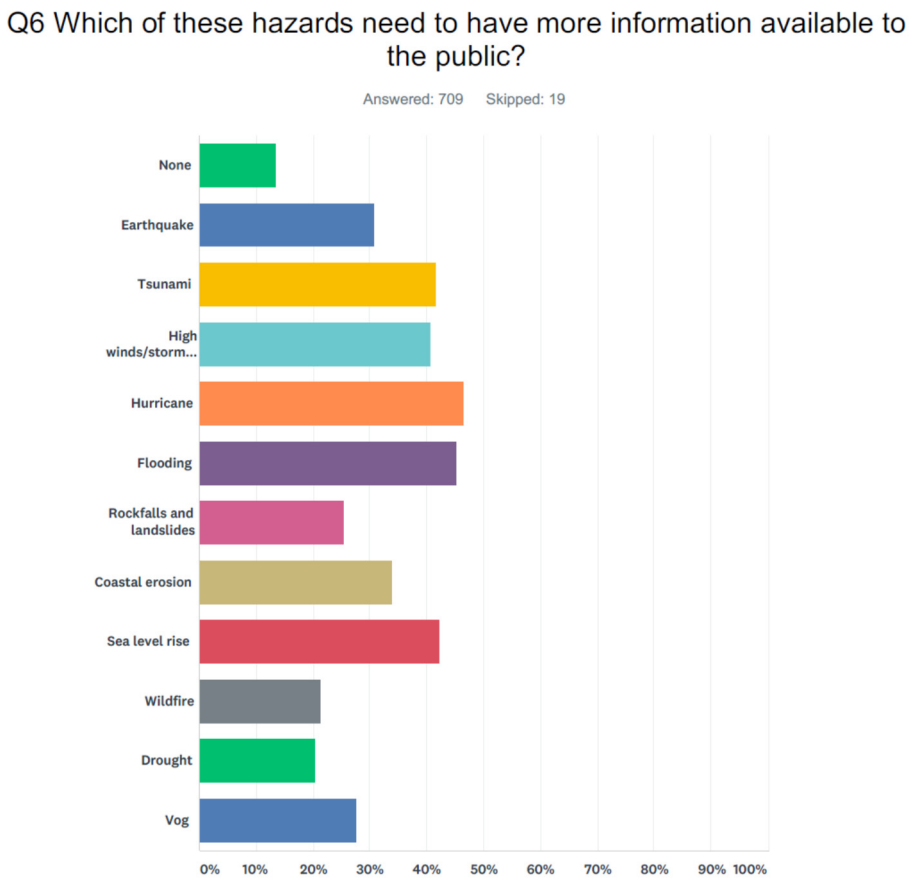


Figure 2-6 Hazards requiring more public information

I don't really know what to do or how to do it	31.64%	193
I can't find a contractor to do the work	8.52%	52
It costs too much	46.56%	284
The odds of being impacted are too remote to justify the cost	21.48%	131
I'm too busy; I'll just prepare when there's any warning	8.20%	50
There isn't any way to stop the hazard and damage	26.56%	162

Figure 2-7 Reasons for not strengthening home prior to a disaster

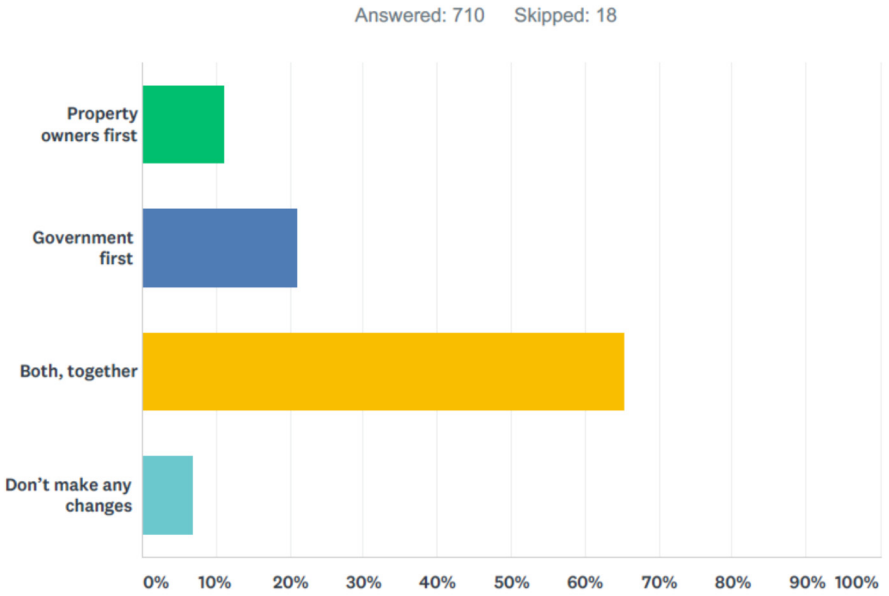
Public briefings in my area on the hazards that are the most important for local residents to understand	48.64%	303
A workshop to learn how you can strengthen your home against earthquakes, hurricanes, or sea level rise	53.61%	334
Have contractors trained on how to strengthen homes and post a list of the contractors willing to do the work	46.39%	289
Prepare videos and guidebooks on how to install home retrofits and make them available to the public	61.64%	384
We need some other assistance, like:	15.73%	98

Figure 2-8 Preferred assistance, per the online survey

	HIGH	MEDIUM	LOW	TOTAL
Retrofit our infrastructure, such as the harbors, airports, highways and bridges, to make them more reliable	73.47% 504	22.16% 152	4.37% 30	686
Work on improving the reliability of power and communications against outages	83.79% 584	14.78% 103	1.43% 10	697
Work on improving the reliability of the supply infrastructure for essential goods and fuel after a disaster, such as Honolulu and Kalaeloa (Barber's Point) Harbors	78.00% 539	19.39% 134	2.60% 18	691
Strengthen essential facilities such as hospitals, so they are better able to remain functional after a disaster	72.07% 498	24.89% 172	3.04% 21	691
Improve safety in the schools and emergency (hurricane) shelters	58.62% 408	35.34% 246	6.03% 42	696
Improve the way government facilities are built or located to resist tsunamis and storms	42.96% 290	40.44% 273	16.59% 112	675
Improve public works standards for storm drainage and flood control construction projects	65.59% 446	29.26% 199	5.15% 35	680
Work on protecting or upgrading infrastructure against the effects of future sea level rise	51.40% 350	34.95% 238	13.66% 93	681
Work on highways and city roadways to reduce the amount of rockfalls, landslides, and coastal erosion	46.54% 316	42.12% 286	11.34% 77	679
Improve the building code used for the construction of new homes to prevent or lessen damage	52.87% 359	35.79% 243	11.34% 77	679
Allow grants or tax credits in addition to insurance discounts for strengthening my home or place of business	63.41% 435	25.66% 176	10.93% 75	686
Provide more public information on how to reduce damage and property losses	50.07% 340	39.62% 269	10.31% 70	679
Cut back trees that may topple on roadways or powerlines	53.37% 364	36.80% 251	9.82% 67	682
Perform regular maintenance to clear streams of debris to prevent flooding	73.37% 507	24.31% 168	2.32% 16	691

Figure 2-9 Prioritized mitigation actions for government funding per the online survey

Q11 A recent referendum vote established the Office of Climate Change, Sustainability and Resiliency (CCSR) that has proposed many changes to account for the effects of climate change, such as: creating a statewide sea level rise vulnerability zone for planning and government policies, retreating from coastal urban areas, and more stringent flood zone requirements. Who should be subject to making these changes and bearing the additional costs?



Q12 When do you believe the government should reallocate your tax money to mitigate the effects of climate change?

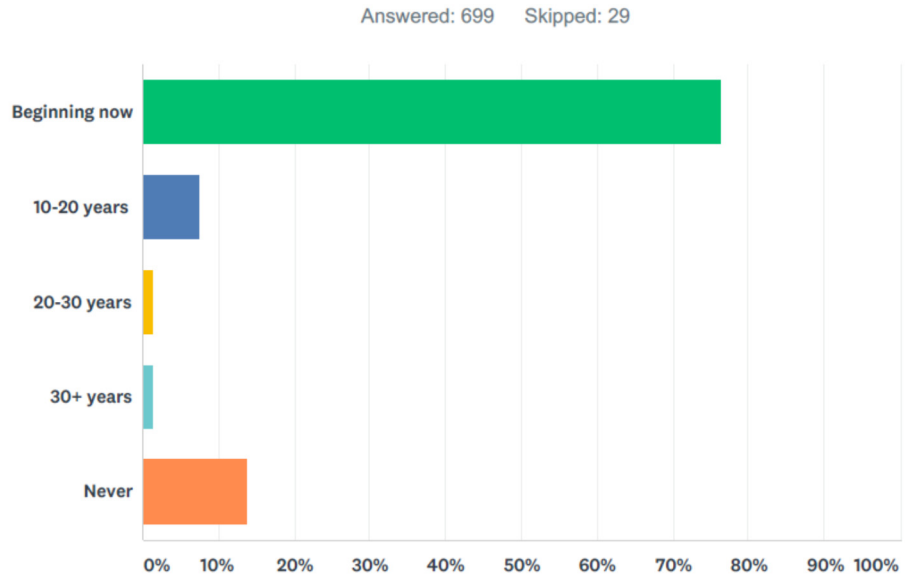


Figure 2-10 Bearing the Costs of Climate Change Adaptation

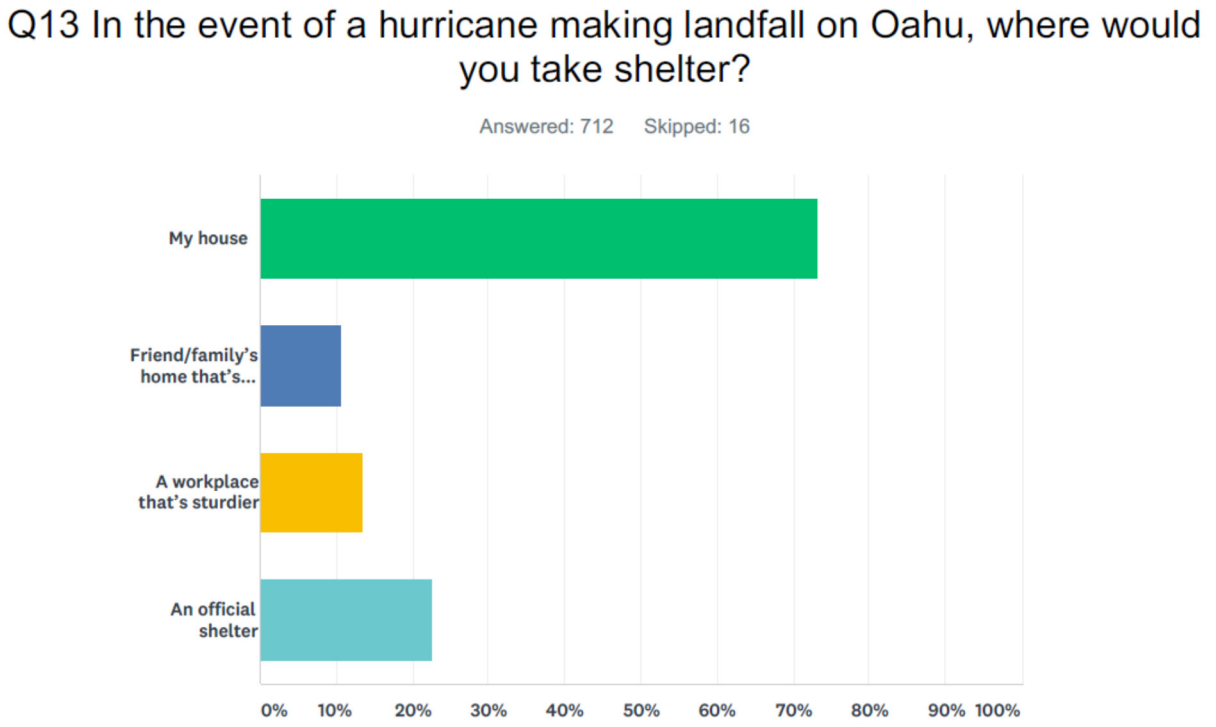


Figure 2-11 Hurricane Sheltering Behavior

Not significantly; I have not required medical attention	82.21%	587
Yes, and I have sought medical attention	17.79%	127

Figure 2-12 Opinion on Whether VOG has Affected the Health of Oahu Residents

Married	65.68%	467
Single	34.32%	244
Own your home	77.11%	539
Rent your home	22.89%	160
Single-family house	74.68%	528
Apartment	7.78%	55
Condominium/townhouse	17.54%	124

Figure 2-13 Survey Respondent Demographic Parameters

On October 4, 2018 the Quarterly Meeting of the Cross Island Communities Resilience Network (CICRN) was convened. This is a network of community organizations actively engaged in emergency preparedness:

Attendee Name	Organization
Justin Gruenstein	CCSR
Mathew Gonser	CCSR
Haley Cook	CCSR
Holly Morgan	CCSR
Gary Chock	Martin & Chock
Dane Sjoblom	HHF Planners
Alice Saul	Hawaii Kai Strong
Arlina Agbayani	HIEMA
Bob Cunningham	Foster Village Resilience Committee
Claudine Miki Tomasa	Kailua Alert & Prepared
Clemmet Jung	Kailua Alert & Prepared
Creighton Higa	Waianae Coast Disaster Readiness Team
Danny Tengan	Aina Haina Prepared
Deborah Barbour	Kaneohe/Kahaluu Community Emergency Response Teaam
Dennis Hwang	UH Sea Grant College
Diane Reece	Hi Voluntary Organizations Active in Disasters (VOAD)
Dorothy Kelly-Paddock	Hauula Emergency Leadership Planning
Earl Morris	BYU Laie Emergency Planning Committee
Ella Siroskey	Hauula Emergency Leadership Planning
Emily Ann Kukulies	Hi Voluntary Organizations Active in Disasters (VOAD)
Flora Obayashi	Kaneohe/Kahaluu Community Emergency Response Teaam
Henri van Beelen	Ewa Emergency Preparedness Committee
John Ching, Jr.	Kaneohe/Kahaluu Community Emergency Response Teaam
John Miller	ARC Hawaii Chapter
Kate Pifer	ARC Hawaii Chapter
Keone Kealoha	Kanu Hawaii
Kevin Bogan	Hawaii Kai Strong
Marc Lawton	Kailua Alert & Prepared
Marie Samudio	Kaneohe/Kahaluu Community Emergency Response Team
Mark Brandle	Kaneohe/Kahaluu Community Emergency Response Team
Matt Glei	Hawaii Kai Strong
Raleigh Ferdun	Be Ready Manoa
Rene Garvin	Hawaii Kai Strong
Rodney Boucher	Ewa Emergency Preparedness Committee
Russell Rebman	Hauula Emergency Leadership Planning
Sasha Asato	Kailua Neighborhood Board
William Sager	Koolaupoko Emergency Preparedness and Response
Zack Kopp	BYU Public Safety Department

Community preparedness groups in the CICRN are shown below:

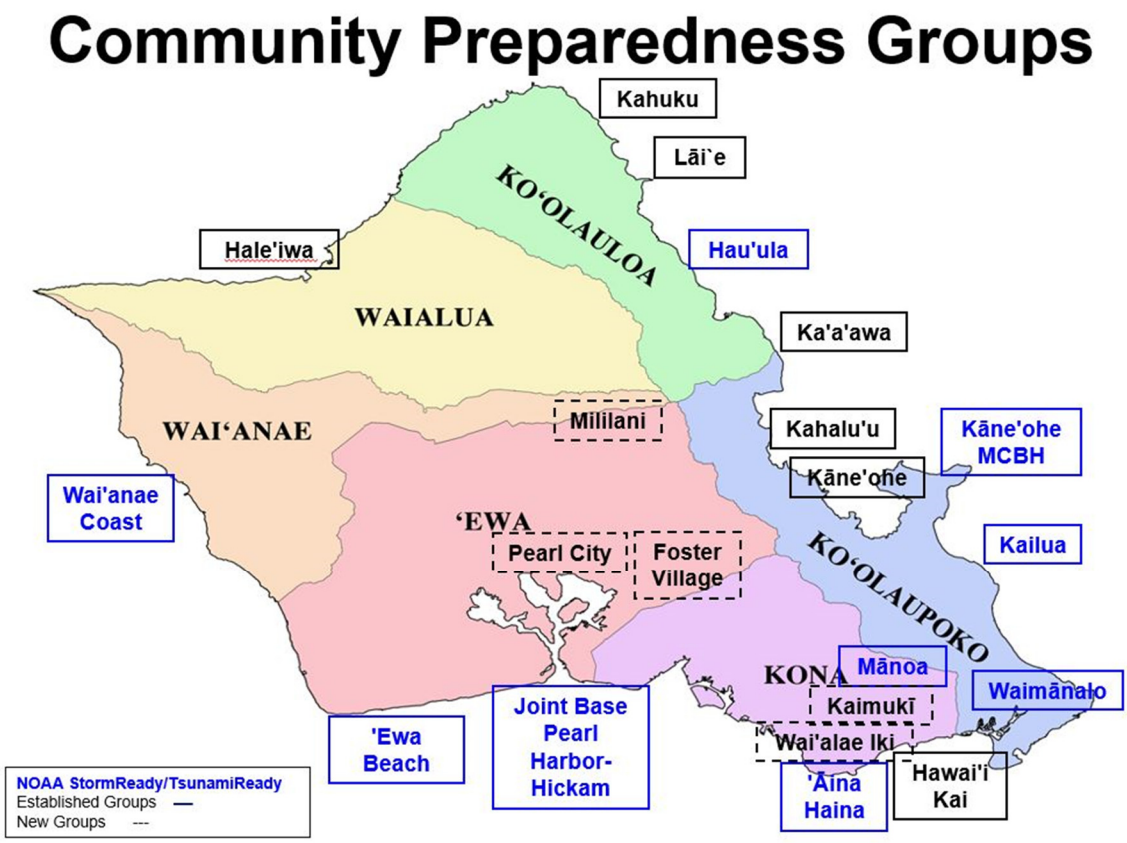


Figure 2-14 CICRN Groups on Oahu

CICRN Discussion Highlights Relevant to the Hazard Mitigation Plan:

- City and State are in discussion to make public Oahu's Dam and Reservoir Evacuation Maps to help the public to be aware of the risks and develop their personal emergency plan if necessary
- City is working on publicizing Storm Surge Planning Maps, (not evacuation maps) to provide public awareness as to possible impact areas.
- Federal Disasters in 2018 related to Oahu include the mid-April Flooding DR-4365-HI and Hurricane Lane DR-4395-HI
- Urban Survival: A Be Ready Manoa Emergency Preparedness Fair, Sat. 10/20/18 from 9 a.m. to 1 p.m., Manoa Valley District Park – public opinion surveys to be distributed
- The CICRN was given a briefing on the Honolulu Multi-Hazard Pre-Disaster Mitigation Plan;
    - Initial results from the online opinion survey
        - 1 out of 4 respondents had their property adversely affected by high winds or storm damage
        - Perception of personal risk is highest for high winds/storms/hurricanes, flooding, earthquakes and tsunamis

    - Less than 15% expected to be adversely affected by sea level rise, but 40% desired to have more information, and 3 out of 4 would advise the government spend money beginning now on mitigation
    - There is a desire to have guides on how to retrofit homes, although about half said it would cost too much
    - Only 1 out of 4 would go to a shelter during a hurricane; 70% would stay in their home
    - Relating to government priorities, 6 out of every 10 respondents would have the government fund the following efforts:
        - Improve the reliability of power and communications against outages
        - Improve the reliability of the supply infrastructure for essential goods and fuel after a disaster, such as Honolulu and Kalaeloa Harbors
        - Perform regular maintenance to clear streams of debris to prevent flooding
        - Strengthen essential facilities such as hospitals, so they are better able to remain functional after a disaster
        - Retrofit our infrastructure, such as the harbors, airports, highways and bridges, to make them more reliable
        - Improve public works standards for storm drainage and flood control construction projects
        - Allow grants or tax credits in addition to insurance discounts for strengthening my home or place of business
- Emerging mitigation strategy components being considered
    - Enhance the public availability of disaster resilience information that can be quickly understood
    - Adopt the 2012 International Building Code now, then the 2018 IBC by 2020 to close resiliency gaps in obsolete design codes
    - Revise regulatory standards of the City to require explicit design consideration of climate change adaptation
    - Improve disaster resiliency of essential and critical facilities, supply chain integrity, and utility services
    - Incorporate tsunami-resilient design requirements for critical facilities and tall buildings in the coastal zone
    - Enable quicker response and recovery by protecting emergency response assets and resources
    - Implement hazard-mitigation policies in all phases of planning and permitting
    - Re-examine Flood Control Criteria - is it adequate for Oahu communities?
    - Plan for flood control public works for the long-term defense of critical facilities and major economic assets
    - Participate in the Community Rating System to reduce flood losses and reduce flood insurance premiums

        - Provide guidance on feasible retrofits for homeowners and building owners
        - Address coastal erosion defense or develop alternatives relating to roadways and economic assets
        - Assess the high wind integrity of existing shelter buildings
- Other areas of community discussion included:
    - A November 3rd Hazard Mitigation Planning workshop
    - The online hazard mitigation survey
    - Integrity of power poles and that replacement poles are not upgraded
    - Communications network resiliency
    - Where shelters are available
    - Multi-jurisdictional issues in stream debris management that exacerbates potential flooding during flash flood rainfall conditions
    - The difficulty of individual mitigation actions within condominiums
    - 2018 Hurricane Season - sea surface temperatures sustaining more intense hurricanes in the Central Pacific
    - Whether there will be an El Nino in 2019

Next, **a half-day open invitation public workshop was held on November 3, 2018** to provide an interactive forum and opportunity for more of the general public to learn about the findings of the updated risk assessment, and to give input regarding their concerns and ideas for reducing risk. There were approximately 70 attendees from the public. The purpose of this meeting was to review plan content and progress on the Multi-Hazard Pre-Disaster Mitigation Plan update effort, as well as to give the public an opportunity to provide input on how the City can reduce the potential for natural hazard impacts. Input received at this meeting helped to inform the consideration of mitigation actions. Another workshop for the general public was subsequently held on February 23, 2019 to provide more discussion of hazard mitigation strategy and specific mitigation actions.



Figure 2-15 The November 3, 2018 Public Meeting / Workshop

November 3 2018 Program:

MEET THE PLANNING TEAM

- 8:30 am **Sign In/Get Refreshments/Open House/Handouts**

LEARN ABOUT PLANNING FOR NATURAL HAZARDS

8:50 am Welcome- Hirokazu Toiya, Department of Emergency Management (DEM)

9:00 am What is the Honolulu Hazard Pre-Disaster Mitigation Plan? Gary Chock, Martin & Chock, Inc.

9:20 am What if Hurricane Lane had made landfall on Oahu? Doug Bausch, Pacific Disaster Center (PDC)

9:30 am Three of the Big Risks – How Bad is the Risk for Oahu? Doug Bausch, Pacific Disaster Center

- Hurricane
- Tsunami
- Flooding

9:50 am Group Instant Polling Questions Gary Chock

10:00 am Plan Integration/other related planning activities Dane Sjoblom, HHF Planners

- 10:10 am **The Office of Climate Change Sustainability and Resiliency** Mathew Gonser, CCSR
- 10:20 am **Small Group Activity Introduction/how to share your thoughts at 4 open stations**

LET'S WORK ON THE PRIORITIES – What do you think?

10:30 am Small Group Activity/Roaming Stations

1. What is the City doing now about disaster mitigation? Crystal Van Beelen
2. What are my big risks? Doug Bausch
3. What should the City be doing in the future? Mathew Gonser
4. Survey - What do you think is important and needed? Dane Sjoblom

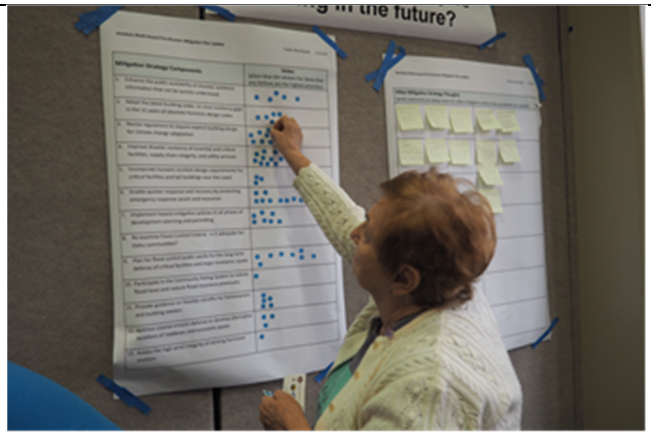
LET'S SUMMARIZE YOUR INPUT

11:40 am Report Back Some Key Points **Crystal Van Beelen, DEM**

FIND OUT HOW HURRICANE TRACKS AND STRENGTH ARE PREDICTED

12:00 pm Box Lunch Presentation-"Inside the Central Pacific Hurricane Center" John H. Bravender, NOAA Warning Coordination Meteorologist

- How we use the suite of predictive models to come up with the expected tracking
- Factoring in Sea Surface Temperature and Vertical Wind Shear
- What conditions are driving the 2018 hurricane season
- What we tell you in the forecast and the differences with what you may have in gust windspeeds at ground level
- Ocean and atmospheric conditions affecting the general prognosis for next year (the El Nino outlook)



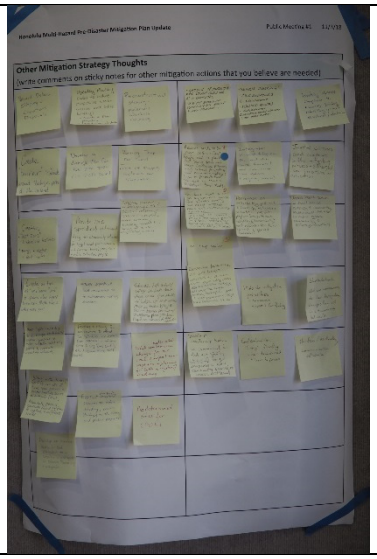


Figure 2-16 Participant Input on Hazard Mitigation Actions and Priorities



Figure 2-17 Activities at the November 3 2018 Public Workshop on Hazards and Risks

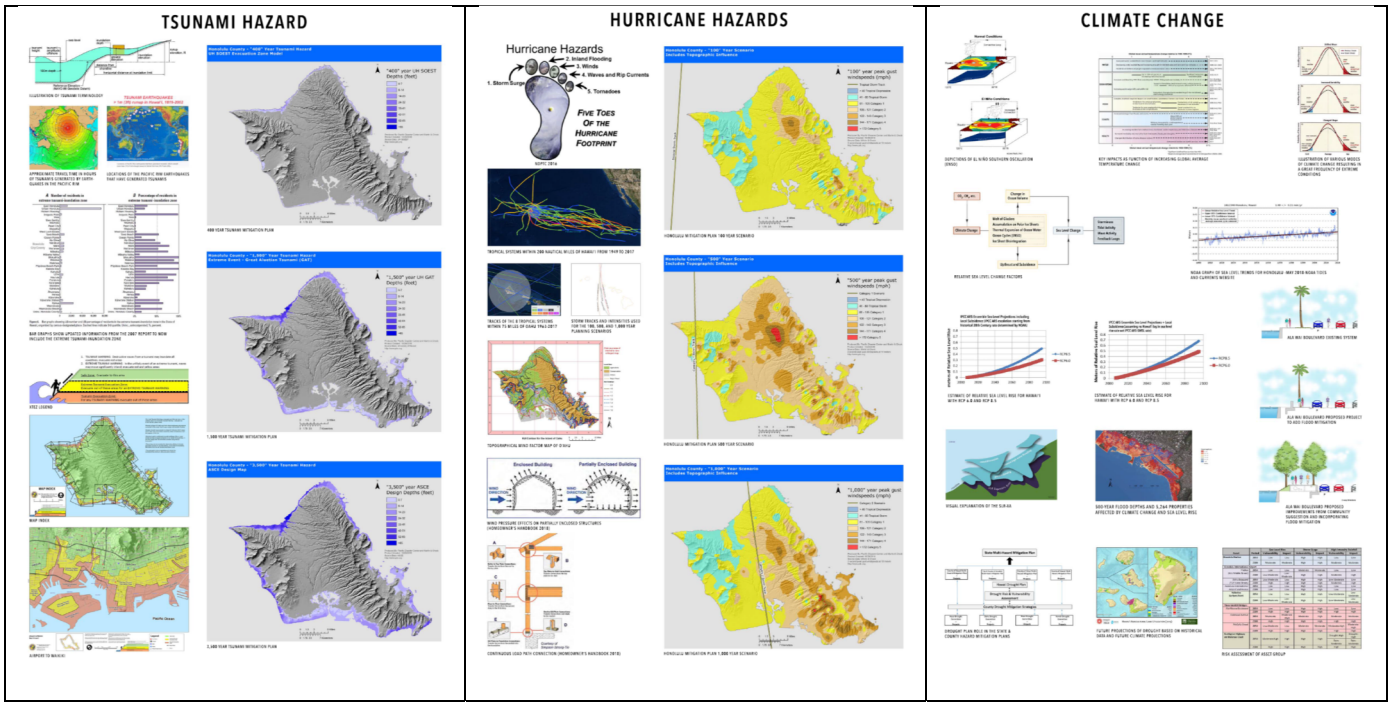


Figure 2-18 Posters were used to summarize information given in the presentations

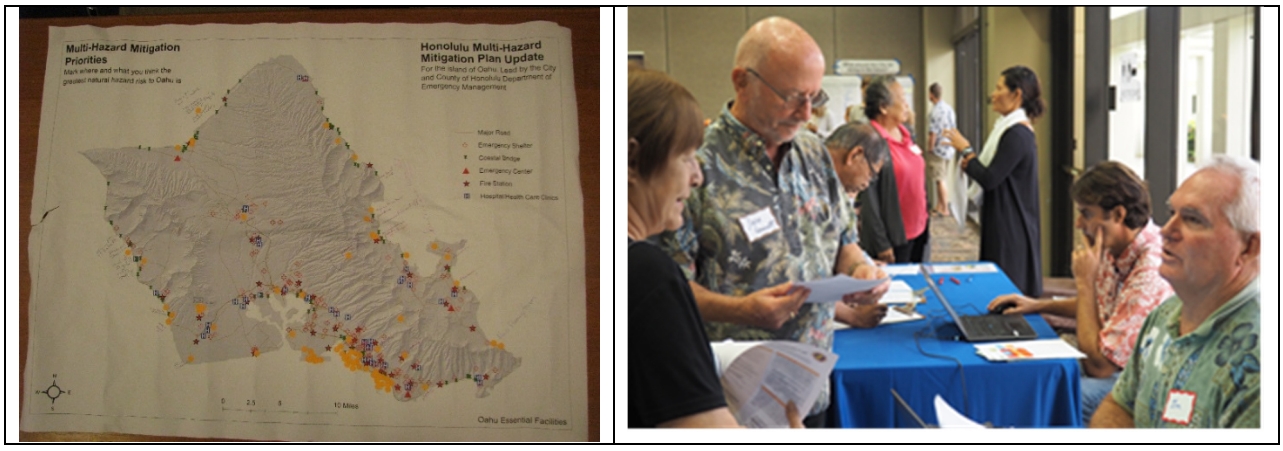


Figure 2-19 Map-based and Electronic Polling Inputs

Public Input was provided graphically as well as electronically captured. The Oahu map for multi-hazard mitigation captured the following areas of concern:

- Coastal flooding and SLR vulnerability of Ewa, HNL airport reef runway, Honolulu Harbor, Sand Island, Kewalo Basin, Ala Moana, Waikiki, and Waikane–Kualoa-Punaluu coastline, and Waimanalo
- Vulnerability of power transmission lines traversing the Koolau mountain ridges
- Vulnerability of Kahe Power Plant
- Vulnerability of HPower in Barber's Point industrial area
- Post-hurricane geographic isolation of Waianae coast and Makakilo
- Post tsunami geographic isolation of the North Shore to Kualoa point
- Health care service fragility along the Waianae coast and Waikane –Kualoa - Punaluu coastline
- Tsunami hazard of Kailua, Waimanalo, Haleiwa, and the North Shore

- Flash flood hazard of Manoa valley and Pauoa valley, and flooding of Kalanianaole Highway (Waialae to Hawaii Kai)
- Hurricane winds and micro-bursts (island-wide)

During the workshop, attendees were given several polling questions relating to hazard mitigation efforts of the City and public utilities, being in favor of strengthening power distribution poles, upgrading storm drainage capacity, defending Honolulu Harbor and the HNL airport reef runway against future Sea Level Rise (SLR) effects, and desiring implementation of a well-designed levee upgrade for the Ala Wai Canal.

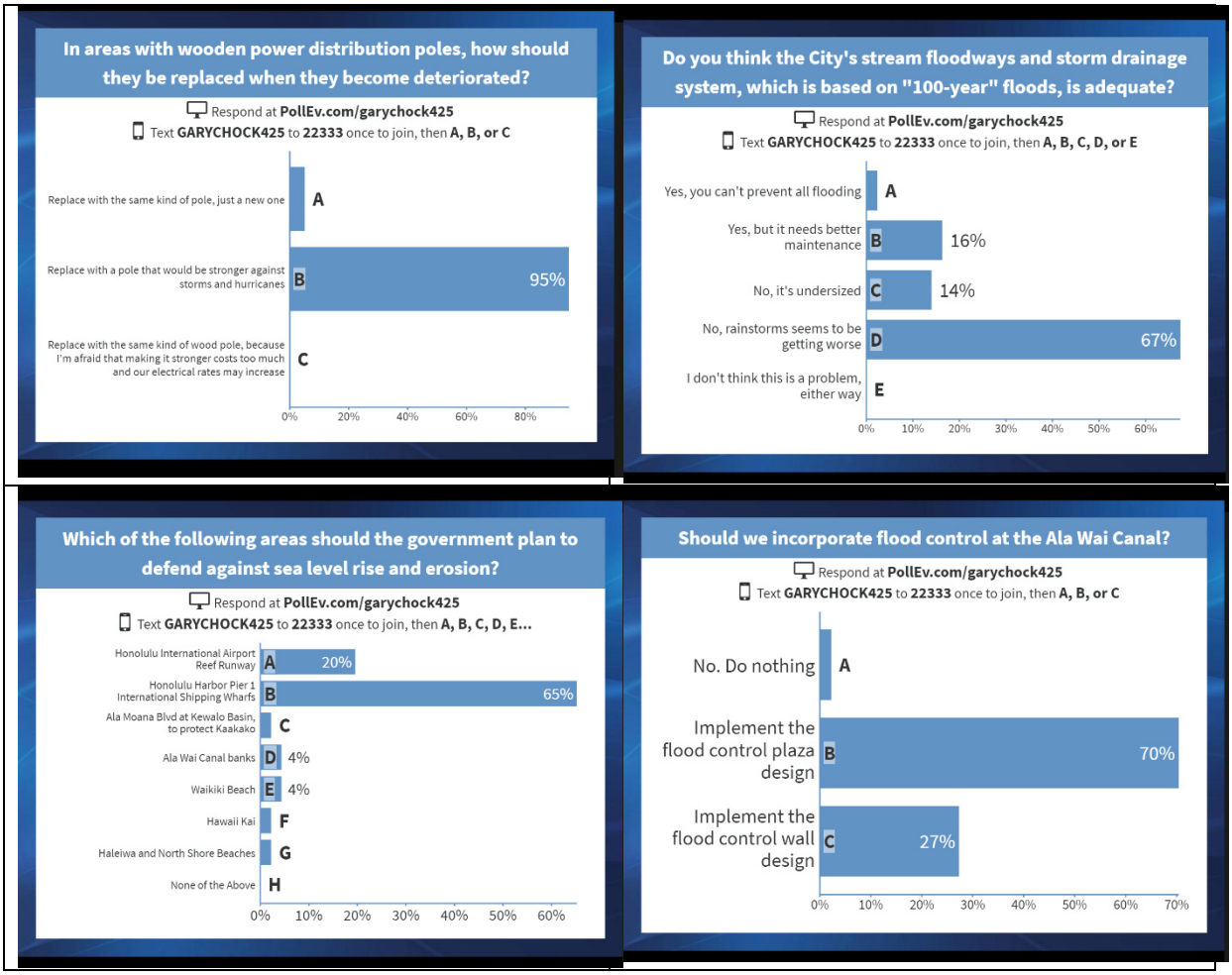


Figure 2-20 Instant Polling Questions

The 2018 Public Opinion Survey pointed in favor of the following government actions (rated high by more than 6 / 10 persons)

- Improve the reliability of power and communications
- Improve the reliability of the supply chain
- Retrofit infrastructure for disaster resilience
- Strengthen essential facilities
- Perform maintenance on streams to remove debris
- Improve public works for storm drainage and flood control

- Allow grants or tax credits for strengthening homes

Some additional risk reduction ideas that were offered by individuals included:

- Involving insurance companies to encourage building and retrofitting resilient structures
- Create financial incentives for businesses and community involvement in resiliency building
- Develop a drainage plan for the year 2100
- Create "barrier islands" around strategic parts of the island
- Integrate Hazard Mitigation Plan and data into General and Community Plan Updates
- Harden/redundancy, communication network
- Develop a means for homeowners to afford the retrofits or move from coastal inundation areas (e.g. fund, credits, etc.) –NOT loans
- What construction (materials) changes for our roads and airport runways are in planning for better mitigation/resiliency?
- Increase capacity of local communities to be autonomous during disasters

(A number of disaster preparedness suggestions were also offered)

A key question subject in a quick real-time poll related to the prioritization of resilience investment, which appear to emphasize governmental actions addressing present-day hazards, especially focused on

- Power and communications system infrastructure,
- Critical supply chain facilities,
- Safety of hurricane shelters,
- Resilience of critical facilities against flooding, and
- Creating tax credits for hazard mitigation by homeowners and businesses.

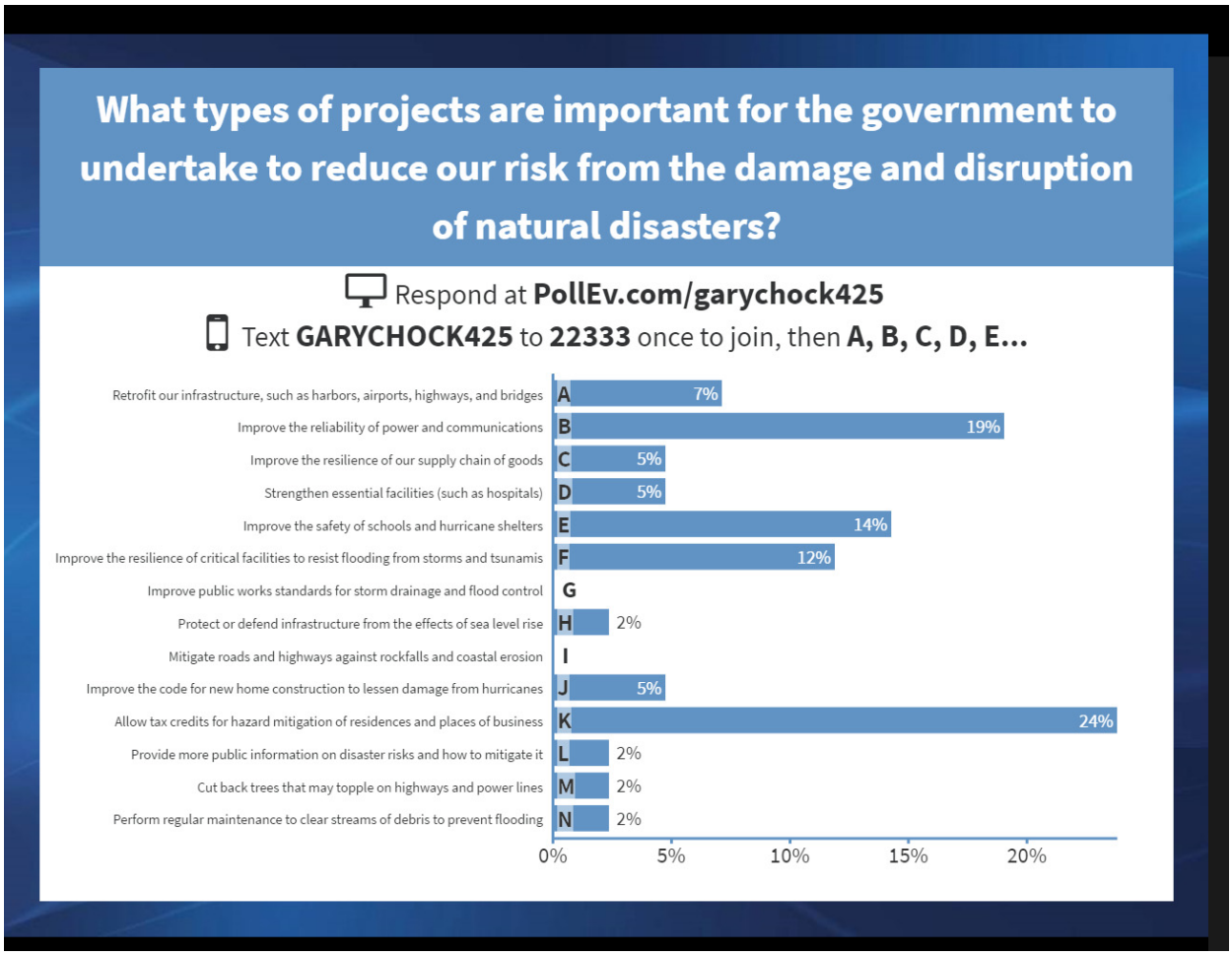


Figure 2-21 Public Input on What Should be Government Priority Actions

During the breakout session, a question of higher priority items to be included in the hazard mitigation strategy, in which respondents had no practical limit on the time taken for the consideration, identified the higher priority key elements to be:

- Improving the resiliency of critical infrastructure
- Updating the building code
- Implementing hazard mitigation policies in all phases of development
- Protection of emergency response assets to enable quicker response and recovery
- Planning for flood control public works for the long-term defense of critical facilities and major economic assets
- Provide guidance on feasible retrofits for homeowners and building owners
- Address coastal erosion defense or develop alternative locations of roadways and economic assets
- Revise regulations to require explicit building design for climate change adaptation

Mitigation Strategy Components	Votes for high priority
1. Enhance the public availability of disaster resilience information that can be quickly understood	7
2. Adopt the latest building codes to close resiliency gaps in the 12-years of obsolete Honolulu design codes	15
3. Revise regulations to require explicit building design for climate change adaptation	10
4. Improve disaster resiliency of essential and critical facilities, supply chain integrity, and utility services	24
5. Incorporate tsunami-resilient design requirements for critical facilities and tall buildings near the coast	4
6. Enable quicker response and recovery by protecting emergency response assets and resources	17
7. Implement hazard-mitigation policies in all phases of development planning and permitting	14
8. Re-examine Flood Control Criteria - is it adequate for Oahu communities?	4
9. Plan for flood control public works for the long-term defense of critical facilities and major economic assets	12
10. Participate in the Community Rating System to reduce flood loses and reduce flood insurance premiums	2
11. Provide guidance on feasible retrofits for homeowners and building owners	12
12. Address coastal erosion defense or develop alternative locations of roadways and economic assets	11
13. Assess the high wind integrity of existing hurricane shelters	4

Attendees (70 attended/90 registered):

	Last Name	First Name
1	Ah Mai	Karen
2	Alegado	Rose
3	Anderson	Cecil
4	Apana	Cyndi
5	Arroyo	Elvin
6	Au	Dwight
7	Auyong	Walton
8	Bagwall	Brian
9	Bailey	Lynn
10	Beasley	Koa
11	Bowers	John
12	Breckberg	Svea
13	Brede	Colin
14	Bush	Lariza
15	Carden	Lyle
16	Chamberlain	Kimberly
17	Curren	Flinn
18	Davison	Nicky
19	Dinoff	Barbara
20	Dupree	Chris

21	Fletcher	Chip
22	Fraser	Bonnie
23	Gruenstein	Justin
24	Hamnett	Michael
25	Hanneman	Katherine
26	Hanneman	Steven
27	Harada	John
28	Heinrich	Tom
29	Hirata	Christina
30	Hirata	Thomas
31	Holloway-Ledo	Savanna
32	Howe	Jim
33	Huddleston	Nick
34	Hwang	Dennis
35	Kam	Elaine
36	Kanda	Larry
37	Kawakami	Howard
38	Kim	Karl
39	King	Harvy
40	Kwock	Michelle
41	Lai	Arthur
42	Lardizabal	Al
43	Lee	Junell
44	McDermott	Michelle
45	Norman	Ashley
46	Obayashi	Flora
47	Ogata-Deal	Ann
48	Ostebo	Ken
49	Randall	Kelly
50	Reece	Diane
51	Renard	Gail
52	Romine	Brad
53	Roth Vena	Lauren
54	Sadovsky	Henry
55	Samudio	Marie
56	Saul	Alice
57	Schindler	JoAnn
58	Schindler	Mark
59	Stanfield	Stan
60	Ta'amu-Miyashiro	Britney
61	Toguchi	Traci
62	Toguchi-Matsuo	Alice
63	Ware	Lani
64	Warneck	Jim
65	Warneck	XilgXilg
66	Welch	Winston
67	Whitney	Phil
68	Woolliams	Akiko
69	Woolliams	Angela
70	Zane	Stephen

Some of the comments captured online at the end of the workshop:

"I am very glad I was invited to be a part of this workshop. I hope to be involved in the future workshops. I found it very informative. More small group and question time would also be productive. "

"Awesome speakers, well scheduled, food was okay. I hope the public's suggestions get implemented in the plan and people are more aware of planning ahead for a disaster."

"Lot of good information. I think too many people asking items off topic. Tables were good in the back."

"Excellent – learned a lot"

"Useful info"

"Thank you. Very informative and solutions-oriented."

"Would have liked more facilitated discussion in small groups"

"Mahalo Nui Loa, Malama Pono"

January 16, 2019 – Crystal van Beelen (Honolulu Department of Emergency Management) and consultant Gary Chock gave a briefing to the **Hawaii Voluntary Organizations Active in Disaster** (**Hawaii VOAD**) hosted at the Hawaii Foodbank. Attendees included representatives of the Hawaii Foodbank, Kailua Alert and Prepared, Catholic Charities, American Red Cross, and the Department of Health Medical Reserve Corps. **VOAD** is open to any organization that has a role to play in helping communities in Hawaii prepare for, respond to, and recover from disasters. Nonprofits, faith-based, community, and private-sector organizations may all become full voting members. Government agencies may become non-voting partners. There was lively discussion of the role of city agencies that should perform ministerial review development plans for conformance to existing requirements, versus the implementation of revised mitigation policies that may affect those requirements later. Mitigation policies need to be specifically established in regulations before they can be administered. Unilateral actions that go beyond the scope of authorized ministerial review may infringe on due process, property rights, and the development entitlements of the land owner or developer.

PUBLIC MEETING

SATURDAY, FEBRUARY 23, 2018 / 8:30 AM - 1:00 PM
Neal Blaisdell Center Hawaii Suites / 777 Ward Avenue

CITY'S MULTI-HAZARD PRE-DISASTER MITIGATION PLAN

City and County of Honolulu Department of Emergency Management

Mahalo. The purpose of this meeting is to

- **review progress on the Multi-Hazard Pre-Disaster Mitigation Plan update, and**
- **to give you an opportunity to provide input on how the City can reduce the risks from natural hazards. Input received at this meeting will help prioritize resilience actions and inform how we implement a mitigation strategy.**

AGENDA

GET UP TO SPEED

8:30 am **Sign In/Get Refreshments/Handouts/ Posters on the Big Risks**

WHERE WE ARE WITH PLANNING FOR NATURAL HAZARDS

8:50 am **Welcome – Hirokazu Toiya, Director, Department of Emergency Management (DEM)**

9:00 am **What are the risks from natural disasters?**

What are the proposed hazard mitigation actions?
- Gary Chock, Martin & Chock, Inc.

9:30 am **Assessment using the Plan Integration for Resilience Scorecard Guidebook**
- Dane Sjoblom, HHF Planners, Inc.

9:45 am **The Office of Climate Change Sustainability and Resiliency Oahu's Resilience Strategy (draft)**
Justin Gruenstein, Deputy Chief Resilience Officer, Office of Climate Change, Sustainability and Resiliency

10:00 am QUICK BREAK

LET'S WORK ON THE PRIORITIES FOR HAZARD MITIGATION POLICIES AND ACTIONS

10:10 am **Small Group Activity**
- Hazard Mitigation Actions for Discussion and Prioritization
- Would they be effective?
- How important is each action to implement?
- Should some mitigation actions become a coordinated package?
- Individually vote on priorities (high, medium, low) for implementation within the next 5 years

LET'S SUMMARIZE YOUR INPUT AND COLLECT YOUR VOTES

11:30 am What Actions Your Group Considers Most Important to Do

11:45 am QUICK BREAK

SAMOA, CHILE, JAPAN, AND INDONESIA AFTER TSUNAMIS – Investigations by an expert

12:00 pm **Buffet Lunch Presentation - Ian Robertson of the University of Hawaii at Manoa**

1:00PM **Adjournment - Thank you!**

For online reservations to this free event, **Creating Oahu's Natural Hazard Mitigation Strategy, Implementation Actions, and Priorities,** go to:
https://bit.ly/2DaL8Zm

ABOUT THE PLAN

The Honolulu Multi-Hazard Pre-Disaster Mitigation Plan is a multi-jurisdictional plan that identifies ways to reduce damage from hazards such as hurricanes, flooding, coastal erosion, etc. The Plan provides a framework for informed decision-making regarding the selection of cost-effective mitigation actions.

The objectives of the multi-hazard mitigation plan are to:

- ***protect people and structures from harm and destruction, and***
- ***reduce or mitigate losses and disruption of services during disasters.***

This mitigation plan is required for local governments seeking Federal Pre-Disaster Mitigation funds for mitigation project grants and is also a key component for maintaining eligibility for future FEMA disaster recovery funding.

YOUR IDEAS ARE VALUABLE

Mahalo for spending time with us to share your ideas on how we can reduce O'ahu's risk to natural hazards. To inform how we implement a mitigation strategy of resilience actions, we are looking for your input in the following topic areas:

- Hurricanes, Flooding and Tsunami
- Adapting and Defending of Infrastructure against Climate Change
- Improving Land Use Policies, Regulations and Building Codes
- Incentives for residential hazard mitigation and hazard resilience information
- Resilience of Essential Services and Facilities – power, communications, water, supply of goods, transportation and ports, and health care

For questions or comments, contact
Crystal van Beelen
Disaster Preparedness Officer 723–8956
cvanbeelen@honolulu.gov

The purpose of this open invitation public workshop was for participants to:

1. review the updated progress on the Oahu Multi-Hazard Pre-Disaster Mitigation Plan since November 2018, and
2. work in small groups to give input on how the City can reduce the risks from natural hazards in the following topic areas:
   - Hurricanes, Flooding and Tsunami
   - Adapting and Defending of Infrastructure against Climate Change
   - Improving Land Use Policies, Regulations and Building Codes
   - Incentives for residential hazard mitigation and hazard resilience information
   - Resilience of Essential Services and Facilities – power, communications, water, supply of goods, transportation and ports, and health care

The workshop also asked participants to arrange themselves into discussion groups along the following topic areas:

- Hurricanes, Flooding and Tsunami
- Adapting and Defending of Infrastructure against Climate Change
- Improving Land Use Policies, Regulations and Building Codes
- Incentives for residential hazard mitigation and hazard resilience information
- Resilience of Essential Services and Facilities – power, communications, water, supply of goods, transportation and ports, and health care
- Open Discussion

After allowing individuals to study and evaluate their own assessment of priorities, each group was asked to subsequently collaborate in determining which mitigation actions had the most affirmative support for high priority of implementation. Each group selected their own spokesperson to report on the group consensus.

- Hurricanes, Flooding and Tsunami:
  1. Hurricanes
     - Perform All-Hazard Assessments of Hurricane Shelters
     - Retrofit Public Shelter Buildings
     - Create Incentives for Homeowners and Businessess to retrofit their structures
     - Identify the Types of Buildings more Suitable for Self-Sheltering
  2. Flooding
     - Develop Flood Maps that go beyond FEMA requirements and consider both rainfall and coastal surge flooding
     - Plan for flood control public works for the defense of critical facilities and major economic assets

- Pursue the Ala Wai Watershed Flood Mitigation project with the US Army Corps of Engineers
- Revise the Electrical Code, to require placement of electrical transformers, switchgear, and emergency generators above the 500-year flood elevation

3. Tsunami
    - Perform preliminary engineering of tsunami and coastal flood mitigation defense of critical infrastructure
    - Board of Water Supply to identify and retrofit critical pumping stations in the tsunami inundation zone
    - Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects to enable use as refuges of safety
    - Evaluate storage tank farm walls in Honolulu Harbor for the ability to withstand tsunamis and hurricanes

- Adapting and Defending of Infrastructure against Climate Change
    1. The group did not prioritize the climate change hazard mitigation actions, but questioned whether individual buildings should be retrofitted to become self-sufficient for power, water, and wastewater rather than be served by city infrastructure
- Improving Land Use Policies, Regulations and Building Codes
    1. City should plan and determine how to execute public works to protect or defend existing critical facilities, infrastructure and utility services, supply chain, and vital economic assets at risk to climate change effects
    2. Encourage an adaptive engineering approach to all current and future projects near the shoreline. Incorporate mitigation of the effects of climate change.
    3. Establish regulatory policy to identify critical facilities during planning design
    4. Install mobile emergency generator switches at all HPD stations; increase emergency generator fuel capacity to more than 16 hours at Kaneohe, Kailua, Kahuku, and Pearl City Stations; upgrade Alapai HQ emergency generator
- (New Ideas for) Incentives for residential hazard mitigation and hazard resilience information
    1. Tax credits for generators, emergency supply kits, solar panels, and retrofitting
    2. Property tax credits over time for developers to build using stricter codes for stronger buildings
    3. Community grants awarded to each community that expire if the community does not utilize it and organize together in preparedness groups
    4. Green tax credits to reduce carbon footprints and building in areas that reduce risk
    5. Solar – reduce roadblocks and permitting requirements. Help reduce storarge costs
    6. Utilize public information events to educate people on hazard mitigation

- Resilience of Essential Services and Facilities – power, communications, water, supply of goods, transportation and ports, and health care:

    1. The PUC to adopt the 2017 NESC* for power transmission and distribution to include amendment with the ASCE topographic windspeed maps. Strategically plan with HECO to achieve a disaster-resilient network. The resiliency of the power distribution network is poor

    2. Evaluate risks and prioritize protective measures for existing infrastructure facilities

    3. Establish regulatory policy to identify critical facilities during planning and design.

    4. Install mobile emergency generator switches at all HPD stations; increase emergency generator fuel capacity to more than 16 hours at Kaneohe, Kailua, Kahuku, and Pearl City stations; upgrade Alapai HQ emergency generator per USCOE recommendation and provide automatic start-up

Other opinions included:

- Water mains need upgrading
- Wastewater plants are really poorly protected
- Seek funding to construct structural and infrastructure mitigation projects
- Grow your own food for self-sufficiency (rather than importing as much)
- HAM radio for emergency communications during large scale events (this is emergency response rather than hazard mitigation)

Attendees:

Alcon	J	Heinrich	T	Nozawa	G
Alcon	A	Henderson	A	O'Leary	M
Anixt	A	Hirata	T	Obayashi	F
Aylett	C	Ho	L	Otaguro	G
Barbour	D	Holloway-Ledo	S	Robertson	I
Bray	M	Izuka	R	Sakamoto	D
Bueno	R	Jeffrey	N	Santos	C
Cates	A	Kaapu	C	Schmitt	S
Cook	M	Kamanuwai	P	Shear	J
Cooley	R	Kanda	L	Shimabukuro	D
Cunningham	B	Keen	B	Tagawa	S
Curren	F	Kusunoki	A	Takazawa	H
Davison	N	Kwock	M	Thurlow	C
Ferdun	R	Lee	F	Tsuhe	D
Fish	R	Lee	G	Uno	E
Fraser	B	Levy	J	Villacis	C
Glei	M	Miranda	R	Wagner	A
Hamnett	M	Mosher	C	Wooliams	A
Hashimoto	E	Nahme	L	Yuen	P
Hashimoto	G	Nakano	H	Zane	S
Hashiro	R				










February 23 2019 Large and Small Group Activities

The form used to gather input on priorities for 55 hazard mitigation actions is shown below:
Multi-Hazard Pre-Disaster Mitigation Plan of the City & County of Honolulu
Recommended Mitigation Actions (For stakeholder and public input on priorities)
(* indicates these measures were developed in detail per: Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability to Coastal Hazards and Climate Impacts In the City and County of Honolulu, 2017)

	Hazard Mitigation Action	Priority of Implementation / Timing (High, Medium , Low)
Policies	**1 Integrate natural hazard policies** into the General Plan & Community Development Plans.	
	2 City government should plan and determine how to execute public works to protect or defend existing critical facilities, infrastructure and utility services, supply chain, and vital economic assets a risk to climate change effects.	
	3 Encourage and adaptive engineering approach* to all current and future projects near shoreline. Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly the Ala Wai Canal.	
	4 HRS 205A Certified Shoreline* For planning purposes, also include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years. **ROH Chapter 23*** Setback rules to establish the setback line about 25 feet from the certified shoreline plus 50 times the average annual coastal erosion rate, or to a minimum of 40 feet.	
	5 HRS Chapter 484 *- Uniform Land Sales Practices Act: Require disclosure of an explicitly defined list of hazards **HRS Chapter 508D* Mandatory Seller Disclosures in Real Estate Transactions**: Make disclosure apply to vacant lots as well. This would require an all-hazards web portal for the property owner to access comprehensive data	
	6 Develop strategic pre-disaster plans for implementation of new resilient and sustainable designs for areas that must be rebuilt post-disaster. Update the LUO accordingly.	
Climate Change	**7 ROH Chapter 25 SMA***: Amend the Special Management Area requirements to: 1) Create a Coastal Construction Control Zone to account for 50-years of erosion, climate change and 2 ft. of Relative Sea Level Rise, and 500-year flooding 2) For Major Permits within the Coastal Construction Control Zone, require that those effects on the functionality of the development and land use be mitigated.	
	8 Produce Regulatory (100-year and 500-year) Coastal Flooding Maps that account for climate change effects on storm intensities and sea level rise*	
	9 Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities*.	

	Hazard Mitigation Action	Priority of Implementation / Timing (High, Medium , Low)
Flooding	**10 Revise and update the Flood Hazard Area, ROH Chapter 21A*** to enable the use of the ASCE 24-14 Standard, *Flood Resistant Design and Construction*. For Critical and Essential Facilities of a community, this standard would require 500-year flood elevations be used for design. Incorporate climate change effects on the storm-generating environment, per the methodology as detailed in Probabilistic mapping of storm-induced coastal inundation for climate change adaptation (Li, N., et al., 2017). **Adopt the 2018 IBC in ROH Chapter 16, Building Code to incorporate ASCE 24-14 Standard ***	
	11 Revise the Honolulu Electrical Code, ROH Chapter 17*: For Essential and Critical Facilities, the Electrical Code should require placement of electrical transformers, switchgear, and emergency generators above the 500-year flood elevation, or alternatively, protected by dry floodproofing.	
	12 Re-evaluate critical inland and stream flooding DFIRMs* to account for a) the details of the watershed and the floodway, and b) from a policy standpoint whether the frequency of flood overtopping is really acceptable in heavily developed areas.	
	13 Participate in the Community Rating System to reduce flood losses and flood insurance premiums.	
	14 Develop Flood Maps that go beyond FEMA requirements and consider both rainfall and coastal surge flooding, concentrating on areas with critical infrastructure	
	15 Plan for flood control public works for the defense of critical facilities and major economic assets. Hardening of critical facilities, utilities, power and communication networks, and port facilities.	
	16 Pursue the Ala Wai Watershed Flood Mitigation project with the US Army Corps of Engineers; include resilience, visual appeal, water quality, and infrastructure improvements; create a watershed district to coordinate infrastructure projects, resilience planning and regulations, watershed data collection, and community engagement.	
	17 Install flood barriers at HPD facilities at areas with habitual flooding	
Infrastructure Facilities	**18 Evaluate risks and prioritize protective measures for existing infrastructure facilities**	
	19 Relocate or locally defend/reinforce vital infrastructure such as roads in coastal eroding regions.	
	20 The PUC to adopt the 2017 NESC* for power transmission and distribution to include amendment with the ASCE topographic windspeed maps. Strategically plan with HECO to achieve a disaster-resilient network.	
	21 Update design and construction standards for utility lifelines.	
	22 Increase HECO generator plant capacity and redundancy of supply.	
	23 R**eplace weathered wood poles** with NESC-conforming poles.	
	24 Improve resiliency of fuel supplies during disasters	

	Hazard Mitigation Action	Priority of Implementation / Timing (High, Medium , Low)
Building Facilities	**25 Rock Fall Buffer Zones** should be developed and incorporated into new developments between high-hazard rock fall areas and homes. Requires new regulatory mapping.	
	26 Modernize ROH Chapter 16 Building-Code - Adopt 2012 and 2018 IBC and related codes per HRS 107 Part II *	
	27 Test Seismic and Wind Performance to develop **Single Wall Construction retrofit techniques**.	
	28 Hazard Mitigation Retrofits and Protection of Essential Facilities on Oahu	
	29 Establish regulatory policy to identify critical facilities during planning and design. CRITICAL FACILITY: Buildings and structures provide services that are essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations.	
	30 Strengthen requirements for building upgrade for hazard resistance when owner remodels	
	31 Harden DFM and DRM Base Yards in Wahiawa and Kaneohe to provide viable pre-hurricane staging of debris clearing equipment and personnel	
	32 Install mobile emergency generator switches at all HPD stations; increase emergency generator fuel capacity to more than 16 hours at Kaneohe, Kailua, Kahuku, and Pearl City stations; upgrade Alapai HQ emergency generator per USCOE recommendation and provide automatic start-up	
Hurricane	**33 Identify the types of buildings more suitable for self-sheltering**	
	34 Perform All-Hazard Assessments of Hurricane Shelters.	
	35 Retrofit public shelter buildings to increase capacity and refine actual evacuation demand and update policies to decrease sheltering deficit.	
	36 Establish a policy for strengthening of critical public facility enclosure integrity for wind and windborne debris.	
	37 Create incentives for homeowners and businesses to retrofit their structures.	
	38 Require hurricane safe rooms in all new residential construction outside of flood zones	
Tsunami	**39 Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects** to enable use as refuges of safety.	
	40 Perform preliminary engineering of tsunami and coastal flood mitigation defense of critical infrastructure.	
	41 ROH Chapter 16 Building-Code Produce higher resolution Oahu probabilistic tsunami hazard maps* (run-up) for use with the ASCE-2016 and IBC-2018 building code design provisions.	
	42 ROH Chapter 16 Building-Code Adopt tsunami design provisions* for buildings for new design and construction.	
	43 Evaluate fuel storage tank farm walls in Honolulu Harbor for the ability to withstand tsunamis and hurricanes.	

	Hazard Mitigation Action	Priority of Implementation / Timing (High, Medium , Low)
	44 BWS to identify and retrofit critical pumping stations in the tsunami inundation zone.	
Drought and Wildfire	**45 Develop low-flow instream flow standards** for environmental protection	
	46 Expand rebate program for new water-saving technologies	
	47 ROH Chapter 20 Fire Code*: utilize maps of historic burn areas as issued in the High Fire Risk Map Zones for regulations based on NFPA-1.	
	48 Fire Break Maintenance - Various fuel breaks/fire roads need to be maintained by DOFAW with heavy equipment, in order to stop advancing fire and provide access to firefighters.	
	49 Assist Oahu communities to become Firewise Communities.	
	50 Establish water tanks at the fringes of threatened communities that can serve as dip tanks	
	51 Complete more detailed wildfire hazard analysis	
	52 Increase setbacks from property lines near wildland fire areas and require fire lanes and vegetation control measures	
Public Information	**53 Enhance the public availability of disaster resilience information** that can be quickly understood, especially regarding: *Hurricane Awareness, Hurricane Retrofits, Hurricanes, Tsunamis and Flooding.*	
	54 Disaster preparedness education for immigrant minority groups on Oahu.	
	55 C**reate financial incentives for business and individuals involved in building resiliency.**	

Recommendations for other proposed Hazard Mitigation Actions or Projects:

Mitigation Actions can be of the following 6 types:

1. ***Prevention****:* Government policy and regulatory actions requiring hazard resilience in land development.
2. ***Protection of Existing Development****:* Actions to modify existing structures to protect them from a hazard.
3. ***Public Education and Outreach****:* Actions to inform / incentivize citizens about the hazards and mitigation.
4. ***Protection of Natural Resources****:* Actions that preserve natural systems that mitigate hazard losses
5. ***Essential Service Resilience****:* Actions that enable essential service continuity during and immediately after a disaster or hazard event, and thereby hasten recovery.
6. ***Structural Mitigation Projects****:* Actions that involve the construction of structures or improvement of infrastructure to reduce the impact of a hazard.

Type (indicate by number per above description)	Description of Hazard Mitigation Action / Project	Effectiveness in Improving Resiliency (High, Medium , Low)

2.2.5 City Multi-Hazard Pre-Disaster Mitigation Plan Update - Advisory Committee Meeting

At this December 3, 2018 meeting, a summary presentation was given on the Risk Analysis of Average Annualized Losses (AAL) for the various natural hazards, which are based on probabilistic hazard whenever feasible. The ranked losses are as follows (per Table 18-5):

Hazard	Risk of Average Annual Loss	Public Survey Rank
Hurricane (Wind)	**$410 Million / Year**	**#1**
Tsunami	**$81 Million / Year**	**#4**
Flood	**$27 Million / Year**	**#2**
Earthquake	**$21 Million / Year**	**#3**
Coastal Erosion/SLR	**$3 Million / Year**	**#5**
Debris Flow and Rockfall	**$1 to $5 Million / Year**	**#8**

Discussion centered on the methodology of computing Average Annualized Losses from probabilistic hazard models, particularly with respect to hurricanes affecting the Hawaii region.

Attendees:

Last Name	First Name	Organization
Chock	Gary	Martin & Chock
Sjoblom	Dane	HHF
Toiya	Hirokazu	DEM
Bravender	John	NWS
Gruenstein	Justin	CCSR
Harter	Robert	DEM
Kanda	Larry	HIEMA
Kinimaka	Chris	DAGS
Lau	Clifford	DDC
Morita	Robert	BWS
Moscovic	Sharon	DFM
Norman	Ashley	PUC

On December 10, 2018 a meeting of the State Hazard Mitigation Forum was convened:
Input from the City for inclusion into the next edition of the State hazard mitigation plan was identified in a short briefing.

The State Hazard Mitigation Forum consists of representatives of each county's planning or emergency management agency and the Hawaii Emergency Management Agency. The State Hazard Mitigation Forum also reviews and votes on priorities for Pre-Disaster Mitigation Program planning projects and mitigation projects.

Attendees:

Last Name	First Name	Organization
Chock	Gary	Martin & Chock
Kanda	Larry	HIEMA
Boteler	Bob	HIEMA
Chu	Pao-Shin	UHM
Gruenstein	Justin	CCSR
Hayes	Juliette	FEMA RIX
Houston	Addison	DOH
Lau Hee	Keanu	Maui Emergency Management Agency
Ma	Sandy	Office of Planning Hawaii Coastal Zone Management Program, DBEDT
Montoro	Alex	County of Hawaii
Morita	Robert	BWS
Parsons	Robert	County of Maui
Romine	Brad	UH- Sea Grant College
Sakai	Chelsie	Kauai Emergency Management Agency
Vacroix	Natalie	FEMA RIX
Van Beelen	Crystal	DEM
Walker	Michael	DLNR-DOFAW
Walter	Jennifer	HIEMA
Want	Mark	DBEDT
Whitmore	Ron	County of Hawaii

December 17, 2018 at CCSR – a summary of the anticipated hazard mitigation actions were discussed and it was determined that the CCSR supported the climate change related mitigation actions of the Honolulu Hazard Mitigation Plan.
Attendees:

Gary Chock	Martin & Chock, Inc.
Justin Gruenstein	CCSR
Mathew Gonser	CCSR
Josh Stanbro	CCSR

Concurrently in 2018, the Honolulu Office of Climate Change, Sustainability & Resiliency (CCSR) was also gathering input towards formulating a Resilience Strategy. The City and County of Honolulu Office of Climate Change, Sustainability and Resiliency (CCSR) was established by City Charter in 2016 by O'ahu voters. As mandated by Charter, the Resilience Office is tasked with tracking climate change science and potential impacts on City facilities, coordinating actions and policies of departments within the City to increase community preparedness, developing resilient infrastructure in response to the effects from climate change, and integrating sustainable and environmental values into City plans, programs, and policies. As a member of the Rockefeller Foundation's 100 Resilient Cities network, the Resilience Office is also responsible for developing O'ahu's Resilience Strategy by, which will include the City's first-ever climate action and adaptation plan (expected release April 2019).

An extensive series of public meetings were conducted that included an O'ahu Resilience Stakeholder Engagement Survey that drew responses from 2,300 stakeholders, which comprised the following community opinions:

Top 5 Shocks		
#1	Hurricane	26%
#2	Tsunami	17%
#3	Infrastructure Failure	12%
#4	Rainfall Flooding	9%
#5	External Economic Crisis	8%

Top 5 Stresses		
#1	Cost of Living	17%
#2	Climate Change Impacts	16%
#3	Aging Infrastructure	16%
#4	Lack of Affordable Housing	16%
#5	Over-reliance on Imports	8%

For developing the Resilience Strategy beginning August 10 of 2018, based on public input workshops to define three major resilience challenges and O'ahu's community strength, CCSR assembled an invited group of diverse stakeholders and organized them into five working groups for a series of monthly meetings ending with a final meeting on November 15 2018 for a workshop to recommend the priorities for the Resilience Actions assembled by each group:

1. Long-Term Affordability ("Remaining Rooted")
2. Resilience in the Face of Natural Disasters ("Bouncing Forward")
3. Tackling Climate Change by Adapting to Impacts ("Island Innovation and Exposure")
4. Tackling Climate Change by Reducing Emissions ("Island Innovation and Exposure")
5. Leveraging the Strength of Communities ("Laulima")

Each Working Group was charged with recommending Resilience Actions to

1. Advance a Resilience Goal
2. Suggest new Resilience Goals or Policies
3. Generate baseline data or fill information gaps

At the November 15 2018 final workshop, all five working groups convened to review, prioritize, and vote on the Resilience Actions they would like to see elevated in Oahu's Resilience Strategy. Each working group plotted their Resilience Actions according to perceived amount of impact and difficulty of implementation. The Resilience in the Face of Natural Disasters and Tackling Climate Change by Adapting to Impacts Groups had the most relevance to the City Hazard Mitigation Plan. The following Resilience Actions related to natural hazard mitigation received strong support:

- **Infrastructure Hardening – Evaluate risks and prioritize protective measures for existing facilities**
- **Update the Building Code Requirements for Coastal Flooding and Shoreline Erosion – applicable to the design and construction of critical facilities**
- **Incentives for Home Hardening - offer property tax and insurance discounts for retrofits to encourage sheltering in place**
- **Participate in the FEMA NFIP Community Rating System**
- **Pursue the Ala Wai Watershed Flood Mitigation project (US Army Corps of Engineers) and ensure that it is well executed and includes as much green infrastructure (with resilience and visually appealing benefits, water quality, and enhanced economic activity) as possible.**
- **Create a watershed district for the Ala Wai to coordinate infrastructure projects, resilience planning and regulations, watershed data collection, and community engagement. Support a community process that engage stakeholders.**
- **Adopt a Sea Level Rise Exposure overlay and corresponding rules as a City and County ordinance, and use the overlay to update or amend all sustainable community plans within the next 5 years.**
- **Update the Land Use Ordinance to accommodate the expected sea level rise.**
- **Revise ROH Chapter 23 to adopt setbacks for new construction and new additions to allow for 50 years of shoreline erosion designated on a regulatory map of expected shoreline. Allow exceptions for either limited lot size or shallowness of lots. Create an expected shoreline map.**
- **Revise ROH Chapter 25 SMA: Amend the Special Management Area requirements applicable to major developments to include adaptation to shoreline changes due to future sea level rise and erosion hazards, and developing the necessary regulatory maps**
- **Resilient Grid: Strategically plan with HECO to achieve a resilient grid**
- **Updated Design Standards for the Power Transmission and Distribution System per NESC 2017 and to include topographic windspeed maps for Hawaii; periodically update that code every 5 years.**
- **Develop strategic pre-disaster plans for implementation of new resilient and sustainable designs for areas that must be rebuilt post-disaster.**

Members of the Resilience in the Face of Natural Disasters and Tackling Climate Change by Adapting to Impacts Groups:

Bouncing Forward

Lynn Bailey, *Hawai'i DOH*
Aaron Cates, *Kunoa Cattle*
Gary Chock, *Martin & Chock*
Barry Choy, *NOAA*
Jimmie Collins, *USPACOM*
Celeste Connors, *Hawai'i Green Growth*
Nalani Fujimori Kaina, *Legal Aid Society*
Sunny Greer, *Emergency Management Professionals of Hawai'i*
Pono Higa, *Wai'anae Coast Disaster Readiness Team*
Chris Hong, *AIA Immediate Past President*
Jim Howe, *Honolulu Emergency Services Department*
Michael Iwashita, *UH NDPTC*
Tim Johns, *Zephyr Insurance*
Keone Kealoha, *Kanu Hawai'i*
Dotty Kelly-Paddock, *Hau'ula Emergency Leadership Plan*
Coralie Matayoshi, *Red Cross*
Ron Mizutani, *Hawai'i Foodbank*
***Ramona Mullahey,** *HUD*
Mike Onofrietti, *Island Insurance Companies*
Rob Porro, *UH NDPTC*
Jennifer Sabas, *PICHTR*
Scott Seu, *HECO*
Jeannine Souki, *Hawai'i Gas*
***Hiro Toiya,** *City & County of Honolulu Office of Emergency Management*
Colin Yost, *Partnership for Pacific Resilience*

Island Exposure & Innovation (Adaptation)

***Lorraine Akiba,** *LHA Ventures*
Wesley Babcock, *Kamehameha Schools*
Danielle Bass, *State of Hawai'i Office of Planning*
Nancy Conrad, *Stantec*
Kitty Courtney, *Tetra Tech Inc.*
Rick Egged, *Waikīkī Improvement Association*
Julius Fischer, *Hawai'i Green Growth*
Chip Fletcher, *UH SOEST*
Mike Foley, *Oceanit*
Kevin Greenwell, *Kamehameha Schools*
Tim Houghton, *City & County of Honolulu Department of Environmental Services*
George Kam, *Quicksilver*
Victoria Keener, *East-West Center*
***Robert Kroning,** *City & County of Honolulu Department of Design and Construction*
Brett MacNaughton, *MacNaughton Group*
Kiana Otsuka, *O'ahu Metropolitan Planning Organization*
Kirstin Punu, *Naval Facilities Engineering Command*
Brad Romine, *UH Sea Grant*
Harrison Rue, *City & County of Honolulu Transit Oriented Development*
Ross Sasamura, *City & County of Honolulu Department of Facility Maintenance*
Kathy Sokugawa, *City & County of Honolulu Department of Planning and Permitting*
Daniele Spirandelli, *University of Hawai'i Department of Urban & Regional Planning*
Genevieve Sullivan, *State of Hawai'i Department of Transportation, Highways*
Barry Usagawa, *City & County of Honolulu Board of Water Supply*
Iris van der Zander, *State of Hawai'i Department of Health, Health Hazard Evaluation and Emergency Response*
Cheryl Walthall, *Pacific Resources Partnership*

December 20, 2018 Internal planning discussion at DEM was held to review the same summary of anticipated hazard mitigation actions (see Table 2-1) to be components of the mitigation strategy to be proposed at the January 15 2019 Cabinet meeting
Attendees:
Gary Chock
Hirokazu Toiya
Crystal Van Beelen

Multi-Hazard Pre-Disaster Mitigation Plan For The City & County of Honolulu December 17, 2018 Outline Draft
Mitigation Goals are to eliminate or reduce risk through the following:

1. Continually strive to improve the state of the art for the identification of hazard areas, risk assessment capabilities, warning systems, and effective response and recovery.
2. Plan, design, and construct future development and retrofit existing structures within hazard areas to minimize losses.
3. Ensure that all emergency response critical facilities and communication systems remain operational during hazard events.
4. Ensure that all lifeline infrastructures are able to withstand hazard events or have contingency plans to quickly recover after a disaster.
5. Provide adequate pre- and post-disaster emergency shelters to accommodate residents and visitors.
6. Develop a level of awareness among the general public and businesses, particularly the visitor industry, that results in calm and efficient evacuations, self-sufficient survival skills, and willingness to abide by preventive or property protection requirements.
7. Minimize post-disaster recovery disruption by developing systems for efficient clean-up, documentation of damage and injury, and processing of appropriate aid to rebuild businesses and the economy.
8. Protect natural and cultural resources to the extent practicable.

Mitigation Action Categories:

1. *Prevention:* Government administrative and regulatory actions or processes that influence the way land and buildings are developed and built.
2. *Property Protection:* Actions that involve the modification of existing structures to protect them from a hazard, or removal from the hazard area.
3. *Public Education and Outreach:* Actions to inform, educate, or incentivize citizens, elected officials, and property owners about the hazards and potential ways to mitigate them.
4. *Natural Resource Protection:* Actions that minimize hazard losses while also preserving or restoring the functions of natural systems.
5. *Essential Services:* Actions that protect people and property during and immediately after a disaster or hazard event, provide essential service continuity, and hasten recovery.
6. *Structural Projects:* Actions that involve the construction of structures or improvement of infrastructure to reduce the impact of a hazard.

After review and development, Pre-Disaster Mitigation activities and projects were presented to the Mayor and selected cabinet officials with the City Council, and then with representatives of all City agencies at 2019 All-Hazards Mitigation Plan workshops.

January 15, 2019 – The Mayor's Cabinet Meeting included a briefing on the hazard mitigation plan update by DEM Administrator Hiro Toiya and obtained directors support to have their representatives participate in a 2/5-6/2019 all agency stakeholder workshop to prioritize hazard mitigation actions.

January 28, 2019 – A meeting of the Department Emergency Coordinators and Agency Emergency Coordinators (DEC/AEC) was held at the Emergency Operations Center.

Attendee Name	Department/Agency
Josh Stanbro	CCSR
Crystal van Beelen	DEM
Colt Yamashiro	DEM
Nicole Nakata	DEM
Gary Chock	Martin & Chock, Inc.
Dane Sjoblom	HHF Planners
Jonathan Levy	Dept. of Planning and Permitting
Terry Hildebrand	Dept. of Planning and Permitting
Curtis Lum	Dept. of Planning and Permitting
Stan Kimura	Honolulu Fire Department
Carlton Yamada	Honolulu Fire Department
Danielle Vassalotti	Department of Health
Matthew Hanabusa	Department of Health
Christian Hellum	Community Services Department
Michael Walker	Division of Forestry and Wildlife, DLNR
Dennis Nagamine	Royal Hawaiian Band
Kevin Allen	Ocean Safety Division, Emergency Services Department
Yoko Tomita	Department of Transportation Services
Georgene Wakui	Department of Parks and Recreation
Clifford Lau	Department of Design and Construction
Walter Billingsley	Department of Design and Construction
Cyndy Aglett	Environmental Services Department
Walter Medina	Department of Human Resources
Noelani Wheeler	Oahu Visitors Bureau
Anglea Woolliams	American Red Cross
Jeanne Tanaka	American Red Cross
Steph Kendrick	Hawaiian Humane Society

The meeting attendees were given a short briefing on the results of the hazard and risk analysis, then allotted time to work on the recommended hazard mitigation actions priority rating input form. Josh Stanbro stated that their extensive public meetings that included thousands of participants gathered input on the perceived greatest "shocks and stressors", and that the top shocks generally aligned with the results of the formalized economic risk analysis. The Department of Parks and Recreation indicated that their facilities are going to be used for some sheltering and for points of distribution of emergency supplies. The Department of Emergency Management stated that hurricane resilient city baseyards were needed in order to have pre-disaster staging of response equipment and responder personnel. The Enviromental Services Department indicated that capital improvements include sea level rise adaptation in any facility hardening projects. The Division of Forestry and Wildlife were in favor of improvements in firebreaks in wildland fire susceptible areas.

The Honolulu Fire Department reported (after the meeting) that their priorities included:

a. Identifying the Honolulu Fire Department (HFD) facilities that are included on the Honolulu Essential Facility Inventory list, if any.

b. Facilitating the HFD facility inventory and infrastructure review for susceptibility to multihazards such as, tsunamis, hurricanes, floods, etc.).

c. Facilitating an evaluation to include cost estimates for hardening of the HFD's facilities

These results were then combined with the priority rating input forms received at the February 5 and 6 stakeholder meetings.

February 5 and 6, 2019 – Two Department / Agency Stakeholders Meetings were held to discuss mitigation actions and determine their priorities from an internal governmental perspective. Those that indicated their attendance prior to the meeting were provided a preview of the meeting handouts for preparation.

Feb 5 Attendee Name	Department/Agency
1. Kurt Nakamatsu	– Corporation Council (COR)
2. Kaanoi Clemente	– HECO
3. Ian Robertson	– UH
4. Mark Yonamine	– Design and Construction (DDC)
5. Kazunari Fujimura	– HPD
6. Georgene Wakui	– Parks & Rec (DPR)
7. Larry Kanda	– HIEMA
8.Justin Gruenstein	- CCSR
9.Lan Yoneda	- Department of Facility Maintenance
Crystal van Beelen	Department of Emergency Management
Gary Chock	Martin & Chock, Inc.

Feb 6 Attendee Name	Department/Agency
1. Tony Valasco	- DIT
2. Shane Kawasaki	– DIT
3. Eugene Takahashi	– Planning and Permitting (DPP)
4. Ashley Norman	– PUC
5. Shawn Enos	– Enterprise Services (DES)
6. Ryan Peralta	- DLNR DOFAW
7. Natalie Jones	- Department of Land Management
8. Sharon Moscovic	Department of Facility Maintenance
9. Clayton Shimazu	Department of Facility Maintenance
10. Carlton Yamada	– HFD
11.Holly Morgan	- CCSR
Crystal van Beelen	Department of Emergency Management
Gary Chock	Martin & Chock, Inc.

Besides gathering each attendees ranking of priorities for hazard mitigation actions, on both days, there was good discussion of what should be modernized in the eight Honolulu Hazard Mitigation Goals. This resulted in the following revisions (see italicized text), reflecting the importance of data networks and internet connectivity to a functioning city as a key element of its infrastructure, and adopting a more practical approach to sheltering:

Mitigation Goals are to reduce risk and increase resilience through the following:

1. Continually strive to improve the state of the art for the identification of hazard areas, risk assessment capabilities, warning systems, and effective response and recovery.
2. Plan, design, and construct future development and retrofit existing structures within hazard areas to *become resilient and* minimize losses.
3. Ensure that all emergency response critical facilities, communication systems*, information technology data networks, and broadband internet connectivity* remain operational during *and after* hazard events.
4. Ensure that all lifeline *and information technology* infrastructures are able to withstand hazard events or have contingency plans to quickly recover after a disaster.
5. *Develop public guidance for the need to shelter in residences that are strengthened as necessary and outside of areas that are subject to flooding, or in alternative resilient structures. Provide pre- and post-disaster emergency shelters to accommodate residents and visitors that are not able to shelter in place.*
6. Develop a *high* level of awareness among the general public and businesses, particularly the visitor industry, that results in self-sufficient survival skills, and a willingness to abide by preventive measures.
7. Minimize post-disaster recovery disruption by developing systems for efficient clean-up, documentation of damage and injury, and processing of appropriate aid to rebuild businesses and the economy.
8. Protect natural and cultural resources that buffer hazard effects to the extent practicable

Composite mitigation action rankings were computed by taking the average of government agency participants' scores, with assignment of a score of 3 to High Priority, 2 to Medium Priority, and 1 to Low Priority. These composite mitigation action scores were not revealed until the very end of the February 23rd public workshop, so that independent public opinions could be sampled from the attendees. Any new mitigation project ideas proposed by government participants were incorporated into the updated ranking form for use at the February 23rd public workshop. Actions deemed at least medium-high or greater by multiple entities are shown in bold text in the following compilation of all input received. • indicates high priority ranking where numerical scoring was not used**.**

Honolulu Hazard Mitigation Actions - Priority Scoring

Per combined input from the

- Public Online Survey 2018
- November 3, 2018 Open to Public Workshop Participants

Feb. 23, 2019 Open to Public Workshop Participants (3 = High; 2 = Medium; 1 = Low Priority)

Government Stakeholders in Feb 5-6, 2019 (3 = High; 2 = Medium; 1 = Low Priority)

- Climate Change Sustainability and Resilience Working Groups- Resilient Oahu Strategy

Ranking by Govt/Workshop Participants

Hazard Mitigation Action	#	Action	Overall Priority	GOVT Composite Score	Feb 23 Workshop Composite Score	November 2018 Workshop	2018 Survey Priority	CCSR Resilient Oahu Priority
Policies	1	**Integrate natural hazard policies into the General Plan & Community Development Plans.**	**3**	**2.9**	**2.6**	•		
	2	**City government should plan and determine how to execute public works to protect or defend existing critical facilities, infrastructure and utility services, supply chain, and vital economic assets a risk to climate change effects.**	**1**	**2.9**	**2.9** •	•	•	•
	3	**Encourage and adaptive engineering approach* to all current and future projects near shoreline. Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly the Ala Wai Canal.**	**14**	**2.5**	**2.5** •	•	•	
	4	**HRS 205A Certified Shoreline* For planning purposes, also include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years. ROH Chapter 23* Setback rules to establish the setback line about 25 feet from the certified shoreline plus 50 times the average annual coastal erosion rate, or to a minimum of 40 feet.**	**15**	**2.5**	**2.5**			•
	5	HRS Chapter 484 *- Uniform Land Sales Practices Act: Require disclosure of an explicitly defined list of hazards. HRS Chapter 508D* Mandatory Seller Disclosures in Real Estate Transactions: Make disclosure apply to vacant lots as well.	43	2.1	2.3			
	6	**Develop Strategic pre-disaster plans for implementation of new resilient and sustainable designs for areas that must be rebuilt post-disaster. Update LUO**	**6**	**2.6**	**2.7**			•

Ranking by Govt/Workshop Participants

Hazard Mitigation Action	#	Action	Overall Priority	GOVT Composite Score	Feb 2019 Workshop Composite Score	November 2018 Workshop	2018 Survey Priority	CCSR Resilient Oahu Priority
Climate Change	7	**ROH Chapter 25 SMA*: Amend the Special Management Area requirements**	**27**	2.4	2.4	•		•
	8	**Produce Regulatory (100-year and 500-year) Coastal Flooding Maps that account for climate change effects on storm intensities and sea level rise***	**30**	2.3	2.0	•		•
	9	**Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities*.**	**33**	**2.6**	2.3			
Flooding	**10**	**Revise and update the Flood Hazard Area, ROH Chapter 21A* to enable the use of the ASCE 24-14 Standard, Flood Resistant Design and Construction. For Critical and Essential Facilities of a community, this standard would require 500-year flood elevations be used for design. Incorporate climate change effects on the storm-generating environment, per the methodology as detailed in Probabilistic mapping of storm-induced coastal inundation for climate change adaptation (Li, N., et al., 2017).**	**12**	**2.6**	2.4	•	•	•
	11	**Revise the Honolulu Electrical Code, ROH Chapter 17*: For Essential and Critical Facilities, the Electrical Code should require placement of electrical transformers, switchgear, and emergency generators above the 500-year flood elevation, or alternatively, protected by dry floodproofing.**	**13**	**2.5**	**2.7** •		•	
	12	Re-evaluate critical inland and stream flooding DFIRMs* to account for a) the details of the watershed and the floodway, and b) from a policy standpoint whether the frequency of flood overtopping is really acceptable in heavily developed areas.	41	2.3	2.3			
	13	**Participate in the Community Rating System to reduce flood losses and flood insurance premiums.**	**32**	1.9	2.1			•

Ranking by Govt/Workshop Participants

Hazard Mitigation Action	#	Action	Overall Priority	GOVT Composite Score	Feb 2019 Workshop Composite Score	November 2019 Workshop Priority	2018 Public Survey	CCSR Resilient Oahu Priority
Infrastructure Facilities	**14**	**Develop Flood Maps that go beyond FEMA requirements and consider both rainfall and coastal surge flooding, concentrating on areas with critical infrastructure**	**22**	-	**2.6** •			•
	15	**Plan for flood control public works for the defense of critical facilities and major economic assets. Hardening of critical facilities, utilities, power and communication networks, and port facilities.**	**2**	**2.8**	**2.7** •	•	•	•
	16	**Pursue the Ala Wai Watershed Flood Mitigation project with the US Army Corps of Engineers; include resilience, visual appeal, water quality, and infrastructure improvements; create a watershed district to coordinate infrastructure projects, resilience planning and regulations, watershed data collection, and community engagement.**	**18**	**2.6**	2.2 •			•
	17	Install flood barriers at HPD facilities at areas with habitual flooding	47	-				
	18	**Evaluate risks and prioritize protective measures for existing infrastructure facilities**	**8**	**2.6**	**2.5** •		•	•
	19	**Relocate or locally defend/reinforce vital infrastructure such as roads in coastal eroding regions.**	**7**	**2.5**	**2.9**	•	•	
	20	**The PUC to adopt the 2017 NESC* for power transmission and distribution to include amendment with the ASCE topographic windspeed maps. Strategically plan with HECO to achieve a disaster-resilient network.**	**23**	**2.7**	1.9 •			•
	21	Update design and construction standards for utility lifelines.	35	2.5	2.4			
	22	Increase HECO generator plant resilience and redundancy of supply.	44	2.1	2.2			
	23	Replace weathered wood poles with NESC-conforming poles.	42	2.4	2.1			
	24	**Improve resiliency of fuel supplies during disasters**	**16**	**2.5**	**2.6**	•	•	
	25	**Rock Fall Buffer Zones should also be developed and incorporated into new developments between high-hazard rock fall areas and homes. Requires regulatory mapping.**	**31**	2.3	**2.6**			

Ranking by Govt/Workshop Participants

Hazard Mitigation Action	#	Action	Overall Priority	Govt Composite Score	Feb 2019 Workshop Composite Score	November 2018 Workshop Priority	2018 Public Survey	CCSR Resilient Oahu Plan
Building Facilities	26	ROH Chapter 16 Building-Code - Adopt 2012 and 2018 IBC and related codes per HRS 107 Part II *	**28**	2.3	2.3	•		•
	27	Test Seismic and Wind Performance to develop Single Wall Construction retrofit techniques.	55	2.1	1.7			
	28	**Hazard Mitigation Retrofits and Protection of Essential Facilities on Oahu**	**9**	**2.7**	**2.7**	•	•	
	29	**Establish regulatory policy to identify critical facilities during planning and design. CRITICAL FACILITY: Buildings and structures provide services that are essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations.**	**4**	**2.8**	**2.7•**			•
	30	Strengthen requirements for building upgrade for hazard resistance when owner remodels	50	-	2.2			
	31	Harden DFM and DRM Base Yards in Wahiawa and Kaneohe to provide viable pre-hurricane staging of debris clearing equipment and personnel	40	-	2.7			
	32	Install mobile emergency generator switches at all HPD stations; increase emergency generator fuel capacity to more than 16 hours at Kaneohe, Kailua, Kahuku, and Pearl City stations; upgrade Alapai HQ emergency generator per USCOE recommendation and provide automatic start-up	54	-	2.4 •			

Ranking by Govt/Workshop Participants

Hazard Mitigation Action	#	Action	Overall Priority	Govt Composite Score	Feb 2019 Workshop Composite Score	November 2018 Workshop Priority	2018 Public Survey	CCSR Resilient Oahu Strategy
Hurricane	**33**	**Identify the types of buildings more suitable for self-sheltering**	**26**	**2.6**	2.2 •			
	34	**Perform All-Hazard Assessments of Hurricane Shelters.**	**17**	**2.7**	**2.7 •**			
	35	**Retrofit public shelter buildings to increase capacity and refine actual evacuation demand and update policies to decrease sheltering deficit.**	**21**	**2.7**	2.4 •			
	36	Establish a policy for strengthening of critical public facility enclosure integrity for wind and windborne debris.	38	2.5	2.3			
	37	**Create incentives for homeowners and businesses to retrofit their structures.**	**19**	**2.4**	2.4 •		•	•
	38	Require hurricane safe rooms in all new residential construction outside of flood zones	53	-	1.8			

Ranking by Govt/Workshop Participants

Hazard Mitigation Action	#	Action	Overall Priority	GOVT Composite Score	Feb 2019 Workshop composite Score	November 2019 Workshop Priority	2018 Public Survey	CCSR Resilient Oahu plan
Tsunami	39	**Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects to enable use as refuges of safety.**	**20**	**2.5**	**2.5 •**			
	40	**Perform preliminary engineering of tsunami and coastal flood mitigation defense of critical infrastructure.**	**25**	2.3	2.3 •			•
	41	ROH Chapter 16 Building-Code Produce higher resolution Oahu probabilistic tsunami hazard maps* (run-up) for use with the ASCE-2016 and IBC-2018 building code design provisions.	45	2.1	2.1			
	42	**ROH Chapter 16 Building-Code Adopt tsunami design provisions* for buildings for new design and construction.**	**36**	2.3	2.4			
	43	**Evaluate fuel storage tank farm walls in Honolulu Harbor for the ability to withstand tsunamis and hurricanes.**	**10**	**2.9**	**2.5 •**			
	44	**BWS to identify and retrofit critical pumping stations in the tsunami inundation zone.**	**11**	**2.6**	**2.7 •**			

Ranking by Govt/Workshop Participants

Hazard Mitigation Action	#	Action	Overall Priority	GOVT Composite Score	Feb 2019 Workshop Composite Score	November 2018 Workshop Priority	2018 Public Survey	CCSR Resilient Oahu Plan
Drought and Wildfire	45	Develop low-flow instream flow standards for environmental protection	52	1.8	1.9			
	46	Expand rebate program for new water-saving technologies	49	1.7	2.1			
	47	ROH Chapter 20 Fire Code*: utilize maps of historic burn areas as issued in the High Fire Risk Map Zones for regulations based on NFPA-1.	46	2.3	1.9			
	48	**Fire Break Maintenance - Various fuel breaks/fire roads need to be maintained by DOFAW with heavy equipment, in order to stop advancing fire and provide access to firefighters.**	**29**	**2.5**	**2.5**			
	49	Assist Oahu communities to become Firewise Communities.	37	2.2	2.5			
	50	Establish water tanks at the fringes of threatened communities that can serve as dip tanks	39	2.1	2.4			
	51	Complete more detailed wildfire hazard analysis	51	2.1	1.9			
	52	Increase setbacks from property lines near wildland fire areas and require fire lanes and vegetation control measures	48		2.2			
Public Information	**53**	**Enhance the public availability of disaster resilience information that can be quickly understood, especially regarding: Hurricane Awareness, Hurricane Retrofits, Hurricanes, Tsunamis and Flooding.**	**5**	**2.7**	**2.8**	•		
	54	Disaster preparedness education for immigrant minority groups on Oahu.	34	2.4	2.6			
	55	**Create financial incentives for business and individuals involved in building resiliency.**	**24**	**2.5**	2.4•		•	

April 23, 2019 Meeting of the Oahu Multi-Hazard Pre-Disaster Mitigation Plan Update Advisory Committee
Meeting Purpose: Project Prioritization & Plan Implementation
Agenda Items:

- **Public Input Outreach Survey Results**
- **Project Prioritization Verification**

The prioritization results of the public input and governmental agency stakeholder balloting of the all-departmental workshops, public workshops and survey, and the CCSR Oahu Resiliency Strategy Working Group ratings were presented and discussed by the Advisory Committee to finalize prioritization of mitigation project recommendations (see the following pages). The hazard considered of highest importance by most people are hurricanes and high winds/storms. This was consistent with the findings of the Risk Analysis of Chapter 18, which was also presented at the earlier workshops in 2019. At this workshop the annualized loss estimates for each hazard were again presented to establish a measure of relative economic importance of particular natural hazards and to confirm the prioritization of 55 potentially effective mitigation actions. The priority ranking of mitigation can be observed that high priority was placed on critical infrastructure and adopting policies, regulations, and building codes and design standards for enhanced resilience to hurricanes, flooding, climate change effects, and tsunamis, particularly in the coastal zone. Participants at this workshop did not change any prioritization, but added useful editorial comments to clarify some of the descriptions of the mitigation actions, which were incorporated in Chapter 19 of this plan. CCSR stated that they now have a staff member, Chris Cunningham, whose work efforts will be dedicated to the implementation of this plan and coordinating hazard mitigation actions across City and State agencies.

Attendees:

Name:	Department:
Crystal van Beelen	DEM
Gary Chock	Martin & Chock
Dane Sjoblom	HHF Planners
Robert Harter	DEM, LEPC
Chris Cunningham	CCSR
Justin Gruenstein	CCSR
Mathew Gonzer	CCSR
Ashley Norman	PUC
Edwin Matsuda	DLNR
Kaanoi Clemente	HECO
Scott Shigeoka	DDC
Lisa Imata	DPP – Planning
Perry Tamayo	DPP – Permitting
Christine Kinimaka	DAGS Planning Branch Chief
Tom Fee	HHF
John Bravender	NWS
Larry Kanda	HIEMA

Ranked Mitigation Actions:

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
1	**Policies**	2	**Plan and determine how to execute public works to protect or defend existing critical facilities, infrastructure and utility services, supply chain, and vital economic assets at risk to climate change effects.**	**High**
2	**Flooding**	15	**Plan for flood control public works for the defense of critical facilities and major economic assets. Harden critical facilities, utilities, power and communication networks, and port facilities.**	**High**
3	**Policies**	1	**Integrate natural hazard policies into the General Plan & Community Development Plans.**	**High**
4	**Building Facilities**	29	**Establish regulatory policy to identify critical facilities during planning and design. CRITICAL FACILITY: Buildings and structures provide services that are essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations.**	**High**
5	**Public Information**	53	**Enhance the public availability of disaster resilience information that can be quickly understood, especially regarding hurricane awareness, hurricane retrofits, hurricanes, tsunamis and flooding.**	**High**
6	**Policies**	6	**Develop strategic master plans for implementation of new resilient and sustainable designs for communities that may need to be rebuilt post-disaster. Update the Land Use Ordinance.**	**High**

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
7	**Infrastructure Facilities**	19	**Relocate or locally defend/reinforce vital infrastructure such as roads in coastal eroding regions. Improve the materials and construction practices of roadways for greater resiliency**	**High**
8	**Infrastructure Facilities**	18	**Evaluate the risks and prioritize protective measures for existing infrastructure facilities.**	**High**
9	**Building Facilities**	28	**Start hazard mitigation retrofits for the protection of essential facilities on Oahu. A Honolulu County All-Hazard Assessment of Critical Facilities ranked the 80 most vulnerable facilities.**	**High**
10	**Tsunami**	43	**Evaluate fuel storage tank farm containment walls in Honolulu Harbor for the capability to withstand tsunami and hurricane flooding.**	**High**
11	**Tsunami**	44	**Board of Water Supply to continue to identify and retrofit critical pumping stations in the tsunami inundation zone.**	**High**
12	**Flooding**	10	**Revise and update the Flood Hazard Area, ROH Chapter 21A to enable the use of the ASCE 24-14 Standard, Flood Resistant Design and Construction. For Critical and Essential Facilities, this standard would require 500-year flood elevations be used for design.** **Incorporate climate change effects on the storm-generating environment, per the methodology as detailed in *Probabilistic mapping of storm-induced coastal inundation for climate change adaptation* (Li, N., et al., 2017).**	**High**

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
13	**Flooding**	11	**Revise the Honolulu Electrical Code, ROH Chapter 17:** **For Essential and Critical Facilities, the Electrical Code should require placement of electrical transformers, switchgear, and emergency generators above the 500-year flood elevation, or alternatively, protected by dry floodproofing.**	**High**
14	**Policies**	3	**Utilize an adaptive engineering approach to all current and future projects near the shoreline. Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly the Ala Wai Watershed Flood Control project.**	**High**
15	**Policies**	4	**HRS 205A Certified Shoreline For planning purposes, include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years. ROH Chapter 23 Establish the setback line about 25 feet from the certified shoreline plus 50 times the average annual coastal erosion rate, or to a minimum of 40 feet. The local geology and soil conditions should be taken in to account.**	**Medium-High**
16	**Infrastructure Facilities**	24	**Improve the resiliency of fuel supplies during and after disasters through the Hawaii State Energy Council and the Hawaii Emergency Preparedness Executive Consortium.**	**Medium-High**
17	**Hurricane**	34	**Perform all-hazard structural safety assessments of hurricane shelters.**	**Medium-High**

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
18	**Flooding**	16	**Pursue the Ala Wai Watershed Flood Mitigation project with the US Army Corps of Engineers; include resilience, visual appeal, water quality, and infrastructure improvements; create a watershed district to coordinate infrastructure projects, resilience planning and regulations, watershed data collection, and community engagement.**	**Medium-High**
19	**Hurricane**	36	**Create incentives for homeowners and businesses to retrofit their buildings.**	**Medium-High**
20	**Tsunami**	39	**Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects to enable their use as refuges of safety during extreme tsunamis. Produce a workshop seminar on this procedure for the visitor industry.**	**Medium-High**
21	**Hurricane**	35	**Retrofit public shelter buildings to increase capacity, refine actual evacuation demand, and update City policies on evacuation to decrease sheltering deficit.**	**Medium-High**
22	**Flooding**	14	**Develop Honolulu flood maps that go beyond FEMA requirements to consider concurrent rainfall and coastal surge flooding, concentrating on areas with critical infrastructure.**	**Medium-High**
23	**Infrastructure Facilities**	20	**PUC should adopt the 2017 National Electric Safety Code for power transmission and distribution, to include an amendment with the ASCE topographic windspeed maps. The PUC should update the NESC requirements periodically. Strategically plan with HECO for a disaster-resilient network using effective wind speed maps consistent with the state building code.**	**Medium-High**

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
24	**Public Information**	55	**Investigate financial incentives for business and individuals to invest in building resiliency. Seek insurance industry involvement in encouraging building and retrofitting resilient structures.**	**Medium**
25	**Tsunami**	40	**Perform preliminary engineering of tsunami and coastal flood mitigation defense of critical infrastructure.**	**Medium**
26	**Hurricane**	33	**Identify the types of buildings more suitable for self-sheltering as alternatives to public shelters.**	**Medium**
27	**Climate Change**	7	**ROH Chapter 25 SMA: Amend the Special Management Area permit requirements to include consideration of climate change effects for major developments. Adopt coastal flooding maps that account for future climate change.**	**Medium-High**
28	**Building Facilities**	26	**ROH Chapter 16 Building-Code - Adopt 2012 and 2018 IBC and related codes per HRS 107 Part II. (Honolulu is presently using the 2006 IBC, which is obsolete by four editions of the national model code.)**	**Medium-High**
29	**Drought and Wildfire**	48	**Fire Break and Fire Road Maintenance by DOFAW to stop advancing fire and provide access to firefighters.**	**Medium**
30	**Climate Change**	8	**Produce regulatory (100-year and 500-year) coastal flooding maps that account for future climate change effects on storm intensities and sea level rise. (associated with high priority Action #10)**	**Medium-High**

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
31	**Infrastructure Facilities**	25	**Rockfall buffer zones should be defined and incorporated into new developments between high-hazard rock fall areas and homes and critical facilities. This requires implementation into planning policy documentation and establishment of mapping to identify the hazard areas.**	**Medium**
32	**Flooding**	13	**Participate in the NFIP Community Rating System to reduce flood losses and lower flood insurance premiums.**	**Medium**
33	**Climate Change**	9	**Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities. Re-evaluate storm water flood control practices that address requirements for storm runoff quantities for flood control for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs.**	**Medium**
34	**Public Information**	54	**Provide culturally appropriate disaster preparedness education for immigrant minority groups, limited English proficiency individuals, individuals with access and functional needs, etc.**	**Medium**
35	**Infrastructure Facilities**	21	**Update the design and construction standards of the City for utility lifelines to improve the disaster resilience of essential services.**	**Medium**
36	**Tsunami**	42	**Adopt the ASCE national standard for tsunami design of new construction for critical, essential, and certain occupancy types of multi-story buildings in ROH Chapter 16 Building-Code.**	**Medium**
37	**Drought and Wildfire**	49	**Assist Oahu communities to become Firewise Communities.**	**Medium**

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
38	**Hurricane**	38	**Establish a policy for strengthening of critical public facility enclosure integrity for wind and windborne debris**	**Medium**
39	**Drought and Wildfire**	50	**Establish water tanks at the fringes of threatened communities that can serve as dip tanks**	**Medium**
40	**Building Facilities**	31	**Harden DFM and DRM Base Yards in Wahiawa and Kaneohe to provide viable pre-hurricane staging of debris clearing equipment and personnel**	**Medium**
41	**Flooding**	12	**Re-evaluate critical inland and stream flooding DFIRMs to account for a) watershed details and the floodway, its extent of urbanization, and b) assess from a policy standpoint whether the frequency of flood overtopping in heavily developed areas is really acceptable.**	**Medium**
42	**Infrastructure Facilities**	23	**Replace weathered wood poles with National Electric Safety Code conforming poles, upgrading them rather than replacing them with the same type as existing.**	**Medium**
43	**Policies**	5	**HRS Chapter 484:- Uniform Land Sales Practices Act: Require disclosure of an explicitly defined list of hazards.** **HRS Chapter 508D: Mandatory Seller Disclosures in Real Estate Transactions: Make disclosure apply to vacant lots.**	**Medium**
44	**Infrastructure Facilities**	22	**Increase resiliency of post-disaster power plant capacity and achieve greater redundancy/reliability of the supply network**	**Medium**

Overall Priority Rank	Hazard Mitigation Area	Action #	Action	Priority
45	**Tsunami**	41	**ROH Chapter 16 Building-Code Produce higher resolution probabilistic tsunami hazard maps (of run-up) for use with the ASCE-2016 and IBC-2018 building code design provisions.**	**Medium**
46	**Drought and Wildfire**	47	**ROH Chapter 20 Fire Code: utilize maps of historic burn areas as issued in the High Fire Risk Map Zones for regulations based on NFPA-1.**	**Low**
47	**Flooding**	17	**Install flood barriers at HPD facilities at areas with habitual flooding**	**Low**
48	**Drought and Wildfire**	52	**Increase setbacks from property lines near wildland fire areas and require fire lanes and vegetation control measures**	**Low**
49	**Drought and Wildfire**	46	**Expand rebate program for new water-saving technologies**	**Low**
50	**Building Facilities**	30	**Create strengthening requirements for a building upgrade for hazard resistance whenever the owner remodels**	**Low**
51	**Drought and Wildfire**	**51**	**Complete more detailed wildfire hazard analysis**	**Low**
52	**Drought and Wildfire**	**45**	**Develop low-flow instream flow standards for environmental protection**	**Low**
53	**Hurricane**	**37**	**Require hurricane safe rooms in all new residential construction outside of flood zones**	**Low**
54	**Building Facilities**	**32**	**Install mobile emergency generator switches at all HPD stations; increase emergency generator fuel capacity to more than 16 hours at Kaneohe, Kailua, Kahuku, and Pearl City stations; upgrade Alapai HQ emergency generator per USCOE recommendation and provide automatic start-up**	**Low**
55	**Building Facilities**	**27**	**Test Seismic and Wind Performance to develop Single Wall Construction retrofit techniques.**	**Low**

2.2.6 Adoption by the Local Jurisdiction

The City Council is responsible for serving and advancing the general welfare, health, happiness, and safety of the people. As the legislative body of the City, the Council performs the following major duties and functions:

- Sets city-wide policies by enacting ordinances and adopting resolutions relating to municipal government programs and services such as police and fire protection, parks and recreation, affordable and special needs housing, sanitation and waste disposal, public transportation and other city government operations;
- Initiates new municipal programs which the City may pursue or improvements to update and refine existing programs and services;
- Adopts the annual operating and capital programs and budgets to fund the operations of the City and County and delivery of city services;
- Adopts measures that will yield sufficient moneys to balance the budget including the setting of the annual real property tax rate;
- Adopts a general plan for the City and land use laws establishing and amending the city's development plans and zoning regulations and processes;
- Conducts an annual financial audit and may conduct performance audits of any or all city agencies to determine whether laws, policies, and programs are being carried out in the most effective, efficient and economical manner;
- Determines the necessity of taking property for public purposes and authorizes condemnation proceedings;
- Confirms city department heads and board and commission members nominated and appointed by the mayor; and
- Fixes fees and charges for all city services and the use of city property;
- Authorizes settlement of claims filed against the city and against its officers and employees acting within the course of their duties;
- Establishes fines and penalties for violations of city ordinances and laws; and
- Accepts gifts and donations to and on behalf of the City of money, securities or other personal property, or real estate or interests in real estate.

All council meetings, with the exception of executive sessions, are open to the public:

07/26/2018 ***Committee on Public Safety & Services.***
Initial briefing to the City Council; Significant plan enhancements provide the city a better gauge of risk, vulnerability, and appropriate mitigation actions for the next five years.

Multi-Hazard Pre-Disaster Mitigation Plan Update Status Overview
The scope of work for this update includes significant plan enhancements to provide the city with a better gauge of risk, vulnerability, and appropriate mitigation actions for the next five years.
2018-2019 Plan Update Primary Goals:

- Fulfill the requirements of the FEMA approval
- Provide hazard and risk analysis information to stakeholders and the public
- Introduce a new chapter on climate change
- Include a vulnerability analysis of Honolulu Harbor
- Update the risk analysis for expected losses during disasters

- Begin efforts to incorporate hazard information in other City planning processes
- Document the hazard mitigation planning process

Anticipated Revisions by Chapter were summarized:

Executive Summary – Abbreviated version updated with new chapter content.

1. **I**ntroduction – To reflect changes from the old plan and new data.
2. Mitigation Planning Process – Documenting the process of the plan update.
3. Land Use and Development – Updated General Plan, development plans, development trends, and census information.
4. Climate Change – Entirely new chapter about the effects that climate change will have on other hazards. To introduce adaptive engineering and regulatory changes to be considered for future implementation, and work of the CCSR
5. Coastal Erosion – Consideration of shoreline setbacks and roadway impacts
6. High Winds – Update with new historical information.
7. Tropical Cyclones – New codes and new wind maps. Future loss indications.
8. Floods – Update with issues exemplified by recent flood loss events.
9. Tsunamis – Update to reflect new maps, new studies, & new codes / standards.
10. Earthquakes – Make historical updates and improvements in design
11. Landslides and Rock Falls – Update for many mitigation projects.
12. Droughts – Incorporate 2017 state drought plan /updated drought risk maps
13. Wildfires – Hawaii Wildfire Management Organization risk maps.
14. HazMat – Identify sites that may be affected by other hazards.
15. Dam Failures – All regulated dams now have EAP's.
16. VOG – Update for LERZ source in 2018 with substantially increased VOG.
17. Hurricane Shelters – Incorporate a catalog of inspected and strengthened structures.
18. Risk Assessment – Pacific Disaster Center will be improving the data and modeling for hurricanes, floods, and tsunamis for use in this update.
19. Mitigation Strategy & Projects – Develop a new mitigation project priority listing with stakeholders
20. Plan Maintenance & Update Procedures – A forward-looking mitigation roadmap

After the presentation by Mr. Chock, Councilman Elefante asked if other councilmembers had questions to ask. Councilmember Menor expressed his concerns about being sure to include stakeholders from the building industry in the code adoption progress in order to include their input on the negative effects of adopting new codes. Mr. Chock replied that individuals representing different industries participate on the State Building Code Council, and that the State code then gets local amendments before it is adopted at the county level. Councilmember Elefante then asked if there was information from the State Hazard Mitigation Plan that could be taken and used in the City & County plan. Mr. Chock replied that the State plan is supposed to look to the County plans for updates, rather than the county plans being taken from the State plan. Councilmember Elefante then invited the CCSR Chief Resilience Officer, Josh Stanbro, from the audience to see if he had any further comments to make. Stanbro commended the DEM & Mr. Chock on including the effects of climate change into their plan and reiterated the importance of staying up to date with the building code, which Mr. Chock had stressed the importance of in his presentation. Stanbro continued, stating that FEMA did not look favorably on the use of outdated building codes and that FEMA post-disaster support may be limited if a disaster occurs before a new code is adopted. Stanbro concluded by mentioning the positive aspects of adopting a new building code, such as updated energy efficiency and in the event of a disaster, "building back smarter." Then Councilmember Elefante adjorned the meeting.

4/25/2019 ***Committee on Public Safety & Services.***
Informational Update on the Multi-Hazard Pre-Disaster Mitigation Plan by the Director Hirokazu Toiya of the Department of Emergency Management; Executive Summary presentation by Gary Chock of the hazard mitigation actions of the Plan being reviewed by the State Civil Defense and thereafter forwarded to FEMA for review and comments.

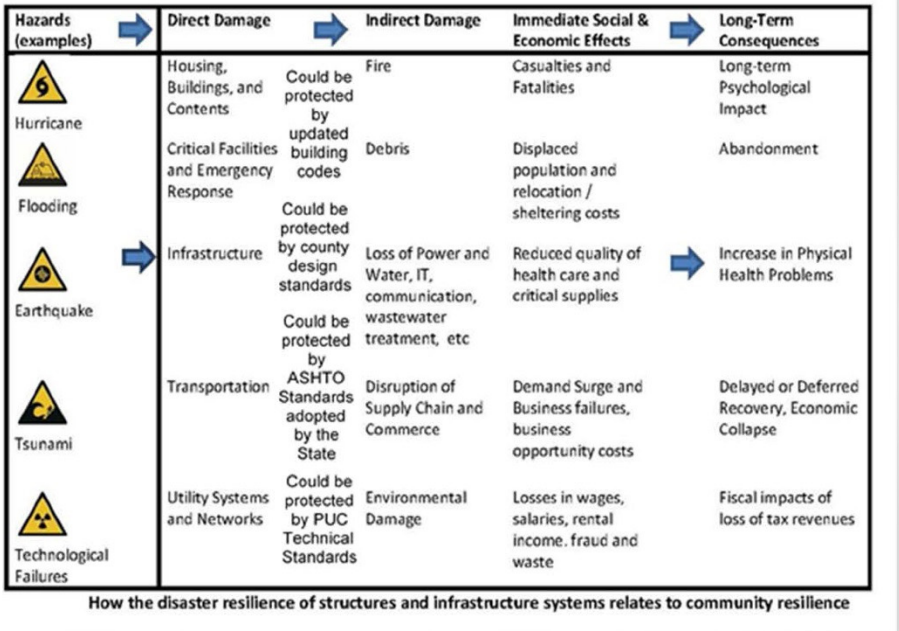
This session was attended by Committee Chair Mike Formby and councilmembers Elefante, Fukunaga, and Anderson. Prior to this committee meeting, copies of the Executive Summary of the hazard mitigation plan had been distributed. Councilmember Fukunaga inquired about where considerations of rainfall-induced flooding was included (Chapters 4 and 8), what benefit-cost information was included (Chapter 18), and how public review of the final plan would be accommodated. (Note: DEM posted and distributed pdf's of the full plan.)

Mitigation Goals are to reduce risk and increase resilience through the following:

1. Continually strive to improve the state of the art for the identification of hazard areas, risk assessment capabilities, warning systems, and effective response and recovery.
2. Plan, design, and construct future development and retrofit existing structures within hazard areas to *become resilient and* minimize losses.
3. Ensure that all emergency response critical facilities, communication systems*, information technology data networks, and broadband internet connectivity* remain operational during *and after* hazard events.
4. Ensure that all lifeline *and information technology* infrastructures are able to withstand hazard events or have contingency plans to quickly recover after a disaster.
5. *Develop public guidance for the need to shelter in residences that are strengthened as necessary and outside of areas that are subject to flooding, or in alternative resilient structures. Provide pre- and post-disaster emergency shelters to accommodate residents and visitors that are not able to shelter in place.*
6. Develop a *high* level of awareness among the general public and businesses, particularly the visitor industry, that results in self-sufficient survival skills, and a willingness to abide by preventive measures.
7. Minimize post-disaster recovery disruption by developing systems for efficient clean-up, documentation of damage and injury, and processing of appropriate aid to rebuild businesses and the economy.
8. Protect natural and cultural resources that buffer hazard effects to the extent practicable.

- Honolulu Hazard Mitigation Plan Goals

Building Codes, Development Rules, the Land Use Ordinance, and Design and Construction Standards are the most effective means of achieving community resilience



Hazards (examples)	Direct Damage		Indirect Damage	Immediate Social & Economic Effects	Long-Term Consequences
Hurricane	Housing, Buildings, and Contents	Could be protected by updated building codes	Fire	Casualties and Fatalities	Long-term Psychological Impact
Flooding	Critical Facilities and Emergency Response		Debris	Displaced population and relocation / sheltering costs	Abandonment
Earthquake	Infrastructure	Could be protected by county design standards	Loss of Power and Water, IT, communication, wastewater treatment, etc	Reduced quality of health care and critical supplies	Increase in Physical Health Problems
Tsunami	Transportation	Could be protected by ASHTO Standards adopted by the State	Disruption of Supply Chain and Commerce	Demand Surge and Business failures, business opportunity costs	Delayed or Deferred Recovery, Economic Collapse
Technological Failures	Utility Systems and Networks	Could be protected by PUC Technical Standards	Environmental Damage	Losses in wages, salaries, rental income. fraud and waste	Fiscal impacts of loss of tax revenues

How the disaster resilience of structures and infrastructure systems relates to community resilience

Prioritized List of Hazard Mitigation Actions

- Priorities are based on a composite scoring from a broad spectrum of participants (govt agencies, public utilities, stakeholders in hazard mitigation, subject matter experts, general public laypersons)
- The following list is of the high, medium-high, and medium priority actions.
- Other lower ranked actions are not included in this presentation but they are included in the plan

Hazard Mitigation Area	Action	Priority
Policies and Processes	Plan and determine how to execute public works to protect or defend existing critical facilities, infrastructure and utility services, supply chain, and vital economic assets at risk to climate change effects.	High
Flooding	Plan for flood control public works for the defense of critical facilities and major economic assets. Harden critical facilities, utilities, power and communication networks, and port facilities.	High
Policies and Processes	Integrate natural hazard policies into the General Plan & Community Development Plans.	High
Building Facilities	Establish regulatory policy to identify critical facilities during planning and design, which are buildings and structures that provide services essential for the implementation of the response and recovery management plan or for the continued functioning of a community.	High
Public Education and Outreach	Enhance the public availability of disaster resilience information that can be quickly understood, especially regarding hurricane awareness, hurricane retrofits, hurricanes, tsunamis and flooding.	High
Policies and Processes	Develop strategic master plans for implementation of new resilient and sustainable designs for communities that may need to be rebuilt post-disaster. Update the Land Use Ordinance.	High
Infrastructure Facilities	Relocate or locally defend/reinforce vital infrastructure such as roads in coastal eroding regions. Improve the materials and construction practices of roadways for greater resiliency.	High
Infrastructure Facilities	Evaluate the risks and prioritize protective measures for existing infrastructure facilities.	High

Hazard Mitigation Area	Action	Priority
Building Facilities	Start hazard mitigation retrofits for the protection of essential facilities on Oahu.	High
Tsunami	Evaluate fuel storage tank farm containment walls in Honolulu Harbor for the capability to withstand tsunami and hurricane flooding.	High
Tsunami	Board of Water Supply to continue to identify and retrofit critical pumping stations in the tsunami inundation zone.	High
Flooding	Revise and update the Flood Hazard Area, ROH Chapter 21A to enable the use of the ASCE 24-14 Standard, Flood Resistant Design and Construction, and revise regulations to require explicit building design for climate change adaptation.. For Critical and Essential Facilities, this standard would require 500-year flood elevations be used for design. Incorporate climate change effects on the storm-generating environment, per the methodology as detailed in Probabilistic mapping of storm-induced coastal inundation for climate change adaptation (Li, N., et al., 2017).	High
Flooding	Revise the Honolulu Electrical Code, ROH Chapter 17: For Essential and Critical Facilities, the Electrical Code should require placement of electrical transformers, switchgear, and emergency generators above the 500-year flood elevation, or alternatively, protected by dry floodproofing.	High
Policies and Processes	Utilize an adaptive engineering approach to all current and future projects near the shoreline. Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly the Ala Wai Watershed Flood Control project.	High
Policies and Processes	HRS 205A Certified Shoreline For planning purposes, include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years. ROH Chapter 23 Establish the setback line about 25 feet from the certified shoreline plus 50 times the average annual coastal erosion rate, or to a minimum of 40 feet. The local geology and soil conditions should be taken in to account.	Medium -High
Infrastructure Facilities	Improve the resiliency of fuel supplies during and after disasters through the Hawaii State Energy Council and the Hawaii Emergency Preparedness Executive Consortium.	Medium -High

Hazard Mitigation Area	Action	Priority
Tropical Cyclones and Hurricanes	Perform all-hazard structural safety assessments of hurricane shelters.	Medium-High
Flooding	Pursue the Ala Wai Watershed Flood Mitigation project with the US Army Corps of Engineers; include resilience, visual appeal, water quality, and infrastructure improvements; create a watershed district to coordinate infrastructure projects, resilience planning and regulations, watershed data collection, and community engagement.	Medium-High
Tropical Cyclones and Hurricanes	Create incentives for homeowners and businesses to retrofit their buildings.	Medium-High
Tsunami	Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects to enable their use as refuges of safety during extreme tsunamis. Produce a workshop seminar on this procedure for the visitor industry.	Medium-High
Tropical Cyclones and Hurricanes	Retrofit public shelter buildings to increase capacity, refine actual evacuation demand, and update City policies on evacuation to decrease sheltering deficit.	Medium-High
Flooding	Develop Honolulu flood maps that go beyond FEMA requirements to consider concurrent rainfall and coastal surge flooding, concentrating on areas with critical infrastructure.	Medium-High
Infrastructure Facilities	PUC should adopt the 2017 National Electric Safety Code for power transmission and distribution, to include an amendment with the ASCE topographic windspeed maps. The PUC should update the NESC requirements periodically.	Medium-High
Climate Change Adaptation	ROH Chapter 25 SMA: Amend the Special Management Area permit requirements to include consideration of climate change effects for major developments. Adopt coastal flooding maps that account for future climate change.	Medium-High
Building Facilities	ROH Chapter 16 Building-Code - Adopt 2012 and 2018 IBC and related codes per HRS 107 Part II. (Honolulu is presently using the 2006 IBC, which is obsolete by four editions.)	Medium-High
Climate Change Adaptation	Produce regulatory (100-year and 500-year) coastal flooding maps that account for future climate change effects on storm intensities and sea level rise.	Medium-High

Hazard Mitigation Area	Action	Priority
Tropical Cyclones and Hurricanes	Investigate financial incentives for business and individuals to invest in building resiliency.	Medium
Tsunami	Perform preliminary engineering of tsunami and coastal flood mitigation defense of critical infrastructure.	Medium
Tropical Cyclones and Hurricanes	Identify the types of buildings more suitable for self-sheltering as alternatives to public shelters.	Medium
Drought and Wildfire	Fire Break and Fire Road Maintenance by DOFAW to stop advancing fire & provide access to firefighters.	Medium
Infrastructure Facilities	Rockfall buffer zones should be defined and incorporated into new developments between high-hazard rock fall areas and homes and critical facilities; this requires regulatory mapping.	Medium
Flooding	Participate in the NFIP Community Rating System to reduce flood losses and lower flood insurance premiums for homeowners.	Medium
Climate Change Adaptation	Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities. Re-evaluate storm water flood control practices that address requirements for storm runoff quantities for flood control for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs.	Medium
Public Education and Outreach	Provide culturally appropriate disaster preparedness education for immigrant minority groups, limited English proficiency individuals, individuals with access and functional needs, etc	Medium
Infrastructure Facilities	Update the design and construction standards of the City for utility lifelines to improve the disaster resilience of essential services.	Medium

Hazard Mitigation Area	Action	Priority
Tsunami	Adopt the ASCE national standard for tsunami design of new construction for critical, essential, and certain occupancy types of multi-story buildings in ROH Chapter 16 Building-Code.	Medium
Tsunami	ROH Chapter 16 Building-Code Produce higher resolution probabilistic tsunami hazard maps (of run-up) for use with the ASCE-2016 and IBC-2018 building code design provisions. (ongoing)	Medium
Drought and Wildfire	Assist Oahu communities to become Firewise Communities.	Medium
Tropical Cyclones and Hurricanes	Establish a policy for strengthening of critical public facility enclosure integrity for wind and windborne debris.	Medium
Drought and Wildfire	Establish water tanks at the fringes of threatened communities that can serve as dip tanks.	Medium
Building Facilities	Harden DFM and DRM Base Yards in Wahiawa and Kaneohe to provide viable pre-hurricane staging of debris clearing equipment and personnel.	Medium
Flooding	Re-evaluate critical inland and stream flooding DFIRMs to account for a) watershed details and the floodway, its extent of urbanization, and b) assess from a policy standpoint whether the frequency of flood overtopping in heavily developed areas is really acceptable. Include rainfall intensification.	Medium
Infrastructure Facilities	Replace weathered wood poles with National Electric Safety Code conforming poles, upgrading them rather than replacing them with the same type as existing.	Medium
Policies and Processes	HRS Chapter 484:- Uniform Land Sales Practices Act: Require disclosure of an explicitly defined list of hazards. HRS Chapter 508D: Mandatory Seller Disclosures in Real Estate Transactions: Make disclosure apply to vacant lots.	Medium
Infrastructure Facilities	Increase resiliency of post-disaster power plant capacity and greater redundancy/reliability of the supply network.	Medium



3. Land Use and Development Planning

3. LAND USE AND DEVELOPMENT PLANNING

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan included general population and economic demographics. It then discusses the county planning process including details of each development plan region.	• Population and economic demographics and development trends have been updated. • The land use and the general and development planning regulations of the City of Honolulu are described and updated. • The status of the eight regional development plans are reported. Performed an analysis of the extent to which other plans consider natural hazards. • A link to the DPP's website for the development plan regions has been included, with more concise summaries provided in this chapter. • The environmental assessment process is described, which now must include the effects of sea level rise. • Relevant information previously found in other sections of the 2012 Plan have been relocated to this chapter. • Future development mitigation projects have been summarized and referenced to Chapter 20, Mitigation Strategy.

Summary of Mitigation Projects for the City and County of Honolulu

Project	Priority
Include natural hazard policies in the General Plan & Community Development Plans.	High
Model the effects of future climate conditions on all other hazards, primarily coastal erosion, flooding, and high surf. All current and future coastal infrastructure projects should strongly consider the effects of climate change when being designed. Planning and preliminary engineering feasibility studies should proceed on the coastal defense options for: Honolulu Harbor and particularly Pier 1, Kewalo Basin-Kakaako, Honolulu International (HNL) Airport reef runway, Sand Island access, Ala Wai Canal flood control, and Waikiki	High
Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly flood control of the Ala Wai Canal.	High
ROH Chapter 25 SMA: Create another level of SMA zone maps defining a *Coastal Construction Control Zone*, to account for the coastal inundation limit of the 500-year flood including the effects of expected climate change by the year 2100 and sea level rise of 2 feet above the year 2000 mean high water, using modeling consistent with CMIP AR5 RCP 8.5 climatic conditions (see Chapter 14). Have this applicable only to major developments.	Medium-High
ROH Chapter 23: Adjust the Shoreline Setback Line Related to the Construction of a New Building or Structure, or to a new Addition to an Existing Building or Structure. The shoreline setback line shall be established 25 feet inland from the certified shoreline plus a distance of 50 times the historical annual erosion hazard rate from the shoreline established by county maps.	Medium-High
HRS Chapter 484 - Uniform Land Sales Practices Act: include disclosure of specifically defined natural hazards**. HRS Chapter 508D Mandatory Seller Disclosures in Real Estate Transactions:** Make the mandatory seller disclosure also	Medium

apply to transactions involving vacant lots: Expand list of disclosable hazards in public offering to include, more explicitly, defined extents.	
Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities. It is recommended that the storm water flood control practices that address requirements for storm runoff quantities for flood control be re-evaluated for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs.	Medium
HRS 205A Certified Shoreline: For planning purposes, also include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years past 2025.	Medium-High
DNLR recommended that Buffer Zones should be developed or at least incorporated into new developments between high-hazard rock fall areas and homes. This would require implementation into planning policy on and establishment of mapping to identify the hazard areas.	Medium

3.1 Population

Oahu's resident population according to a 2017 estimate totaled approximately 988,650, accounting for 69.3% of the state's population of 1.43 million. The Oahu population has grown by 0.5% since the 2010 census, which is slower than the statewide growth rate of 0.7%. The City and County of Honolulu experienced negative population growth, -0.1%, from 2016 to 2017 and from July 1, 2010 to July 1, 2017 has had a net loss of 1,080 people a year. This number comes from a yearly average of 6,583 people moving to the mainland while only 5,773 people move to Oahu from foreign countries. These demographics are summarized in Table 3-1, with further population and employment demographics for the City & County of Honolulu provided in Table 3-2 from the U.S. Census Bureau's website: (https://www.census.gov/quickfacts/fact/dashboard/honolulucountyhawaii/POP060210).

Table 3-1. Honolulu and State of Hawaii Demographic Profiles

Characteristic	Honolulu	State
Resident population, 2010	953,209	1,360,301
% change, April 1, 2010 to July 1, 2017	3.7%	4.9%
Average de facto population (2016)	1,049,121	1,583,265
Resident population per square mile, 2010	1,587	212
Residents <18 years old, % (2016)	21.4	21.6
Residents 18 to 64 years old, % (2016)	62.0	61.3
Residents 65 years and older, % (2016)	16.6	17.1
Per capita income in past 12 months (2016 dollars)	32,194	30,970
Median household income (2016 dollars)	77,191	71,977
Source: State of Hawaii, Databook and U.S. Census Bureau		

Table 3-2. Population and Employment Demographics for Oahu

Population	
Population estimates, July 1, 2017, (V2017)	988,650
Population estimates, July 1, 2016, (V2016)	992,605
Population estimates base, April 1, 2010, (V2017)	953,209
Population estimates base, April 1, 2010, (V2016)	953,207
Population, percent change - April 1, 2010 (estimates base) to July 1, 2017, (V2017)	3.7%
Population, percent change - April 1, 2010 (estimates base) to July 1, 2016, (V2016)	4.1%
Population, Census, April 1, 2010	953,207

Age and Sex	
Persons under 5 years, percent	⚠ 6.5%
Persons under 18 years, percent	⚠ 21.4%
Persons 65 years and over, percent	⚠ 16.6%
Female persons, percent	⚠ 49.6%
Race and Hispanic Origin	
White alone, percent (a)	⚠ 22.2%
Black or African American alone, percent (a)	⚠ 2.8%
American Indian and Alaska Native alone, percent (a)	⚠ 0.3%
Asian alone, percent (a)	⚠ 42.9%
Native Hawaiian and Other Pacific Islander alone, percent (a)	⚠ 9.5%
Two or More Races, percent	⚠ 22.3%
Hispanic or Latino, percent (b)	⚠ 9.7%
White alone, not Hispanic or Latino, percent	⚠ 18.6%
Population Characteristics	
Veterans, 2012-2016	79,534
Foreign born persons, percent, 2012-2016	19.3%
Housing	
Housing units, July 1, 2017, (V2017)	350,786
Owner-occupied housing unit rate, 2012-2016	55.0%
Median value of owner-occupied housing units, 2012-2016	$602,700
Median selected monthly owner costs -with a mortgage, 2012-2016	$2,424
Median selected monthly owner costs -without a mortgage, 2012-2016	$568
Median gross rent, 2012-2016	$1,587
Building permits, 2017	1,968
Families & Living Arrangements	
Households, 2012-2016	309,548
Persons per household, 2012-2016	3.07
Living in same house 1 year ago, percent of persons age 1 year+, 2012-2016	85.0%
Language other than English spoken at home, percent of persons age 5 years+, 2012-2016	27.9%
Education	
High school graduate or higher, percent of persons age 25 years+, 2012-2016	91.1%
Bachelor's degree or higher, percent of persons age 25 years+, 2012-2016	33.4%

Health	
With a disability, under age 65 years, percent, 2012-2016	6.4%
Persons without health insurance, under age 65 years, percent	⚠ 3.8%
Economy	
In civilian labor force, total, percent of population age 16 years+, 2012-2016	61.3%
In civilian labor force, female, percent of population age 16 years+, 2012-2016	58.6%
Total accommodation and food services sales, 2012 ($1,000) (c)	5,273,221
Total health care and social assistance receipts/revenue, 2012 ($1,000) (c)	6,302,644
Total manufacturers shipments, 2012 ($1,000) (c)	D
Total merchant wholesaler sales, 2012 ($1,000) (c)	8,052,799
Total retail sales, 2012 ($1,000) (c)	13,036,448
Total retail sales per capita, 2012 (c)	$13,352
Transportation	
Mean travel time to work (minutes), workers age 16 years+, 2012-2016	28.7
Income & Poverty	
Median household income (in 2016 dollars), 2012-2016	$77,161
Per capita income in past 12 months (in 2016 dollars), 2012-2016	$32,194
Persons in poverty, percent	⚠ 8.5%
BUSINESSES	
Businesses	
Total employer establishments, 2016	21,404
Total employment, 2016	359,766
Total annual payroll, 2016 ($1,000)	16,368,921
Total employment, percent change, 2015-2016	1.2%
Total nonemployer establishments, 2015	64,258
All firms, 2012	76,176
Men-owned firms, 2012	39,248
Women-owned firms, 2012	28,490
Minority-owned firms, 2012	54,725
Nonminority-owned firms, 2012	17,672
Veteran-owned firms, 2012	6,943
Nonveteran-owned firms, 2012	65,269
GEOGRAPHY	
Geography	
Population per square mile, 2010	**1,586.7**
Land area in square miles, 2010	600.74
FIPS Code	15003

Table 3-3. Housing and Employment Demographics for State of Hawaii

HOUSING OCCUPANCY	
Total housing units	530,289
Occupied housing units	452,030
Vacant housing units	78,259
Homeowner vacancy rate	1.2
Rental vacancy rate	9.4
UNITS IN STRUCTURE	
Total housing units	530,289
1-unit, detached	284,886
1-unit, attached	45,318
2 units	12,498
3 or 4 units	23,369
5 to 9 units	34,767
10 to 19 units	27,741
20 or more units	100,624
Mobile home	956
Boat, RV, van, etc.	130
YEAR STRUCTURE BUILT	
Total housing units	530,289
Built 2014 or later	1,787
Built 2010 to 2013	10,725
Built 2000 to 2009	74,152
Built 1990 to 1999	77,317
Built 1980 to 1989	80,996
Built 1970 to 1979	122,530
Built 1960 to 1969	78,277
Built 1950 to 1959	46,939
Built 1940 to 1949	19,271
Built 1939 or earlier	18,295

(all values are 2016 estimates from the U.S. Census Bureau's FactFinder website: https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml).

INCOME AND BENEFITS (IN 2016 INFLATION-ADJUSTED DOLLARS)	
Total households	452,030
Less than $10,000	25,329
$10,000 to $14,999	15,336
$15,000 to $24,999	31,791
$25,000 to $34,999	31,922
$35,000 to $49,999	49,405
$50,000 to $74,999	81,190
$75,000 to $99,999	64,035
$100,000 to $149,999	83,962
$150,000 to $199,999	35,851
$200,000 or more	33,209
Median household income (dollars)	71,977
Mean household income (dollars)	91,169
With earnings	365,446
Mean earnings (dollars)	86,812
With Social Security	154,305
Mean Social Security income (dollars)	18,529
With retirement income	105,379
Mean retirement income (dollars)	28,661
With Supplemental Security Income	19,119
Mean Supplemental Security Income (dollars)	9,263
With cash public assistance income	15,865
Mean cash public assistance income (dollars)	4,579
With Food Stamp/SNAP benefits in the past 12 months	52,270
Families	314,721
Less than $10,000	9,749
$10,000 to $14,999	6,462
$15,000 to $24,999	14,632
$25,000 to $34,999	18,889
$35,000 to $49,999	31,861
$50,000 to $74,999	56,886
$75,000 to $99,999	49,241
$100,000 to $149,999	69,560
$150,000 to $199,999	29,695
$200,000 or more	27,746
Median family income (dollars)	83,451
Mean family income (dollars)	102,538
Per capita income (dollars)	30,970
Nonfamily households	137,309
Median nonfamily income (dollars)	41,693
Mean nonfamily income (dollars)	57,080
Median earnings for workers (dollars)	34,054
Median earnings for male full-time, year-round workers (dollars)	48,723
Median earnings for female full-time, year-round workers (dollars)	40,646

3.2 Land Use

The City and County of Honolulu guides and directs land use and growth through a three-tier system of objectives, policies, planning principles, guidelines and regulations. The General Plan forms the first tier of this system. First adopted by resolution in 1977, the General Plan is a relatively brief document, consisting primarily of one-sentence statements of objectives and policies. It has been amended several times, but the basic objectives and policies set forth in the 1977 plan remain intact.

The second tier of the system is formed by the Development Plans or Sustainable Community Plans, which are adopted and revised by ordinance. These plans address eight geographic regions of the island; the Primary Urban Center (PUC), Central Oahu, Ewa, Waianae, North Shore, Koolauloa, Koolaupoko, and East Honolulu as shown in Figure 3-1. The East Honolulu Development Plan was first adopted in 1983. The regional plans for the Primary Urban Center and Ewa are Development Plans while the plans for East Honolulu, Waianae, North Shore, Koolauloa, and Koolaupoko are Sustainable Community Plans. For brevity, all the regional plans are referred to as Development Plans.

The third tier of the system is composed of the implementing ordinances, including the Land Use Ordinance (Honolulu's zoning code). Mandated by the City Charter, these ordinances constitute the principal means for implementing the City's plans. These ordinances are required to be consistent with the General Plan, the Development Plans, and each other. The following are the key elements of the Land Use Ordinance: (LUO)

- The LUO is probably one of the key points of regulatory review and enforcement or exemptions, with a high degree of political visibility. Permitting is for "conditional use" that essentially involves conditions of additional specific requirements to meet "intent."
- Development and design standards for the location, height, size of structures, density and open spaces, traffic and amount and type of parking, property line setbacks, outdoor lighting and zoned uses. Includes Specific Use Development Standards by type of occupancy and economic activity.
- Zoning Classification System implemented in maps; also includes preservation zoning for lands having an elevation below the maximum inland line of the zone of wave action, land susceptible to floods and soil erosion, land undergoing major erosion damage or susceptible to inundation (See ROH Chapter 24 § 24-1.3 for land use categories).
- Flood hazard areas: "Dwellings in country, residential and agricultural districts, as well as detached dwellings and duplex units in apartment and apartment mixed use districts, may exceed the maximum height in the district by no more than five feet if required to have its lowest floor elevated to or above the base flood elevation, provided such additional height shall not be greater than 25 feet above the base flood elevation."
- Special Districts such as Diamond Head, Waikiki, and Haleiwa, each having design controls.

- Pre-permitting process requires public input at neighborhood boards.
- Includes the process for zone changes that are essentially negotiated.

In addition to these three Charter-mandated tiers, the development plans are supplemented by two planning mechanisms that are not required by the Charter, including the functional planning process and special area planning. Functional planning activities, some of which are mandated by state or federal regulations, provide long range guidance for the development of public facilities such as the water system, wastewater disposal, and transportation. Special area plans are intended to give specific guidance for neighborhoods, communities, or specialized resources.

3.3 The General Plan

The General Plan for the City and County of Honolulu, a requirement of the City Charter, is a written commitment by the City and County government to a future for the Island of Oahu that it considers desirable and attainable. The Plan is a two-fold document. First, it is a statement of the long-range social, economic, environmental, and design objectives for the general welfare and prosperity of the people of Oahu. These objectives contain both statements of desirable conditions to be sought over the long run and statements of desirable conditions that can be achieved within an approximate 20-year time horizon. Second, the General Plan is a statement of broad policies that facilitate the attainment of the objectives of the Plan.



Figure 3-1. Geographic areas represented by regional Development Plans

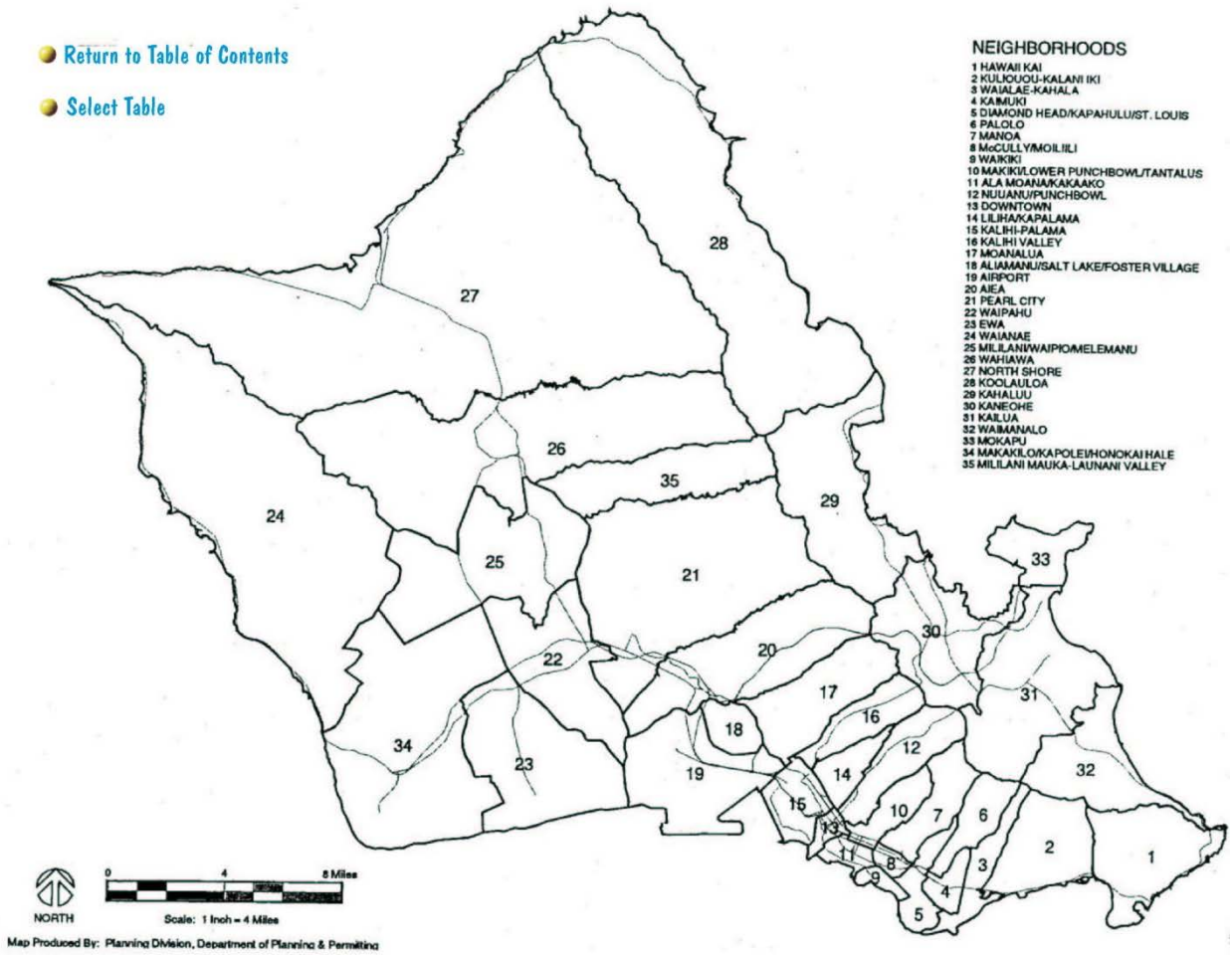


Figure 3-2. City and County of Honolulu neighborhood subdivisions

3.3.1 Content of the General Plan

The General Plan is a guide for all levels of government, private enterprises, neighborhood and citizen groups, organizations, and individual citizens in eleven areas of concern:

1. population
2. economic activity
3. the natural environment
4. housing
5. transportation and utilities
6. energy
7. physical development and urban design
8. public safety
9. health and education
10. culture and recreation
11. Government operations and fiscal management

Eleven subject areas provide the framework for the City's expression of public policy concerning the needs of the people and the functions of government. The objectives and policies reflect the comprehensive planning process of the City and County that addresses all aspects of the health, safety, and welfare of the people of Oahu.

The current edition of the City and County of Honolulu General Plan was last revised in 2002. It has since gone through the updating process and is expected to be adopted by the City and County of Honolulu in 2019. The Plan is a comprehensive statement of objectives and policies for Honolulu's future development. The Plan sets out the basic growth policy for Oahu which calls for full development of the Primary Urban Center (the area from Kahala to Pearl City), development of the secondary urban center at Kapolei and the Ewa and Central Oahu urban-fringe areas, and managing the physical growth and development in the remaining urban-fringe and rural areas sustain their low density or rural characteristics.

3.3.2 Implementation of the General Plan

By itself, the General Plan cannot bring about all of the changes and improvements that the City and County government considers to be desirable and attainable. It is, by design, a very general document, and one of its purposes is to establish a coherent set of broad guidelines which can be used in developing plans, programs, and legislation for guiding Oahu's future. It is largely implemented through the Development Plans Sustainable Communities Plans.

Implementation of the General Plan also occurs through the budgetary responsibilities of government. The budget process or function is closely intertwined with the planning process of the City. It involves developing the yearly operating budget and the projected capital improvement program budget. Both documents represent the final step in the comprehensive planning process relating the long-range objectives and policies of the City's General Plan to the specific uses of public revenues. To ensure the implementation of the General Plan, the City budget and programs

must comply with the purposes of the General Plan and implement applicable provisions of the Development Plans.

3.4 Development Trends

Annually, the City and County of Honolulu Department of Planning and Permitting (DPP) publishes an annual report on the Status of Land Use on Oahu to gauge recent development against the objectives and policies of the general plan. The latest report was published in June 2016 for Fiscal Year 2014. This report shows trends in three categories of land use: conservation, agriculture and urban between 1975 and 2014. In that time urban land use has increased from 22% to 26% of the total available land area, agricultural land use has dropped from 38% to 33% and conservation land has stayed approximately constant at around 41%. Therefore, there has been a gradual transition of agricultural land to urban usage.

The general plan has set population distribution objectives for each of the eight development plan regions of Oahu, provided in Table 3-4. This shows that Ewa is the region targeted for a large proportion of the growth with a significant increase in the percentage of Oahu's population. The PUC should also absorb a large proportion of the anticipated increase in total population, although there will be a slight reduction in the percentage of the population in this area. Central Oahu and East Honolulu are targeted to grow at approximately the same rate as the overall population growth. The other regions are targeted for a moderate decline in the percentage of population corresponding to minimal overall growth in these regions. The projected 2030 growth of population and corresponding water demand in each of the regions is shown in Figure 3-3.

Table 3-4. Oahu Population Distribution

Region	Actual Population 2010	Projected Population 2020	General Plan (2002) Estimated Percentage 2025
Primary Urban Center	45.6%	44.3%	46.0%
Ewa	10.6%	13.0%	13.0%
Central Oahu	17.7%	17.4%	17.0%
East Honolulu	5.2%	5.1%	5.3%
Koolaupoko	12.1%	11.5%	11.6%
Koolauloa	1.8%	1.7%	1.4%
North Shore	1.9%	1.9%	1.7%
Waianae	5.1%	5.0%	4.0%
Total	100%	100%	100%
Total Population	953,207	1,003,700	1,078,050

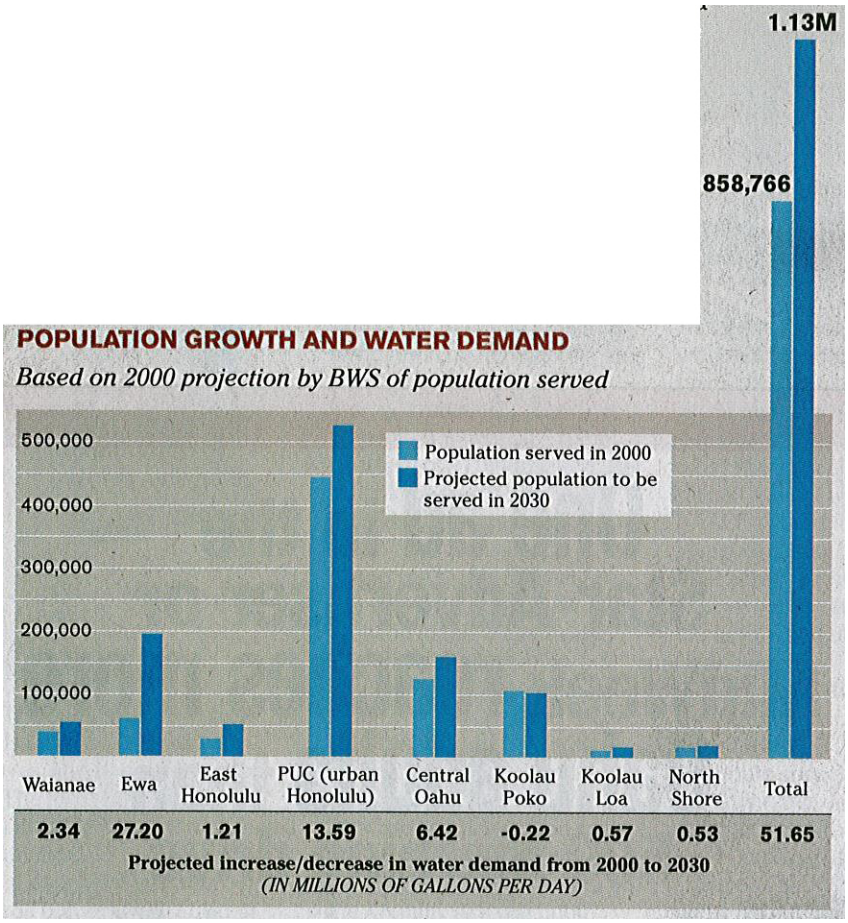


Figure 3-3. Projected change in population and water demand for each of the planning regions by 2030 (Honolulu Star Advertiser, 7/26/10)

3.5 Development Plans and Sustainable Communities Plans

Development Plans, according to the City Charter, are relatively detailed guidelines for the physical development of the Island over a 20+ year time span. They are intermediate means of implementing the objectives and policies of the General Plan in the various parts of the Island. Development Plans contain statements of standards and principles with respect to land uses and 'statements of urban design principles and controls'. The City Council adopts Development Plans and amendments thereto by ordinance. The Development Plans provide for land use and public facilities planning as well as indicate the sequence in which development will occur. They must implement and accomplish the objectives and policies of the General Plan.

Oahu is divided into eight planning areas, as shown in Figure 3-1. Each area has a Development Plan (or Sustainable Community Plan) which is adopted by City Council ordinance and administered by the Department of Planning and Permitting. Each Development Plan implements the objectives and policies of the General Plan and guides the long-range land use and infrastructure planning for each area. Each of the plans identifies a vision for the future of each area that reflects the special conditions of each area and the views and values of its communities. Plans for two of the areas (the PUC and Ewa) are called Development Plans, indicating the focus

on developing the Primary Urban Center and the second city in Ewa. Six of the Plans are designated "Sustainable Communities Plans" to highlight the intent that these areas are not to be heavily developed, and that existing communities and special qualities of the respective region should be sustained and improved. In addition to the Development and Sustainable Community Plans, there is a separate Public Infrastructure Map (PIM) that gives more details on future infrastructure projects than in the eight regional plans.

The plans provide a robust set of guidelines that help translate how the vision is to be implemented. By providing guidance, the plans help developers, reviewers, and decision makers assess the suitability of the proposed projects, and decide if any mitigation efforts are required for projects which are approved.

All the plans make clear where development proposals will be welcomed and where they will not be considered for processing. They do this by establishing boundaries for the urban and rural communities as shown. A primary reason for establishing these limits is to protect agricultural and conservation lands that have great cultural and environmental value in addition to their economic value. All the plans seek to enhance and protect recreational resources and to identify and protect important community cultural and historical resources. All of the plans use zoning as a primary means to implement the vision and policies. However, the boundary has also been drawn so as to provide ample developable land to meet the need to build new housing and establish job centers for at least the next 25 years.

They also provide for a review and possible revision of the zoning code and other land use controls such as subdivision approval and building permit regulations if needed to insure implementation of the plan vision and policies.

All of the plans use special plans as a way of providing additional policies to guide communities and neighborhoods that need more detailed attention than can be provided in the plan for the entire area. These special area plans are developed through consultation with the community affected by the plan.

The plans provide guidance for the evaluation of the city's infrastructure investments including projects developed through the community vision process, and long range functional plans and individual projects proposed by line agencies responsible for infrastructure and public facilities. As part of the annual city budget process, all capital improvement projects are reviewed to determine if they are consistent with the respective Development Plan. Development Plans are also intended to guide City land use approvals and permits and influence private sector investment decisions.

In summary, the Plans provide guidance for:

1. Special area plans and neighborhood plans
2. Line agency - long range infrastructure and public facility
3. Planning and specific infrastructure and public facility projects
4. Implementation of land use approvals and permits, including:
    - Zoning

- Subdivision
- Building permits

3.5.1 Development Plan and Sustainable Communities Plan Revision Program

Major revisions of each of the Development Plans, based on a 1992 City Charter change, were last adopted: Ewa (in 2013), East Honolulu (in 1999 but new is drafted, estimated for 2018/2019), Ko'olau Loa (in 1999, but new drafted), North Shore (in 2011), Wai'anae (in 2012), Koolaupoko (in 2017), Central Oahu (in 2017), and the Primary Urban Center (in 2004, but new is drafted, expected 2019/2020). The revised plans are visionary, conceptual plans without the parcel-specific detail of the first Development Plans (which were adopted in the early 1980s). Each plan is required to have a review by the Department of Planning and Permitting every five years to revalidate the Plan vision and make appropriate adjustments to policies, principles, and guidelines. A series of public outreach activities, including interviews, focus groups, presentations, and two public workshop will be held in order to prepare a report and proposed revised Plan.

The updates and highlights of each Development Plan are summarized in Table 3-5. The Development Plans are available on the DPP's website: (http://www.honoluludpp.org/).

3.6 Zoning Ordinances and Functional Plans

The Development Plans should not be confused with zoning ordinances. Zoning ordinances will continue to regulate the use of land within clearly demarcated zones and set detailed standards for the height, bulk, and location of buildings. In addition to zoning ordinances, the functional plans and programs of the City and County agencies must conform to the General Plan and implement the Development Plans. This will ensure that the provision of City services is in accord with the General Plan's objectives and policies and provisions contained in the Development Plans.

Table 3-5. Summary of Regional Development Plans

DP/SCP Area	Status	Highlights
'Ewa	Adopted Ord. 13-26 Effective 7/22/13	• Expected to absorb a significant portion of future Oahu population, and offer 87,000 jobs by Year 2035 • Reflects a directed growth policy (develop City of Kapolei and create jobs in Ewa at industrial areas, resorts, and University) • Continues commitment to master planned transit-friendly new communities
East Honolulu	Adopted Ord. 99-19 Effective 7/27/99 Next: Circulate Preliminary Findings and Public Review Draft for public review & comment	• Population relatively stable with little commercial employment growth • Focus is on protecting natural resources; supporting the seniors, the young, and the most vulnerable; meeting housing needs (affordability and choice); and reducing vulnerability and improving resiliency to coastal hazards and impacts of climate change
Ko'olau Loa	Adopted Ord. 99-72 Effective 2/14/00 Next: Review completed Dec. 2012. Plan under review by Council as Bill 1 (2017).	• Maintain the distinctive character of its rural neighborhoods • Protect scenic views, open spaces and other natural resources • Represents a haven for residents, and a place of special interest for visitors
North Shore	Adopted Ord. 11-3 Effective 5/3/11	• Retain and enhance the rural character • Focus on unique open space, coastal resources, and historical heritage • Growth to be limited to Haleiwa and Waialua
Wai'anae	Adopted Ord. 12-3 Effective 3/2/12	• To reflect communities embedded in a rural landscape, with a diversity of cultures and small town values • The ahupua'a/ecosystem concept is suggested as a tool for physical and resource planning
Ko'olau Poko	Adopted Ord.17-42 Effective 8/9/17	• Adapt the concept of "ahupua'a" as a basis for land use and natural resource management; protecting agricultural and open space areas • Direct growth within the Urban Community Boundary • Enhance existing commercial and civic districts
Central Oahu	Adopted Ord. 02-62 Effective 2/18/03 Next: Introduced as Bill 75 (2017) and under review by Council.	• Long-term protection of agricultural and open space areas • Revitalization of Waipahu and Wahiawa • Master planned new communities in Royal Kunia, Koa Ridge Makai, and Waiawa • Transit-oriented development in Waipahu and at Leeward Community College
Primary Urban Center	Adopted Ord. 04-14 Effective 6/21/04 Review underway	• The premier Pacific city and travel destination in a beautiful natural setting, offering a unique quality of life, and a wide range of housing choices, and economic opportunities • Between 2000 and 2035, an 18% increase in non-construction jobs and a 20% increase in total housing units are anticipated

3.6.1 Functional Planning

Functional planning is the process through which various City agencies determine needs, assign priorities, phase projects, and propose project financing to implement the vision articulated in the Development Plan. This process may take a variety of forms, depending upon the missions of the various agencies involved, as well as upon requirements imposed from outside the City structure, such as federal requirements for wastewater management planning. Typically, functional planning occurs as a continual or iterative activity within each agency.

Through the functional planning process, City agencies responsible for developing and maintaining infrastructure and public facilities or for provision of City services review existing functional planning documents and programs. As a result of these reviews, the agencies then update existing plans or prepare new long-range functional plans that address facilities and service system needs. Updates of functional planning documents are also conducted to assure that agency plans will serve to implement the Development Plan as well as to provide for coordination of plans and programs among the various agencies.

The number and types of functional planning documents will vary from agency to agency, as will the emphases and contents of those documents. A typical agency may develop a set of core documents such as:

- A resource-constrained long-range capital improvement program. A "resource-constrained" program is one that identifies the fiscal resources that can be reasonably expected to be available to finance the improvements.
- A long-range financing plan, with identification of necessary new revenue measures or opportunities.
- A development schedule with top priorities for areas designated for earliest development.
- Service and facility design standards, including level of service guidelines for determining adequacy.

Other documents may also be developed as part of an agency's functional planning activities, such as master plans for provision of services to a specific region of the island. In some cases, functional planning activities will be undertaken in cooperation with agencies outside the City structure, such as the transportation planning activities that are conducted in association with the Oahu Metropolitan Planning Organization.

3.6.2 Review of Zoning and Other Development Applications

The different zoning district categories and their map designations are listed in Table 3-6. One way in which the vision of the Development Plans will guide land use will be through the review of applications for zone changes and other development approvals. Approval for all development projects should be based on the extent to which the project supports the policies, principles, and guidelines of the Development Plan.

Table 3-6. Zoning District Categories

Zoning District Category	Zoning District Title	Map Designation
Preservation	Restricted Military and Federal General	P-1 F-1 P-2
Agricultural	Restricted General	AG-1 AG-2
Country	Country	C
Residential	R-20 R-10 R-7.5 R-5 R-3.5	R-20 R-10 R-7.5 R-5 R-3.5
Apartment	Low-Density Medium-Density High-Density	A-1 A-2 A-3
Apartment Mixed Use	Low-Density Medium-Density High-Density	AMX-1 AMX-2 AMX-3
Resort	Resort	Resort
Business	Neighborhood Community	B-1 B-2
Business Mixed Use	Community Central	BMX-3 BMX-4
Industrial	Limited Intensive Waterfront	I-1 I-2 I-3
Industrial - Commercial Mixed Use	Industrial - Commercial Mixed Use	IMX-1

Source: **Land Use Ordinance**. Department of Land Utilization, City and County of Honolulu. Last Updated 10/17/2017.

3.6.3 Environmental Assessment

Projects involving a significant zone change will be required to submit an Environmental Assessment (prepared in compliance with procedures for Chapter 343, Hawaii Revised Statutes) to the Department of Planning & Permitting to help the Department determine whether the project involves a significant environmental effect. A project will be considered to involve a significant zone change if:

- The application involves a zone change of 25 acres or more to any zoning district or combination of zoning districts, excluding preservation and agricultural zoning districts; or
- The project is more than 10 acres and involves a change from one zoning district to a Residential, or Country zoning district; or

- The project is more than 5 acres and involves a change from one zoning district to an Apartment, Resort, Commercial, Industrial, or Mixed Use zoning district; or
- The project would have major social, environmental, or policy impacts, or cumulative impacts due to a series of applications in the same area.

The Director of Planning & Permitting will determine, based on review of the environmental assessment, whether an Environmental Impact Statement (prepared in compliance with procedures for Chapter 343, Hawaii Revised Statutes) will be required or whether a Finding of No Significant Impact should be issued. All EA/EIS must now consider the effects of sea level rise due to Act 17, effective July 1, 2018 (see Chapter 14).

Projects that do not involve significant zone changes will be reviewed by the Department of Planning and Permitting for consistency with the policies, principles, and guidelines of the Primary Urban Center Development Plan during the Zone Change Application process. Those projects requiring environmental assessments shall follow the provisions of Hawaii Revised Statutes, Chapter 343. Projects involving significant zone changes will require an Environmental Assessment.

In applying for a zoning change, the applicant must either:

- Receive a determination from the Director of Land Utilization that the project does not involve a significant zone change, or
- Submit an Environmental Assessment that will include a Project Master Plan when required, with the zone change application.

Before an application for a significant zone change can be initiated by the Department of Planning & Permitting, the applicant must either:

- Receive a Finding of No Significant Impact from the Director of Planning and Permitting, or
- Receive an acceptance of a Final Environmental Impact Statement for the project from the Department of Planning and Permitting.

All Environmental Assessments/Environmental Impact Statements required for a significant zone change involving 25 acres or more shall include a Project Master Plan (See Section 5.4.2 below). The scope of the EA/EIS must cover at a minimum the specific development associated with a particular zone change application, but at the option of the applicant may cover subsequent phases of a larger project, as well. Zone change applications for a project already assessed under the National Environmental Policy Act, Hawaii Revised Statutes Chapter 343, Revised Ordinances of Honolulu Chapter 25 (Shoreline Management), or a preceding zoning change application will not require a new Environmental Assessment so long as the Director of Planning & Permitting determines that the desired zoning and land use generally conform to that described in the existing Environmental Assessment/Environmental Impact Statement.

In order to guide development and growth in an orderly manner as required by the City's General Plan, zoning and other development approvals for new developments should be approved only if

the responsible City and State agencies indicate that adequate public facilities and utilities will be available at the time of occupancy or if conditions the functional agency indicates are necessary to assure adequacy are otherwise sufficiently addressed.

The Department of Planning and Permitting, as part of its report on the consistency of the project with the Development Plan vision, will review and summarize any individual agency's findings regarding public facilities and utilities adequacy which are raised as part of the EA/EIS process. The Department of Planning and Permitting will address these findings and any additional agency comments submitted as part of the agency review of the zone change application and recommend conditions that should be included in the Unilateral Agreement or Development Agreement to insure adequacy of facilities.

Table 3-7. Stages in Coastal Development – Key Decisions Regarding Shoreline Management, Existing Roles of Government Agencies and Parties (Hwang, 2003)

Development Stage	Key Coastal Management Decisions	Primary Agencies and Organizations
State Districts	Types of Use, Density of Use	State Land Use Commission and Planning Departments. For Urban, Rural and Ag land less than 15 acres, City Council and Planning Commissions
General and Community Planning	Character of Area, Goals and Policies for Growth and Development, Community Input to Zoning and Subdivisions, Design Standards	City Dept. of Planning & Permitting – Division of Planning & Development; City Administration, City Council, Planning Commission, Citizen Advisory Groups, Government Advisory Committees, Neighborhood Boards, Landowners,
Local Zoning	Types of Use, Density of Use	City Dept. of Planning & Permitting – Division of Planning & Development
Subdivision of Land	Location and Size of Lots, Configuration of Lots, Mix of Lot Size, Location of Streets, Cluster Developments, Planned Developments, Planned Unit Developments, Setbacks, Variances	City Dept. of Planning & Permitting – Site Development Division
Infrastructure Improvement	Preservation of Coastal Dune, Infill of dune, Grading of Land, Grading Permits, Drainage, Utility Placement	City Dept. of Planning & Permitting – Site Development Division
Lot Transfer	Disclosure of Erosion, Flooding, and Hazard Risks	State Legislature, Landowner, Homeowner
Home Construction	Location of Home on Lot, Setbacks, National Flood Insurance Regulations, Building Codes to Address Wind, Hurricane Damage, Seismic Loads	City Dept. of Planning & Permitting - Building Division
Erosion/Hazard Noticed – Remedial Options Evaluated	Erosion & Repetitive Flooding, Seawalls, Revetments, Sand Replenishment, Dune Reconstruction, Retreat, Compensatory Mitigation, Retrofit	Dept. of Planning & Permitting - Permits Division, State Dept. of Land and Natural Resources – Office of Conservation & Coastal Lands

3.7 State Land Use Districts

(after Hwang, 2003)

For Hawaii, the top stage in the development hierarchy relates to State classification and reclassification of land districts, which is a zoning scheme of land use control.

Role of the Hawaii State Plan in State Reclassification Decisions

The Hawaii State Plan does contain goals, objectives and policies that influence the land-use district classification stage. In the Hawaii State Plan, the following policies affect State land-use decisions:

1. Ensure compatibility between land-based and water-based activities as well as natural resources and ecological systems. [HRS § 226-11(b)(2)]

2. Manage natural resources and environs to encourage their beneficial and multiple-use without generating costly or irreparable environmental damage. [HRS § 226-11(b)(4)]

3. Encourage the design of developments and activities that complement the natural beauty of the islands. [HRS § 226-12(b)(5)]

4. Reduce the threat to life and property from erosion, flooding, tsunamis, hurricanes, volcanic eruptions, and other natural or man-induced hazards and disasters. [HRS § 226-13(b)(5)]

5. Coordinate state, county, federal and private transportation activities and programs toward the achievement of statewide objectives. [HRS § 226-17(b)(2)]

6. Promote design and location of housing development taking into account the physical setting, accessibility to public facilities and services, and other concerns of existing communities and surrounding areas. [HRS § 226-19(b)(5)]

7. Promote the recreational and educational potential of natural resources having scenic, open space, cultural, historical, geological, or biological values while ensuring that their inherent values are preserved. [HRS § 226-23(b)(4)]

Some priority guidelines in the Hawaii State Plan that are also relevant to proper coastal development are:

1. Direct future urban development away from critical environmental areas or impose mitigating measures so that negative impacts on the environment would be minimized. [HRS § 226-104(b)(9)]

2. Identify critical environmental areas including scenic and recreational shoreline resources, open space and natural areas. [HRS § 226-104(b)(10)]

3. Utilize Hawaii's limited land resources wisely, providing adequate land to accommodate projected population and economic growth needs while ensuring the protection of the environment and the availability of the shoreline, conservation lands, and other limited resources for future generations. [HRS § 226-104(b)(12)]

4. Protect and enhance Hawaii's shoreline, open spaces and scenic resources. [HRS § 226-104(b)(13)]

Land use decisions made by State agencies are required to conform to the goals, objectives and policies in the Hawaii State Plan and utilize the priority guidelines within the Act as well as follow the State Functional Plans approved in the Chapter. Thus, the policies and priority guidelines in the Hawaii State Plan that are recited above influence and guide State district reclassification decisions.

3.7.1 State Functional Plans

The State Functional Plans are part of the Hawaii State Planning System and set forth policies, guidelines and objectives within a specific field or activity. In Hawaii, there are twelve such plans with the ones relating to conservation lands, housing, recreation and transportation being the most relevant. These plans were last updated in 2017. When they are updated again, specific policies, guidelines and objectives relating to coastal erosion and hazard mitigation could be included.

3.7.2 State District Classification System

In Hawaii, the four major State districts are conservation, rural, agriculture, and urban. In general, conservation districts include areas necessary for protecting watersheds and water resources, preserving scenic and historic areas, providing beach reserves, preventing floods and soil erosion, and preserving areas of value for recreational or conservation purposes. [HRS §205-2(e)] Rural districts are characterized by low-density residential lots of not more than one house per half acre in areas where "city-like" concentration of people, structures, streets and urban level of services are absent. [HRS §205-2(c)] Agricultural districts are to include uses characterized by the cultivation of crops, orchards, forests, farming activities and related uses, which support agricultural services. [HRS §205-2(d)] Finally, there is the urban district, characterized by a high concentration of structures, people and streets. The land use zoning for Oahu is shown in Figure 3-4.

Standards in the land use commission rules provide that conservation lands must include lands necessary for the conservation and preservation of unique ecological resources. [HAR § 15-15-20-4] Conservation lands shall also include lands with topography, soils, climate, or other related factors that may not be normally adaptable or presently needed for urban, rural or agricultural use. [HAR § 15-15-20-7] Conservation districts may include "lands susceptible to floods and soil erosion, lands undergoing major erosion damage and requiring corrective action by the State and Federal government.

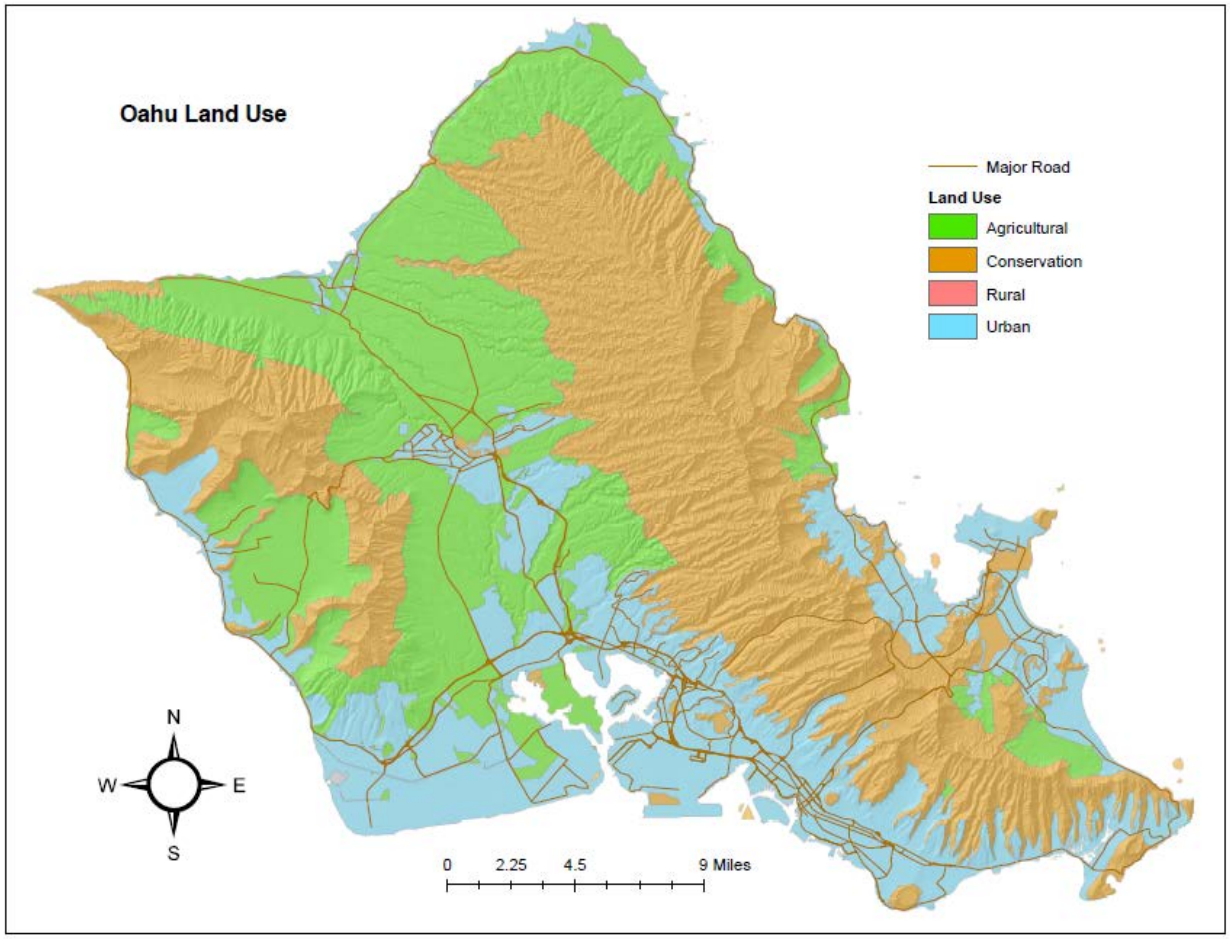


Figure 3-4 Oahu Land Use Districts

3.8 Lot Purchase

Disclosure of erosion, flooding and inundation risks serves several purposes. With proper disclosure, the purchaser of a coastal home or lot is better informed of the risks of natural hazards. To a knowledgeable buyer, coastal homes and lots that are designed to mitigate for coastal hazards are more valuable than properties in which this risk has been ignored.

Table 3-8. Required Permitting, Environmental and Hazard Assessments at Different Stages of Development

Stage of Development	Special Management Area Permit HRS §205A	Hawaii EA/EIS HRS §343	Other Applicable Requirements in Agency rules	Potential Gaps in Hazard Assessment
State District	No HRS §205A-29	Yes - for reclassification or use of conservation districts.	LUC rules require assessment	County reclassification of State districts (land <15 acres).

Stage of Development	Special Management Area Permit HRS §205A	Hawaii EA/EIS HRS §343	Other Applicable Requirements in Agency rules	Potential Gaps in Hazard Assessment
		No – for agricultural, rural changes to urban		Standards for hazard mitigation analysis.
General, Community, Development Plans	No HRS §205A-29	Yes- when an individual changes zones other than to agriculture or preservation. No – for county proposed changes that go through comprehensive review process	No – for county amending	Actions proposed by county that go through review process. Standards for hazard mitigation analysis.
County Zoning	No HRS §205A-29	No	Honolulu exempts for <10 acres	Small zoning changes (less than 10 acres), Standards for hazard mitigation analysis
Subdivision	Yes	No		Standards for hazard mitigation analysis
Infrastructure Improvement	Yes	No		Standards for hazard mitigation analysis
Lot Transfer	No	No		
Home Construction	Yes – county discretion	No		Standards for hazard mitigation analysis
Hazard Noticed-Remedial Action Analyzed	Yes	Yes- for use within the shoreline setback area		Standards for hazard mitigation analysis

From the landowner/developer prospective, disclosure of hazard risks creates an incentive to design projects, subdivisions or lots that avoid hazard problems. This is because the combination of a poorly designed (substandard) lot and a knowledgeable buyer will reduce market value. The developer benefits from proper hazard mitigation design by offering a more valuable product and establishing a quality reputation.

Aside from protecting the buyer and providing incentive for the landowner to implement hazard mitigation measures, seller disclosure laws promote economic efficiency. Hawaii's disclosure law was implemented, in part, after statistics showed that a leading cause of real estate litigation was due to the failure to disclose material facts regarding a property.

There is one Federal and two State consumer protection laws related to the potential disclosure of hazard risks. Although these laws are potentially useful, significant gaps limit their capability to assist in the implementation of hazard mitigation strategies. These laws are summarized below along with suggested changes for improvement to the two State laws. (Hwang, 2003)

3.8.1 Mandatory Seller Disclosures in Real Estate Transactions

The Mandatory Seller Disclosures in Real Estate Transactions Act ("Mandatory Disclosures Act") was passed in 1994. [HRS § 508D] This law requires the seller or the seller's agent to prepare a disclosure statement in good faith and with due care regarding material facts that would be expected to measurably affect the value to a reasonable person of the residential real estate being offered for sale.

Related to hazard mitigation, disclosure is expressly required for residential property in the special flood hazard area. [HRS § 508D-15(a)(1)] These are areas on the Federal Insurance Rate Maps subject to the 100-year flood and are equivalent to FEMA's V, VE, A and AE zones. Disclosure is also required for anticipated inundation areas designated on the on the Department of Defense's civil defense tsunami inundation maps. [HRS § 508D-15(a)(4)] The maps for tsunami and flood inundation are required to be kept by the counties and disclosure is required only if the maps are present and relate the hazard zone to the tax map key of a property.

Although flooding and tsunami inundation are expressly addressed in the Mandatory Disclosures Act, erosion is noticeably absent. Intuitively, erosion is a material fact that would require disclosure. Structures in the flood zone may be subject to flooding and tsunami inundation, since Hawaii's FIRMs factor tsunami inundation into the V and A zones. Generally, structures in the erosion zone would be subject to the most intense tsunami and flooding forces, as well as erosion and scour. Erosion is a coastal hazard that should be addressed as a siting issue, whereas tsunami inundation and flooding can in some cases be addressed during the construction stage.

The Hawaii Supreme Court has indirectly indicated that erosion is a material factor to disclose. The Court ruled that a shoreline property boundary that was in dispute was a material fact that required disclosure. [Shaffer v. Earl Thacker Co., 6 Haw. App. 188, 716 P.2d 163 (1986)] Erosion changes the location of shoreline property boundaries, resulting in diminution of coastal lot size over time. [County of Hawaii v. Sotomura, 54 Haw. 176 (1973)] The Hawaii legislature should consider amendment to the Mandatory Disclosure Law to expressly address erosion. Some additional recommended changes to the Mandatory Disclosure Act are suggested.

Another gap in the Mandatory Disclosures Act is that it covers only residential real property with one to four dwelling units or a condominium or cooperative apartment, the primary use of which is occupancy as a residence. [HRS § 508D-1] Empty lots with no structures on them are not covered, even though the lot may have a history of flooding and erosion.

3.8.2 Uniform Land Sales Practices Act

The Uniform Land Sales Practices Act ("Land Sales Act") was passed in Hawaii in 1967 and deals specifically with the sale of lands that are subdivided. [HRS § 484] Under this Act, a public

offering statement is to be delivered to all purchasers and prospective purchasers of a lot in a subdivision. [HAR § 16-104-26(a)] The public offering statement is to fully and accurately disclose the physical characteristics of the subdivided lands offered and all unusual or material circumstances or features affecting the subdivided lands. [HAR § 16-104-2]

Required information in the public offering statement that is relevant to hazard mitigation includes:

1. Existing zoning regulations, including land use classifications and general plan;
2. Encumbrances, easements, liens, restrictions;
3. Elevation of the land;
4. Soil conditions- drainage; and
5. Exposure to natural hazards; e.g., earthquakes, floods, tidal waves, volcano, forest fires, slides, etc. [HAR § 16-104-25]

3.9 Plan Integration for Resilience

3.9.1 Introduction

Alignment of government land use plans and policies is important because of the influence they have on how our communities develop over time. However, inconsistencies in plans and policies are common and may be related to the number and complexity, the timing of their issuance, or the result of resource constraints (e.g., competing priorities, manpower or budget limitations). A simple example of inconsistent planning policy is a situation in which a hazard mitigation plan recommends retreat from a high-hazard area, while another comprehensive or special district plan encourages buildout in the same hazardous location without specifying the need to build in a way that mitigates the hazard, thereby increasing vulnerability.

Plans are created and scaled to address particular concerns, such as regional growth patterns or design guidelines for a commercial district. Examples of Types of Plans in a Community's Network of Plans, from the Plan Integration for Resilience Scorecard Guidebook, is provided in Table 3-9.

Table 3-9 - ***Examples of Types of Plans in a Community's 'Network of Plans'***

Plan Type	Purpose	Contribution (+/-) to Vulnerability
Comprehensive/ General Plan	Main community planning document	Policies can guide future development into or away from hazard zones.
Hazard Mitigation Plan	Reduce long-term risk to human life and infrastructure	Advocates vulnerability reduction and resiliency building, often via general policies or specific "action items"
Disaster Recovery Plan	Address disaster recovery related needs to be activated during recovery	Advocates vulnerability reduction and resiliency building post-disaster. Coordinates agencies to assist people post-disaster.
Area Plans:	Address planning issues pertaining to a portion of the community	Targeted policies may increase or decrease vulnerability, depending on purpose and location. Area plans may also contribute to policy district delineation.

Plan Type	Purpose	Contribution (+/-) to Vulnerability
Functional or Sector-specific Plans:	Focus on individual or related functions or sectors in need of specialized planning	Individual plan policies may increase or decrease vulnerability, and are often distinct from those found in comprehensive or hazard mitigation plans. Applicability to individual policy district may be aided by additional function/sector maps.

Source: Plan Integration for Resilience Scorecard Guidebook (Hicks Masterson, J. et al. 2017).

The US Department of Homeland Security's (DHS) Coastal Resilience Center and the National Research Council issued recent guidance on best practices to align local plans and policies in the area of Hazard Mitigation Policy. This assessment applies the screening methods and techniques reported in the DHS-funded "Plan Integration for Resilience Scorecard Guidebook" (Guidebook) to the City & County of Honolulu's General Plan (GP), O'ahu Resilience Strategy (ORS), Development Plans (DP), and Sustainable Communities Plans (SCP), as a general prototype. The screening method focuses on eight "land use approaches" or policy categories:

1. Development Regulations
2. Land Acquisition
3. Density Transfer Provisions
4. Financial Incentives and Penalties
5. Land Use Analysis and Permitting Process
6. Public Facilities (including Public Housing and Emergency Shelters)
7. Post-Disaster Reconstruction Decisions
8. Capital Improvements

Dr. Philip Berke, Professor of Land Use and Environmental Planning at Texas A&M University and Director of the Institute for Sustainable Communities, and co-creator of the Guidebook, explains that "preventative land use policies have the highest benefit-cost ratios and Community Rating System incentives, yet are the least used actions to reduce vulnerability and promote mitigation." (FEMA PrepTalk 2018) The Plan Integration for Resilience Scorecard Guidebook provides a process for applying a consistent method to plan evaluation.

The Federal Emergency Management Agency (FEMA) created guidance to evaluate consistencies between land use planning documents with regard to natural hazard vulnerabilities. Related guidance began with a question-based approach (FEMA Plan Integration Guide, 2014). This practice has evolved to include a quantitative assessment of hazard vulnerability and policies that are focused on reducing related vulnerabilities (Hicks Masterson, J. et al., 2017). The former is helpful for assessing guidance for regional growth, and the latter provides a more detailed accounting of neighborhood level considerations.

The intent of this policy analysis is to provide information to local leadership and community stakeholders for use in creating or updating the plans that:

1. Guide investments and highlight priorities for hazard mitigation actions
2. Strengthen the ability of communities to withstand the acute shocks of natural hazard events
3. Adapt to environmental changes that are expected or currently being experienced as a result of climate change (e.g., more severe and frequent storms and inland flooding, coastal

erosion, changes to coastal flood zones, risks related to drought and wildfire, impacts to agriculture and native species, slope stability, etc.).

3.9.2 Policy Analysis

Here we examine the City's island-wide and regional guidance (i.e., GP, DP/SCPs). The assessment indicates that the referenced planning documents align around a number of the standardized "land use approaches" documented in the Guidebook, while other areas are not well aligned. The second component, scorecard creation, is only addressed at a conceptual level. The goal of this evaluation is to develop findings from application of the policy analysis portion of the plan integration for resilience scorecard at the regional land use planning level, and provide some information and context for the follow-on efforts that would be needed to provide a more detailed accounting of the integration of hazard mitigation principles in Oʻahu's network of plans (i.e., census-block-level analysis of vulnerability, planned mitigation, and potentially contradictory policies).

Steps taken in this policy analysis:

- Define the network of plans for the community being analyzed and compile related documents
- Develop lists of all policies (or "policy-like" language) for each planning document
- Select policies that are intended to mitigate hazards or may increase vulnerability related to stormwater/inland flooding, coastal flooding, coastal erosion, wind/hurricane, and wildfire
- Identify the categories for hazard mitigation that are addressed by the policies of each plan
- Provide findings and considerations for future plan updates

O‘ahu’s Network of Plans

Policy analysis focused on the GP (2018 proposed revision) and DP/SCPs because these are the foundation of the City and County of Honolulu’s comprehensive vision for guiding O‘ahu’s future. The eight DP/SCP areas include (date of plan version used in this analysis indicated):

1. *Central O‘ahu Sustainable Communities Plan (COSCP), *2016—proposed plan update*
2. **East Honolulu Sustainable Communities Plan (EHSCP), *2019—currently being updated*
3. ‘Ewa Development Plan (EDP), 2013
4. *Ko‘olau Loa Sustainable Communities Plan (KLSCP), *2012—pre-final plan update*
5. Ko‘olau Poko Sustainable Communities Plan (KPSCP), 2017
6. North Shore Sustainable Communities Plan (NSSCP), 2011
7. **Primary Urban Center Development Plan (PUCDP), *2004—currently being updated*
8. Wai‘anae Sustainable Communities Plan (WSCP), 2012

**Plan update not formally adopted*

***Plan update in process*



Figure 3-5 O‘ahu’s Development Plan and Sustainable Communities Plan Areas

The GP provides “a coherent set of guidelines, values, and principles which can be used in developing plans, programs, and legislation.” The DPs and SCPs “are a tool for implementing the objectives and policies of the General Plan, serving as a policy guide for the City’s more detailed zoning maps and regulations, and public and private sector investment decisions. The DPs and SCPs provide for land use and public facilities planning as well as indicate the sequence in which development will occur. They must implement and accomplish the objectives and policies of the General Plan.” Furthermore, while zoning ordinances regulate land uses and set detailed development standards, “zoning ordinances, the functional plans and programs of the City and County agencies must conform to the General Plan and implement the DPs and SCPs [to] ensure that the provision of City services is in accord with the General Plan’s objectives and policies and provisions contained in the lower tiers of plans.” (City and County of Honolulu, 2018)

O‘ahu’s network of plans is summarized in Table 3-10 (intended to be representative and not exhaustive). Geographic areas are defined as:

1. State (i.e., applicable to all Counties)
2. County (i.e., island-wide/focused solely on O‘ahu)
3. Regional (e.g., DP/SCP areas, or areas that extend beyond or between distinct districts)
4. Districts (e.g., special planning area/district plans)

Table 3-10– *O‘ahu’s Network of Plans*

#	Plan	Geographic Area
Included in this analysis		
Type	***Comprehensive/General Plan***	
1.	General Plan	County
2.	Central O‘ahu Sustainable Communities Plan	Regional
3.	East Honolulu Sustainable Communities Plan	Regional
4.	‘Ewa Development Plan	Regional
5.	Ko‘olau Loa Sustainable Communities Plan	Regional
6.	Ko‘olau Poko Sustainable Communities Plan	Regional
7.	North Shore Sustainable Communities Plan	Regional
8.	Primary Urban Center Development Plan	Regional
9.	Wai‘anae Sustainable Communities Plan	Regional
Type	***Hazard Mitigation Plan***	
10	Honolulu Pre-Disaster Multi-Hazard Mitigation Plan (incorporated by reference)	County
11	O‘ahu Resilience Strategy	County
Not Included in this analysis		
Type	***Comprehensive/General Plan***	
12	City and County of Honolulu Building Code (plumbing, fire, electrical, traffic, etc.)	County
13	Land Use Ordinance (Chapter 21, Revised Ordinances of Honolulu)	County
14	Subdivision Rules and Regulations (Department of Planning and Permitting, pursuant to Chapter 22, Revised Ordinances of Honolulu)	County
Type	***Disaster Recovery Plan***	
	Not yet created	County
Type	***Area Plans:***	
15	Special Design District Plans (e.g., Chinatown, Capital, Punchbowl, Waikīkī, Diamond Head, Hale‘iwa), Kaka‘ako, He’eia (Hawai‘i Community Development Authority), Mākaha Special Area Plan	State/County
16	Transit oriented development (TOD) neighborhood plans (various, e.g., Aiea and Waipahu Neighborhood TOD Plans)	District
Type	***Functional or Sector-specific Plans:***	
	Transportation	
17	Bicycle and Pedestrian Master Plans	County
18	Bus Facilities and Systems Plans	County
19	Complete Streets Plan	County
20	Hawai‘i Statewide Transportation Improvement Program	State
21	O‘ahu Regional Transportation Plan	County
22	State Highways Division Procedures Manual, Vol. 8, Chapter 5, Section 4 (State Department of Transportation, Highways Division)	State
23	Traffic Standard Manual (Department of Transportation Services, July 1976, as revised)	County

#	Plan	Geographic Area
	Public Facilities/ Utilities/Services	
24	Hawai‘i DOE Public School Master Plans	State
25	Park Facilities Functional Plan, Park Master Plan	County
26	Park Dedication Rules and Regulations (Department of Planning and Permitting, pursuant to Chapter 22, Article 7, Revised Ordinances of Honolulu)	County
27	Infrastructure Facility Plans	County/various
28	Standard Details for Public Works Construction (Dept. of Planning and Permitting)	County
29	State Integrated Solid Waste Management Plan (2000)	State
30	Storm Drainage Standards (Department of Design and Construction, March 1986)	County
31	Stormwater Management Plans	Regional
32	Wastewater Facility Plan	County
33	Wastewater Management Design Standards	County
34	Water Code (Chapter 174C, Hawai‘i Revised Statutes)	State
35	Watershed Management Plans	Regional
	Housing	
36	Housing Development Programs	State
	Natural and Cultural Resources	
37	Coastal Erosion Management Plan	State
38	Conservation District Management Plan	Regional
39	Hawaii Coastal Nonpoint Pollution Control Program Management Plan	State
40	Historic Preservation Program (Chapter 6E, Hawai‘i Revised Statutes)	State
41	Hawai‘i Revised Statutes Chapter 205A, Special Management Area (SMA) permitting system (i.e., Coastal Zone Management (CZM) Program)	County
42	O‘ahu Water Management Plan (1990)	County

3.9.2.1.1 Policy Analysis Relating to Plan Integration

Based on guidance provided in the Plan Integration for Resilience Scorecard Guidebook, policies in the plans analyzed were selected based on their ability to meet the following criteria:

- Plans should still be relevant (i.e., still influence policy decision-making)
- Area Plans must (at least partially) intersect with a designated hazard zone. If the subject of an area plan is located entirely outside of hazard zone, it is relatively safe and therefore should not be included in this analysis.
- Impact the way a community grows or develops referring to spatial aspects of a community *(Hicks Masterson, J. et al. 2017)*

Policies selected as relevant to plan integration were limited to those that identified a place-specific term (in some cases this was interpreted as the planning region in general), reduces or increases vulnerability, and included a recognizable policy tool. This summarizes the alignment of the core GP and DP/SCP policies with principles of the Honolulu Multi-Hazard Pre-Disaster Mitigation Plan. Additional analysis of risk vulnerability and development plans at the district level would be required to determine compliance with these guiding principles and provide a basis for scoring related policies. The plans reviewed and basic statistics for the policies included therein are shown in Table 3-11

Table 3-11 – Basic statistics for the policies reviewed and selected for plan integration consideration

Plan	**Number of policies in each plan**	**Number of policies related to land use approaches for hazard mitigation**	
1. General Plan	297	20	7%
2. Oʻahu Resilience Strategy	44	10	23%
2. Central Oʻahu Sustainable Communities Plan*	99	15	15%
3. East Honolulu Sustainable Communities Plan**	184	38	21%
4. ʻEwa Development Plan	104	15	13%
5. Koʻolau Loa Sustainable Communities Plan*	225	18	8%
6. Koʻolau Poko Sustainable Communities Plan	115	20	17%
7. North Shore Sustainable Communities Plan	272	31	11%
8. Primary Urban Center Development Plan**	141	9	6%
9. Waiʻanae Sustainable Communities Plan	97	16	16%
Total	**1578**	**192**	**12%**

*Plan update not formally adopted
**Plan update in process

Of the nine plans, over 1,500 policies were reviewed, an average of twelve percent of which were considered related to hazard mitigation principles presented in Honolulu Pre-Disaster Multi-Hazard Mitigation Plan and relevant for inclusion in the policy analysis for plan integration.

3.9.2.1.2 Land Use Approach for Selecting Related Policies

Hazard Mitigation Planning Principles used in this policy analysis follow those established in the Plan Integration for Resilience Scorecard Guidebook, which could mitigate or increase hazard vulnerability, with additions made by the planning team shown in italics:

1. DEVELOPMENT REGULATIONS
   1.1. Permitted Land Use: Provision regulating the types of land use (e.g., residential, commercial, industrial, open space, etc.) permitted in areas of community; may be tied to zoning code
   1.2. Density of Land Use: Provision regulating density (e.g., units per acre); may be tied to zoning code

1.3. Subdivision Regulations: Provision controlling the subdivision of parcels into developable units and governing the design of new development (e.g., site storm water management)
1.4. Zoning Overlays: Provision to use zoning overlays that restrict permitted land use/density in hazardous areas; may be special hazard zones or sensitive open space protection zones
1.5. Setbacks or Buffer Zones: Provision requiring setbacks or buffers around hazardous areas (e.g., riparian buffers and ocean setbacks)
1.6. Cluster Density: Provision requiring clustering of development away from hazardous areas, such as through conservation subdivisions

2. LAND ACQUISITION
   2.1. Acquire Land & Property: Purchase land/property in hazard area
   2.2. Open Space or Easement Requirement/Purchase: Provision encouraging open space purchase by the community or open space easements as an element of development approval
3. DENSITY TRANSFER PROVISIONS
   3.1. Transfer/Purchase of Development Rights: Provision for transferring development rights to control density; may be transfer of development rights or purchase of development rights
4. FINANCIAL INCENTIVES AND PENALITIES
   4.1. Density Bonuses: Density bonuses such as ability to develop with greater density in return for dedication or donation of land in areas subject to hazards
   4.2. Tax Abatement: Tax breaks offered to property owners and developers who use mitigation methods for new *[or existing]* development
   4.3. Impact/Special Study/ Protection Fees: Provision requiring impact fees, special study fees, or protection fees for development in hazardous areas; fees could cover costs of structural protection
5. LAND USE ANALYSIS AND PERMITTING PROCESS
   5.1. Land Suitability: Hazards are one of the criteria used in analyzing and determining the suitability of land for development
   5.2. Site Review: Provision requiring addressing hazard mitigation in process of reviewing site proposals for development
   5.3. Design/Construction Guidelines/Requirements: Guidelines or requirements that apply to the design or construction of developments in hazard areas
6. PUBLIC FACILITIES (including Public Housing *and emergency shelters*)
   6.1. Siting: Provision to site public facilities, including municipal buildings and public housing, out of hazard areas
   6.2. Sizing/Capacity: Provision limiting capacity of public facilities, including public housing, in hazard areas to cap amount of development
   6.3. Condition/code compliance: Provision requiring that designated shelters maintain compliance with relevant design codes and adequate physical condition
7. POST-DISASTER RECONSTRUCTION DECISIONS
   7.1. Development Moratorium: Provision imposing a moratorium on development for a set period of time after a hazard event to allow for consideration of land use change
   7.2. Post-Disaster Land Use Change: Provision related to changing land use regulations following a hazard event; may include redefining allowable land uses after a hazard event

7.3. Post-Disaster Capital Improvements: Provision related to adjusting capital improvements to public facilities following a hazard event

8. CAPITAL IMPROVEMENTS
   8.1. Infrastructure "Hardening" or Weatherproofing; Redundancy; Evacuation: Provision encouraging or requiring development in hazard zones to increase structural resilience to hazards; require alternate routes for egress and provision of basic utilities in the event that primary routes are damaged in a disaster event; provision requiring that adequately sized evacuation routes be located outside of high hazard areas to ensure that community members can move out of the way of incoming disasters (e.g., tsunami or hurricane) and are not physically isolated after a disaster event
   8.2. Elevating: Provision pertaining to the physical elevation of structures in hazard zones
   8.3. Drainage Improvements or Flood Control: Provision that pertains to drainage or flooding issues within the community
   8.4. Ecosystem Enhancement: Provision that seeks to improve or preserve the functioning of the natural environment within the community
   8.5. Slope/Dune Stabilization: Provision that pertains specifically to stabilization of slopes or dunes or seeks to control erosion

(Hicks Masterson, J. et al. 2017)
**Italics indicates additions made by the Honolulu Hazard Mitigation Plan Update team*

This listing provides parameters for categorizing the policies included in the analysis and the basis for scoring to determine the consequence of either increasing or reducing hazard vulnerability. Scoring is not provided at the regional level because spatial consideration of risks, investments, and mitigation actions would be overly generalized and muddle attempts to provide meaningful policy scoring. Therefore, this analysis focused on accounting for the land use policy categories and sub-categories used in the policies of these regional plans, with the understanding that these foundational policies would be used to guide district-level planning. Coverage of these categories, based on the policies reviewed in the nine planning documents, is provided next.

3.9.2.1.3 Coverage of Hazard Mitigation Planning Principals

Coverage of hazard mitigation planning principals in the planning documents reviewed is provided in Table 3-12. A more detailed table, indicating the assigned numbers of respective policies, was prepared for this analysis and could be made available upon request.

Table 3-12 - Policy Coverage of Land Use Approaches for the Nine Planning Documents

Land Use Approach	GP	ORS	COSCP	EDP	EHSCP	KLSCP	KPSCP	NSSCP	PUCDP	WSCP	
1. DEVELOPMENT REGULATIONS:											
1.1. Permitted Land Use	X	X						X		X	3
1.2. Density of Land Use	X										1
1.3. Subdivision Regulations											0
1.4. Zoning Overlays				X			X	X	X	X	5
1.5. Setbacks or Buffer Zones	X	X	X	X	X	X	X	X	X	X	9
1.6. Cluster Density								X		X	2
2.LANDACQUISITION											
2.1. Acquire Land and Property		X				X		X		X	3
2.2. Open Space or Easement Requirement or Purchase		X									0
3. DENSITY TRANSFER PROVISIONS											
3.1.Transfer/Purchase of Development Rights		X									0
4. FINANCIAL INCENTIVES AND PENALITIES											
4.1. Density Bonuses											0
4.2. Tax Abatement		X	X	X			X				3
4.3. Impact/Special Study/ Protection Fees		X									0
5. LAND USE ANALYSIS AND PERMITTING PROCESS											
5.1. Land Suitability	X						X				2
5.2. Site Review	X					X					2
5.3. Design/Construction Guidelines/Requirements	X	X		X		X	X	X	X		6
6. PUBLIC FACILITIES (including Public Housing and emergency shelters)											
6.1. Siting	X	X								X	2
6.2. Sizing/Capacity			X		X						2
6.3. Shelter Provision/Code Compliance/Condition			X	X		X	X	X		X	6

Land Use Approach	GP	ORS	COSCP	EDP	EHSCP	KLSCP	KPSCP	NSSCP	PUCDP	WSCP	
7. POST-DISASTER RECONSTRUCTION DECISIONS											
7.1. Development Moratorium		X									0
7.2. Post-Disaster Land Use Change		X					X				1
7.3. Post-Disaster Capital Improvements		X									0
8. CAPITAL IMPROVEMENTS											
8.1. Infrastructure "Hardening" or Weatherproofing; Redundancy; Evacuation	X	X				X	X	X		X	5
8.2. Elevating											0
8.3. Drainage Improvements or Flood Control	X	X	X	X	X	X	X	X	X	X	9
8.4. Ecosystem Enhancement	X	X	X	X	X	X	X	X		X	8
8.5. Slope/Dune Stabilization			X			X	X			X	4
Number of categories addressed in the plan	10	15	8	7	4	9	11	10	4	11	

**Blue text indicates additions made by the Honolulu Hazard Mitigation Plan Update team*

i. Findings from the Analysis of Policy Approaches Used in the Land Use Plans

Review of the GP and DP/SCP policies provided insight into the extent to which each plan addressed the eight policy categories, as well as the extent to which the policy tools in each category are used in plans.

There was near-universal references to 1.5. Setbacks or Buffer Zones, 8.3. Drainage Improvements or Flood Control, and 8.4. Ecosystem Enhancement.

- Policies related to "Setback or Buffer Zones" included minimum setbacks along the shoreline (with consideration of extended setbacks where justified) based on historic or adopted projections of coastal erosion rates, setbacks from the Conservation District to reduce the risk of wildfire spreading to developed areas, protecting wetland and wildlife habitat areas, establishing riparian buffer zones along streams, and generally preserving gulches or ravines as natural drainageways and storm water retention areas (see COSCP). The policy used in the NSSCP is noteworthy for its acknowledgement of the need to protect and facilitate natural shoreline processes: Modify shoreline setbacks as needed to protect the natural shoreline, lessen the impact to coastal processes, and address sea level rise.
- Policies specifying drainage improvements and flood control were repeated throughout the plans, and included the use of golf courses as passive drainage ways, limiting stormwater runoff from large land areas, creating or expanding retention areas, or maintaining and cleaning drainage ways and flood mitigation structures of debris to ensure that they achieve the purpose for which they were designed (see KLSCP).
- Policies calling for ecosystem enhancement included actions related to improving watershed and stream/gulch conditions (see WSCP), avoiding channelization unless necessary, developing and implementing beach management plans (see NSSCP), and prohibiting the use of shore armoring structures along the shoreline in favor of beach replenishment (see KPSCP).

Other common policy tools, but distributed more sporadically in the set of plans reviewed, included 1.4. Zoning Overlays, 5.3. Design/Construction Guidelines/ Requirements, and 6.3. Shelter Provision/Code Compliance/Condition.

- Policies that were considered to fall in the "zoning overlay" category included provisions to protect and preserve watersheds, streams and gulches as part of the open space system; reclassifying important watershed areas designated as State Agricultural or Urban Districts to the State Conservation or City Preservation Districts; and preventing new coastal development in vulnerable or sensitive areas (see WSCP).
- Provisions for design and construction requirements included solutions seeking to reduce exposure to natural hazards (including those related to or exacerbated by climate change and sea level rise); minimizing impervious surfaces to reduce stormwater runoff (see KPSCP); promoting the use of detention basins and grassed swales for stormwater drainage; and requiring new structures to be designed to be compatible with coastal hazards such as coastal erosion, tsunami and hurricane overwash (see NSSCP);
- Six of the plans addressed the need to provide shelters and/or retrofit existing public buildings to make up the shortfall in hurricane resistant shelters, as well as to require new City buildings that are identified as "critical facilities used for public assembly and able to perform as shelters" to be designed and built to withstand a Category 3 hurricane (see COSCP, EDP, KPSCP);

Infrastructure hardening/redundancy/evacuation (policy tool 8.1) and "8.5. Slope/Dune Stabilization" (used to capture efforts aimed at protecting structures/infrastructure from coastal inundation) were used in nearly half of the plans that were reviewed. Dune stabilization, in these cases, referred mainly to beach management/nourishment. Shore armoring was specifically discouraged in the WSCP.

Other noteworthy, but rarely used approaches/policies include:
1.1. Permitted Land Use: in some cases, the plans included policies that encouraged development in hazardous areas (e.g., current or expected coastal inundation areas) without specifying the need for adaptive design, while other plans had policies for limiting new development along the shoreline.
2.1. Acquire Land & Property: the KLSCP, NSSCP, and the WSCP included policies that encouraged the acquisition of coastal lands to improve public access and to reduce vulnerability to coastal hazards.
4.2. Tax Abatement: related policy could provide tax breaks for the use of mitigation methods for new or existing development. Great gains could be achieved with relatively minor investments to protecting personal property and avoiding displacement and disruption if a potentially disastrous event occurred (e.g., Category 3 or higher hurricane). Three of the plans offered example policy language, but incentives could be expanded to include home retrofits for wind resistance:

- COSCP, EDP, and KPSCP: Provide incentives for private organizations to create hurricane resistant shelter areas in their facilities and for homes to include hurricane resistant "safe rooms".

5.1. Land Suitability: this tool recommends analyzing hazards as one of the criteria used in determining the suitability of land for development, which is particularly important for considering future risk potential. The KPSCP offers example language:

- KPSCP: Analyze the possible impact of sea level rise for new public and private projects in shoreline areas and incorporate, where appropriate and feasible, measures to reduce risks and increase resiliency to impacts of sea level rise.

7. Post-Disaster Reconstruction Decisions: The O‘ahu Resilience Strategy calls for the development and implementation of a long-term disaster recovery plan for O‘ahu as the third goal of Pillar 2, Bouncing Forward. This plan would help guide recovery actions if a major disaster occurred (e.g., rebuilding of housing and infrastructure, reestablishment of health and social services, and restoration of natural and cultural resources). This would address the three categories of land use approaches highlighted in the Plan Integration for Resilience Scorecard Guidebook: 7.1 Development Moratorium (as appropriate), 7.2. Post-Disaster Land Use Change, and 7.3. Post-Disaster Capital Improvements. Incorporating these concepts into the GP and DP/SCP planning processes and policies would help build community understanding of the need for a long-term disaster recovery plan, the types of actions that would help communities build back safer and stronger, and how the recovery strategies can inform land use decisions and mitigation actions in the interim.

Approaches that were not present in these plans include:

1. 1.3. Subdivision Regulations: these are covered under a separate City policy that was not analyzed; providing a reference in the DP/SCPs could help align and reinforce related points (e.g., storm-water management and impermeable surface ratios)
2. 2.2. Open Space or Easement Requirement/Purchase provisions that require or encourage open space purchases by the community or easements as a condition of development approval; these approaches are covered under other planning documents (e.g., park dedication ordinance and zoning unilateral agreements) that were not analyzed
3. 3.1. Transfer/Purchase of Development Rights provisions that could be used to help control the density of development in certain areas through the transfer or purchase of development rights
4. 4.1. Density Bonuses are being provided through other mechanism (e.g., TOD plans), but are not addressed in the DP/SCPs; this approach could be useful for limiting development in hazardous areas by offering density increases for development outside of hazardous areas
5. 4.3. Impact/Special Study/Protection Fees: several policies addressed siting and design considerations, and the need to conduct studies to inform these development decisions, but none of the policies explicitly required impact fees, special study fees, or protection fees for development in hazardous areas. This policy approach could be used to clarify property specific needs and pay for the appropriate structural protection measures.
6. Elevating requirements (e.g., elevating lowest floor above the regulatory flood elevation) are defined in Article 11 of the City of Honolulu Building Code; however, including elevation as a policy approach in DP/SCPs could encourage the use of more conservative designs that account for modelled future flood height estimates and what are now considered to be lower probability events (e.g., 500 or 1,000 year storms).

This initial policy analysis is intended to provide information on the level to which the policy approaches proposed in the Plan Integration for Resilience Scorecard Guidebook are addressed by County plans and policies. It is recommended that these land use policy categories, and example policy language from selected plan policies, as well as policy language encouraging the mitigation of, or adaptation to, anticipated impacts associated with climate change and sea level rise, be considered in future plan updates.

ii. Next Steps to Consider for Plan Integration – Score Card Creation

Follow-on plan integration efforts should include identifying "mappable areas" and additional plans to consider from O'ahu's network of plans. It is noted that the creation of the Plan Integration for Resilience Scorecard method was informed by consideration of 27 other resilience assessment tools, indices, and scorecards (via Susan Cutter's 2016 publication: The landscape of disaster resilience indicators in the USA), aligns with FEMA's previous mitigation planning guidance, and is a part of FEMA's ongoing efforts to improve plan integration. The scorecard creators want to be clear that this tool not be used in isolation, but in concert with, both informing and being informed by, other planning efforts that are being pursued.

Mappable areas are defined in the Plan Integration Scorecard Guidebook as: "An area in the community that can be mapped or is place-specific. Such areas can include, existing neighborhoods, existing commercial centers, natural areas, floodplain, native habitats, wetlands, primary conservation area, secondary conservation area, structures that frequently flood, and

existing community facilities. Area/place: neighborhood, park; line: river, bike path, road; Point: critical infrastructure (school, fire department)." *(Hicks Masterson, J. et al. 2017)*

The mapping effort provides an overlay of planning areas (e.g., districts) with defined hazard areas for current and expected (i.e., modelled) future risks (see Figure 4). Mappable areas can be created using census-block information to delineate each community's investment areas. Plan integration analysis would then compare the development guidance expressed in the network of plans, including proposed investment or retreat actions, with block-level hazards. Scores can then be generated, based on policy guidance that either increases or decreases a community's vulnerability to specified hazards and reveal "hotspots" with high vulnerability and areas of conflict for the various plans.

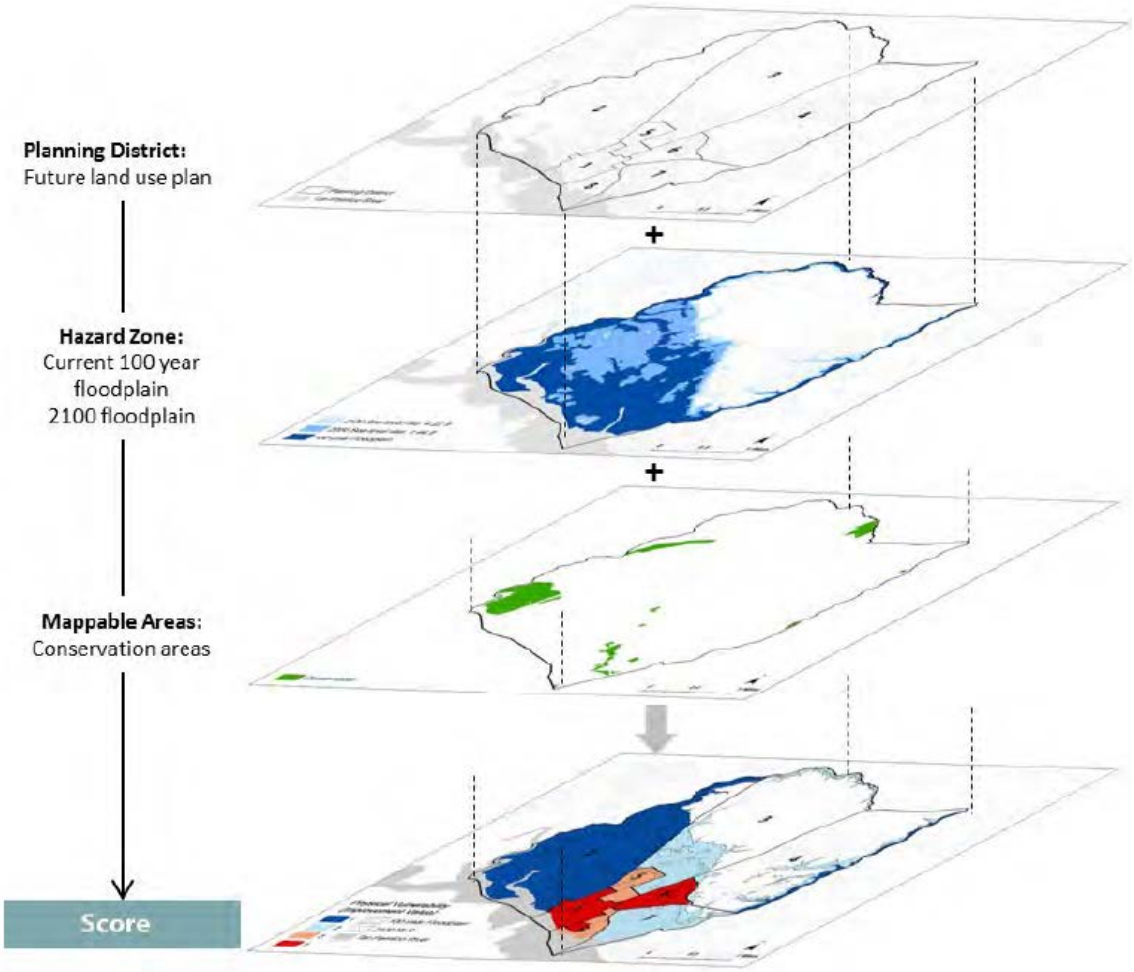


Figure 3-6 - ***Example layering of area boundaries, hazards, resources, and policies for scoring (Hicks Masterson, J. et al. 2017)***

This prototype policy analysis is intended to provide information and context for the mapping and scoring that would be needed to provide quantitative and graphic depictions of the consequences of O'ahu's network of plans policies in reducing or increasing vulnerability.

3.10 Future Mitigation Projects

The proposed mitigation projects relating to land use and development policy are as follows:

- Include natural hazard policies integrated into the General Plan & Community Development Plans.
- Model the effects of future climate conditions on all other hazards, primarily coastal erosion, flooding, and high surf. All current and future coastal infrastructure projects should strongly consider the effects of climate change when being designed. Planning and preliminary engineering feasibility studies should proceed on the coastal defense options for: Honolulu Harbor and particularly Pier 1, Kewalo Basin-Kakaako, Honolulu International (HNL) Airport reef runway, Sand Island access, Ala Wai Canal flood control, and Waikiki
- Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly flood control of the Ala Wai Canal. High
- ROH Chapter 25 SMA: Create another level of SMA zone maps defining a Coastal Construction Control Zone, to account for the coastal inundation limit of the 500-year flood including the effects of expected climate change by the year 2100 and sea level rise of 2 feet above the year 2000 mean high water, using modeling consistent with CMIP AR5 RCP 8.5 climatic conditions (see Chapter 14). Have this applicable only to major developments.
- ROH Chapter 23: Adjust the Shoreline Setback Line Related to the Construction of a New Building or Structure, or to a new Addition to an Existing Building or Structure.
- The shoreline setback line shall be established 25 feet inland from the certified shoreline plus a distance of 50 times the historical annual erosion hazard rate from the shoreline established by county maps.
- HRS Chapter 484 - Uniform Land Sales Practices Act: include disclosure of specifically defined natural hazards. HRS Chapter 508D Mandatory Seller Disclosures in Real Estate Transactions: Make the mandatory seller disclosure also apply to transactions involving vacant lots: Expand list of disclosable hazards in public offering to include, more explicitly, defined extents.
- Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities. It is recommended that the storm water flood control practices that address requirements for storm runoff quantities for flood control be re-evaluated for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs.
- HRS 205A Certified Shoreline: For planning purposes, also include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years past 2025.
- DNLR recommended that Buffer Zones should be developed or at least incorporated into new developments between high-hazard rock fall areas and homes. This would require implementation into planning policy on and establishment of mapping to identify the hazard areas.

The proposed projects are integrated with others in Chapter 19.



4. Climate Change Effects

4 CLIMATE CHANGE EFFECTS

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan did not include a chapter on Climate Change, however the effects of it were discussed in other chapters..	• Due to the significance of its effects and new research, a new chapter was created for climate change, which has potential exacerbating effects on the other weather related hazards that affect Oahu. • Brief explanations include the climate change effects could occur on Oahu. • Of all the Hawaiian Islands, Oahu is projected to have the most significant losses due to climate change, both economically and in terms of structures. • The current attempts at reducing Oahu's carbon footprint and energy consumption are recognized. • Suggested projects and code changes to implement Oahu's adaptation to climate change are included.

Summary of Mitigation Projects for the City and County of Honolulu Project	Priority
All current and future coastal infrastructure projects should strongly consider the effects of climate change when being designed. Planning and preliminary engineering feasibility studies should proceed on the coastal defense options for: Honolulu Harbor and particularly Pier 1, Kewalo Basin-Kakaako, Honolulu International (HNL) Airport reef runway, Sand Island access, Ala Wai Canal flood control, and Waikiki	High
Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly flood control of the Ala Wai Canal.	High
T**he PUC needs to adopt the 2017 NESC with a local amendment to include the ASCE topographic windspeed maps of the 2012 IBC-based Hawaii State Building Code**	Medium-High
ROH Chapter 16 Building-Code applicable revisions for Risk Category III and IV structures to have revised rainfall intensity design map; required design flood elevations that include the effect of relative sea level change; required consideration of 50-years of shoreline erosion and relative sea level rise on foundation design; required design to the 500-year flood elevation for essential and critical structures, together with placement of critical equipment above those elevations.	Medium-High
ROH Chapter 23 to adopt setbacks for new construction or new additions based on 25 ft. plus 50-years of expected shoreline erosion, built include exceptions for either the limited size or shallowness of lots.	Medium-High
ROH Chapter 25 SMA: The City should establish a *Coastal Construction Control Zone*, applicable to Risk Category III and IV Structures, to account for the coastal inundation limit of the 500-year flood including the effects of expected climate change by the year 2100 and sea level rise of 2 feet above the year 2000 mean high water, using probabilistic storm modeling consistent with CMIP AR5 RCP 8.5 climatic conditions. Within this area, relative sea level rise, shoreline erosion shall be considered for Major Developments when applying for an SMA permit. This requires a new coastal inundation design map based on the probabilities of future tropical cyclone activity and intensities	Medium-High

HRS 205A Certified Shoreline: For planning purposes, also include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years.	Medium-High
HRS Chapter 484 - Uniform Land Sales Practices Act: include disclosure of specifically defined natural hazards. HRS Chapter 508D Mandatory Seller Disclosures in Real Estate Transactions: Make the mandatory seller disclosure also apply to transactions involving vacant lots.	Medium
ROH Chapter 20 Fire Code: Due to anticipated increases in drought conditions associated with wildfires, the City should utilize maps of historic burn areas as issued in the High Fire Risk Map Zones of the Hawaii Wildfire Management Organization for use in these regulations based on NFPA-1.	Low
Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities. It is recommended that the storm water flood control practices that address requirements for storm runoff quantities for flood control be re-evaluated for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs.	Medium

4.1 Hazard Description

This section on climate variability and change has been incorporated as a separate section of the plan beginning with this 2018 Plan Update. Climate Variability and Climate Change can each can exacerbate and facilitate impacts from other hazards included in this Mitigation Plan.

One reason that this section is separated from the other hazards is to avoid confusion in causality, as the other hazards have occurred independently in accordance with natural periods of climate variability (such as El Nino). The other weather-related hazards addressed in this plan (hurricanes, floods, droughts, high surf, coastal erosion, and wildfires) are associated with seasonal, inter-annual, and decadal cycles of climate variation. Nevertheless, global warming in the long-term climatic changes can lead to increased disaster occurrence rates or increased severity of the events.

In order to address a range of climate risks for the City and County of Honolulu in this mitigation plan, the plan developers and the members of the Honolulu Mitigation Plan Advisory Committee decided to incorporate the discussion of climate change into a separate chapter of the plan that includes discussions of climate variability and change and sea level rise. This chapter enables the City and County of Honolulu to examine the characteristics and science of the climate system, and to consider planning for adaptation to climate-related impacts.

Relative sea level rise is the combination of long-term land subsidence and sea level change. In the Intergovernmental Panel on Climate Change - Fifth Assessment Report of 2013, the ensemble mean estimates of the increasing rates of relative sea level rise are given, which is intended to convey the best estimate of a dozens of climate models and filtering out the outlier extreme results of any individual models. The current rate of Hawaii relative sea level rise data is actually lower than the global rate. Using this information and applying this to Hawaii together with the rate of land subsidence, for the more severe RCP8.5 Representative Carbon Pathway scenario, and assuming no lag between Hawaii and the global rate, a range of 0.5m to 0.67m (1.6 ft. to 2.2 ft.) is indicated at the end of the century. Accordingly, 2 ft. is suggested as the relative sea level rise for Hawaii based on IPCC AR5 and discounting the present lag in measurement.

Changes in Sea Surface Temperatures (SST) and climatic circulation patterns may affect the distribution of storm tracks; thus, the hazard for hurricane wind speeds and storm surge/wave setup inundation may not be stationary over time. Sea level rise (combined with land subsidence of the older islands) can result in shoreline changes and higher apparent sea level (relative to a point on land), and this can exacerbate inundation, especially for low-lying areas subject to hurricanes and high surf. Ambient groundwater in the coastal zone will respond to sea level and tidal fluctuations.

Long-term climate risks from these changes will have significant impacts on the Hawaiian Islands in terms of: changes to ecosystems and shoreline communities. Development choices in combination with these changes will have consequences on the degree of severity and costs associated with future hazard events. Therefore, there should be a basic understanding of the characteristics of climate variability and change to better inform risk management decisions discussed in later chapters.

Climate Variability: El Niño-Southern Oscillation and the Pacific Decadal Oscillation

Climate variability refers to relatively short-term variations in the natural climate system. The climate variations often show in seasonal, inter-annual, and decadal climate in periods that deviate significantly from the "normal" average climate, such as the patterns associated with the El Niño-Southern Oscillation (ENSO) cycle (El Niño, conversely La Niña) or the Pacific Decadal Oscillation (PDO). Numerous resources are available in explaining the phenomena of El Niño-Southern Oscillation, which has significant impacts for the climatology of the islands.

There is a wealth of materials created to provide a concise understanding of climate variability. The following explanations are from the NOAA Pacific Marine Environmental Laboratory website: http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html.

4.1.1 Understanding El Niño

El Niño is an oscillation of the ocean-atmosphere system in the tropical Pacific having important consequences for weather around the globe. In normal, non-El Niño conditions (see Figure 4-1, top panel of schematic diagram), the trade winds blow towards the west across the tropical Pacific. These winds pile up warm surface water in the west Pacific, so that the mean sea surface is actually about 1/2 meter higher on the coast of Indonesia than it is on the coast of Ecuador.

The sea surface temperature is about 8 degrees Celsius higher in the west, with cool temperatures off South America, due to an upwelling of cold water from deeper levels. This cold water is nutrient-rich, supporting high levels of primary productivity, diverse marine ecosystems, and major fisheries. Rainfall is found in rising air over the warmest water, and the east Pacific is relatively dry.

During El Niño (see Figure 4-1, bottom panel of the schematic diagram), the trade winds relax in the central and western Pacific leading to a depression of the thermocline in the eastern Pacific, and an elevation of the thermocline in the west. This results in a rise in sea surface temperature. The weakening of easterly trade winds during El Niño is evident in Figure 4-1 as well. Rainfall follows the warm water eastward. Temperature increases of the surrounding ocean results in a greater number of hotter days during El Niño.

ENSO events vary and are categorized as "strong, moderate, or weak" events. This variation in the strength of the ENSO event means that the impacts that are experienced on land will also vary. Pacific Islands feel the impacts directly as the ocean water around the islands warms and the rainfall patterns change significantly, depending on the geographical position of the island related to the "warm pool" of water. Some islands experience wetter than normal conditions in weak events, but many of the islands become drier than normal. Rainfall decreases can be significant as to precipitate drought, especially in areas that rely on rainfall surface water catchments for the primary water supply. When the cycle moves into La Niña phase, where the water begins to cool, some of the islands experience heavy rainfall and flooding. During periods of climate variability, such as El Niño and La Niña, there are effects that during that period dominate over the longer-term trends in climate change. Accordingly, El Niño is a catalyzing event that multiplies the impacts of various climate phenomena such as heat waves, large ocean waves that approach from

the north and northwest, lack of trade winds, high Sea Surface Temperatures (SST) and coral bleaching, extreme rain, higher than normal sea level and more.

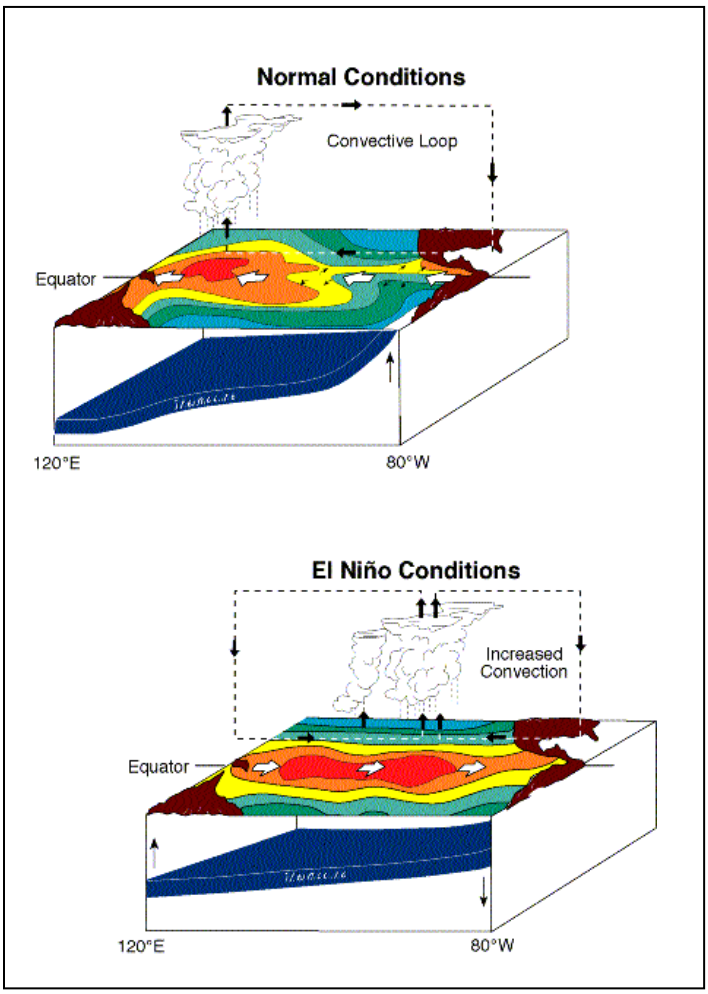


Figure 4-1 Depictions of El Niño Southern Oscillation (ENSO) Warm and Normal in the Cycle[1]

Other significant impacts in the Pacific have been noted as well, including: tropical cyclones generating further east because of the warm waters; sea level variation as thermal expansion from warm water raises sea level and alternatively decreases sea level significantly as the water cools; increased risk of wildfires associated with drought; coastal erosion with changes in sea level and storm impacts; coral reef bleaching (and coral reefs protect islands from waves and storm impacts); loss of plants, agriculture, and degradation of habitat; and, landslides associated with heavy rainfall. Health of many ecosystems, such as the coral reefs that provide shoreline protection, will be compromised and many species will not survive.

Strong El Niño years in Hawai‘i bring more hot days, intense rains, windless days, active hurricane seasons, and spikes in sea surface temperature. During the strong El Niño of 2015, Honolulu set

[1] National Oceanic and Atmospheric Administration, Pacific Marine Environmental Lab, TAO Array, http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html

or tied 25 days of record heat. This compelled the local energy utility to issue emergency public service announcements to curtail escalating air conditioning use that stressed the electrical grid. Oahu has experienced severe drought during ENSO periods (such as affected by changes in the trade winds per Garza, et al. 2012). The changes in rainfall can have ramifications on ecosystem functions and on water supply.

4.1.2 Climate Change Impacts on Society

The following Figure 4-2 comes from the IPCC Fourth Assessment report, which summarizes the anticipated global impacts projected for climate changes associated with the increase in global average surface temperature in the 21st century. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left hand side of text indicates the approximate onset of a given impact associated with global increase in mean annual temperature. The impacts of climate change will vary by extent of adaptation, rate of temperature change, and socio-economic pathway. It generally shows the expected changes to various ecosystems based on increased temperature scenarios up to as much as 5 degrees Celsius; 2 degrees Celsius is considered closer to the "mean" estimate. As Figure 4-2 shows, there are predictions of increased hazards. The graphic also indicates that rising global temperatures in tropical areas will result in decreased water availability.

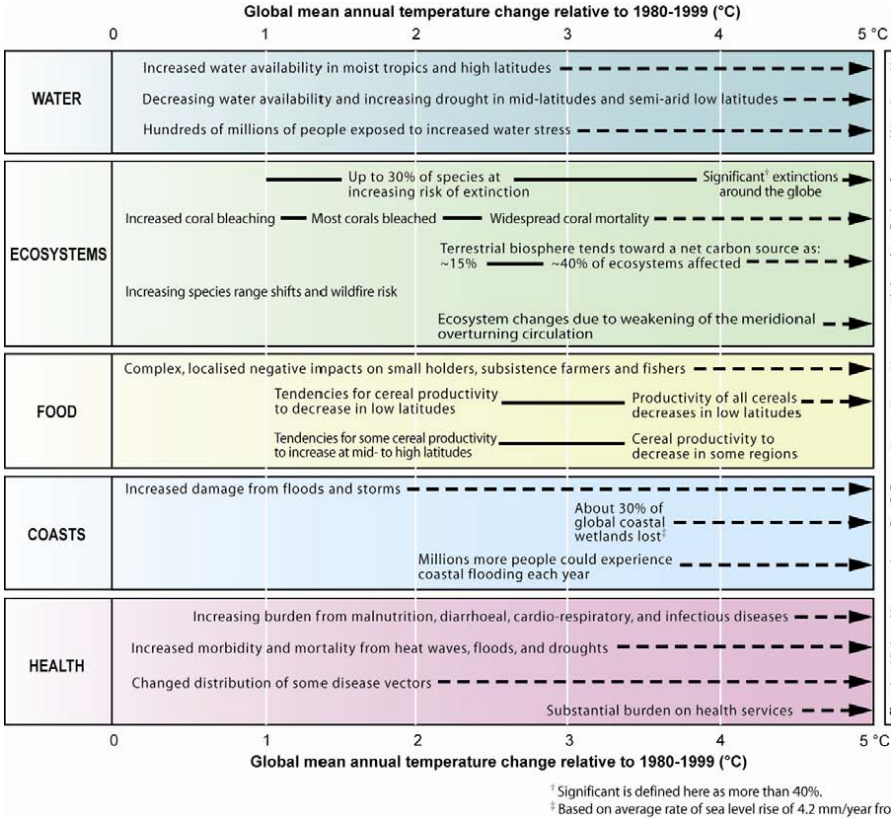


Figure 4-2 Key Impacts as a Function of Increasing Global Average Temperature Change[2]

[2] Climate Change 2007: Impacts, Adaptation and Vulnerability, Summary for Policymakers, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, p.16, April 2007, accessed from http://www.ipcc.ch/

4.2 Anticipated Future Coastal Hazard and Climate Impacts to the City and County of Honolulu

Climate change can be summarized as including the following potentially adverse effects:

i. Sea level rise and increasing rates of beach erosion
ii. Groundwater rise
iii. Sea Surface Temperatures increasing with more frequent Central Pacific El Nino Southern Oscillation (ENSO) events and increased tropical cyclone activity
iv. Inundation / flooding from storms and tropical cyclones
v. Increase in the number of unusually warm days
vi. More severe and longer drought periods due to reduced annual rainfall following a documented drier climate trend for Hawaii; rainfall as affected by the duration of ENSO episodes

An illustration of climate changes in temperature distributions affecting the frequency of extreme weather conditions is shown in Figure 4-3 for the example of temperature. (IPCC (2012): Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.) Change can take the form of a shift of the entire distribution, and change in the variability of the distribution, or a change in the frequency distribution of the weather metric itself.

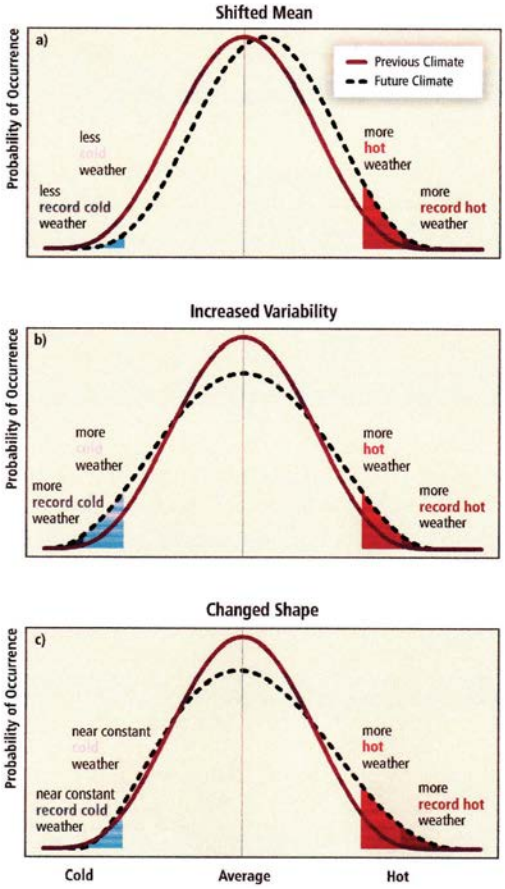


Figure 4-3. Illustration of Various Modes of Climate Change Resulting in a Greater Frequency of Extreme Conditions

In the Pacific Ocean, the frequency of intense El Niño events is projected to double in the 21st century, with the likelihood of extreme events increasing to roughly once every decade. Models project a near doubling in the frequency of future extreme La Niña events, from one in every 23 years to one in every 13 years. Approximately 75% of the increase occurs in years following extreme El Niño events, thus projecting more frequent swings between opposite extremes from one year to the next (Cai, et al., 2017).

Effects i. through iv. are pertinent to the vulnerability of buildings and their foundations located in the coastal zone. These climate change impacts are also of potential relevance to state and county design standards to include stormwater and wastewater infrastructure, flood control infrastructure, coastal zone utility vulnerability, coastal transportation infrastructure, and port and harbor operations.

Effect v., i.e., warming air temperatures, lead to heat waves, expanded pathogen ranges and invasive species, thermal stress for native flora and fauna, increased electricity demand, increased wildfire, potential threats to human health, and increased evaporation which both reduces water supply and increases demand.

Effect vi. may be pertinent to, water availability, water demand, and reductions in agricultural and ranching productivity, but it does not create an increased vulnerability of the building stock or infrastructure itself. Rapid warming at highest elevations impedes precipitation, the source of Hawaii's freshwater. It may require the implementation of water conservation requirements.

In Hawai‘i, the rate of warming air temperature has increased in recent decades. Currently, the air is warming at 0.3^{o}F (0.17^{o}C) per decade, four times faster than half a century ago (Giambelluca, et al., 2008). Statewide, average air temperature has risen by 0.76°F (0.42^{o}C) over the past 100 years, and 2015 and 2016 were the warmest years on record (Mckenzie, et al., 2016). *Some model projections for the late 21st century* indicate that surface air temperature over land will increase 1.8^{o} to 7.2^{o}F (2° to 4°C) with the greatest warming at the highest elevations and on leeward sides of the major islands (Zhang, et al., 2016).

Models indicate that the primary environmental responses to Radiative Forcing are, per Figure 4-4:

- Increasing ocean temperatures, which results in Sea Level Rise due to thermal expansion.
- Melting of glaciers (on land)
- Greenland and Antarctic land-ice sheets and Arctic floating ice sheets are not high contributors to sea level rise, according to the IPCC

This effect is not uniform and regional relative sea level rise must be considered. However, predictive climate models are admittedly subject to much uncertainty and much variation between numerous models. Therefore, usually an ensemble mean of model results is used as an estimate (such as presented by the IPCC assessments), or a range of the likely values (i.e., more than a 66% likelihood of realization) is considered.

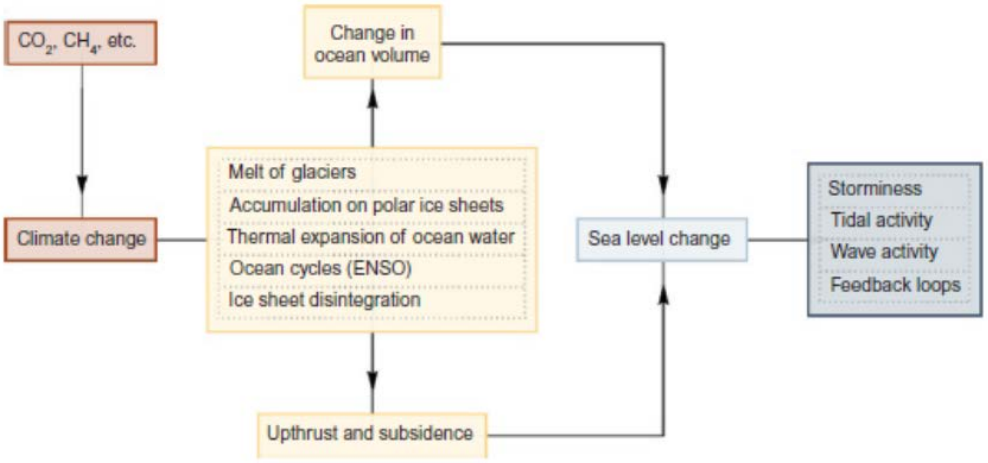


Figure 4-4. Relative Sea Level Change Factors

4.3 Historical Relative Sea Level Rise

NOAA has collected sea level data for over a century in Honolulu Harbor and reports such data on their publicly available website. There is a second data gathering station on the Windward side at Mokuoloe which gives very similar results to the data from Honolulu. According to their data, the Honolulu relative sea level trend is 1.48 millimeters/year with a 95% confidence interval of +/- 0.21 mm/yr based on monthly mean sea level data from 1905 to 2017. This is equivalent to a change of 0.49 feet in 100 years. The slope of the lines of Figure 4-5 indicates the rate of change in sea level, which is roughly constant (Please note that the graph displays the actual change in water level, not the change in rate of sea level rise). This historical data does not show an acceleration in the rate of sea level rise.

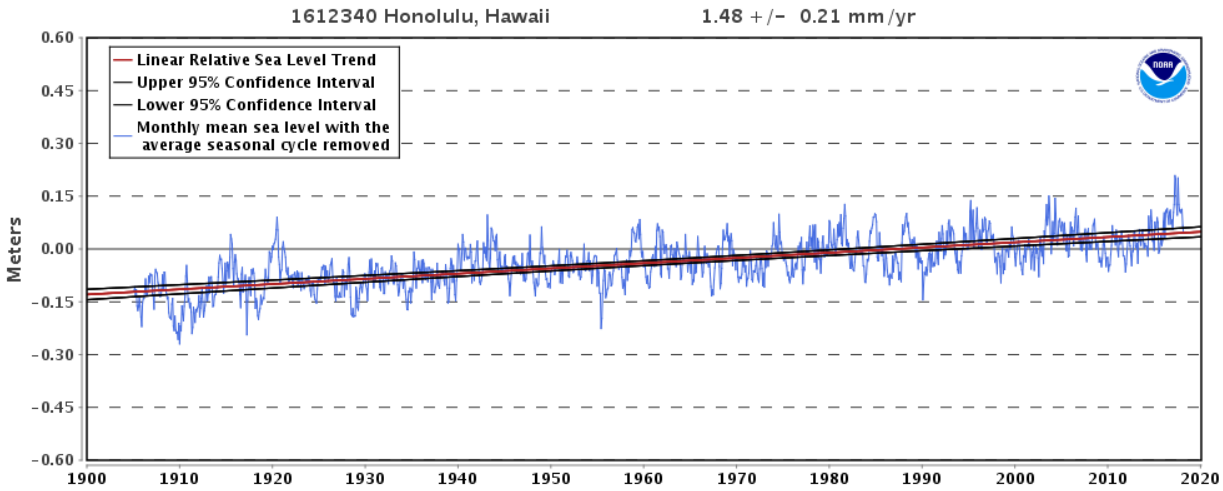


Figure 4-5. NOAA Graph of Sea Level Trends for Honolulu (NOAA Tides and Currents Website, 5/23/18, https://tidesandcurrents.noaa.gov/map/index.shtml?region=Hawaii)

4.4 Anticipated Sea Level Rise for Hawaii

Future sea level rise estimates for the Hawaii region of the Central Pacific are based on model simulations. In the Intergovernmental Panel on Climate Change - Fifth Assessment Report of 2013, The Physical Science Basis, Chapter 13 Sea Level Change (Church, et. al., 2013), the ensemble mean estimates of the increasing rates of relative sea level rise are given. Using this information and applying this to Hawaii together with the rate of land subsidence, a range of ensemble estimates can be calculated for the two more severe Representative Carbon Pathways (RCP), scenarios 6.0 and 8.5.

Future sea levels can be estimated starting from the published rate of Hawaii relative sea level rise, which is lower than the global rate, or for an upper bound of this parameter, assuming that the local rate in the Hawaii region would not lag behind the global rate (even if this assumption is actually contrary to the historical data trend up to 2017). Recent studies (Kopp et al., 2015; Slangen et al., 2014; Sweet et al., 2017) would indicate that global SLR rates could become 0.3–0.5m higher within the Hawaiian Islands under an intermediate high scenario (1.5m global mean SLR by the year 2100) eventually due to static equilibrium effects (Sweet et al., 2017). That is suggesting that future RSL rise could be amplified in Hawaii and other Pacific islands by static-equilibrium effects, because they are in the far field of all sources of melting land ice.

Figures 4-6 and 4-7 show the results of variations of the present sea level rise rate and the RCP6.0 and RCP8.5 carbon pathway scenarios. For the more severe RCP8.5, a range of 0.5m to 0.67m (1.6 ft. to 2.2 ft.) is indicated. Applying this to Hawaii together with the rate of land subsidence, a range of ensemble estimates can be calculated for the two more severe Representative Carbon Pathways (RCP), scenarios 6.0 and 8.5. The State of Hawaii Sea Level Rise Report utilizes the modeling available from the IPCC without accounting for any lag and therefore estimates that Hawaii could experience as much as 3.2 ft. of SLR by 2100.

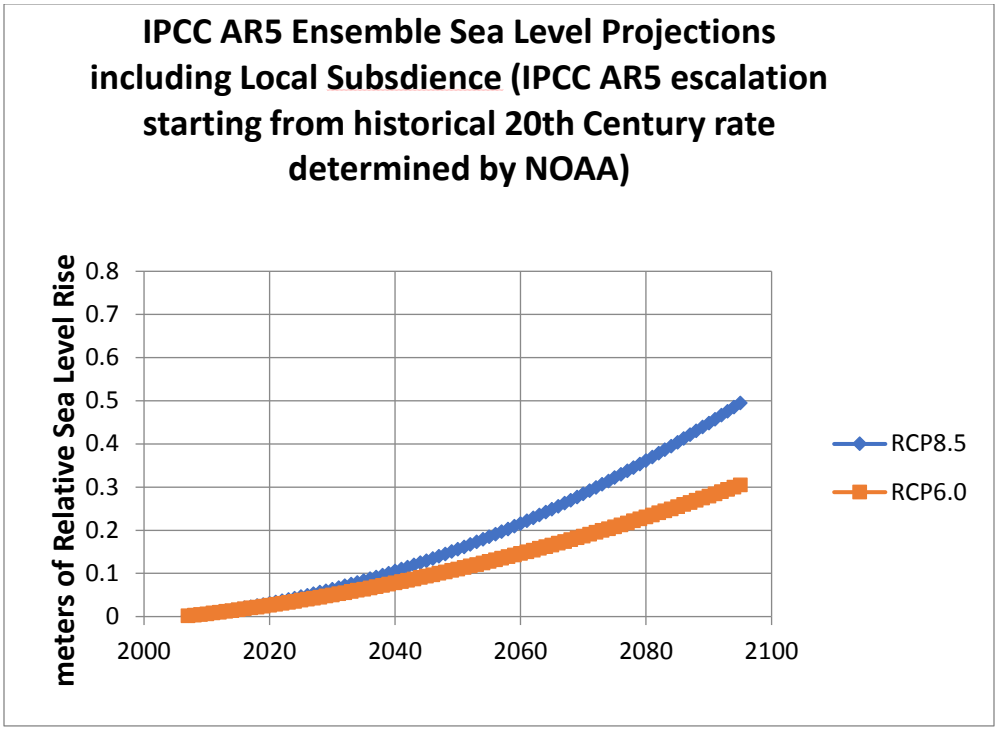


Figure 4-6. Estimate of Relative Sea Level Rise for Hawaii with RCP 6.0 and RCP 8.5, assuming the present local relative sea level rise rate is the value given in the NOAA literature based on empirical 20th century data (which lags the estimated global rate of sea level rise)

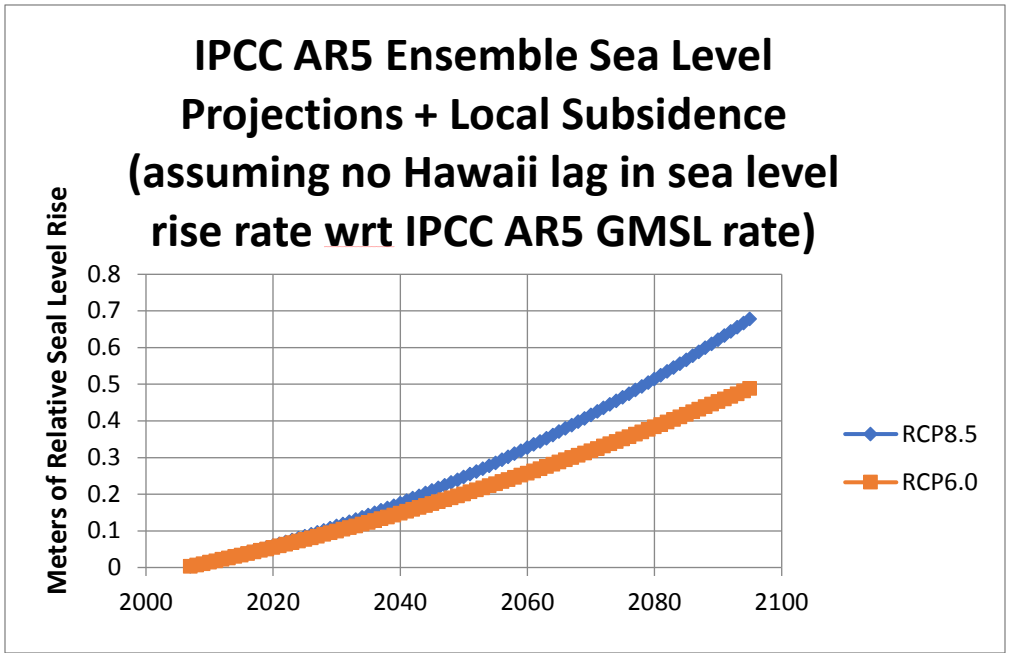


Figure 4-7. Estimate of Relative Sea Level Rise for Hawaii with RCP 6.0 and RCP 8.5, discounting the present local relative sea level rise rate lag with respect to the IPCC global estimated rate

4.5 Estimating Changes in Tropical Cyclone Activity

Particularly relevant to building and infrastructure planning and design are the effects of sea level rise and the effects on tropical cyclone activity. These effects can result in increases in coastal inundation and wind hazard levels from storms and tropical cyclones, and flooding from the associated intense rainfall, which could reduce the disaster resilience of coastal infrastructure and development unless adaptive measures are implemented in future design standards.

Changes in Sea Surface Temperatures (SST) and climatic circulation patterns may affect the distribution of storm tracks; thus, the hazard for hurricane windspeeds and storm surge/wave setup inundation may not be stationary over time. Sea level rise (combined with land subsidence of the older islands) can result in shoreline changes and higher apparent sea level (relative to a point on land), and this can exacerbate inundation, especially for low-lying areas subject to hurricanes.

Recently, downscaling of the improved Coupled Model Intercomparison Project 5 (CMIP5) global climate models indicated increased tropical cyclone activity in the Pacific, but with less severe change in the Central Pacific than previously postulated. Emanuel (2013) modeled the potential hurricanes as initiated through random space-time seeding across the world's tropical oceans based on the Genesis Potential Index. A global climate model provides the ambient weather to determine the storm evolution from each seed. From Emanuel's recent work, it is now possible to obtain stochastic simulations of tropical cyclone tracks based on downscaled CMIP5 global climate models that have improved modeling of ENSO and Pacific Decadal Oscillation cycles (Bellenger, et. al., 2013). The sea surface temperature increase due to climate change can degrade the natural

storm inhibitor of colder waters around Hawaii and impacts the storm pattern in the subtropics. The results show a shift of the future storms toward the Hawaiian Islands with more northerly headings. In a subsequent section, we discuss how these new models can provide insight into storm surge hazard mapping for regulatory use including the effect of climate change. The change in cyclone track density is shown in Figure 4-8 (from Emanuel, 2013).

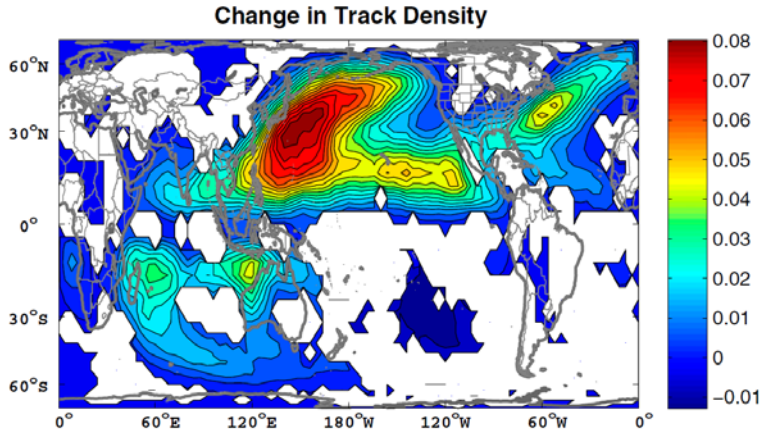


Fig. 2. Change in track density, measured in number of events per 4° × 4° grid box per year, averaged over the six models. The change is the average over the period 2006–2100 minus the average over 1950–2005. The white regions are where fewer than five of the six models agree on the sign of the change.

Figure 4-8. Change in Tropical Cyclone Track Density per a Suite of CIMP5 models (Emanuel, 2013)

4.6 Vulnerability and Potential Losses from Climate Change

Based on results of IPCC AR5 (2013), there has been increased attention to quantifying and understanding risk and vulnerability. The problem has been that risks and vulnerability will vary by type of impact and sector, and the degree or extent of the impacts is still uncertain, which makes quantification of costs difficult.

4.7 Costs from Climate-Related Disasters

The costs can be projected from looking at an accumulation of impacts and costs from past climate disasters. These include extreme climate events, such as tropical storms and high winds, floods, drought, wildfire, coastal inundation, landslides, and erosion. During periods of ENSO, there are likely to be impacts from several events together. For example, during El Niño, Hawai‘i is prone to increased likelihood of drought, wildfires, and tropical storms. As the cycle shifts to La Niña extremes, there were severe flooding events, prior to recovery from disasters occurring in the previous year. In the list of worst disasters in Hawai‘i, all of the climate events occurred during ENSO periods. The Kīholo Earthquake occurred just prior to an El Nino drought, and it had damaged irrigation infrastructure, demonstrating how the accumulation of events close to each other can exacerbate impacts and lead to additional disasters if there has not been recovery.

4.8 Costs from Sea Level Rise

Low-lying areas of the coast can expect serious flooding as rising seas push up the water table, creating an effect called "groundwater inundation." As indicated in a report by Kolja Rotzoll (postdoctoral researcher at the University of Hawai'i Water Resources Research Center) and Charles H. Fletcher (Associate Dean of the University of Hawai'i School of Ocean and Earth Science and Technology), taking the City and County of Honolulu as an example, sea level rise will lift the island of O'ahu's aquifer, a lens of fresh water that rests atop seawater in a complex of underground sedimentary deposits that range from porous limestone to less permeable alluvium or caprock. The water table will eventually break out above the land surface, "creating new wetlands and expanding others, changing surface drainage, saturating the soil, and inundating the land depending on local topography." Rotzoll and Fletcher further state that "Flooding will start sporadically but will be especially intense seasonally when high tide coincides with rainfall." Of the flooded area, 58% is attributable to groundwater rather than seawater. All that won't happen for several decades, (Rotzoll and Fletcher, 2013).

In addition to the extensive built environment, including public facilities and residences, the coastal areas of the island have extensive critical infrastructure. Coastal highways are worth billions that may be at risk in sections because they can be cut off and that also add to costs if damaged. Moreover, water lines, sewer lines, and utilities follow the path of coastal highways.

According to the State of Hawai'i Sea Level Rise Vulnerability and Adaptation Report, Oahu will incur the most significant economic losses to sea level rise in the state. As the island with the largest financial contributions to the state and the island with the most residents in coastal regions, Oahu is very susceptible to the effects of sea level rise. With 3.2 ft. of sea level rise, the island is expected to lose an estimated $12.9B from structure and land loss alone. Those land losses would displace roughly 13,300 residents in coastal areas, incurring even greater economic losses and decreasing available housing. The report details that with 3.2 ft. of sea level rise, flooding would occur in 3,880 structures and 17.7 miles of major roads.

The SLR report did not look at water resource management, public safety and infrastructure, public health, agriculture, tourism, and coastal and marine ecosystems, but they are areas where island environments are particularly vulnerable to the impacts. Each of these areas could lead to substantial economic costs in addition to increasing vulnerability of certain populations that may be living at the poverty line. There needs to be more assessment and quantification of risks to understand the full range of costs.

The SLR report had an associated Sea Level Rise Viewer, used for visualizing the impacts of SLR: http://www.pacioos.hawaii.edu/shoreline/slr-hawaii/. The area highlighted in blue composes the estimated 2.0 ft. Sea Level Rise Exposure Area (SLR-XA) zone, which is described as the superposition of several hazards affected by SLR in Figure 4-9. The SLR Viewer also has options to view Potential Economic Loss, Flooded Highways, and a variety of useful area overlays.

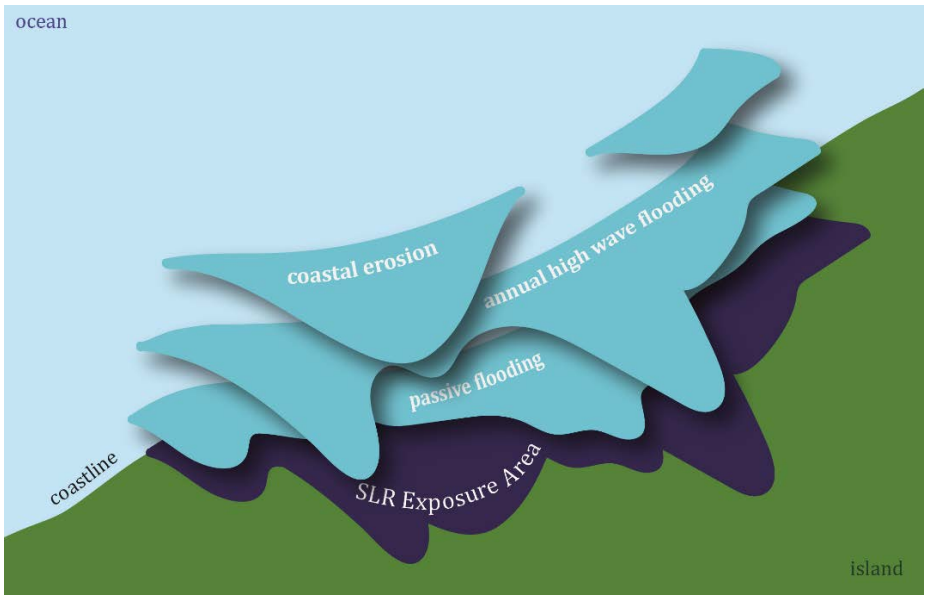


Figure 4-9. Visual explanation of the SLR-XA



Figure 4-10. 2.0 ft. SLR model from Sea Level Rise Viewer for Haleiwa-North Shore area

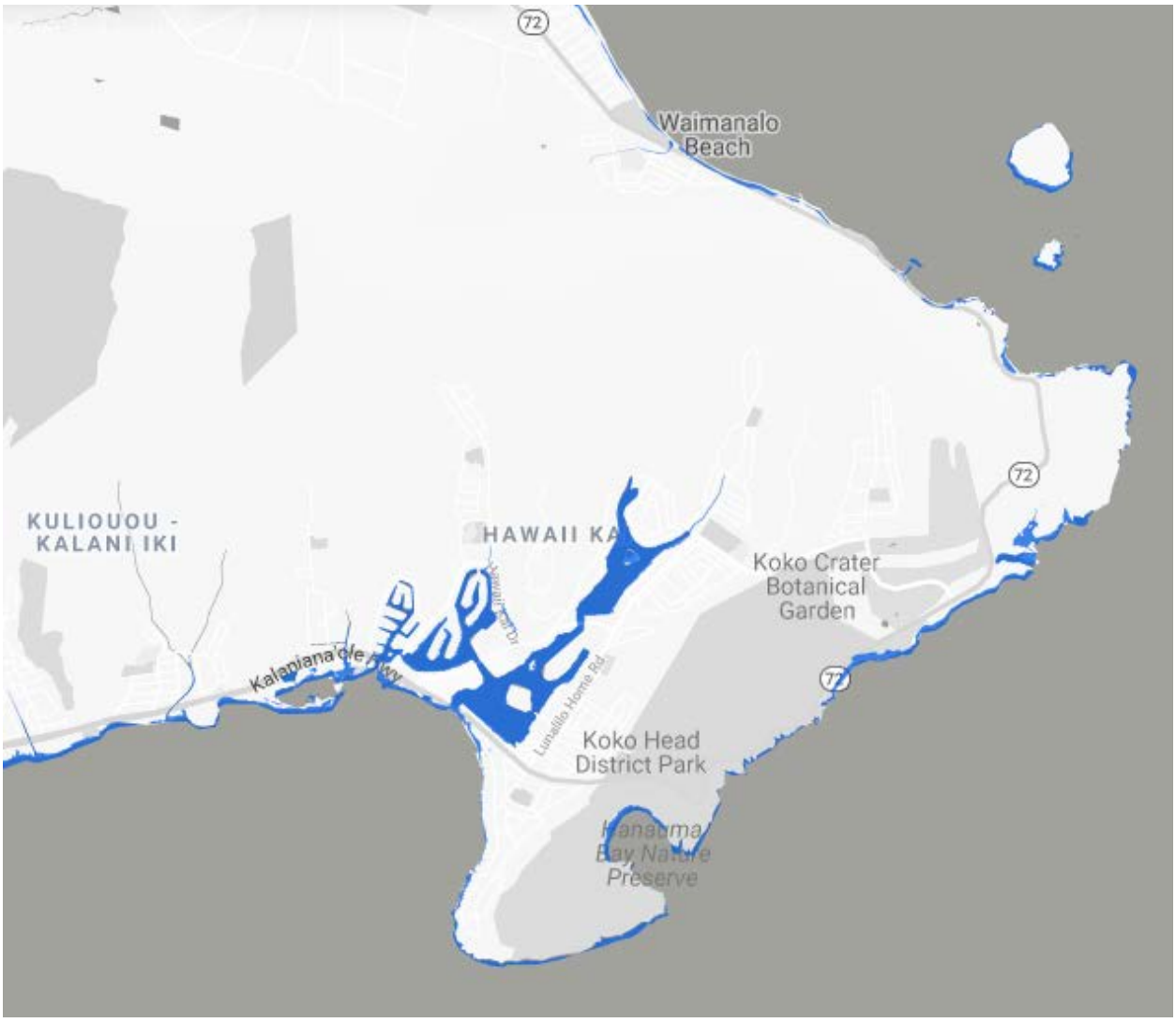


Figure 4-11. 2.0 ft. SLR model from Sea Level Rise Viewer for Eastern Oahu

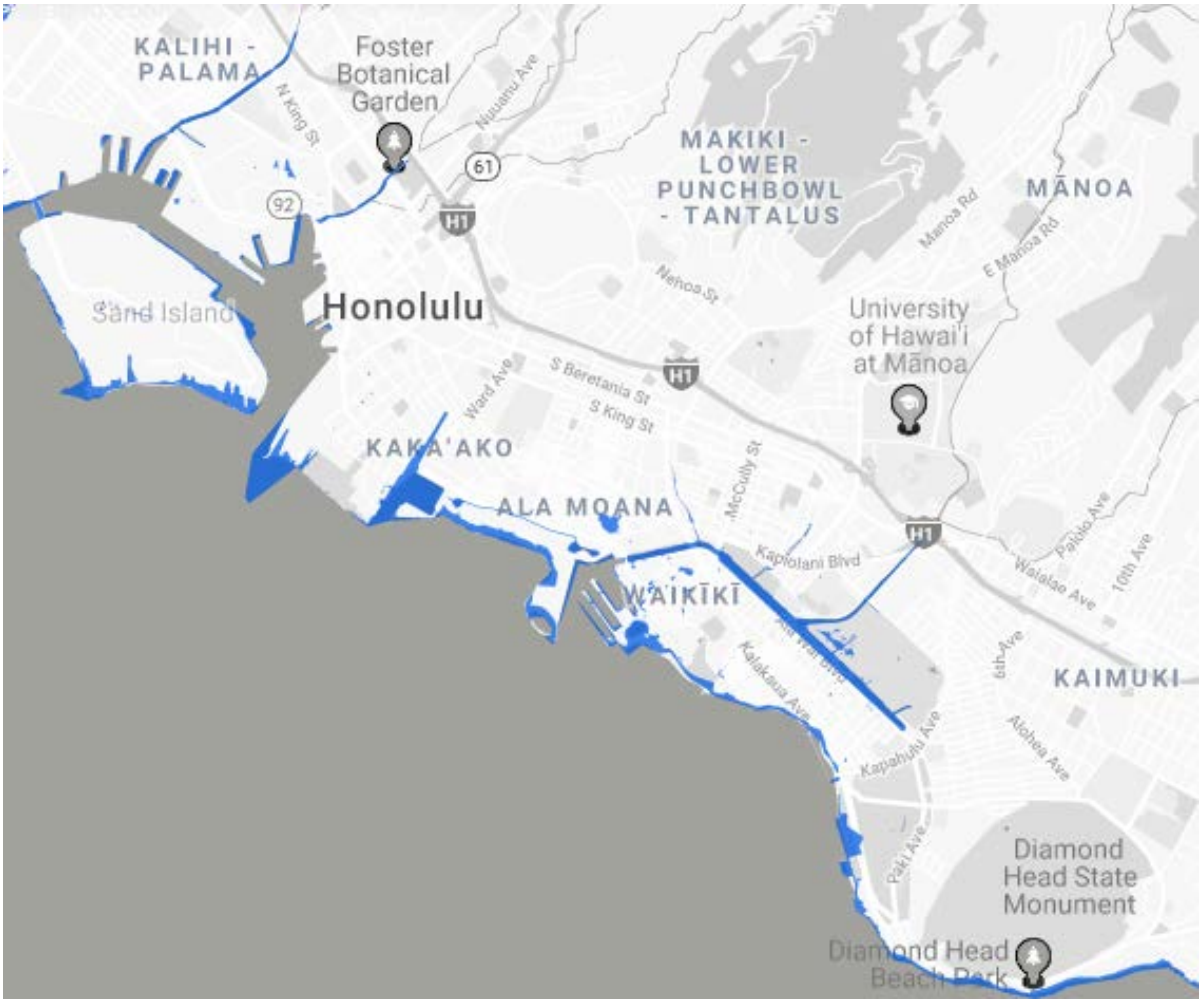


Figure 4-12. 2.0 ft. SLR model from Sea Level Rise Viewer for Kalihi-Diamond Head area

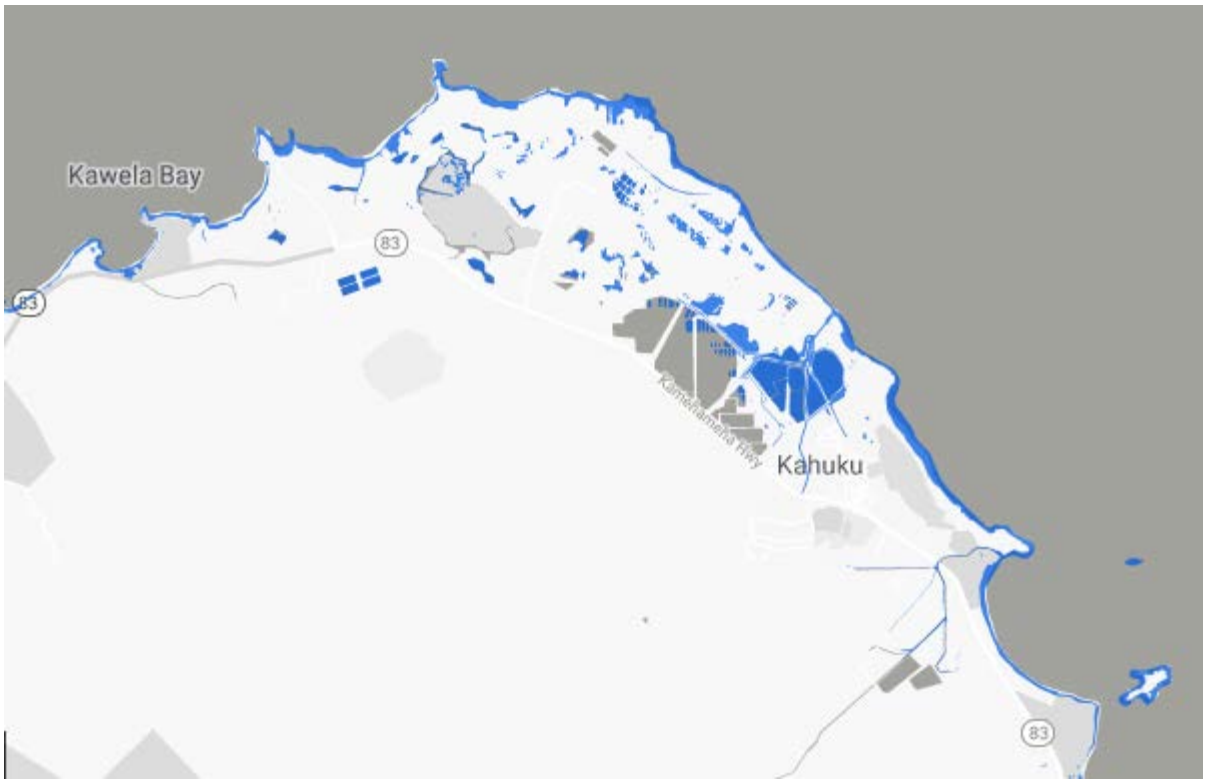


Figure 4-13. 2.0 ft. SLR model from Sea Level Rise Viewer for Kahuku

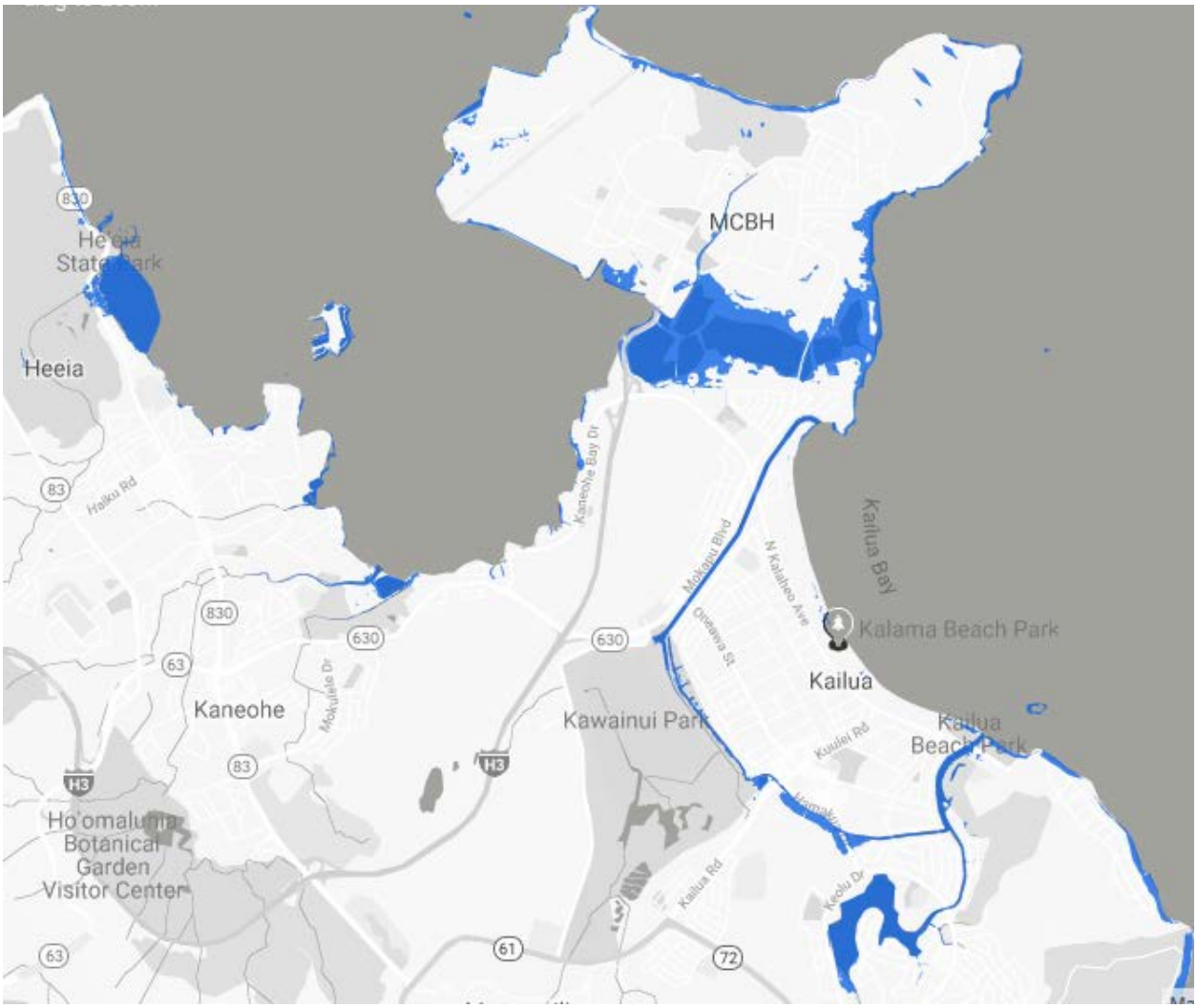


Figure 4-14. 2.0 ft. SLR model from Sea Level Rise Viewer for Kailua-Kaneohe area



Figure 4-15. 2.0 ft. SLR model from Sea Level Rise Viewer for Airport area

As shown by Figure 4-15, the coastal airports and harbor infrastructure are also especially at risk. In the 2010 structural risk and vulnerability assessment, damage from hurricanes (even 16% damage) to the Honolulu International Airport results in the greatest total damage costs ($320 million). Kahului Airport on the island of Maui shows a loss of $11.6 million with less than 10% damage. Most of the airports have been located near the ocean and will be impacted by sea level rise. Relocating airports in places that have little land for developing is not necessarily an option.

Martin & Chock, Inc. (Chock, 2018 and Li, N. et al., 2018) performed a risk analysis to assess the inventory of buildings and structures in Honolulu that would be exposed to increased flood risks due to climate change. This was done for the Kakaako-Waikiki coastal area of the pilot study. City Property Tax records and the National Structure Inventory database were used to compile information on building occupancy, size, height, and valuations, and geocoded to location (TMK properties). The aforementioned flood inundation modeling results with water elevations were produced in GIS layers, and the water depths determined by normalizing the data by the topographic digital elevation model layer. Then, documentation on flood depth-damage curves (previously compiled in the FEMA HAZUS software) were extracted and converted to loss functions in GIS. With these steps, the structural and nonstructural damages were calculated for each property based on the inundation depth for the storm scenarios of interest. The number of affected properties were also determined for each occupancy.

Under the following scenarios depicted in the view of the south shore of O‘ahu, including Waikīkī. In Figure 4-16 and 4-17, the City would suffer severe economic losses from sustained sea level rise. The following scenarios were used to compute flood losses:

1. The expected 500-year flood depths for climate conditions at the end of the century, with consideration of 2 ft. sea level rise, for all properties affected.
2. The expected 500-year flood depths for climate conditions at the end of the century, without consideration of any sea level rise, for all properties affected.

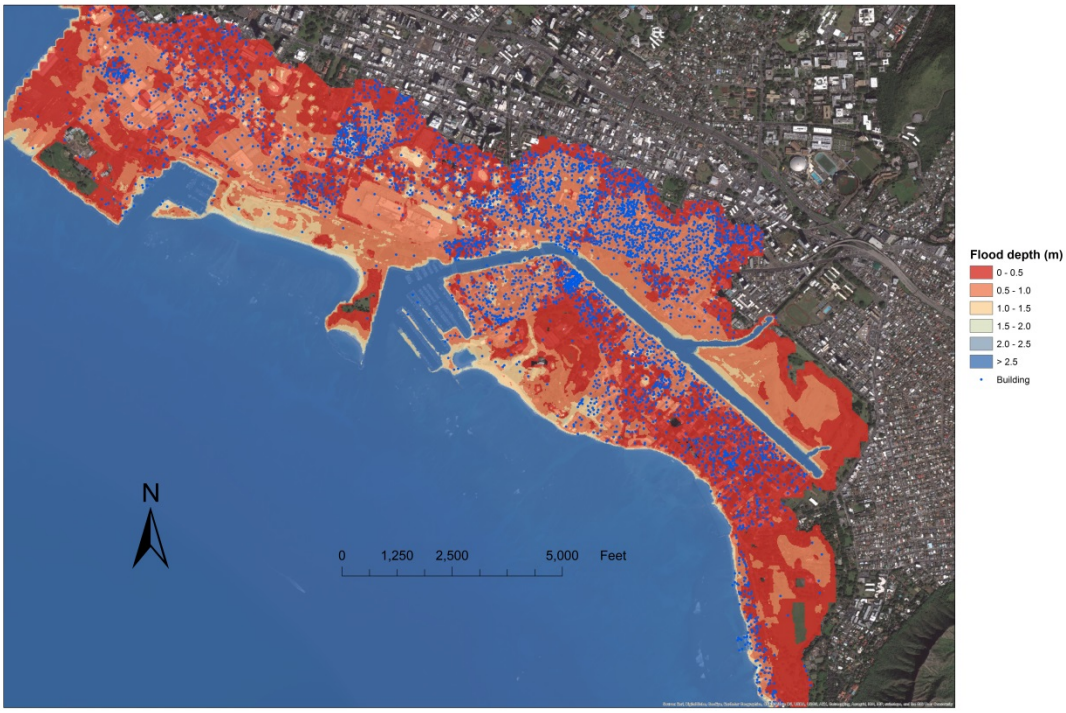


Figure 4 -16. 500-year flood depths and the 5264 properties affected by climate change and sea level rise



Figure 4 -17. 500-year flood depths and the 3053 properties affected by climate change but if sea level unchanged

The effect of climate change and sea level rise increases the future expected hurricane flooding damage in Waikiki to Kakaako from $ 0.76 Billion to $3.623 Billion, or about a 475% increase.

- The sea level rise contribution to the future expected hurricane flooding damage in Waikiki to Kakaako is responsible for about 75% of the future total losses. That is, the

total losses from hurricane flooding due to climatic shift in hurricane hazard and sea level rise are four times that of a similar hurricane hazard today without sea level rise.

- Due to sea level rise alone, about 1,750 additional properties become affected by hurricane flooding; almost all of these are not presently in the FEMA flood zones (and therefore presently not required to be insured). Future Losses are $1.228B in this new area of flooding, with an aggregate Average Annualized Loss of $2.46M. This is the primary contributor to increased losses that are not presently mitigated by the flood ordinance.
- The increased flooding does not result directly from coastal wave set-up and runup, but in this area occurs primarily due to overtopping of the Ala Wai Canal embankments and its tributary. The combined surge and waves give rise to considerable flow depth and speed that might be damaging to infrastructure near the shore. These short-period waves, however, do not supply sufficient floodwater to produce substantial inland flows. Therefore, mitigation of the increased flooding extent would need to include the Ala Wai Canal.
- Increased losses from a major hurricane with climate change compounded by sea level rise are approximately the following per building in the flooded area:
    - Residential $380,000 but this average is dominated by multi-unit buildings, not single family residences
    - Commercial $410,000 – this figure is dominated by the retail sector
    - Industrial $210,000 – this figure is dominated by food processing
    - Government $715,000 - this figure is dominated by government offices and emergency services
    - Religious $300,000
    - Education $1,430,000 - this figure is dominated by Grade Schools and community colleges
    - Agricultural $95,000
- The Average Annualized Loss per larger residential, retail, professional service office buildings, hospitals and medical clinics, government buildings and emergency services, and schools and colleges exceeds $1,500 per building. Flood damage to contents is about more than 30% of the total losses for these types of buildings. Average total losses (structural and contents) per building for future climatic conditions are generally at least double the losses that would occur without the sea level rise effect on flooding.
- All the above losses suggest that some mitigation of sea level rise could result more stringent requirements for the above occupancy types. Applying a 30-year financing model with an interest rate of 4% to fund the additional project costs, given that the annualized loss is about $2,200 per property, a $475,000/property present day investment on average for these larger buildings would be justified on a break even basis to mitigate damage. For government and infrastructure projects with much longer functional lifespan requirements, the investment for sea level rise would be applicable for projects in current planning.

- However, investment costs for climate change effects (primarily sea level rise) could also be justified to be deferred for properties with an economic lifespan (or payoff period of investment) of less than 50 years, i.e., low-rise single family residential properties. This deferrable period would be economically arguable because the increased risk occurs only after sea levels rise approximately 2 ft., and would not exist to nearly the same extent under present day sea levels.
- A risk transfer approach to the increased flooding of single family residential properties would justify additional insurance basis annual costs of only about $100, plus the insurance company's costs and return on investment. If the results of this study are considered by the insurance industry, this nominal increase for single family residential buildings should not presently warrant cost concerns about disclosure considerations for low-rise residential properties in the area of flood zones that include climate change effects.

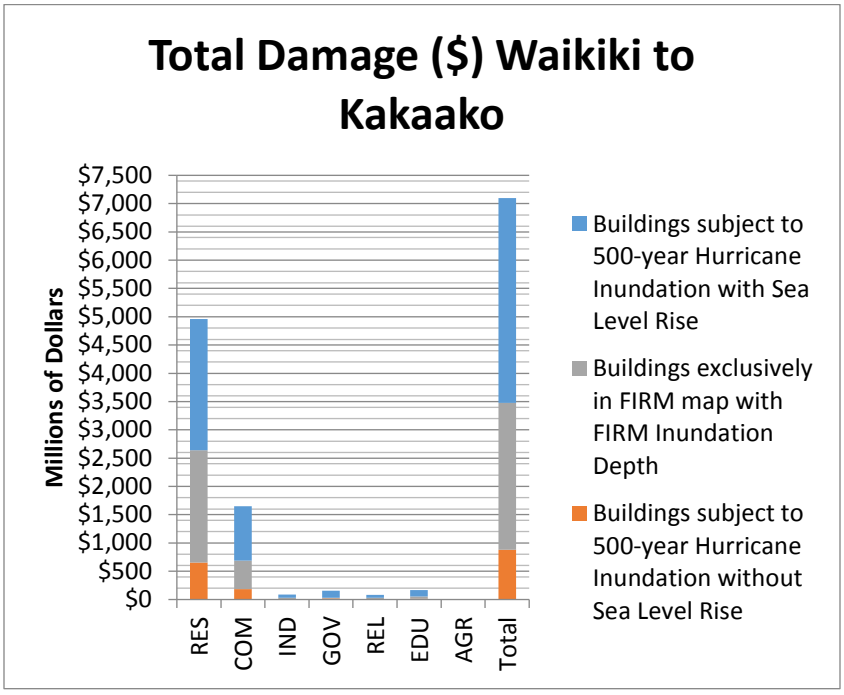


Figure 4-18. Total Damage from Storm Inundation to Buildings from Waikiki to Kakaako

4.9 Adapting Building Construction and Civil Infrastructure to Climate Change

Climate change adaptation measures take the projected climate change effects into account in future regulations. They can be characterized by the following concepts:

Accommodation of sea level rise (some of these have been implemented, depending on the jurisdiction)

- Increased setbacks within existing parcels
- Codes and design standards for siting, elevation, building structures and systems

- Alteration / Retrofitting to mitigate flooding and erosion
- Post-disaster redevelopment
- Stream levees and government flood control projects
- Pumps and tidal gates for short-term mitigation of high tide events

Protection of existing development (all of these have been done in various situations)

- Coastal seawall armoring to defend existing property at the expense of public beaches
- Beach and dune restoration – sand replenishment from offshore
- Dune Vegetation (sometimes done as a defacto change to shoreline extent)
- Groins and breakwaters to lessen wave erosion

Retreat (hypothetical considerations of possible adaptive risk reduction mechanisms)

- Acquisition of repetitive loss properties
- Acquisition of easements
- Increased zoning restrictions in the coastal zone to prohibit larger developments
- Transferable development rights/land swapping

Risk Transfer

- Flood insurance
- Litigation for economic compensation for harmful effects/damages/loss of property value

Application of climate change adaptation could be considered in the following sectors:

- Buildings and other structures (buildings of all types and structural aspects of other infrastructure)
- Transportation networks (highways, bridges, culverts, airports, ports, fuel supply)
- Water resources (flood control and risk management, dams, levees, reservoir management, irrigation systems, drought management)
- Urban water systems (storm water systems, water supply, and wastewater systems)
- Coastal management (erosion, seawalls, groins, dredging)
- Energy supply (power distribution, solar and wind power, thermal plant cooling)

4.10 Adaptive Engineering

Adaptive Engineering is the approach to include future flexibility in the design of facilities without incurring excessive costs prior to the time when features for climate change are necessary (i.e., it is a low regret adaptive strategy in which expenditures have a higher probability of public benefit despite the uncertainty in future scenarios) (ASCE, 2018):

1. Design to the most probable (not the worst case) climate conditions expected within the lifespan of the facility
2. Incorporate the design capability to make further alterations to adapt to greater climate change effects as observations indicate to be necessary.
3. This recognizes the high uncertainty of modeling and enables the cost of adaptation to be incrementally paid over time.

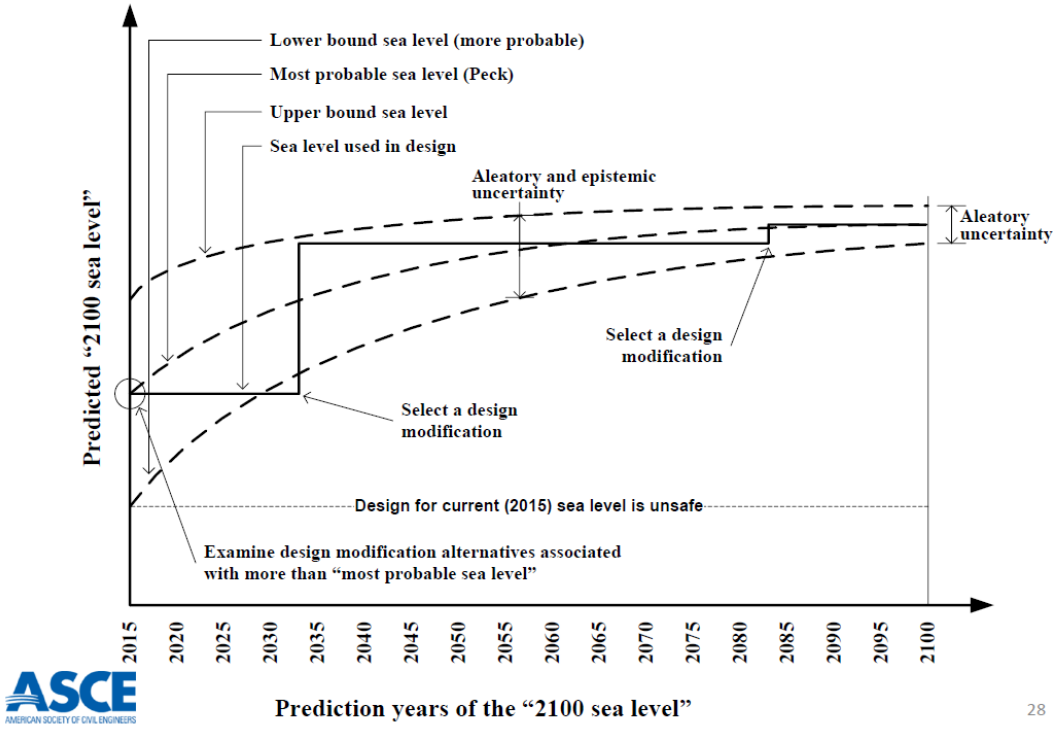


Figure 4-19. Illustration of an Adaptive Engineering Process (ASCE, 2015)

Besides natural hazards, there are various sources of change and uncertainty of knowledge that are already recognized to impact the functionality of infrastructure, such as changes in demand, changes in technology and services, land use development, population changes, and development in the coastal zone. Over the course of time after initial construction, a facility may be renovated, expanded, or realigned to adapt to these changes. Recognizing the effect of climate change on a facility has an analogous impact on future suitability for use. Engineering standards would then need to be revised to account for the uncertainty of a changing climate. Greater variability results in a higher frequency of extreme conditions that engineering standards are meant to mitigate. For example, the standard 100-year (1% annual chance of exceedance) flood may actually have much more frequency in the future. Also, rainfall intensity maps used to design roof and site drainage may need to be revised.

If climate change impacts can also be evaluated for a consistent probability of occurrence, it then becomes a parameter of hazard intensity that can included in engineering design standards. When climate change effects enter into design requirements, then an economic incentive is created for responding to climate change in planning, siting, and construction. Then, there will be an economic investment in the cost of increased resilience to offset the economic consequences of failures to adequately perform their function, loss due to damage, loss of marketability, or even failures of life safety. That is, rational economic analysis would become a tool of climate change adaptation, rather than solely by measures of regulatory prohibition. Adaptive designs that are more resilient would be seen as acceptable as opposed to zoning restrictions that affect entitlements of use.

4.11 Mitigation Strategies

4.11.1 Carbon Footprint Reduction

The state and city are engaging in many measures to reduce their carbon emissions, below are some examples:

- Acts effective since July 1, 2018:
  - Act 15 – Established the goal for Hawaii to be carbon-neutral by 2045 and created the Greenhouse Gas Sequestration Task Force
  - Act 16 – Established the beginnings of a carbon credit program
  - Act 17 – Established the requirement for Environmental Impact Statements and Environmental Assessments to consider the effects of sea level rise
- State has set standards for energy efficient electrical production
- HECO is decommissioning inefficient power generation systems
- HECO is now utilizing solar and wind farms for renewable energy
  - In 2017, 21% of HECO power came from renewable sources
- More solar and wind farms are being built
  - 3 new solar farms are expected to be operational by mid-2019 in Mililani, Waialua, and Waipio
  - An additional 8 turbines are approved, bringing the total in Kahuku to 20
- Increased bike lanes around Oahu
- Electric buses are being tested to eventually replace some of the current buses
- Creation of the Office of Climate Change, Sustainability and Resiliency
  - The office is tasked with seeking local information from scientists and tracking climate change science and potential impacts on city facilities, coordinating actions and policies of departments within the city to increase community preparedness, protecting economic activity, protect the coastal areas and beaches, and developing resilient infrastructure in response to the effects from climate change.

4.11.2 O‘ahu Metropolitan Planning Organization: Transportation Asset and Climate Change Risk Assessment Project

The O‘ahu Metropolitan Planning Organization[3] (O‘ahuMPO) was selected by the Federal Highway Administration (FHWA) as one of five pilots nationwide to perform and evaluate a risk assessment of climate change on important transportation assets. The report, which was completed on November 2011 by SSFM International for O‘ahuMPO, addresses the vulnerability and impact of specific transportation assets to climate change. The report is based on the following framework:[4]

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[3] O‘ahuMPO was created by State of Hawai‘i Legislature in 1975 as a response to the Federal Surface Transportation Assistance Act of 1973 which required the formation of a metropolitan planning organization (MPO) for any urbanized area with a population greater than 50,000. The federal level mandate was based on the need to ensure that existing and future expenditures for transportation projects and programs were based on a comprehensive, cooperative, and continuing planning process.

[4] SSFM International, Transportation Asset Climate Change Risk Assessment, O‘ahu Metropolitan Planning Organization, November 2011, p.1-2

1. Understand climate change factors as they apply specifically to O‘ahu and, more generally, to island environments in the Pacific Ocean, over time. Given the climate data available and the evolving state of climate science understanding, the years 2050 and 2100 were defined as the time horizons for considerations. A baseline of 1970-2000 was set as the measure against which future years’ impacts would be evaluated.

2. Conducted a two-day workshop to bring together both the climate science community and key planners and engineers from the City and County of Honolulu, State of Hawai‘i, FHWA, and private industry to identify asset of transportation assets that may be particularly at risk due to climate change. The outcome of this workshop established a total of five assets that – if impacted adversely by climate change – have potentially high socioeconomic consequences to the island do O‘ahu and the State of Hawai‘i.

3. Analyzed the vulnerability of the selected assets based on the climate stressors that were identified during the workshop.

The five assets included in O‘ahu MPO’s study are:

- Honolulu Harbor Area
- Honolulu International Airport (now Daniel K. Inouye International Airport) area, Honolulu International Airport, including Highways Division O‘ahu District Baseyard at 727 Kakoi Street, and 811 Middle Street Maintenance Facility and Middle Street Intermodal Transit Center
- Kalaeloa Airport, Kalaeloa Barbers Point Harbor, and Campbell Industrial Park
- Ala Moana Boulevard, Kalākaua Avenue, and McCully Street bridges to Waikīkī
- An example of a community where there was little system redundancy – Farrington Highway (State Highway 93) along the Wai‘anae Coast.

All five transportation assets were first ranked for a level of vulnerability and a level of structural impact for both the years 2050 and 2100. The ranking levels were based on a scale ranging from high to medium to low. Rankings were assigned for different hazard categories such as sea level rise, storm surge, high intensity rainfall, wind, and air temperature. Table 4.1 provides a summary of risk assessment for all of the five assets included in the study for the three main hazard categories (sea level rise, storm surge, and high intensity rainfall).

Next, all assets were assigned a value based on social and economic consequences to society. To assign a value to society, the following items were considered: level of use; use of asset for evacuation, civil defense activities, and emergency functions; degree of redundancy; cost to replace; economic loss; environmental impacts; cultural value; loss of life; and recovery time needed. Value to society assignments were also based on hazard categories such as sea level rise, storm surge, and high intensity rainfall. A summary of value to society for all five assets is included in Table 4.2.

Table 4-1 Risk Assessment of Asset Group[5]

Asset	Period	Sea Level Rise		Storm Surge		High Intensity Rainfall	
		Vulnerability	Impact	Vulnerability	Impact	Vulnerability	Impact
Honolulu Harbor	2050	Low	Low	High	High	Low	Low
	2100	Moderate	Moderate	High	High	Moderate	Moderate
Honolulu International Airport							
TheBus (811 Middle Street)	2050	Low	Low	Moderate	Moderate	Low	Low
	2100	Low-Moderate	Low-Moderate	High	High	Moderate	High
Oahu Baseyard (727 Kakoi Street)	2050	Low-Moderate	Low	High	High	Low-Moderate	Low
	2100	High	High	High	High	Moderate	High
Honolulu International Airport and Access	2050	Low	Low	High	High	Low	Low
	2100	Low	Low	High	High	Low	Low
Kalaeloa Barbers Point	2050	Low	Low	High	High	Low-Moderate	Low-Moderate
	2100	Low-Moderate	Low-Moderate	High	High	Low-Moderate	Low-Moderate
Three Waikiki Bridges							
Ala Moana Boulevard	2050	Low	Low	High	High	Low	Low
	2100	High	High	High	High	High	High
Kalakaua Avenue	2050	Moderate	Moderate-High	Moderate	High	Moderate	Moderate
	2100	High	High	High	High	High	High
McCully Street	2050	Low-Moderate	Low	Moderate	Moderate	Moderate-High	Moderate-High
	2100	High	High	High	High	High	High
Farrington Highway on Waianae Coast	2050	Moderate-High	High	High	High	Drought: High	Drought: High
						Rain: Moderate	Rain: Moderate
	2100	High	High	High	High	High	High

Table 4-2 Importance of Asset Group to Society[6]

[5] SSFM International, Transportation Asset Climate Change Risk Assessment, Oʻahu Metropolitan Planning Organization, November 2011, Table 5, p.70

[6] SSFM International, Transportation Asset Climate Change Risk Assessment, Oʻahu Metropolitan Planning Organization, November 2011, Table 5, p.71

4.11.3 From the State Office of Planning 2017 report titled: Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability to Coastal Hazards and Climate Impacts in the City and County of Honolulu

The primary goal of this project was to develop disaster resilient measures for use with the relevant codes applicable to the City and County of Honolulu, in order to reduce building construction vulnerability to coastal natural hazards with consideration of climate change effects. Disaster resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. Building codes and regulatory standards currently in effect for the City and County of Honolulu are evaluated with respect to any applications that may need to be updated due to future changes in these hazards. The following effects are pertinent to the vulnerability of buildings and their foundations located in the coastal zone:

i. Sea level rise and increasing rates of beach erosion and groundwater rise
ii. Sea Surface Temperatures increasing and increased tropical cyclone activity
iii. Inundation / flooding from storms and tropical cyclones

Sea level rise (combined with land subsidence of the older islands) can result in shoreline changes and higher apparent sea level (relative to a point on land), and this can exacerbate inundation, especially for low-lying areas subject to hurricanes and high surf.

Inundation hazard maps that include climate change effects can be developed for Hawaii regulatory implementation. It is now possible to obtain stochastic simulations of future tropical cyclone tracks based on downscaled CMIP5 global climate models that have improved modeling of ENSO and Pacific Decadal Oscillation cycles to account for future hurricane events influenced by climate change under various greenhouse gas scenarios. A pilot study of coastal storm inundation for the Kakaako-Waikiki coastline including climate change (i.e., sea level rise and change in the distribution of storm track effects) has been performed as a proof-of-methodology. This work should continue so that impacts on the other coasts can be determined.

Sea-level rise and storm intensification pose a combined engineering, social, and economic problem to coastal communities. The regulatory needs addressing climate change have been discussed with stakeholder groups and enforcement agencies under the state or county sponsorship, and the relevant future revisions to improve climate change resiliency were further developed with their input. The language of coordinated revisions to the appropriate codes and standards are now assembled in this report for consideration by the City and for evaluation of their potential applicability by other counties in the state. Such regulatory updates are appropriate to consider implementing over time because the physical and functional lifespans of many types of structures, particularly critical facilities and public infrastructure built by government, will extend into the end of the century.

Major Findings/Recommendations

- Along the south shore of the Honolulu urban core, the present day National Flood Insurance Program Flood Insurance Rate Maps (NFIP FIRM), ostensibly representing a 100-year coastal flood, was found to be expanded well past the expected 100-year flood using a refined model, even when sea level rise and the future storm climatology are explicitly included. Therefore, especially for residential construction, it does not appear justified to consider any expansion of the NFIP FIRM due to climate change effects up

through the end of the century. The NFIP FIRM maps appear to be similar to 200-300 year flood hazard maps, and implicitly if unintentionally, accounts for some sea level rise.

- The adequacy of the flood insurance rate maps is not known for the north and east shores with respect to future climate change influences, and these areas should be studied further using the techniques of this pilot study and applying this methodology towards a new generation of coastal inundation hazard maps for the remainder of the island of Oahu.
- Probabilistic flood hazard assessments can facilitate planning and regulation of coastal development. In this work a pilot study was performed to establish a practical methodology for mapping of coastal flood hazards associated with sea-level rise and storm intensification toward the end of the 21st century. As demonstrated in the pilot study, the data products from this methodology can define the risk basis for future updates of building codes and other regulations to account for climate change. Therefore, use of this methodology should be continued so that end of the century probabilistic inundation maps for the other coastal areas of Oahu and the other Hawaiian islands can be used in the implementation of the climate adaptation process.
- Additional technical watershed and hydrographic studies should be started based on future rainfall intensification during tropical cyclones. The inherent target reliabilities of civil flood control infrastructure should be re-examined. It is recommended that the storm water flood control practices that address requirements for storm runoff quantities for flood control be re-evaluated for possible changes to various flood control design practice standards
- The severity and probability of extreme flood events depend more significantly on the likelihood of more intense hurricanes in the future than the uncertainties in the sea level. Government infrastructure and flood control projects would be the most effective investment in mitigating these effects, based on the pilot study of the south coast of urban Honolulu. For government and infrastructure projects with much longer functional lifespan requirements, the investment for sea level rise would be applicable for projects in the current planning timeframe.
- However, investment costs for climate change effects could also be justified to be deferred for properties with an economic payoff period of investment of less than 50 years, i.e., low-rise single family residential properties. This deferrable period would be economically arguable because the increased risk to these properties occurs only after sea levels rise approximately 2 ft.
- Therefore, the general approach recommended for adaptation to climate change effects is to focus on public investment in the design of critical facilities (Risk Category III per the building code), essential facilities (Risk Category IV per the building code), and civil and transportation, combined with appropriate shoreline setbacks and mandatory disclosures of natural hazards that would include future expected sea level rise and erosion of the shorelines.
- The City should consider an adaptive engineering approach. Adaptive Engineering is the approach to include the flexibility in the design of facilities to accommodate future modifications without incurring excessive costs prior to the time when features for

climate change are necessary (i.e., it is a low regret adaptive strategy in which expenditures have a higher probability of public benefit despite the uncertainty in future scenarios). In accordance with Adapting Infrastructure and Civil Engineering Projects to a Changing Climate (ASCE, 2015), the report utilized best-available science available as of the report's drafting date to arrive at its analyses, findings, conclusions, opinions, and/or recommendations.

4.12 Future Mitigation Projects

Due to the fact that there is a lag in the actual sea level rise in Hawaii compared to the modeled estimated global rate, the combined effect of sea level rise and land subsidence would be expected to result in approximately only 0.05m (2 inches) of relative sea level rise in the 2025-2030 timeframe. It is therefore recommended that the implementation initiation of climate change adaptive codes and regulations would be in the 2025-2035 timeframe. From that point in time, projects with service lifespans of 50-75 years hence would fall into the period of the last decades of the 21st century when the climate change effects considered in this plan would take place.

4.12.1 Ala Wai Canal Improvements

Ala Wai Canal is the largest single improvement that can be made to mitigate economic losses in Honolulu. To preclude the increased flooding of the urban core of Honolulu in the future period that is about 75 years from the present, a master–planned flood control project involving the Ala Wai Canal and the adjacent tributary stream from Manoa and Palolo would become necessary. The annualized cost of the increased flooding damage will become approximately $2.46M (in present dollars) per year. Applying a 30-year muni-bond financing model with a coupon rate of 5% to fund an infrastructure project with a Benefit Cost ratio of 1.5, a $22.5 million present day additional investment would be justified for sea level rise considerations. The flood control project may have basic justification of initial costs to mitigate present day flooding due to heavy rainfall and tropical storms, to which the $22.5 million would be added to ensure future reliability of flood control beyond 2050.

In comparison, the U.S Army Corps of Engineers has been developing a proposed $173M project to mitigate flooding due to Ala Wai Canal overtopping, to include the construction of concrete canal walls 4 ft. higher, pump stations and floodwater repositories along streams in Manoa, Palolo and Makiki, to prevent $318 M in expected damage to 3000 properties due to a “100-year” flooding event ($3.2M average annualized loss).

The community has expressed displeasure with the current proposed plans for a small retaining wall to prevent overtopping done by the U.S. Army Corps of Engineers, shown in Figure 4-21. An artistic rendering, Figure 4-22, of the potentially beneficial effects that a better design of this project could have on the community has been included for consideration.

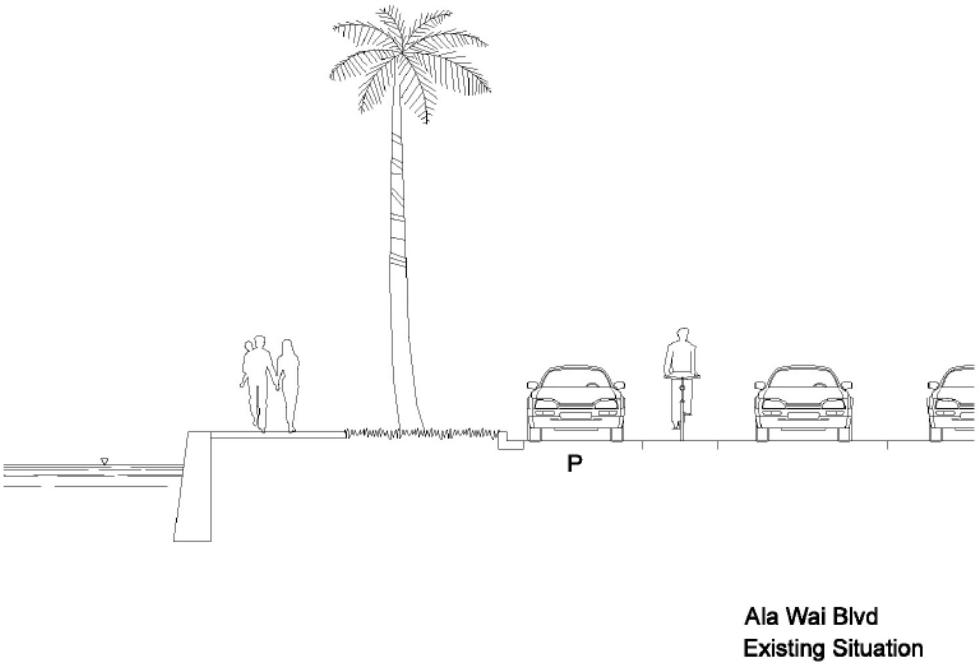


Figure 4-20. Ala Wai Boulevard existing system

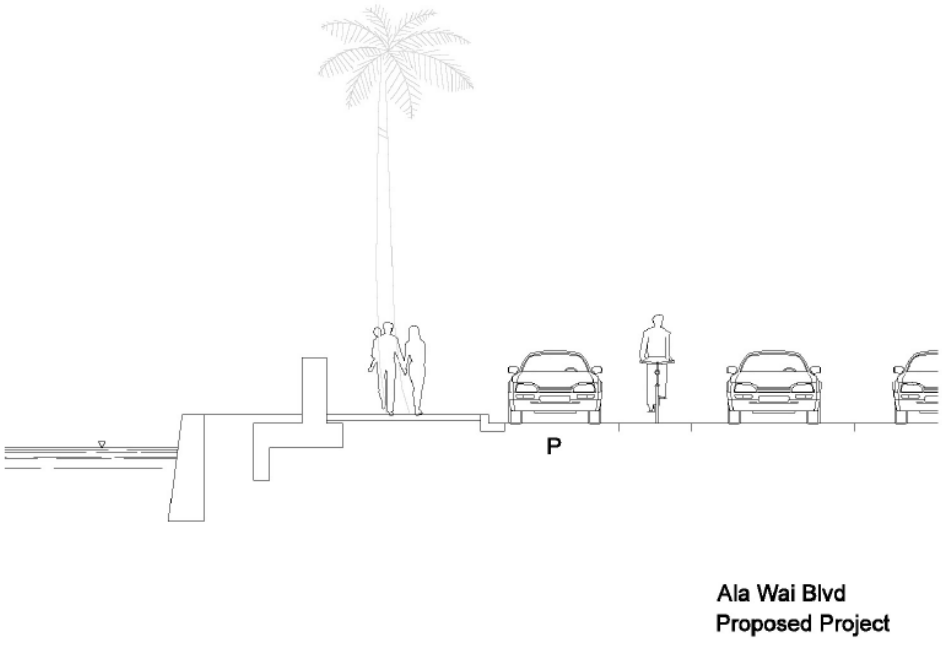


Figure 4-21. Ala Wai Boulevard proposed project to add flood mitigation

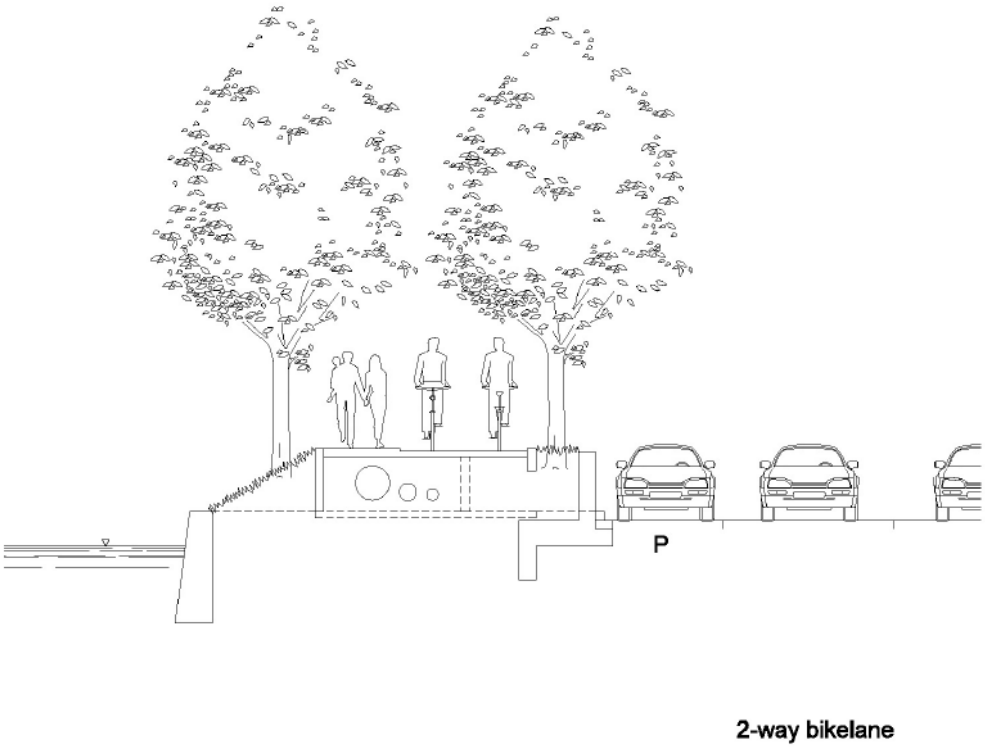


Figure 4-22. Ala Wai Boulevard proposed improvements from community suggestion and incorporating flood mitigation

4.12.2 Coastal Roadway and Infrastructure Improvements

As mentioned in greater depth in Chapter 5, coastal infrastructure such as highways are at high risk due to hazards that are further exacerbated by climate change. Chapter 5 focuses on coastal erosion but flooding is also an associated major concern that affects coastal infrastructure. All current and future coastal infrastructure projects should strongly consider the effects of climate change when being designed. Existing coastal infrastructure must be reevaluated according to the expected results of climate change, and in some cases like coastal highways, should be relocated or protected.

4.12.3 City Standards

Building Codes and Regulatory Standards Currently in Effect for the City and County of Honolulu that are intended to protect life and property from coastal hazards – assessment of potential future changes to address gaps in consideration of future climate conditions. Also included for consideration are some non-City related suggestions. Refer to the State Office of Planning 2017 report titled: Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability to Coastal Hazards and Climate Impacts in the City and County of Honolulu for more detailed explanations and the full report.

Suggestions for immediate implementation (i.e., already needed for present-day codes):

ROH Chapter 16 Building-Code applicable revisions for Risk Category III and IV structures: The current roof design requirement for rain loading has no allowance for long-term trends of climate causing more intense storms. Also, at the very least, for building design purposes, the 15 minute rainfall rate is now considered by national standard ASCE 7-16 as the more appropriate measure of intensity for roof drainage design. The City should therefore revise their rainfall intensity maps. If coastal storm inundation depths increase due to any effects of coastal erosion, shoreline recession, subsidence, or sea level rise, then greater "freeboard" requirements for clearance above the base flood elevation should be implemented. This can be mandated in the Honolulu Building Code, without seeking changes to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM). The City should dictate the minimum elevation of the lowest horizontal structural member based on a 500-year flood elevation accounting for relative sea level change. Current foundation design requirements do not account for shoreline erosion, thus the City should consider shoreline erosion in foundation design. **In summary, revise rainfall intensity design map; develop and require design flood elevations that include the effect of relative sea level change; require consideration of 50-years of shoreline erosion and relative sea level rise on foundation design; require design to the 500-year flood elevation for essential and critical structures, together with placement of critical equipment above that elevation.**

The following further proposed amendments, changes and/or revisions to the existing federal, state and/or county codes, laws, statutes, ordinances, regulations and/or standards discussed in the report were not suggested for immediate adoption and implementation. The proposed amendments, changes and/or revisions must still be evaluated for county priorities, financial costs and benefits, additional data needs, and operational capabilities, which are beyond the scope of the report.

Public Utilities Commission: Improve power transmission and distribution system resilience to high wind by using modern codes and existing knowledge. The PUC-mandated code is 15 years obsolete. The PUC-mandated code before 2007 was adopted in 1967.

The PUC needs to adopt the 2017 NESC with a local amendment to include the ASCE topographic windspeed maps of the 2012 IBC-based Hawaii State Building Code to replace the NEC 2017 Figure 250-2. Then it needs to periodically update that code every 5 years thereafter. This high wind standard should apply to all new infrastructure and to the replacement of existing poles and towers when they become deteriorated, damaged, or fail.

Implementation of coastal flooding mitigation by 2025 (some prerequisite technical maps to be further developed)

ROH Chapter 21A – Flood Ordinance: A 100-year flood hazard, which is what most current systems are designed for, has a 40% chance of being exceeded with a 50-year economic horizon; these are reliability targets that are far below any other engineering standard, even before the consideration of climate change effects that may increase inundation in the future. This is a case of risk transfer for insurance purposes that does not provide high reliability of structures and sufficient protection of lives and property. **The City should locally develop and adopt a 500-year flood zone applicable to Risk Category III and IV Structures that incorporates sea level rise.**

This requires a new coastal inundation design map based on the probabilities of future tropical cyclone activity and intensities. The effects of future climate change on the storm hazard and sea level can be incorporated into flood hazard maps for Hawaii regulatory implementation. End of the century probabilistic inundation maps for coastal areas of Oahu can be created for the implementation of the climate adaptation process.

ROH Chapter 17 Electrical Code: Currently, there are no restrictions on locating electrical transformers and switchgear in basements within the flood hazard zone. To address this, **the City should require placement of critical equipment for Risk Category III and IV Structures above the 500-year flood height as determined by the Coastal Construction Control Zone map or incorporate dry floodproofing protection.**

ROH Chapter 23 – The existing regulations are not based on historic shoreline erosion rates, although such information exists and is readily available for Oahu. Therefore, the level of setback protection for structures is not consistent, such that properties with high erosion rates have less protection over a shorter time than others. So the city should adopt 50-year setbacks based on historic shoreline erosion rates for Oahu for new construction and with exemptions for size or shallowness of lot.
Adopt setbacks for new construction or new additions based on 25 ft. plus 50-years of expected shoreline erosion, built include exceptions for either the limited size or shallowness of lots. The regulatory map would need to have greater detail to account for localized geologic and soil conditions. Consideration of relative sea level rise could also be included in the modeling necessary to produce a regulatory map. Adopting such maps would inform planners of the potential changes that climate change could potentially have and establish precedence for updating regulations based on changing conditions on Oahu. Map development will potentially be controversial so it should have a completely independent peer review and validating of methodology. The map showing the expected shoreline 50 years henceforth should be updated every 15 years.

ROH Chapter 25 SMA: SMA maps may need adjustment in the future in high erosion rate areas. There is no statutory minimum lifespan of development defined for SMA considerations; the actual lifespan of major building and infrastructure development

(excluding single family homes) will typically be over 100 years. This brings standing to considerations of climate change to address shoreline retreat and relative sea level rise in the early stages of project planning of coastal development.. **The City should establish a *Coastal Construction Control Zone*, to account for the coastal inundation limit of the 500-year flood including the effects of expected climate change by the year 2100 and sea level rise of 2 feet above the year 2000 mean high water, using probabilistic storm modeling consistent with CMIP AR5 RCP 8.5 climatic conditions.**
Within this area, relative sea level rise, shoreline erosion shall be considered for Major Developments when applying for an SMA permit. For Major Developments exceeding 25,000 square feet of building gross area, the application shall establish the means to enable the adaptation (either immediately or by enabling a later renovation) to 2 ft. of relative sea level rise and 50-years of shoreline erosion, and include provisions for the mitigation of the deleterious effects of the proposed use, and require the director to consider that as a criteria for permitting new development and any variances therefrom.

HRS 205A Certified Shoreline: **For planning purposes, also include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years. This map would be updated periodically.**

> The " Expected Future Shoreline" means the future expected upper reaches of the wash of the waves, other than storm and seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, estimated including the effects of 2 feet of sea level rise and 50 years of shoreline erosion projected forward from the year 2025."

HRS Chapter 484 - Uniform Land Sales Practices Act: include disclosure of **"Exposure to natural hazards that are mapped: e.g., 2500-year earthquake ground motion in excess of SDC C levels, 100-year and 500-year flooding including 2 ft of sea level rise, tsunami evacuation zone and extreme tsunami zone, lava inundation hazard zone 1, 2, or 3 per USGS 1992 map, forest and wildfire historic burn areas designated by the Hawaii Wildfire Management Organization, effective windspeed hazards above 145 mph per Hawaii State Building Code, dam failure evacuation map per DLNR, and/or within the Expected Future Shoreline as defined in HRS 205A. High surf inundation, earthquake –induced ground failure, and potential rockfalls / landslides shall also be disclosed to the extent known."**

Additional implementation of planning and supporting codes for consistency and comprehensiveness of climate change effects on weather

City government should plan and determine how to execute public works to protect existing critical facilities and infrastructure and vital economic assets at risk to climate change effects.

Public works planning and preliminary engineering feasibility studies should proceed on the coastal defense options for: Honolulu Harbor and particularly Pier 1, Kewalo Basin-Kakaako, Honolulu International (HNL) Airport reef runway, Sand Island

access, Ala Wai Canal flood control, and Waikiki. These are developed assets that are not economically feasible to abandon and relocate.

ROH Chapter 19 Honolulu Plumbing Code: The current requirement has no allowance for long-term trends of climate change causing more intense storms. To address that, the City should develop and adopt 500-year rainfall intensity maps for Risk Category III and IV Structures.

ROH Chapter 20 Fire Code: Due to anticipated increases in drought conditions associated with wildfires, the City should utilize maps of historic burn areas as issued in the High Fire Risk Map Zones of the Hawaii Wildfire Management Organization for use in these regulations based on NFPA-1 and for mandatory seller disclosures.

ROH Chapter 32 Building Energy Conservation Code: To adapt the City's codes for climate change, they should adopt American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 169, Weather Data.

HRS Chapter 508D Mandatory Seller Disclosures in Real Estate Transactions: Make the mandatory seller disclosure apply to transactions involving vacant lots. Include disclosure of **"Exposure to natural hazards that are mapped: e.g., 2500-year earthquake ground motion in excess of SDC C levels, 100-year and 500-year flooding including 2 ft of sea level rise, tsunami evacuation zone and extreme tsunami zone, lava inundation hazard zone 1 or 2 per USGS 1992 map, forest and wildfire historic burn areas designated by the Hawaii Wildfire Management Organization, effective windspeed hazards above 145 mph per Hawaii State Building Code, dam failure evacuation map per DLNR, and/or within the Expected Future Shoreline as defined in HRS 205A. High surf inundation, earthquake – induced ground failure, and potential rockfalls / landslides shall also be disclosed to the extent known."**

<u>Other Considerations</u>: Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities. It is recommended that the storm water flood control practices that address requirements for storm runoff quantities for flood control be re-evaluated for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs. There needs to be an overarching assessment of what rate of failure is acceptable and what the benefit cost analysis would yield for enhanced storm water capacity standards.

City and County of Honolulu Rules Relating to Storm Drainage Standards (June 2013)

- Re-evaluate the Hydrologic Criteria of the Standards for Flood Control and the design basis Rainfall Intensity maps, in keeping with the risk level including climate change and the longevity of City infrastructure

City and County of Honolulu Design Standards of the Department of Wastewater Management, General Requirements for Wastewater Facilities

- Re-evaluate the wet weather design period for Quantity of Wastewater for Chapter 20, Sewers and for Chapter 30, Pump Stations
- Re-evaluate the 20-year and 50-year Design Periods and Flow Projections for design peak flow capacity, Chapter 40, Wastewater Treatment Facilities



5. Coastal Erosion

5 COASTAL EROSION

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan described the causes of coastal erosion and exacerbating factors. The beaches of Hawaii are vital economic, environmental, and cultural resources. A healthy, wide sandy beach provides protection against high surf impacts. Coastal erosion and beach loss are chronic and widespread problems in the Hawaiian Islands. Proposed legislation to increase setbacks was discussed. High surf was a separate chapter.	• The coastal erosion rate maps (now published) developed by the University of Hawaii are highlighted to document coastal erosion. The 2012 plan included all of them, but now an example and link to the rest are included. • Updated shoreline setback regulations based on these values and the use of Maui County's strategy are suggested. • Recent wave run-up simulations, beach nourishment programs, and projects to relocate or reinforce vital infrastructure in coastal regions are described. • It was determined that high surf contributes to coastal erosion and is not a hazard on its own, so it was moved to this chapter as a subsection. • A 2018 coastal vulnerability study was included with a pilot study of a section of critical North Shore coastline.

Summary of Mitigation Projects for the City and County of Honolulu

Project	Priority
Projects to relocate or reinforce vital infrastructure such as roads in coastal regions.	High
Create another level of SMA zone maps defining a *Coastal Construction Control Zone,* to account for the coastal inundation limit of the 500-year flood including the effects of expected climate change by the year 2100 and sea level rise of 2 feet above the year 2000 mean high water, using modeling consistent with CMIP AR5 RCP 8.5 climatic conditions (see Chapter 14). Have this applicable only to major developments.	Medium-High
Adjust the Shoreline Setback Line Related to the Construction of a New Building or Structure, or to a new Addition to an Existing Building or Structure. The shoreline setback line shall be established 25 feet inland from the certified shoreline plus a distance of 50 times the historical annual erosion hazard rate from the shoreline established by county maps.	Medium-High
Disclose Hazard Risks as Mandatory Seller Disclosures in Real Estate Transactions Act: Expand list of disclosable hazards in public offering to include, more explicitly, defined extents.	Medium
Make mandatory seller disclosure apply to vacant lots as well	Medium
Use of Numerical Wave Run-up and Storm Surge Models to develop improved coastal flood zones with consideration of climate change effects	High

5.1 Description of Hazard

The beaches of Hawaii are vital economic, environmental, and cultural resources. A healthy, wide sandy beach provides protection against the effects of storm surge and high surf impacts. The beach environment provides habitat for marine and terrestrial organisms with beach dependent life stages and is home to species of indigenous and endemic Hawaiian plants. Beaches are also the basis for the visitor industry, exceeding by a factor of three all other industries combined when providing direct income to the State. (DLNR, 2000)

Coastal zones are dynamic areas that are constantly undergoing change in response to a multitude of factors including sea level rise, wave and current patterns, hurricanes, and human influences. Beaches change their shape, depth, and slope in response to wind, wave, and current forces, and the availability of sand. The sources and sinks of sand within a particular beach system and the mechanisms by which they affect the beach morphology are often cumulatively referred to as the sediment budget of the beach. Seaward sources of sand to the sediment budget of a beach include longshore currents moving sand along the coast and cross-shore currents moving sand onshore. Landward sources of beach sand include dunes, ancient shorelines, and other onshore sand deposits that release sand to the beach by the forces of the wind and waves. High waves will cause a beach to change its shape, or profile by redistributing sand across the shoreline.

Causes of coastal erosion and beach loss in Hawaii are numerous but are poorly understood and rarely quantified. Factors contributing to beach loss include reduced sediment supply, large storms, and sea-level rise. reduction in sand supply, either from landward or seaward sources (primarily reef) can have a myriad of causes. More complex issues of sediment supply can be related to reef health and carbonate production, which in turn, may be linked to changes in water quality. Second, the accumulated effect of large storms is to transport sediment beyond the littoral system. Third, rising sea level leads to a landward migration of the shoreline.

The signs of erosion are much subtler and typically start as a "temporary" hardening structure designed to mitigate an immediate problem which, eventually, results in a proliferation of structures along a stretch of coast. Obvious causes such as beach sand mining and structures that prevent natural access to back beach deposits remove sediment from the active littoral system. Construction of shoreline hardening structures limits coastal land loss but does not alleviate beach loss and may actually accelerate the problem by prohibiting sediment deposition in front of the structures. The natural ability of the sandy shoreline to respond to changes in wave climate is lost. Dramatic examples of coastal erosion, such as houses and roads falling into the sea, are rare in Hawaii, but the impact of erosion is still very serious in certain areas. (See Figure 5-1 as an example case.)

Despite the fact that Hawaii appears to have a well-developed and comprehensive governmental system in place to respond to coastal erosion and beach loss, beach loss still occurs. It appears obvious that the erosion problem in Hawaii would be much less critical if adequate setback rules were established to implement a greater standoff for construction in the coastal zone.

Typical erosion rates in Hawaii are in the range of 0.5-1 ft/yr (Hwang, 1981; Sea Engineering, Inc., 1988; Makai Engineering, Inc. and Sea Engineering, Inc., 1991). Oahu shorelines are by far

the most studied. Studies on Oahu (Fletcher et al., 1997) have shown that nearly 24% or 17.1 miles of an original 72 miles of sandy shoreline (1940s) has been either significantly narrowed (10.7 mi) or lost (6.4 mi). Nearly one-quarter of the islands' beaches have been significantly degraded over the last half-century and all shorelines have been affected to some degree. The impact of the beach loss at Waikiki has been estimated to be about around $1 million per year, in order to maintain the beach in its current state. Extrapolating that island-wide, the estimated losses from coastal erosion are $2-3 million per year.

The University of Hawaii Coastal Geology Group within the School of Ocean and Earth Sciences and Technology (SOEST) has generated a series of maps showing changes to most of the beaches on Oahu over the last century. A key showing the location of maps for the various beaches is provided in Figure 5-2. Detailed maps showing the shoreline changes and estimates of erosion or deposition rates along each of the beaches, are available on the SOEST website: (http://www.soest.hawaii.edu/coasts/erosion/oahu/). They show that erosion is more prevalent than accretion, with local peak erosion rates of up to 5 ft per year. The largest erosion rates are observed Iroquois Point, several beaches on the west side of the island including Maili Beach, Keaau Beach, and Ohikilolo Beach, and Kahuku Beach at the northeast. At most of these beaches there are areas of large erosion rates and adjacent areas of accretion.

Figure 5-3 is an example of a detailed coastal erosion map, this one at Sunset Beach, a popular beach for surfers where heavy surf significantly contributes to coastal erosion. In December of 2017, the erosion had gotten so dramatic that a lifeguard tower was moved for safety concerns due to the near 20 ft. cliff where there was once sand. In a method similar to Adaptive Engineering (as discussed in Chapter 4), the Department of Emergency Services has designed and plans to implement the world’s first portable Lifeguard station.



Figure 5-1. September 2018 Shoreline Erosion near Ehukai Beach (photo by Dennis Oda of the Honolulu Star Advertiser). Note that beach sand had naturally recovered significantly by the winter

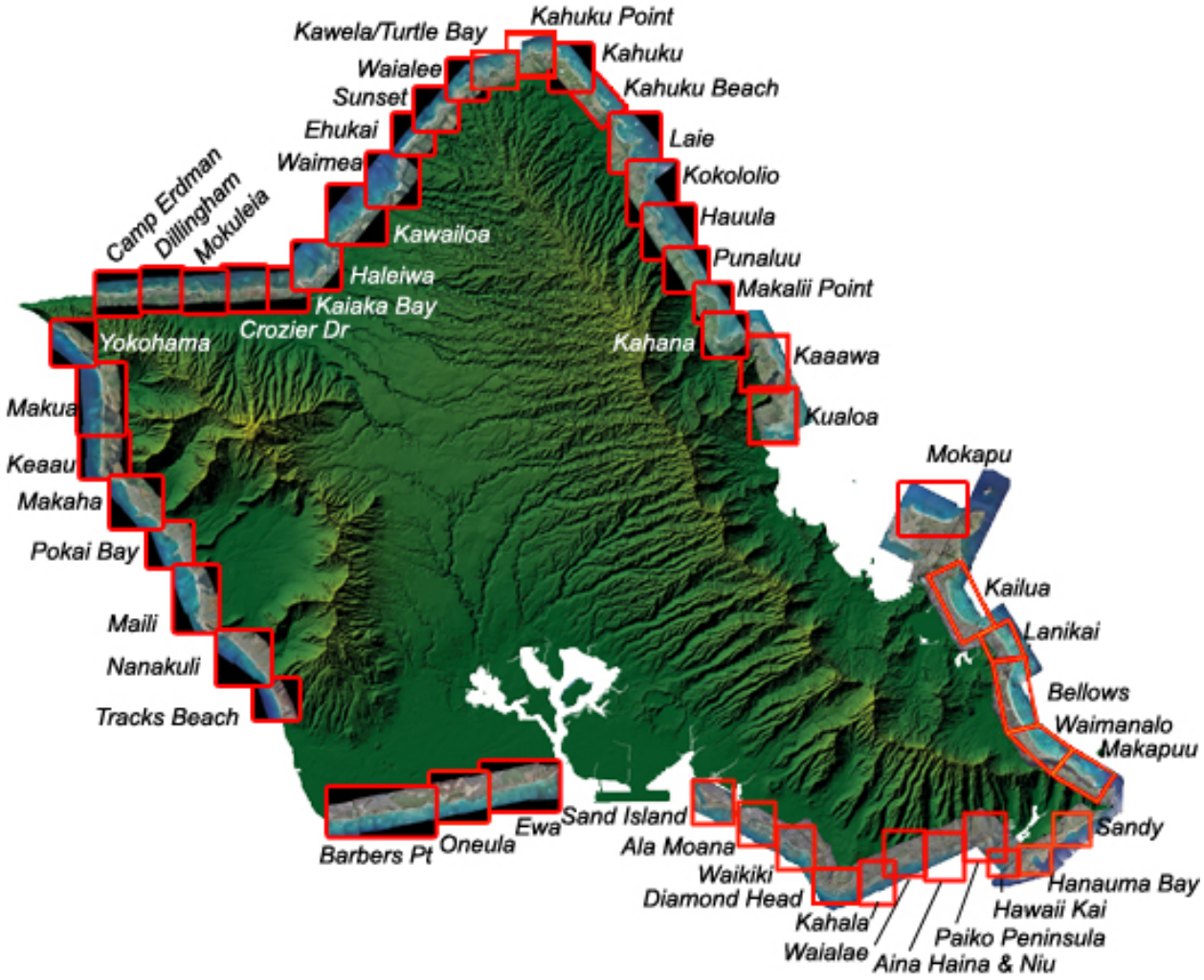


Figure 5-2. Coastal Erosion and Deposition Maps around Oahu

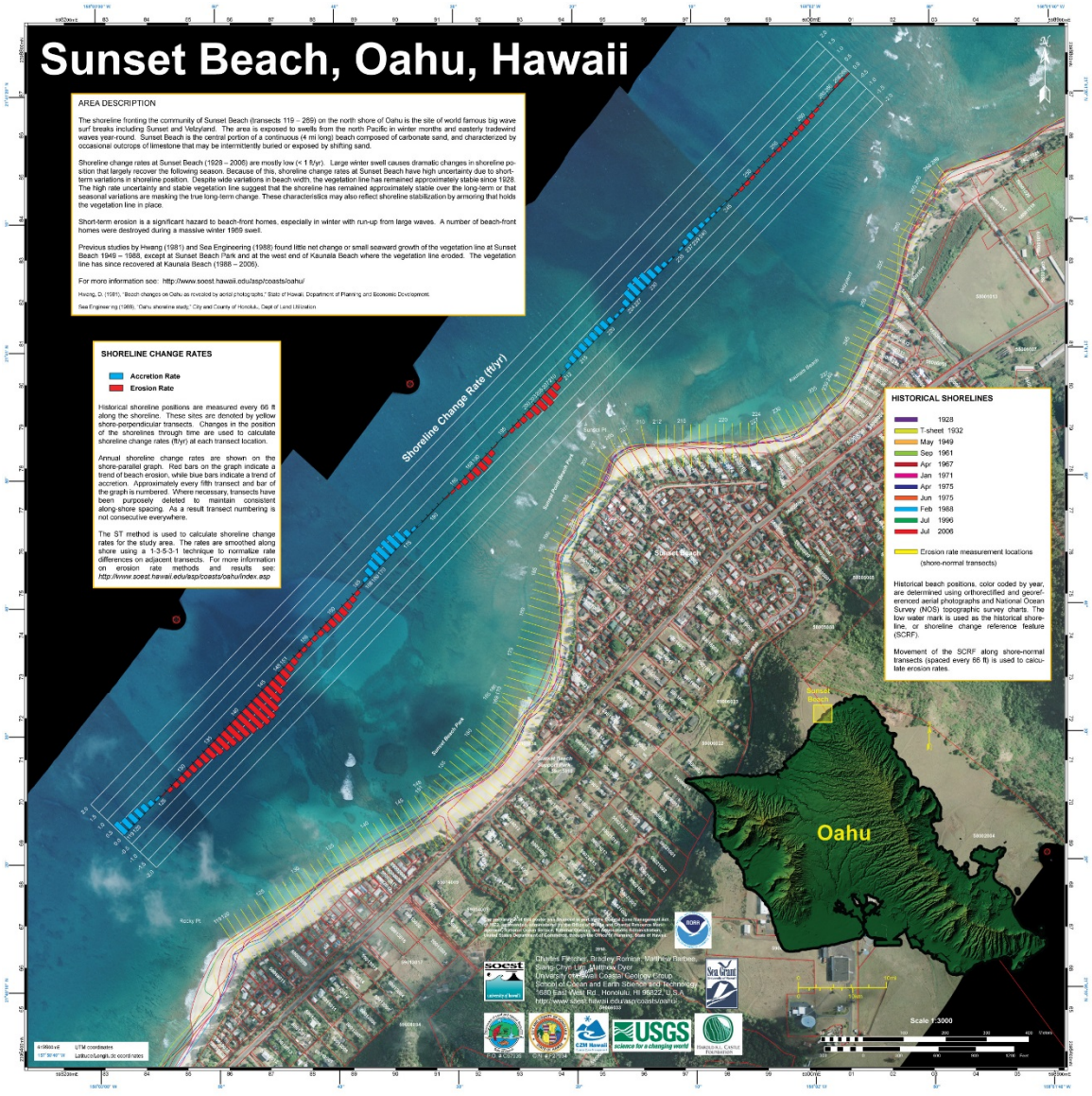


Figure 5-3. Coastal Erosion and Deposition Maps of Sunset Beach

5.2 High Surf

The Department of Emergency Management classifies high surf as a condition of very dangerous and damaging waves ranging in height from 10 ft to 20 ft or more. These waves result from open ocean swell generated by storms passing through the north and south Pacific Oceans.

High waves are common along Hawaiian shores, making the islands perhaps the most popular destination for big wave surfing in the world. Lying in the center of the North Pacific Ocean, Hawaii receives high waves from distant storms in the northern and southern hemispheres and from tropical cyclones passing in the vicinity. The hazards associated with high waves include debris overwash, flooding, increased erosion, high wave energy and turbulence in the nearshore zone, and strong currents. These high wave episodes create significant coastal erosion on many of Oahu's beaches. When deep-water ocean swells encounter the shallow island margins they rise to great heights because their tops stack up on their slower moving bottoms due to friction along the shallower seafloor. Because the contact between deep water and the shallow margins around the Hawaiian Islands is abrupt, surface waves can grow very tall, very rapidly. Large waves tend to travel in sets, and after breaking they rush up onto the beach temporarily elevating the sea surface near the shoreline. The highest hazard occurs in most cases for north-facing shorelines where winter swell arrives with regularity in heights exceeding 12 ft (often exceeding 20 ft). Sets of these large waves are characterized by rapid onset so that within a few seconds they can double in size.. The water level on the coast increases with these sets of large waves and rip currents are generated as this excess water surges seaward. Rip currents form as the water that is pushed up on the shore by successive large waves tries to flow back to the sea, often carrying sand with it.

Annually, waves that reach Hawaii's shores originate from four primary sources, north Pacific swell, northeast trade wind swell, south swell, and Kona storm swell. North Pacific swell deliver the highest waves annually (8-20 ft) with moderate- to long-wave periods (10-18 seconds), due to the high intensity and proximity of sub-polar and mid-latitude storms in the north Pacific. North swell occur throughout the year, but are most common between October and May and have the greatest impact on north-facing coasts. Northeast trade-wind swell range 4-12 ft in height ~70% of the year (April to November) and can reach slightly greater heights during intense tradewind events that occur for 1-2 weeks each year. Because trade wind waves have short wave periods (5-8 seconds), they are only moderately energetic when they reach the shoreline. Waves from south Pacific swell travel great distances and have very long wave periods (14-22 seconds) and moderate wave heights (1-4 ft). Long-wave periods associated with south swell, however, translate into very energetic waves when they reach Hawaii's shores, especially along south-facing coastlines. South swell is most common between April and October, but occur all year. Waves from Kona storms, central Pacific storms associated with fronts passing just north of the main Hawaiian Islands, are commonly very steep with moderate heights (10-15 ft) and short to moderate periods (8-10 seconds). Kona storm waves have the greatest impact on south-and west-facing coasts. Waves from hurricanes and tropical storms (June-November) can reach extreme heights (10-35 ft) and occur mostly on east-, south-, and west-facing coastlines, however, occasionally north-facing shores are impacted.

Hurricanes and tropical storms are also important sources of waves that impact Hawaii's coasts. High waves from hurricanes present a more complex hazard, as they may coincide with high tide, storm surge, and wind and wave setup, to produce a combined threat. High waves from hurricanes generally occur during hurricane season between June 1 and December 1. High waves from hurricanes most often hit the eastern shores as hurricanes approach the islands from the east, and south-and west-facing shorelines as the storm passes to the south and west. Hurricane generated waves have exceeded 15 ft along east Oahu and 20 from Oahu's southern shores. Combined with storm surge and high tides, hurricane waves can overwash coastal roads and properties, as they did along the Kaaawa and Kaneohe coasts during Hurricane Fernanda in 1993 and along the Honolulu and Waianae coasts during Hurricane Iniki in 1992.

Large surf has the potential to temporarily close highways and cause damage to coastal properties. In early 2016, large surf caused the closure of Kamehameha Highway along the North Shore, which has been closed regularly during large surf in recent years due to flooding, high surf bringing debris onto the road, and erosion of the road itself. Coastal properties have also taken damage due to flooding and experience rapid coastal erosion due to the increased surf. The inland extent of the wave zone is expected to be much greater than the erosion zone. For example, on December 1-4, 1969, large winter waves generated from a tropical storm in the North Pacific eroded the vegetation line at Waimea Bay on Oahu an estimated 50-60 feet, while inundation, as indicated by rocks and sand was more than 750 feet inland (State of Hawaii, DLNR, 1970). Climate change has the potential to further increase the negative effects of high surf by future sea level rise.

5.3 Impoundment

In addition to the natural processes that cause erosion, human alterations are affecting erosion rates. Human interference with sand transport processes underlies much of the chronic erosion impacting portions of the shoreline. The original sandy shoreline along many segments of coast has been replaced by shoreline hardening structures of various designs and construction materials (i.e., seawalls, revetments, groins of concrete, stone, and wood). The presence of a shoreline structure is indicative of an erosion hazard, but in many places the structure probably exacerbates the problem and changes a condition of shoreline erosion into one of beach loss (Fletcher et al., 1997). It is anticipated that the amount of shoreline hardening on Oahu will increase significantly as sea levels rise. Due to the properties of the sand in Hawaii, when beaches experience chronic erosion and the shoreline shifts landward, a supply of sand is released to the adjoining beach and near-shore region. The beach then remains wide even as it moves landward with the eroding shoreline.

Most beach sand in Hawaii is composed of carbonate grains derived from the skeletons of corals, mollusks, algae, and other reef-dwelling, carbonate-producing organisms. Sand supplies are limited relative to mainland coasts where terrigenous sand derived from large rivers and other sources dominate. The formation of beachrock, storage of sand in coastal dunes, and irretrievable sand loss to deeper water beyond the reef crest all contribute to relatively low volumes of sand available to the system. On many Hawaiian beaches, the available sand ends beyond the toe of the beach in a water depth of 4-6 ft where the bottom becomes reef or a reef pavement. In contrast, on mainland beaches the sand deposits often extend a considerable distance (hundreds to thousands of meters) offshore.

Sediment impoundment accompanies coastal armoring. Sands that would normally be released into coastal waters during high wave events and with seasonal profile fluctuations are trapped behind walls and revetments and prevented from adding to the beach sediment budget. One wall may have minimal impact, but along many Hawaiian coastlines myriad armoring types combine to reduce sand availability to nearly zero. Natural coastal erosion does not damage beaches that have access to a robust sediment budget. Armoring traps those sands and a sediment deficiency develops, such that the beach does not withstand seasonal wave stresses and begins to narrow with time. Chronic beach erosion and beach loss eventually results. If sand is not available to the beach, such as when a wall is built to protect the land (e.g., sand is trapped behind the wall), then beach erosion will ensue as a result of sand impoundment, which leads to beach narrowing and eventually beach loss. Sand condition changes to different beaches throughout the Island of Oahu are quantified in Table 5-1.

Table 5-1. Beach Narrowing and Loss on Oahu
(adapted from Coyne et al., 1996 and Fletcher et al., 1997)

Beach Condition and Change	Mokuleia	Kaaawa	Kailua-Waimanalo	Maili-Makaha	Island-wide
Originally sandy (km)	12.2 +/- 1.0	7.5 +/- 0.6	15.5 +/- 1.3	6.0 +/- 0.5	115.6 +/- 9.8
Narrowed beach (km)	2.1 +/- 0.2	3.2 +/- 0.3	0.9 +/- 0.1	1.3 +/- 0.1	17.3 +/- 1.5
Lost beach (km)	0.2 +/- 0	0.8 +/- 0.1	1.6 +/- 0.1	0.2 +/- 0	10.4 +/- 0.9
Degraded beach (%)	18.7	53.6	16.3	24.9	23.9
Net shoreline change rate (m/yr)	-0.2 to 0.3	-1.7 to 1.8	-0.9 to 0.6	-0.4 to 0.6	N.C.
Non-armored mean sandy beach width (m)	26.8	13.2	22.4	43.7	N.C.
Armored mean sandy beach width (m)	12.8	8.9	7.1	24.5	N.C.
Mean long-term shoreline change rate for armored sites (m/yr)	-0.2	-0.3	-0.6	-0.5	N.C.
Range of shoreline change rates for armored sites (m/yr)	-0.1 to -0.3	0 to -1.7	0.2 to -1.8	-0.2 to -1.0	N.C.

In Hawaii, coastal erosion issues are addressed by three layers of jurisdiction with varying degrees of overlap and coordination: The Army Corps of Engineers; the State Coastal Zone Management Program and State Department of Land and Natural Resources, and County Government. Federal jurisdiction applies to the navigable waters of the United States, extending from the mean high water mark to the 200-mile limit of the Exclusive Economic Zone. State jurisdiction is the conservation district, which extends from the certified shoreline (often the vegetation line) to the limit of state territorial waters. County jurisdiction extends landward from the certified shoreline to the limit of the special management area boundary, which varies in width from a couple hundred yards to a few miles.

5.4 Sea Level

Hawaii has a system of tide gauges, maintained and operated by the federal National Ocean Service, located on the islands of Kauai, Oahu, Maui, and Hawaii that record fluctuations in sea-level. Analysis of these records provides scientists with rates of long- term sea-level rise around the state. A fascinating outcome of this has been the realization that each island has its own rate of rising sea level. This is not because of ocean behavior, it is due to island behavior. The Big Island, because of the heavy load of geologically young volcanic rocks, is flexing the underlying lithosphere causing the island to subside. This creates a relatively rapid rate of sea-level rise, on the order of 1.5 in/decade. Because it lies near the Big Island and is also geologically youthful, Maui is affected by the flexure process and is experiencing rapid sea-level rise, nearly 1 in/decade. Oahu and Kauai lie outside the area of subsidence and have lesser rates of rise, subsiding approximately 0.6 in/decade as shown in Figure 5-4.

Sea-level rise (SLR) is not presently a cause for immediate alarm, but planning questions regarding future rates of rise resulting from an enhanced greenhouse effect have been discussed by scientists, planners, and policymakers since the 1980's. Recent studies (Kopp et al., 2014; Slangen et al., 2014; Sweet et al., 2017) showed that global SLR rates are 0.3–0.5m higher within the Hawaiian Islands under an intermediate high scenario (1.5m global mean SLR by the year 2100) due to static equilibrium effects (Sweet et al., 2017). The impact of rising sea level in the Hawaiian Islands will be severe unless planners and resource managers incorporate sea-level rise scenarios into their coastal management efforts. As sea-level rise accelerates in the future, low-lying, low relief, readily erodible and low slope coasts will be the most vulnerable to sea-level hazards.

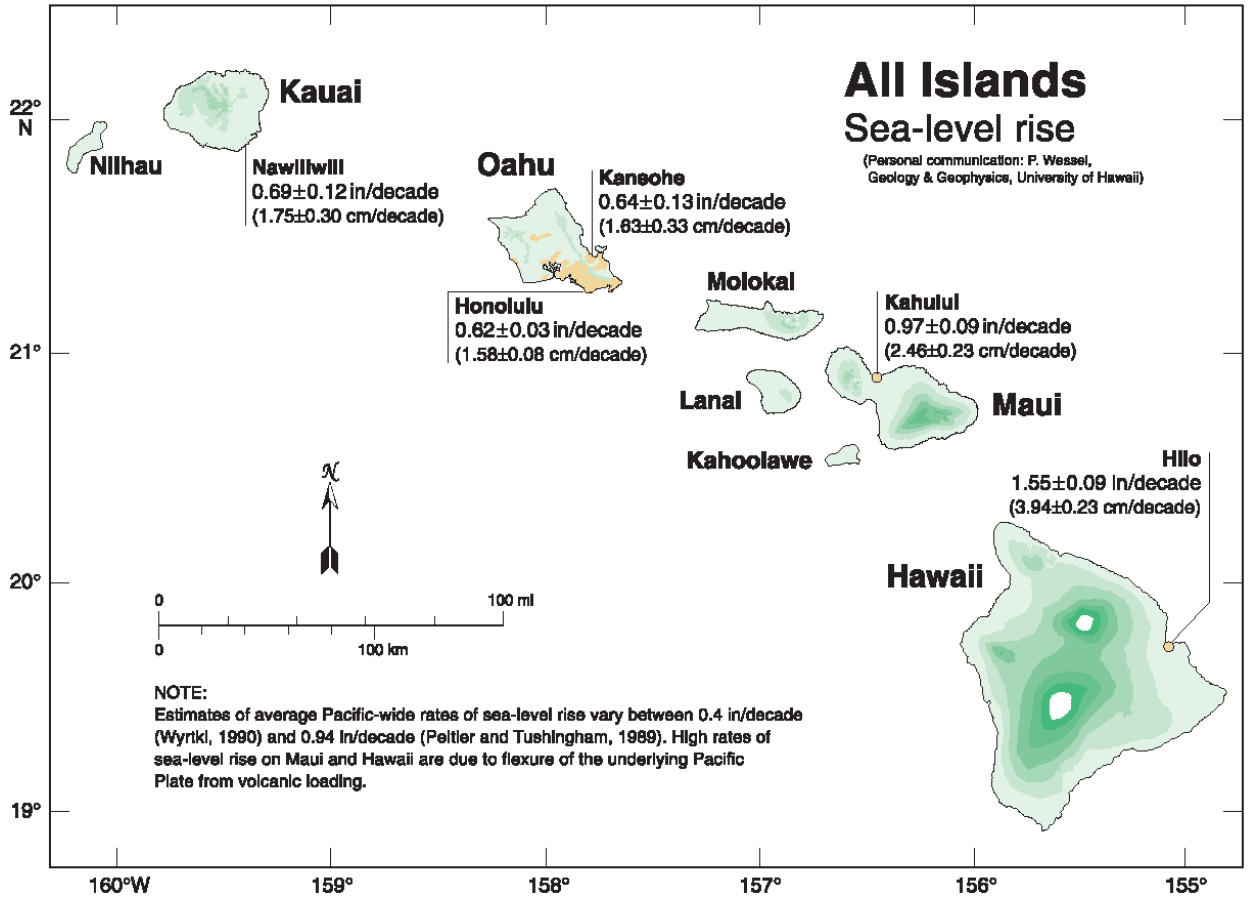


Figure 5-4. Relative Sea Level Rise in Hawaii

5.5 Vulnerability Assessment

A statewide vulnerability assessment (Onat et al., 2018) of Hawai‘i, Kaua‘i, Maui, Lana‘i, Kaho‘olawe, O‘ahu, and Moloka‘i using GIS modeling was done to determine the most vulnerable beaches in Hawaii. In the study, the overall coastal exposure of Hawai‘i's shoreline, accounting for topography, bathymetry, wave, surge, and sea level rise was estimated along with interactions with natural habitats, coastal defense structures, and human activities. The study employed a widely used method of assessing coastal vulnerability. The input data was gathered from both local and national sources, and the sources were compiled in Table 5-2. Once the data was gathered, it was statistically fit to a curve and each section of coastline then had its individual data compared against the total data to obtain a percentile rank. That percentile rank corresponds to a value found in Table 5-3, and that was then averaged with equal weighting with all other factors to determine the coastal vulnerability value shown in Table 5-4. The relative coastal EI for each 250m shoreline segment is calculated by:

$$EI = \prod_{i=1}^{n} (R_n)^{1/n}$$

Where R is the rank of the variable and n is the number of variables. The study includes estimates of the probability of erosion and calculates exposure index metrics for at-risk areas shown in Table 5-5. The erosion index (ErI) is the geometric mean of geomorphology, habitats and wave exposure. The ranks range from 1 for low exposure to 5 for high exposure. Figure 5-5 shows the results of this assessment graphically.

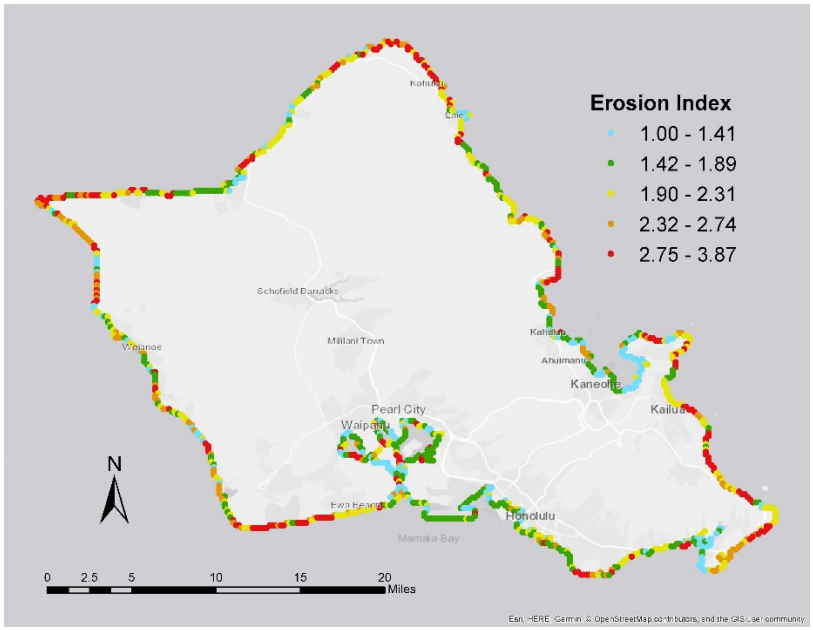


Figure 5-5. Vulnerability assessment of Oahu (Onat et al., 2018)

Table 5-2. Input data layers and their sources (Onat et al., 2018)

Table 1
Input data layers and their sources. The GIS files are given in Onat et al. (2018b).

Input Variable	Description	Source
Bathymetry & Relief	Fifty meter bathymetry and topography hillshade grids. Projection changed	(Hawai'i Mapping Research Group, 2014)
Continental Shelf	The original file is used.	(Natural Capital Project, 2016)
Geomorphology	Modified file by clipping and joining a created table to the attributes of the file. The created table includes descriptions and ranks. Duration of data: 1978–2001	(NOAA Office of Response and Restoration, 2001)
Land Polygon	Modified file by creating a polygon from line shape file	(Fletcher et al., 2002)
Sea Level Rise	Created polygons with attributes of sea level trends. The tide gauge measurements are from the Permanent Service for Mean Sea Level (PSMSL) and GPS data from the Nevada Geodetic Laboratory (NGL) which uses the GIPSY/OASIS-II Version 6.1.1 software developed at the Jet Propulsion Laboratory (JPL) to study long-term relative SLR.	(Yang and Francis, 2018)
Climatic Forcing	Compiled wind and wave hindcast data from WAVEWATCH III for 2008–2016 are used.	(Natural Capital Project, 2016)
Natural Habitats	Created polygon to match the Google Earth images of the islands. Created tables to join the modified attribute between 1977 and 2001	(NOAA Office of Response and Restoration, 2001)
Population	Modified file by clipping area. The ocean, river, and lake polygon census blocks are deleted. Polygon shapefile was then transformed into a raster file using the attribute of the 2010 population	(U.S. Census Bureau, 2010)
Structures & Roads	Modified polyline shapefile to the polygon by buffering the area. Area buffer size was taken by the average size of roads to fill line on both ends. Created polygon structures of human-made structures such as buildings. Both files were then merged into one file	(State of Hawaii Office of Planning, 2015)

Table 5-3. The ranking system for coastal exposure (Onat et al., 2018)

Table A.1The ranking system for coastal exposure (Sharp et al., 2016)

Rank	Very Low	Low	Moderate	High	Very High
Variable	1	2	3	4	5
Geomorphology	Rocky; high cliffs; fjord; fiord, seawalls	Medium cliff; indented coast, bulkheads and small seawalls	Low cliff; glacial drift; alluvial plain, revetments, rip-rap walls	Cobble beach; estuary; lagoon; bluff	Barrier beach; sand beach; mud flat; delta
Relief	0 to 20 Percentile	21 to 40 Percentile	41 to 60 Percentile	61 to 80 Percentile	81 to 100 Percentile
Natural Habitats	Coral reef; mangrove; coastal forest	High dune; marsh	Low dune	Seagrass; kelp	No habitat
Sea Level Change	0 to 20 Percentile	21 to 40 Percentile	41 to 60 Percentile	61 to 80 Percentile	81 to 100 Percentile
Wave Exposure	0 to 20 Percentile	21 to 40 Percentile	41 to 60 Percentile	61 to 80 Percentile	81 to 100 Percentile
Surge Potential	0 to 20 Percentile	21 to 40 Percentile	41 to 60 Percentile	61 to 80 Percentile	81 to 100 Percentile
Population	0 to 20 Percentile	21 to 40 Percentile	41 to 60 Percentile	61 to 80 Percentile	81 to 100 Percentile

Table 5-4. Ranked input metrics (Onat et al., 2018)

Table 3
Ranked input vulnerability metrics. (1: very low vulnerability, 5: very high vulnerability). The table gives the average(μ), and standard deviation (σ) of each island ranked shorelines metrics. ANOVA F-values of the each metric compared to different islands are given to indicate the significant differences of the means. The *p-value* < 0.05 for all metrics.

		Kaua'i		O'ahu		Moloka'i		Mau'i		Lana'i		Kaho'olawe		Hawai'i	
Shoreline Segments		612		1039		591		866		286		204		1775	
Exposed Shorelines (%)		33.82		19.15		29.44		29.21		46.85		36.94		36.39	
	F-value	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Geo.	169.9	3.21	1.28	3.33	1.12	3.03	1.06	2.51	1.25	3.07	1.07	2.09	0.95	2.16	1.05
Relief	32.3	3.0	1.41	3.0	1.41	3.03	1.51	2.71	1.41	2.96	1.07	4.22	0.81	3.0	1.41
Nat. Habitat	144.1	1.55	0.33	1.83	0.69	1.38	0.36	1.53	0.33	1.39	0.28	1.8	0	1.73	0.19
Wave Exp.	6.5	3.02	1.43	3.0	1.41	2.93	1.24	2.88	1.55	3.47	1.23	3.0	1.43	3.0	1.41
Surge Pot.	15.6	3.14	1.33	2.94	1.22	3.14	1.26	3.26	1.46	3.19	1.45	2.43	1.3	3.24	1.47
SLR	1141.	3.0	0	3.53	0.50	1.50	0.5	4.23	1.25	3	0	5	0	2.98	0.72
Population	247.0	2.96	1.41	2.96	1.41	2.86	1.28	3.75	1.21	1.28	0.60	1	0	3.17	1.16

Table 5-5. Erosion index (ErI) comparison of the islands (Onat et al., 2018)

Table 5
Erosion index (ErI) comparison of the islands. (1: very low, 5: very high, the average(μ), and standard deviation (σ) The probability density function equations and their parameters are given in Appendix C.).

	Kaua'i	O'ahu	Moloka'i	Maui	Lana'i	Kaho'olawe	Hawai'i
μ	2.14	2.07	1.93	2.19	2.49	2.62	2.13
σ	0.63	0.62	0.41	0.59	0.37	0.49	0.52
Max	3.41	3.66	2.91	3.87	3.22	3.87	3.46
Min	1	1	1	1	1	1	1
PDF	Generalized Pareto	Generalize extreme value	Weibull	Weibull	Extreme value	Generalized Pareto	Weibull
	k: −0.8277	k: −0.3611	β: 2.0927	β: 2.4190	μ:2.6656	k: 0.6423	β: 2.3399
	σ:1.9970	σ:0.4470	α: 5.3914	α: 4.1072	σ:0.3036	σ:1.3850	α: 4.6701
	θ: 1	μ:2.5467				θ: 1.7320	
ErI w/o structures μ	2.46	2.68	1.96	2.40	2.50	2.62	2.26
ErI w/o structures σ	0.48	0.43	0.38	0.53	0.36	0.49	0.42

By understanding which shorelines are most sensitive and the dominant factors affecting their vulnerability, policymakers can promote public awareness and support planning, design, and implementation of adaption strategies. A subsequent case-study vulnerability assessment (Onat et al., 2018) of a stretch of coast along Oahu's North Shore determined some of the recommended courses of action for coastal erosion mitigation in high wave energy areas, incorporating the effects of future sea level rise as well. The report focused on the coast from Waimea to Rocky Point, which includes a Marine Life Conservation District (MLCD) and several popular surfing spots due to the large waves there. One of such surf spots was previously mentioned in Section 5.1 as an example of the exacerbating erosion effects that accompanies high wave energy. The planning process for the suggested mitigation strategies included interviews in February 2015 with eight residents in Ke Nui Road, 20 beachgoers, and five experts representing six agencies:

- Department of Land and Natural Resources – Office of Conservation and Coastal Lands (DLNR-OCCL)
- City and County Department of Parks & Recreation (DPR)
- State Hawaii Department of Transportation (DOT)
- City and County Department of Planning and Permitting (DPP)
- State Coastal Zone Management Program (CZM)
- Sea Grant College Program

The interviewees were asked about their knowledge of SLR, their experiences, what has been done to improve the condition, drawbacks, and conditions for the vulnerability and adaptation of the study area. The five options of coastal erosion mitigation that were asked about were: creation of an artificial reef, increase the amount of vegetative cover, beach nourishment projects, shore protection projects, and elevating homes. The study decided to split the mitigation approach for two different sections of the coast: surf spots such as Sunset Beach and the MLCD.

For the surf spots, vegetative cover and beach nourishment were considered to be the best solutions to maintain the shoreline there. Vegetative cover is very easy to implement and does not have significant drawbacks, and thus was the preferred technique to mitigate coastal erosion in the area. Beach nourishment was preferred as well, due to government experience with the method and the visual appeal for tourism. Artificial reefs reduce wave energy and should not be utilized near surf spots, as they could significantly negatively impact the tourism and local recreation. Shore protection, such as shoreline hardening like groins and breakwaters, have the potential to even further decrease the amount of sand along the coast, despite their protective features for property owners. The individuals interviewed preferred the natural approach to maintaining the beaches, rather than shoreline hardening. Elevating homes was considered to be expensive and should be at the discretion of the homeowner, so it would not be up to government officials and therefore not ideal as a mitigation technique.

For the MLCD, artificial reefs were the first choice, with shore protection options being the second choice. Artificial reefs encourage marine life while dissipating wave energy and therefore erosion seem ideal for the MLCD. Shore protection was not strongly opposed in the MLCD and has significant benefits to reducing erosion at the cost of aesthetics and remaining beach. Much of the MLCD shore is rocky with no houses, therefore the other mitigation techniques are not very practical.

This case study identified many of the social concerns associated with coastal erosion mitigation projects, especially in high wave energy areas popular with both locals and tourists. However, major government action must take place for any of these projects to come to fruition, as this particular case study area has overlapping jurisdiction. Government can also deal with mitigating the effects of coastal erosion through policy.

5.6 Erosion Zone Calculations

Data on both chronic and episodic erosion hazards is crucial when determining effective building setbacks. The erosion rate maps, as shown by example in Figure 5.2, could be used to determine the anticipated beach loss over time. Agencies could consider applying these maps with an appropriate level of additional study. Coastal regulations must be adapted given the changes that coastal areas are undergoing. Maui County has already established a method of determining erosion zones, and therefore appropriate shoreline setbacks for property owners. The erosion rate values are based on site specific erosion rates which can be found online on the interactive SOEST map in Figure 5-2. Maui County has given this formula in Chapter 203 of the Maui Planning Commission:

Shoreline Setback = Life of Structure × Annual Erosion Rate + Safety/Design Buffer

Using the above formula, the extent of the erosion zone and appropriate shoreline setback based on different erosion rates are summarized in Table 5-6 below. For Maui County, it is always assumed a 50 year structure life and safety buffer of 25 feet. For Oahu, it should be the same but incorporating a minimum shoreline setback of 40 feet according to the ROH Chapter 23 on Shoreline Setbacks, Section 1.4 (ROH Sec 23-1.4). *This table assumes the inland soil substrate to be the same as the beach that is presently eroding, such that the same rate of erosion would be maintained over the long-term once the present beach shoreline is lost. A regulatory map would need to have greater detail and account for localized geologic and soil conditions. Consideration of relative sea level rise could also be included in the modeling necessary to produce a regulatory map. Adopting such maps would inform planners of the potential changes that climate change could potentially have and establish precedence for updating regulations based on changing conditions on Oahu.*

Table 5-6. Extent of Erosion Zone Assuming Constant Erosion Rate

Erosion Rate (in feet per year)	Safety / Design Buffer (in feet)	Life of Structure (in years)	Erosion Zone (in feet)	Recommended Shoreline Setback (in feet)
0	25	50	25	40
.1	25	50	30	40
.2	25	50	35	40
.3	25	50	40	40
.4	25	50	45	45
.5	25	50	50	50
1.0	25	50	75	75
1.5	25	50	100	100

For Oahu, there is a 60-foot setback for new subdivisions (ROH Sec 23-1.7), otherwise the standard setback is 40-feet. It is suggested for the City and County of Honolulu to establish a revised setback ordinance based on anticipated erosion rates. The FEMA Coastal Construction Manual (FEMA, 2011) recommends that for the building lifetime, a minimum of 50 years be utilized. To reduce confusion, it is recommended that the value of 50 years always be used, similar to Maui County. A safety/design buffer and overall minimum of 25 feet is also suggested. The recommendations for Oahu are as follows:

Adjustment of Shoreline Setback Line Related to the Construction of a New Building or Structure, or to a new Addition to an Existing Building or Structure.

i. The shoreline setback line shall be established 25 feet inland from the certified shoreline plus a distance of 50 times the historical annual erosion hazard rate from the shoreline established by county maps.
ii. Where the lot has average depth of less than 160 feet, the shoreline setback need not exceed 40 feet.
iii. A lot with an average lot depth of more than one hundred feet but less than one hundred sixty feet shall have a shoreline setback line forty feet from the shoreline; and
iv. A lot with an average lot depth of one hundred sixty feet or more shall have a shoreline setback line located at a distance from the shoreline equal to twenty-five percent of the average lot depth, but not more than one hundred fifty feet.
v. For irregularly shaped lots, or where cliffs, bluffs, or other topographic features inhibit the safe measurement of boundaries and/or the shoreline, the shoreline setback line will be equivalent to twenty-five percent of the lot's depth as determined by the Director, but in no case shall be greater than 150 feet.

Accretion rates shall not be considered.

5.7 Hazard Intensity Rank

The hazard ratings at a site based on different categories of the two sources of beach loss, erosion and sea level rise, are listed in Table 5-7.

Table 5-7. Hazard Intensity Factor

Hazard	Low (1)	Moderately Low (2)	Moderately High (3)	High (4)
Erosion	long-term accretion (>10 yr) with no history of erosion, or dynamic cycles with consistent annual accretion	long-term stable or minor erosion / accretion cycles with erosion fully recovered by accretion; low rocky coasts; perched beaches	long-term erosion rate <1 ft/yr or highly dynamic erosion / accretion cycles with significant lateral shifts in the shoreline	chronic long-term erosion >1 ft/yr, or beach is lost, or seawall at water-line for portions of the tidal cycle
Sea Level (0.04 in=1mm)	steep coastal slope where rise >0.04 in/yr or gentle slope where rise <0.04 in/yr	gentle or moderate slope, where rise >0.04 in/yr or steep slope where rise >0.08 in/yr	gentle or moderate slope, where rise >0.08/yr or steep slope where rise >0.12 in/yr	gentle or moderate slope, where rise >0.12 in/yr

Federal Regulations

5.7.1 Army Corps of Engineers

An Army Corps permit must be obtained for any dredge, fill, and/or discharge activities regardless of land ownership.[1] Corps permits will not be issued until all other applicable state and county permit requirements have been met. In addition to the navigable waters authority, federal jurisdiction is triggered for projects needing a federal permit if significant federal funding is involved, or if any major federal action significantly affecting the environment is required.[2]

5.7.2 Pertinent Legislation

Section 10, Rivers and Harbors Act of 1899 (33 USC 403) – prohibits the obstruction or alteration of navigable waters of the United States without a COE permit

Section 404 Clean Water Act (33 USC 1344) – prohibits discharge of dredged or fill material into waters of the US without a COE permit

Section 103, Marine Protection, Research and Sanctuaries Act of 1972, as amended (33 USC 1413) – authorizes the COE to issue permits for the transportation of dredged material for the purpose of dumping it into ocean waters

5.8 State Regulations

5.8.1 Hawaii Coastal Zone Management Program

The National Coastal Zone Management Act (CZMA) was enacted in 1972 to assist coastal states in developing management policies for the coastal resources located within the state coastal zone. Coastal erosion is specifically mentioned in the CZMA as an area of concern to be addressed by state policy. The CZMA requires that state programs include a planning process for assessing the effects of shoreline erosion, study ways to lessen the impact, and restore areas adversely affected by erosion. (DLNR, 2000)

The Hawaii Coastal Zone Management Program (CZMP) was enacted in 1977 (Chapter 205A, HRS). Hawaii's coastal zone includes all lands, and all waters from the shoreline to the seaward limit of the state's jurisdiction. The State Office of Planning (OP), in the State Department of Business and Economic Development and Tourism (DBEDT), is the lead agency for administering the CZMP in Hawaii. The OP administers the CZMP through a network of state agencies and the county planning departments.

The erosion planning and management activities fall primarily under the jurisdiction of the counties through the administration of the Special Management Area (SMA) and shoreline setback provisions of Chapter 205A, HRS, and the Department of Land and Natural Resources (DLNR), Conservation District Regulations.

5.8.2 Land Use/Zoning

[1] Section 10, Rivers and Harbors Act of 1899 (33 USC 403); Section 404 Clean Water Act (33USC 1344); Section 103, Marine Protection, Research and Sanctuaries Act of 1972 as amended (33 USC 1413).

[2] The National Environmental Policy Act of 1969 (NEPA) requires the preparation of a federal Environmental Impact Statement (EIS) or Environmental Assessment (EA).

The Conservation District includes all submerged lands seaward of the shoreline, to the limit of state territorial waters. The Board of Natural and Land Resources (BNLR), staffed by the DLNR, is responsible for establishing the procedures and certifying where the shoreline is located, and for promulgating and administering the Conservation District use Regulations. All activities proposed within the Conservation District must submit to an application and review permit in order to obtain a Use Permit (CDUP) from BLNR.

5.8.3 Certified Shoreline

The State Board of Land and Natural Resources was authorized by Chapter 205A, HRS, to adopt rules for determining the shoreline and appeals of shoreline determinations, and to enforce the established rules. The coastal setback in Hawaii is measured from the Certified Shoreline, defined in the CZM as:

The upper reaches of the wash of the waves, other than storm and seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by the edge of vegetation growth, or the upper limit of debris left by the wash of the waves. (HRS 205A)

5.9 Recent and Ongoing Mitigation Projects

5.9.1 Changes to Shoreline Setbacks for State Conservation Land

Recent changes to the Conservation Land Use Rules, Chapter 13-5 of the Hawaii Administrative Rules have established that for DLNR Conservation land, there is a more stringent rule regarding shoreline setbacks in place to further protect state property. The shoreline setback follows the earlier formula in Section 5.6, but with 40 feet of buffer and using a 70 year building life: Shoreline Setback = 70 × Annual Erosion Rate + 40

5.9.2 Waikiki Beach Sand Replenishment Program

In response to the continued beach erosion of Waikīkī Beach, a sand replenishment project was completed in 2012 for a total of $2.4M from both private and public funding contributions. 27,000 cubic yards of sand were pumped from offshore onto the beach from just offshore of Waikīkī Beach. Figure 5-6 shows the overall project map, detailing where sand was coming from, where it was going, and some of their best management practices. Beach nourishment must be done frequently to keep Waikīkī Beach as a popular tourist attraction, so it is anticipated that similar projects to this one will continue.



Figure 5-6. Map of 2012 Waikīkī Beach Nourishment Project (DLNR)

5.9.3 Department of Transportation Highway Protection

Approximately 15% of state highways are expected to be significantly affected by coastal erosion and rising sea level. The DOT has estimated that the total cost for protecting or rerouting these highways to be around $15B and plans to release a more detailed plan in June, 2019. These roads are often vital and non-redundant, meaning their failure could cause large problems.

5.9.4 Dune and Beach Maintenance

Sand dunes and wide beaches protect inland properties by providing a barrier and breakwater for coastal storms. Maintenance programs can preserve these features and, in some cases, increase their size or effectiveness. Maintenance of dunes and beaches include protection from disruption by traffic or construction through regulations against foot and vehicle traffic and building codes. Stairs and boardwalks over dunes protect the sand and the plants that help keep the sand in place. Other maintenance projects including planting vegetation and installing fences that catch and hold sand.

Encouraging vegetation growth for coastal properties would allow vegetation to naturally protect against coastal erosion in a visually appealing way and move the certified shoreline makai (towards the ocean). This benefits the property owner by easing the restrictions due to the certified shoreline while allowing the public to enjoy the beach with less erosion.

Beach nourishment differs from beach maintenance in that sand is excavated from one site and placed to prevent a retreating beach. The effectiveness of nourishment programs depends on the type of sand imported, the slope of the natural beach, cross shore currents, and the frequency of storms. Therefore, careful professional design is essential. The State Department of Land & Natural Resources has sped up review of sand replenishment requests for beaches that have lost sand. Smaller, quicker permits, such as the Small Scale Beach Nourishment (SSBN) Category II, which do not exceed 10,000 cubic yards of sand per project, are anticipated to be utilized to fight beach erosion quicker in the future.

This process will allow the applicant to seek State and Federal approvals under a single permit and for the review to take place simultaneously. The applicant still will have to obtain county approvals separately. The reviewers include the U.S. Army Corps of Engineers, State Department of Health water quality officials, and State Land Board members.

It is possible and ideal to utilize multiple mitigation styles at the same location, for example encouraging vegetation growth after a beach nourishment project is completed. This would expand the beach and then further protect the beach against being eroded again.

5.10 Future Mitigation Actions to Reduce Damages Caused by Coastal Erosion

5.10.1 Use of Numerical Wave Run-up and Storm Surge Models

Numerical modeling can be a valuable source of information for formulating criteria for the safe siting of coastal development, defining BFEs for building codes, and for improving the evaluation of the certified shoreline and the appropriateness of the existing setback regime in Hawaii. In the development of the FIRM maps storm surges were modeled using computer simulation tools while numerical wave run-up models were not employed for the analysis. The focus of the study was on the south and western shores of the islands. Surge and run-up models can be used to improve understanding of adequate Base Flood Elevations for currently unmapped regions of the coast in Hawaii.

5.10.2 Adjust the Shoreline Setback Line Related to the Construction of a New Building or Structure, or to a new Addition to an Existing Building or Structure.

The shoreline setback line shall be established 25 feet inland from the certified shoreline plus a distance of 50 times the historical annual erosion hazard rate from the shoreline established by county maps.

Where the lot has average depth of less than 160 feet, the shoreline setback need not exceed 40 feet.

A lot with an average lot depth of more than one hundred feet but less than one hundred sixty feet shall have a shoreline setback line forty feet from the shoreline; and

A lot with an average lot depth of one hundred sixty feet or more shall have a shoreline setback line located at a distance from the shoreline equal to twenty-five percent of the average lot depth, but not more than one hundred fifty feet.
For irregularly shaped lots, or where cliffs, bluffs, or other topographic features inhibit the safe measurement of boundaries and/or the shoreline, the shoreline setback line will be equivalent to twenty-five percent of the lot's depth as determined by the Director, but in no case shall be greater than 150 feet.
Accretion rates shall not be considered.

5.10.3 Special Management Area, ROH Chapter 25 (amended November 2011)

- Special management area (SMA) means the land extending inland from the shoreline, as established by Chapter 25 and delineated on the maps established by the City Council.
- Special controls on development within an area along the shoreline are necessary to avoid permanent loss of valuable resources and foreclosure of management options, and to insure that adequate public access is provided to public owned or used beaches, recreation areas, and natural reserves, by dedication or other means. It is also the policy of the City and County of Honolulu to avoid or minimize damage to natural or historic special management area wetlands wherever prudent or feasible.
- "Development" does not include construction or reconstruction or improvements of a single-family residence that is less than 7,500 square feet of floor area and is not part of a larger development; nor repair or maintenance of roads and highways or streams, channels, and drainage ways, nor underground utilities.
- "Shoreline" means the upper reaches of the wash of the waves, other than storm and tidal waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by the edges of vegetation growth or the upper limit of debris left by the wash of the waves.
- SMA use assessments include the following, among others:
    - Adequate access to publicly-owned beaches
    - Protection of water resources and water quality and natural habitats
    - Consistent with the general plan and Chapter 24 development plans and Chapter 21 zoning
    - Minimizes dredging and filling

Gap:
SMA maps may need adjustment in the future in high erosion rate areas. There is no statutory minimum lifespan of development defined for SMA considerations; the actual lifespan of major building and infrastructure development (excluding single family homes) will typically be over 100 years. This brings standing to considerations of climate change.

Proposed Changes: starting in 2025,

- **Create another level of SMA zone maps defining a *Coastal Construction Control Zone*, to account for the coastal inundation limit of the 500-year flood including the effects of expected climate change by the year 2100 and sea level rise of 2 feet above the year 2000 mean high water, using modeling consistent with CMIP AR5 RCP 8.5 climatic conditions (see Chapter 14). Have this applicable only to major (definition to be determined) long-term developments.**

- ***For Major Permits (exceeding 25,000 square feet of building gross area) within the Coastal Construction Control zone, require that the effects of 50-years of erosion and the adverse effects of climate change and sea level rise, as defined by the Coastal Construction Control Zone, on the functionality of the development and land use be minimized to the extent practicable, and include provisions for the mitigation of the deleterious effects of the proposed use, and require the director to consider that as a criteria for permitting new development and any variances therefrom.***

5.10.4 Disclosure of Hazard Risks

It would be appropriate that any lots with a history of erosion would be fully disclosed along with any county policy against hardening of the shoreline with seawalls and revetments. If a landowner knows there is a disclosure requirement for erosion, or any policy against hardening of the shoreline, the tendency would be to make a greater effort to plan for this hazard when lots are created in the subdivision process. Recommendations for the disclosure of hazard risks during property transfer are shown below.

5.10.5 Uniform Land Sales Practices Act, HRS Chapter 484

The Uniform Land Sales Practices Act was enacted in 1967 and deals specifically with the sale of subdivided lands. Under this law, a public offering statement is to be delivered to all purchasers and prospective purchasers of a lot in a subdivision. HAR § 16-104-26(a). The public offering statement is to fully and accurately disclose the physical characteristics of the subdivided lands offered and all unusual or material circumstances or features affecting the subdivided lands. HAR § 16-104-2.

Required information in the public offering statement that is relevant to hazard mitigation includes:

1. Existing zoning regulations, including land use classifications and general plan;
2. Encumbrances, easements, liens, restrictions;
3. Elevation of the land;
4. Soil conditions- drainage; and
5. Exposure to natural hazards; e.g., earthquakes, floods, tidal waves, volcano, forest fires, slides, etc. HAR § 16-104-25.

From the landowner/developer prospective, disclosure of hazard risks creates an incentive to design projects, subdivisions or lots that avoid hazard problems. This is because the combination of a poorly designed (substandard) lot and a knowledgeable buyer will reduce market value. The developer benefits from proper hazard mitigation design by offering a more valuable product and establishing a quality reputation. Aside from protecting the buyer and providing incentive for the landowner to implement hazard mitigation measures, seller disclosure laws promote economic efficiency. Hawai‘i’s disclosure law was implemented, in part, after statistics showed that a leading cause of real estate litigation was due to the failure to disclose material facts regarding a property.

Gap:
The statutes do not reference any particular hazard maps or criteria of the severity of the hazard that warrants disclosure. Another problem with the public offering statement is the timing of

receipt – at "time of sale" which is after a decision has been made to purchase. This coupled with vagueness of information required renders disclosure less effective. A buyer has little recourse after the sale if the seller did not follow the disclosure requirements. Tropical cyclones are not considered. Climate change effects are not considered.

Proposed Change:

Expand list of disclosable hazards in public offering to include, more explicitly: "Exposure to natural hazards that are mapped: e.g., 2500-year earthquake ground motion in excess of SDC C levels, 100-year and 500-year flooding including 2 ft of sea level rise, tsunami evacuation zone and extreme tsunami zone, lava inundation hazard zone 1 or 2 per 1992 USGS map, adjacency to forest and wildfire historic burn areas per DOFAW, effective windspeed hazards above 145 mph per Hawaii State Building Code, dam failure evacuation map per DLNR, and 50-years of shoreline erosion. High surf inundation, earthquake – induced ground failure, and potential rockfalls / landslides shall also be disclosed to the extent known."

5.10.6 Mandatory Seller Disclosures in Real Estate Transactions, HRS Chapter 508D

The Mandatory Seller Disclosures in Real Estate Transactions Act ("Mandatory Disclosures Act") was passed in 1994. [HRS Chapter 508D] This law requires the seller or the seller's agent to prepare a disclosure statement in good faith and with due care regarding material facts that would be expected to measurably affect the value to a reasonable person of the residential real estate being offered for sale.Related to hazard mitigation, disclosure is expressly required for residential property in the special flood hazard area. HRS § 508D-15(a)(1). These are areas on the Flood Insurance Rate Maps subject to the 100-year flood and are equivalent to FEMA's V, VE, A and AE zones. Disclosure is also required for anticipated inundation areas designated on the on the Department of Defense's civil defense tsunami inundation maps. HRS § 508D-15(a)(4). The Hawai'i Supreme Court has indirectly indicated that erosion is a material factor to disclose. The Court ruled that a shoreline property boundary that was in dispute was a material fact that required disclosure. Shaffer v. Earl Thacker Co., 6 Haw. App. 188, 716 P.2d 163 (1986). Erosion changes the location of shoreline property boundaries, resulting in diminution of coastal lot size over time. County of Hawai'i v. Sotomura, 54 Haw. 176 (1973).

Gap:

The Mandatory Disclosures Act covers only residential real property with one to four dwelling units or a condominium or cooperative apartment, the primary use of which is occupancy as a residence. [HRS § 508D-1] Empty lots with no structures on them are not covered, even though the lot may have a history of flooding and erosion**.**

Proposed Change:

Make mandatory seller disclosure apply to vacant lots as well.

Recommendations for Disclosure of Hazard Risks

- The legislature should consider changes to the Mandatory Seller Disclosures in Real Estate Transactions Act to require disclosure regarding exposure to erosion, bluff erosion, and lava as well as disclosure of any county policy against hardening of the shoreline for new structures as a material fact.
- The legislature or Department of Commerce and Consumer Affairs should consider changes to the Uniform Land Sales Act to require a public offering statement for small subdivisions (less than 20 acres) along the coast in order to notify potential purchasers of the risks of natural hazards.
- County planning departments should continuously evaluate the status of State laws regarding the disclosure of hazard risks. Any gaps can be compensated for by requiring disclosure to prospective purchasers as a condition for a land use approval. The disclosure would be for any erosion or hazard risks (e.g., intentionally building in an erosion zone) and for any county policy regarding hazard mitigation (e.g., policy against shoreline hardening).
- The landowner should properly design lots and structures for natural hazards. Along with disclosing the risks of coastal hazards, the benefits of the enhanced design can be marketed.
- The prospective purchaser of real estate (empty lots or lots with a residence) should fully investigate the physical condition of the site to assess the risks of erosion and other natural hazards. Due diligence should not be compromised by belief that consumer protection laws will address all risks or issues. Generally, consumer protection laws do not place a duty on the seller to investigate problems, only a duty to disclose what is material and known.
- Due diligence by the prospective purchaser may include: (1) review of existing reports on erosion and coastal hazards, (2) hiring a consultant, (3) review of the report "Natural Hazards in the Hawaiian Coastal Zone," (Fletcher, et al., 2002), (4) a site visit to check for evidence of erosion or other hazards, (5) specific questions that are posed to the seller of the property and (6) specific requests for information on the physical condition of the property.
- Produce a real estate brochure to inform potential purchasers of the risks of coastal hazards and how to identify those risks.



6. Strong Winds

6. STRONG WINDS

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan included detailed descriptions of wind hazards. Made a clear distinction between non-tropical cyclonic winds (Trade winds and Kona winds as discussed in this chapter) and tropical cyclones. •The different hazard curves of tropical cyclones and all other wind events are discussed. It gave a history of high wind events and mentioned work on quantifying the topographic effects on windspeed due to Oahu's unique geography.	• A previous discussion of wind and wind effects nomenclature has been refined. Wind roses to show the annual wind patterns are also refined. • Redundant information and tables on hurricanes are removed from this chapter and placed exclusively in the next chapter. • An updated chronology of high wind events on Oahu not related to hurricanes is given, which have historically reached to over 100 mph gusts. This is important to distinguish extreme events of synoptic winds of the regular climatology from tropical cyclone activity in the Central Pacific region. • Topographic effects due to Oahu's mountainous terrain are quantified using information now adopted in the Honolulu Building Code and awarded the Outstanding Civil Engineering Achievement of 2010 by the Hawaii Chapter of the American Society of Civil Engineers. The 2012 plan had many of these maps included, now an example and a link of where to find them is included. • The chapter is updated to reflect changes in building codes. • Public survey indicates that the highest perceived risk from natural hazards on Oahu is from high wind storms and hurricanes

Summary of Mitigation Projects for the City and County of Honolulu

Refer to the following chapter for proposed mitigation activities for hurricanes that also apply to non-hurricane strong wind hazards, including:

- further upgrades to utility lifeline design standards and electrical transmission design standards;
- studies of vulnerable critical facilities; periodic adoption of current building codes;
- test single wall construction for wind loading resistance;
- provision of incentives for homeowners to perform retrofits;
- screening and certification of private sector shelters, and; all hazards public shelter evaluations.

6.1 Overview

Wind is one of the most costly insured property perils. There are several ways to measure the speed at which air is moving, or windspeed. The most commonly used methodologies for measuring windspeed are:

- *Sustained Wind* is the windspeed averaged over 1 minute.
- *Peak Gusts* are the maximum wind gust speeds averaged over a period of 3 seconds.

It is important to understand though, that it is wind pressure, and not windspeed, that causes wind damage. There are three types of wind pressure: positive, negative, and internal.

- *Positive wind pressure* is the direct pressure from the force of the wind that pushes inward against walls, doors and windows.
- *Negative wind pressure* occurs on the sides and roof of buildings. Negative pressure causes buildings to lose all or a portion of their roofs and side walls, and pulls storm shutters off the leeward side of a building.
- *Interior pressure* increases dramatically when a building loses a door or window on its windward side. The roof has internal pressures pushing up from inside of the building together with the negative wind pressure lifting the roof from the outside.

In some wind storms, but especially in hurricanes, windborne debris can also be a major factor in causing damage along with wind pressures. Flying objects such as tree limbs, outdoor furniture, signs, roofs, gravel, and loose building components from progressively failing adjacent buildings can impact the building envelope, creating openings that allow internal pressure to build within. The internal pressures add to the external pressures producing more severe pressures on the building components of the structure. The roof then is subjected to tremendous internal pressure building from inside, together with the negative wind pressures lifting the roof from outside. The resulting combined forces may cause roof system failure if the roof has not been adequately designed and constructed. If the roof is breached, high winds and rain destroy the inside contents of the building.

6.2 Wind Patterns

Winds on Oahu originate from three main sources: trade winds; Kona winds, and tropical cyclones that include tropical depressions, tropical storms and hurricanes. High winds from trade winds, Kona winds and tropical cyclones all affect the island of Oahu . The hazards from tropical cyclones are discussed in the following chapter. This chapter focuses the other two wind patterns and the relative risk between the tropical cyclonic and other wind patterns. The directionality and intensity of winds measured at the Honolulu International Airport for every 3 months of the year, averaged over 20 years of wind measurements, are shown by wind roses in Figure 6-1.

6.2.1 Trade Winds

On Oahu northeast and east-northeast "trade winds" occur about 70% of the time. Because trade winds are by far the most common winds over Hawaiian waters, they play a major role in defining the climatology of the region. North Pacific high pressure systems are responsible for the majority of the gusty trade wind episodes over Hawaiian waters, which commonly persist for several days before tapering off. Trade winds greater than 25 mph and up to between 40–60 mph occasionally occur for several days when the sub-tropical high pressure cell north of the islands intensifies. The east-facing coastlines, as a result, are the windward coasts and most impacted by trade wind energy.

Figure 6-1 shows that northeast and east-northeast trade winds are dominant most of the time and generally range in velocity between 10 and 20 mph. In summer months trade winds occur up to 90% of the time, while in winter months there is more variability with trade winds around 50% of the time. Samples in 3 month intervals were chosen to demonstrate this, as the wind roses from a given season look very similar. For the full year of wind roses, visit the National Weather and Climate Center website.

6.2.2 Kona Winds

"Kona" winds is the vernacular used for the stormy, rain-bearing winds that blow over the islands from the SW or SSW, from the opposite direction of trade winds. Kona winds can become very strong in the winter when very strong storm systems move across the central North Pacific draw air from the south toward their low pressure troughs. The western or leeward sides of the islands, then, become windward in this case, as the predominant wind pattern is reversed.

Kona winds are most likely to occur when a low pressure center is located within 500 miles NW of the islands and has an unusually low central pressure, below 1000 millibars for the subtropics, generally during the winter and spring seasons. Damaging Kona winds have reached velocities of 50 miles per hour for several days on end. Kona storms generally form in the region bounded by 15^{o} - 35^{o} N and 175^{o} E – 140^{o} W and move erratically, though with a slow tendency toward the west (Kodama 1998). These storms are persistent and can last up to two weeks. On land, effects of strong Kona winds can be very dramatic. It is not uncommon for trees to be uprooted, branches downed, and roofs blown off houses. When reinforced by mountainous topography, downslope winds can increase and can be very destructive to land in low lying areas. The Kaneohe-Kahaluu area, below the Koolau Mountains, has had extensive wind damage due to strong Kona winds.

In January 1980, a severe Kona storm caused closure of all airports with sustained winds of 40-50 mph gusting over 100 mph in certain regions due to topographical features. In December of 2008, the entire electrical grid on Oahu was blacked out for around 12 hours due to a Kona storm. The blackout was triggered by lightning strikes on or near the Hawaiian Electric 138 kV transmission system, which short circuited the system and tripped protective relay switches shutting down the entire grid.

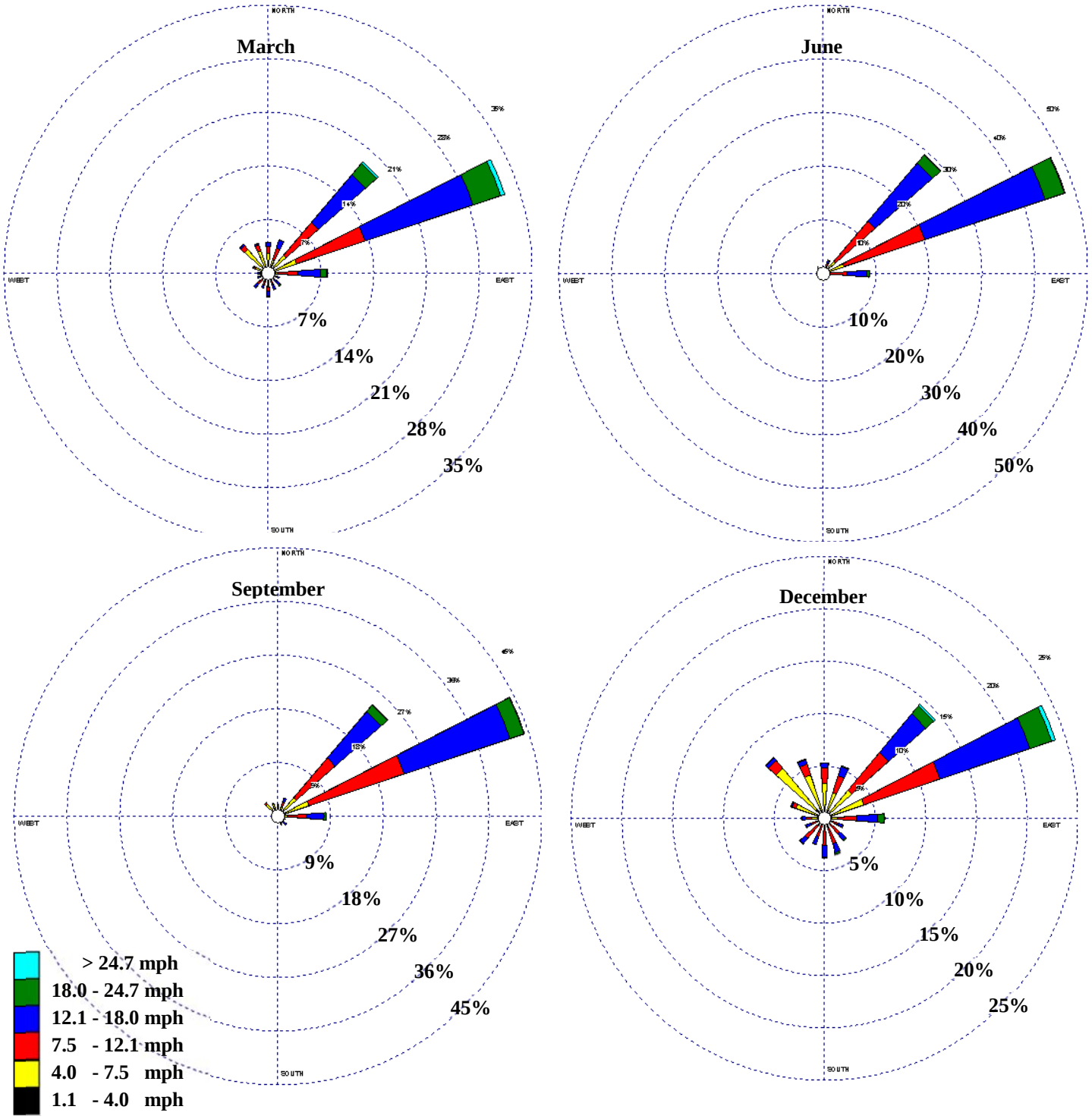


Figure 6-1. Wind roses at Honolulu International Airport for the months of March, June, September, and December based on hourly wind data averaged over 30 years from 1961 to 1990

(From the National Weather and Climate Center, https://www.wcc.nrcs.usda.gov/climate/windrose.html)

6.3 Significant Historical Events

High wind events, distinct from tropical cyclones, affect the Islands on a relatively regular basis. Table 6-1 provides a comprehensive list of recorded high wind events for the past 50 years. For example, in 1970 it was reported that windspeeds reached up to 117 mph. It can be observed from more recent events that the major damage is typically: power outages due to fallen distribution poles; fallen trees, which create debris that often results in damage to structures or other property, and; roof damage due to uplift of shingles, tiles or other types of cladding. Occasionally there are deaths associated with the debris and structural collapses. The storms that produce these high winds often have associated flooding and other hazards that provide further damage and losses. Further information on historic occurrences of strong winds from storms is provided in Figure 6-2 (Fletcher, et al., 2002).

Table 6-1. Historical High Wind Events on Oahu
(Fletcher et al., 2002 and NOAA website https://www.ncdc.noaa.gov/stormevents/)

Date	Description
January 16-17, 1968	Winter storm, wind gusts > 50 mph
February 15-18, 1968	SW winds, gusts to 62 mph
April 9-10, 1968	30-50 mph winds
November 28, 1968	Strong winds up to 69 mph
January 30, 1969	Strong winds
February 20-21, 1969	Strong winds
January 13-15, 1970	High winds, 96 mph, gusts to 117 mph
December 25-29, 1970	Winter storm, 50-60 mph
January 5, 1971	Strong winds
January 21, 1971	Tornado at Whitmore Village
February 4, 1972	Gusts to 69 mph
August 15, 1973	Dust devil
February 5-7, 1976	Strong winds
November 6-7, 1976	Strong winds
October 22, 1978	70 mph winds
January 8, 1980	Storm
February 11, 1981	Strong winds
February 11, 1982	Winter storm, strong winds
February 13, 1982	Tornado
December 18-19, 1982	Gusty trade winds up to 60 mph
December 23-24, 1982	High winds
September 23, 1983	Tornado at Pearl City
September 29, 1983	High winds
December 24-25, 1983	Winter storm, gusts > 50 mph
March 1-3, 1984	Gusts 30-40 mph
December 24-25, 1984	Kona Storm
January 29-30, 1985	High winds, Nanakuli & Waianae
March 1-11, 1985	Gale force trade winds

Table 6-1. Historical High Wind Events on Oahu
(Fletcher et al., 2002 and NOAA website https://www.ncdc.noaa.gov/stormevents/)

Date	Description
November 30, 1985	Strong northerly winds
April 8, 1986	Strong winds at Nanakuli
May 13, 1986	Small tornado at Waipahu
March 28, 1986	Tornado at Barbers Point
December 5, 1986	Gusts up to 50 mph
January 19, 1987	High winds, 35 mph
November 4-5, 1988	Storm with gusts of 40-50 mph.
December 5-6, 1988	S winds of up to 50 mph
December 30-31, 1988	40-50 mph winds
March 1-4, 1989	Storm, strong winds
December 9-11, 1989	Gusty winds
February 6-9, 1990	Gusts to 60 mph
March 9, 1993	Frontal system, strong winds, minor damage
December 4-6, 1993	Strong trade winds, 60-80 mph
March 12-16, 1994	Strong gusty trade winds, 40-50 mph
April 14-19, 1995	Strong trade winds, 40-50 mph
December 7-8, 1996	N winds, gusts to 60 mph
December 26-31, 1996	S and SW winds, gusts to 75 mph
January 2-3, 1997	S winds, gusts to 60 mph
January 27-29, 1997	SW winds, 60 mph
April 9-11, 1998	NE winds up to 55 mph, power outages
March 20-21, 1999	Wind gusts up to 55 mph, fallen trees, power outages, minor roof damage
May 5, 1999	Dust devil in Kunia
July 26-27, 1999	Winds up to 50 mph, fallen trees, power outages, dust storms
November 28-29, 1999	Strong winds 30-45 mph
February 14-16, 2001	NE winds 35 to 40 mph, gusts to 55 mph, localized power outages
February 26, 2001	Waterspout ashore at Ehukai beach
August 31, 2001	Sustained winds 25 to 35 mph, gusts to 51 mph
November 26-27, 2001	SW winds 40-45 mph, gusts to 50 mph, fallen trees, localized roof damage, power outages
December 2-3, 2001	NE to E winds 30 to 40 mph, gusts to 50 mph., fallen trees, power outages, localized roof damage
December 11-14, 2001	NE to E winds 30 to 40 mph, gusts to 55 mph., fallen trees, power outages
January 17-20, 2002	E to E/NE winds 30 to 40 mph, gusts to 50 mph
January 29-30, 2002	E to E/NE winds 30 to 40 mph, gusts to 45 mph
March 17-18, 2002	N to NE winds 30 to 40 mph, gusts to 50 mph
January 4-5, 2003	SW to W winds, fallen trees, power outages, localized roof damage
January 14-16, 2003	SW to W winds, gusts to 50 mph., fallen trees, power outages
June 3, 2003	F0 tornado
November 19, 2003	NE winds 30 to 40 mph, gusts to 65 mph, fallen trees, power outages, localized roof damage
January 14, 2004	High winds, fallen trees, power outages, considerable roof damage, school closures
January 22-23, 2004	Thunderstorm, gusts to 60 mph
January 25, 2004	Funnel cloud, F0 tornado
February 7, 2004	F0 tornado

Table 6-1. Historical High Wind Events on Oahu
(Fletcher et al., 2002 and NOAA website https://www.ncdc.noaa.gov/stormevents/)

Date	Description
February 27-28, 2004	S thunderstorm winds, gusting to 58 mph, fallen trees, power outages, localized roof damage
November 14-16, 2004	Winds gusting to 46 mph, power outages
January 8-9, 2005	Gusty thunderstorms, fallen trees and fences, power outages
February 11-12, 2005	20-25 mph, 50 mph gusts, fallen trees, power outages
March 14-15, 2005	Gusty winds, fallen trees, power outages, property damage
December 4, 2005	F0 tornado, minor damage to one house
December 18, 2005	Gusty winds, power outages, localized roof damage, 1 fatality
February 2, 2007	High winds, gusts to 70 mph.
December 4, 2007	High winds, gusts to 55 mph. One injury.
February 26, 2009	High winds, gusts to 50 mph. One death.
March 4, 2011	High winds, gusts to 50 mph. $350K of property damage.
March 16-17, 2011	High winds, gusts to 45 mph. Six injuries.
December 10, 2011	High winds, gusts to 45 mph. $10K of property damage.
February 7, 2012	High winds, gusts to 40 mph. 2 injuries. $16K of property damage.
February 16-18, 2013	High winds, gusts to 55 mph. $8K of property damage.
January 22, 2014	High winds, gusts to 40 mph.
February 9, 2015	High winds, gusts to 55 mph. $3.5K of property damage.
February 13-14, 2015	High winds, gusts to 55 mph. One injury. $7K of property damage.
February 16, 2016	High winds, gusts to 55 mph. One injury.
March 8, 2016	High winds, gusts to 55 mph. One injury.
February 5, 2017	High winds, gusts to 55 mph. $110K of property damage.
February 11, 2017	High winds, gusts to 45 mph. Three injuries.
February 13, 2017	High winds, gusts to 50 mph. $60K of property damage.
March 1, 2017	High winds, gusts to 50 mph. $7K of crop damage.
October 23, 2017	High winds, gusts to 55 mph. One injury. $6K of property damage.
January 17-18, 2018	High winds, gusts to 45 mph. $25K of property damage. $2K of crop damage.

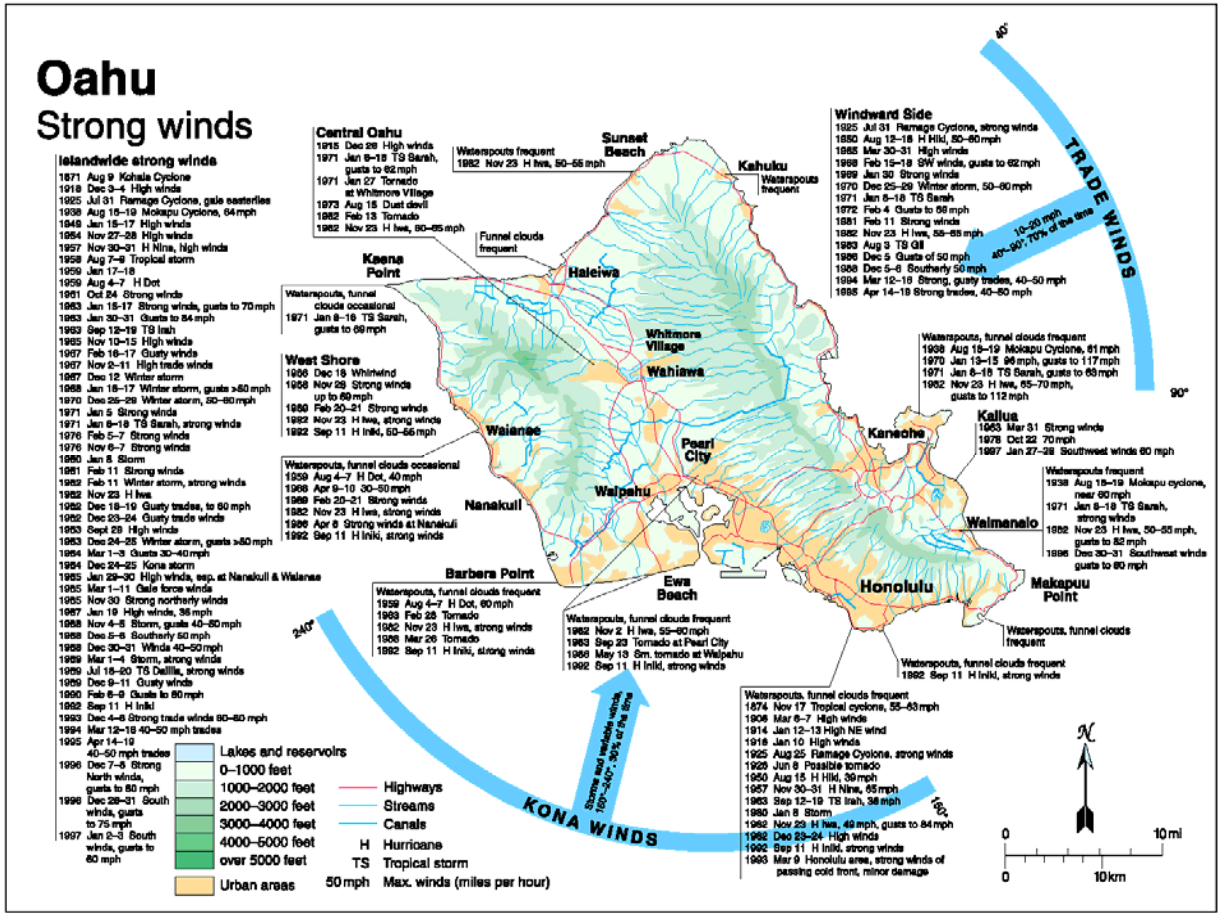


Figure 6-2. Historic occurrences of damaging winds from trade winds, Kona Storms, and tropical cyclones (Fletcher, et al., 2002)

6.4 Development of Topographical Amplification Criteria for Hawaii

6.4.1 Topographic Effects on Windspeed

Historically, the magnitude of wind speed-up caused by topography in Hawaii has not been well understood, and it was not previously considered in any code used in Hawaii prior to the 2007 adoption of the IBC 2003. The topographical wind speed-up map for Oahu shows the areas subject to topographic wind amplification. As a result, buildings of all types constructed after 2007 are built to a uniform level of risk, that is, all occurrences of amplified wind are addressed in the design of that building using the new wind maps, so that no building has disproportionate risk with respect to buildings on mild flat terrain, and all are compliant with structural integrity for Category 3 storms.

The topographical factor map for Oahu is provided in Figure 6-3, and an example of a more detailed figure for only one area is Figure 6-4. This work was awarded the Outstanding Civil Engineering Achievement of 2010 by the Hawaii Chapter of the American Society of Civil Engineers. The full map set for Oahu is available on the Structural Engineers Association of Hawaii's website: (http://www.seaoh.org/wp-content/uploads/2014/10/contour.pdf)

The International Building Code (IBC) 2018 does have micro-zonation maps for Hawaii that implicitly include topographic factors, which are applicable. However, the Honolulu Building Code has maps of all terrain related factors and should preferably be utilized.

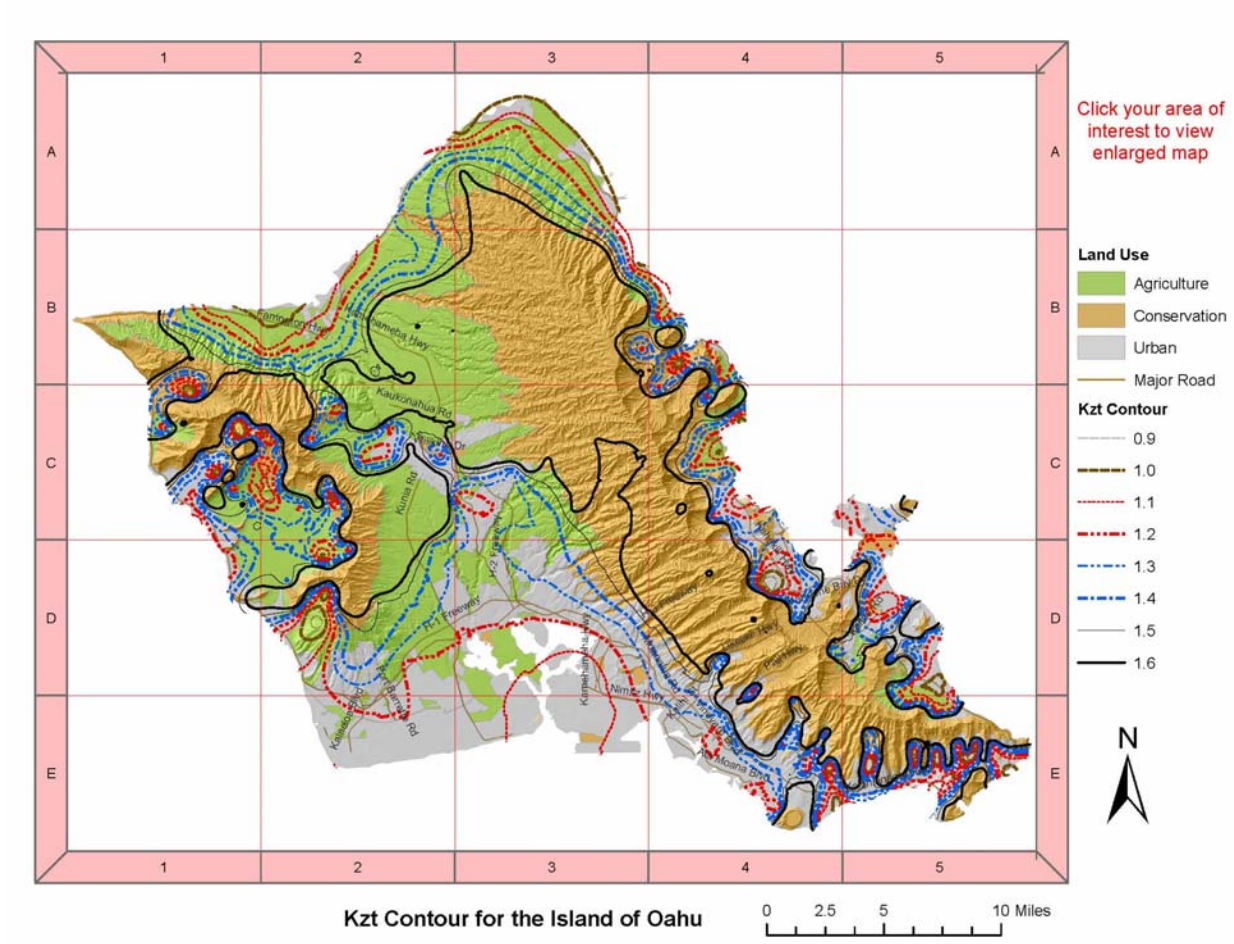


Figure 6-3. Topographical factor map of Oahu

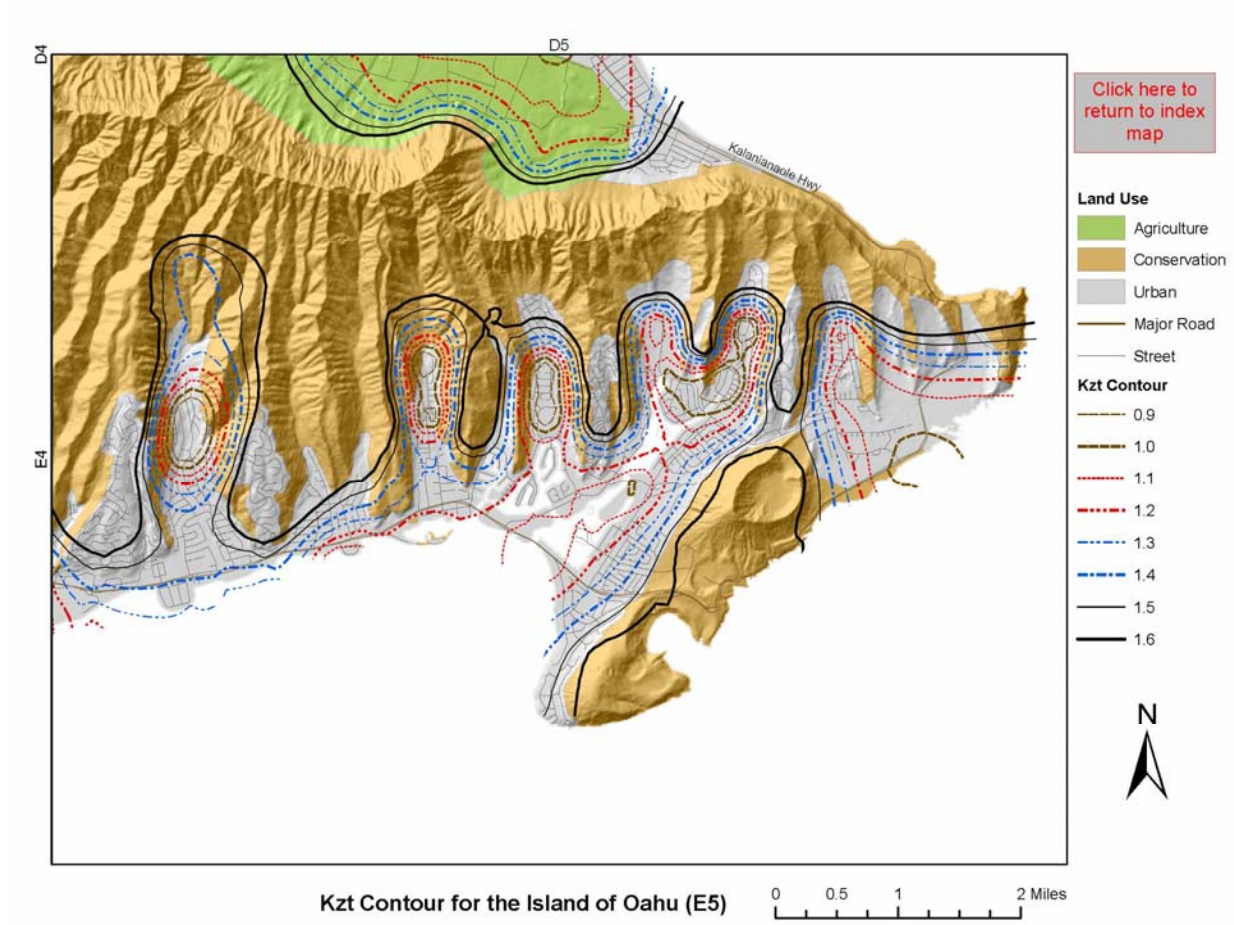


Figure 6-4. Example of one of the more detailed section maps of topographical factors for Oahu

6.5 Wind Hazard Curves

Figure 6-5 shows the hazard curves for the Hawaiian Islands for tropical cyclonic winds and non-tropical cyclonic trade and Kona winds. The figure shows that winds of 68 mph or less, which can still be very damaging, are more likely to occur due to non-tropical cyclonic winds. High wind speeds are more likely to be experienced during a tropical cyclone (tropical depression, storm, or hurricane), which are more damaging, however these events are less frequent.

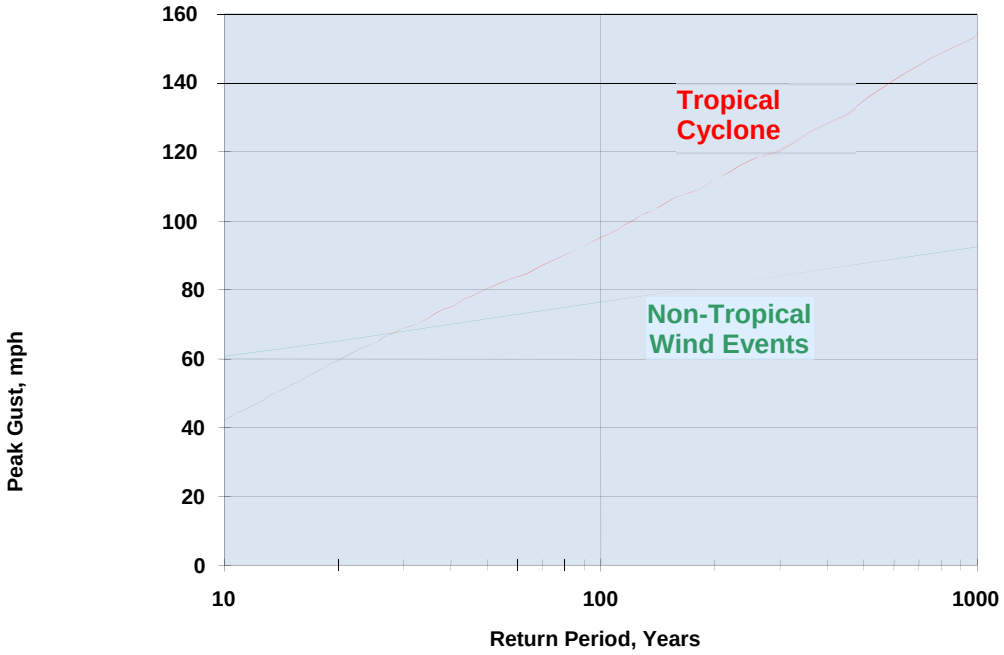


Figure 6-5. Wind hazard curves for the Hawaiian Islands for Hurricane and Non-Hurricane Winds

For example, at the lower windspeeds, a 60 mph or greater trade wind or Kona wind event is expected to occur once every 10 years, while the 60mph or greater tropical cyclone is expected to occur once every 20 years. At the higher windspeeds, a 90 mph or greater tropical cyclone is expected to occur 80 years, while a 90 mph or greater trade or Kona storm is expected to be extremely rare and occur only once every 700-800 years. Therefore major structural damage, due to the high winds are more likely to be caused by tropical cyclones in the form of hurricanes. However, damage associated with storms with lower windspeeds is more likely to be caused by trade or Kona wind storms. These damages can typically be: minor structural damage for structures deficient compared to current building standards, non-structural water damage due to wind blown rain, flooding associated with wind storms, or damage to power distribution systems deficient compared to current building standards.

Utilities:
Power distribution lines are susceptible to strong winds due to the relatively low design standards for older portions of the grid, which may also have preexisting damage in the wood poles due to decay and termite attack. Electrical shorts due to lightening strikes may also cause disruption of electrical service. One of the most common impacts of a storm is the loss of electrical service to some communities. The PUC adopted the 2002 National Electrical Safety Code which improves the design standards for electrical transmission and distribution systems. This code is now 15 years out of date. Moreover, this code does not consider topographic wind effects and should be locally amended to include the previously mentioned work that was incorporated in the Honolulu Building Code. A discussion of the electrical transmission and distribution systems on Oahu, and recent updates, is provided in Chapter 7.

6.6 Future Hazard Mitigation Projects

Refer to the following chapter for proposed mitigation activities for hurricanes that also apply to non-hurricane strong wind hazards, including: further upgrades to utility lifeline design standards, electrical transmission design standards, studies of vulnerable critical facilities, periodic adoption of current building codes, testing of single wall construction for wind loading, provision of incentives for homeowners to perform retrofits, , screening and certification of private sector shelters, and all hazards public shelter evaluations.



7. Tropical Cyclones

7. TROPICAL CYCLONES

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
In the 2012 plan, this chapter included hurricanes, discussing the hurricane hazard, risks, and vulnerabilities. It included many figures and historical events. Wind speed maps were completed for the 2006 IBC adoption and incorporated for each of the major islands. The FEMA flood insurance study of the south and west coasts of Oahu based on tropical cyclones was summarized. Some shelter information was included.	• Several figures were outdated and were either updated or removed. Historical data was also updated. • An analysis of hurricane hazard for the climate at the end of the century was performed. This is discussed in Chapter 4. • State Building Code: The chapter discusses changes to the recent building codes. • HAZUS MH includes a hurricane loss estimation module. The hazard assessment using average annualized losses has been updated using HAZUS MH and an updated profile of housing construction on Oahu. This is the highest rated hazard in terms of average annualized losses anticipated. • A public survey indicates that the highest perceived risk from natural hazards on Oahu is from high wind storms and hurricanes . • Hurricane hazard mitigation projects have been revised. • All hurricane shelter information has been moved to Chapter 17.

Summary of Mitigation Projects for the City and County of Honolulu

Project	Priority
Establish regulatory policy to identify critical facilities during planning and design**.** CRITICAL FACILITY: Buildings and structures provide services that are essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations.	High
Hazard Mitigation Retrofits of the Honolulu Essential Facility Inventory and State Essential Facility Inventory based on HAZUS-MH and BCA. Detailed evaluations of these selected buildings may result in revisions to the risk rankings, and more importantly, will identify specific mitigation measures to reduce vulnerabilities and improve expected building performance.	High
Update design and construction standards for utility lifelines. Establish further upgrades to the electrical transmission and distribution design standards to incorporate Hawaii specific topographical, directionality and exposure information for the design of above ground utility using effective wind speed maps consistent with the State Building Code. • Replace weathered wood poles with NESC-conforming poles.	Medium-High
Adopt 2012 IBC, then the 2018 IBC and related codes per HRS 107 Part II,	Medium-High
Provide incentives for homeowners and businesses to retrofit their structures.	Medium-High
Establish a policy for strengthening of the enclosure of critical public facilities.	Medium
Test the Wind Performance of Single Wall Construction	Low

7.1 Overview

Tropical cyclone winds present a distinctly different hazard to Hawaii than winds from other storm systems of the normal climatology (strong trade winds or Kona winds, winter storms, etc.). Tropical cyclones typically form in the warm tropical waters to the south of Hawaii and travel from east to west but sometimes migrate north and impact the islands either as hurricanes or weakened tropical storms or depressions. They are characterized by a large counter-clockwise circulation of air and lower barometric pressure near the center. The maximum winds in a tropical cyclone occur near the perimeter of a calm eye and diminish with distance from the eyewall.

Tropical cyclones are categorized based on their sustained wind speeds as defined below:

- **Hurricane:** An intense tropical weather system with a well defined circulation and maximum sustained winds of 74 mph (64 knots) or higher.
- **Tropical Storm:** An organized system of strong thunderstorms with a defined circulation and maximum sustained winds of 39 to 73 mph (34-63 knots).
- **Tropical Depression:** An organized system of clouds and thunderstorms with defined circulation and maximum sustained winds of 38 mph (33 knots) or less.

A summary of the most significant Hawaiian Hurricanes over the last century along with the estimated damage from each hurricane is summarized in Table 7-1. A list of tropical cyclones in the Pacific Ocean that had significant impact on Oahu through high winds, flooding, storm surge, or other factors since 1950, along with the annual frequency of tropical storms in the Central Pacific from 1970-2018 is provided in Table 7-3. In 2018, the near-misses of Hurricane Lane and Hurricane Olivia reminded Honolulu residents of the threat of tropical cyclones.

Table 7-1. Significant Hawaiian Hurricanes of the 20th Century

Name	Date	Damage (1990 Dollars)	Deaths
Mokapu Cyclone	Aug. 19, 1938	Unknown	Unknown
Hiki	Aug. 15, 1950	Unknown	Unknown
Nina	Dec., 2, 1957	$900,000	4
Dot	Aug. 6, 1959	$28,000,000	0
Iwa	Nov. 23, 1982	$394,000,000	1
Iniki	Sept. 11, 1992	$1,800,000,000	4

Actual hurricane strikes on the Hawaiian Islands are relatively rare in the modern record. Historically, most tropical storms and hurricanes have passed the Hawaiian Islands to the south and west. Figure 7-1 shows hurricane tracks for the Central Pacific systems and their relationship to the ocean water temperature. Those hurricanes that head north to the east of the Islands cross colder water and tend to dissipate before reaching the Islands. Table 7-2 lists the hurricanes and tropical storms that are recorded to have had some significant effect on the Islands since 1871.

Table 7-2. Historical Tropical Cyclones Affecting the Hawaiian Islands (Fletcher 2002, NOAA NWS Website http://www.prh.noaa.gov/hnl/pages/stormdata/)

August 9, 1871	Kohala Cyclone, gale winds
July 31, 1925	Ramage Cyclone
August 18-19, 1938	Mokapu Cyclone
January 23-26, 1948	High winds
August 15, 1950	Hurricane Hika
November 30-31, 1957	Hurricane Nina, gusts to 92 mph.
August 6-9, 1958	Tropical Storm
August 4-7, 1959	Hurricane Dot, strong winds
September 12-19, 1963	Tropical Storm Irah, strong winds
August 8-10, 1967	Tropical Storm
January 8-18, 1971	Tropical Storm Sarah
July 21-22, 1982	Tropical Storm Daniel
August 1, 1982	Tropical Storm Gilma
November, 23, 1982	Hurricane Iwa
October 15-20,1983	Hurricane/Tropical Depression Raymond
July 22-23, 1986	Hurricane Estelle, rain and high surf
July 18-20, 1989	Tropical Storm Dalilia
September 11, 1992	Hurricane Iniki, heavy rain, high winds, and high surf
July 16, 1993	Hurricane Fernanda, rain and high surf
July 14, 1994	Tropical Storm Daniel, moderate surf
July 24, 1994	Tropical Storm Fabio, heavy rainfall
August 15, 1999	Hurricane Dora, mild rain
September 1, 2003	Hurricane/Tropical Storm Jimena, 4 to 8-foot swell
August 3, 2004	Hurricane Darby, heavy rain and 4 to 8-foot swell
September 22, 2005	Hurricane/Tropical Storm Jova, 8 to 12-foot swell
September 30, 2005	Hurricane/Tropical Storm Kenneth, 8 to 10-foot swell
August 13, 2007	Hurricane Flossie, rain
August 10, 2009	Hurricane/Tropical Storm Felicia, rain
August 8, 2014	Hurricane Iselle, heavy rain, high winds, and high surf
September 26, 2015	Tropical Storm Niala
July 18, 2016	Hurricane/Tropical Storm Celia, heavy rain and up to 15-foot swells
July 24, 2016	Hurricane/Tropical Storm Darby, heavy rain
August 7, 2016	Tropical Storm Howard, heavy rain
September 1, 2016	Hurricane/Tropical Storm Madeline, heavy rain and high winds
September 3, 2016	Hurricane/Tropical Storm Lester, heavy rain
August 24, 2018	Tropical Storm Lane, harbor closure, heavy rain for days after
September 12, 2018	Tropical Storm Olivia, heavy rain

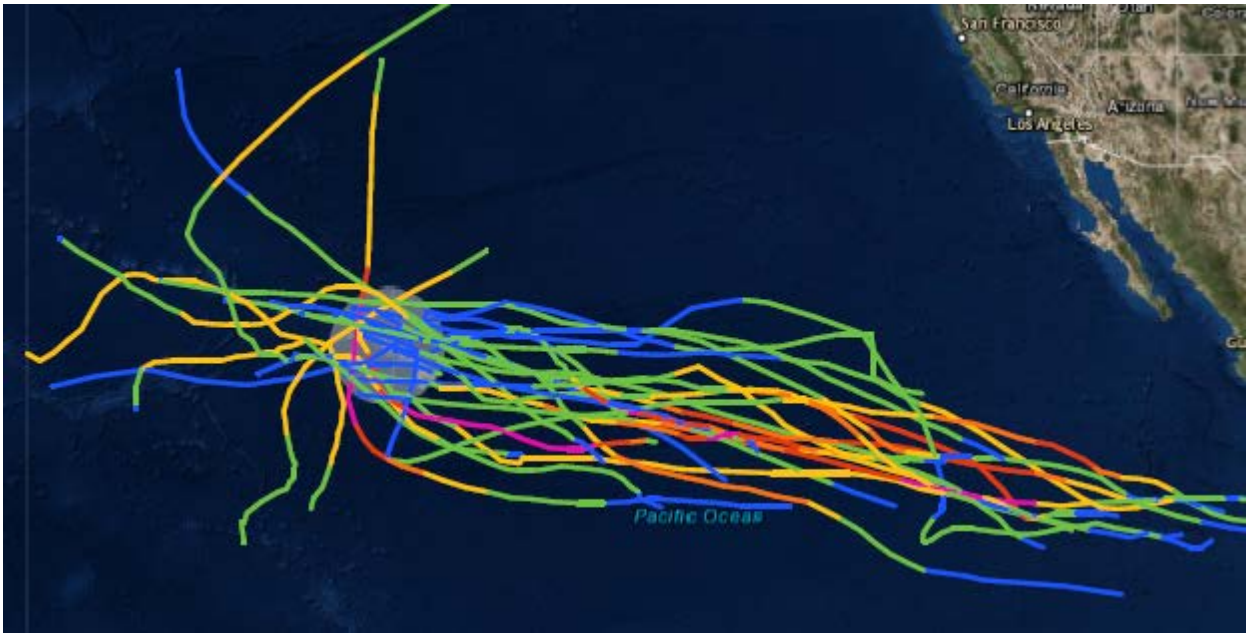
				Wind			Low	Rate of				Marine	Tidal	Max.	High			
				Closest	Average	Gust	BP	Travel	Eye	Rain	Stream	Surf	Surge	Run-up	Water		Damage	
Year	Date	Name	Track	island	(mph)	(mph)	(mbar)	(kts)	(nmi)	(in)		(ft)	(ft)	(ft)	(ft)	Type of damage	(1998 $)	Comments
2018		Olivia																
		Lane																
2016	7/23	Darby	W-NW, landfall on	Hawaii	120		958			5-8						All islands: Flash floods and heavy rain		Cat. 3 Hurricane, rapidly downgraded
			Hawaii island															eventually made landfall on Hawaii
2014	8/2	Iselle	W-NW, landfall on	Hawaii	140		947									Hawaii: Major agricultural losses	$54.5M	Cat. 4 Hurricane, downgraded to TS
			Hawaii island															
2000	31-Jul	Daniel	NW, passed N	All				10				10 ft				All islands: Heavy showers and thunderstorms		Cat. 3 hurricane weakened
			of islands															east of the islands, briefly reintensified
1994	21-Jul	Emilia	NW, passed 200	All								10 ft				Oahu: Caused minor damage to roofs and some		Cat. 5 hurricane, weakened
			miles S of Oahu													trees uprooted.		as it passed south of islands
1993	8/16	Fernanda	WNW, Disintegrated	Hawaii	105	125	*970	10-15		Locally		10-15				Hawaii: 3 small boats broke their moorings, high		Hurricane warning issued for Hawaii.
			400 mi E of Oahu							heavy						waves closed roads in Hilo and Puna, 1 home		
																damaged by water. Oahu, Windward side (Kaaawa):		
																some coastal flooding, debris on highway.		
																Maui, Molokai: High waves, 1 house damaged		
1992	9/11	Iniki	S-N, passed just	Kauai	130	160	945			Heavy	No	20-35	4.5-6.2	26.3	18.5	Kauai: 1,421 houses destroyed, 13,000 homes	$500M–$5B	Stro ngest and most destructive
			W of Port Allen,								flooding					with minor to heavy damage, 3 people dead.		hurricane to hit islands in this century.
			crossed over													Oahu: Some flood/wind damage SW shore.		Sixth costliest hurricane in U.S. history.
			Kauai													Hawaii: Twelve houses damaged by surf.		$1.8 billion in damage to Kauai alone.
1989	7/17-	Dalilia	NW, passed	Hawaii	75		989					10-15				Hawaii, S shore: 40 kts. Wind downed trees		
	7/21		100 mi S of													and powerlines, rains caused minor flooding.		
			Hawaii													Oahu, Kauai: Heavy rain (1.5-9 in), esp. NE shores.		
1988	8/28-	Uleke	NW, passed S,			120						High				Oahu: High surf along S shores.		
	8/29		threatened													Kauai: Two people drowned.		
1986	7/21-	Estelle	W, passed S		132			20				10-20				Hawaii: 10-20 ft surf and 50 mph	$2M	Steadily weakened as
	7/25															winds demolished 5 houses, SE shores		she directly aimed at
																evacuated. Oahu: Two drowned.		Hawaii.
																Maui: Stretch of dirt road washed away.		
1985	9/5-	Pauline	W, turned N,	Hawaii				10				10-15				Hawaii: 15 ft surf along Puna and Kau, debris on		Hurricane watch was
	9/9		passed E of Hawaii													roads. All Islands: High surf on E shores.		issued.
1982	11/23	Iwa	NE, passed NW	Kauai	92	126	964	18		3-6.5	No	20-30	5-6	600 ft		Kauai: Flooding from Kekaha to Poipu, 67% damage.	$312M	Kauai, Oahu, Niʻihau federal disaster
			of Kauai								flooding					Oahu: Flooding from Makaha to Koko Head, 1 dead		areas. Most destructive hurricane
																as ship was hit by 30 ft wave, 30% damage.		to date, 1,591 acres flooded in state.
																465 houses demolished, 1,712 damaged. 1 dead.		
1978	7/17-	Fico	WNW, passed	Hawaii	115		955	10	30			30				Hawaii: 30 ft surf caused heavy damage.		
	7/28		175 mi S													Other Islands: 8-12 ft surf, 65 ft tugboat		
			of South Point													went aground, brought 6 in rain to Oahu.		
1976	9/19-	Kate	NW, passed NE	Hawaii								8-15				Hawaii, Maui, Oahu: 8-15 ft surf NE shores.		
	10/1		of Hawaii															
1972	8/18-	Fernanda	WNW, passed 150	Hawaii		115										Hawaii: Flash food in Waipio Valley,	$2,000	
	9/3		nmi NE of Hawaii													high surf damaged 3 small boats.		
1959	8/4-	Dot	NNW, Eye passed	Kauai	75	165	984	9	20-30	5						Kauai: Agricultural losses	of	$5.5-6M,100's Kauai.
	8/7		over Kauai, then													trees damaged, coastal areas flooded.		
			turned west													Oahu, Hawaii: Minor wind, flood damage.	$150,000	
1957	11/30-	Nina	NNW, passed	Kauai	92			8		21		35				Kauai: 20 in rain in 14 hrs, 12 homes damaged by	$1,056,000(?)	
	[BP, barometric pressure; mph, miles per hour; mbar, millibars; kts, knots; nmi, nautical miles; in, inches; ft, feet; $, dollars; M, million; B, billion]																	

Table 7-3. Significant Tropical Storms in the Pacific that affected Oahu since 1957

Due to the dependence of tropical storm activity on ocean surface water temperature, tropical storm activity in the Pacific is most prevalent over the summer months. The monthly frequency of hurricanes in the central pacific with most activity in July through September, reducing in frequency and strength in October through December. El Nino weather patterns also increase the frequency of hurricanes.

Despite the predominance of tropical cyclones to the south and west many systems do pass over the Islands. Figure 7-1 shows historical tracks of tropical storms that have passed within 200 mi of the islands while Figure 7-2 shows the tracks of systems that have passed within 75 mi of Oahu in particular.

Because they spin counter-clockwise in the Northern Hemisphere, east-facing coastlines in Hawaii receive the brunt of strong onshore winds as storms approach the islands, while the south and west coastlines feel onshore winds as the storms pass to the west. The highest wind speeds, however, may occur on the side opposite the storm approach, as localized microbursts and downdrafts accelerate downslope as they descend over the palis (cliffs). As Hurricane Iwa passed west of Oahu the highest winds were observed at the base of the Pali in Kaneohe. Even so, coastlines facing the passing storms usually are adversely impacted by both wind and storm surge damage, like the Waianae Coast was as Hurricane Iniki passed to the west, before slamming into Kauai. History has shown that the islands do not have to take a direct hit from a storm to sustain a high level of damage. Wind strength, storm radius of maximum winds, timing, and proximity, are important factors that control storm impact to the coastal zone.



7-1. Tropical Systems within 200 nautical miles of Hawai‘i from 1949 to 2017 (https://coast.noaa.gov/hurricanes/)

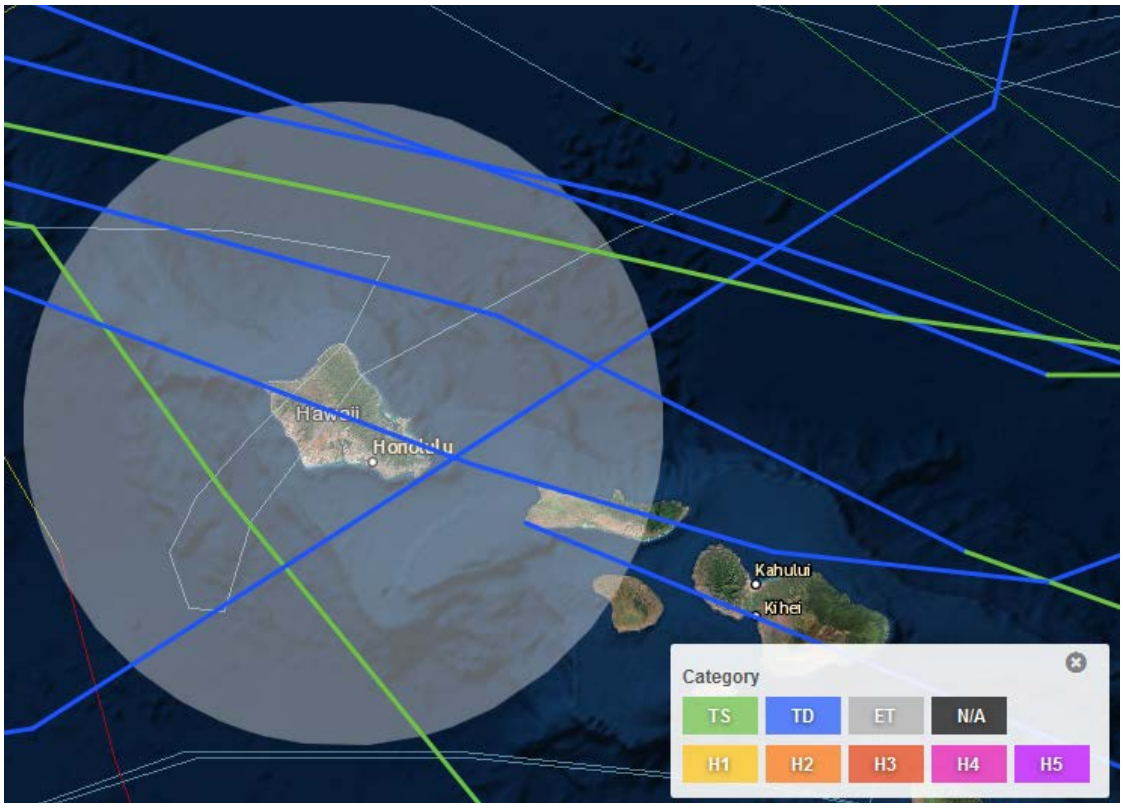


Figure 7-2. Tracks of the 8 Tropical Systems within 75 Miles of Oahu 1963-2017 (For full key and scaling, visit the NOAA Interactive Map **at https://coast.noaa.gov/hurricanes/)**

7.2 Intensity of Tropical Cyclones

Once a tropical cyclone has been categorized as a hurricane (i.e. sustained maximum winds greater than 74 miles per hour), its intensity is measured by the Saffir-Simpson Hurricane Scale. The scale provides examples of the type of damages and impacts associated with winds of the indicated intensity. Essentially, a hurricane is categorized by number and range from 1 (low) to 5 (high). *"A hurricane's approximate damage potential increases as the square of the integer value for the Saffir-Simpson category… A hurricanes' peak windspeed distribution is a direct function of its rotational windspeed and forward speed. Storms that have a higher traveling speed do not stay in one place for long, minimizing the possibility of damaging buildings and other stationary structures. However, faster moving storms tend to be more destructive further inland."* (IIPLR, 1994). The Simpson/Saffir Hurricane Scale is presented in Table 7-4 along with damage potential to Island infrastructure.

Table 7-4. Saffir/Simpson Hurricane Scale Ranges

Hurricane Category	Central Pressure		Sustained Winds	Fastest Mile Speed mph	Peak Gust (over land) mph	Approximate Storm Surge Height (ft.)	Damage Potential
	Mm of mercury at 0 degrees C (32 degrees F)	Sea level pressure (inches)					
Tropical Depression	# 1008	# 29.77	< 40 mph (< 64 km/hr)			# 2 ft (# 0.61m)	**Virtually None.** Some small dead limbs, ripe coconuts, and dead palm fronds blown from trees. Some fragile and tender green leaves blown from trees such as papaya and fleshy broad leaf plants.
Tropical Storm	979-1007	28.91-29.74	40-73 mph (64-117km/hr)			2-3 ft (0.61-0.91m)	**Some.** Minor damage to buildings of light material. Moderate damage to banana trees, papaya trees, and most fleshy crops. Large dead limbs, ripe coconuts, many dead palm fronds, some green leaves, and small branches blown from trees.
1	980-992	28.94-29.30	74-95 mph (118-153 km/hr)	67-88	81-105	4-5 ft (1.22-1.52m)	**Significant.** Corrugated metal and plywood stripped from poorly constructed or termite-infested structures and may become airborne. Some damage to wood roofs. Major damage to banana trees, papaya trees, and fleshy crops. Some palm fronds torn from the crowns of most types of palm trees, many ripe coconuts blown from coconut palms. Some damage to poorly constructed signs. Wooden power poles tilt, some rotten power poles break, termite-weakened poles begin to snap. Low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings.
2	965-979	28.50-28.91	96-110 mph (178-209 km/hr)	88-110	106-121	6-8 ft (1.83-2.44 m)	**Moderate.** Considerable damage to structures made of light materials. Moderate damage to houses. Exposed banana trees and papaya trees totally destroyed, 10%-20% defoliation of trees and shrubbery. Many palm fronds crimped and bent through the crown of coconut palms and several green fronds ripped from palm trees; some trees blown down. Weakened power poles snap. Considerable damage to piers; marinas flooded. Small craft in unprotected anchorages torn from moorings. Evacuation from some shoreline residences and low-lying areas required.
3	945-964	27.91-28.47	111-130 mph (178-209 km/hr)	110-136	122-143	9-12 ft (2.74-3.66 m)	**Extensive.** Extensive damage to houses and small buildings; weakly constructed and termite-weakened house heavily damaged or destroyed; buildings made of light materials destroyed; extensive damage to wooden structures. Major damage to shrubbery and trees; up to 50% of palm fronds bent or blown off; numerous ripe and many green coconuts blown off coconut palms; crowns blown off of palm trees; up to 10% of coconut palms blown down; 30%-50% defoliation of many trees and shrubs. Large trees blown down. Many wooden power poles broken or blown down; many secondary power lines downed. Air is full of light projectiles and debris; poorly constructed signs blown down. Serious coastal flooding; larger structures near coast damaged by battering waves and floating debris.
4	920-944	27.17-27.88	131-155 mph (210-249 km/hr)	136-169	144-171	13-18 ft (296-5.49 m)	**Extreme.** Extreme structural damage; even well-built structures heavily damaged or destroyed; extensive damage to non-concrete failure of many roof structures, window frames and doors, especially unprotected, non-reinforced ones; well-built wooden and metal structures severely damaged or destroyed. Shrubs and trees 50%-90% defoliated; up to 75% of palm fronds bent, twisted, or blown off. Many crowns stripped from palm trees; numerous green and virtually all ripe coconuts blown from trees; severe damage to sugar cane; large trees blown down; bark stripped from trees; most standing trees are void of all but the largest branches (severely pruned), with remaining branches stubby in appearance; trunks and branches are sandblasted. Most wood poles downed/snapped; secondary and primary power lines downed. Air is full of large projectiles and debris. All signs blown down. Major damage to lower floors of structures due to flooding and battering by waves and floating debris. Major erosion of beaches.
5	< 920	< 27.17	> 155 mph (> 250 km/hr)			> 18 ft (> 5.49 m)	**Catastrophic.** Building failures; extensive or total destruction to non-concrete residences and industrial buildings; devastating damage to roofs of buildings; total failure of non-concrete reinforced roofs. Severe damage to virtually all wooden poles; all secondary power lines and most primary power lines downed. Small buildings overturned or blown away.

7.3 High Wind Effects

During a tropical storm, high directional winds may damage or destroy homes, businesses, public buildings, and infrastructure. Barometric pressure is very low during a tropical storm, for example, usually 29 inches of mercury or less in a hurricane. Windspeeds are directly related to the lowest barometric pressure reading at the center of the storm. Windspeeds are greatest near the Radius of Maximum Winds, the area within the storm path near the lowest central pressure. The larger the radius, the larger the area of maximum destruction. The strongest winds are usually on the right side of the eye, as one faces the direction the storm is moving. Wind speeds decrease with increased distance away from the radius of maximum winds.

Termed "microbursts" and "mini-swirls," small scale localized wind bursts may reach wind speeds in excess of 200 miles per hour. During Hurricane Iniki, damage patterns and debris indicated that there were more than 26 mircobursts (sudden intense downdrafts) and two mini-swirls (a violent whirlwind, not tornado) had occurred on Kauai. Structural damage can be caused by the high pressures as well as impacts from debris carried by the high winds.

7.4 Hurricane Storm Surge and Scour Effects

In addition to damage from high winds, and more commonly, tropical storms generate large swells causing varying degrees of damage. This is the hallmark of hurricanes that pass close to but do not directly impact the islands. Impacts from these swells can be severe and lead to beach erosion, large waves, and marine overwash despite the fact that the hurricane may have missed the island. Communities on the Waianae coast of Oahu suffered severe damage from hurricanes Iwa and Iniki, yet neither of these storms actually hit Oahu.

Storm surge flooding is water that is pushed up onto otherwise dry land by onshore winds, referred to as "wind set-up." Friction between the water and the moving air creates drag that, depending upon the distance of water (fetch) and velocity of the wind, can pile water up to depths greater than 20 feet (6.1 m) from the shoreline inland. The storm surge is the most dangerous part of a hurricane as pounding waves create very hazardous flood currents. Worst-case scenarios occur when the storm surge occurs concurrently with high tide. Stream flooding is much worse inland during the storm surge because of backwater effects. About 90% of the deaths experienced in the past near the coast resulting from hurricanes are caused not by wind, but by storm surge. The height of storm surge along the open coast depends on a number of factors, which include:

(1) Wind speed and associated barometric pressure
(2) Depth of water or shoaling factor
(3) Storm trajectory
(4) Speed of the storm

Coastal configuration in the form of estuaries or bays can cause a funneling or amplification effect. Coincidence with high tide will also increase surge height. Although the maximum surge usually affects only a relatively short length of coastline, combined storm surge and wave action may have damaging effects over the entire coastline facing a major storm center.

Wind-driven waves on top of the storm surge pose a number of added problems, referred to as "wave set-up". The wave set-up can flood areas not reached by the surge or wind set-up itself. The scouring power of waves is also considerable. The duration of storm surge is usually relatively short, being dependent upon the elevation of the tide, which rises and falls twice daily in most coastal places and the speed of a storm's onset. The large waves however are constant for the duration of the storm. The high velocities of hurricane winds often produce wave heights higher than the maximum level of the prevailing high tide in Hawaii.

In studying the aftermath of Hurricane Iniki it was discovered by researchers at the Army Corps of Engineers and the University of Hawaii (Fletcher et al., 1994) that the greatest threat related to hurricane overwash in the Hawaiian Islands is due to water-level rise from wave set-up rather than wind set-up, as exemplified in Figure 7-3. This differs from the mainland where the wind set-up tends to be more prevalent.

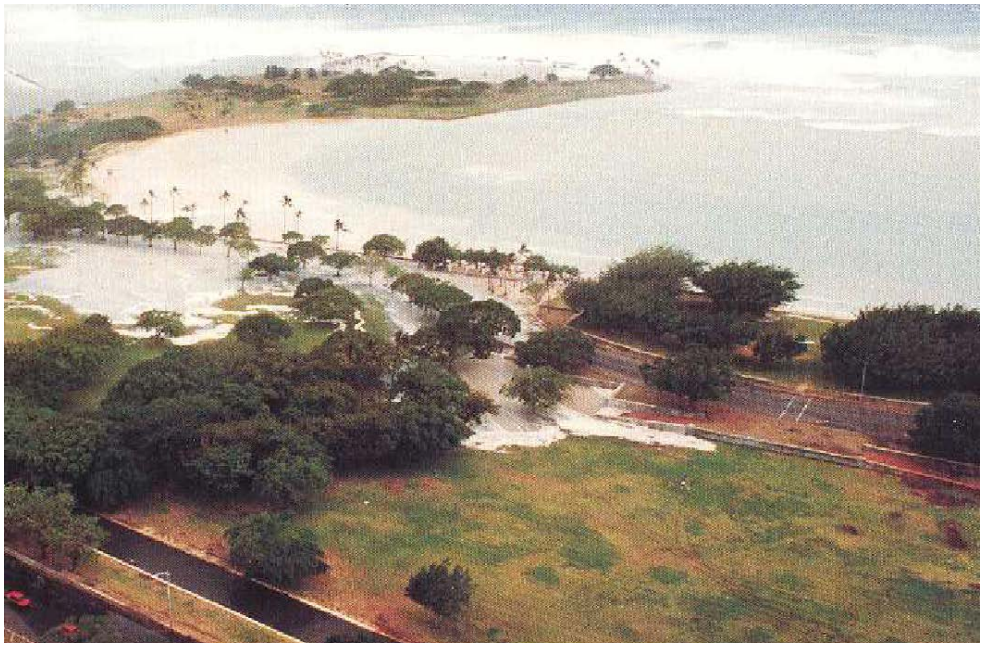


Figure 7-3. Ala Moana Flooding Caused by Wave Set-up during Hurricane Iniki (1992)

Other factors leading to coastal overwash are the low atmospheric pressure, the tide stage, coastal topography, and the location relative to the eye of the hurricane. Unfortunately, few of these can be predicted before a hurricane is in the neighborhood and thus overwash mitigation must be enacted prior to the event. This would include adequate building setbacks so that development does not occur in high hazard areas of the coastal zone, elevation of existing structures to recommended levels, break- way ground floors that permit overwash flooding without compromising an entire structure, and other construction techniques designed to reduce flood damage.

7.4.1 Hurricane Flood Insurance Study for the Hawaiian Islands

FEMA incorporated hurricane inundation from model scenarios into a flood insurance study for all islands including Hawaii, The last Hurricane Flood Insurance Study (FIS) for the Hawaiian Islands was conducted under FEMA contract number EMW-2003-CO-0046, RMTC/URS Task Order 013. Under this contract, RMTC/URS, a joint venture consisting of R.M. Towill, URS, Dewberry, TerraPoint, Airborne 1, and Sea Engineering, was tasked to evaluate and map the magnitude and extent of coastal hazards due to hurricanes for six Hawaiian Islands, divided into four counties: Kauai (Kauai County), Oahu (City and County of Honolulu), Molokai, Maui, Lanai (Maui County), and Hawaii (Hawaii County). The hurricane flood hazard had not been previously separately evaluated in a comprehensive study throughout the islands. In general, the hurricane coastal hazard analysis was limited to the southern and western coasts of each island. The limits of the study for Oahu are from Kaena Point to Kawaihoa Point as illustrated in Figure 7-4. The hazard analysis considered the combination of storm surge and hurricane-induced wave hazards.

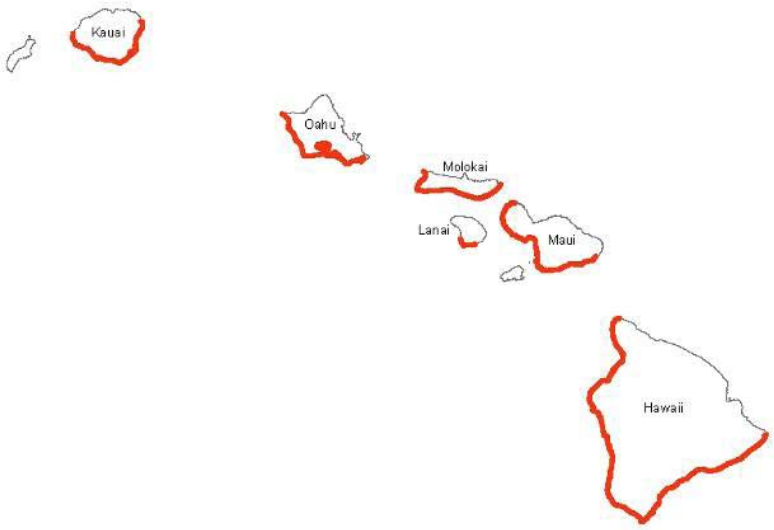


Figure 7-4. Extents of Hurricane Storm Surge Inundation Study

The coastal hazards determined from the above analyses were synthesized in the form of the standard 100-year FEMA special flood hazard boundaries for the Zone VE, Zone AE, Zone AO, and Zone X hazard areas. Definitions for the different zones are provided in Chapter 10. The boundaries are presented in a Technical Support Data Notebook (TSDN) as workmaps produced at a scale of 1':500". The workmaps also include stillwater stations, topographic elevation contours, FIS and mapping transect locations, and the shoreline. Wave analysis for the 0.2% annual chance event was not included in the scope of the study; the boundary of the 0.2% annual chance (500-year) event was not delineated. The SFHAs are only identified by the position of the 100-yr flood boundary. Mapped Base Flood Elevations (BFE's) are considerably dependent to the topographic representation at each transect. As a result, localized variations in the topography at other locations may not be fully reflected in the mapped SFHAs and BFE's.

A TSDN was compiled for each county in the study area. Storm surge and return frequency elevation analyses were inclusive of all counties, and thus all materials pertaining to those

analyses, including model input, output, and documentation are included in each county TSDN. The remainder of the data, including wave modeling, mapping, workmaps, topography, etc., is island and county specific. Therefore, these data are only presented in the appropriate countywide TSDN.

7.5 Other Hurricane Effects

The damage to and destruction of the built environment, particularly public infrastructure such as transportation, utilities, and communications often represents enormous economic, social, and general functional costs to a community, while also impeding emergency response and recovery activities. A nonfunctional road can have major implications for a community: general loss of productivity, disruption of physical access preventing residents from getting to work or other daily activities, prevention of emergency vehicles from reaching their destinations, and the associated health and safety implications and the potential access difficulties causing the disruption of important lifeline supplies such as food and other deliveries to the community.

A summary of different elements of hurricane damage are listed in Table 7-5.

Table 7-5. Elements of Hurricane Damage

Hurricane	Storm Center
Hazard	• Wind • Rain • Waves
Exacerbation	• Local tides • Local coastal configuration
Results	• Wind damage from hurricane and spawned micro-bursts • Storm Surge and Wave Damage • Coastal Stream flooding
Losses	• Structures & contents, including lifeline structures and equipment, such as roads, bridges, and roadway culverts • Lives/injuries • Communications • Beach erosion • Fire • Shipping & fishing • Soil fertility from saline intrusion • Vegetation • Crops • Livestock

Indirect costs include the widespread distribution of debris, accidental spills of fuel, sewage and industrial waste, household chemicals, or other contaminants onto the land or into the marine environment; in addition to environmental damage associated with storm debris or material cleanup, including the loss of landfill capacity.

7.6 Hurricane Vulnerability

Thee historic wind pressure criteria used for the wind design of structures in Hawaii. have changed over the years in the Uniform Building Code (UBC) and more recently the International Building Code (IBC) as indicated in Table 7-6 (excepting single-family dwellings, which are subsequently discussed). Although the overall design wind pressure dropped from the last UBC to the IBC, the IBC is based on the ASCE 7 Standard that is more rigorous and includes a more accurate distribution of wind pressures and localized increases in pressure on cladding and components of the building. The critical benchmark year identifying structures previously designed to an inadequate wind pressure would be 1984, the date of Oahu's adoption of the 1982 or later UBC editions, shown along with other code update adoption dates in Table 7-7.

Table 7-6. Design Wind Pressures with Different Codes

UBC/IBC Code Years	Service Level Design Wind Pressure at 10m height, at a reference site not affected by topography*
IBC 2012 to 2018	22 to 26 psf
IBC 2003 to 2009	26 psf
UBC 1991 to 1997	30 psf
UBC 1982 to 1988	26.5 psf
UBC 1958 to 1979	15 psf

*Based on component and cladding wall pressures, for an enclosed building, near the coastline, not near a corner of the building.

Table 7-7. Chronology of City & County of Honolulu Adoption of Building Codes

UBC Edition	Date Adopted
1958	November 25, 1959
1961	March 20, 1964
1964	(UBC-61 continued)
1967	January 1, 1969
1970	December 23, 1971
1973	May 5, 1975
1976	January 1, 1978
1979	December 5, 1980
1982	September 17, 1984
1985	March 1, 1987
1988	October 1, 1990
1991	January 12, 1994
1994	August 14, 1997
1997	June 28, 2000
IBC Edition	
2003	September 18, 2007
2006	April 16, 2012

Single-family residential construction has typically been permitted to be built using "conventional construction" provisions based on historical trade practices until problems were demonstrated by unacceptable wind damage. As a result, hurricane roof to wall uplift ties only were required for new single family residential construction in Honolulu subsequent to Hurricane Iwa with the County's 1987 adoption of the 1985 Uniform Building Code.

Table 7-8. Code Benchmark Years for Single Family Residences

Kauai	Honolulu	Maui	Hawaii
1989	1987	1989	1993

Windspeed hazard curves have been derived by two separate investigations, both utilizing Monte Carlo simulations of storm tracking and updated regional windfield models. Due to the rarity of tropical cyclone occurrence at a specific location, the prediction of design wind speeds must frequently be obtained by statistical means, such as a Monte Carlo simulation. A probabilistic model incorporates an analysis of hundreds of thousands of simulated tropical storms and cyclones in a region. A well-evaluated windfield model is then used to predict the wind speeds at a given location for each storm. The expected hazard information deals only with long-term hazard level; seasonal hurricane hazard is typically addressed by NWS and CPHC advisories. Based on a model simulation, Figure 7-5 shows the frequency of a hurricane passing within 75 nautical miles of a given location in a northern tropical band through the central and eastern Pacific ocean.

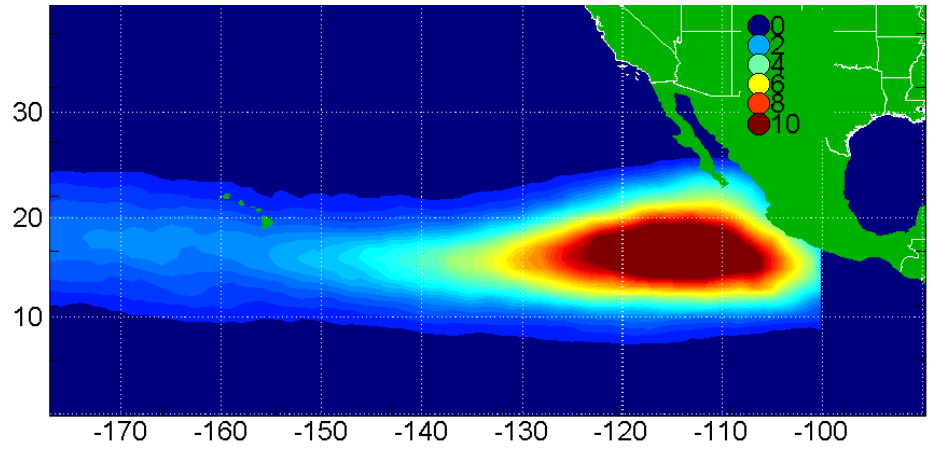


Figure 7-5. Contours show number of times a hurricane (intensity >64 knots) passes within 75 Nmi per 10 years (Peterka, 2002)

The 3-second peak gust is the wind parameter now used in American Society of Civil Engineers 7-05 (ASCE7-05), *Minimum Design Loads for Buildings and Other Structures*, which forms the basis for the *International Building Code* (IBC). The 3-second gust windspeed standard established for structural strength design in the 2012 IBC is 130 mph statewide. The most recent windspeed hazard curve developed for Hawaii first appeared in ASCE 7-10 as shown in Figure 7-6. The vertical axis is the 3 second peak gust windspeed while the horizontal axis is the average return period. This hazard curve generally reflects a similar return period to those described in Table 7-9 except for hurricanes of Category 3 or greater which are predicted to be less frequent by the ASCE 7-10 hazard curve with a return period of around 750 years.

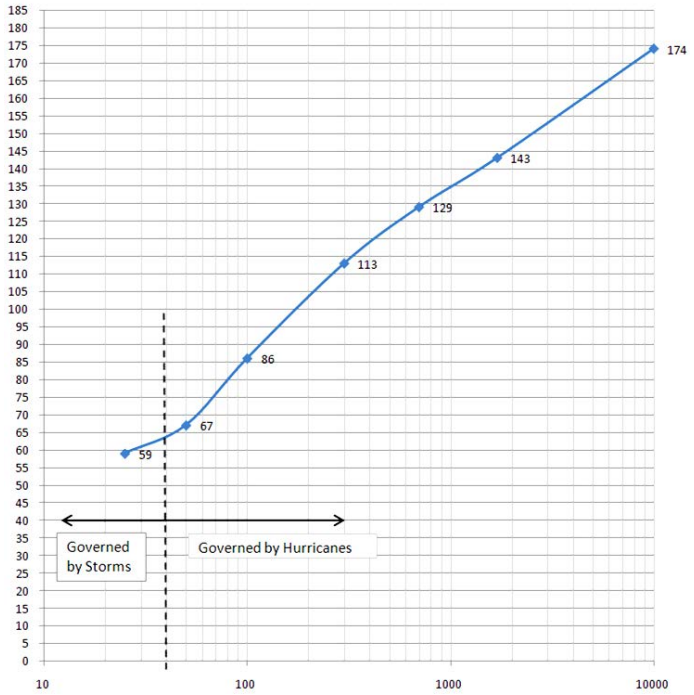


Figure 7-6. Windspeed Recurrence Intervals for Hawai‘i based on ASCE-7

The conversion between the sustained 1-minute windspeeds used by the National Weather Service and the peak gust used in structural engineering criteria are given in Table 7-9.

Table 7-9. Hurricane Windspeeds by Category

Hurricane Category	Sustained Wind	3-sec. Peak Gust
1	74 to 94 mph	81 to 105 mph
2	94 to 110 mph	106 to 121 mph
3 or 4	110 to 155 mph	122 to 171 mph
Any Hurricane	Greater than 74 mph	Greater than 81 mph

Maps have also been developed to account for the wind speed amplification that occurs due to local island topography (Chock, 2013). In short chronology, wind speed-ups have been empirically determined utilizing the data from a NASA-sponsored project (Chock et al. (2002). The topographical wind speed-up map for Oahu shows the areas subject to topographic wind amplification. These maps for Oahu were initially adopted by the City and County of Honolulu in 2007 when the IBC 2003 was adopted as the building code. As a result, buildings of all types constructed after 2007 are built to a uniform level of risk, that is, all occurrences of amplified wind are addressed in the design of that building using the new wind maps, so that no building has disproportionate risk with respect to buildings on mild flat terrain, and all are compliant with basic structural integrity for Category 3 storms.

Hawaii is considered a windborne debris region and consequently the IBC requires impact protection of the glazing. In lieu of glazing protection, the 2003 IBC allowed any unprotected glazing in to be considered as openings and consequently the building must be designed for internal pressurization. This provision is omitted from the 2006 IBC for buildings in wind debris regions. However, risk analyses found that the benefits of providing windborne debris protection for all glazing did not exceed the costs for the relatively low hurricane hazard in Hawaii. Therefore, the Hawaii State Building Code amendments to the 2006 and later IBC provide designers with flexibility in allowing Occupancy Category II buildings and some Occupancy Category III buildings (not healthcare or high occupancy facilities) to be designed with unprotected glazing provided they are designed for the internal pressurization. If a residential building is not provided with glazing protection then it must have a residential safe room installed which does have appropriate glazing protection and must satisfy other structural and non-structural criteria as described in Appendix U of the State Building Code. Refer to Chapter 17 (Shelters) for more information on the design of hurricane shelters.

Where used, debris protection for glazing may be in the form of a transparent protective film, on the exterior surface or between glazing layers in laminated glass. Alternatively, window shutters, precut removable plywood panels or another system may be used. Any protective film or other system must undergo testing based on ASTM E 1996 to verify the required level of protection.

An update to the wind design criteria will occur with the 2012 IBC. The major impact of this update will be that structures located near the coastline are considered to be in Exposure D for hurricane prone regions, which will increase design pressures for these structures. Moreover, with that code, the design basic wind speed is given at the (ultimate) strength design level rather than the service level. A map of effective ultimate windspeeds resulting from amplification of the basic wind speed for topographical and directionality effects is shown in Figure 7-7. ASCE 7-16 / IBC 2018 has incorporated similar design criteria, but a Honolulu specific amendment is still necessary for statutory compliance with the Hawaii State Building Code. The 2012 International Building Code should be adopted by all Counties in the State of Hawaii through the State Building Code statute, which each county must adopt by state legislation after a grace period that is intended to allow development of any specific requirements a particular county may desire. Statute HRS 107 Part II, State Building Code and Design Standards, is intended to ensure regular updates of the building codes and uniformity between the counties.

Continued future adoption of the current building codes, should reduce the hurricane vulnerability of the building stock as the old structures are retrofitted and replaced with new structures built to the current standards.

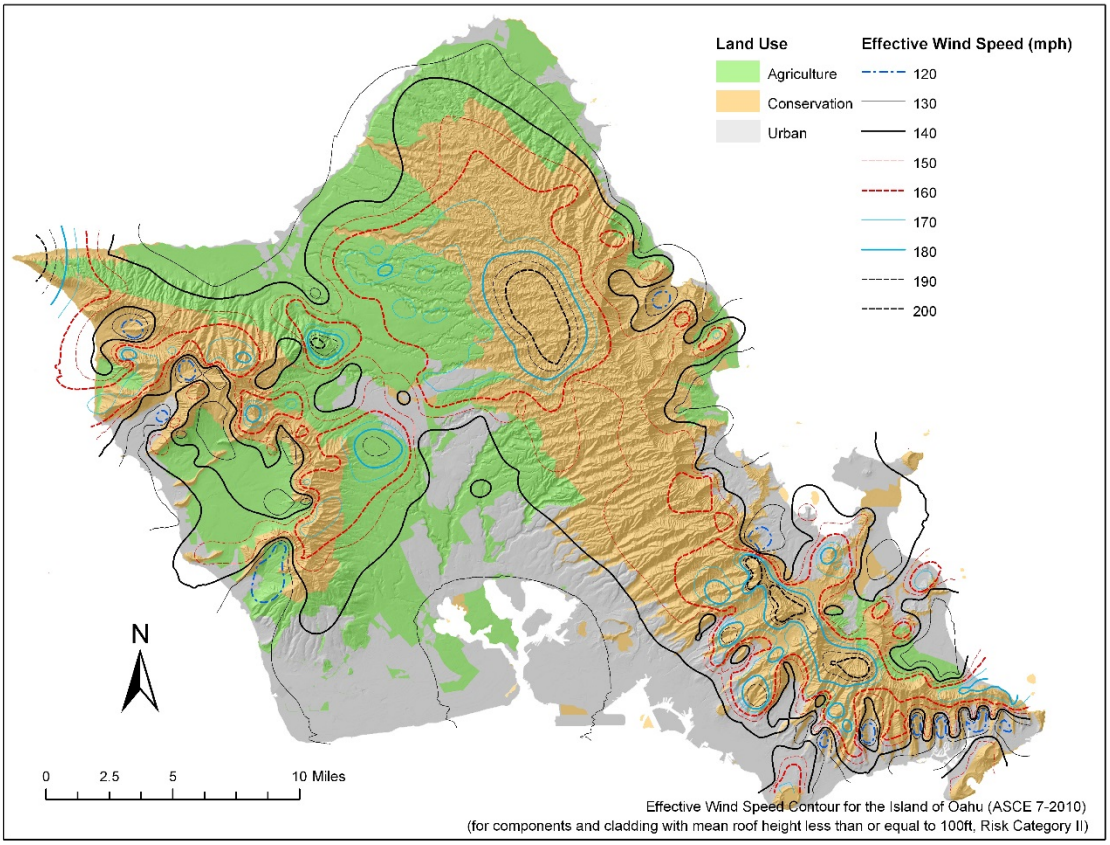


Figure 7-7. Effective Ultimate Wind Speed (mph) for Components and Cladding for Buildings less than 100 ft. tall – for use with the IBC 2012 and 2018

7.6.1 Building Damage Functions

The vulnerability of single-family residences on Oahu is primarily dictated by the county's code adoption legacy that neglected hurricane risk for a significant period. There are four predominant factors that correlate to construction vintage:

1) In past building codes prior to 1990, windspeed criteria and uplift pressures on roof components were underestimated, moreover,

2) It was not until 1987 and 1994 that light-frame residential construction requirements included hurricane clips for roof to wall attachment and complete load path to the foundation, respectively.

(Honolulu building codes have typically allowed exceptions to engineered structural design of single family residences. Honolulu has adopted the International Residential Code (IRC) for convenience of the permit review process of single lot projects, even though that comprises prescriptive, non-engineered construction practices that are not intended for high wind regions; the IRC structure is invalid for almost all parts of Oahu. Fortunately, most all subdivision projects will use the Honolulu adoption of the International Building Code, which requires an engineered design of the structure and includes topographic windspeeds.)

3) In past building codes prior to the year 2000, it was permitted to build single-wall homes that have significantly less structural integrity for high winds and earthquakes (now they are only permitted for repairs or additions to existing single wall homes).
4) It was not until 2007 that topographic wind amplification was included in the Honolulu Building Code.

Residential building damage curves have been developed that permit a wide variety of endemic Hawaii building types to be evaluated as a function of peak gust windspeed and construction features. Hawaii building damage functions and risk of damage ratios (risk relativity factors) were developed (Chock, 2005) using a comprehensive building database from Hurricane Iniki linked to property tax record information of construction attributes with parcel-specific resolution. The risk relativity factors are statistically validated by Hawaii loss information. The influence of the following construction attributes was analyzed:

- Single or Double Wall Construction
- Height; one story or more than one story
- Roofing: Metal; Built-up Roofing or Composition; Shingles, Shakes, Tile, Others
- Building Tax Valuation Categories
- Age: age split brackets, which depend on wall construction type and code benchmark years (which vary with each County)
- Foundation: Wood Piers or Concrete Slab
- Roof design: Gable or Hip

In general, based on the validated loss models, the risk relativities for endemic single wall construction with metal roofing are about 2 to 3 times higher than those for modern day stud wall construction built after Hurricane Iniki, as shown in Figure 7-8. Single wall construction is the most vulnerable type of residential construction for both hurricane and earthquake events.

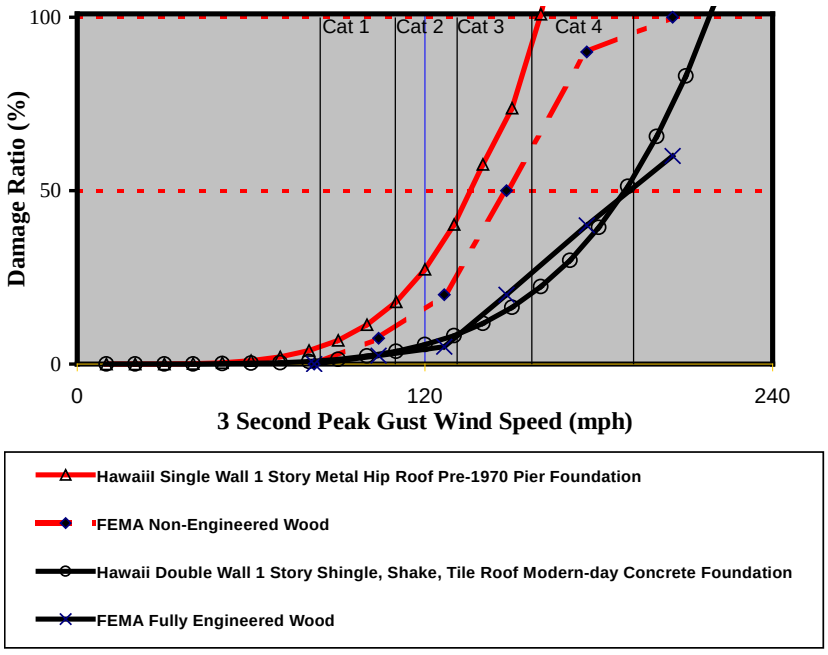


Figure 7-8. Vulnerability of Hawaii Single Wall Construction Compared to Other Forms of Construction (Chock, 2005)



Figure 7-9. Roof Failure of Single Wall House on Kauai during Hurricane Iniki

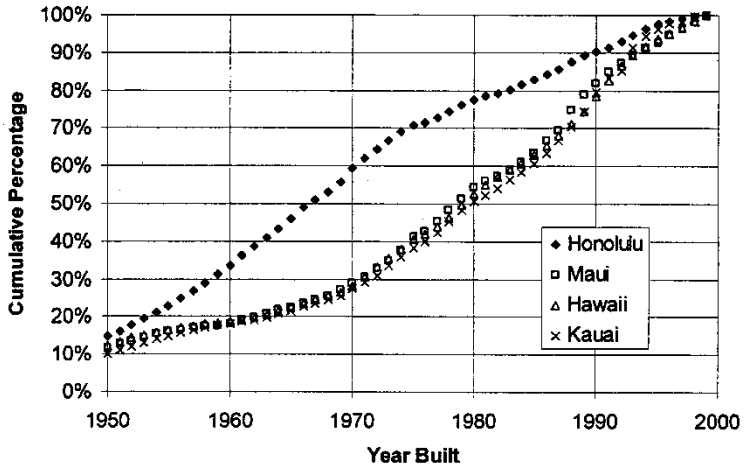


Figure 7-10. Cumulative Distribution of Houses by County as a Function of Year Built

7.6.2 Exposure

In a year 2000 study conducted by the Hawaii Hurricane Relief Fund, based on a database of property tax records, it was estimated that 155,000 single family homes existed on Oahu. 65% were single wall and 45% were "double-wall" stud construction. Based on this data and the 1987 code benchmark for hurricane strap requirements, it is inferred that at that time:

> 34% of double-wall construction lacked hurricane straps, and 99.4% of single wall construction lacked hurricane straps, for a total of 123,860 single-family homes in the Oahu

inventory of the year 2000 having been built without roof to wall hurricane straps. This was 79.9% of the total Oahu single-family inventory of that time.

Subsequent to the year 2000, three out of the four significant factors (the fourth being the topographic wind design requirements of 2007) would have been addressed in single-family home construction. As of the 2016 data point, there are now estimated to be 192,889 single-family homes on Oahu (comprising mostly of the west Oahu and later Central Oahu subdivision development expansions). Also, since that time there would be no further single wall construction permitted. Accordingly, that newer inventory, amounting to 22,389 homes, would be less vulnerable than its predecessor building stock:

12% of double-wall construction lack hurricane straps, and 99.4% of single wall construction lack hurricane straps, for a total of 123,860 single-family homes in the Oahu inventory of the year 2016 having been built without roof to wall hurricane straps. The remainder, 69,029 homes, would have been built with hurricane straps and some included a complete load path to foundation anchorages.

Therefore, at least 64.2% of the total Oahu single-family inventory as of the year 2016 would be considered deficient with respect to hurricane resistance.

A breakdown of the key properties of the single family residences is provided in Table 7-10, showing that about 64% of the single-family homes on Oahu would not be expected to have mitigation against hurricane wind uplift on their roofs. It should be noted that this estimate does not account for topographic wind amplification, and because wind uplift pressures increase with the square of the effective windspeed at a site, the hurricane resistance of (custom) homes built under the International Residential Code of any date, and some of those built under the International Building Code prior to 2007 (approximately 5,800 homes) that may be lacking in strength. With this consideration, the total number of deficient homes could approach a maximum of about 125,000.

Table 7-10. Oahu Single-Family Dwelling Construction Profile

Total #	**Conventional "double-wall" stud framing**	**Single-wall w/o studs**	
		On slab	**On post and pier**
193,000	48%	23%	29%
Typical size of living space	1500+ sf	1200 sf	1200 sf
Percentage of the total without high wind roof straps	12.3%	51.9%	
Percentage of the total with high wind roof straps	35.5%	0.3%	
Proportion of Exposed Value (building and contents) Single-Family Dwellings			
Homes with some Hurricane Mitigation		Homes without any Hurricane Mitigation	
36%		64%	

An HHRF study (Chock, 2005) estimated that the gross tax valuations represent approximately 70% of the total replacement value of single-family homes in Hawaii. Then, assuming typical content values of 18% estimated for Hawaii, which is less than the HAZUS default due to the higher relative structural cost, and appurtenant structure of 10%, the total county property exposure for single-family homeowners is 1.28 times the total single-family building exposure.

7.7 Anticipated Risk from Hurricane Scenarios on Oahu:

Average Annualized Loss (AAL) is an objective measure of future losses averaged on an annual basis. This information can be very useful in assessing the relative contributors to total natural hazard losses. Quantitative risk information would be very helpful to assessing the relative risk contributors (weightings) to long-term total natural hazard losses.

Formula Expression: $\mathbf{AAL} = \sum \mathbf{L_i \times P_i}$

L_i = Estimated Loss for Event *i*

P_i = Annual Probability of Event *i*

Description: Sum of the expected loss for each event (i.e., sum of the products of the estimated loss from each event and that event's rate of occurrence)

The Average Annualized Loss Ratio (ALR) is defined as the AAL divided by total building exposure value.

The Federal Emergency Management Agency (FEMA), in conjunction with the National Institute of Building Science, has developed Geographic Information Systems (GIS) software to compute estimates of damage and losses that could result from natural disasters. This natural hazards loss estimation software is known as Hazards United States (HAZUS). Currently, HAZUS MH has been expanded to include multi-hazard modules such as high winds and tropical cyclones. The hazard component of the HAZUS Tropical Cyclone Model makes use of an existing state-of-the-art wind field model, which calculates wind speed as a function of central pressure, translation speed, and surface roughness.

Based on a 2018 analysis, which included an analysis of the general building stock on Oahu, with new windspeed information, the hurricane AAL risk was estimated using HAZUS MH to be $410 Million.

To calculate Average Annualized Losses, a probabilistic simulation of tropical cyclones over the central Pacific was conducted for the present day climate. Fifty 20-year downscaled simulations representative of the 1980-1999 period were performed using the NCAR-CCSM4 model, generating a catalog of 2436 tropical cyclones for evaluation of storms with up to a 1000-year mean recurrence interval (Table 18-2). This model has better representation of the El Niño Southern Oscillation (ENSO) and atmospheric feedback as shown by Bellenger et al. (2014). Each 20-year period captures several cycles of the ENSO, which strongly influences the storm and wave activities in the Pacific. Each storm track includes time histories of the central pressure, radius of maximum winds, maximum sustained wind speed, and forward velocity at two-hour intervals. This quasi-stationary dataset of 1000 years provides the basis for probabilistic analysis.

Table 7-11. Number and percentage of hurricanes by intensity from 50 downscaling simulations of the 1980-1999 period.

Storm Category	1980 - 1999	
Tropical Storm	779	32.0%
Category 1	648	26.6%
Category 2	332	13.6%
Category 3	321	13.2%
Category 4	266	10.9%
Category 5	90	3.7%
Total	2436	100%

From this representative catalog, the top 20 storms entering the local region around Oahu were ranked, and the parametric Holland windfield was used to determine the 10-minute sustained windspeeds on Oahu as each storm had its closest approach. From this, the 1st, 2nd, and 10th ranked storms were identified that yields the 1000-year, 500-year, and 100-year windspeed scenarios from the 1000-year catalog. Then, the directional windfields were converted to peak gust windspeeds at 10 m height above ground and the topographic speed-ups were determined over a grid of reference points based on the modeling by Chock that had been previously implemented in the Hurrevac/MMS model. Thus, the topographically amplified peak gust windspeeds were interpolated to calculate the windfields over the entire island for the probabilistic 1000-year, 500-year, and 100-year mean return periods.

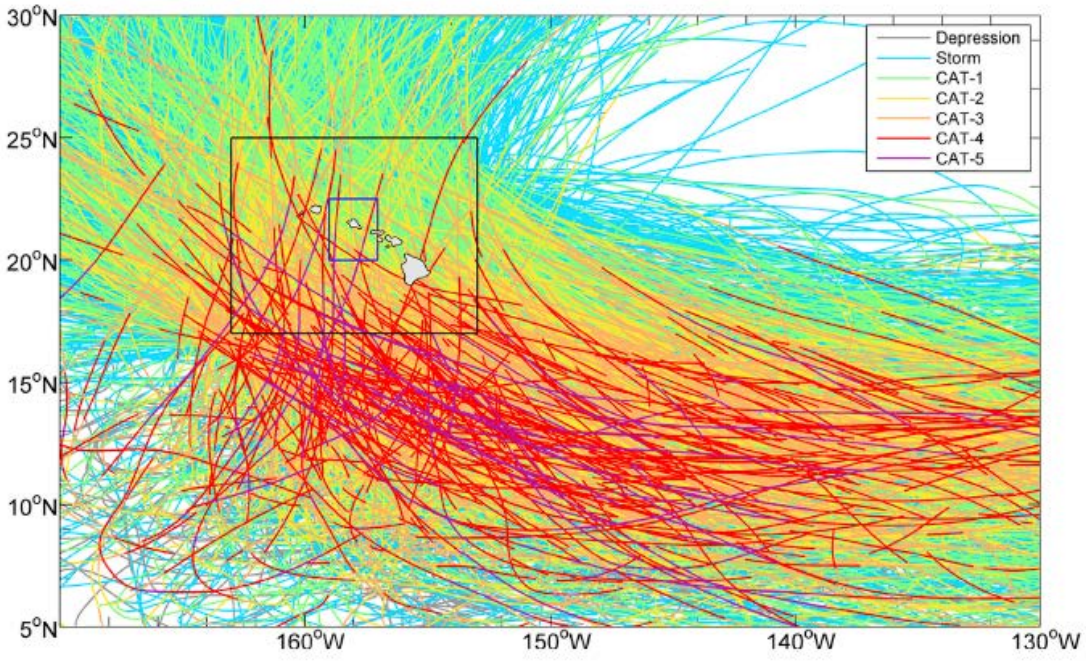


Figure 7-11. Simulated tropical storms and hurricanes passing through the Hawaii region from 50 downscaling computations of the period from 1980 to 1999. The black and blue boxes indicate the Hawaii region and the potential impact zone around Oahu

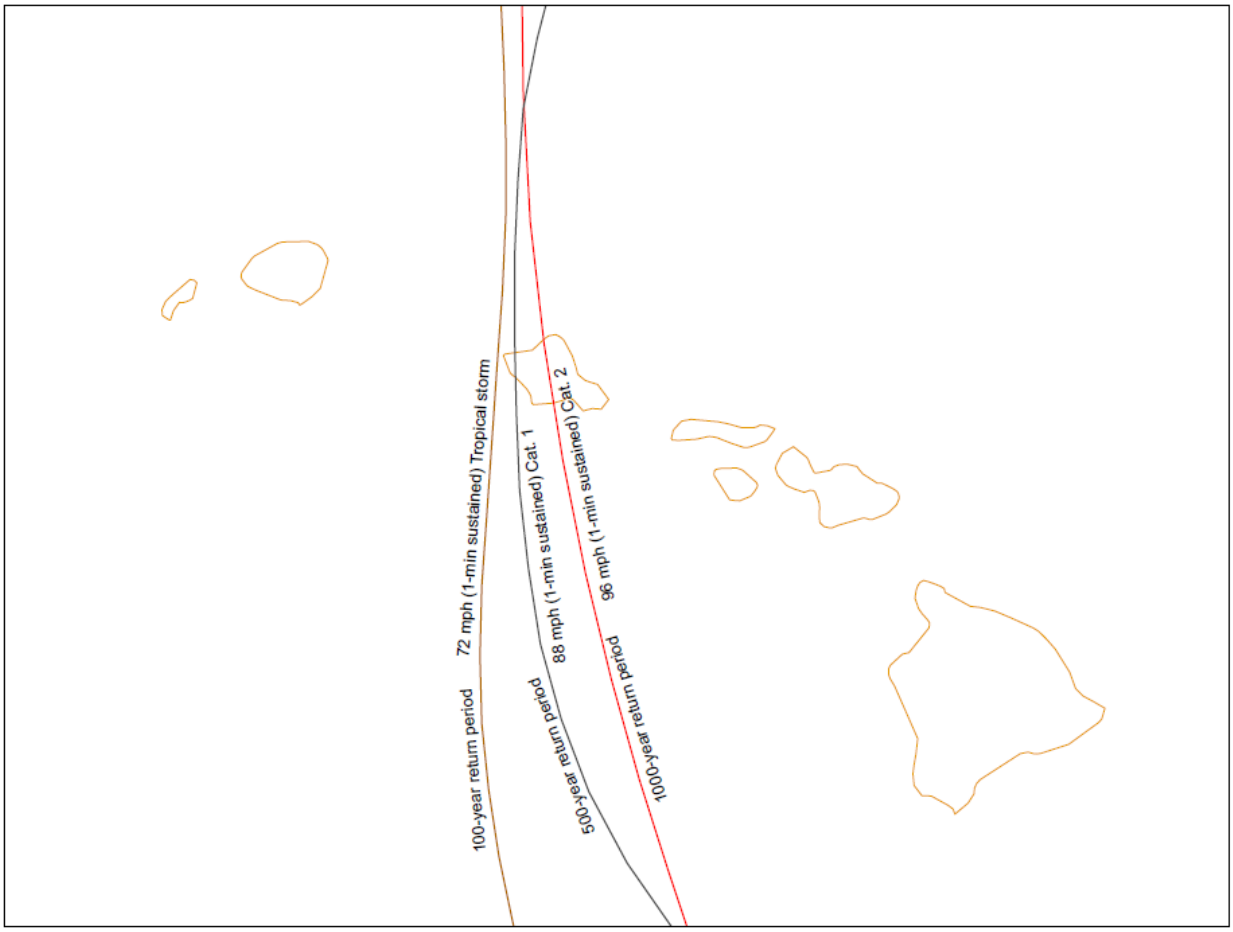


Figure 7-12. Probabilistic Storm Tracks for the 1000-year, 500-year, and 100-year windspeed storms. The resulting peak gust wind speeds around the island are shown in Figures 7-13 and 7-14.

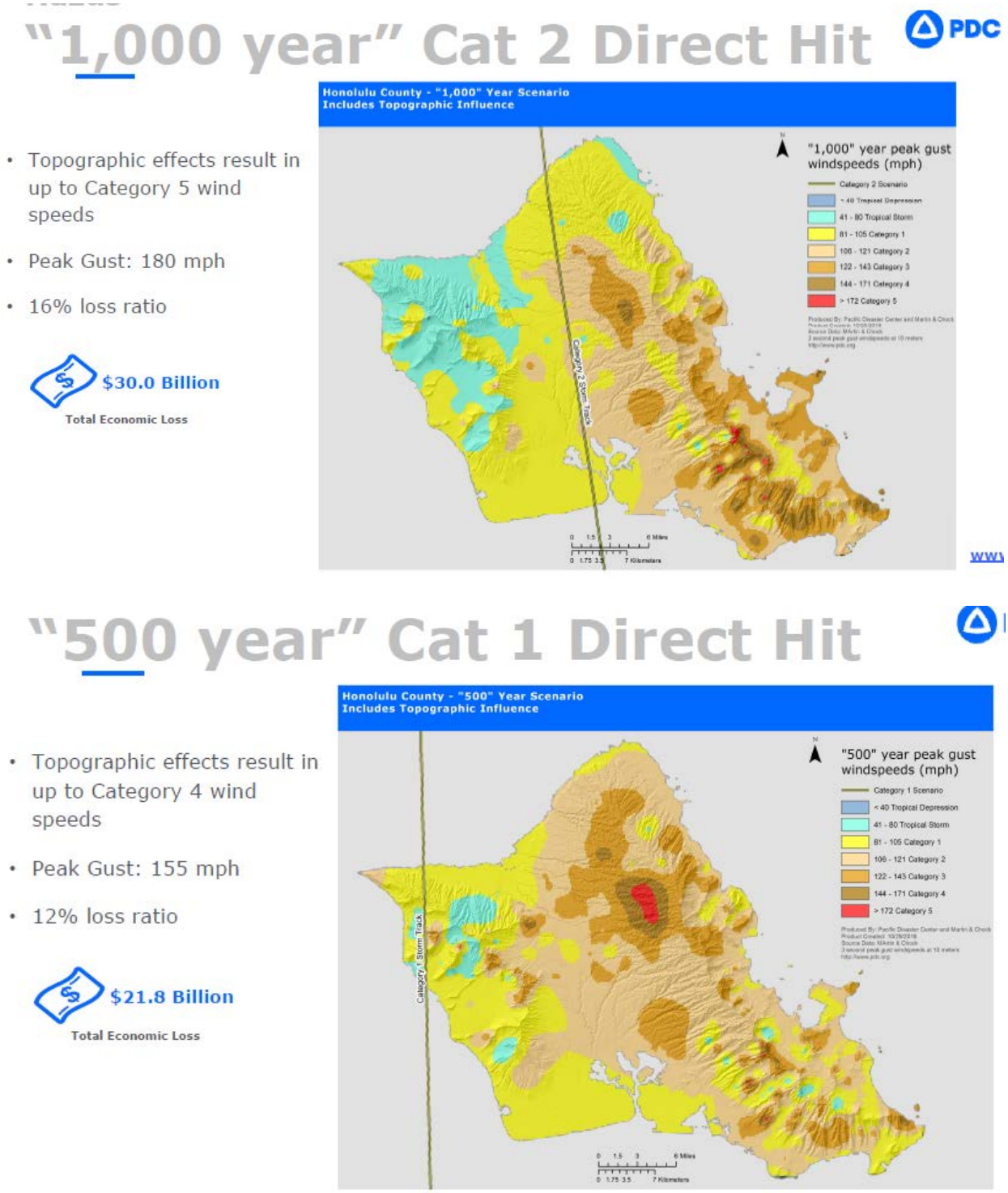


Figure 7-13. 1000-year and 500-year hurricane scenario tracks and peak wind gusts including topography

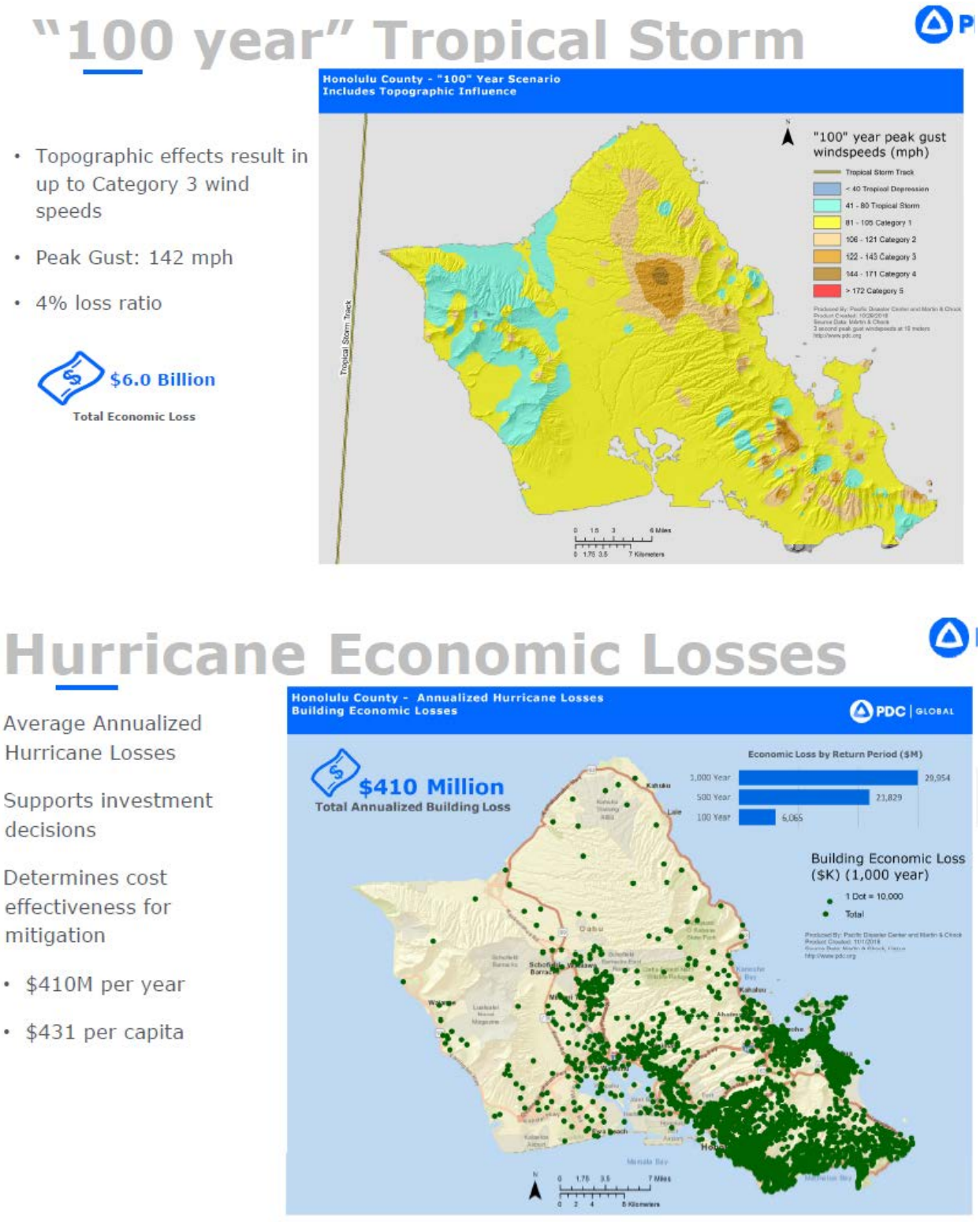


Figure 7-14. 100-year hurricane scenario track and peak wind gusts including topography and economic losses

7.8 Recent Hazard Mitigation Activities

7.8.1 Utilities

Damaged or destroyed utility lines and facilities – including electricity, computer and satellite links, gas sewer, and water services – can cripple a region after a disaster. Power lines are often badly damaged or destroyed resulting in the loss of power for days, weeks, or even months. In addition to basic modern household appliances being affected, public water supplies, water treatment, and sewage facilities can also be impacted. Electric pumps cannot pump drinking water into an area without power. Disaster victims who do get water may have to boil it to eliminate waterborne pathogens introduced to the supply in breached areas. Electrical transmission and distribution lines have been particularly susceptible to failure in previous hurricanes, with 30% of the wooden power distribution poles and 26% of transmission poles on Kauai failing during Hurricane Iniki.

In April, 2007, the overhead electricity line design and construction criteria were further updated with the adoption of Chapter 6-73 of the Hawaii Administrative Rules which concurrently repealed GO-6. Chapter 6-73 also governs underground electrical and communication line installation and repeals the earlier criteria of General Order #10. The purpose of the new provisions is to *"adopt standards for the installation, operation, and maintenance of overhead and underground electrical supply and communications lines that are used to provide public utility service in the State, in order to ensure the adequacy and reliability of service and the safety of the general public and of all persons who engate in the installation, operation, and maintenance of the lines."* The provisions adopt by reference the 2002 National Electrical Safety Code (NESC) as it applies to overhead and underground electrical and communication lines. The NESC uses a procedure that follows the ASCE 7-98 wind load provisions for Exposure C. This is an improvement over the previous prescriptive criteria. However, the formulation for calculating wind loads does not account for amplification due to topographical features, which have a significant impact on local wind speeds in Hawaii. Therefore, it is recommended to incorporate the Hawaii specific topographical and directionality factors, developed for the building code, into the design methodology for wind loading on transmission and distribution lines. Procedures should also be implemented to ensure the adoption of the new standards so that when a power pole fails and is replaced, the replacement should meet the current standards.

7.8.2 Risk Assessment of Honolulu Essential Facilities and University of Hawaii Buildings

A deterministic analysis using a Category 2 hurricane impact of Oahu estimated losses of $637 million to the essential facilities. This is described in more detail in Chapter 18. The scope of this project did not include examination of building construction drawings or any site visits of these facilities. It is recommended that a future project undertake detailed building multi-hazard evaluations of the highest risk facilities, numbering about 80 buildings and detailed structural analysis of the most vulnerable facilities.

7.8.3 Hawaii Certification of Residential Safe Room Assemblies

Based on extensive windborne debris impact testing of various wall assemblies by the University of Hawaii, the Hawaii amendments incorporated for the 2012 IBC include the following Approved Debris Impact Resistant Wall Assemblies.

1. ¾-inch plywood on wood studs spaced at 16 inches on-center with #8 X 3 inch wood screws at 6 inches on-center.
2. ¾-inch plywood attached to double studs spaced at 16 inches on-center with #8 X 3 inch wood screws at 6 inches on-center.
3. 8-1/4 inch cementitious lap siding over 22 gage sheet metal attached to 350S-162-33 studs spaced at 24 inches on-center.
4. 8-1/4 inch cementitious lap siding attached to 350S-162-33 studs spaced at 24 inches on-center studs with interior ¾-inch interior plywood sheathing.
5. 8-1/4 inch cementitious lap siding attached to 350S-162-33 studs spaced at 24 inches on-center with ½-inch interior 22 gage sheet metal composite gypsum wallboard.
6. 8-1/4 inch cementitious lap siding attached to 2 inch X 4 inch wood studs spaced at 16 inches on-center with ½-inch interior 22 gage sheet metal composite gypsum wallboard.
7. 8-1/4 inch cementitious lap siding attached to 2 inch X 4 inch wood studs spaced at 16 inches on-center with 22 gage sheet metal and ½-inch interior gypsum wallboard.
8. Cementitious lap siding attached to 5/8-inch structural plywood on 2 inch X 4 inch wood studs spaced at 16 inches on-center.
9. Cementitious-panel siding attached to 5/8-inch structural plywood on 2 inch X 4 inch or 362S-137-43 steel studs spaced at 16 inches on-center.
10. EFS with ½-inch dens-glass gold exterior sheathing on 362S-137-43 steel studs spaced at 16 inches on-center and ½-inch interior gypsum wallboard.
11. 24 gage steel sheet (50 ksi) on girts.
12. Concrete with a thickness of 4 inches with reinforcing.
13. Concrete masonry units with a thickness of 6 inches with partial grouting and reinforcing spaced at 24 inches on-center.
14. Concrete masonry units with a thickness of 8 inches with partial grouting and reinforcing spaced at 24 inches on-center.
15. Interior or exterior wall with laterally braced 2 inch x 4 inch wood studs with sheathing on either side of 22 gage sheet metal.

Sheathing shall be attached to studs with fasteners at 6 inches (152 mm) on center for edge and field fastening.



Figure 7-15. Windborne Debris Pneumatic Cannon used for testing

7.8.4 Honolulu Building Code, ROH Chapter 16 (adopted October 18, 2012)

The Honolulu Building Code is presently based on the 2006 International Building Code (IBC), which has the following local amendment provisions relating to hurricane and flood protective design measures:

- The basic wind speed and design equations are intended to result in achieving structural integrity of typical new construction for windspeeds up to 130 mph, which is a mid-Category III hurricane.
- Recognizes Hawaii as a Special Wind Region with maps that account for topographic wind effects.
- Windborne debris protection is mandated for critical facilities.
- State- and City-Owned High Occupancy Buildings have Enhanced Hurricane Protection Area wind, windborne debris, and flood design requirements.
- For other categories of buildings, internal pressurization requirements are included to address glazing breakage during hurricanes.
- Certain atypical single-family residences without windborne debris protection, where located outside of the flood zone, have safe room provisions for refuge with safety equivalent to that of a shelter.
- There are Complete Load Path wind uplift resistance requirements for light frame residential construction.
- Design rain load maps for a 100-year 1-hour rainfall rates apply to roof design and roof drainage, the same as in the Plumbing Code.
- Flood hazard requirements are to document compliance with the American Society of Civil Engineers (ASCE) 24 Standard based on a 100-year flood, which is the same minimal flood level as the National Flood Insurance Program (NFIP).

Gaps to be addressed in the upcoming Honolulu Building Code update based on the 2012 IBC:

- Upgraded fastening of roofing underlayment and roofing systems for high wind.
- Wind design of photovoltaic panels and their attachments.
- Use of the more severe Exposure D wind profile for the coastal zone based on the effect of more intense hurricane windspeeds acting on open ocean wave breaking.

Remaining Gaps:

- The roof design requirement for rain loading has no allowance for long-term trends of climate causing more intense storms. Also, at the very least, for building design purposes, the 15 minute rainfall rate is now considered by national standard ASCE 7-16 as the more appropriate measure of intensity for roof drainage design. This design data is available at the NOAA Precipitation Frequency Data Server (http://hdsc.nws.noaa.gov/hdsc/pfds/index.html).
- There isn't a Honolulu regulatory policy to explicitly identify critical facilities during planning and design**.** These are buildings and structures that provide services that are essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations.

Proposed Honolulu Building Code Changes for Risk Category III and IV structures:

- **Revise rainfall intensity map figure 1611.1 to add 15 minute duration 500-year intensity to comply with the latest ASCE 7 Standard. This data is already available at the NOAA Precipitation Frequency Data Server (http://hdsc.nws.noaa.gov/hdsc/pfds/index.html)**
- **Use windspeed maps for Risk Category III and IV structures based on 1700-year and 3000-year windspeed, respectively, to comply with the latest ASCE 7 Standard.**

7.8.5 Honolulu International Residential Code (IRC), ROH Chapter 16 (October 18, 2012)

- This is an alternative set of non-engineered semi-prescriptive code provisions that are permitted as an *exception* to the Honolulu adoption of the International Building Code. Applies to detached one- and two-family dwellings and multiple single family dwellings (townhouses) not more than two stories high with separate means of egress and their accessory structures.
- Typical users of these provisions are sole proprietor architectural practices and drafting services that do not use engineers except as plan "stampers".
- Designers of major subdivision developments typically will use the Honolulu International Building Code rather than the Honolulu IRC, due to liability concerns.

Gaps:

- Wind Limitations: the IRC model code is a code that does not include the engineering of the structure. Instead, prototypical assumptions of building types were

used to develop a series of prescriptive requirements for low to moderate seismic and low wind conditions outside of the hurricane-prone regions.

- However, the wind uplift prescriptive requirements of the IRC pertain only to the roof to wall connections; a complete load path of prescriptive connections is not provided and must be otherwise designed.
- Maps were developed to show where the IRC assumptions were violated and the prescriptive structural requirements would not be adequate.
- Construction in regions where the effective wind speed, V_{eff}, shown on the Oahu wind maps, equal or exceed 100 miles per hour shall be structurally designed in accordance with engineered design standards.
- However, it does not appear that the building permit review process includes checking for applicability. As a result, many homes and accessory structures are permitted under the alternative IRC where the structural integrity provisions are invalid. Thus, as presently administered, the Honolulu IRC is a loophole for single family residence permitting without adequately designing for hurricanes.
- The public interest in having protection from hurricane winds is not met in the current IRC, since the adoption of this alternative code leads to a lower tier of substandard construction compared to the requirements of the building code.
- The ICC-600, Standard for Residential Construction in High-Wind Regions, was developed by the International Code Council in 2008 to provide a set of residential specifications that is consistent with the ASCE 7 wind loads. This is a contemporary set of prescriptive requirements that can supplement the International Residential Code provisions. However, as of the present, these high-wind requirements have not been adopted as amendments to the International Residential Code by the State or any of the counties. The supplemental standard would need to reference the effective wind speed maps as the source of the design windspeed.

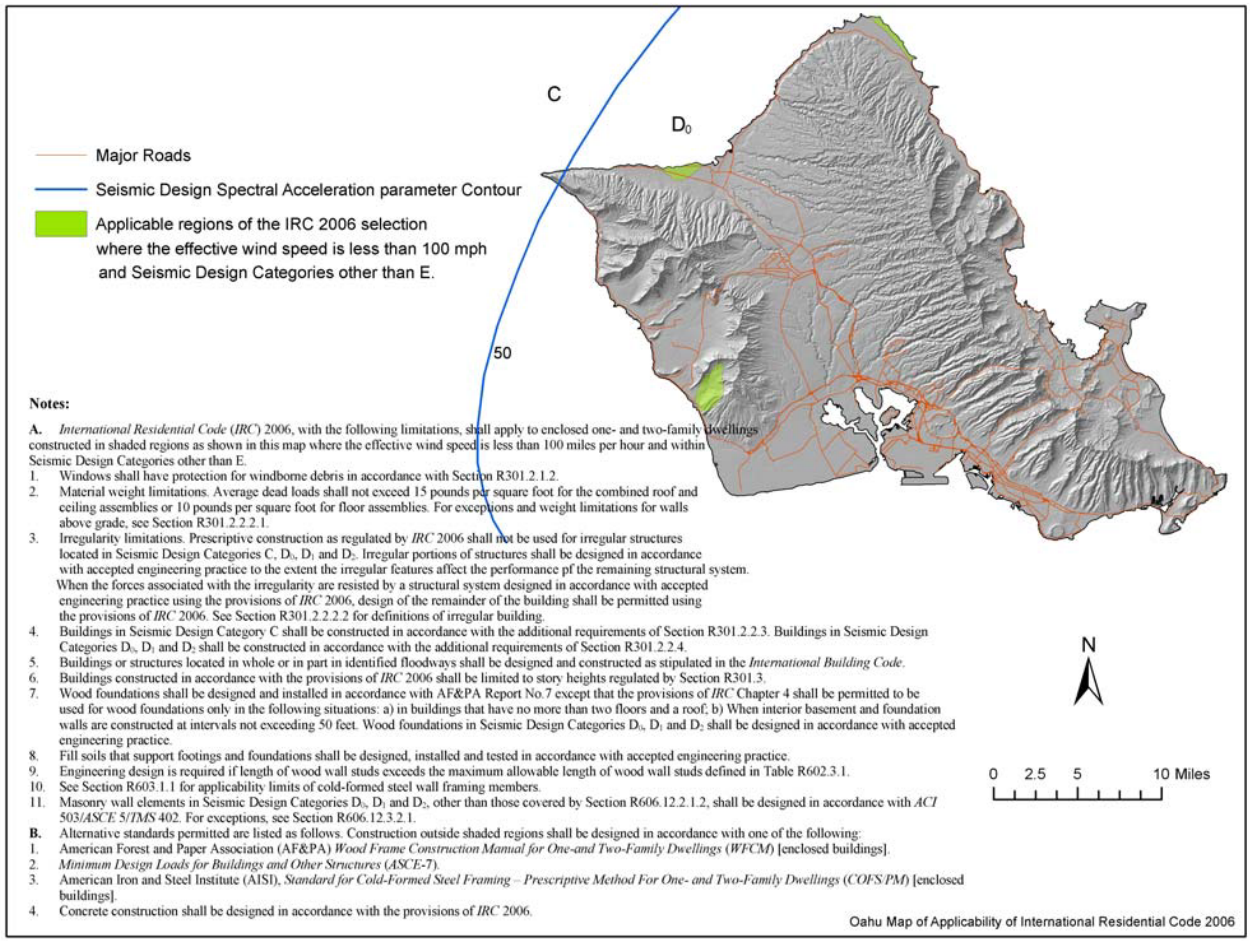


Figure 7-16. City and County of Honolulu Map showing the very few areas in green where the IRC is applicable without an engineered structural design using the IBC or other referenced wind and seismic standards (IRC (Honolulu) Figure R301.2)

7.9 Future Hazard Mitigation Projects

As the losses from hurricanes was estimated to be greater than any other hazard, future proposed hazard mitigation projects to reduce tropical cyclone vulnerabilities should be considered of the highest priority. Proposed projects that will help to reduce hurricane vulnerability are:

- Update design and construction standards for utility lifelines.
- Establish further upgrades to the electrical transmission and distribution design standards to incorporate Hawaii specific topographical, directionality and exposure information for the design of above ground utility using effective wind speed maps consistent with the State Building Code.
- Improve emergency communication reliability during disasters.
- Replace weathered wood poles with NESC-conforming poles.

- Hazard Mitigation Retrofits of the Honolulu Essential Facility Inventory and State Essential Facility Inventory based on HAZUS-MH and BCA. Detailed evaluations of these selected buildings may result in revisions to the risk rankings, and more importantly, will identify specific mitigation measures to reduce vulnerabilities and improve expected building performance.
- Adopt 2012 IBC, then the 2018 IBC and related codes per HRS 107 Part II, incorporating the previously mentioned suggestions from this chapter.
- Testing of the Wind Performance of Single Wall Construction
- Perform a comprehensive screening evaluation of private sector candidate building types for possible hurricane refuge use and create a certification system for private shelter refuges. Create a voluntary\certification system for private shelter refuges.
- Emergency shelter evaluation: Implement a comprehensive All-Hazard Assessment of Hurricane Shelters
- Retrofit public shelter buildings to increase capacity and refine actual evacuation demand and update policies to decrease sheltering deficit.
- Incentives for homeowners and businesses to retrofit their structures.
- Develop post & pier/single wall hurricane retrofit guide and Expert Tool for internet application, similar to what was done for earthquake retrofits by the University of Hawaii.
- Establish regulatory policy to identify critical facilities during planning and design**.** CRITICAL FACILITY: Buildings and structures provide services that are essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations.
- Establish a policy for strengthening of critical public facility enclosure integrity.

Further details of the proposed projects are provided in Chapter 19.



8. Floods

8. FLOODS

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan described historic floods, the NFIP and its local implementation, high risk areas, DFIRM maps Oahu were adopted that were hurricane-based for the south and west shores, flood ordinances, and planning.	• The major flooding events in Hawaii are caused by storms, storm surge, high surf (and on rarer occasions, tsunamis). • The effect of coastal erosion on coastal flood hazard increase is described. • Historic flood data has been updated, particularly considering the 2018 east Oahu floods. • A rainfall intensity map is provided with discussion of flash floods. • NFIP flood insurance study maps for the coastal zone are described and exhibited. • The City of Honolulu floodplain ordinance is described. • Annual losses and all repetitive loss properties have been updated and mapped. Floods are estimated to cause $27 million in damage per year. • The repetitive flood loss analysis is also performed on properties only within flood zones. For Oahu, the number of Severe Repetitive Flood Loss properties is relatively few. • The hazards considered of high importance by most people for personal planning and preparation were hurricanes, high winds/storms, tsunami, earthquake and flooding. • The FHAT tool is discussed as a decision support tool to enable better compliance with flood regulations • Planning and zoning regulatory measures are detailed. • New flood hazard mitigation activities are recommended. Adjustments of flood maps may become necessary to account for climate change-related rainfall intensification and hurricane intensification • Recent and future mitigation activities are discussed.

Summary of Mitigation Projects for the City and County of Honolulu

Project	Priority
ROH Chapter 16 Building-Code and ROH Chapter 17 Electrical Code - Adopt special flood-related code provisions applicable to essential and critical facility design and construction	High
ROH Chapter 21A – Flood Ordinance: Adopt 500-year flood zone applicable to essential and critical facility design and construction	Medium-High
Prepare to participate in the Community Rating System	Medium

8.1 Description of Hazard

8.1.1 Overview

Floods are temporary inundation of land from excessive rainfall or other sources. Although floods are caused by natural events, most flood damage is a result of human occupation and development of lands that are susceptible to flooding without having provided for adequate protection. Development along shorelines has occurred due to the aesthetic and recreational values of these sites. The result has been a gradual increase in exposure to damage from coastal flooding.

Because flooding causes millions of dollars of damage each year, the federal government created the National Flood Insurance Program (NFIP) to assist those who suffer from flood disasters administered by the Federal Emergency Management Agency (FEMA). Under the NFIP, each county has mapped flood hazard areas and established a permit system to regulate development within these flood hazard areas. The Flood Insurance Rate Maps (FIRMs) include areas prone to rainfall flooding (A zones) and high waves (V zones). In this County, the permit system is set forth in Revised Ordinances of the City and County of Honolulu, Sections 16 and 21. The NFIP mandates federal insured banks to require purchasing of flood insurance as a condition for financing the construction of buildings in flood plain areas, thereby shifting the primary burden for flood disaster relief to those who choose to live or conduct business in flood hazard areas. There is a benefit to reduce this cost through flood hazard mitigation.

8.1.2 Climatic Pattern

The predominant northwesterly trade winds directly influence the rainfall and flood patterns of the Hawaiian Islands. Rainfall quantities vary considerably from one part of an island to another. Generally, leeward locations get significantly less rainfall and have more sunshine hours the windward slopes. On the island of Oahu, the peaks of the windward Koolau mountain range at altitudes of 2,000 to 2,700 ft receive up to 280 inches of rainfall each year. In sharp contrast, the driest places on the southern leeward locations of the island, around Ewa Beach and Koolina receive less than 20 inches per year. High rainfall quantities are prevalent in the winter season between December and March, although rainfall and flood conditions can occur year round.

8.1.3 Flood Sources

Major flooding events are caused by rainfall from storms, storm surge, tsunamis, dam failures, and high surf. Floods caused by rainfall from storms and storm surge are discussed in this chapter. Floods due to tsunamis, dam failures, and high surf are discussed in Chapters 9, 15, and 4, respectively. Major floods typically occur during the rainy winter season (October through April), with January being the month with the greatest flooding frequency. The winter months account for 84 percent of the floods in the islands. Four types of storms commonly produce heavy precipitation in Hawaii:

Kona Storms. Because the predominant northeasterly tradewinds do not usually bring flood-producing rainfall, most major rainstorms are caused by the non-trade wind or Kona-wind condition. The Kona-wind condition frequently occurs from October through April and can bring

intense local showers affecting a small area, sometimes with thunder and lighting, or it can blanket the entire island with rain. The distribution of peak discharges of streams follows the general seasonality of Kona-wind storms, with 89 percent of the peaks occurred between October and May. Because of the potential combination of high winds and heavy rains, these events can cause combined inland and coastal flooding over larger geographic areas, wind damage (Chapter 6) and coastal erosion (Chapter 4).

Frontal Storms. Frontal storms usually occur during the period from December through March. They originate over the Pacific Ocean as a result of the intersection between polar and tropical Pacific air masses and move eastward over the Islands. Rainfall from these storms are enhanced by mountainous areas and can be accompanied by widespread precipitation. Heavy rainfall, continuous over a period of several hours, quickly creates disaster conditions in high sloping areas such as these, prone to landslides and flash flood conditions in lowlands with poor drainage. A frontal system brings intense rains and strong northwest winds, but the duration of extreme weather relatively short compared to other major storms. Most frontal systems have weakened before reaching the latitude of the Hawaiian Islands; remnants of the front may be only an eastward-trending line of low clouds.

Upper level lows. Unrelated to the above conditions are rare storms caused by low pressure areas in the upper atmosphere. When this condition exists, trade-wind conditions are capable of producing heavy downpours. In fact, some of Oahu's heaviest rains, such as the New Year's Eve Storm of 1987-88, the Manoa Flood of 2004, and the April 13-15, 2018 floods on east Oahu have been caused by upper-level low pressure areas above trade winds. Upper level lows and troughs can occur any time of the year. The weather can become severe in the form of thunder showers or intense rains from extensive bands of clouds combined at times with strong southwest surface winds. Extreme weather from the upper level low-pressure system can have the longest duration of any major storm type because the system is large and moves or weakens slowly. The presence of the upper level low, in combination with a frontal system, adds to the severity and duration of extreme weather. The combination produces thunderstorms having intense rainfall.

Tropical Cyclones. Heavy rainfall can also be associated with the tropical storm and hurricane season. Impacts from these events have included coastal erosion, severe inland and coastal flooding and wind damage as described in Chapter 7.

8.2 Types of Floods

8.2.1 Coastal Floods

8.2.1.1 Storm Surge Floods

Floods from storm surge in immediate coastal areas occur primarily as a result of tropical cyclones. During these events, the low pressure cell at the center of the storm can cause a local rise in sea level. Conditions can be exacerbated by large waves that form on top of rising water as described in Chapter 5. The degree of damage caused by storm surge depends on the tidal cycle occurring at the time of the event. During high tides, water levels can be significantly higher and can inundate further inland causing more extensive damage. Of the coastal shorelines, areas that are uniformly

flat or only a few feet above mean-sea-level are more susceptible to storm because the inundation can spread inland rapidly.

Storm surge floods typically result in coastal erosion, salination of subaerial and subterranean water sources, and contamination of nearshore waters. These floods can also create significant losses, loss of life and damage to public and private structures and infrastructure.

8.2.1.2 High Surf Floods

In the Hawaiian Islands, floods due to high surf most commonly occur on the islands' north shores during the north ocean swells of the winter season. Floods caused by high surf are discussed in Chapter 4.

8.2.2 Inland Floods

8.2.2.1 Stream Floods

Stream flooding is the accumulation of water within a water body and the overflow of excess water onto adjacent floodplain lands. A floodplain is the land adjoining the channel or river, stream, or other watercourse or water body that is susceptible to flooding. Most drainage basins are characterized by amphitheater-shaped valley heads, steep walls, and gently sloping floors. Two basin shapes, illustrated in Figure 8-1, are predominant on Oahu: the long, narrow valleys with V-shaped cross-sections and the short, broader valleys. Most short, broad valleys are along the windward side of the Koolau Range. Similar shapes are found along the southwestern side of the Waianae Range. Long, V-shaped basins are found on the leeward side and northern part of the Koolau Range and along the northeastern side of the Waianae Range. The most frequent and severe flooding occurs in the short broad valleys.

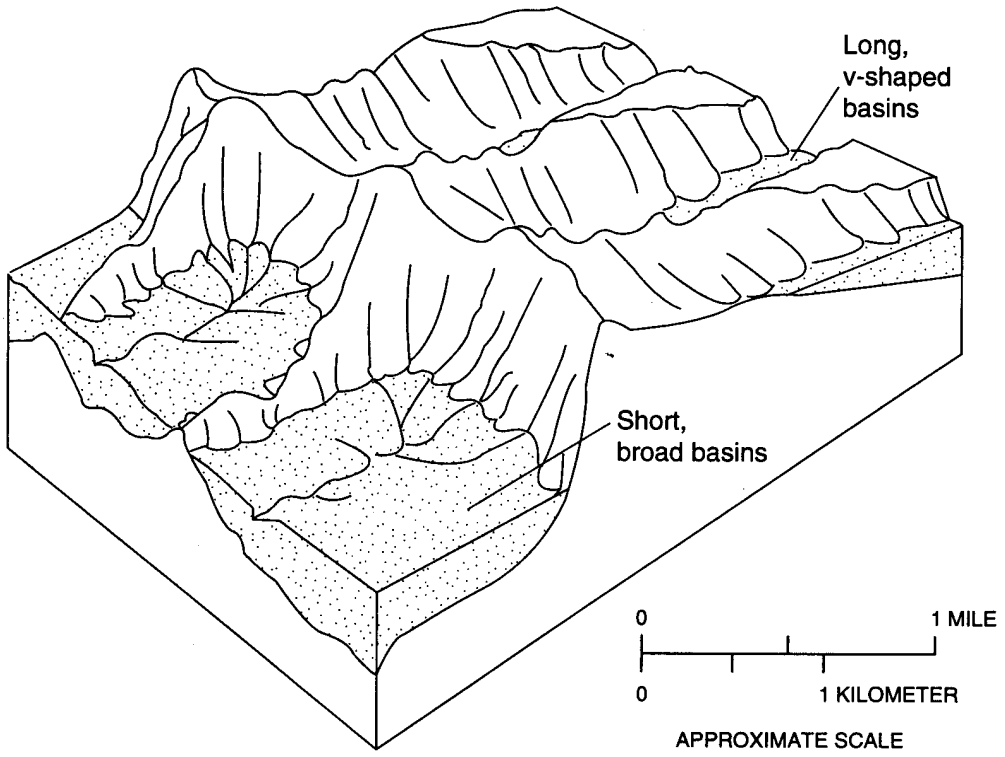


Figure 8-1. **Block diagram showing typical drainage-basin shapes for Oahu, Hawaii (by S.K. Izuka, U.S. Geological Survey)**

For both basin shapes the upstream ends are steep mountain slopes, which cause rapid rates of runoff, and the downstream ends are flat coastal plains, which result in slower rates of runoff. Most drainage basins on Oahu have rapid runoff response to rainfall, characterized by a steep triangular shaped hydro graph and usually with a time to peak of less than 1 hour. Watershed boundaries on Oahu are shown in Figure 8-2. Stream mouths are susceptible to flooding during marine storm or high wave events, as runoff from streams reaches a sea that is partly elevated by the combination of high waves, winds, and storm surge.

Most of the drainage basins in Hawaii are less than 10 mi^2 (square miles), and many are less than 5 mi^2, especially on the island of Oahu. Storms that produce intense rainfall over most or all of the drainage area of small basins can cause runoff having large unit discharges (discharge per square mile of drainage area) due to the small contributing drainage area. Some gauging stations on streams having less than 1.0 square mile of contributing drainage area have recorded unit discharges of greater than 5,000 cubic feet per second per square mile. Small-basin floods such as these can be devastating, but the damage is confined to a small area.

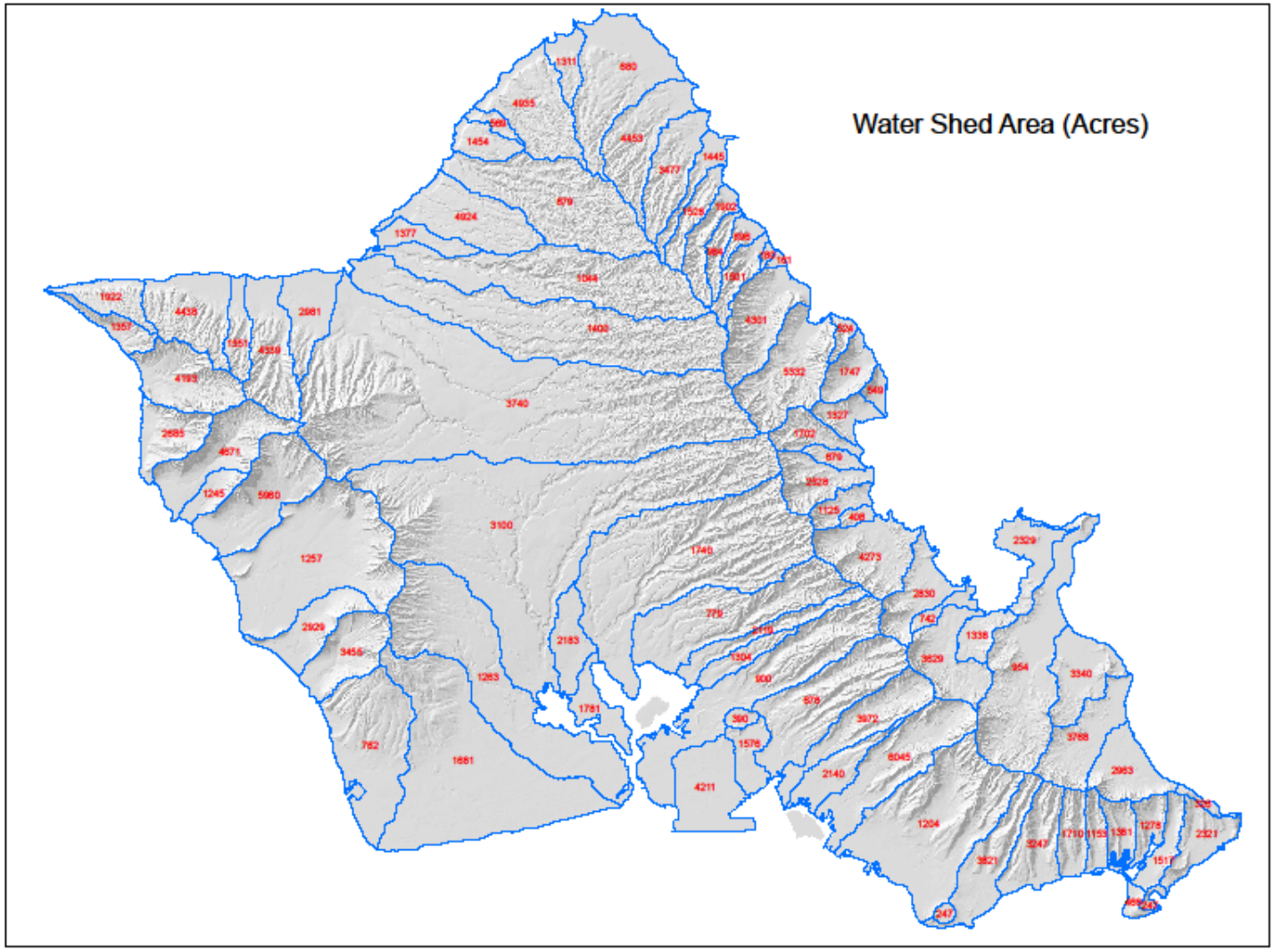


Figure 8-2. Drainage basins and watershed boundaries on Oahu (in Acres, 640 Acres=1 mi2)

The hazard for stream floods depends on a number of factors including the history of flooding at the site, coastal zone slope, the seasonal rainfall in the adjacent watershed, and the level of mitigation by the Army Corps of Engineers and/or the City, Department of Design, and Construction. The highest hazard applies to low-lying streams with high rainfall watersheds (seasonal monthly max. >7.9 in where a historically high level of flooding has occurred, and where no mitigation improvements have been attempted since the most recent damaging flood. The definitions for different stream flooding hazard intensity factors are given in Table 8-1.

Table 8-1**. Hazard Intensity Factors for Stream Floods**

Hazard	Low (1)	Moderately Low (2)	Moderately High (3)	High (4)
Stream Flooding	No history of coastal or stream flooding and no reasonable basis for expected flooding due to low seasonal rainfall in watershed (<4.9 in per month); or steep coastal slope (>45%)	history of non-damaging flooding near streams or highlands with seasonal high rainfall present (>7.9 in per month) and coastal slope >20%; or history of flood damage with full mitigation since last major flood	Abundance of streams and high seasonal rainfall in watershed (>7.9 in per month) and history of damaging floods with partial mitigation or no mitigation where slope >20% and <45%	Historically high flood damage on gentle slope, high watershed rainfall (>7.9 in per month) and no mitigation efforts or improvements since last damaging flood

8.2.2.2 Flash Floods

Flash floods are typically caused by unusually high-intensity rainfall and are characterized by a rapid rise in water level, high velocity, and large amounts of debris. (Flash floods may also result from dam failure, causing the sudden release of a large volume of water in a short period of time.) The major factors affecting flood levels are the intensity and duration of rainfall and the steepness of watershed and stream gradients. Additionally, the amount of watershed vegetation, the natural and artificial flood storage areas, and the configuration of the streambed and floodplain are also important. Flash floods are also more prevalent in areas where there is a predominance of clay soils that do not have high enough infiltration capacities to absorb water from heavy precipitation.

Flash floods are capable of tearing out trees, undermining buildings and bridges, and scouring new channels. The greatest risk involved in flash floods is that there is little to no warning to people who may be located in the path of a flash flood's high velocity water, debris, and/or mudflow.

8.2.2.3 Storm Water Runoff and Ponding Floods

Stormwater runoff floods may occur when the capacity of the storm water pipes or channels is exceeded at a critical point in the system causing overflow. This often occurs in conjunction with flash flood conditions. If there is a blockage of the system due to debris or a failure of the system then this can lead to ponding and exacerbation of the flood conditions.

According to the Honolulu Storm Drainage Standards, a 100-year recurrence interval for the design storm should be used for drainage areas greater than 100 acres and all streams. As shown by Figure 8-2, every catchment on Oahu is greater than 100 acres when measured from mauka to makai. This means that all coastal stormwater systems on Oahu should be designed to handle the water flow from storms that have a 1% of being exceeded in a year (a 100-year storm). However, since catchments are measured from the upstream (highest point on the mountain) to where the storm drain is located, it is possible to have catchment areas less than 100 acres on Oahu. For these areas, the standards say to design the system for a storm that has a 10% annual chance of being exceeded (a 10-year storm). These standards were last updated May, 2013, and utilize several maps of the island showing rainfall for a given storm to account for when designing a stormwater system.

8.3 Rainfall Data, Streamflow Gauges, and Flood Forecasting

8.3.1 Hydronet System

The Hydronet system is a State of Hawai‘i wide network of National Weather Service (NWS) maintained and operated tipping bucket rain gauges whose primary purpose is to support the flash flood forecast and warning operations of the Honolulu Forecast Office. Each data logger records rainfall to a resolution of 0.01 inches every 15 minutes and contains enough memory to hold several days of data. The Hydronet computers are programmed to automatically interrogate each gauge every three hours during benign weather conditions. This frequency can be increased to automatically interrogate every hour when heavy rain is anticipated or is already occurring. Monthly data is available from the National Weather Service website back to January 1994 (http://www.prh.noaa.gov/hnl/hydro/hydronet/hydronet-data.php).

Each gauge is also programmed to notify the Hydronet computers when rainfall intensities reach or exceed one of four pre-selected thresholds. These threshold values are currently set for 0.25, 0.50, 0.75, and 1.00 inches per 15-minute period, or 1.00, 2.00, 3.00, and 4.00 inches per hour, respectively. After receipt of a heavy rain data message from the gauge, the Hydronet workstation notifies the forecasters of the event via printed message, on-screen computer terminal message, and audible and visual signals in the office. Alarm messages are also sent to participating county warning points for intensities of 2.00 inches per hour or greater.

8.3.2 Areal Mean Basin Estimated Rainfall (AMBER)

AMBER is a product derived from WSR-88D weather radar data that is used for flash flood forecasting and detection purposes. The AMBER system utilizes the maximum spatial and temporal resolution radar data available to produce specific basin averaged rainfall estimates. For the State of Hawaii, AMBER output is currently available from the WSR-88D radar on Moloka‘i with basins delineated over the island of Oahu and other islands in the County of Maui. Flash Flood Guidance (FFG) values are also tied to AMBER data to assist forecasters in the warning and advisory decision-making process. FFG values indicate the amount of basin-averaged rainfall needed to produce small stream flooding over different time periods.

8.3.3 Stream Discharge Data

StreamStats is a Web-based Geographic Information System (GIS) that provides users with access to an assortment of analytical tools that are useful for water-resources planning and management, and for engineering design applications, such as the design of bridges, based on the most recent stream flood estimate study (https://streamstats.usgs.gov/ss/). StreamStats allows users to easily obtain streamflow statistics, drainage-basin characteristics, and other information for user-selected sites on streams. StreamStats users can choose locations of interest from an interactive map and obtain information for these locations. If a user selects the location of a U.S. Geological Survey (USGS) data-collection station, the user will be provided with a list of previously published information for the station. If a user selects a location where no data are available (an ungauged site), StreamStats will delineate the drainage-basin boundary, measure basin characteristics and estimate streamflow statistics for the site. These estimates assume natural flow conditions at the site. StreamStats also allows users to identify stream reaches that are upstream or downstream from user-selected sites, and to identify and obtain information for locations along the streams where activities that may affect streamflow conditions are occurring.

8.4 Historic Flood Damage

Flooding in Hawaii can be frequent and extensive. In the City & County of Honolulu, from about 1915 to 2018, floods caused by rainstorms, tsunamis, and hurricanes have claimed more than 140 lives and inflicted more than $200 million dollars of direct and indirect damage. The cost of damage from significant floods is listed in Table 8-2. This table shows that in recent times there has been a consistent increase in economic impacts of flooding.

8.4.1 Coastal Floods

An example of storm flooding due to storm surge and wave set-up in Ala Moana on Oahu during Hurricane Iniki, is shown in Chapter 7. There are other examples of such flooding from hurricanes and tropical storms. Coastal flooding of roadways and personal property due to high surf is a relatively regular occurrence on the North Shore of Oahu during high surf events. Some examples of this are provided in Chapter 5.

8.4.2 Stream and Other Inland Floods

A summary of stream flooding events resulting from heavy rainfall around the island since 1917 are shown in Table 8-2. Some of the largest rainfall counts and most severe flooding events have occurred in the last few decades. Recent severe events on Oahu include October 1981 flooding of Waiawa Stream after heavy rains that led to $786,000 damage and January 1968 flooding in Pearl City, which caused $1.2 million damage. A series of slow-moving storms with prolonged rains that saturated the soils of south-central Oahu culminated on New Year's Day of 1988 in severe runoff and hillside erosion, resulting in catastrophic damage of $35 million to stream flood mitigation channels, homes, and roads in Aina Haina and Niu Valleys. The heaviest rainfall during the 1990's in Kaneohe occurred on October 15–16, 1991, when 15 inches fell in 48 hr. leading to intense flash flooding. On October 25, 1993, 2–4 inches of rainfall caused flash flooding and extensive street flooding throughout the Honolulu area. On the windward side of Oahu, flooding

has been common after heavy precipitation such as on April 12, 1994, in Kahuku, November 26, 1992, in Kaneohe, and October 11, 1992.

During the first 15 days of November 1996, record-breaking rainfall occurred along the Waianae Coast, where 21 inches fell in an area where the average annual rainfall is only 2 inches. In Ewa, 12.5 in fell in 7 hr on the 5th of that month, inducing flooding of the low coastal plain.

The most costly flood damage in Hawaii history, excluding hurricane and tsunami events, was the Manoa flood of October 30, 2004. A 50 year rainstorm in Manoa valley, with a precipitation rate of 4 inches in one hour at its peak, caused blockages of Manoa stream resulting in flooding of the valley. The water flooded large portions of the University of Hawaii, including Hamilton Library, the Biomedical Sciences Building, Bliger Hall, and Sakamaki Hall. It also flooded Noelani Elementary School and many Manoa residences. It damaged the footbridge across Manoa stream as shown in Figure 8-4. Further damage adjacent to Manoa stream is shown in Figure 8-5. The total damage from the floods was estimated at $85 million.

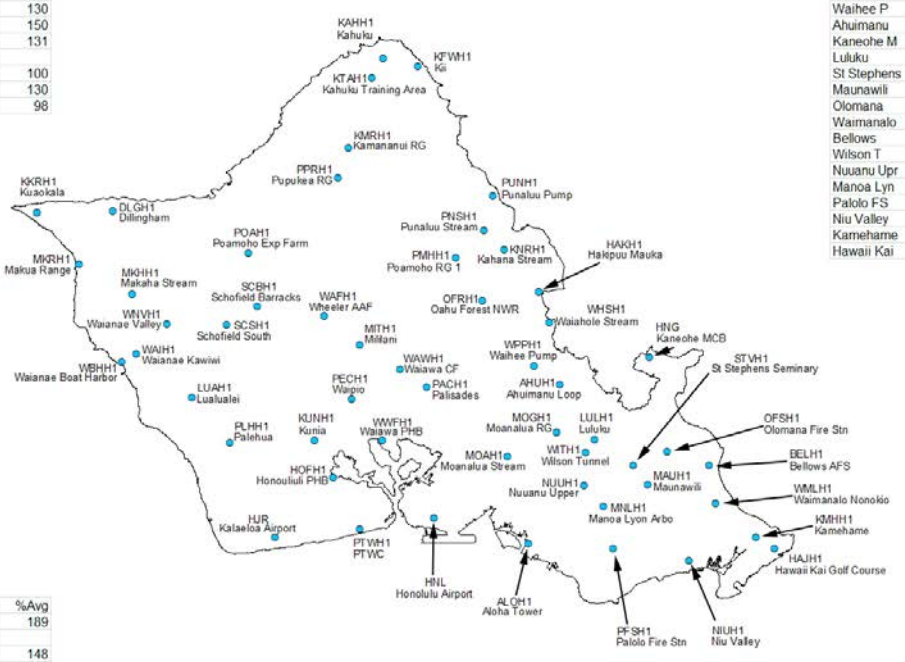
In 2008, severe flooding occurred due to heavy rains that persisted for several days on Kauai and Oahu. Between December 10 and 16, 2008, the floods damaged 4 dozen buildings. The resulting FEMA disaster declaration resulted in $1.08M in grant and loan assistance from FEMA. Rainfalls of up to 11 inches were recorded in a 24 hr period at Schofield Barracks on Oahu.

The April 13-15, 2018 floods on east Oahu were caused by upper-level low pressure areas above trade winds, together with stormwater runoff exceeding the capacity of the streams and storm water channels causing overflow. Rain on Kauai and Oahu caused flooding, mudslides, and rockslides. (Figures 8-6 and 8-7) It was later declared a major disaster and most severely impacted the island of Kauai, which recorded a new record rainfalls over 24-hour periods. East Oahu experienced significant flooding during the highest intensity rainfall of over 5 inches per hour on April 13, 2018. The area of intense rainfall with rates greater than 5 inches per hour moved across east Oahu between 7:00 PM and 9:00 PM HST on April 13. This appears to be consistent with greater than 100-year rainfall intnesity. Drainage systems were over capacity and blockage contributed to increased flooding on both the windward and leeward sides of east Oahu. https://www.kitv.com/story/37971283/worst-flooding-for-east-oahu-in-30-years
410 properties were affected, with 104 residential structures receiving major damage. NOAA estimated that these storm events caused a total of $20 million in damage for just public properties; that report can be found here: (http://www.prh.noaa.gov/hnl/hydro/pages/apr18sum.php).

A rainfall map from this event follows in Figure 8-3.

Location	Apr18	Avg	%Avg
Waiawa CF	6.67	3.49	191
Palisades	6.04	5.35	113
Moanalua	7.62	6.75	113
Moanlua RG	26.18	10.76	243
Mililani	4.25	2.49	171
Schofield B	4.24	2.53	168
Schofield S		3.40	
Wheeler	3.10	2.50	124
Poamoho	6.77	2.13	318
PoamhoRG1	28.52	21.94	130
Pupukea Rd	9.75	6.51	150
Kamananui	11.25	8.61	131
Dillingham		2.34	
Makua Ran	2.45	2.46	100
Makaha Str	5.42	4.16	130
Kuaokala	1.75	1.79	98

Location	Apr18	Avg	%Avg
Kahuku	3.71	3.25	114
Kahuku Tng	5.21	4.08	128
Kii		2.99	
Punaluu P	6.17	5.34	116
Punaluu Stm	16.42	10.72	153
Kahana	13.90	7.46	186
Hakipuu M	7.54	4.79	157
Oahu Forest	13.07	14.15	92
Waiahole	6.94	4.26	163
Waihee P	15.76	7.25	217
Ahuimanu	12.52	6.39	196
Kaneohe M		2.17	
Luluku	15.27	7.34	208
St Stephens	14.48	5.32	272
Maunawili	19.58	6.04	324
Olomana	9.91	3.21	309
Waimanalo	10.35	2.99	346
Bellows	6.13	2.30	267
Wilson T		10.10	
Nuuanu Upr	23.02	10.66	216
Manoa Lyn	32.53	14.08	231
Palolo FS	7.00	5.01	140
Niu Valley	9.48	2.82	336
Kamehame	7.17	1.88	381
Hawaii Kai	5.70	1.71	333



Location	Apr18	Avg	%Avg
HNL AP	1.19	0.63	189
Kalaeloa		1.12	
Waianae	1.81	1.22	148
Waianae BH	0.98	1.11	88
Waianae Vly	4.68	3.15	149
Lualualei	3.28	2.12	155
Palehua	3.22	3.94	82
Kunia Sub	3.20	1.32	242
Waipio	2.83	1.03	275
Honouliuli	1.80	1.07	168
Waiawa PH	3.28	1.01	325
Aloha Twr	1.78	1.66	107

Figure 8-3. **Oahu Rainfall - first half of April 2018**

Table 8-2. **Major Floods Affecting Oahu and Associated Damage, 1917-2018**

Date	Lives Lost	Location	1998 $	Cause
1917	3	Statewide		Heavy rains
1/16/1921	4	Honolulu	$ 500,000	Heavy rains
1922, 1927	6	Statewide		Heavy rains
1928, 1929	2	Statewide		Heavy rains
ll/3/1930	30	Kalihi, Moanalua, Halawa valleys, Oahu		Heavy rains
1932	3	Statewide		Rainstorm
2/27/1935	14	Oahu	$ 1,000,000	Severe rainstorm
1938	2	Statewide		Severe rainstorm
1/4-5/1947	1	Hawaii, Maui, Oahu	$ 2,200,000	High seas
l/23-26/1948	1	Hawaii, Maui, Oahu	$ 250,000	Strong winds and rainstorm
1/15-17/1949	4	Kauai, Oahu	$ 550,000	Intense Kona storm
3/26-27/1951	1	Oahu	$ 1,303,000	Heavy rains and strong winds
1/21/1954	2	Oahu	$ 500,000	Heavy rains and strong winds
11/27-28/1954		Kauai, Oahu	$ 810,000	Heavy rains
12/19-21/1955	7	Statewide		Kona storm
1/24-25/1956	1	Wailua, Kauai, Oahu, Hawaii	$ 700,000	Heavy rains
2/25/1956		Sunset Beach, Oahu	$ 250,000	Flash flood
2/7/1957	2	Honolulu, Waimanalo, Aina Haina, Oahu	$ 400,000	Flash flood
12/1/1957		Kauai, Oahu, Maui,Hawaii	$ 1,056,000	*Hurricane Della total damage*
3/5/1958		Oahu	$ 500,000	Heavy rain
8/6-7/1958	2	Oahu, Maui, Hawaii	$ 552,000	Heavy rain, strong wind, high seas
1/17-18/1959		Oahu, Molokai, Maui, Hawaii	$ 1,393,000	Heavy rain, strong wind, high seas
8/4/1959	2	Kauai, Oahu, Maui, Hawaii	$ 11,524,000	*Hurricane Dot total damage*
5/12-13/1960		Oahu, Maui	$ 250,000	Kona storm
10/27/1961	1	Oahu, Maui, Hawaii	$ 2,045,731	Heavy rain, strong wind, high seas
11/15-17/1963	3	Statewide	$ 790,000	Heavy rains, strong winds
5/14/1963		Pearl City, Oahu	$ 300,000	Heavy rains
12/19-23/1964	1	Statewide	$ 439,000	Heavy rains, strong winds, high seas
2/4/1965	0	Oahu, Molokai, Maui	$ 593,000	Heavy rains
5/3/l965		Kahaluu, Oahu	$ 711,300	Heavy rains
11/10-15/1965	4	Oahu	$ 500,000	Heavy rains, strong winds
1966	2	Statewide		Heavy rains
12/17-18/1967	1	Kauai, Oahu	$ 1,355,000	Heavy rain, high seas, tornado
1/5/1968		Pearl City, Oahu	$ 1,243,000	Heavy rains
2/1/1969		Keapuka, Oahu	$ 705,100	Heavy rains
4/19/1974	11	Kauai, Oahu, Maui	$ 3,868,300	Heavy rains
l/3O-2/l/l975		Kauai, Oahu	$ 566,000	Heavy rains
2/5-7/1976		Oahu	$ 802,000	Heavy rain, high seas, strong winds
1/6-7/1976	2	Oahu	$ 270,000	Heavy rain and strong wind
1978	2	Statewide		Rainstorm
1/6-14/1980		Statewide	$ 42,578,000	Heavy rains, high seas, strong winds
10/28/1981		Walawa Stream, Oahu	$ 786,350	Heavy rains
11/23/1982	1	Statewide	$ 307,859,000	*Hurricane Iwa total damage*
12/31/87-1/1/88		Oahu	$ 35,000,000	Heavy rains
7/21-23/1993		Statewide		Heavy rains, remnants of hurricane
8/3-4/2004		Statewide		Heavy rains, remnants of hurricane
10/30/2004		Manoa, Oahu	$ 85,000,000	Heavy rains, Manoa Stream overflow
2/19-4/2/2006		Statewide	$ 50,000,000	Sustained rainfall, Kauai dam break
12/4-11/2007		Statewide	$ 3,400,000	Heavy rains, high winds
12/10-16/2008		Kauai, Oahu	$ 1,100,000	Heavy rains
6/4/2011		Windward Oahu		Heavy rains
3/5/2012		Oahu		Heavy rains
8/25-9/6/2015		Oahu		Heavy rains
7/24/2016		Oahu		Heavy rains
4/13/2018		East Oahu	$ 13,000,000	Heavy rains



Figure 8-4. **Damaged Footbridge over Manoa Stream**
(NOAA Website, http://www.prh.noaa.gov/hnl/pages/events/ManoaFlood20041030/)



Figure 8-5. **Cars inundated by floodwaters adjacent to Manoa Stream**
(NOAA Website, http://www.prh.noaa.gov/hnl/pages/events/ManoaFlood20041030/)



Figure 8-6. **An innuandated playground due to heavy rain April, 2018**
(Hawaii News Now, http://www.hawaiinewsnow.com/story/37956117/photos-flooding-causes-major-damage-across-oahu)



Figure 8-7. **Damage from overflow of nearby stream during April, 2018 flooding**
(Hawaii News Now, http://www.hawaiinewsnow.com/story/37956117/photos-flooding-causes-major-damage-across-oahu)

8.5 Probability of Occurrence

8.5.1 Precipitation Frequency Maps

The most up to date precipitation frequency estimates for the Hawaiian Islands were performed by NOAA and are included in Volume 4 of Atlas 14 – Precipitation Frequency Atlas of the United States, Version 3 (NOAA, 2009). The Atlas provides precipitation frequency estimates for 5-minute through 60-day durations at average recurrence intervals of 1-year through 1,000-year. The information in NOAA Atlas 14 Volume 4 Version 3 supersedes previous precipitation frequency estimates (US Weather Bureau, 1962; 1965). The precipitation estimates are based on improvements in three primary areas: denser data networks with longer periods of record; the application of regional frequency analysis, and; new techniques for spatial interpolation and mapping. The new techniques for spatial interpolation and mapping account for topography and have allowed significant improvements in areas of complex terrain. The results are provided at high spatial resolution and include confidence limits for the estimates. The Atlas includes temporal distributions designed for use with the precipitation frequency estimates and seasonal information for annual maxima. In addition, the potential effects of climate change on annual maxima were examined. Figure 8-8 shows a map of Oahu indicating the estimated rainfall intensity for a 60-minute duration and for 100-year average recurrence interval. Watersheds downstream from the regions of highest rainfall intensity are at the greatest risk of flash floods.

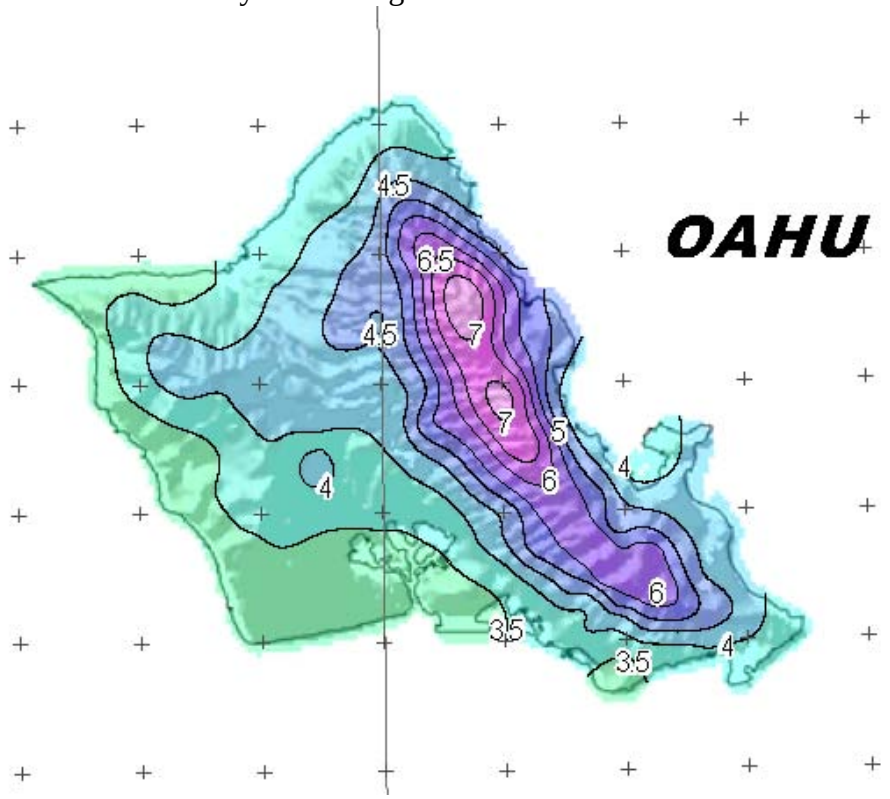


Figure 8-8**. One hour rainfall intensity map for Oahu with 1% annual probability of exceedance** (NOAA Precipitation-Frequency Atlas, 2009)

8.5.2 Stream Flood Frequency Estimates

A study was completed that provides an updated analysis of the magnitude and frequency of peak stream discharges in Hawaii (Oki et al., 2010). Annual peak-discharge data collected by the U.S. Geological Survey during and before water year 2008 (ending September 30, 2008) at stream-gaging stations were analyzed. The existing generalized-skew value for the State of Hawai‘i was retained, although three methods were used to evaluate whether an update was needed.

Regional regression equations were developed for peak discharges with 10-, 25-, 50-, 100-, and 500-year recurrence intervals for unregulated streams (those for which peak discharges are not affected to a large extent by upstream reservoirs, dams, diversions, or other structures) in areas with less than 20 percent combined medium- and high-intensity development. The generalized-least-squares (GLS) regression equations relate peak stream discharge to quantified basin characteristics (for example, drainage-basin area and mean annual rainfall) that were determined using geographic information system (GIS) methods.

Oahu, as with the other islands, was divided into two regions, generally corresponding to a wet region and a dry region. Unique peak-discharge regression equations were developed for each region. In general, estimated 100-year peak discharges from this study are lower than those from previous studies, which may reflect the longer periods of record used in this study. Improved estimates of the magnitude and frequency of peak discharges in Hawai‘i will require continued operation of existing stream-gaging stations.

8.6 Risk Assessment

8.6.1 Flood Insurance Rate Maps

The National Flood Insurance Program (NFIP) is administered by the Federal Emergency Management Agency (FEMA). As a condition of making flood insurance available for the residents of counties participating the NFIP, communities agree to regulate new construction in a base floodplain. Floodplains are defined by Flood Insurance Rate Maps (FIRMs). These maps capture site specific information on vulnerable flood prone properties that can be used to determine insurance premiums. The flood insurance rate map is summarized for the Island of Oahu in Figure 8-7.

The FIRM zone designations are defined in Table 8-3. The maps were digitized and now use the acronym DFIRM (Digital Flood Insurance Rate Maps). The digital maps are available on the Hawaii National Flood Insurance Program Website where the flood insurance zone for individual properties may be determined using the Flood Hazard Assessment Tool (FHAT) (http://gis.hawaiinfip.org/fhat/). The DFIRM maps were updated and took effect on November 5, 2014.

Table 8-3. **FEMA Flood Insurance Rate Map Definitions**

Zone V
Zone V is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Base flood elevations are not determined in this zone.

Zone VE
Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone A
Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE
Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, whole foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH
Zone AH is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO
Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-depths derived from the detailed hydraulic analyses are shown within this zone

Zone D
Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

Zone X
Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, and to areas of 100-year flooding where average depths are less than 1 foot, areas of flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

8.6.2 Special Flood Hazard Areas (SFHA)

The FIRMs depict the Special Flood Hazard Areas (SFHA) within a studied community. SFHA are areas subject to inundation by a flood having a one percent chance or greater of occurring in any given year. A flood with this probability of occurrence, also referred to as the 100-year flood or base flood, is the national standard on which the floodplain management and insurance requirements of the NFIP are based. The FIRM shows Base Flood Elevations (BFE) and flood insurance risk zones. The different A zones and V zones are considered SFHA. The FIRM also shows areas designated as a regulatory floodway. The regulatory floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 100-year flood discharge can be conveyed without increasing the BFE more than the specified amount. Within the SFHA identified by approximate analyses, the FIRM shows only the flood insurance zone designation.

8.6.3 Repetitive Losses

The City & County started participation in the NFIP as of September 3, 1980. The City and County of Honolulu has been identified by FEMA as being a Category C repetitive loss flooding community, for a community with ten or more repetitive loss properties. A repetitive loss structure is important to the NFIP because structures that flood frequently put a strain on the flood insurance fund. It should also be important to the community because residents' lives are disrupted and may be threatened by the continual flooding. Per FEMA, counties are encouraged to develop plans that address the mitigation of target repetitive loss properties, as insured properties may be eligible for Flood Mitigation Assistance and Hazard Mitigation Grant Program (HGMP) Funds, in order to reduce the number of repetitive claims against the NFIP.

A repetitive loss property is a structure that:

- has suffered flood damage exceeding $1,000 each on two or more occasions over a ten-year period. This period ends on the date when a second claim is made.

The City & County has accumulated 114 repetitive loss residential properties with initial losses dating from 1978, which are listed in Table 8-4. During this period, major El Nino events were recorded in the years 1982–83, 1997–98, and 2014–16; El Nino is associated with lower rainfall during the winter months. Most of these homes are of Pre-FIRM construction. Many of these properties are not currently insured under the NFIP;49 or the 114 RL properties did not have flood insurance. The NFIP Claims list for Oahu was further sorted based on whether they are currently insured and by descending total cumulative claim amount. They were then assigned a rank from 1 to 114. Nearly all the repetitive loss structures are located at coastal sites.

In the prior hazard mitigation plan, the cumulative number of repetitive loss properties was 83. Of the 31 new properties since 2011, most of the losses occurred in the years of 2012, 2014, 2016, and 2018, and not necessarily all due to a major flooding event. The homes damaged in 2014 and 2016 were due to summer floods. 80% of these recent repetitive loss properties are Pre-FIRM construction. 70% of the 31 latest repetitive loss properties are not in a flood zone. This suggests that the repetitive losses since 2011 were due to high rainfall events generally consistent with the seasonal climatology that overwhelmed existing infrastructure, primarily affecting homes not designed or constructed in accordance with modern flood zone requirements.

A check was also made to determine whether any of the properties would fall under the ICC (Increased Cost of Compliance) coverage funding criteria, i.e.:

- The home or business is damaged by flood to the point that repairs will cost 50 percent or more of the building's pre-damage market value, i.e., substantial damage*.
- If the community has a repetitive loss provision in its floodplain management ordinance and determines that your home or business was damaged by a flood two times in the past 10 years, where the cost of repairing the flood damage, on the average, equaled or exceeded 25 percent of its market value at the time of each flood. Additionally, there must have been flood insurance claim payments for each of the two flood losses.

ICC coverage provides up to $30,000 of the cost to elevate, demolish, or relocate a home. None of the losses would have qualified for this Increased Cost of Compliance coverage.

*A Substantially Damaged Building has incurred damage of any origin whereby the cost of restoring the building to its before damaged condition would equal or exceed 50% of the market value of the building before the damage occurred.

FEMA's national Severe Repetitive Loss (SRL) property criteria was used to identify structures with higher priority for mitigation, having:

- 4 or more separate claim payments of more than $5,000 each (including building and contents payments) and with the cumulative amount of such claims payments exceeding $20,000; or
- 2 or more separate claim payments (building payments only) with the cumulative amount of such claim payments exceed the fair market value of the insured building on the day before each loss..

Only 9 of the 114 properties met the criteria to be classified as Severe Repetitive Loss structures. The total damage to these 9 SRL structures in their last claim year was over $600,000. Just one of these SRL properties was affected by the April 14-15 2018 intense rainfall flooding. One of the properties identified as a Severe Repetitive Loss property was new to that category since the previous hazard mitigation plan (that had 8 severe repetitive loss properties). Only two of the SRL properties are of Post-FIRM construction. Only one of the SRL is outside of a flood zone. The principle trend amongst these 9 SRL is that almost all are in a flood zone.

The areas with RL and SRL properties are shown in Figure 8-8.

Table 8-4. **Oahu Repetitive Loss Properties**

Rank	Place	Zip Code	post FIRM?	Insured?	FIRM Zone	Dates of Most Recent Losses (Last Updated 09/30/2009)			Number of Losses	SRL
1	HONOLULU	96819	NO	NO	A00	11/03/2000	11/14/1996	02/27/1995	10	YES
2	HAUULA	96717	NO	SDF	V14	12/11/2008	03/02/2006	05/06/2002	8	YES
3	KAAAWA	96730	NO	SDF	AE	07/09/14	03/02/2006	01/19/1997	8	YES
4	HONOLULU	96826	NO	SDF	B	07/24/16	03/31/2006	11/13/1996	7	YES
5	HONOLULU	96819	YES	NO	X	08/29/17	7/24/2016	03/26/2004	7	YES
6	KAAWA	96730	NO	NO	V14	02/13/1994	03/19/1991	01/29/1988	5	YES
7	KAAAWA	96730	NO	SDF	AE	07/19/14	03/02/2006	02/13/1994	5	YES
8	HONOLULU	96821	NO	SDF	A04	**04/14/18**	09/11/1992	03/19/1991	4	YES
9	MAKAHA	96792	YES	NO	V22	09/11/1992	11/23/1982		2	YES
10	HONOLULU	96816	YES	YES	X	08/24/15	03/31/2006	03/24/2006	5	
11	HALEIWA	96712	NO	NO	C	09/07/1996	01/24/1996	12/19/1987	5	
12	HONOLULU	96819	NO	NO	AE	07/24/16	8/24/2015	03/19/1980	4	
13	KAILUA	96734	NO	YES	A04	03/31/2006	03/03/2004	02/14/1985	4	
14	HONOLULU	96816	NO	YES	AO	03/06/12	03/31/2006	03/23/1991	4	
15	HONOLULU	96821	NO	NO	AE	11/03/1993	03/19/1991	01/08/1980	4	
16	HONOLULU	96801	NO	NO	A04	09/11/1992	03/19/1991	01/20/1982	4	
17	WAIMANALO	96795	NO	YES	X	**04/13/18**	01/25/1996	12/31/1987	4	
18	HALEIWA	96713	NO	NO	AE	01/22/14	12/27/2013	1/11/2010	4	
19	HONOLULU	96821	NO	YES	D	**04/13/18**	03/19/1991	12/31/1987	3	
20	LAIE	96762	NO	YES	A	12/11/2008	03/19/1991	01/01/1988	3	
21	HONOLULU	96821	NO	YES	C	03/23/2006	01/29/2005	09/11/1992	3	
22	HONOLULU	96826	NO	YES	AO	03/31/2006	11/13/1996	12/30/1992	3	
23	HONOLULU	96819	NO	NO	A0B	12/18/1990	08/25/1982	01/20/1981	3	
24	KAAAWA	96730	NO	YES		12/11/2008	11/05/2007	03/03/2006	3	
25	HONOLULU	96821	NO	YES	D	**04/13/18**	09/12/1992	01/01/1988	3	
26	HALEIWA	96712	NO	NO	A	11/12/1996	11/23/1995	11/02/1989	3	
27	HALEIWA	96712	NO	YES	AE	12/11/2008	03/01/2004	11/04/1996	3	
28	LAIE	96762	NO	YES	A	12/10/2008	03/20/1991	11/27/1984	3	
29	HALEIWA	96712	NO	YES	AE	11/13/1996	03/19/1991	01/10/1989	3	
30	KAILUA	96734	NO	YES	X	02/26/2004	11/29/2003	11/27/1984	3	
31	HONOLULU HI	96821	NO	NO	AE	11/14/1996	03/21/1991	12/31/1987	3	
32	HALEIWA	96712	NO	NO	V24	07/21/1989	02/10/1983	03/18/1980	3	
33	KAAAWA	96730	NO	NO	A04	12/26/1992	03/19/1991	02/14/1985	3	
34	KAAWA	96712	NO	NO	AE	07/19/14	03/20/1991	01/29/1988	3	
35	WAIANAE	96792	NO	NO	D	09/11/1992	10/20/1985	11/23/1982	3	
36	HONOLULU	96817		NO	EMG	06/15/1980	03/18/1980	01/09/1980	3	
37	HONOLULU	99999	NO	NO	A04	11/23/1982	01/07/1982		2	
38	HAUULA	96717	NO	NO	VE	11/11/1996	03/20/1991		2	
39	WAINAE	99999		NO	A04	11/23/1982	01/07/1982		2	

Rank	Place	Zip Code	post FIRM?	Insured?	FIRM Zone	Dates of Most Recent Losses (Last Updated 09/30/2009)			Number of Losses	SRL
40	MAKAHA	96792	NO	NO	V22	09/11/1992	11/23/1982		2	
41	LAIE	96762	NO	NO	AH	12/11/2008	11/29/2003		2	
42	HONOLULU	99999	NO	NO	A04	11/23/1982	01/07/1982		2	
43	HONOLULU	96821	NO	YES	AE	10/12/1992	09/11/1992		2	
44	HONOLULU	96816	NO	YES	X	03/23/1991	12/06/1988		2	
45	HONOLULU	99999	NO	NO	X	02/28/1995	09/11/1992		2	
46	KAILUA	96734	NO	YES	AH	01/01/1988	01/09/1980		2	
47	HAUULA	96717	NO	YES	X	12/11/2008	03/02/2006		2	
48	HONOLULU	96822	NO	NO	A	12/13/1987	01/08/1980		2	
49	PUNALUU	96717	NO	NO	VE	02/27/1997	08/15/1993		2	
50	HONOLULU	96821	NO	YES	A05	09/11/1992	01/01/1988		2	
51	HONOLULU	96822	NO	YES	X	12/11/2008	03/31/2006		2	
52	LAIE	96762	NO	NO	A	03/20/1991	03/21/1982		2	
53	HAUULA	96717	NO	NO	C	04/04/1989	01/06/1982		2	
54	HONOLULU	96821	YES	YES	AE	11/05/1993	10/12/1992		2	
55	EWA BEACH	96706	NO	YES	A	03/01/2004	11/05/1996		2	
56	WAIANAE	96792	NO	YES	V22	09/11/1992	11/23/1982		2	
57	KAILUA	96734	NO	NO	C	01/20/1993	02/14/1985		2	
58	LAIE	96762	NO	NO	A	03/20/1991	03/27/1982		2	
59	LAIE	96762	NO	YES	A	03/20/1991	03/21/1982		2	
60	KAILUA	96734	NO	NO	AH	12/31/1987	01/08/1980		2	
61	HONOLULU	96821	NO	NO	A04	09/11/1992	12/31/1987		2	
62	HONOLULU	96816	NO	NO	AO	10/12/1992	03/23/1991		2	
63	WAIANAE	96792	NO	NO	AE	11/14/1996	10/16/1991		2	
64	KAILUA	96734	NO	NO	EMG	01/08/1980	11/01/1978		2	
65	KAILUA	96734	NO	YES	X	04/13/2006	02/27/2004		2	
66	HONOLULU	96815	NO	YES	A04	10/12/1992	11/23/1982		2	
67	KAAAWA	96730	NO	NO	A	12/31/1987	02/14/1985		2	
68	HAUULA	96717	NO	NO	A06	02/14/1985	03/15/1982		2	
69	KAAAWA	96730	NO	YES	AE	03/20/1991	01/29/1988		2	
70	KAILUA	96734		YES	X	03/31/2006	02/25/2004		2	
71	HONOLULU	96826	NO	YES	AO	03/30/2006	10/30/2004		2	
72	WAIANAE	96792	NO	NO	A	01/23/1983	01/10/1980		2	
73	WAIANAE	96792	NO	YES	AE	12/11/2008	03/31/2006		2	
74	KAILUA	96734	NO	NO	A	02/14/1985	12/15/1980		2	
75	KAILUA	96734	NO	NO	C	02/14/1985	05/23/1978		2	
76	HAUULA	96717		NO	X	02/13/1994	03/19/1991		2	
77	HAUULA	96717	NO	NO	A	03/20/1991	11/24/1984		2	
78	HAUULA	96717	NO	NO	VE	03/23/1991	11/18/1990		2	
79	PEARL CITY	96782	NO	NO	A	12/31/1987	10/28/1981		2	
80	HALEIWA	96712	NO	NO	X	11/20/1990	02/23/1986		2	
81	HONOLULU	96819	NO	NO	C	12/12/1987	10/19/1985		2	

Rank	Place	Zip Code	post FIRM?	Insured?	FIRM Zone	Dates of Most Recent Losses (Last Updated 09/30/2009)			Number of Losses	SRL
82	HONOLULU	96817	NO	NO	A06	08/25/1982	03/18/1980		2	
83	HONOLULU	96819	NO	NO	EMG	06/15/1980	01/08/1980		2	
84	HAUULA	96717	NO	YES	X	07/19/14	3/8/2012	12/11/2008	3	
85	LAIE	96763	NO	NO	A	03/08/12	12/11/2008	3/20/1991	3	
86	HAUULA	96717	NO	YES	AE	07/20/1014	11/13/2009	12/11/2008	3	
87	KANEOHE	96744	NO	NO	X	03/09/12	6/4/2011	10/5/2009	3	
88	LAIE	96763	NO	YES	AH	03/09/12	12/11/2008	3/19/1991	3	
89	HONOLULU	96821	NO	YES	AE	**04/13/18**	3/11/2011		2	
90	HONOLULU	96821	YES	YES	X	**04/13/18**	3/8/2012		2	
91	HONOLULU	96821	NO	YES	AE	**04/13/18**	3/9/2012		2	
92	HONOLULU	96825	YES	YES	X	10/23/17	2/11/2017		2	
93	KAILUA	96733	NO	YES	X	03/09/12	6/4/2011		2	
94	KANEOHE	96744	NO	YES	D	02/18/18	6/4/2011		2	
95	KAILUA	96735	NO	NO	X	03/09/02	3/31/2006		2	
96	HAUULA	96718	NO	NO	X	07/19/14	12/11/2008		2	
97	HONOLULU	96816	YES	YES	X	03/06/12	03/313/2006		2	
98	HAUULA	96717	NO	YES	AE	07/20/14	3/2/2006		2	
99	KANEOHE	96744	NO	YES	X	02/28/18	7/24/2016		2	
100	HONOLULU	96821	YES	YES	X	12/26/17	3/9/2012		2	
101	KANEOHE	96744	NO	NO	X	03/09/12	3/31/2006		2	
102	HAUULA	96717	NO	YES	VE	07/20/14	3/2/2006		2	
103	HAUULA	96717	NO	NO	VE	07/20/14	3/2/2006		2	
104	HONOLULU	96816	NO	NO	X	02/11/17	7/24/2016		2	
105	HONOLULU	96821	NO	NO	X	08/28/16	2/3/2008		2	
106	HONOLULU	96815	NO	NO	AE	08/24/15	12/19/2010		2	
107	HAUULA	96717	NO	YES	AE	07/19/14	12/11/2008		2	
108	HONOLULU	96816	NO	YES	X	12/26/17	12/19/2010		2	
109	HONOLULU	96822	NO	YES	X	11/23/15	7/20/2014		2	
110	KANEOHE	96744	NO	YES	X	02/18/18	7/24/2016		2	
111	HONOLULU	96816	YES	YES	X	02/28/18	3/7/2012		2	
112	KAAAWA	96730	no	NO		12/31/87	2/14/1985		2	
113	KAILUA	96735	NO	NO	X	03/08/12	12/10/2010		2	
114	HONOLULU	96821	NO	NO	X	02/18/18	12/26/2017		2	

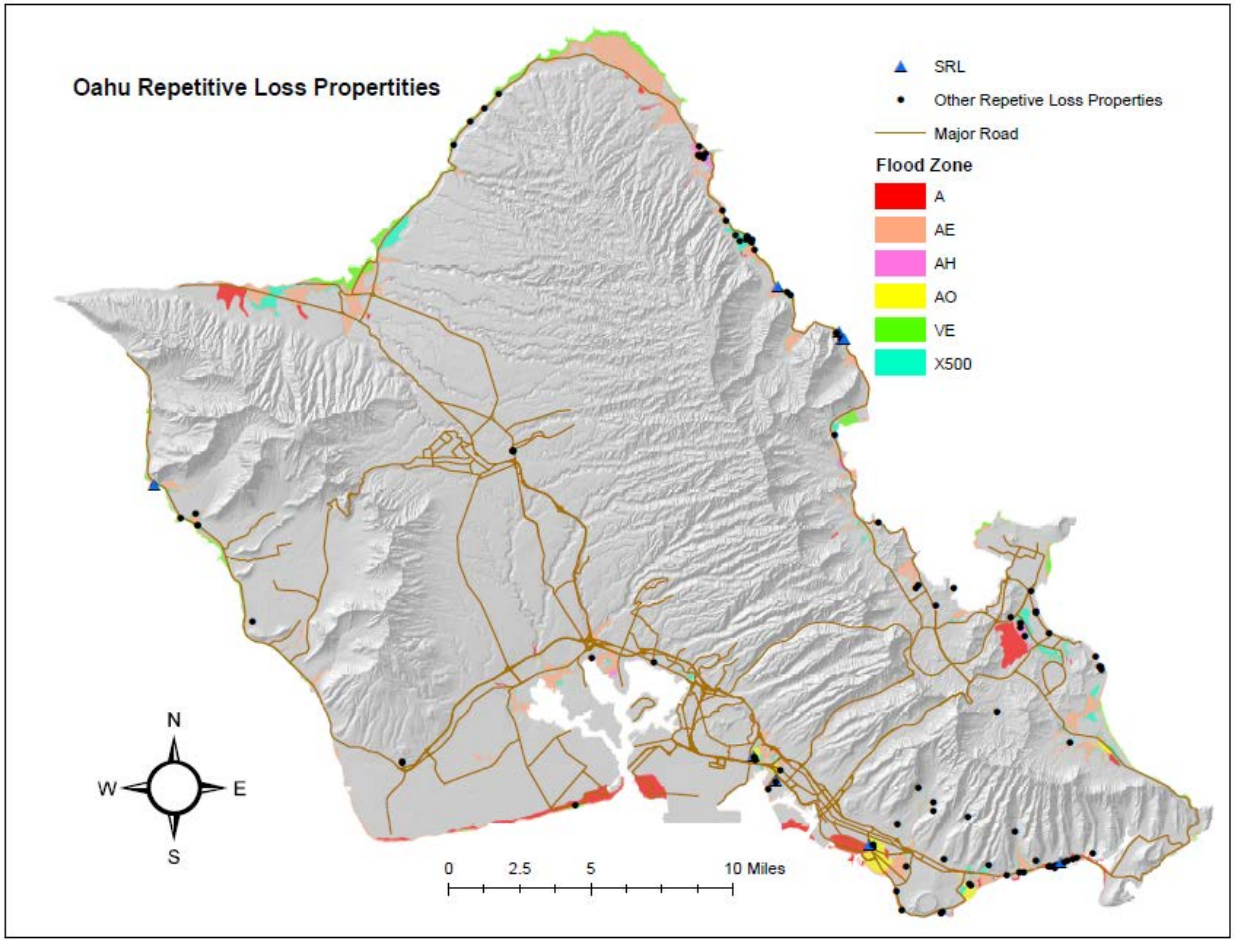


Figure 8-9. **Oahu Repetitive Loss Properties in Flood Zones**

Accordingly, it appears that *uninsured* properties with higher losses would not be targeted for mitigation, as there would be no insurance consequence to the decision. There may be good reason to examine these cases to determine why they are not continuing under coverage, as part of an annual repetitive loss area outreach project (Flood insurance could have lapsed after repayment of a disaster assistance loan).

8.7 Mitigation Strategies

8.7.1 General

Flood hazard mitigation includes those actions taken to protect people and property from flooding. Many Federal, State, local, and private agencies and organizations can affect hazard mitigation. The City and County of Honolulu (City) has been a participating community in the NFIP since September 3, 1980.

Based on NFIP records as of October 2017, there are 37,990 flood insurance policies in the City and County of Honolulu (The State of Hawaii has a total of almost 60,000 flood insurance policies). Interestingly more than 50% of these policies are for properties located in low-to-moderate flood risk zones (X and D zones), although statistics show that 25% of flood claims do come from these low-to-moderate flood zones.

As a condition of participation in the NFIP program, the City adopted floodplain management regulations that met the minimum regulations as set forth in Title 44 of the Code of Federal Regulations §60.3. The Department of Land and Natural Resources (DLNR) has been designated as the State Coordinating Agency responsible for assisting the coordination of the program between the Federal and County agencies in Hawaii.

Under the authority set forth in HRS Chapter 179, the Department of Land and Natural Resources (DLNR) has been appointed as the State Coordinating Agency, responsible for administering flood control and mitigation through the DLNR 810 Program for Prevention of Natural Disasters. The goals of the DLNR 810 program is to "protect people and their property from unwise floodplain development, and to protect society from the costs associated with developed floodplain through floodplain management activities and regulations of dams and reservoirs". In this effort, the State has implemented three policies to carry out these goals:

Policy A: Utilize strategies and objectives for floodplain management from the State's Flood Hazard Mitigation Plan.

Policy B: Administer the National Flood Insurance Program to protect the public by incorporating a proactive Floodplain Management Plan.

Policy C: Administer the State Dam Safety Program to reduce the risk for loss of life and property damage caused by dam related failures and incidents (discussed in the following Chapter)

The State of Hawaii's NFIP Coordinating office (DLNR), periodically evaluates the City's floodplain management program to ensure that the community is adequately enforcing its floodplain management regulations. This evaluation is conducted through a Community Assistance

Visit (CAV).

There is a program developed by DLNR that recognizes whether a local official is qualified for floodplain management. This program, called the Certified Floodplain Manager (CFM), is a nationally accredited program to certify local, state, federal, and private sector floodplain managers. The role of the floodplain manager has expanded largely due to the increase in federally declared disasters and the inherent task to break the repetitive damage - rebuild damage cycle. This need for accredited professionals resulted in the creation of the Certified Floodplain Manager Program. The designation of CFM ensures that the individual has received formal, measurable training, and is proficient in the duty of floodplain mitigation. The primary goal of the CFM is to assist in the reduction of flood fosses and protect and enhance the natural resources and functions of the floodplains by improving the knowledge and ability of the floodplain manager. Hawaii currently has 30 CFM listed on their website (http://dlnreng.hawaii.gov/nfip/certified-flood-plain-managers/).

There are four significant benefits of participating in the NFIP. One focuses on property protection and three focuses on financial security. Specifically:

1. Development that complies with the minimum NFIP performance criteria is less likely to experience major damage. Studies have shown that, on average, buildings that meet the NFIP criteria sustain approximately 75 percent less damage than those that do not.

2. Federally insured or regulated lenders must require that improvements located in mapped flood hazard areas be insured for flood damage. If a community does not participate in the NFIP, then lenders must notify borrowers that federal disaster assistance for flood damage will not be available, including grants and loans.

3. People who have flood insurance have a significant advantage over those who have no financial support or those who have to get loans to help repair and rebuild. Most homeowners' property insurance explicitly excludes damage from floods, and non-NFIP flood insurance is hard to find. However, it is easy for most home and business owners to get NFIP flood insurance because many private companies write and sell policies on behalf of the NFIP.

4. Federal disaster assistance is available to repair or restore public infrastructure and public buildings in flood hazard areas if damaged by a disaster that is declared by the president.

In participating communities, NFIP flood insurance is available for both residential and non-residential buildings, and additional coverage is available for contents. Policies on buildings in flood hazard areas show on Flood Insurance Rate Maps (FIRMs) include coverage that provides claim payment to help defray the cost of bringing a flood-damaged building into compliance with community floodplain management requirements.

The National Flood Insurance Program (NFIP) sets minimum requirements for participating communities' building construction regulations. These are complied with in the County's flood ordinance. The NFIP minimum requirements are summarized as follow:

There are five major floodplain regulation requirements. (Additional floodplain regulatory requirements may be set by state and local law.)

1. All development in the base floodplain must have a permit from the community. Agriculture and forestry activities are not exempt.

2. Development should not be allowed in the floodway. The floodway is the channel and central portion of the floodplain that is needed to convey the base flood. It is usually the most hazardous area of a riverine floodplain and the most sensitive to development. At a minimum, no development in the floodway can cause an obstruction to flood flows.

3. New buildings may be built in the floodplain, but they must be protected from damage by the base flood. The lowest floors of residential building must be elevated to or above the base flood elevation. Non-residential buildings must be elevated or flood proofed.

4. When an addition, improvement or repair of damage to an existing building is valued at 50% or more than the value of the original building, then it is a considered a substantial improvement. A substantial improvement is treated as new construction and the building must be protected from damage by the base flood.

5. In coastal high hazard areas (V-zone), new buildings and substantial improvements to existing buildings must be elevated on open columns or piles and be on an anchored foundation engineered for the site. Construction projects are not allowed to alter sand dunes.

The different approaches to flood hazard mitigation under the NFIP are organized under six general strategies:

- Prevention – keeping things from getting worse
- Property protection – protecting things that will flood
- Natural resources protection – preserving beneficial floodplain uses
- Emergency services – actions taken during a flood
- Structural projects – controlling where floodwaters go
- Public information – helping people understand and help themselves

The NFIP also has a voluntary program, the Community Rating System (CRS) that recognizes community mitigation activities beyond the minimum requirements for regulating floodplain development. Details about the CRS are included in Appendix 10A – The NFIP Community Rating System (CRS). Among the goals of the CRS are the following:

- Reduce flood losses;
- Facilitate accurate insurance rating; and

- Promote the awareness of flood insurance.

For CRS participating communities, flood insurance premium rates are discounted in increments of 5%; i.e., a Class 1 community would receive a 45% premium discount, while a Class 9 community would receive a 5% discount (a Class 10 is not participating in the CRS and receives no discount). The CRS classes for local communities are based on 18 creditable activities, organized under four categories:

- Public Information,
- Mapping and Regulations,
- Flood Damage Reduction, and
- Flood Preparedness.

The City and County of Honolulu does not currently participate in the CRS. One of the proposed mitigation activities is to investigate the feasibility of its participation. Significant savings in insurance premiums could be realized by the residents if the county participated.

8.7.2 Prevention

Prevention measures are designed to keep the problem from occurring or getting worse. They ensure that future development does not increase flood damage. Preventive measures are usually administered by building, zoning, planning, and/or code enforcement offices. They include:

- Planning and zoning
- Floodplain open space preservation
- Building construction regulations
- Regulation of other facilities
- Stormwater management

Prevention techniques tend to be programmatic in nature and are generally suited for use throughout the County. Land use planning, maintaining open space, ordinance standards, and storm water management practices all can have an impact on the entire watershed. Wetland protection and drainage system maintenance can have a significant impact when practiced throughout the watershed, but can also be effectively targeted at areas in and adjacent to the floodplain.

8.7.3 Property Protection

Property protection measures are used to modify buildings or other facilities subject to flood damage rather than to keep floodwaters away. Property protection measures include:

- Building Elevation
- Relocation
- Acquisition (Demolition)
- Floodproofing (non-coastal)
- Lifeline Protection
- Flood Insurance

FEMA has found that in areas subject to significant wave action, elevation that keeps the lower area open and free of obstruction is the only in-place measure that can prevent structural damage . In areas subject to significant storm-induced scour (vertical erosion), residences whose foundations are not embedded well below the potential scour zone incur significant damage or total loss as a result of foundation failure. In areas subject to significant shoreline retreat over the long term (horizontal erosion), relocation and demolition are the only viable flood proofing measures unless actions are taken to forestall the erosion.

8.7.4 Natural Resource Protection

Preserving or restoring natural areas or the natural functions of floodplains and watershed areas produce flood loss reduction benefits as well as improve water quality and habitats. These activities are usually implemented by parks, recreation, or conservation agencies, or organizations. In addition to the four measures listed here, other measures, such as zoning and preservation of open space can also protect natural resources.

- Wetland protection
- Erosion and sediment control
- Best management practices
- Coastal barrier protection

8.7.5 Emergency Services

Emergency services measures protect people during and after a flood. The National Weather Service and the Pacific Tsunami Warning Center report potential flood threats to the State Civil Defense Agency. The information is verified, and the potential effect of the threat is evaluated. If a threat to public safety and property arises, warnings are transmitted to the public through the press, radio, and television. Oahu and State coordinate warning, response, and recovery during a disaster. Measures include:

- Flood threat recognition
- Warning dissemination
- Flood response
- Critical facilities protection
- Health and safety maintenance
- Post disaster recovery and mitigation

8.7.6 Structural Projects

Planning for flood control strategies requires a consideration of accommodating development in flood-prone regions through measures such as building code requirements, land use regulations, relocation, and emergency evacuation. In addition, an approach consisting of mitigating structures, such as levees and dikes, improved channels, flood water storage structures and other types of drainage diversion features are employed. Together these two approaches constitute the flood control and flood plain management approach typically utilized by regulatory authorities.

Structural projects are used to prevent floodwaters from reaching properties. These measures are "structural" because they involve construction of manmade structures to control water flows. They can be grouped under six measures:

- Reservoirs/impoundments
- Levees/floodwalls/seawalls
- Diversions
- Channel modifications
- Channel and basin maintenance
- Dune and beach maintenance
-

Most structural projects can have the following shortcomings:

- They can be too expensive for the county to afford
- They disturb the land and disrupt natural flows, often destroying habitats
- They require regular maintenance, which if neglected, can have disastrous consequences
- They are built to certain flood protection level that can be exceeded by larger floods, causing extensive damages.
- They can create a false sense of security, as people protected by a project often believe that no flood can ever reach them.

8.7.7 Public Information

Public education about flood hazards is achieved through newsletters, informational pamphlets, booklets, and mailings, web posting, radio and television ads and infomercials, and other media outlets. Informational booths and kiosks held at public and/or private events area also good means of educating the public about the risk and hazards of floods.

8.8 Recent and Proposed Hazard Mitigation Activities

8.8.1 Waiahole Bridge Replacement

Planned to begin in 2021 and take 2 years, the State Department of Transportation intends to replace the 1922 Waiahole Bridge, located south of Waiahole Valley Road, to widen the stream and the roadway, and prevent storm debris that presently tends to dam at its foundation piers during heavy rains causing blockage to flow. Rather than having support piers in the streambed, the bridge would free-span over the entire stream floodway. The budget is $14.5 Million.

8.8.2 FEMA Digital Flood Insurance Rate Maps (DFIRM)

The Digital Flood Insurance Rate Map (DFIRM) Database depicts flood risk information and supporting data used to develop the risk data. The primary risk classifications used are the 1-percent-annual-chance flood event, the 0.2-percent-annual-chance flood event, and areas of minimal flood risk. The DFIRM Database is derived from Flood Insurance Studies (FISs), previously published Flood Insurance Rate Maps (FIRMs), flood hazard analyses performed in support of the FISs and FIRMs, and new mapping data, where available. The FISs and FIRMs are published by the Federal Emergency Management Agency (FEMA). The file is georeferenced to

earth's surface using the UTM projection and coordinate system. The specifications for the horizontal control of DFIRM data files are consistent with those required for mapping at a scale of 1:12,000.

8.8.3 Flood Hazard Assessment Tool (FHAT)

The Flood Hazard Assessment Tool is a geographic information system (GIS)-based application available to the public. The FHAT was developed and is maintained by the State of Hawai‘i Department of Land and Natural Resources (DLNR). The application is available via the Internet at the following website address: (http://gis.Hawai‘infip.org/fhat/). The GIS database for the FHAT includes effective FIRM and/or DFIRM shape files, associated meta-data, and a high resolution imagery base map. Currently, the FHAT allows users to retrieve the historic, preliminary, and effective FIRM and/or DFIRM zones for a determined property based on either address or Tax Map Key (TMK). Information regarding Letters of Map Change (LOMC), state regulated dams, and Flood Insurance Studies (FIS) are also available at this time through the FHAT. In the future, the DLNR has plans for the FHAT to provide the following additional information:

- Map of Repetitive Loss Structures
- Map of Community Zoning Maps
- Map of the State of Hawai‘i’s CIP’s Flood Control Projects
- Map of current stream maintenance
- Map of Rain/Stream Gauge Stations
- Dam Break Inundation Zones
- Building Permit Data

8.8.4 City and County of Honolulu Revised Floodplain Ordinance

Section 21.9-10 of the Land Use Ordinance defines Flood Hazard Districts and their appropriate uses including public parks, conservation, agriculture, wetlands and planned developments that keep buildings out of the floodplain. Intensive development is not permitted. This section received several updates, it was added to in 2014 (Ordinance 14-9) and then amended in 2016 (Ordinance 16-30). These updates were needed in order prevent a possible suspension from the NFIP. The 2014 update made the language of the section to conform to the language of the NFIP. The 2016 amendment further met FEMA’s standards and established fine values for Flood Hazard Areas.

8.8.5 Floodplain Management Plan

The Five Year Floodplain Management Plan is maintained to assist the Federal Emergency Management Agency (FEMA) in identifying the total workload necessary to provide an effective floodplain management plan for the State of Hawaii. This is administered through the Community Assistance Program – State Support Service Element (CAP-SSSE). The CAP-SSSE is a federal program designed to utilize State assistance in ensuring that communities participating in the National Flood Insurance Program (NFIP) are achieving the flood loss reduction goals of the NFIP. Through a State grant mechanism, the Department of Land and Natural Resources provides

technical assistance to NFIP communities and evaluates the community's performance in implementing NFIP floodplain management activities. Available CAP-SSSE funding is provided on a 75 percent Federal and 25 percent State cost-share basis. As a product-based program, FEMA and the State mutually agree upon specific flood loss reduction activities that will be undertaken each fiscal year through a cooperative agreement.

The basic requirements for participation in the CAP-SSSE program, achieved through state appropriated funding are as follows:

- Provide ordinance assistance for all four communities;
- Conduct Biennial Community Assistance Visits for each community;
- Publish and distribute a quarterly newsletter; and
- Provide technical assistance to community officials as well as the general public.

Through supplemental FEMA grants additional floodplain management activities are possible, which include:

- V-Zone inspections of current flood insured properties;
- Detailed Repetitive Loss Investigations;
- Additional training opportunities;
- Development of a V-Zone coastal construction workshop that focuses on Hawaii's unique island environment.

Table 8-5**. Comparison of National Flood Insurance Program and Local Flood Standards**

Issue	NFIP Requirements	Oahu
Applicable Law	NFI Act of 1968 (P.L. 90-418 &91-152), U.S. Disaster Protection Act of 1973 (P.L. 93-234)	Land Use Ordinance – City & County of Honolulu – Art. 9 (see Appendix 10D)
V-Zone Standards	(1) Bottom of lowest structural member of lowest floor above BFE on anchored columns or piles; (2) restrict alteration of dunes; (3) no fill for structural support; (4) space below BFE only for parking access, storage; (5) walls not used for support.	Same as NFIP, and (1) dune alteration cannot increase flooding; (2) height limit of building increased 5 ft. and not more than 25 ft. over BFE.
A-Zone Standards	(1) Elevate lowest floor above BFE; (2) Below lowest floor – (a) for parking, access, storage; (b) 2 wall openings 1 in^2 for ever 1 ft^2 subject to flood; (c) convey entry/exit flood waters.	Same as NFIP with (1) height limit of building increased 5 ft. and not more than 25 over BFE.
V-Zone Applicability	Zones VE, V1-V30, and V	Coastal High Hazard District
A-Zone Applicability	Zones AE, A1-30, AO and A	Flood Fringe District
Erosion zone	The adjustment of flood zones for erosion is not a regulatory requirement of the national or State flood insurance program. It is a proactive measure that the counties, or the proponents of a development consider in order to reduce the risks of flooding to future occupants.	Setback required

8.8.6 Honolulu Electrical Code, ROH Chapter 17

The Honolulu Electrical Code contains the following relevant requirements:

- Special requirements for electrical work in the flood hazard zone, typically the installation of ground fault protectors and ground fault circuit interrupters.
- Elevation of electrical equipment above the base flood elevation or ground fault protection is required.
- Applicability is essentially linked to the BFEs of the flood insurance rate maps.

Gap:
There are no restrictions on locating electrical transformers and switchgear in basements within the flood hazard zone.

Proposed Change for Risk Category III and IV Structures:

- **Require placement of electrical transformers, switchgear, and emergency generators above 500-year flood or dry floodproofing for 500-year flood.**

8.8.7 Flood Hazard Area, ROH Chapter 21A (May 2014)

The Flood Hazard Area contains the following:

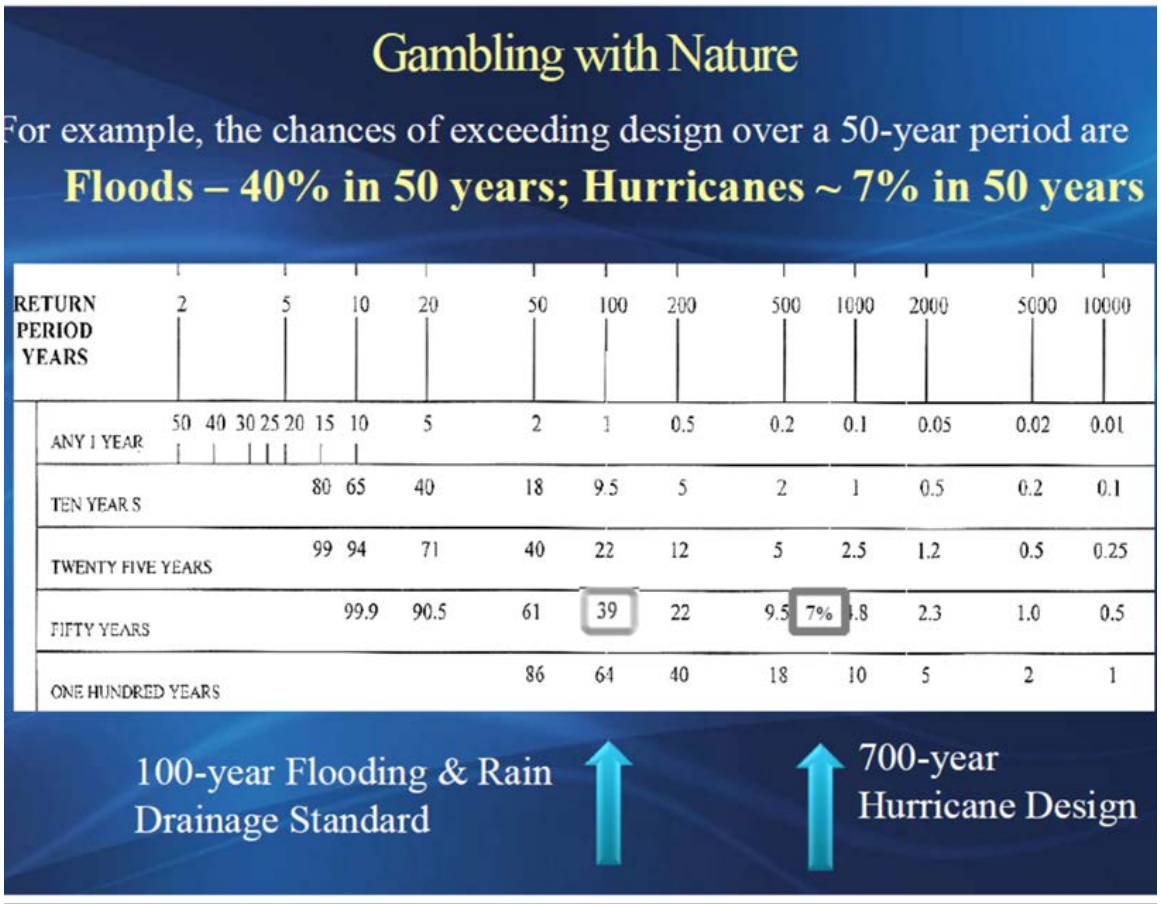
- Enacted to maintain compliance with the National Flood Insurance Program (NFIP). Regulations administered by the Department of Planning and Permitting.
- Stated to be for the purposes of flood and tsunami protection; however, no tsunami provisions exist.
- One of the amended provisions was the use of “market value” instead of “replacement value” for purposes of establishing when proposed renovations, additions or expansions of non-conforming structures in a flood zone should be made compliant with the flood ordinance requirements.
- A project that equals or exceeds 50 percent of the market value of the existing structure within a cumulative period of five years is subject to full compliance with flood ordinance requirements.
- "Substantial improvement" means any reconstruction, rehabilitation, addition, or series of reconstruction, rehabilitation, or additions, or other proposed new development of a structure or repetitive loss structure, in any five-year period, the cumulative cost of which equals or exceeds fifty percent of the market value of the structure (excluding land) before the "start of construction" of the first improvement during that five-year period.
- Functionally dependent use includes only docking facilities, port facilities for cargo and passengers, and ship building and repair facilities.
- Based on FEMA 100-year flood zones in the Flood Insurance Rate Maps (FIRM) that also establish the 1% annual exceedance base flood. Digital Flood Insurance Rate Maps (DFIRM) was effective September 30, 2004; coastal revision to account for hurricane storm surge was effective January 19, 2011.
    - V-zones: Minimum elevation of the lowest structural member above the Based Flood Elevation (BFE); break-away wall construction below the BFE; use of fill for structural support is prohibited in the V-zone.
    - A zones: Minimum elevation of lowest floor or basement above the BFE.
- Areas beneath the BFE has restricted use as parking or storage only and must meet minimum opening requirements.

- Certification standards for the flood boundary, flood elevation, lowest floor elevation certification, and post –construction certification.

Gap:

The FEMA coastal flood zones are typically supposed to take in account the 1% annual chance tropical cyclone inundation. The flood elevations associated with that are not going to produce much risk mitigation because over a normal economic lifetime the cumulative odds of floods exceeding that are very high – 40% in 50 years, when the odds of exccedance are simply computed as an annual Bernoulli series per 1- [(1-1/100)^50]. Over a 100 years, that exccedance probability rises to 64%.; these are reliability targets that are far below any other engineering standard, even before the consideration of climate change effects that may increase inundation in the future.

This is a case of risk transfer for insurance purposes that does not provide high reliability of structures and sufficient protection of lives and property. Exceedance probabilities are illustrated in the graphic below, with a comparison between current design risk for floods and hurricanes indicated as examples.



The ASCE 24-14 Standard , *Flood Resistant Design and Construction* , 2014 version, states the minimum requirements and expected performance for the siting and design and construction of buildings and structures in flood hazard areas that are subject to building code requirements. For Critical and Essential Facilities of a community, this standard would require 500-year flood elevations be used for design. That would produce significantly better performance against

failure for the city's infrastructure and critical services (10% exceedance probability rather than 40% !). However, there are two problems:

1. The City has not adopted the version of the building code that cites ASCE 24-14 as a requirement – so it is not used.
2. FEMA does not have 500-year flood elevations for Hawaii; it only has map layers indicating the partial extent of some 500-year floods. So even if ASCE 24-14 was enabled in the code, its implementation would be vague and ambiguous without the 500-year flood elevations

Proposed Changes for Risk Category III and IV Structures:

- Locally develop and adopt a 500-year flood zone that incorporates sea level rise and RCP 8.5 equivalent storm inundation to enable the design of essential facilities and critical infrastructure to produce greater reliability and resilience. This would not involve housing construction.
- Do not engage FEMA-led mapping procedures; make this a local map process referenced to a local county ordinance and not associated with mandatory NFIP requirements.
- Use the methodology described the journal paper *Probabilistic mapping of storm-induced coastal inundation for climate change adaptation* (Li, N., et al., 2017).

8.9 Proposed Mitigation Activities

The following are recommended projects that would reduce vulnerability to future flood hazard:

- ROH Chapter 16 Building-Code and ROH Chapter 17 Electrical Code – make revisions for Risk Category III and IV structures: revise rainfall intensity design map; develop and require design flood elevations that include the effect of relative sea level change; require consideration of 50-years of shoreline erosion and relative sea level rise on foundation design; require placement of critical equipment above the 500-year flood elevation.
- ROH Chapter 21A – Flood Ordinance: Locally develop and adopt a 500-year flood zone applicable to Risk Category III and IV Structures that incorporates sea level rise. This requires a new coastal inundation design map based on the probabilities of future tropical cyclone activity and intensities.
- Critical inland and stream flooding DFIRMs should be re-evaluated systematically to account for a) the details of the watershed and the floodway, and b) from a policy standpoint whether the frequency of flood overtopping is really acceptable in heavily developed areas. Any re-evaluation of flood frequency would need to emphasize the rainfall intensification, finer spatial resolution in the modeling and better representation of the nature of the developed areas and any degradation of the natural areas, and accounting for the consequences of less than ideal floodway conditions.
- Prepare to participate in the Community Rating System.

Further details of the proposed projects are provided in Chapter 19.



9. Tsunamis

9. TSUNAMIS

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan discussed causes of tsunamis, historic tsunamis, the tsunami hazard, and evacuation maps.	• The Hawaiian Islands have a long history of destruction due to tsunamis and are the most vulnerable place in the world, particularly vulnerable to tsunamis originating in the north and the southeast Pacific Ocean. 28 tsunamis with flood elevations greater than 3.3 ft (1 m) have made landfall in the Hawaiian Islands during recorded history, and 10 of these had significant damaging effects on Oahu. This translates into a recurrence interval of one large tsunami reaching Hawaiian shores every 7 years and one damaging tsunami reaching Oahu every 19 years. • Additional general discussion of tsunamis, a more complete treatment of their various source mechanisms and damaging effects. • Included recent damage from the Samoa and Japan tsunamis. • Further historical data on tsunamis affecting Hawaii during the past 100 years is presented. • Additional information on tsunami detection and warning is provided. • A discussion of a recent community vulnerability study is provided. • New tsunami inundation and evacuation map products are discussed, now including the Extreme Tsunami events. The previous inventory of all maps has been removed and replaced with an example and a link to the maps. • Historical sections have been refined to only include the most relevant information. • An estimate of tsunami average annualized losses is calculated based on these maps and property values in a GIS-geocoded database. Annual tsunami losses are estimated at $81 million. • A recently completed project towards implementation of the new ASCE tsunami design standard in Hawaii is discussed. • A recent study of the effects of tsunamis entering Honolulu Harbor is presented. • An ongoing tsunami hazard mitigation project is discussed, relating to implementation in a future Honolulu Building Code based on the IBC 2018.

Summary of Mitigation Projects for the City and County of Honolulu

Project	Priority
Evaluate fuel storage tank farm walls in Honolulu Harbor for the ability to withstand tsunamis	High
Identify and retrofit critical water pumping stations in the tsunami inundation zone.	High
Conduct preliminary engineering of tsunami and coastal flood mitigation retrofit of critical infrastructure.	Medium
Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects	Medium-High
Adopt tsunami design provisions for major buildings in new design and construction.	Medium
Adopt higher resolution Oahu probabilistic tsunami hazard maps (now being developed) for use with the ASCE 7-2016 and IBC-2018 building code design provisions.	Medium

9.1 Description of Hazard

9.1.1 General

Tsunami is a Japanese word represented by two characters: "tsu" and "nami". The character "tsu" means harbor, while the character "nami" means wave. In the past, tsunamis were often referred to as "tidal waves." Tsunamis are not caused by the tides, nor are they related to the tides (though the tide level influences a tsunami striking a coastal area at the time of impact). A tsunami can be generated by any disturbance that displaces a large water mass from its equilibrium position. Seafloor movement may include faulting, land sliding, or submarine volcanic eruptions. Other geologic disturbances, such as volcanic activity and landslides occurring above or below the sea surface, can also generate tsunamis.

As a tsunami leaves the deep water of the open sea and propagates into the shallower waters near the coast, it undergoes a transformation. Since the speed of the tsunami is related to the water depth, as the depth of the water decreases, the speed of the tsunami diminishes and the height of the wave grows. Because of this "shoaling" effect, a tsunami that was almost imperceptible in deep water may grow to be several feet or more in height. Tsunami induced waves have considerable energy to run up and flood the coastal areas and the ability to inundate much farther inland than ordinary wind-generated waves.

Tsunamis manifest themselves as either large breaking waves, often largest around headlands where they are concentrated by wave refraction, or as rapidly rising sea level like a flooding tide. The geography of the shoreline often plays an important role in the form of the tsunami.

A tsunami's effect at the shoreline is measured in terms of run-up height and inundation limit. Figure 9-1 shows an illustration with the definition of these terms. Run-up and inundation can be considerably different within very short distances. A general rule regarding the devastation distribution of a tsunami is that run-up heights tend to be greatest near areas where the offshore bathymetry (underwater topography) is steeper. Along gentle-sloping coasts, wave energy is dissipated upon shoaling. Even so, inundation can be significant and is usually greatest along low-lying coastal plains.

Surrounded by tsunami-generating tectonic plate boundaries around the Pacific Ocean basin, the State of Hawaii is likely to experience more tsunamis in the future, generated either by near-field sources in the Hawaiian Islands or by far-field sources from around the basin.." (U.S. Geological Survey - Jones, J.L., Jamieson, M.R., and Wood, N.J., (2016))

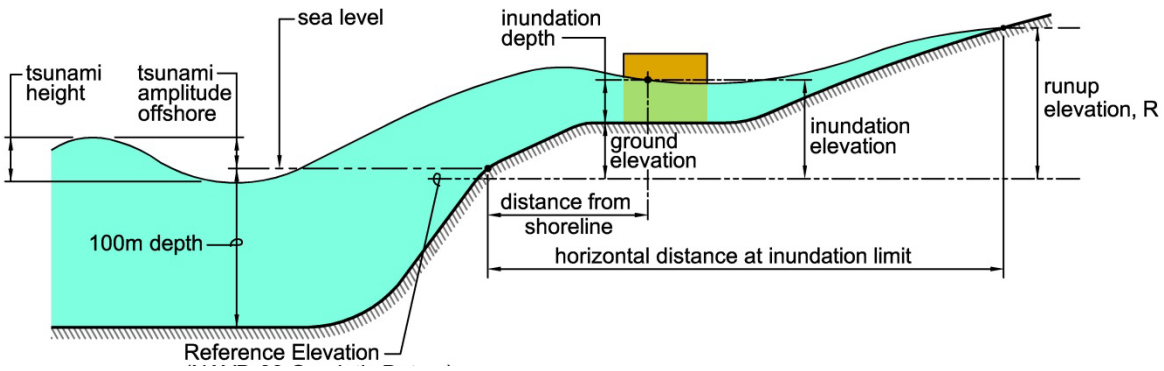


Figure 9-1 **Illustration of Tsunami Terminology (Courtesy of ASCE 7 Tsunami Loads and Effects Subcommittee)**

Besides loss of property such as buildings and transportation vehicles, tsunamis can cause death and major damage to public infrastructure such as port facilities and public utilities. It can damage breakwaters and piers because of the wave impact and scoring action. Ships and smaller craft moored in harbors may be swamped, sunk or left stranded on shore. Oil tank farms near the waterfront are particularly vulnerable to damage, which can result in spreading of hazardous materials or fire. Any resulting oil fire could be spread by the wave. Communities may be disrupted due to tsunami damage until debris can be cleared, wharves and piers rebuilt, and utilities restored.

For illustration purposes, pictures of infrastructure damage in American Samoa caused by the September 29, 2009 tsunami are included in Figure 9-2 through Figure 9-4. Images of damage from the 2011 Tohoku, Japan earthquake and subsequent tsunami are also included in Figure 9-5 through 9-7. After that event, the City and County of Honolulu updated their tsunami maps to include evacuation zones for Extreme Tsunami occurrences to ensure citizen safety in extreme events like in Japan, 2011.



Figure 9-2. Infrastructure Damage in American Samoa after September, 2009 Tsunami (Martin & Chock, Inc, 2009)



Figure 9-3. Infrastructure Damage in American Samoa after September, 2009 Tsunami (Martin & Chock, Inc, 2009)



Figure 9-4. Infrastructure Damage in American Samoa after September, 2009 Tsunami (Martin & Chock, Inc, 2009)



Figure 9-5. Infrastructure Damage in Japan after March, 2011 Tohoku Tsunami (Martin & Chock, Inc, 2011)



Figure 9-6. Engineers Inspecting the Damage in Japan after March, 2011 Tohoku Tsunami (Martin & Chock, Inc, 2011)



Figure 9-7. Infrastructure Damage in Japan after March, 2011 Tohoku Tsunami (Martin & Chock, Inc, 2011)

9.1.2 Tsunami Sources

9.1.2.1 General

Tsunamis can be categorized according to their source into three common types: tsunamis induced by earthquakes, tsunamis induced by landslides, and tsunamis induced by submarine volcanic explosions.

9.1.2.2 Tsunamis Induced by Earthquakes

The earthquakes associated with tsunamis are referred to as tsunamigenic earthquakes. The association between earthquakes and tsunamis results from the fact that both are generated by the tectonic displacement of the earth's crust. Earthquakes generate tsunamis when the sea floor abruptly deforms and displaces the overlying water from its equilibrium position. Waves are formed as the displaced water mass, which acts under the influence of gravity, attempts to regain its equilibrium.

The main factor that determines the initial size of a tsunami is the amount of vertical sea floor deformation. The earthquake's magnitude, depth, fault characteristics, and coincident slumping of sediments or secondary faulting control the size of the tsunami. Other features that influence the size of a tsunami along the coast are the shoreline and bathymetric configuration, the velocity of the sea floor deformation, the water depth near the earthquake source, and the efficiency at which energy is transferred from the earth's crust to the water column.

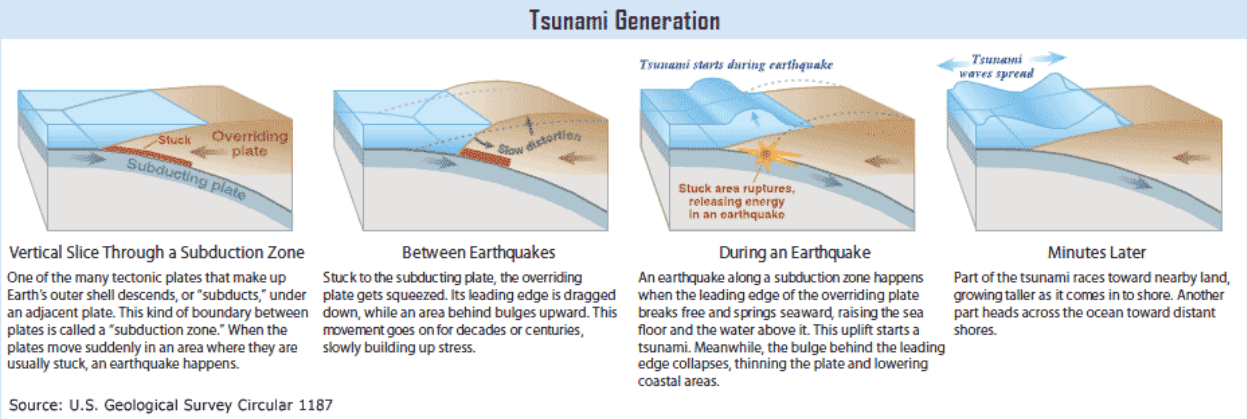


Figure 9-8 Seismic Generation Mechanism for Tsunamis (USGS, 2005)

9.1.2.3 Tsunamis Induced by Landslides

The second most common cause of tsunamis is landslides. A tsunami may be generated by a landslide originating above sea level but plunging into the sea, by a landslide occurring mainly beneath the sea level, or by a landslide occurring entirely beneath sea level.

Submarine landslides often occur during a large earthquake. During a submarine landslide, the equilibrium sea level is altered by sediment moving along the sea floor. Gravitational forces then propagate the tsunami, given the initial perturbation of the sea level. For example, the Hawaiian

island chain is flanked by at least 20 large submarine landslides. Marine deposits found 230 feet above sea level in the island of Molokaʻi must have been deposited by tsunamis caused by one of these landslides (Dawson and Stewart, 2007). Deposition in association with higher sea levels is ruled out since the Hawaiian Islands have probably experienced long-term subsidence instead of uplift.

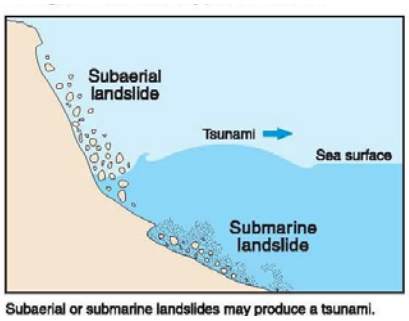


Figure 9-9 Common Sources of Tsunamis
(USGS Website, retrieved October 13, 2009 from http://pubs.usgs.gov/circ/c1187/)

Subaerial (above water) landslides, on the other hand, disturb the water from above the surface. Similar to submarine landslides, subaerial landslides typically occur during large earthquakes. Review of submarine geology around Mauna Loa volcano on the island of Hawaiʻi shows evidence of past landslides along the volcano's southwestern flank. Figure 9-10 shows a map of the island of Hawaiʻi indicating the extent of past landslides of Mauna Loa's southwestern flank. Above the water surface, the slope of Mauna Loa is unusually steep. There are no large escarpments of faults that would indicate gradual slippage in recent times. However, gradual subsidence has occurred in the past along the southern flank. The magnitude 8.0 Kau Earthquake of 1868 resulted in extensive subsidence of the southern flank of Mauna Loa volcano, which also affected the southern flank of Kīlauea volcano (Pararas-Carayannis 2002).

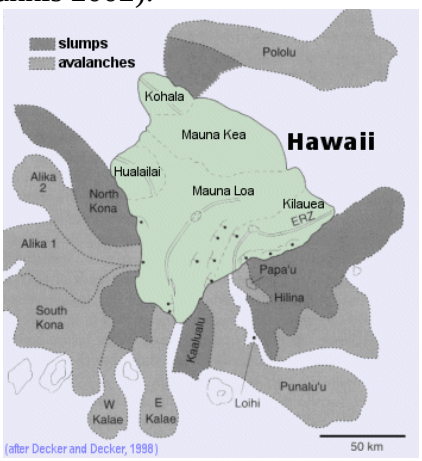


Figure 9-10. Past Landslides of the Volcanoes of the Island of Hawaiʻi (Decker, 1997)

9.1.2.4 Near-Source Tsunamis

Hawaiʻi is also vulnerable to tsunamis that can be induced "locally" by such events as volcanic eruptions, earthquakes, or subaerial and submarine landslides. These local events are most likely to be generated on the island of Hawaiʻi and could reach the coastlines of most major Hawaiian Islands within less than one hour. Recent volcanic activity beginning in 2018 has caused

earthquakes and raised concerns about near-source tsunamis from media sources. The previously mentioned Extreme Tsunami Evacuation Maps are not applicable to near-source tsunamis, and the Hawaii Emergency Management Agency has this note above their maps: *These maps do not consider the destructive effects of a locally generated tsunami. If you feel shaking, move inland immediately, well away from the evacuation zone.*

9.1.2.5 Tsunamis Induced by Submarine Volcanic Explosions

Similarly to submarine landslides, a violent marine volcanic eruption can create an impulsive force that displaces the water column and generates a tsunami. The most known of a submarine volcanic eruption generating a tsunami is the eruption of the Santorini Volcano in the island of the same name (Eastern Mediterranean Sea) approximately 3500 years before present time (Pararas-Carayannis, 2002). That mechanism is not a consideration that is likely in Hawaiian volcanology.

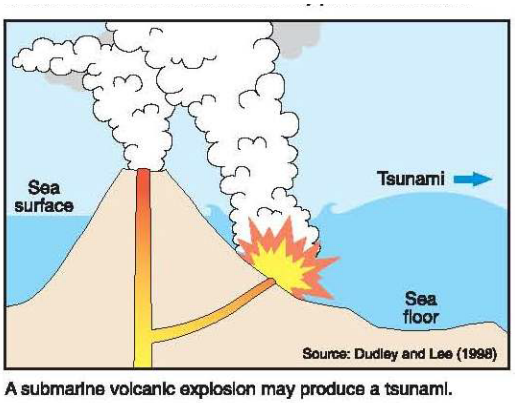


Figure 9-11. Common Sources of Tsunamis
(USGS Website, retrieved October 13, 2009 from http://pubs.usgs.gov/circ/c1187/)

9.1.3 Tsunamis in Hawai‘i and Travel Time

9.1.3.1 Distant-Source Tsunamis (Teletsunamis)

The Hawaiian Islands are exposed to tsunamis generated by seismic events at the boundaries of the tectonic plates bordering the Pacific Ocean. In particular, areas with subduction fault lines such as the coasts of the State of Alaska’s mainland and Aleutian Islands, the countries of Chile and Japan, and Russia’s Kamchatka Peninsula, are common places of earthquakes that generate tsunamis that have affected Hawai‘i in the past.

Radiation of a remote-source tsunami from the focus of an earthquake is directional, depending on the geometry of the seafloor in the source region. The source region for major tectonic earthquakes is usually elliptical, and the major axis is as much as 600 km long and corresponds to the activated part of the fault. The major part of the tsunami energy is transmitted at right angles to the direction of the major axis, both toward the near shore and along a great circle path toward the shore on the opposite side of the ocean. Thus, Hawaii, which lies in the central Pacific Basin, is vulnerable to remote-source tsunamis generated both in the North Pacific and along the coast of South America.

Although these tsunamis originate in earthquakes with epicenters far away from Hawai‘i, they are only moderately weakened in the open ocean and can, consequently, cause large devastation when they reach the islands’ coasts. In the case of tsunamis that originate in locations distant from Hawai‘i is, the time for the waves to reach the islands is measured in hours. Figure 9-12 shows the travel times of tsunamis originated from earthquakes in the Pacific Rim.

The earthquake and subsequent tsunami centered around Tohoku, Japan on March 11, 2011 caused damage in the State of Hawaii and raised concerns about the possibility of similarly extreme events potentially harming the state to a larger degree. As mentioned in the 2016 USGS report titled Hawaii Community Exposure, the tsunami events that cause the most potential harm to Hawaii are earthquakes centered in the Aleutian chain with moment magnitudes of 9.3 and 9.6. Models based on these scenarios are how the Oahu Extreme Tsunami Evacuation Maps were created.

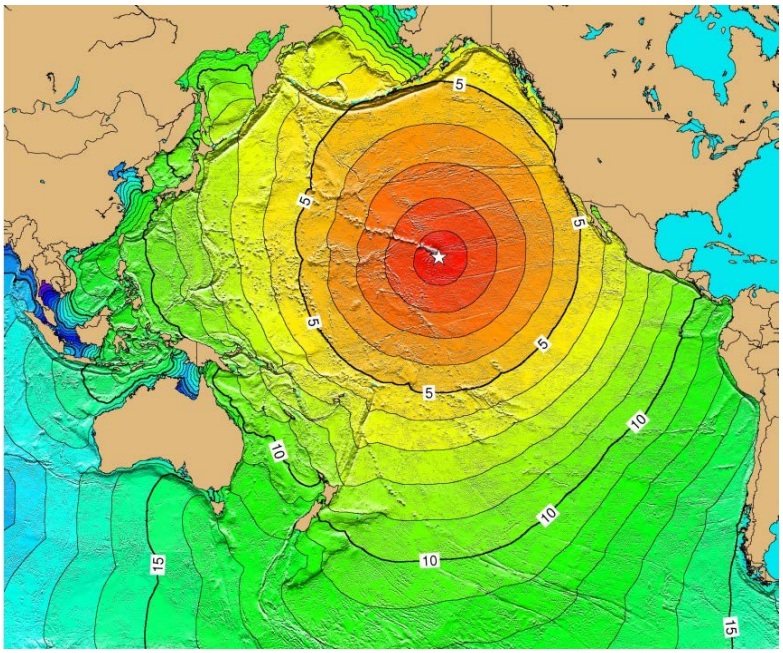


Figure 9-12. Approximate Travel Time in Hours of Tsunamis Generated by Earthquakes in the Pacific Rim
(NOAA Website, retrieved October 14, 2009 from http://www.ngdc.noaa.gov/hazard/icons/1975_1129.jpg)

9.2 Historic Oahu Tsunamis

The Hawaiian Islands have a long history of destruction due to tsunamis. Hawaii, the highest risk area in the world, averages one tsunami every year with a damaging occurrence every seven years. The earliest well-documented recording of a tsunami goes back to April 11, 1819 when a wave from Chile reached a height of 2 m somewhere along the west coast of the Island of Hawaii. The same wave was also observed in Honolulu but it was of small magnitude. Tsunamis pose a significant hazard in the Hawaiian coastal zone. Historically significant run-up data has been compiled and visualized by NOAA and the International Tsunami Information Center in Figure 9-13.

Large run-ups were reported on Oahu for the 1946 tsunami; six persons were killed and many homes were destroyed or damaged (including Sandy Beach, Kahana Bay, and Kahuku). This was one of the most damaging Tsunami to hit the Hawaii Islands, resulting in 61 deaths and causing $23 million in damage.

The most damaging waves on Oahu are listed in Table 9-1. If wave run-ups like those of the 1957, 1960, or 2011 tsunamis occurred again today in low-lying coastal areas such as Waikiki, Waimanalo, Kaaawa, Punaluu, and Nanakuli, there exists a high probability that they would suffer significant damage, primarily because of the risk that has been taken by developing within these inundation zones.

Table 9-1. Tsunamis Damaging to Oahu, 1812-2016 (> 1 M Run-up)

Yr		Mo	Day	Ms	MM	Run-up (m)	Run-up (ft)	Run-up Station Location	Source	Notes (Oahu only)
1878	1/20/1878	1	20			3	10	Oahu		
1926	3/20/1926	3	20			1.5	5	Wailupe, Oahu		
1952	11/4/1952	11	4	8.2		9.1	30	Kaena Point, Oahu	Kamchatka	$0.8-1.0 million
1957	3/9/1957	3	9			5.2	17	Haleiwa, Oahu	Aleutian Isl.	
1964	3/28/1964	3	28	8.4		4.9	16	Waimea Bay, Oahu	Alaska	
1975	11/29/1975	11	29			6.6	22	Honuapo, Oahu	Hawaii Isl.	
2011	3/11/2011	3	11	8.3		5.2	17	Kaena Point, Oahu	Japan	$3.4 million

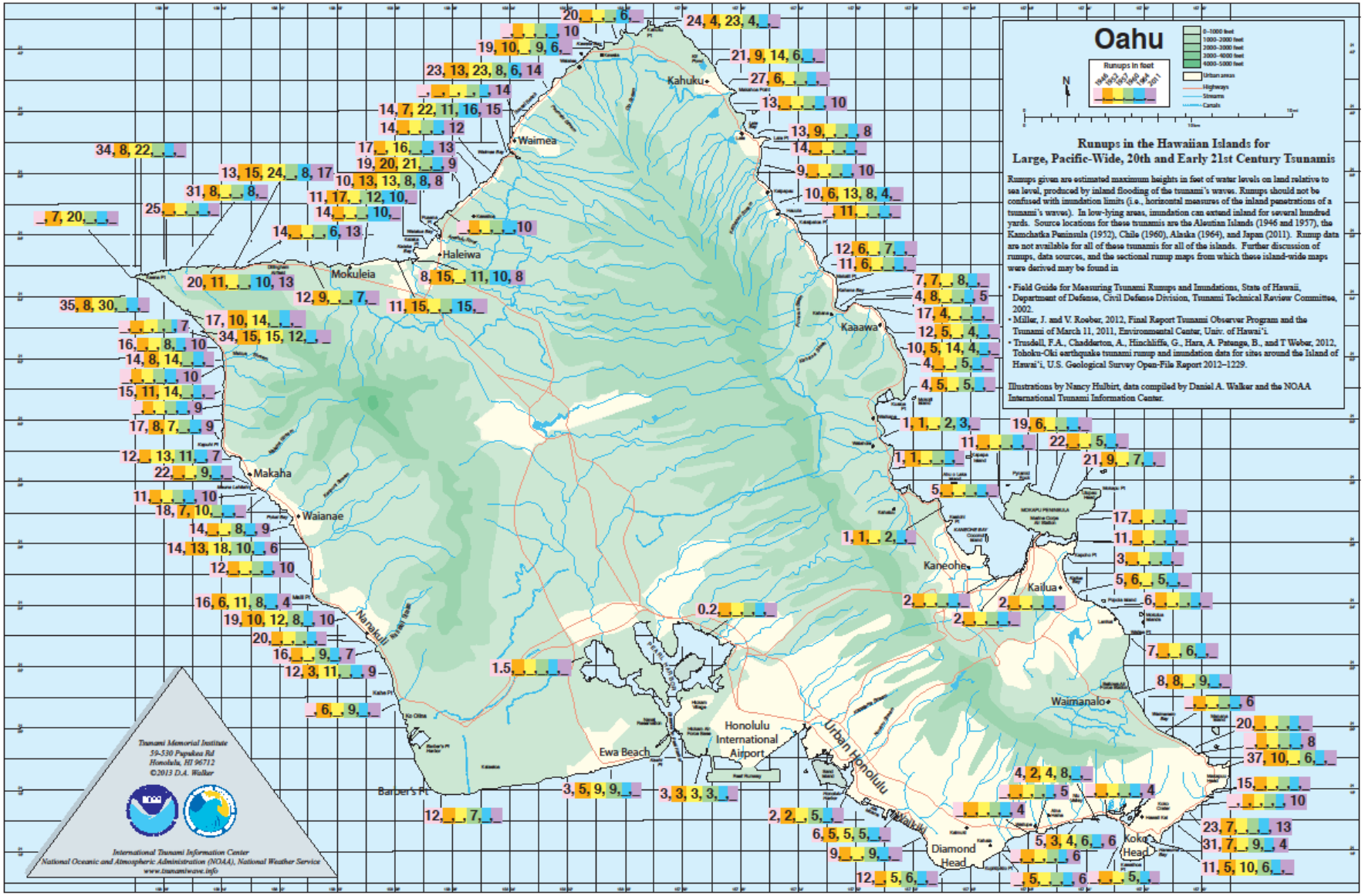


Figure 9-13. **Oahu Tsunami Run-up Data**
(For a higher resolution, more detailed version, visit http://tsunami.org/7science/pdfs/Oahu_2012_11x17_small.pdf)

History has shown that damaging tsunamis in Hawaii are generated from distant locations around the Pacific Ocean margins, as well as locally in Hawaiian waters. Most of the destructive tsunamis in the Hawaiian Islands have been generated along the coast of South America, the Aleutian Islands, the Kamchatka Peninsula, and Japan. More than one-half of all the tsunamis recorded in Hawaii have originated in the Kuril-Kamchatka-Aleutian regions of the north and northwestern Pacific, and approximately one-fourth along the coast of South America. The locations of the earthquake sources for the tsunamis most significant to Hawaii are shown in Figure 9-14, not including recent events like the 2011 Tohoku tsunami. The source region of tsunami genesis has important implications for the amount of damage caused by a tsunami and for the ability to respond to their impact. Models show that a tsunami generated in Alaska can travel to Oahu in 5 hr.

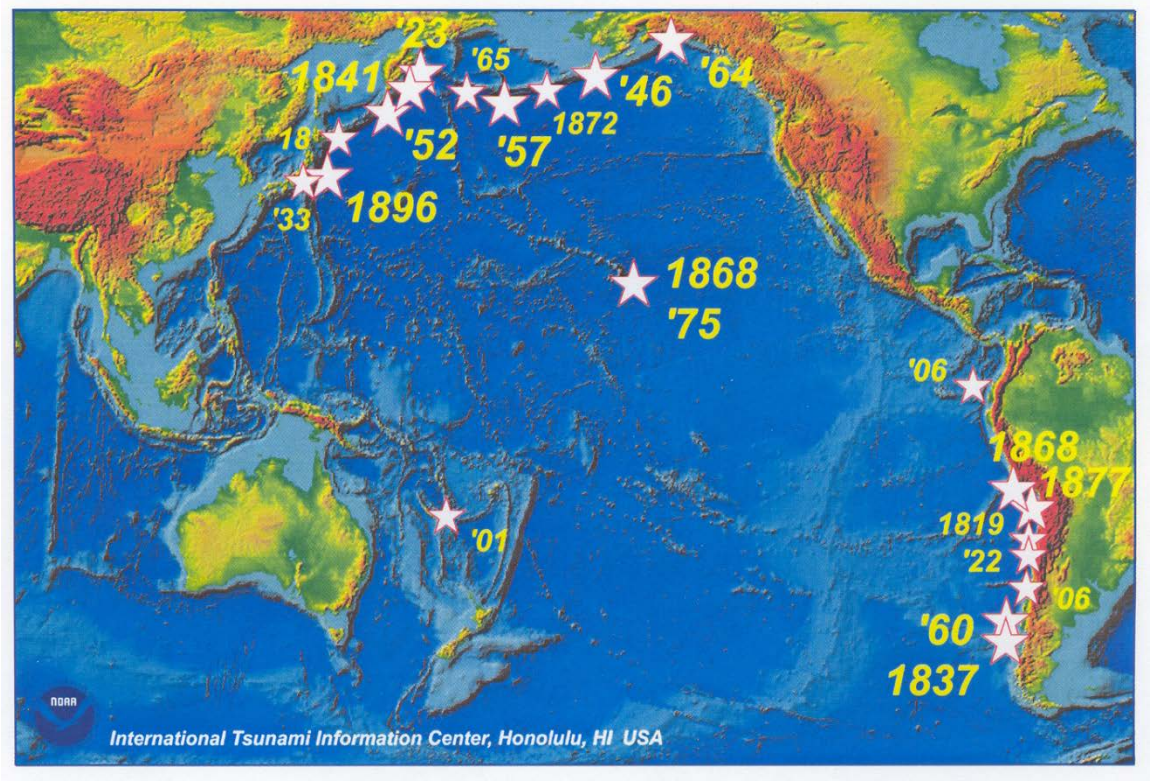


Figure 9-14. Locations of the Pacific Rim earthquakes that have generated tsunamis that caused more than 1m (3 ft) of wave height run-up in Hawaii between 1819-2002

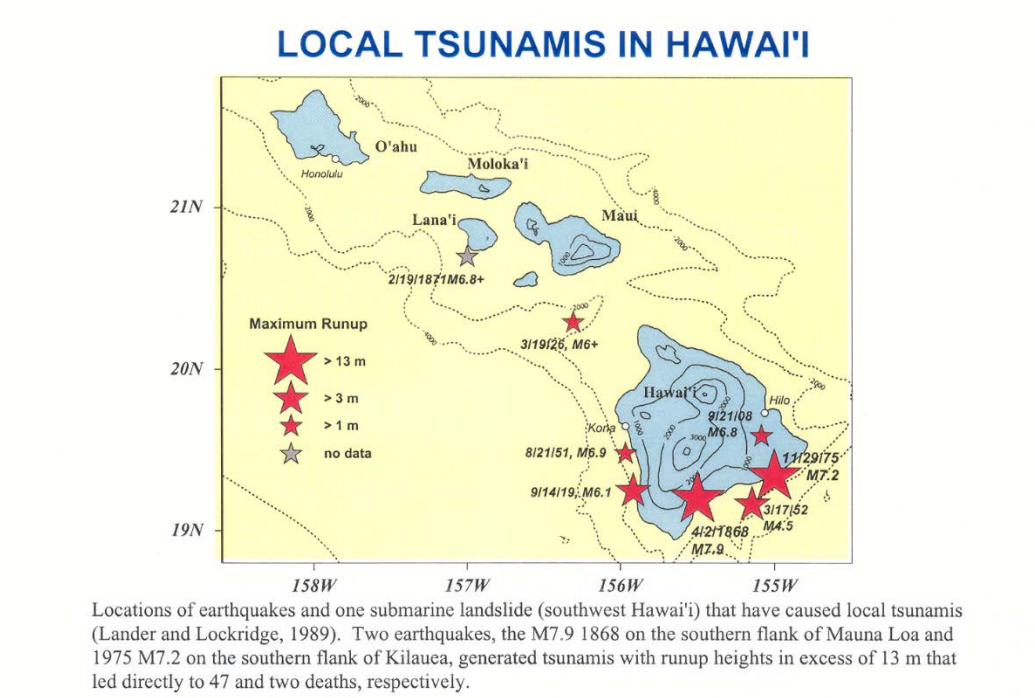
9.2.1 Local Tsunamis

The number of locally generated tsunamis is very small, and none of these events have had any significant effect on Oahu. The seismic events that have generated local tsunamis since 1868 are illustrated in Figure 9-15. Over the last one hundred and fifty years there have been only four significant tsunamis generated near the Hawaiian chain and of those only one was extremely destructive to property and human life. Some dramatic examples of such local tsunamis include those generated by tectonic landslides occurring during large earthquakes. Of the locally generated events the tsunami of April 2, 1868 was reported to have a run up of about 20 m along the South Puna coast of the Island of Hawaii. The effects of this tsunami to the other Hawaiian Islands were insignificant as well.

The 1975 Kalapana earthquake was the largest earthquake to strike Hawaii since 1868. Residents were awakened at 3:35 a.m. by a magnitude-5.7 earthquake located a few miles inland of Laeapuki on Kilauea's south coast. A little more than one hour later, at 4:47 a.m., the main shock struck with a magnitude of 7.2. The epicenter was located at Kamoamoa, just a few miles east, and closer to the shoreline, from the foreshock. Much of the south coast of Hawaii Island slid horizontally towards the ocean and subsided.

The maximum horizontal displacement, near Keauhou Landing several kilometers east of Halape, was about 26 feet. The displacements decreased to the east and west from this area. Similarly, subsidence of the coast was greatest in this same area and amounted to about 11.5 feet.

The earthquake also caused a moderate-sized tsunami. Tide gauge records indicate that the initial motion was upwards at all stations. This observation suggests that the sea floor offshore uplifted as the onshore section of the volcano down-dropped and moved outward. The area of sea floor inferred to have uplifted is about 70 kilometers along the coast and 30 kilometers perpendicular to the coast. This entire offshore region rose about 3.9 feet. The tsunami, with a maximum height of 20 feet at Halape, arrived at Punaluu a mere 84 seconds after a seismic sensor located there recorded the strong ground motion of the earthquake.



Locations of earthquakes and one submarine landslide (southwest Hawai'i) that have caused local tsunamis (Lander and Lockridge, 1989). Two earthquakes, the M7.9 1868 on the southern flank of Mauna Loa and 1975 M7.2 on the southern flank of Kilauea, generated tsunamis with runup heights in excess of 13 m that led directly to 47 and two deaths, respectively.

Figure 9-15. Locally generated tsunamis, earthquake source and travel times

9.3 Tsunami Forecasting

Operational forecast responsibilities for tsunamis are divided among two warning centers: the Pacific Tsunami Warning Center (PTWC) with headquarters Ford Island, island of O‘ahu, Hawai‘i and the West Coast and Atlantic Tsunami Warning Center (WC/ATWC) with headquarters in Palmer, Alaska. The two centers are operated by the National Oceanic and Atmospheric Administration’s (NOAA) National Weather Service and have the responsibility for the dissemination of messages and the provision of interpretive information to emergency managers and other officials, news media, and the public.

9.3.1 Pacific Tsunami Warning Center (PTWC)

This center provides warnings for Pacific basin tele-tsunamis to the State of Hawai‘i and United Sates Territories and interests in the Pacific (Guam, American Samoa, Wake Island, Johnston Island, the Commonwealth of the Marianas, The Federated States of Micronesia, The Republic of the Marshal Islands). PTWC is also responsible for warnings to almost every country around the Pacific Rim and most of the Pacific island states. This last function is carried out under the auspices of the United Nations

Educational, Scientific, and Cultural Organization Intergovernmental Oceanographic Commission (UNESCO/IOC) International Coordination Group for the Pacific Tsunami Warning System.

The PTWC will issue a Tsunami Warning, Watch, Advisory or Information Bulletin/Statement, in decreasing order of risk, depending on the level of seismic activity recorded and potential for a tsunami. Warnings indicate and imminent threat of a tsunami and will advise appropriate actions such as evacuation of low lying areas and movement of ships into deep water. A watch will indicate the potential for a tsunami and will be upgraded to a tsunami warning or downgraded to an advisory as the tsunami threat is better understood. An advisory is issued to coastal areas not in immediate danger but when a warning or watch has been issued to other coastal areas within the same ocean. An information bulletin or statement is generally issued to announce that an earthquake has occurred but that there is no threat of a tsunami.

For local tsunamis there may be insufficient time to evacuate all low lying areas within the Tsunami inundation zone, therefore mid to high rise structures that are structurally sufficient to withstand the impact and drag forces of a tsunami bore may need to be used as shelters. An Oahu behavioral analyses (SMS 2009) found that for tsunami evacuations, 49% of people would evacuate and 17% of people indicated that they would go to a public shelter if a general announcement was made by civil defense administrators. There was a high rate of people who would evacuate even in inland areas outside the tsunami inundation zones if a general evacuation announcement was made. The evacuation needs could be reduced with a more descriptive message targeting only those people within one of the published tsunami evacuation zones.

9.3.2 Tsunami Evacuation Mapping

2010-vintage tsunami evacuation maps, which were developed for the State of Hawai‘i Emergency Management Agency, were based on just the historical events within the last 100 years. That is, the modeling approach was intended to numerically reconstruct the inundations from the five major Trans-Pacific tsunamis that have affected Hawai‘i within the last 100 years. The 2010 evacuation zones were then developed by taking tsunami inundation data created by the Tsunami Inundation Mapping Project in 2007-2011 and applying a safety buffer utilizing existing streets, roads, highways and other features as landmarks. Populated areas within the tsunami evacuation zones have been designated as such throughout the islands of Hawai‘i, Maui, and Moloka‘i, and Oahu.

The City and County of Honolulu undertook a reassessment of tsunami evacuation zones in the island of Oahu. A second set of inundation modeling was considered a priority of the state mitigation plan to establish another level of evacuation zones for the worst-case Aleutian earthquakes, referred to as Extreme Tsunamis, which have been completed. A tsunami inundation and runup analysis of the island of Oahu was performed though the University of Hawaii, School of Ocean and Earth Science and Technology using 2-dimensional modeling with updated topographical data utilizing recent LIDAR topographical surveys that provide a higher resolution of the shallow reef forms below sea level and shoreline above sea-level than previously available. Evacuation maps have recently been updated with an additional Extreme Tsunami Evacuation Zone based on the results of this analysis. The tsunami evacuation map index is shown in Figure 9-17a. Figure 9-17b is the tsunami evacuation map for Waikiki. Refer to the description of the figures for higher resolution images, or the official website:
(http://www.honolulu.gov/demhazards/tsunamimaps.html).

9.3.3 Signage

Populated areas within the tsunami evacuation zones should have signage as such throughout the islands of all counties. Figure 9-16 shows the standard signs used to define tsunami evacuation areas for use in the State of Hawai‘i. Oahu does not presently have any tsunami zone signage in place.



Figure 9-16. Tsunami Evacuation Area Signage in the State of Hawai‘i

The City conducted a project to study tsunami inundation zones and determine where improved escape routes or clear signs are needed to better inform the public of where to go during a tsunami warning and evacuation. The analyses determined where to place signs for tsunami evacuation areas and developed strategies to minimize traffic congestion. It developed specific emergency evacuation route plans and identified and updated refuge areas as appropriate, that will integrate and align with actions to be implemented by the City and County of Honolulu in the event of a Tsunami Warning notification.

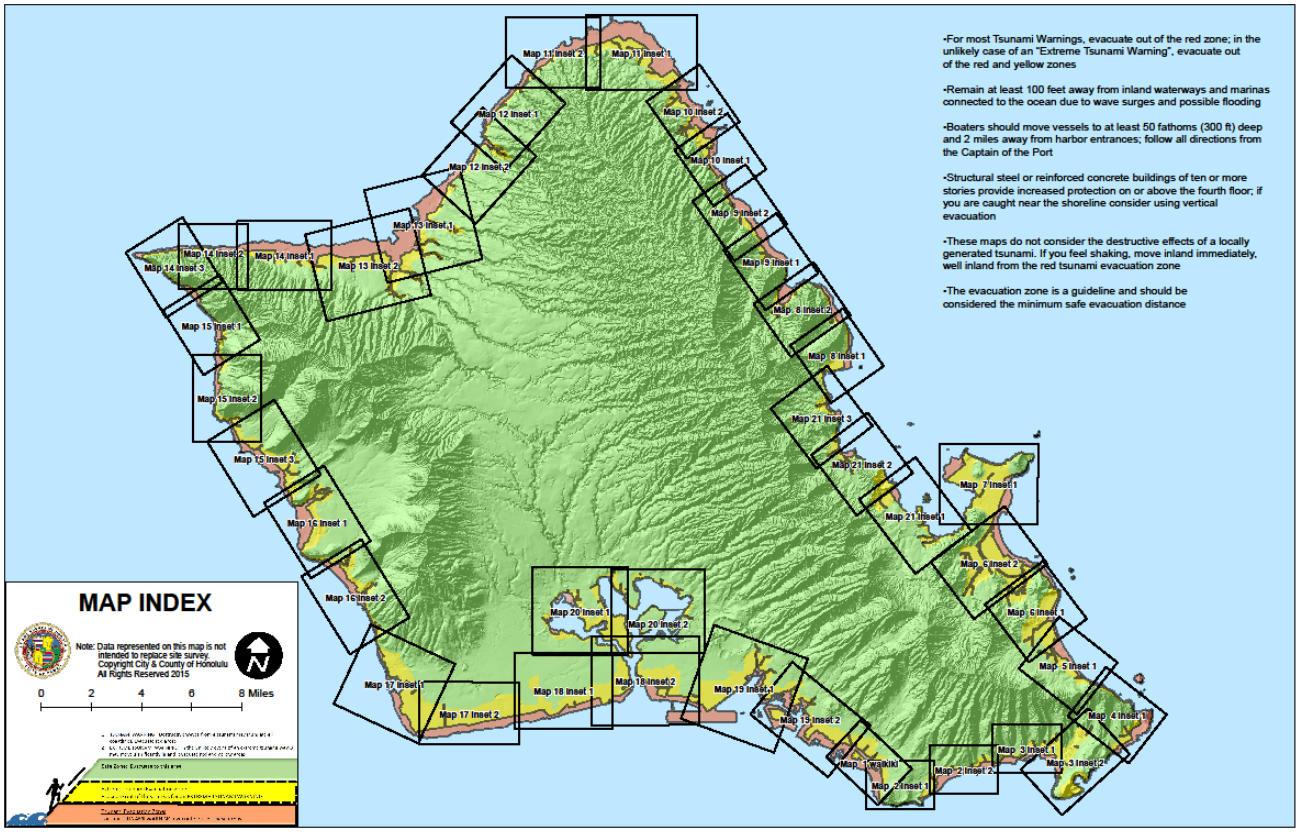


Figure 9-17a & 9-17b. Oahu Evacuation Map Index (visit City and County's Website for interactive map with full series of detailed area maps http://cchnl.maps.arcgis.com/apps/webappviewer/index.html?id=39a9e07068a14d01a85b437adcf50beb)

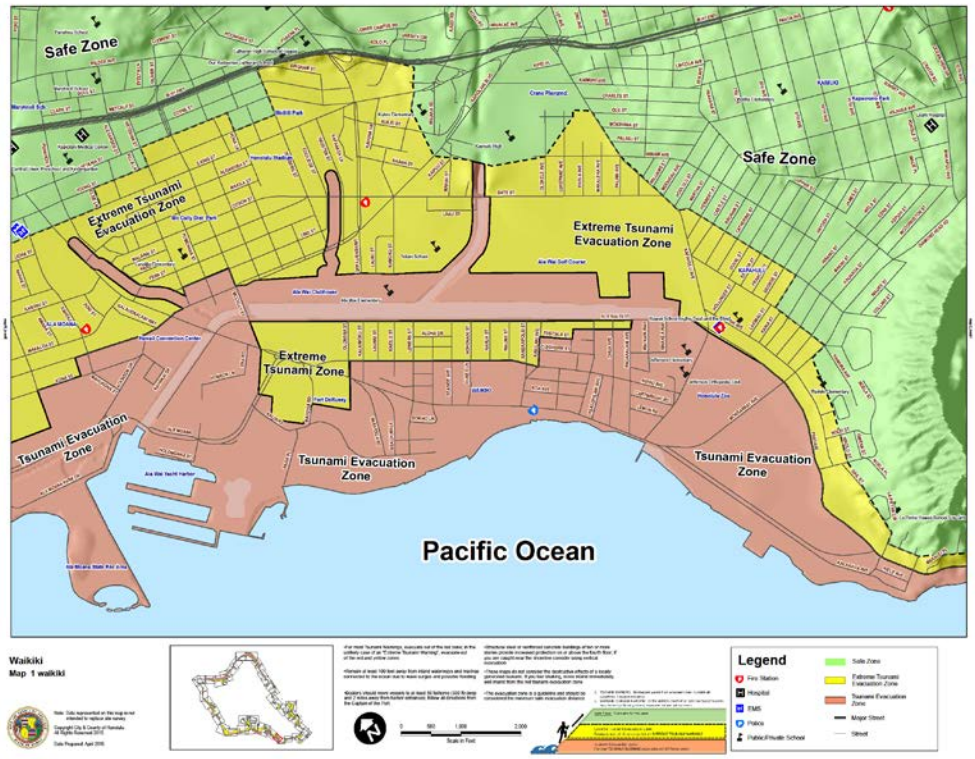


Figure 9-17b. Waikiki Evacuation Map Index (visit City and County's Website for interactive map with full series of detailed area maps http://cchnl.maps.arcgis.com/apps/webappviewer/index.html?id=39a9e07068a14d01a85b437adcf50beb)

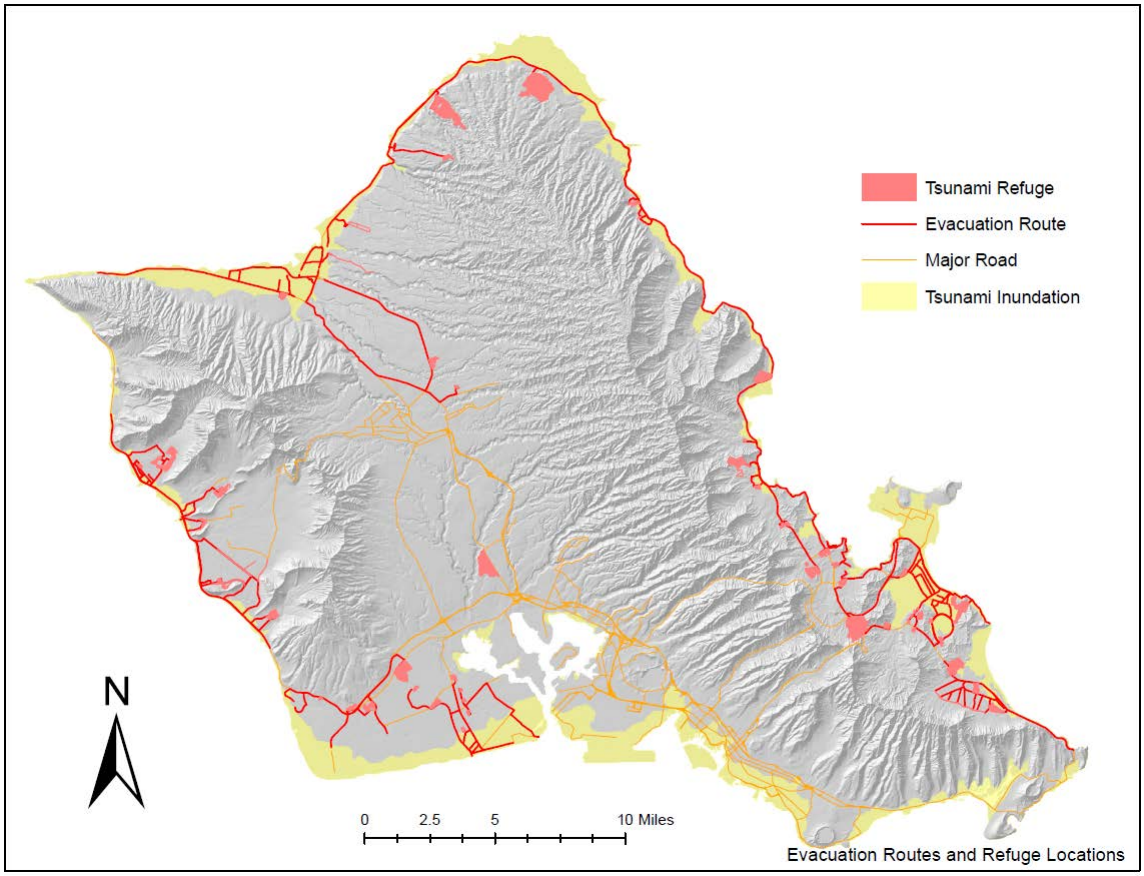


Figure 9-18 Oahu's Evacuation Routes Leading to Refuge Areas

9.3.4 Sirens

Operational warning sirens exist on most densely populated coastal areas of all islands. Warning sirens are tested monthly on the first State work day of every month at 11:45 in the morning. The test consists of a 45-second solid tone. When the PTWC issues an urgent tsunami warning, a tsunami warning, or a tsunami evacuation, a steady three-minute siren tone is the attention alert signal. An interactive map with locations and information on each siren is available on the State's website at: (https://data.hawaii.gov/Public-Safety/Map-of-Civil-Defense-Sirens/rr54-pkun/data).

Table 9-2. Statewide Tsunami Siren Data from State Website

Total number of sirens statewide	340
Number of outdated and malfunctioning sirens to be replaced	125
New sirens to be installed	146
Total number of sirens after overhaul	517

9.4 Variations in Community Vulnerability

Although tsunami-evacuation zones have been delineated and much has be done to understand the tsunami hazard, the vulnerability of the population and infrastructure to tsunamis is less understood. Wood et al. (2007) investigated Hawaii community vulnerability to tsunamis in terms of: exposure, the amount of assets in tsunami-prone areas; sensitivity, the relative percentage of assets in tsunami- prone areas, and; resilience, the ability of a community to withstand, absorb, adapt to, and recover from losses. It was found that the city of Honolulu has the highest exposure of anywhere in Hawaii, although not the highest sensitivity (Punaluu, Hawaii) or overall vulnerability (Kaanapali, Maui). Statewide, the communities with the highest exposure and sensitivity, considering quantities and percentages respectively of developed land, residents, employees, average daily visitors and parcel value are shown in Figure 9-18. Results indicate that the Hawaii tsunami- evacuation zones contain approximately 56,678 residents (5% of the total population), 67,113 employees (11% of the State labor force), and 50,174 average daily visitors to hotels (44% of the State total). With regards to economic conditions, the tsunami-evacuation zone contains 5,779 businesses that generate $10.1 billion in annual sales volume (both 11% of State totals), and tax parcels with a combined total value of $36.1 billion (18% of the State total).

With the addition of the Extreme Tsunami Evacuation Zone, the USGS reexamined their findings from the 2007 report and created a new report in 2016, titled Community Exposure to Tsunami Hazards in Hawaii (Jones, et al. 2016). The findings were largely extensions of the dramatic results mentioned in the previous report, for example it was found that Urban Honolulu has the largest number of residents in the Extreme Tsunami Zone (74,855). Figures 9-19 through 9-21 summarize the new findings for community vulnerability within the Extreme Tsunami Evacuation Zone.

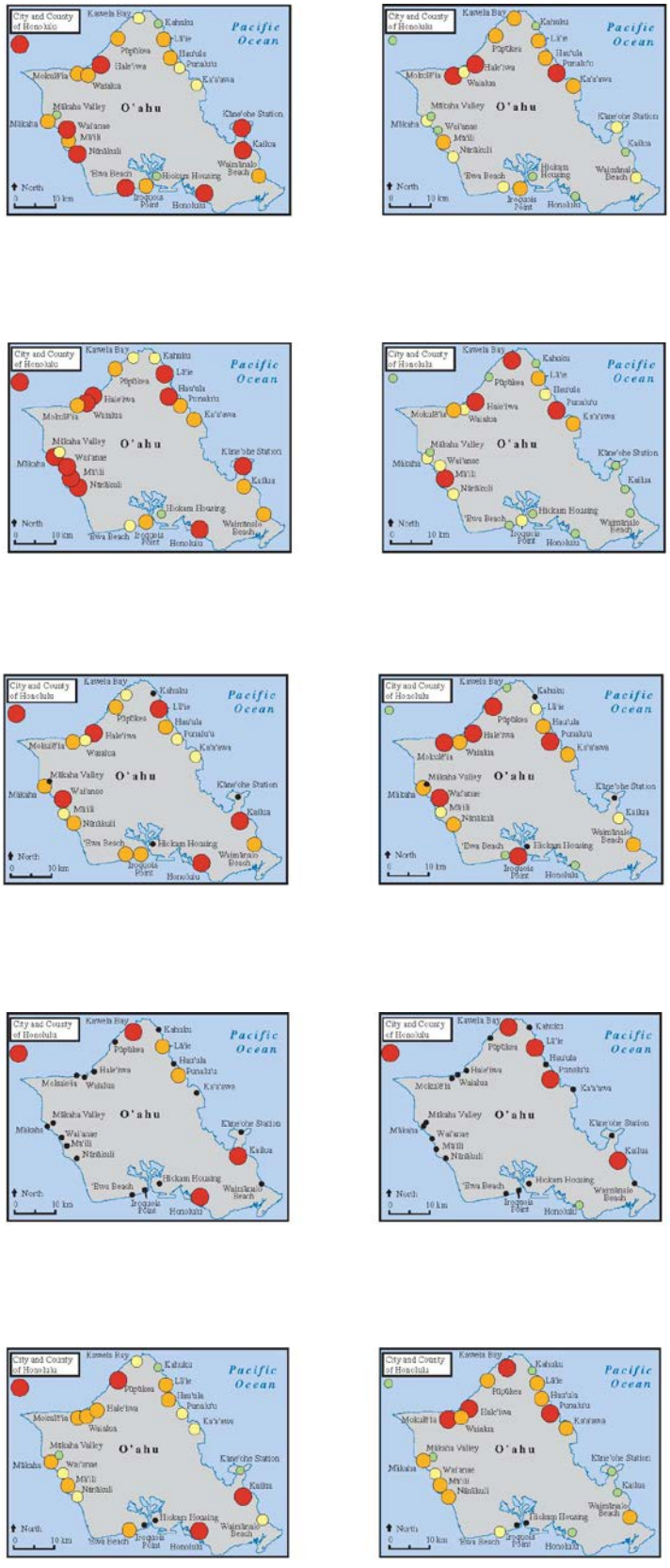


Figure 9-19. Quantities and percentages of different factors that describe tsunami vulnerability for different communities (Wood et al. 2007)

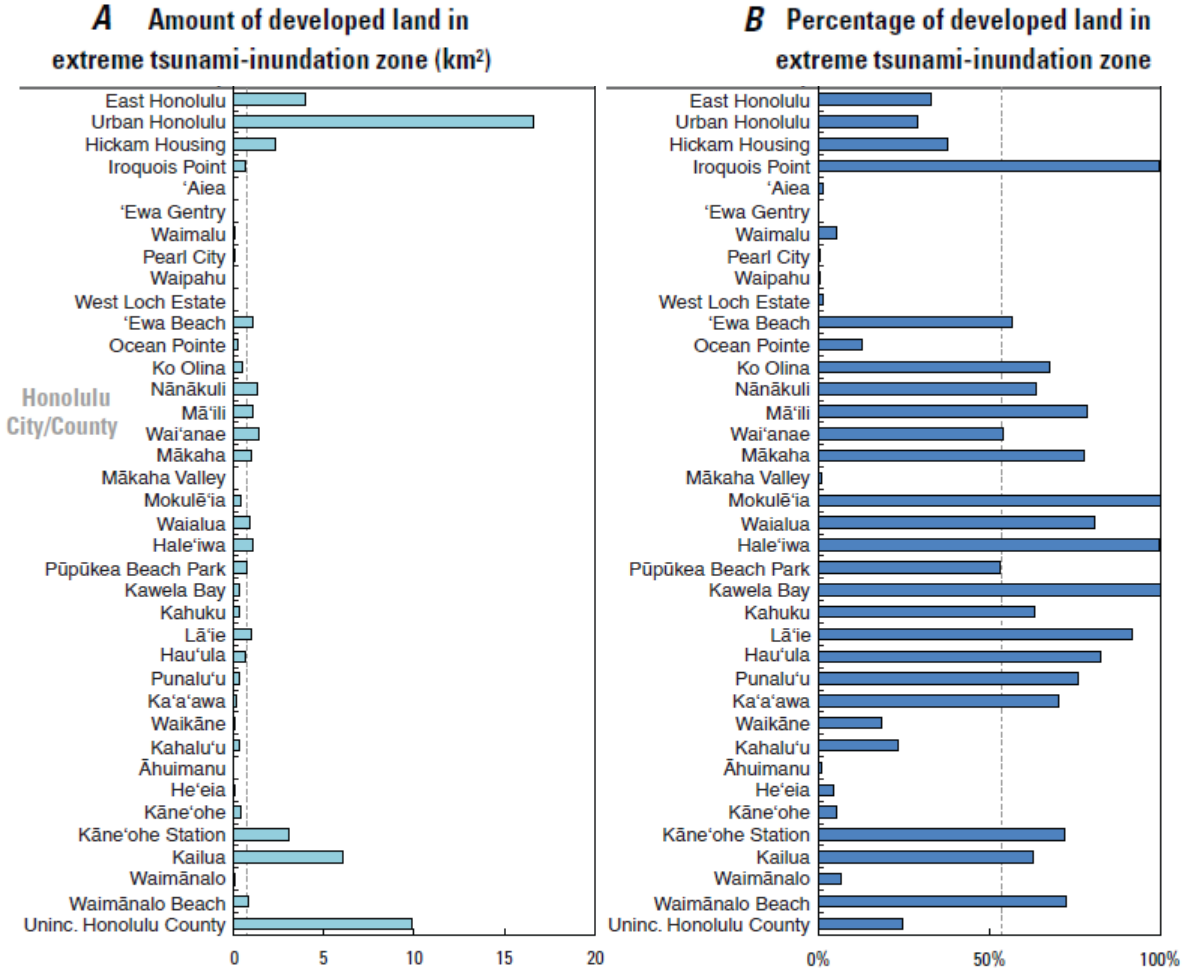


Figure 5. Bar graphs showing (*A*) amount and (*B*) percentage of National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP) land-cover area (in square kilometers, km²) classified as developed in the extreme tsunami-inundation zone, organized by census-designated place for the State of Hawaii. Dashed lines indicate 3rd quartile. Uninc., unincorporated; km², square kilometer; %, percent.

Figure 9-20. Bar graphs show updated information from the 2007 report to now include the extreme tsunami-inundation zone (USGS 2016)

Table 9-3. **Direct Exposure of the State of Hawai‘i to Tsunami Hazard**

State	Population at Direct Risk (Lower-bound estimates based on present evacuation zones[1])	Profile of Economic Assets and Critical Infrastructure
Hawai‘i	>200,000 residents plus another 175,000 or more tourists and approximately 1,000 buildings directly relating to the tourism industry; 750 miles of coastline	$40 Billion, plus 3 international airports, and 1 military port, 1 medium port, 4 other container ports, and 1 fuel refinery intake port, 3 regional power plants; 100 government buildings
	Total resident population of area at immediate risk to post-tsunami impacts: 400,000	

[1] United States Geological Survey (USGS) Scientific Investigations Reports 2007-5208 (HI) updated, 2007-5283 (OR), 2008-5004 (WA), 2012-5222 (CA)

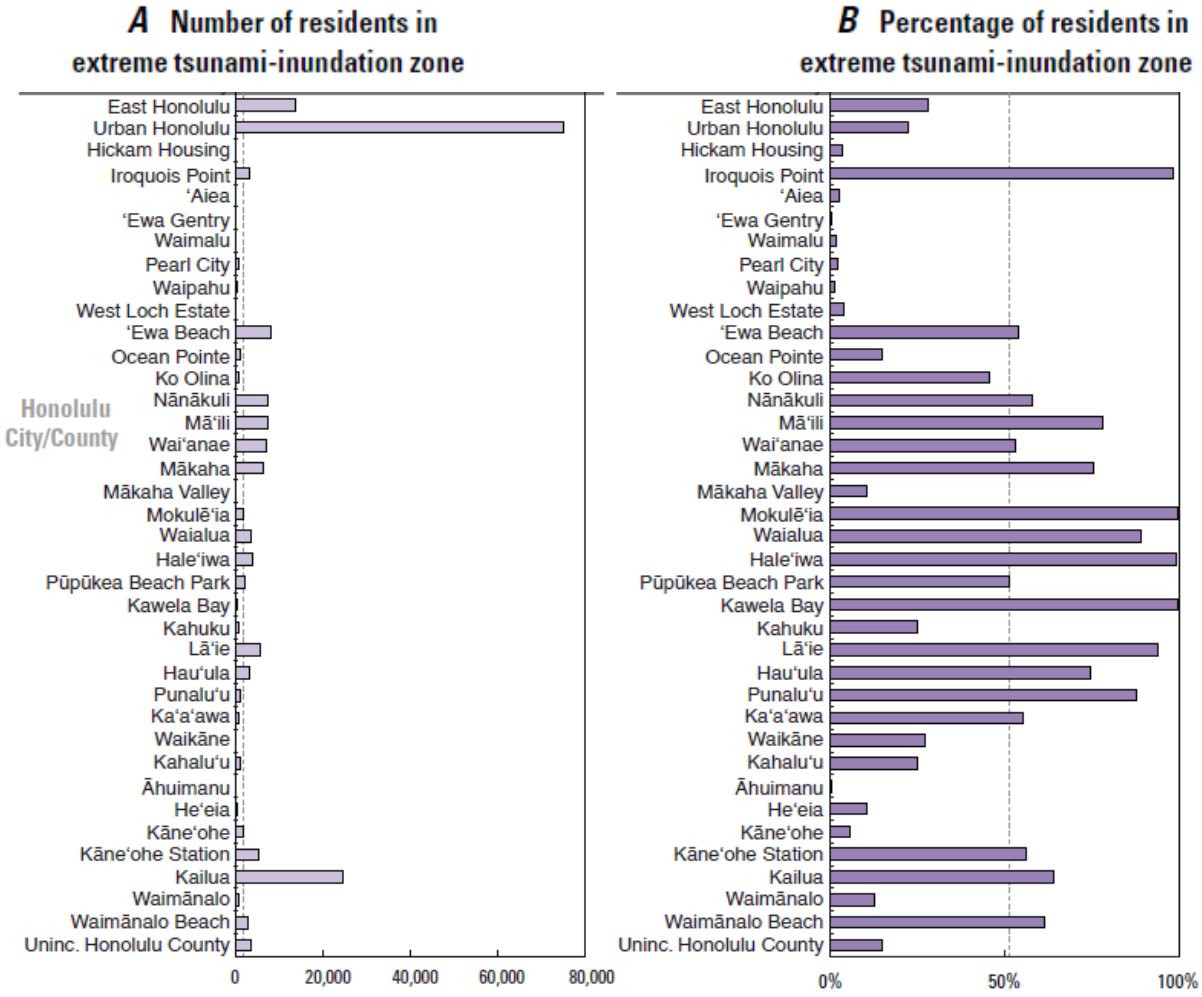


Figure 6. Bar graphs showing (*A*) number and (*B*) percentage of residents in the extreme tsunami-inundation zone in the State of Hawaii, organized by census-designated place. Dashed lines indicate 3rd quartile. Uninc., unincorporated; %, percent.

Figure 9-21. Bar graphs show updated information from the 2007 report to now include the extreme tsunami-inundation zone (USGS 2016)

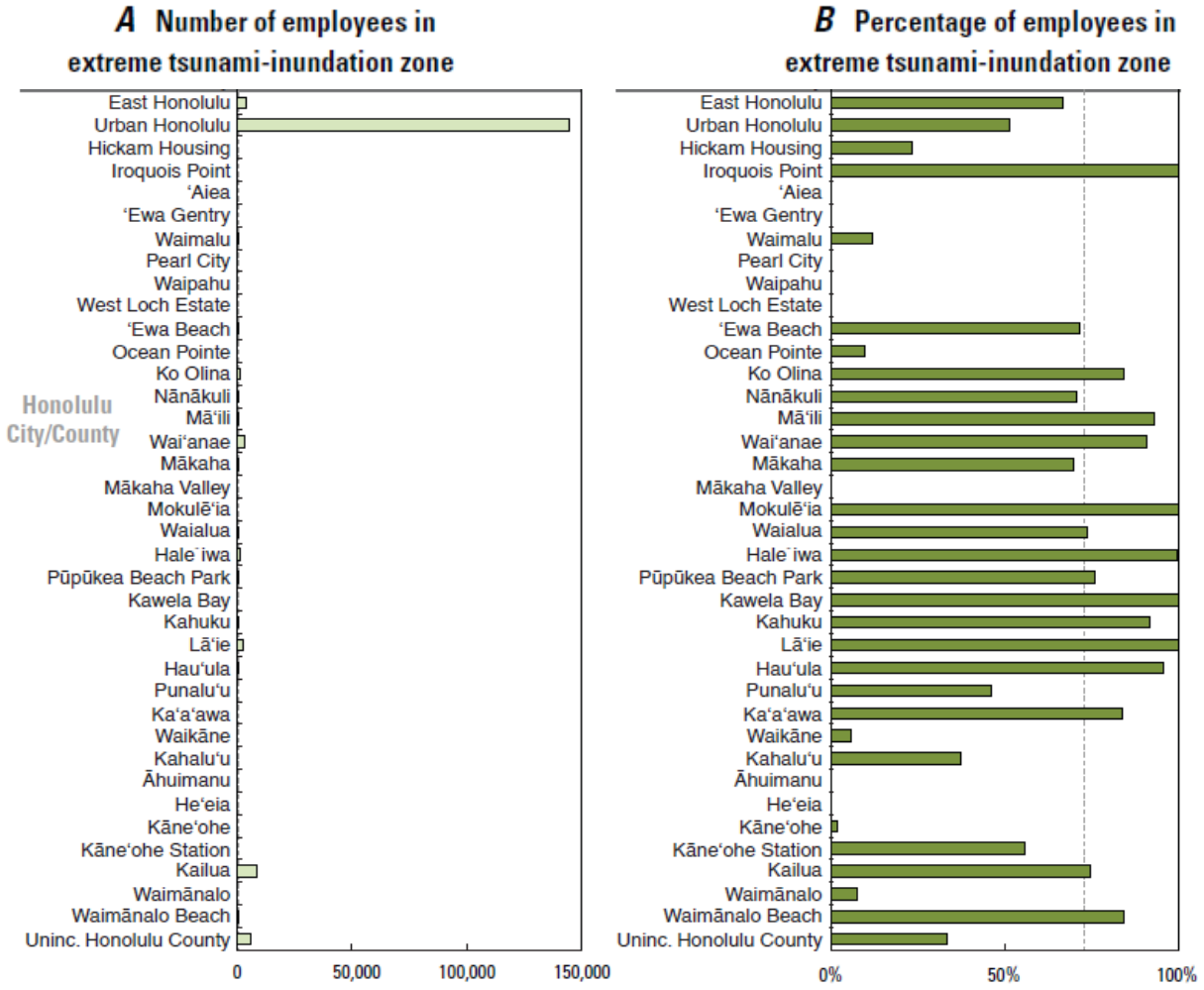


Figure 7. Bar graphs showing (*A*) number and (*B*) percentage of employees in the extreme tsunami-inundation zone in the State of Hawaii, organized by census-designated place. Dashed lines indicate 3rd quartile. Uninc., unincorporated; %, percent.

Figure 9-22. Bar graphs show updated information from the 2007 report to now include the extreme tsunami-inundation zone (USGS 2016)

9.5 Ongoing Hazard Mitigation Activities

9.5.1 ASCE 7-16 Tsunami Resilient Design Requirements and the International Building Code

An engineering standard of practice now exists that includes probabilistic hazard criteria setting a tsunami design zone for resilient building design and construction, which has spurned an ongoing effort relating to updating Hawaii building codes. Considering that tsunamis are the flooding hazard most likely to occur on the Hawaiian Islands, the American Society of Civil Engineers has developed probabilistic inundation Tsunami Design Zone maps for application of its new tsunami-resilient design standard, such that critical facilities around the state could be designed with protection against tsunamis. A Probabilistic Tsunami Hazard Analysis (PTHA) performed by the American Society of Civil Engineers (ASCE) developed maps based on probabilistic simulations. That is, hazard maps were produced for Alaska, Washington, Oregon, California, and Hawaii showing the extent of inundation based on the methodology of PTHA, incorporating all seismic sources and their feasible tsunamigenic earthquakes (see Section 9.5.2).

The Tsunami Loads and Effects Subcommittee of the American Society of Civil Engineers (ASCE) and Structural Engineering Institute (SEI) ASCE/SEI 7 Standards Committee completed a new Chapter 6 - Tsunami Loads and Effects for the 2016 edition of the ASCE 7 Standard. Chapter 6, Tsunami Loads and Effects, is the first national tsunami design provisions established in a standard referenced in the International Building Code (IBC) 2018. Chapter 6 provides loads for tsunami and requirements to mitigate its effects, and the design approach enables better planning of site selection for essential and critical facilities. These new provisions apply to a limited class of Risk Category III and IV buildings and structures and will include certain taller Risk Category II buildings as defined in the Honolulu Building Code. The provisions will not apply to low-rise Risk Category II and Risk Category I buildings.

ASCE 7-16 directly provides a means to effectively influence community resilience and the reliability of critical infrastructure. The ASCE 7 tsunami provisions applies to community planning and design for resilience before a tsunami event. After a tsunami, it will have even more significance as means to plan, site, and design what (and where) is appropriate and necessary in reconstruction, to enable Building Back Better.

9.5.2 Probabilistic Tsunami Hazard Analysis

The lesson from recent tsunami events is that historical records alone do not provide a sufficient measure of the potential heights of future tsunamis. Engineering design must consider the occurrence of events greater than scenarios in the historical record, and should properly be based on the underlying seismicity of subduction zones. Therefore, physics-based Probabilistic Tsunami Hazard Analysis (PTHA) consistent with source seismicity must be performed in addition to consideration of historical event scenarios. This is the methodology used in the new ASCE 7-16 Tsunami Loads and Effects chapter that establishes for the first time a national design standard for tsunami-resilient structures. Maps and criteria in the ASCE 7 design standard are based on engineering risk analysis and reliability targets, rather than deterministic scenario assumptions.

Probabilistic Tsunami Hazard Analysis (PTHA), adapted from the Probabilistic Seismic Hazard Assessment (PSHA), assesses tsunami risks based on a reliability analysis that considers the uncertainty and variability of seismic events. For critical facilities and structures of greater importance, the PTHA method provides a probabilistic design of flow characteristics, hydrodynamic and geometric factors affecting the forces imparted to the structure and variability in the as-built capacity of the structural elements subjected to the flow. Thus, the hazard is probabilistic and the corresponding design methodology is reliability-based on structural performance. The effort to develop the offshore probabilistic tsunami parameters and governing earthquake scenarios for each community regional analysis is a key linchpin to enable the probabilistic inundation mapping and later local code adoption of the tsunami design provisions of ASCE 7-16. The ASCE 7-16 probabilistic hazard map of offshore tsunami wave heights at the 2,500-year Mean Recurrence Interval were used as the input basis for the computed onshore inundation flooding zones for tsunami hazards.

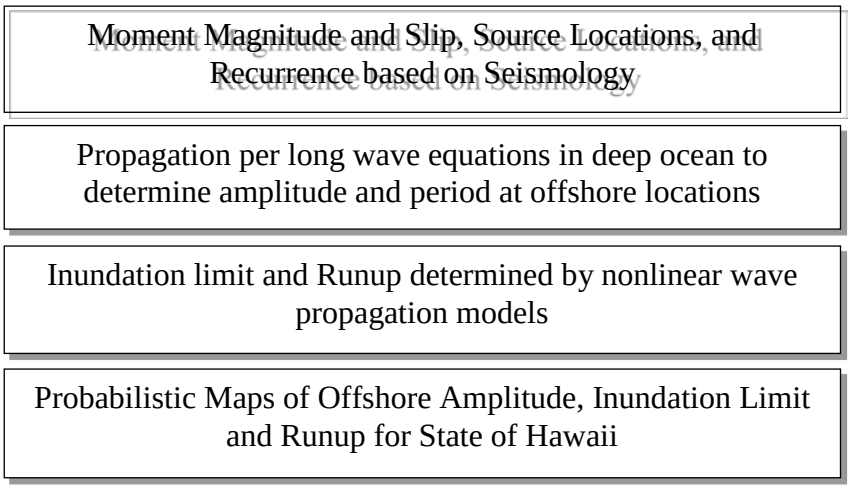


Figure 9-23. Summary of the Probabilistic Tsunami Hazard Analysis Map Process

The ASCE TDZ maps were developed at a grid resolution of 2 arc sec (~ 60 m). The ASCE maps provide the default design maps, which in turn should be produced in finer spatial resolution as local Hawaii map amendments for application in Hawaii building codes. A 2016 project, *Tsunami Probabilistic Reference Maps for Benchmarking Hawaii Tsunami Design Zone Maps,* was undertaken by the University of Washington Joint Institute for the Study of the Atmosphere and Ocean (UW JISAO). It used PTHA to develop some higher-resolution versions of the ASCE PTHA maps for 8 reference areas in Hawaii, as examples of how these maps can be produced for the entire state for use as Tsunami Design Zone map amendments in the state and county building codes.

The total effort to accomplish the tsunami hazard mapping of the City of Honolulu for community risk mitigation through structural design can be itemized into the following sequential steps:

1. Probabilistic Tsunami Hazard Analysis of Offshore Wave Height and associated disaggregated governing scenario definition for input to the national inundation model.

2. Development by Pacific Marine Environmental Laboratory/University of Washington (PMEL/UW) of general probabilistic design maps based on 60-meter grid of topography, published in the ASCE 7-16 standard.
3. Development of higher resolution 10-meter probabilistic design maps for PMEL reference sites. This effort establishes reference benchmarking for the later development of consistent local probabilistic inundation maps covering greater geographical extent under the National Tsunami Hazard Mitigation Program and NOAA.
4. Honolulu needs to leverage this work and develop higher resolution 10-meter Tsunami Design Zone maps for adoption as local map amendments to the Honolulu Building Code for the IBC 2018 model code adoption.

Figure 9-23 below illustrates these steps. Items 1, 2, and 3 above have been accomplished and incorporated in the ASCE 7-16 Standard, and the International Building Code 2018 will reference its design requirements and its maps. In the Hawaii state and county code adoption process, there is then the local jurisdiction's authority to adopt higher resolution Tsunami Design Zone maps produced in more detail, using the ASCE criteria.

Hawaii is now proceeding further to develop additional high resolution (10 meter) inundation maps for other coastal areas as needed in accordance with the procedure of the ASCE 7 Standard, for local adoption during the timeframe when the IBC 2018 is adopted by the states and local county jurisdictions. Ongoing is the development of high-resolution maps of Oahu comprising the City and County of Honolulu, and later phases will develop them for the other Counties of Hawaii, Kauai, and Maui. These efforts are to be performed by tsunami modelers selected by the State and sponsored by NOAA via the State of Hawaii Office of Planning Coastal Zone Management program. This project is a critical coordinating bridge between the Probabilistic Tsunami Hazard Analysis mapping criteria set by ASCE for design and subsequent implementation of these requirements in local state and county level building codes in Hawaii.

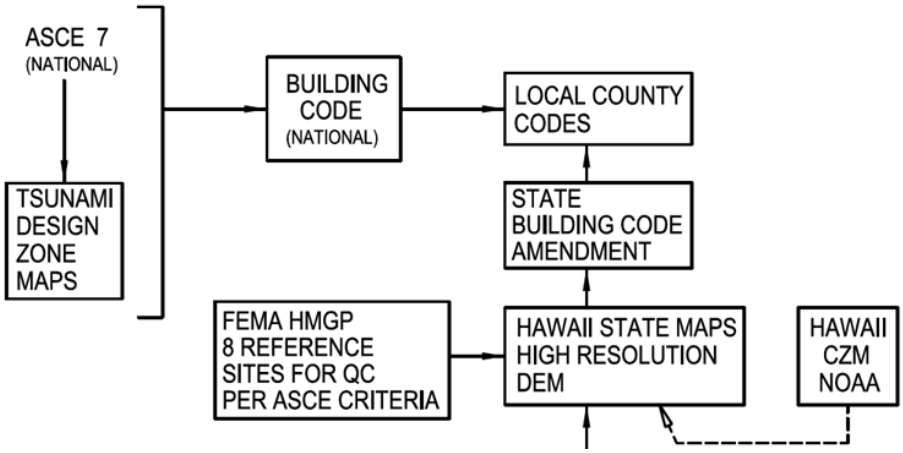


Figure 9-24. The Process for Implementing Amended Tsunami Design Zone Maps with Finer Spatial Resolution

The following press release accompanied the start of the Oahu high-resolution mapping project:

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT AND TOURISM

OFFICE OF PLANNING

DAVID Y. IGE
GOVERNOR

MIKE McCARTNEY
DIRECTOR

JUSTINE NIHIPALI
COASTAL ZONE MANAGEMENT, PLANNING PROGRAM MANAGER

FOR IMMEDIATE RELEASE
Jan. 28, 2019

State Starts Development of Probabilistic Tsunami Design Zone Maps

HONOLULU -- The Office of Planning's Coastal Zone Management Program (OP-CZM) has begun developing comprehensive high resolution probabilistic Tsunami Design Zone (TDZ) maps for the Island of Oahu.

The current 2018 State of Hawaii Multi-Hazard Mitigation Plan (SHMHMP) and the previous 2013 SHMHMP identified tsunamis as a hazard of high concern for Hawaii and a significant coastal hazard risk to the state.

However, there were no national standards for designing facilities against the effects of a tsunami. As a result, in 2016, the American Society of Civil Engineers (ASCE) developed ASCE 7-16, Chapter 6 – Tsunami Loads and Effects – the first national, consensus-based standard for tsunami resilience in Hawaii and Western states. The new ASCE 7-16 tsunami design provisions will be referenced in the 2018 International Building Code (IBC 2018) and will apply to a limited class of residential, commercial and critical and emergency facilities to ensure Hawaii's resilience to coastal hazards.

To assist in the use of the ASCE 7-16 tsunami design standards in Hawaii, maps of 2,500-year probabilistic tsunami inundation for Hawaii will be developed through OP-CZM's high resolution (10-meter) probabilistic TDZ mapping project for the Island of Oahu. OP-CZM is working with Ian Robertson, Ph.D., SE, and his expert team to develop the mapping products.

"The high-resolution maps to be produced are important because they replace the low-resolution TDZ maps currently in the ASCE 7-16 standard so that future tsunami design on Oahu will benefit from more accurate and informative maps," Robertson said. "Some areas that are currently considered by ASCE 7-16 to fall within the Tsunami Design Zone may in fact not need tsunami design at all. Development of the high-resolution maps will clarify exactly what areas are exposed to the tsunami hazard."

Figure 9-25 2019 Announcing the High-Resolution Tsunami Design Map Project

In Hawaii, the tsunami design requirement is required per statute HRS Chapter 107, Part II. The requirement to incorporate the charging language for tsunami is triggered by the March 11, 2016 final approval of the tsunami provisions in the ASCE 7-16 national standard. The laws says the state code shall include it, as follows:

§107-25 Hawaii state building codes; requirements. There is established the Hawaii state building codes applicable to all construction in the State of Hawaii. **The Hawaii state building codes shall be based upon**:

(1) The state fire code as adopted by the state fire council;

(2) The Uniform Plumbing Code, as copyrighted and published by the International Association of Plumbing and Mechanical Officials, including its appendices;

(3) The International Building Code, the International Residential Code, and the International Energy Conservation Code, as published by the International Code Council;

(4) The National Electrical Code, as published by the National Fire Protection Association;

(5) Hawaii design standards implementing the criteria pursuant to Act 5, Special Session Laws of Hawaii, 2005, as applicable to:

(A) Emergency shelters built to comply with hurricane resistant criteria, including enhanced hurricane protection areas capable of withstanding a five hundred-year hurricane event as well as other storms and natural hazards; and

(B) Essential government facilities requiring continuity of operations; and

(6) **Code provisions based on nationally published codes or standards that include** but are not limited to residential and hurricane resistant standards related to loss mitigation standards in accordance with section 431P-12, elevator, mechanical, flood and **tsunami,** existing buildings, and onsite sewage disposal. [L 2007, c 82, pt of §2; am L 2014, c 164, §6]

9.5.3 Tsunami Risk Analysis

Average Annualized Losses were based on three scenarios that have the following estimated probabilities:

1. The ASCE 7-16 Tsunami Design Geodatabase, which is estimated to have a mean hazard level equivalent to a 3500 year mean recurrence interval based on a fully probabilistic tsunami hazard analysis.
2. The City of Honolulu Extreme Tsunami inundation zone, which is estimated to have a mean hazard level equivalent to a 1500 year mean recurrence interval
3. The City of Honolulu inundation zone based on historical flooding, which is estimated to have a mean hazard level equivalent to a 400 year mean recurrence interval

This risk analysis was conducted using HAZUS MH with an enhanced building inventory database that is now uploaded to the Pacific Disaster Center. An average annualized loss for the tsunami hazard is estimated to be $81 million per year. Of this amount, $4.1 million occurs in the essential facility buildings, located mostly in the Honolulu south coast urban core area. A listing of the most vulnerable facilities is provided.

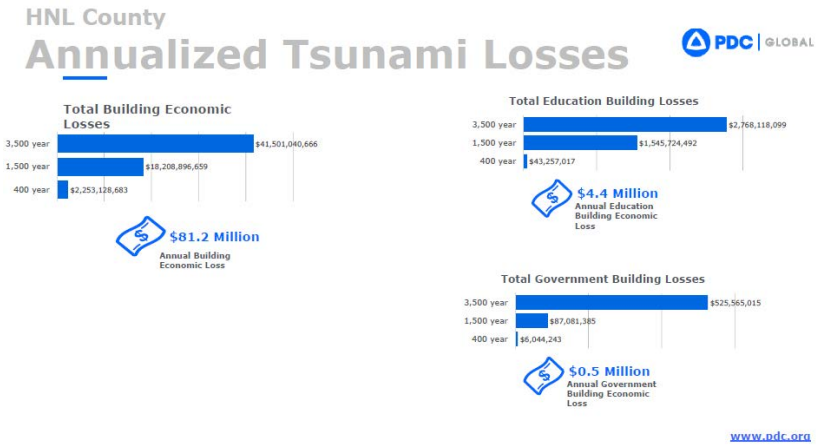


Figure 9-26. Tsunami Average Annualized Losses

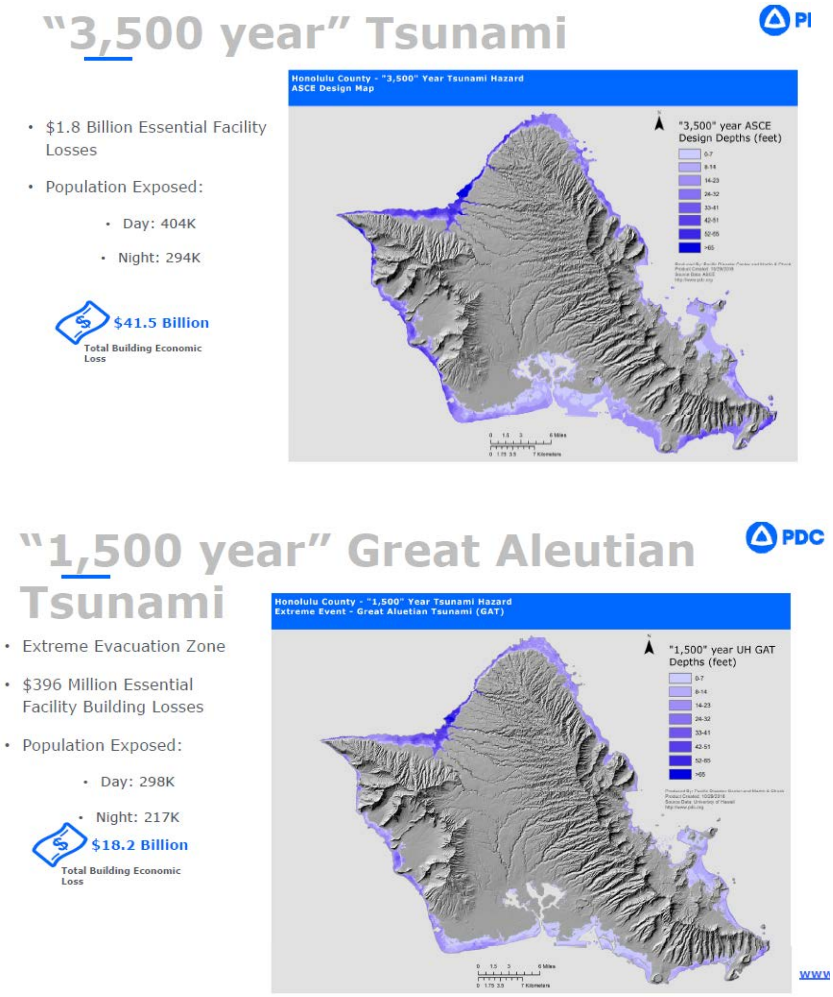


Figure 9-27. 3500-year and 1500-year Tsunami Inundation Zones

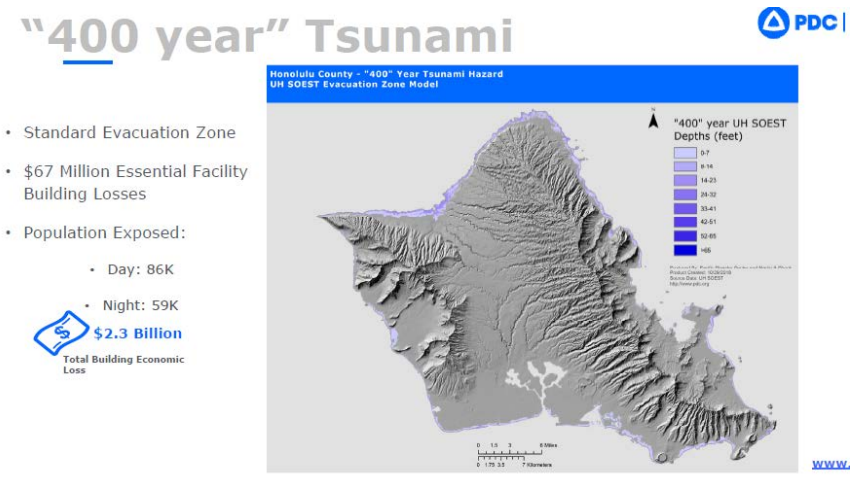


Figure 9-28. 400-year tsunami scenario

Facilities Subject to High Losses or Loss of Functionality (Extreme Tsunami)

- Honolulu International Airport Runways
- **Honolulu Harbor**
- Power Plants
  - AES
  - Kalaeloa
  - **Honolulu Nimitz** (presently not in service)
- Ala Wai Canal and surrounding communities
- Bridges
  - Kuliouou Stream Bridge
  - Kahaluu Stream Bridge
  - Kaluanui Bridge
  - Makaha Stream Bridge #3A
  - Maipalaoa Bridge
  - Makaha Stream Bridge #3
  - Kaelepulu Stream Bridge
- State
  - Courts – Alii Aimoku Hale, Kaahumanu Hale
  - Plant Quarantine Branch on Aukiki Street
- Health Care
  - Queen's, Straub, and Kaiser Clinics Hawaii Kai
  - Kaiser Clinic Kailua
  - Kaiser Clinic Waianae
  - Kaiser Clinic Kahuku
  - Waianae Comprehensive Health Center
- Fire Stations
  - Airport
  - **Waterfront N. Nimitz Hwy**
  - Pawaa
  - McCully
  - **Wailupe**
  - Kailua
  - **Hauula**
  - **Sunset**
  - **Waialua**
  - Nankuli
  - **Waianae**
- Police Substations
  - **Waikiki**
  - Kailua
  - **Waianae**
- EOC
  - **Waialua**
  - **Waianae**
  - **Coast Guard**
- Schools
  - Wailua ES
  - Maile ES
  - Kalani HS

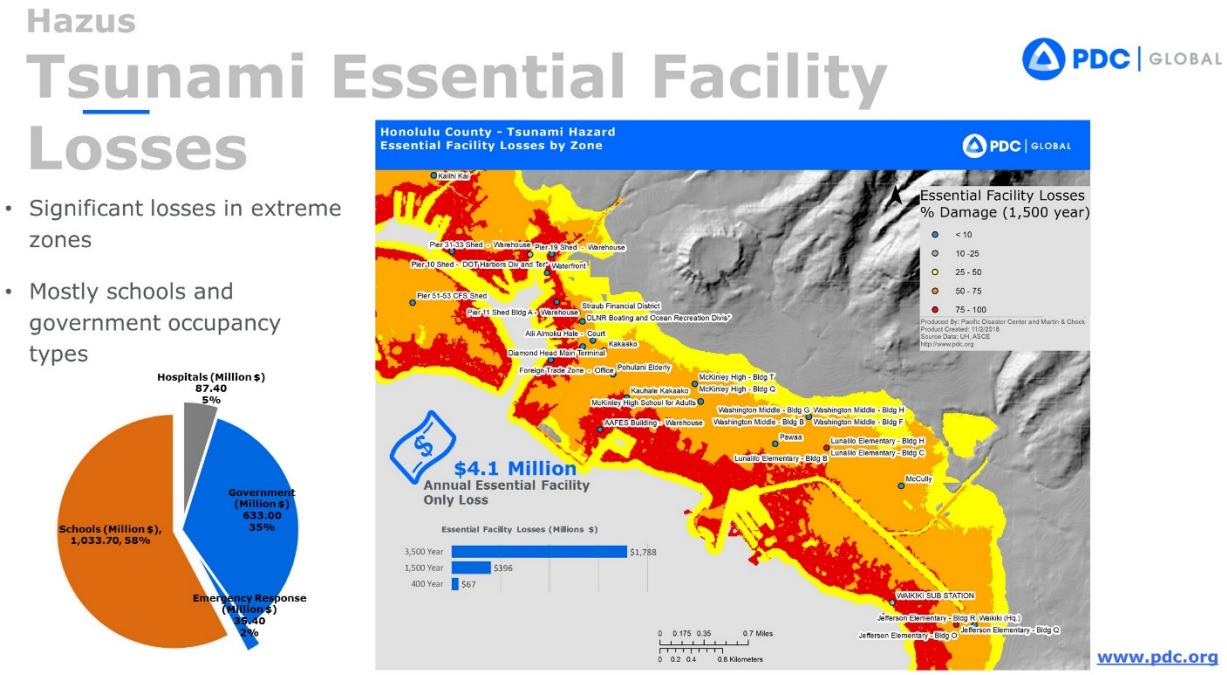


Figure 9-29 Average Annualized Losses for Oahu Essential Facilities

9.5.4 Honolulu Port Analyses for the Hawaii Tsunami Scenarios

The Port of Honolulu is Hawaii's critical lifeline in the supply chain for Oahu's total population exceeding 1 million residents. It is also the hub of cargo transfer for delivery of goods to all the neighbor islands. Hawaii imports over 90% of its goods. If the port is closed, there is only about a week's worth of food stored within the state. Transport by sea takes 6 to 8 days of transit time from the mainland.

Honolulu Harbor serves about 8000 vessels per year. Honolulu Harbor handles a total of almost 12.7 million tons of cargo including nearly 1.1 million tons of foreign trade and over 11.6 million tons of domestic cargo. The largest single category of cargo was manufactured equipment and machinery (over 9.1 million tons). Other major categories of cargo moving through Honolulu Harbor included food and farm products (more than 1.5 million tons) and petroleum and petroleum products (almost 1.1 million tons). Petroleum and petroleum products accounted for the majority of foreign cargoes in Honolulu Harbor, and food and farm products accounted for most domestic cargo. In 2011, Honolulu Harbor handled a total of almost 746,000 TEU's (Twenty-Foot Equivalent Units) of containerized cargo.

A Martin & Chock, Inc. 2017 study for the USGS and HEMA titled Honolulu Port Analyses for the Hawaii Tsunami Scenarios detailed the effects that the previously mentioned extreme Aleutian tsunamis would have on Honolulu Harbor. For greater detail, refer to the full report (Chock, 2017).

The USGS Pacific Coastal and Marine Service Center and its Science Application for Risk Reduction (SAFRR) project have partnered with Hawaii Emergency Management Agency to assess potential disruptive impacts of destructive tsunamis to the Port of Honolulu. For tsunami scenarios with greater risk of affecting the port of Honolulu, the following assessments are needed: 1) damages to the ports, cargo, and vessels, 2) port functionalities and trade disruptions.



Figure 9-30. Honolulu Harbor

The operational areas of Honolulu Harbor are identified from publically available information and a previous report by the University of Hawaii (Robertson, 2014). Such operational areas include the piers and wharves and their specific dock area functions, several container yards and other cargo facilities, fuel storage yards, drydock facilities, and vessel docking/mooring, as well as the harbor channel itself.

The NEOWAVE finite difference model utilized by Kwok Fai-Cheung under a separate but coordinated USGS project (Cheung, 2016), Port of Honolulu Hydrodynamic Modeling for the Hawaii Tsunami Scenario, developed time histories of tsunami inundation flow into Honolulu Harbor from tsunamigenic sources in the Aleutian Islands and Kamchatka Peninsula. Megathrust earthquakes along these subduction fault zones generate tsunamis with strong directionality orientation to Hawaii. Mw 9.1 Aleutian and an Mw 9.3 Kamchatka earthquakes can produce approximately 2 m of Offshore Tsunami Amplitudes at 100 m depth outside the harbor. Detailed geospatial time history data of the tsunamis were produced from a high resolution digital model of the Honolulu Harbor area. The most energetic waves and currents occur during the first two hours after tsunami arrival. The Aleutian scenario produces greater inundation with relatively shorter cycles of inflow and retreating outflow.

Damage assessment for these two events was based on harbor currents, inundation depth onland, and flow velocity onland. With respect to harbor currents, the work of Pat Lynett (2014) relating tsunami-induced current speeds to damage of piers and wharves is utilized. For damage assessment of buildings next to the piers where the modeled inundation was found to be significant, we used tsunami reconnaissance and depth to damage relationships by the US Army Corps of Engineers Galveston District, as developed for average, light industrial low-rise buildings.

Important facilities significantly impacted by these levels of tsunami waves include:

- Pier 1, which handles foreign containers, bulk cargo, and foreign imported vehicles, has about half of its containers and vehicles floated and strewn inland and into the channel.

- The Honolulu Harbor Emergency Operations Center at Pier 2 may lose power and its emergency generator would be flooded by seawater and may become inoperable after the tsunami.
- Piers 20, 24, 26, and 35 (which have some redundancy for handling general and roll-on roll-off cargo), 39F, 40A, 40B (interisland barge loading and unloading) would become nonfunctional due to damage from high currents and overtopping flow.
- At Piers 39-40, the "Young Brothers" container yard and interisland supply barge docks are overtopped by 2 to 3 feet with higher velocity. Therefore, it is expected that nearly all containers being staged for interisland barge delivery would float and be strewn landward onto Nimitz Highway and into Kapalama Stream, and outward into the harbor waters and becoming grounded on a wharf or sinking in the harbor. The interisland barges would also become waterborne debris and may become strewn onto the Pier 51-52 deck, with some possibility of striking the ship to shore gantry cranes. The Pier 39 container yard is expected to be nonfunctional for a long period of time following these tsunami scenarios, and the channel and Pier 40 would be heavily damaged by current flow, scour, and debris. The interisland barge docks may lose 50% or more of their handling capacity. The nearby Nimitz Highway Kalihi Bridge deck would be overtopped by about 5 feet, and is likely to become blocked by debris.
- Piers 51B and 52 that handle container shipping to and from the mainland USA would be nonfunctional due to high tsunami currents and waterborne debris that would damage dock pavements and container loading capabilities. This is about half of the loading dock available for container shipping from the mainland USA. The container handling gantry cranes would be damaged if they remain at Pier 51B and 52. These piers are susceptible to barge and container impacts from the interisland barge and container yard docks across the channel. However, the Sand Island container yard would be flooded but its containers should not become disrupted, although the goods within may become water-damaged losses due to the seawater inundation.
- Drydocks at Pier 24 and 41 could be uplifted and potentially broken free of their moorings.
- The Aviation Fuel Tank farm near Sand Island has containment walls of only three feet high that were designed for fluid on the inside. It appears that the entire west facing wall of the containment walls would be overtopped by flow exceeding 3 feet, flooding the entire tank farm and damaging equipment and controls.

Inundation depth of overtopping tsunami flow is up to 3 feet at the following building areas:

- Nuuanu Stream mouth Kewalo Basin Annex– Piers 16 and 17 extending landward past Nimitz Highway and Iwilei Road into Aala Park.
- The "Fisherman's Village" fish auction house, and retail and restaurant structures adjacent to Pier 38. These facilities would become nearly 50% flood losses to the tenants due to finishes, content and equipment damages, and mold remediation.
- The Kapalama Basin light industrial and ship repair and freight station has older vintage metal buildings that would have their contents and exterior siding destroyed.

Important facilities affected to a lesser extent such that functionality may remain:

- The Marine Fuel terminal next to Pier 30 should remain intact from flooding and debris impacts due to its containment walls, assuming those have adequate structural strength for external flooding. ***The containment walls should be evaluated for the external loads of both***

hydrostatic and hydrodynamic tsunami forces. The waterfront dock in front of the Marine Fuel Terminal may not be functional.

- The Sand Island Bridge, which is nonredundant, should remain intact for bearing traffic.
- The Sand Island Sewage Treatment Plant is not heavily flooded, but ***the exposure of ground-level mechanical and electrical equipment should be assessed to evaluate whether there would be disruption to waste-water plant operations***, since the plant design may not have anticipated flooding events.
- The Coast Guard facility and docks may receive up to 2 feet of inundation, which should not be significantly damaging but may affect onshore operations.
- The Kalihi Kai Fire Station should be intact and unflooded and available for firefighting and rescue operations.

It appears that the tsunami damage projections for these major megathrust scenarios were very significant but potentially manageable at Honolulu Harbor, having critical facilities with functional alternatives that were not all severely damaged. For emergency management, the main concern for planning is to have alternative yards and roll-on roll-off terminal facilities available as an operational contingency at up to 50% reduced capacity and efficiency overall for about 30 days.

Piers with the greatest importance were Piers 1 (the international shipping yard), Piers 19 and 20 (cruise ship operations), Pier 29 (container-handling capable pier and 12 –acre yard modernized in 2012), Pier 35 (University of Hawaii research pier), Pier 38 (the Gas Company), Piers 39, 40-43 (container yard and interisland supply barge docks), 51-53 (domestic shipping containers and automobiles). Of these, the Pier 1yard loses about half of its containers and vehicles, Piers 20 and 35 are completely damaged with respect to functionality, Pier 38 is flooded to about an 8 ft depth, Piers 39 to 40 have major damage or are completely damaged with respect to functionality, and Piers 51 and 52 are completely damaged with respect to functionality.

The total effect on the Hawaii supply chain cannot be assessed until the effects at the neighbor island harbors at Hilo, Kahului, and Nawiliwili, and the Kalaeloa Barbers Point Harbor were evaluated for these same scenarios. However, the analysis shows that shipping to the neighbor islands is likely to be the most disrupted since most of the interisland cargo barge facility in Honolulu Harbor would not be functional after these tsunamis and would require major repairs. Furthermore, it would be expected that tsunami damage to the north-facing bays of Hilo Harbor and Kahului Harbors would be more severe than at the south-facing Honolulu Harbor.

Within Honolulu Harbor, it is strongly recommended that the containment walls of the Marine Fuel terminal next to Pier 30 should be evaluated for external loads resulting from both hydrostatic and hydrodynamic tsunami forces. These walls might be designed primarily for internal hydrostatic pressures rather than compounded external hydrostatic and hydrodynamic pressures.

The containment walls of the aviation fuel storage facility nearby to Sand Island Access Bridge should also be evaluated for external tsunami forces, and equipment and monitoring/control services need to be evaluated for flooding due to overtopping of these walls by the tsunami.

The tsunami events evaluated in this study are not the maximum tsunamis possible for this site. Nevertheless, addressing the mitigation and preparation for the tsunami effects provided in this study should diminish the predominant part of the tsunami risk at this site.

In the future, mitigation of tsunami risk to newer facilities should follow the ASCE 7 Standard, Chapter 6, Tsunami Loads and Effects, which is becoming a part of the Hawaii and Honolulu building codes.

9.6 Future Hazard Mitigation Actions

The following is a summary of the proposed tsunami hazard mitigation actions:

- Adopt tsunami design provisions for buildings for new design and construction and for evaluating existing buildings.
- Adopt by local code amendment the high-resolution Tsunami Design Zone maps presently under preparation
- Preliminary engineering of tsunami and coastal flood mitigation retrofit of critical infrastructure.
    - Identify and retrofit critical water pumping stations in the tsunami inundation zone.
    - Evaluate fuel storage walls in Honolulu Harbor for the ability to withstand tsunamis
- Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects



10. Earthquakes

10. EARTHQUAKES

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
• The 2012 plan provided a basic description of seismicity for Hawaii effects and distribution of soil types and risk assessment. It added a discussion on the 2006 Kiholo Bay earthquake. • The average annualized risk analysis was updated per HAZUS MH along with related mitigation activities. Based on an analysis of Hawaii construction cost data, projected earthquake average annual loss is about $21 million on Oahu .	• More information is provided on the fundamental seismological mechanisms for earthquakes in Hawaii, which is unlike continental seismology. Oahu is subject to deep earthquakes resulting from the plate flexural stresses in the lithosphere generated by the emplaced weight of the superimposed volcanic island mass on top of the oceanic crust. • Outdated figures have been updated or removed if unnecessary. • Seismic hazard mapping of Hawaii developed by the U.S. Geological Survey (USGS) was updated in the ASCE 7-10 Standard to reflect the Risk-Targeted Maximum Considered Earthquake • The most current seismic design code available is the International Building Code (IBC). Seismic hazard for Oahu based on the International Building Code is explained. • The continuation of bridge seismic retrofits is described. • The 2018 lower Puna eruption did not seismically affect Oahu in any significant way but is mentioned. • Earthquake risk was estimated to account for the fourth largest amount of annualized financial losses behind flood losses. • Seismic hazard mitigation project recommendations are updated.

Summary of Mitigation Projects for the City and County of Honolulu

Project	Priority
Adopt 2018 IBC and related codes per HRS 107 Part II	Medium-High
USGS intends to complete an update of the Hawaii seismic hazard maps in 2020.	Medium

10.1 Historic Record of Earthquakes

Earthquakes in the State of Hawaii are caused by two mechanisms. So called “mantle” earthquakes are caused by the long-term accumulation and release of lithospheric flexural stresses generated in the crust and mantle by the weight of the volcanic rock that composes the islands. The deeper mantle earthquakes, at typically 30 to 40 km depth, result from flexural fracture of the underlying lithosphere in long-term geologic response to the load of the island mass. This is one of the seismotectonic mechanisms for damaging (but not the largest) earthquakes in the Hawaiian Islands. Past examples of such “mantle” earthquakes include the 1973 M6.2 Honomu (on the northeast coast of the island), the 1938 M7 Maui, and the 1871 M7 Lana‘i earthquakes, and the 2006 M6.7 Kiholo Bay earthquake.

The second mechanism resulting in historically the largest earthquakes in Hawai‘i have occurred at shallower depths, beneath the flanks of Kilauea, Mauna Loa, and Hualalai Volcanoes on the Island of Hawaii. The flanks of these volcanoes adjust to the intrusions of magma into their adjacent rift zones by storing compressive stresses and occasionally releasing it in “crustal” earthquakes. The active fault surfaces for these large earthquakes is associated with a near-horizontal basal décollement separating the ancient oceanic crust from the emplaced volcanic pile, lying approximately 10 km beneath the Earth's surface. (A décollement is a tectonic surface that acts as a plane of detachment between two masses.) Examples of such crustal or décollement earthquakes occurred in 1975, the M7.2 (or greater) Kalapana earthquake beneath Kilauea’s south flank, and in 1868, the largest earthquake in recorded Hawaiian history beneath the Ka‘u district on Mauna Loa’s southeast flank, estimated as a M7.9 earthquake.

On May 3, 2018, Kilauea once again erupted, triggering increased local seismic activity. The next day, a M6.9 earthquake with a preceding M5.4 earthquake originating from Kilauea set the record for the strongest earthquake in Hawaii since 1975. However, according to the USGS “Did You Feel It?” population questionnaire report, it was not noticed on Oahu and caused little to no reported damage. The USGS has cataloged more than 4,350 recorded earthquakes above M1.0 in the region around the Island of Hawaii between April 30, 2018 and May 30, 2018. A shakemap from USGS is given in Figure 10-1, demonstrating the minimal seismic impact that the 2018 lower Puna eruption has had on Oahu. Refer to the USGS Earthquake catalog for up to date information on volcanic activity and corresponding seismic activity: (https://earthquake.usgs.gov/earthquakes/search/).

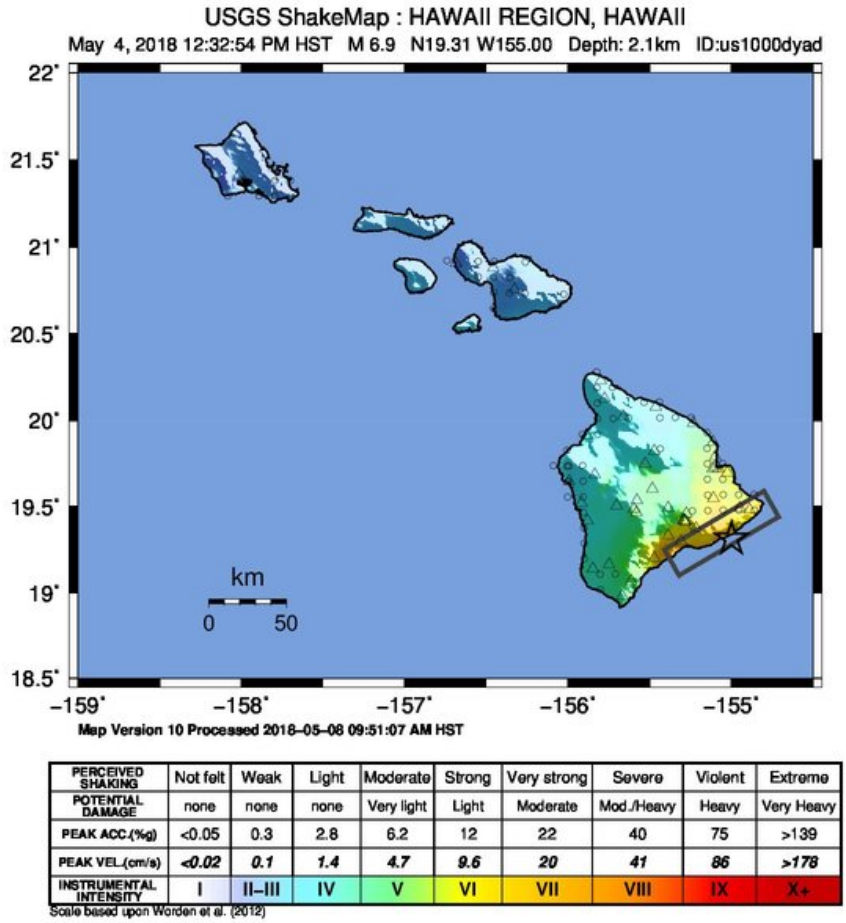


Figure 10-1. Mercalli Intensities of the May 4, 2018 Earthquake Associated with the Lower Puna Eruption (retrieved May 30, 2018, https://earthquake.usgs.gov/earthquakes/eventpage/us1000dyad#shakemap)

The epicenters of recent earthquakes in the State of Hawaii show that most of the seismic activity is centered on the Island of Hawaii with the number and magnitude of earthquakes diminishing greatly between Hawaii and Kauai. This distribution is reflected in the building codes by the most rigorous seismic design criteria on Hawaii with reduction in seismic design criteria for Maui County, Oahu, and Kauai respectively. Hawaii is considered highly seismic while Oahu is considered to have low to moderate seismicity. The historic earthquakes with the greatest impact on Oahu with Honolulu MMI intensities of V or greater are summarized in Table 10-1. Previous lists of earthquakes and the contemporary accounts of those earthquakes definitely felt on Oahu were compiled by Cox (Cox, 1986a, 1986b). The Honolulu intensity of each of these earthquakes was estimated from the contemporary descriptions of its effects found in the newspapers and elsewhere using a continuous equivalent of the MM scale chosen so that its values, if rounded to the nearest integer, were identical to those of the conventional discrete-valued scale.

Table 10-1 **Historic Hawaiian Earthquakes with Honolulu Modified Mercalli Intensities of V and Greater**

Event	Epicenter		Depth	Richter Magnitude	Honolulu Intensity
Date	Latitude	Longitude	Km	M	MMI Ave.
1871 Feb 19	20.7	157.0	--	7.0	6.5
1948 Jun 28	21.2	157.9	--	4.6	6.0
1938 Jan 22	21.2	156.1	--	6.8	5.5
2006 Oct 15	19.9	155.9	39	6.7	5.0
1973 Apr 26	19.9	155.1	45	6.2	5.0
1981 Mar 5	21.4	156.8	10	5.0	5.0
1895 Dec 8	Oahu vicinity		--	--	5.0
1861 Dec 5	Molokai-Lanai vicinity		--	--	5.0

The historic earthquake with the generally highest Oahu intensities was found to have been one that occurred on February 19, 1871. (Cox, 1985) From the geographic distribution of its effects, its Richter magnitude was estimated at about 7 and its epicenter near the south coast of the island of Lanai. The earthquake with the second highest intensity at Honolulu was found to have been one that occurred on June 28, 1948. (Cox, 1986c). Although several seismographs were then in operations in Hawaii, neither the magnitude nor the epicenter of the earthquake had been determined from seismographic information. From the geographic distribution of its effects, its Richter magnitude was estimated in the study at only about 4.6, but its epicenter was estimated to have been only a few miles south of Honolulu, where its MMI intensity was estimated at 6.

10.1.1 2006 Kiholo Bay Earthquake

Little physical damage was observed on Oahu after the Kiholo Bay earthquake, but due to technical issues, all 19 generators on Oahu with a combined capacity of 1225 megawatts had shut down within 20 minutes of the earthquake. Honolulu International Airport was not operational on October 15th because it lacked sufficient emergency power, and it took nearly 19 hours for the Hawaiian Electric Company (HECO) to restore power to 99.2% of its 291,000 customers. HECO has since replaced the mercury switches that failed during the 2006 earthquakes with dry-contact switches less susceptible to ground shaking that will help mitigate against false triggering of shutdowns. The USGS Shakemap for the Kiholo Bay earthquake is provided in Figure 10-2, demonstrating that even weak seismic activity can have significantly adverse effects.

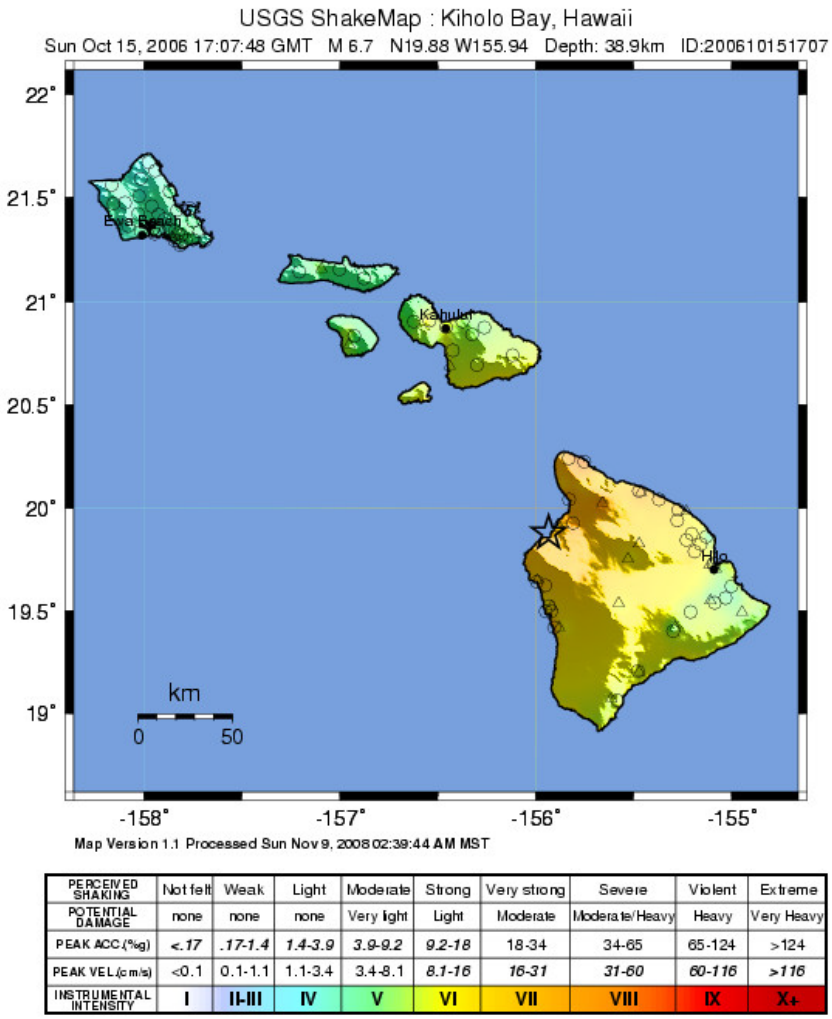


Figure 10-2. Mercalli Intensities of the October 15, 2006 Kiholo Bay Earthquake (retrieved October 8, 2009, http://earthquake.usgs.gov/eqcenter/shakemap/hv/shake/200610151707/)

10.2 Design Seismic Hazard

The International Building Code (IBC) defines seismic hazard using two series of maps indicating 0.2 second and 1.0 second spectral acceleration ordinates. Risk-Targeted Maximum Considered Earthquake (MCE_R) maps are the modern version of these maps, which have been updated for the 2012 IBC and later codes. These new MCE_R maps were developed to achieve a targeted design reliability against failure, such that there would be a 1% collapse probability over 50 years. The applicable maps for the Hawaiian Islands are shown in Figure 10-3 for a rock site (Site Class B). The design spectral accelerations for a given site are 2/3rds of the MCE_R level shown in these maps. USGS intends to complete another update of the Hawaii seismic hazard maps in 2020.

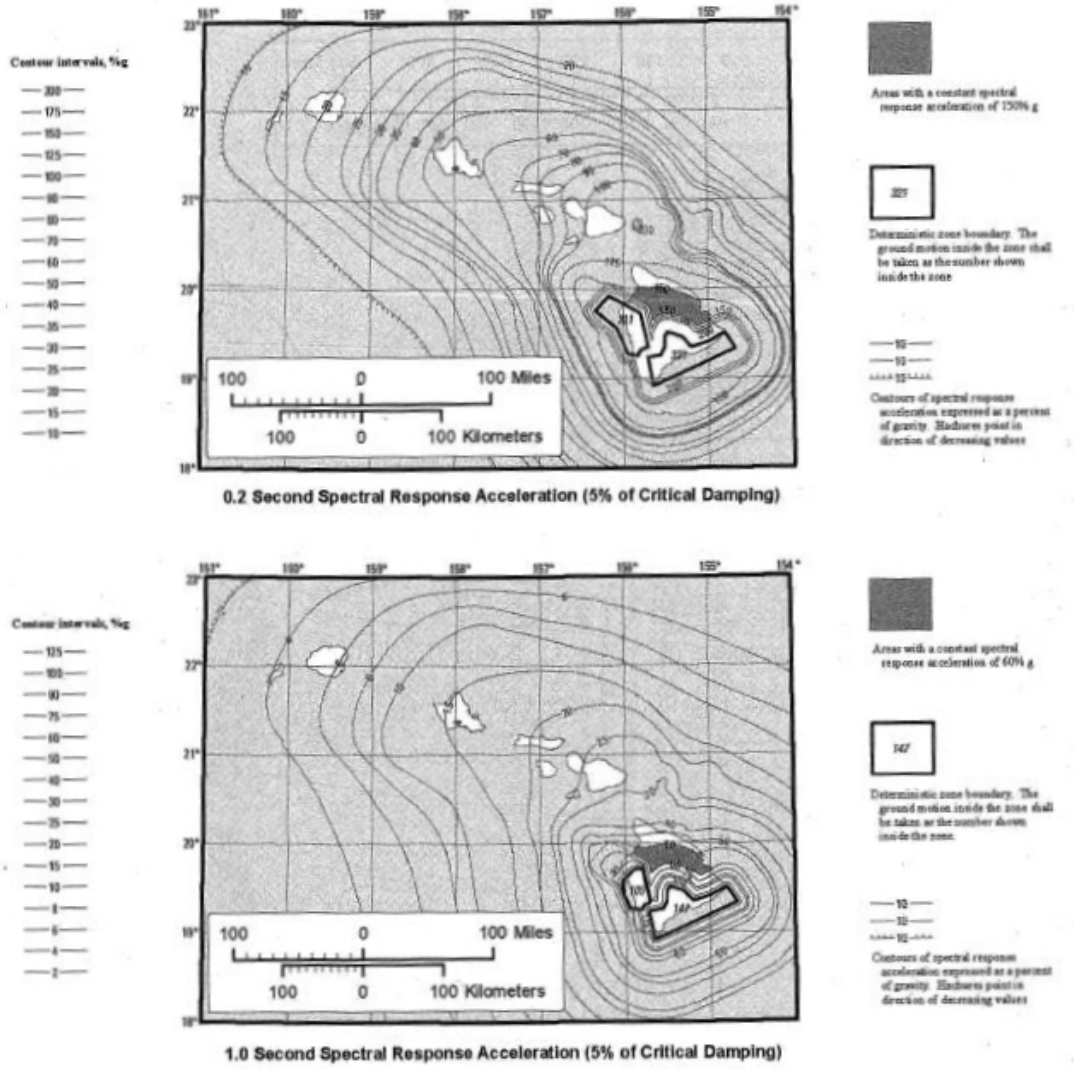


FIGURE 1613.2.1(3)
RISK-TARGETED MAXIMUM CONSIDERED EARTHQUAKE (MCE_R) GROUND MOTION RESPONSE ACCELERATIONS FOR HAWAII OF 0.2- AND 1-SECOND SPECTRAL RESPONSE ACCELERATION (5% OF CRITICAL DAMPING)

`Figure 10-3`. IBC MCE Spectral Accelerations for Site Class B

10.2.1 Soil Conditions

The seismic ground motion at a particular site can be significantly increased by weaker or "softer" soil conditions. Rock and soil conditions are categorized in the IBC by Site Classes A through F, sometimes referred to as Soil Types. The accelerations are then amplified by the soil conditions underneath the site, where conditions other than hard contiguous rock exist. In Hawaii, there aren't any locations with Site Class B – Site Class C and D predominate, which result in greater amplification of ground motion.

Other earthquake-induced ground failure hazards include liquefaction and landslide. Liquefaction occurs when loose granular soils *below* the water table temporarily lose strength due to excess pore water pressure build-up during prolonged strong earthquake ground shaking. Accordingly, higher potential would tend to occur at sites with these subsurface characteristics in regions of higher seismicity, since events of Richter magnitude 6 or greater with Effective Peak Ground Accelerations of greater than 0.10g are generally necessary to begin to induce liquefaction. A preliminary assessment of Waikiki's liquefaction potential was conducted in 1991 under the sponsorship of State Civil Defense. There could be further work done to better define areas on Oahu susceptible to liquefaction and landslide. However, this is assessed by geotechnical engineers during the design of building projects, so it is not essential from a master planning standpoint of the City.

10.2.2 Historic Design Criteria

The maps in Figure 10-3 show the seismic hazard varies in a continuous manner as used in the current IBC from the highest seismic hazard at the south end of Hawaii and reducing earthquake hazard between Hawaii and Kauai. In that sense, "seismic zones" are no longer used for design of buildings and structures. The building codes have historically increased the design seismic criteria for Oahu as the building codes evolved as shown in Table 10-2. The reference for the early historic criteria used for seismic design of buildings is *A Brief History of Seismic Zonation for the Hawaiian Islands,* by the Hawaii Earthquake and Tsunami Advisory Committee (HETAC, 1991). The historic seismic zonation of Hawaii is presented in Figure 10-4. The former design code used by the City and County of Honolulu up until 2007, the 1997 Uniform Building Code (UBC), defined the seismic hazard with a 10% probability of exceedance in 50 year map based on peak ground acceleration. Design peak ground accelerations in the UBC were based on distinct seismic zones with the Island of Oahu located in Zone 2A in the 1997 UBC. (Note that in 1999 a revised seismic zone 4 for the island of Hawaii was adopted in the 1997 Uniform Building Code (UBC) by the Hawaii County Council.

A comparison with current assessments of seismic hazard provides the fundamental background information on why new codes have recently been adopted and why there are so many existing seismically deficient buildings in Hawaii, *due to past under-estimation of seismic hazard*. Table 10-2 shows comparative force levels for the codes as they historically applied to Oahu. Prior to the 1978 adoption of the 1976 UBC, engineered low rise structures had less than ½ of the seismic resistance required by current standards. Similar historically obsolete seismic codes have affected bridges with many bridges undergoing or having been recently retrofitted.

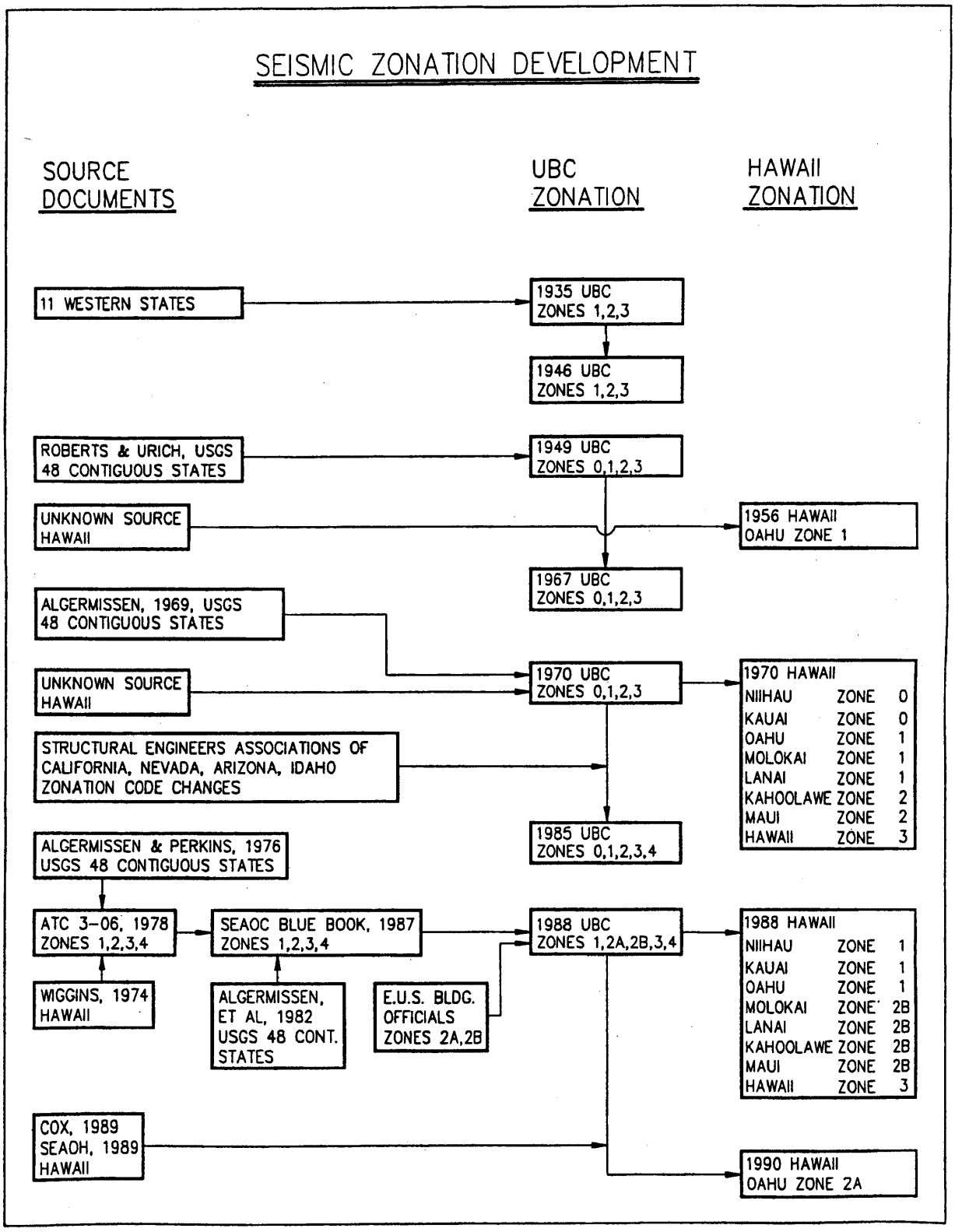


Figure 10-4. Historic Seismic Zonation in the State of Hawaii

Table 10-2. Historic Seismic Force Comparisons for Oahu
(100% = Current USGS & International Building Code Seismic Hazard on Rock Sites)

CODE	Approximate Height		
	25 ft.	75 ft.	180 ft
	Structural Period (seconds)		
	0.20	0.50	1.0
Pre-1973 UBC	41%	38% - 51%	43% - 71%
1973 UBC	41%	51%	71%
FEMA 310 Benchmark Cutoff			
1976 – 1985 UBC	43% - 51%	57% - 85%	72% - 107%
Oahu Zone Change to 2A			
1988 – 1994 UBC	99%	120% - 165%	133% - 200%
1997 UBC	90% - 132%	120% - 219%	106% - 226%
1998 Hawaii State Seismic Hazard Mapping by USGS/HSEAC			
2000-2018 IBC	100% - 130%	100% -210%	100% -186%

10.3 Assessment of Relative Risks:

Average Annualized Loss (AAL) is an objective measure of future losses averaged on an annual basis. This information can be very useful in assessing the relative contributors to total natural hazard losses.

Formula Expression: $\mathbf{AAL} = \sum \mathbf{L_i \times P_i}$

L_i = Estimated Loss for Event *i*

P_i = Annual Probability of Event *i*

Description: Sum of the expected loss for each event (i.e., sum of the products of the estimated loss from each event and that event's rate of occurrence)

The Average Annualized Loss Ratio (ALR) is defined as the AAL divided by total building exposure value.

HAZUS computes losses, L_i, for eight earthquake scenario events with different return periods (*1/ exceedance probability*): 100-year, 250-year, 500-year, 750-year, 1000-year, 1500-year, 2000-year, and 2500-year. The Probability versus Loss Curve is approximated through curve fitting, and the area under the fitted curve is integrated to obtain the AAL results.

Independent analysis by the HETAC showed that using the actual Building Inventory Database (BID) significantly increased the average annualized earthquake loss ratio (AELR).

Based on a HAZUS AAL analysis incorporating soil site factor mapping and Hawaii Construction Cost Data, *earthquake* capital AAL is about $21 million on Oahu. Annual income losses are

estimated at another $2 million. The predominant contributor to loss is the single-family residential construction.

A HAZUS earthquake scenario was also run to produce loss estimates for a Maximum Considered Earthquake event of magnitude 7 occurring offshore of Oahu, consistent with the expected seismic source capacity utilized in the USGS National Seismic Hazard Mapping Project described by Klein, Frankel, et al (2001) for seismic hazard maps developed by USGS. This event also replicates the estimated ground motion of the 1871 Lanai earthquake documented by Cox (1985). Estimated Losses identify multi-unit masonry housing and several bridge locations experiencing moderate to severe damage.

10.4 Recent Hazard Mitigation Activities

10.4.1 ***Oahu Metropolitan Planning Organization Transportation Improvement Program*** *(TIP) On-going Mitigation of Risk Relating to Transportation Seismic Retrofit Projects*

The Oahu TIP is a programming document that lists transportation projects that will be undertaken by the State of Hawaii and City and County of Honolulu, and funded in part with federal money. Projects identified in the TIP must be consistent with the Oahu Regional Transportation Plan (ORTP). The TIP is the short-term three-year implementation program for federally assisted surface transportation projects. It describes and prioritizes federally assisted and regionally significant locally-funded transportation programs and projects selected by the Oahu Metropolitan Planning Organization (OMPO) Policy Committee for implementation during the program period. It identifies funding amounts by source of funding, jurisdictional responsibility, type of project, and year of funding for these projects. An annual review and a major biennial update of the TIP are scheduled, with off-schedule amendments considered as needed. The TIP is adopted by the OMPO Policy Committee and sent to the Governor for approval. Upon approval, the TIP is incorporated as the Oahu element of the Statewide TIP (STIP). The TIP shows an extensive on-going seismic retrofit program of bridges prioritized based on more detailed in-house studies.

In the TIP cycle from FY 2008 to FY 2011 there were 6 seismic retrofit projects, all of these a continuation of projects scheduled for design in earlier cycles as listed in Table 10-3. There are 22 other bridge replacement, rehabilitation, or other related bridge projects also considered in the TIP. From FY 2011 to FY 2015 there were 4 seismic retrofit projects, all of these a continuation of projects scheduled for design in earlier cycles. There were 18 other bridge replacement, rehabilitation, or other related bridge projects also considered in the TIP. From FY 2015 to FY 2018 there were 3 seismic retrofit projects, all of these a continuation of projects scheduled for design in earlier cycles as. There are 13 other bridge replacement, rehabilitation, or other related bridge projects also considered in the TIP.

Table 10-3. Bridge Seismic Mitigation

Oahu Transportation Improvement Program - FY 2015 through FY 2018

Project	Total Amount Programmed						Estimated Total Project Cost (1$1000)
	FFY 2015 (1$1000)	FFY 2016 (1$1000)	FFY 2017 (1$1000)	FFY 2018 (1$1000)	(For Information Only) FFY 2019 (1$1000)	(For Information Only) FFY 2020 (1$1000)	
Interstate Route H-3, Seismic Retrofit, Kuou Bridge and Halekou Interchange, Structures 1, 2, and 3		1080			6,240		7,320
Moanalua Freeway (Route H-201), Seismic retrofit, Puuloa Interchange, Ramp "A".			4,030				4,500
Moanalua Freeway (Route H-201), Seismic retrofit, Puuloa Interchange, Puuloa Separation.			6,580				7,200

Oahu Transportation Improvement Program - FY 2011 through FY 2014

Project	Total Amount Programmed						Estimated Total Project Cost (1$1000)
	FFY 2011 (1$1000)	FFY 2012 (1$1000)	FFY 2013 (1$1000)	FFY 2014 (1$1000)	(For Information Only) FFY 2015 (1$1000)	(For Information Only) FFY 2016 (1$1000)	
Interstate Route H-3, Seismic Retrofit, Halekou Interchange, Structures 1, 2, and 3						1,080	3,500
Moanalua Freeway (Route H-201), Seismic retrofit, Puuloa Interchange, Ramp "A".						3,950	4,800
Moanalua Freeway (Route H-201), Seismic retrofit, Puuloa Interchange, Puuloa Separation.						6,450	7,300
Seismic Bridge Retrofit (City and County of Honolulu Sponsored)				300		600	900

Oahu Transportation Improvement Program - FY 2008 through FY 2011

Project	Total Amount Programmed						Estimated Total Project Cost (1$1000)
	FFY 2008 (1$1000)	FFY 2009 (1$1000)	FFY 2010 (1$1000)	FFY 2011 (1$1000)	(For Information Only) FFY 2012 (1$1000)	(For Information Only) FFY 2013 (1$1000)	
Interstate Route H-1, Seismic retrofit, Farrington Highway (Route 9107) Separation & Makakilo Separation	80	1,800					2,500
Interstate Route H-1, Seismic retrofit, Pali Highway (Route 61) Overpass, Ramp & Pali Highway - Nuuanu Avenue Separation					3,786		4,250
Interstate Route H-3, Seismic retrofit, Mokapu Boulevard (Route 65) Interchange						3,016	3,500
Moanalua Freeway (Route H-201), Seismic retrofit, Puuloa Interchange, Ramp "A".						3,692	4,600
Moanalua Freeway (Route H-201), Seismic retrofit, Puuloa Interchange, Puuloa Separation.						5,928	7,200
Seismic Bridge Retrofit (City and County of Honolulu Sponsored)					600		2,100

10.4.2 Risk Assessment of Honolulu Essential Facilities and University of Hawaii Buildings

Two separate risk assessment screening exercises were performed for the critical facilities on Oahu and the University of Hawaii campus buildings. HAZUS-MH was used to produce earthquake loss estimates and identify the most vulnerable essential facilities using an updated essential facility database for the City and County of Honolulu described in Chapter 19. For all buildings with a known year of construction the following rules applied:

For typical building types: Pre-Seismic Code: (Before 1978) PC
Low Seismic Code: (1978 - 1990) LC
Low Special Seismic Code (1991 – present) LS

Exceptions:

Unreinforced Masonry Structures: Use for URML and URMM
Pre-Seismic Code: (all years) PC

Steel Moment Frame: Use for S1L, S1M, and S1H,
Benchmark year = 1994 UBC (adopted August of 1997)
Pre-Seismic Code: (Up to1997) PC
Low Special Seismic Code (1998 – present) LS

Steel Braced Frame: Use for S2L, S2M, and S2H
Benchmark year = 1988 UBC (adopted October 1990)
Pre-Seismic Code: (Up to1990) PC
Low Special Seismic Code (1991 – present) LS

Reinforced Masonry Structures: Use for RM1L, RM1M
Benchmark year = 1997 (adopted June of 2000)
Pre-Seismic Code: (Up to 2000) PC
Low Special Seismic Code: (2001- present) LS

Tilt-Up Concrete Construction: Use for PC1 structures
Benchmark year = 1997 (adopted June of 2000)
Pre-Seismic Code: (Up to 2000) PC
Low Special Seismic Code: (2001- present) LS

State Government buildings would have been required to comply with DAGS DPW Directive for Seismic Zone 3 Structural Design, Calendar Years of Design 1982 – 1998. Accordingly, as an exception, state buildings designed during that policy timeframe were assigned a Design Level of High Code. For buildings lacking the construction date, the design level was assumed to be pre-code (PC), or low-code (LC) if some background knowledge of the building indicated a slightly higher design level.

The soil conditions of different sites were modeled using the SSURGO database (US Dept. of Agriculture, 1995). Using NCSS mapping standards, soil maps in the SSURGO database are made using field methods. Surveyors observe soils along delineation boundaries and determine map unit composition by field traverses and transects. Aerial photographs are interpreted and used as the field map base. Based on this survey the soil types throughout the Island of Oahu are shown in Figure 10-5.

For loss estimation and building vulnerability ranking a magnitude 6.8 earthquake scenario with an epicenter near the Island of Lanai was analyzed within the HAZUS model. Shake maps prepared by David Wald of USGS for peak ground acceleration, velocity, and spectral accelerations were imported into the model for this study. This is a deep lithospheric earthquake with a similar seismogenic mechanism as the Kiholo Bay earthquake, i.e., plate flexural failure. Maximum peak ground accelerations on Oahu were about 12% gravity at the southeastern most point of the island, with values elsewhere of between 2% to 10%.

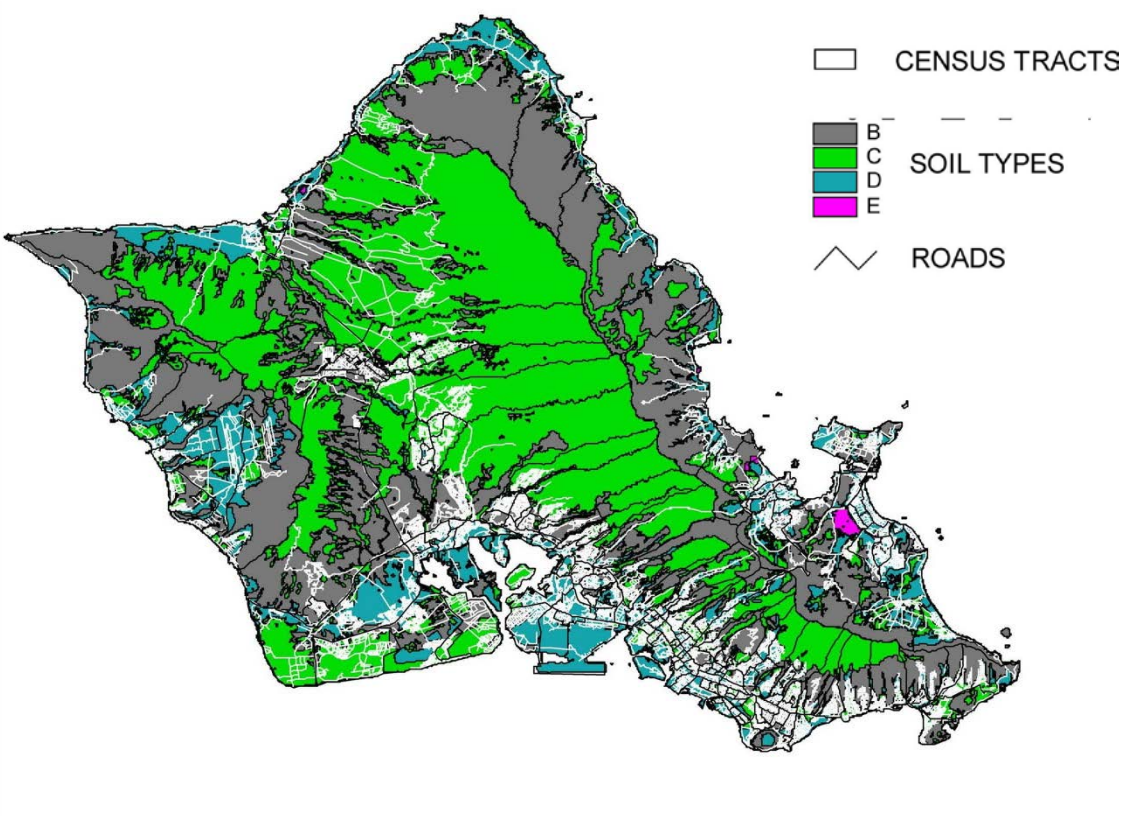


Figure 10-5. Consolidated Soil Types as Referenced by the IBC on the Island of Oahu

The results of these analyses are discussed in Chapter 19. The buildings most vulnerable to earthquakes were identified from these analyses, although the earthquake vulnerabilities were typically much less than the hurricane vulnerabilities.

10.5 Future Mitigation Projects

The following are recommended projects that would reduce seismic vulnerability within the City and County of Honolulu:

- Adopt 2018 IBC and related codes per HRS 107 Part II



11. Landslides, Debris Flows and Rock Falls

11. LANDSLIDES, DEBRIS FLOWS AND ROCK FALLS

2012 Plan	Description of Updates / Revisions in the 2018 Plan
The 2012 plan discusses the various mechanisms for landslides and rockfalls in Hawaii and high hazard areas. It contains a detailed history of rockfalls on Oahu.	• This chapter is slightly reorganized and then significantly modernized. Honolulu combines several of the essential components for landslide and rockfall hazards: steep hillsides, heavy rainfall, and strong pressure for residential development in upland areas. They are dangerous because they occur suddenly and move rapidly by flowing or avalanching down hillslopes and channels. They generally occur during or immediately after severe rainfall of more than 3 inches in a peak 6-hour period. • Information on rockfalls due to seismic activity is removed due to it being incredibly unlikely to occur on Oahu. • More data on historic debris flows has been added, and unnecessary historical details have been removed. • Mudslides on Kauai and Oahu in April 2018 are discussed. • The 2012 update to the Rockfall Hazard Rating System is discussed. • There have recently been a number of other mitigation measures funded by various organizations. A significant amount of such rockfall mitigation has been accomplished. A description of recently completed mitigation activities by the state and other organizations has been added. • Different rockfalls mitigation techniques are discussed.

Summary of Mitigation Projects for the City and County of Honolulu

Project	Priority
DNLR recommended that Buffer Zones should be developed or at least incorporated into new developments between high-hazard rock fall areas and homes. This requires implementation into planning policy documentation and further planning projects to create mapping to identify the hazard areas for regulatory purposes, and include rockfall mitigation in the project approval process.	Medium

11.1 Landslides and Debris Flows

A landslide happens when gravity forces land downward, often due to precipitation, runoff, or ground saturation. Debris flows, sometimes referred to as mudslides, mudflows, lahars, or debris avalanches, are common types of fast-moving landslides and occur in a wide variety of environments. Flows are characterized by shear strains distributed throughout the mass of material. Flows are distinguished from slides by high water content and the distribution of velocities resembles that of viscous fluids. These flows are a form of rapid mass movement in which loose soils, rocks, and organized matter, combined with air and water, form a slurry that flows downslope. These flows generally occur during periods of intense rainfall.

The consistency of debris flows ranges from watery mud to thick, rocky mud that can carry large items such as boulders, trees, and cars. Debris can also include larger rocks and even boulders causing extensive damage. Debris flows from many different sources can combine in channels where their destructive power may be greatly increased. They continue flowing down hills and through channels, growing in volume with the addition of water, sand, mud, boulders, trees, and other materials in its path. When the flows reach flatter ground, the debris spreads over a broad area, sometimes accumulating in thick deposits that can wreak havoc in developed areas. Once started, however, debris flows can travel even over gently sloping ground. The most hazardous areas are canyon bottoms, stream channels, areas near the outlets of canyons, and slopes excavated for buildings and roads.

Several features on land may be noticeable prior to a landslide. These features include:

- Springs, seeps, or saturated ground appears in areas usually not wet
- New cracks or unusual bulges in the ground, street pavements, or sidewalks
- Soil moves away from foundations

11.1.1 Physical and Historical Setting

The Honolulu District combines several of the essential components for debris-flow hazards: steep hillsides, heavy rainfall, and strong pressure for residential development in upland areas. Debris flows are dangerous because they occur suddenly and move rapidly by flowing or avalanching down hillslopes and channels. They generally occur during or immediately after severe rainfall of more than 3 inches in a peak 6-hour period as illustrated for example in the Kaluanui Study Area in Figure 11-1.

The precipitation map showing the different rainfall intensities based on a 100 year, 1-hour rainfall event is shown in Figure 11-2. It can be seen that the highest rainfalls are concentrated at the top of the Koolau mountain range.

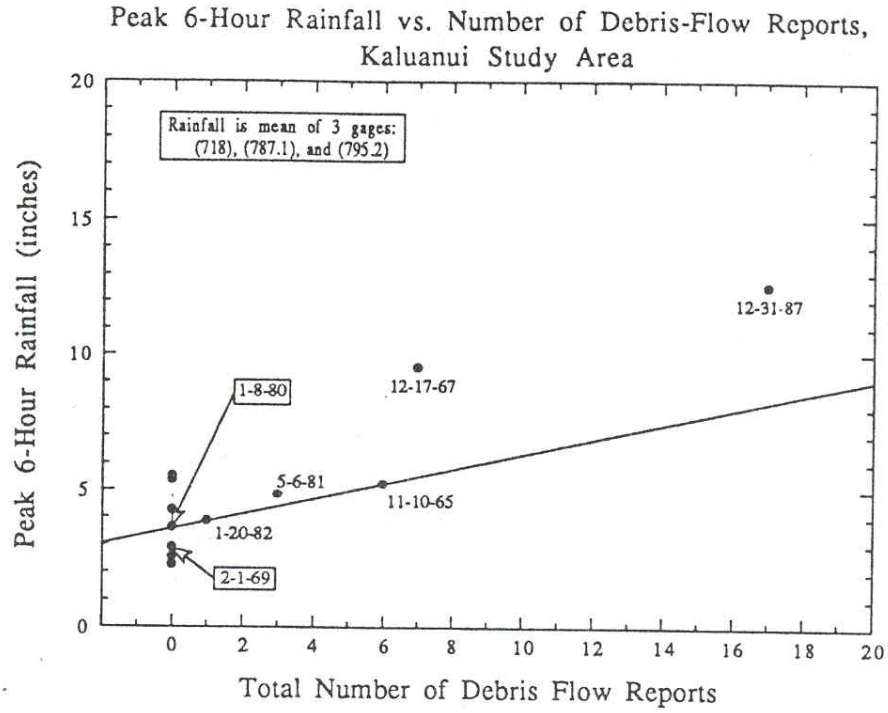


Figure 11-1 - . Correlation between the Number of Debris Flow Reports and Peak 6 Hour Rainfall in Kaluanui Study Area

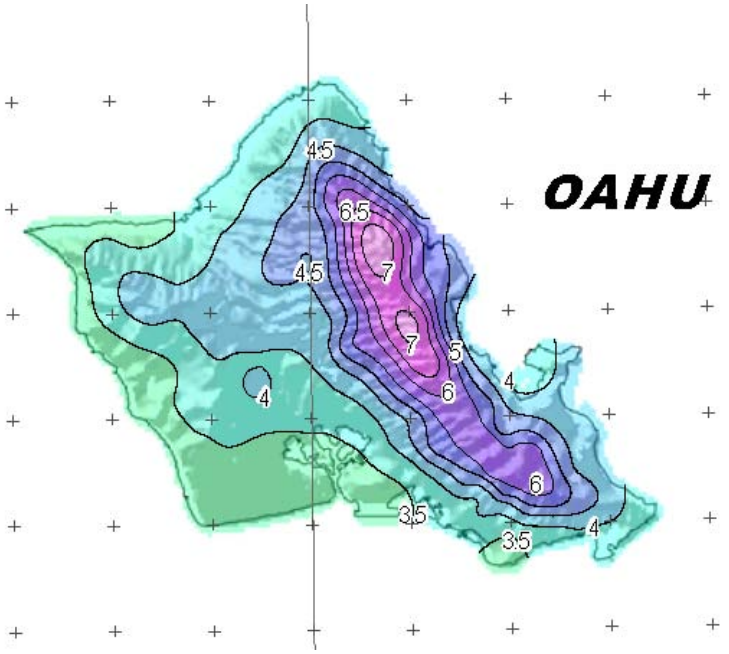


Figure 11-2 . Rainfall Intensity Map for Oahu with an average return period of 100 Years (Contours in Inches of Rainfall per Hour)

USGS has performed a number of studies of historical debris flows affecting Oahu, particularly in the major populated residential areas of Honolulu. The selected storm periods resulting in debris flow are listed in Table 11-1. Storm periods since 1991 are listed based on disaster declarations that include debris flow and other reports on Oahu.

Table 11-1. Selected Storm Periods, 1935-2018, Resulting in Debris Flows

Date	Year
February 27-March 1	1935
January 16-20	1949
December 2-6	1950
March 10-13	1951
March 24-28	1951
March 5-6	1958
March 6	1963
May 14--15	1963
February 3-4	1965
November 10-14	1965
December 17-18	1967
January 31-February 2	1969
February 13-16	1969
February 5-8	1976
May 11-14	1977
October 30-31	1978
January 7-11	1980
May 6-7	1981
January 20-21	1982
February 12-14	1985
December 30-January 1	1987-1988
March 31-April 2	1989
November 5-16	1996
May 9	1999
October 30	2004
February - April	2006
December 4-11	2007
March 3-11	2012
September 11-14	2016
April 13-16	2018

11.1.2 Historic Debris Flows

Reports of possible debris flows summarized in USGS Open-File Report 92-486 (Torikai and Wilson, 1992) for 23 selected Oahu storms in the period of 1935-1991 were utilized to gather data. Historical accounts were also obtained from the Department of Emergency Management (DEM), local government storm publications, and Honolulu's two daily newspapers. The DEM logs also include the dispatches by the Honolulu Police Department, Honolulu Fire Department, and National Weather Service.

More than 1,779 landslides and resulting debris flows have been recognized in aerial photographs of the Honolulu District flown during a period of approximately 50 years per USGS Open File Report 93-213 (Ellen, et al. 1993) USGS Open-File Report 93-514 (Peterson, et al., 1993). Because some proportion of debris- flow features are concealed in photographs of this steep and heavily

vegetated terrain these numbers underestimate the debris flows that have actually occurred. Significant numbers of debris flows appeared in each decade of this period, and particularly large numbers have accompanied major rainstorms.

The debris-flow reports from all sources were classified as either landslides or floods. Landslides refer to flows predominantly consisting of solid material such as rocks and boulders, and floods refer to flows predominantly consisting of water.

Debris flows can cause damage either directly, by colliding with man-made structures, or indirectly, by plugging drainage systems so that flood waters are diverted out of the channels. Debris flows also can sever or cover roads, blocking access to (or egress from) neighborhoods, and thus interfere with emergency operations and evacuations.

A disaster involving debris flow on Oahu occurred in 2006 when a sustained period of heavy rain from February through April caused a number of instances of flooding and mudslides on Oahu and Kauai. On Oahu this included debris flow and mudslides onto Highway 61 (Kailua road) causing closures of the road. In another incident, a mudslide buried cars and other property on Maunaloa road in Makiki. There were further reports of mudslides on Puuhonua Street and flooding in Manoa. Kahala Mall was flooded, causing closure of many of the stores and theaters for up to 9 months.

In April of 2018, record setting rainfall caused similar, although less severe, results to occur on the eastern portion of Oahu as well. During that event, debris clogged drainage systems that were already over capacity, which led to even greater levels of flooding. Refer to Chapter 8 for more information about this event.

11.1.3 Steep Slopes and Unstable Soils

Development on steep slopes or unstable soils can result in hazardous conditions. Where these valley locations have deposits of unstable soils, slow-moving landslides can cause property damage, prompting claims against the City - as has happened in Manoa and Moanalua.

Incremental build-out of hillsides and lower valley slopes can also affect drainage systems, both natural and urbanized. Increased lot coverage by larger buildings and more extensive paving has increased the volume and rate of stormwater discharge. Over the long term, the cumulative impact of greater lot coverage threatens to exceed the capacity of the drainage system, resulting in flood conditions. Under such conditions, stricter development standards may be considered - such as maximum lot coverage and structural stability - than those that apply to level land. The Primary Urban Center Development Plan Land Use Guidelines indicate that the City should “prevent development on properties with average slopes of 40% or more, or on lands with slopes of 20% or more . . .” While the reasoning for this guideline is to avoid “significant adverse visual impact,” it also discourages development in areas subject to debris flows.

A map showing debris flow hazard regions in the City of Honolulu is provided in Figure 11-4.

11.2 Rock Falls and Topples

Rock falls occur when masses of rock or other material detach form a steep slope or cliff and descend by free fall, rolling, or bouncing, as shown, for example, in Figure 11-3. About 2:30 p.m. on May 9, 1999, a landslide killed seven hikers and 50 other were injured in a rockslide at Sacred Falls State Park, near Hauula on the north shore of Oahu, Hawaii. One of the injured hikers later died of injuries received in the landslide. Then Governor of Hawaii, Ben Cayetano, ordered that the park be closed due to concern about continuing landslide hazard near the falls.



Figure 11-3. The scene, a day after the May 9, 1999 landslide at Sacred Falls (Department of Land and Natural Resources photograph, 1999)

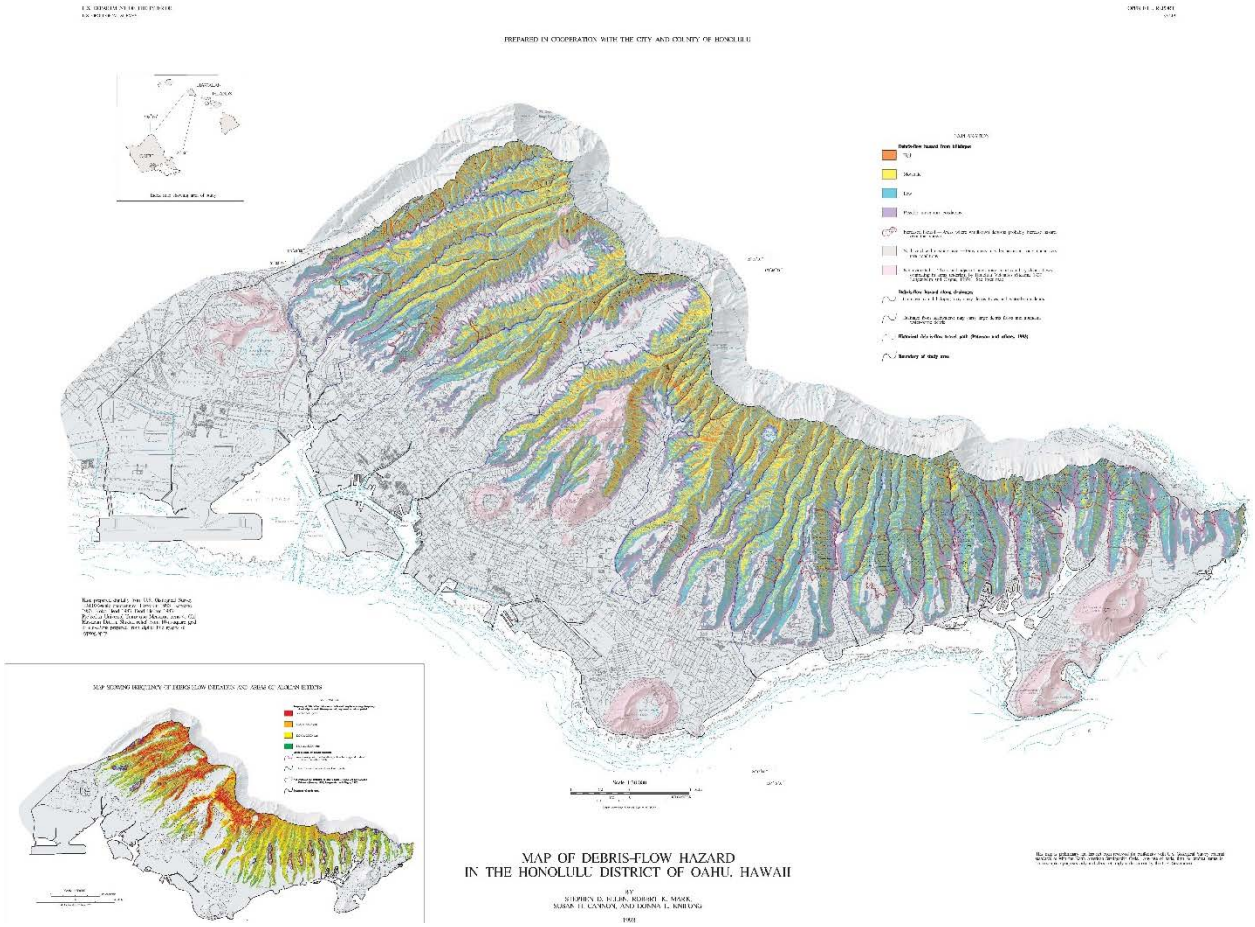


Figure 11-4. Map of Debris Flow Hazard in Honolulu (Ellen, etal., 1993)

11.2.1 Weathering Processes and Rock Alteration

Rockfalls may be initiated through a combination of weathering, fracture, and steep slope. Several natural mechanisms contribute to the alteration and breakdown of rock along Hawaii roadways. Mechanical weathering represents breaking up of rock by physical disintegration. Examples of mechanical or physical weathering are stream erosion, wave erosion, or the fragmentation of rock faces caused by enlargement of fractures. In addition to destabilization of rockfall and landslide locations due to rain, the destabilization can also be caused by seismic activity.

11.2.2 Historic Rock Falls

Notable rockfalls include a Waimea Bay rockslide in March, 2000 which hit two cars and resulted in total closure of highway 83 affecting 6,000 vehicles a day for more than two weeks. Emergency design and construction of a realigned roadway cost $10 million. An October 15, 2002 rockslide at Makapuu Point closed a lane of highway 72, affecting 10,200 vehicles a day for several months. Though there have not been highway deaths in recent years due to falling rocks, there have been severe injuries.

The death of a woman who died in her bed when a six-ton boulder crashed into her Nuuanu home August 9, 2002 highlighted the danger of falling rocks in residential areas near steep slopes. Other incidents that have highlighted the instability of Hawaii's hillsides and cliffs include evacuation of a section of Hawaii Kai townhomes after a boulder rolled onto a resident's car on November 28, 2002. On April 12, 2018, a 4.5 ft by 3.5 ft boulder estimated at five tons crashed into a Manoa home late at night. Although no one was injured, that boulder and subsequent other rocks did damage to several homes in that area.

In 2003, the State had identified 66 highway sites on Oahu that had a high risk of rockfall (or landslide) and began work to fix a significant number of these in recent years. A number of these completed or continuing projects can be seen in Table 11-4. Presently, the Honolulu City and County roads needing immediate remediation are those listed as Class A in the Rockfall Hazard Rating System.

11.2.3 Rockfall Hazard Assessment

The Oahu rockfall study was designed and implemented based solely on the guidance presented in *Rockfall Hazard Mitigation Methods* (Publication No. FHWA SA-93-085, March 1994) and *Rockfall Hazard Rating System* (Publication No. FWHA SA-93-057, November 1993) (Lim, 2003). Initially created in 2002, the database for the ratings of City streets received an update in November, 2012.

11.2.3.1 Preliminary Rockfall Rating

The preliminary rockfall rating is a subjective rating that groups the hazard conditions into three classes:

- Class A - High estimated potential for rockfall on roadway with high historical rockfall activity. A Class A rating means that the chances of rock falling in a site is moderate to high, and that when the rockfall occurs, it will certainly reach the roadway pavement. An example of a Class A condition is where rocks on the cut slope overhang the roadway and in an area where little or no rock catchment ditch is present, as shown in Figure 11-7. Figure 11-8 illustrates high risk due to several vehicles in a potential rockfall area at a given time.
- Class B - Moderate estimated potential for rockfall on roadway with moderate historical rockfall activity. As the rockfall risk is reduced, a Class B rating indicates that although a rockfall is probable, the chances of it reaching the roadway pavement are low to moderate. A possible scenario for Class B is a condition where a rockfall from the slope is clearly possible, and the catchment ditch is large enough to prevent most of the rocks from reaching the pavement (Figure 11-9).
- Class C - Low estimated potential for rockfall on roadway with low historical rockfall activity. Class C rating pertains to a condition in which there is a low chance for a rockfall event, but should one occur, there is no chance for the rocks to reach roadway pavement.

In the 2002 report, 256 rockfall sections were selected along 122 City streets and had the aforementioned rating system applied to them. 56 sections received Class “A” ranking, 93 sections received Class “B” ranking, and 107 sections received Class “C” ranking. Due to mitigation efforts, undesired changes, or changes in development, the 2012 report updated their rankings. 59 sections received Class “A” ranking, 93 sections received Class “B” ranking, and 104 sections received Class “C” ranking. Many slopes had their rating changed, despite the numbers appearing almost the same. For example, Koko Mai Drive had its ranking changed from “A” to “C” due to a rockfall mitigation project while Ala Lani Street’s ranking went from “C” to “A” due to a nearby rockslide. Some slopes were added to the list and others were removed as well. For the full report, visit the City and County of Honolulu Department of Design and Construction’s website: (http://www.honolulu.gov/ddc.html).

The given highways are mapped in Figure 11-5 for reference. A detailed evaluation was conducted at the most hazardous sites as described below. Table 11-2 lists the top ten high-scoring rockfall sites on Oahu. The approximate locations of these ten sites are shown in the accompanying Figure 11-6. .

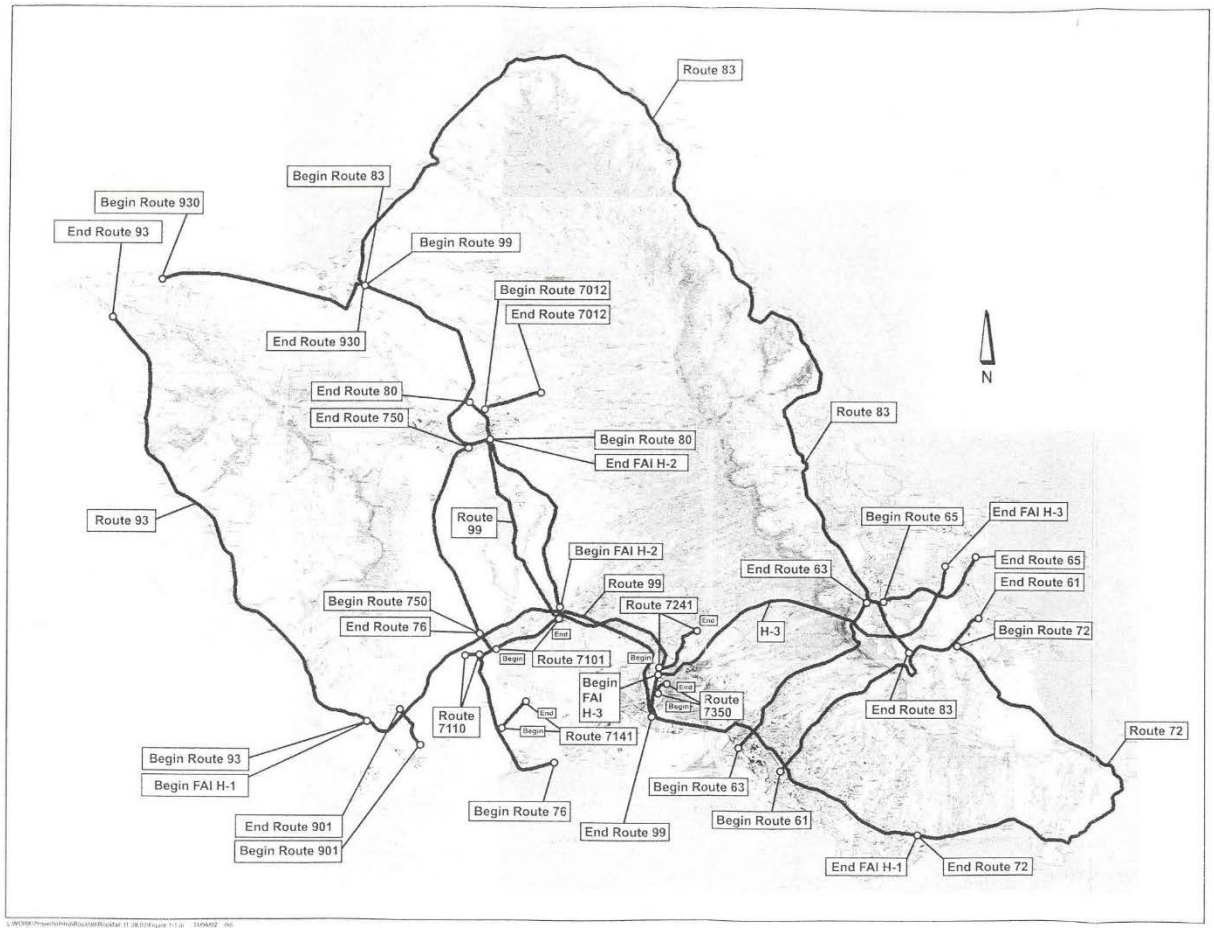


Figure 11-5. State of Hawaii Department of Transportation Highways and Roadway Routes - Oahu, Hawaii

Table 11-2. Top Ten High-Scoring Rockfall Hazard Sites on Oahu

No.	Highway Name	Hwy. No.	Beg MP	End MP	Total Hazard Score	Long-term Solution Preliminary Cost (subject to HDOT review)	ADT	Current Status	Lowest Cost Alternative
1	Kalanianaole Hwy	72	8.14	8.45	638	$1,500,000	10,179	Retaining wall repair and steel mesh fence installed	Draped steel mesh
2	Kamehameha Hwy	83	5.40	5.52	628	$8,400,000	5,973	Rockfalls 3-4 times a year, future remedial work expected	Realign roadway
3	Kamehameha Hwy	83	13.85	14.00	582	$3,800,000	6,401	Occasional falls, mitigation considered no longer a priority by HDOT	Realign roadway
4	Pali Hwy	61	8.20	8.50	576	$4,300,000	22,858	Cut corrected slope completed	
5	Pali Hwy	61	7.68	7.93	568	$6,000,000	22,858	Corrected slope cut completed	
6	Kamehameha Hwy	99	14.05	14.35	519	$18,500,000	25,824	Mitigated with draped steel mesh, further work ongoing	Rockfall protection canopy
7	Kamehameha Hwy	80	0.60	0.69	512	$2,600,000	23,161	Landslide 2-3 times a year, project deferred	Create mechanically stabilized earth embedment
8	Pali Hwy	61	10.25	10.45	497	$4,800,000	13,100	Many falls, road realignment completed	
9	Farrington Hwy	93	18.78	19.40	494	$2,600,000	1,791	Many rockfalls	Draped steel mesh
10	Kamehameha Hwy	80	0.80	1.00	493	$3,500,000	23,161	Occasional falls, project deferred	Cut corrected slope

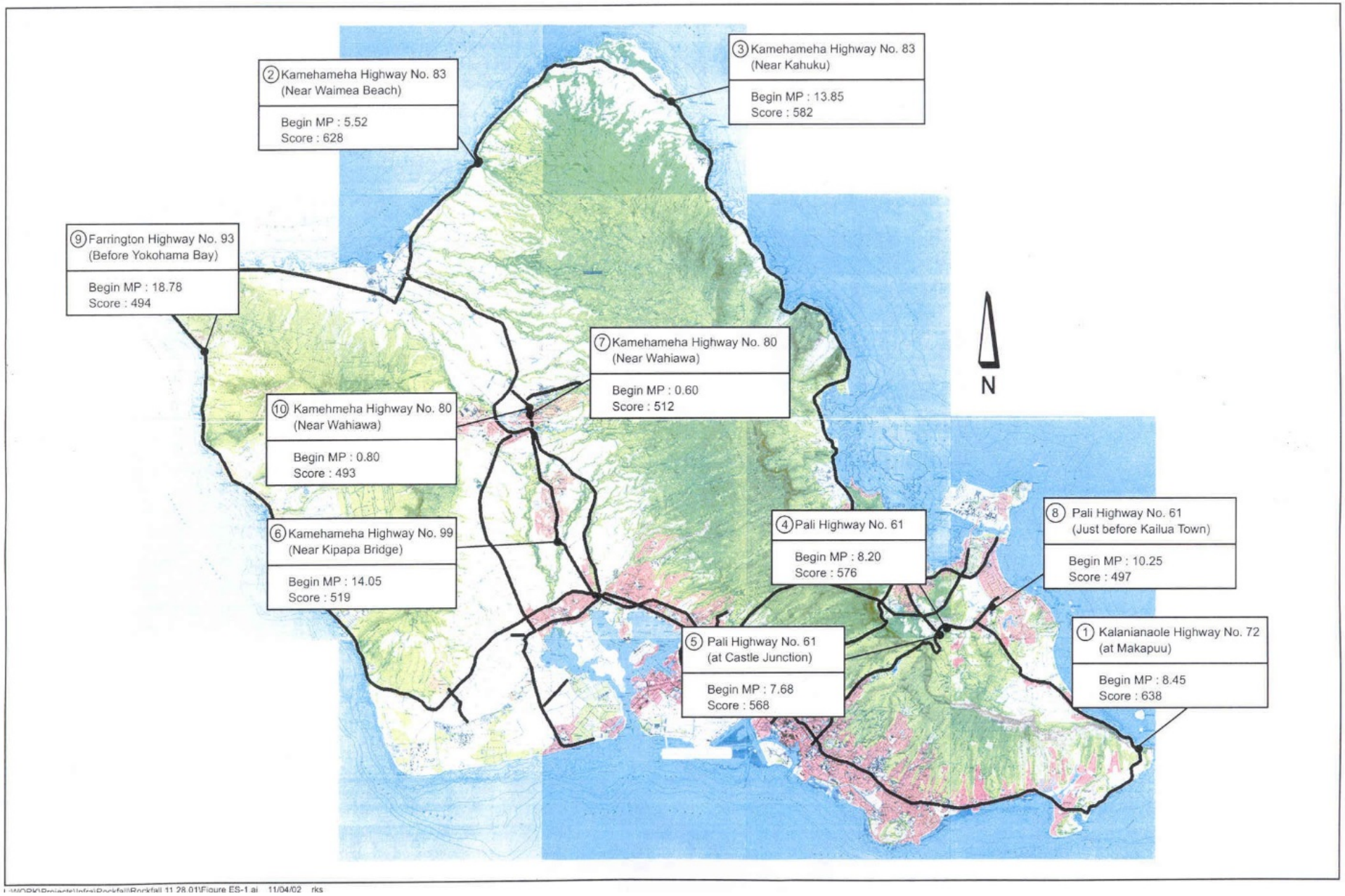


Figure 11-6. Top Ten High-Scoring Rockfall Hazard Sites on Oahu



Figure 11-7. Example of a Class A Rated Slope Hazard

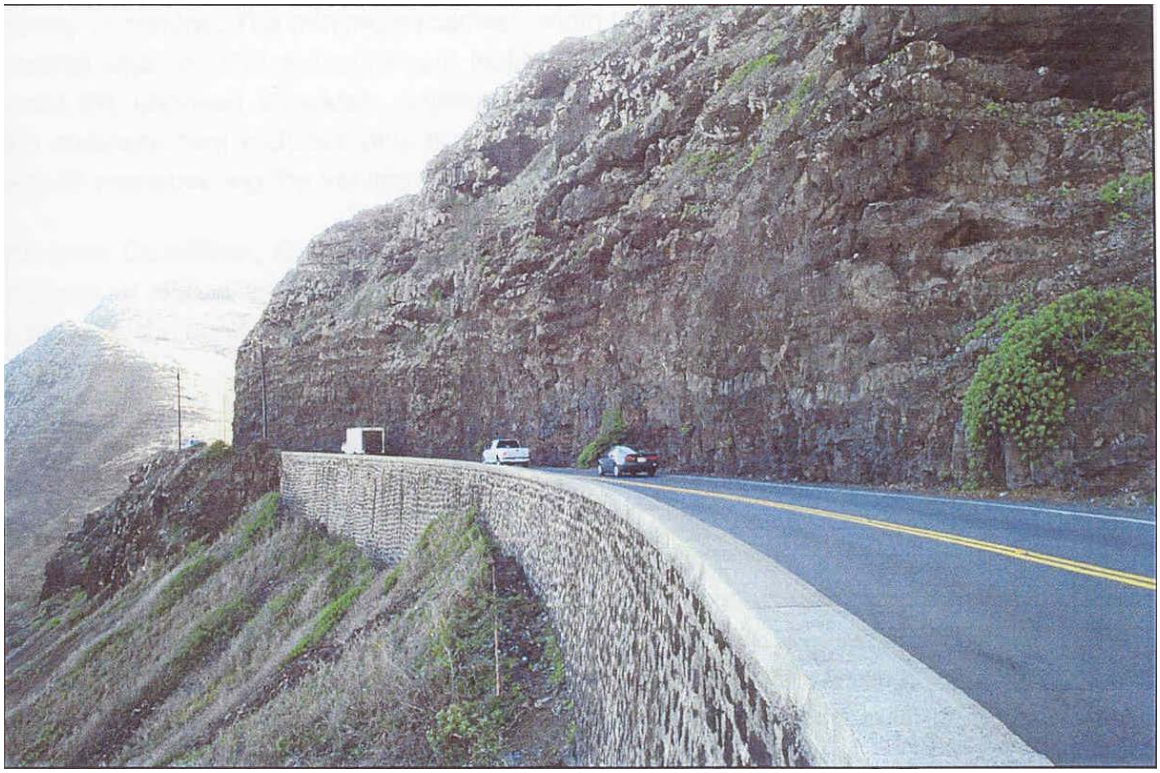


Figure 11-8. Average Vehicle Risk: Shows how many vehicles were in the rockfall section at any one time. Kalanianaole Highway, 2000.



Figure 11-9. Updated picture of Kalanianaole Highway after rockfall a mitigation project was completed. Photo from Google Maps, taken June 2011.

11.2.3.2 Detailed Rock Fall Rating

The study evaluated each of these potential rockfall sites in greater detail and gave them a hazard rating. The detailed rockfall rating produces a numerical score of the probability of rockfall at a site based on the cumulative scores of 12 evaluation categories. On that basis, each site was given a final point total and rated high, moderate, or low in rockfall danger.

1. Slope height
2. Ditch effectiveness
3. Average vehicle risk, derived from Average Daily Traffic (ADT)
4. Percentage of decision sight distance
5. Roadway width
6. Structural condition, Case One slopes (movement along discontinuities)
7. Rock friction
8. Structural condition, Case Two slopes (differential erosion or over-steepening leads to rockfall)
9. Difference in erosion rates
10. Volume of rockfall event
11. Climate and the presence of water on slope
12. Rockfall history

Table 11-3 below presents the 12 evaluation categories along with the benchmark criteria used to assign scores to a slope. The categories and criteria are from the RHRS, adapted for Oahu conditions. Some categories require subjective evaluation, while others require field measurements.

Table 11-3 Rating Criteria and Scores, Detailed Rockfall Hazard Rating

Category		Benchmark Criteria			
		Points 3	Points 9	Points 27	Points 81
Slope Height[a]		25 ft.	50 ft.	75 ft.	100 ft.
Ditch Effectiveness		Good catchment	Moderate catchment	Limited catchment	No catchment
Average Vehicle Risk (Fig. 7-6)		25% of the time	50% of the time	75% of the time	100% of the time
Percent of Decision Sight Distance[b]		Adequate sight distance, 100% of low design value	Moderate sight distance, 80% of low design value	Limited sight distance, 60% of low design value	Very limited sight distance, 40% of low design value
Roadway Width Including Paved Shoulders		44 ft.	36 ft.	28 ft.	20 ft.
Case 1	Structural Condition	Discontinuous joints, favorable orientation	Discontinuous joints, random orientation	Discontinuous joints adverse orientation	Continuous joints, adverse orientation
	Rock Friction	Rough, irregular	Undulating	Planar	Clay infilling, or slickensided
Case 2	Structural Condition	Few differential erosion features	Occasional differential erosion features	Many differential erosion features	Major differential erosion features
	Difference in Erosion Rates	Small difference	Moderate difference	Large difference	Extreme difference
Block Size / Volume of Rockfall/Event		1 ft./3 yd.^{3}	2 ft./6 yd.^{3}	3 ft./9 yd.^{3}	4 ft./12 yd.^{3}
Climate and Presence of Water on Slope		Low to moderate precipitation; no freezing periods; no water on slope	Moderate precipitation or short freezing periods or intermittent water on slope	High precipitation or long freezing periods or continual water on slope	High precipitation and long freezing periods or continual water on slope and long freezing periods
Rockfall History		Few falls	Occasional falls	Many falls	Constant falls.

Source: Pierson and Van Vickle, 1993

[a] slope heights greater than 100 feet received a score of 100 points

[b] Percent of Decision Sight Distance lower than 40 percent received a score between 82 and 100 points

11.3 Recent or Current Landslide and Rockfall Mitigation Projects:

11.3.3 Discussion of Mitigation Techniques

There are several popular rockfall mitigation techniques, many of which are visible around Oahu in current mitigation projects. The three main elements that engineers consider when designing rockfall mitigation projects are: impact kinetic energy (the size and speed of the expected rocks), site geometry (height, steepness, and area around the slope), and cost-benefit reasoning (design cost efficient projects). Projects normally fall into two design types: ditches and barriers or nets

and fences. The idea behind ditches and barriers is to allow rocks to roll down and impact strong barriers that cause them to lose energy and therefore cause no harm. Nets and fences are designed to do the same thing but they do not require the use of a large ditch along the roadside. Due to a significant number of Oahu's roadways being either coastal or mountainous, existing roads often do not have room for these ditches, thus making nets and fences a more popular choice locally. In areas with room for catchment ditches, netting is attached at the top of the slope and draped down like in Figure 11-10 along Kalanianaole Highway. In areas without room for catchment ditches, metal rods called "pins" are utilized to keep both the netting and hillside in place. Pins on their own can also be inserted to create stable slopes. Rockfall fences are designed to expand upon contact to absorb energy from the rocks and cause them to stop moving. Removing potentially hazardous material and replacing it with engineered material like concrete can also stabilize a slope.



Figure 11-10. Example of rockfall mitigation techniques used by Prometheus Construction during their work on Pupukea Road in 2014 (http://prometheusconstruction.com/pupukea-road-rockfall-mitigation-phase-1/)

11.3.4 Recent Projects

In addition to the recently developed Highways Modernization Plan the ongoing Oahu Transportation Improvement Program (TIP) is a programming document that lists transportation projects that will be undertaken by the State of Hawaii and City and County of Honolulu, and funded in part with federal money. Projects identified in the TIP must be consistent with the Oahu Regional Transportation Plan (ORTP). The TIP is the short-term three-year implementation program for federally assisted surface transportation projects. It describes and prioritizes federally assisted and regionally significant locally-funded transportation programs and projects selected by the Oahu Metropolitan Planning Organization (OMPO) Policy Committee for implementation during the program period. It identifies funding amounts by source of funding, jurisdictional

responsibility, type of project, and year of funding for these projects. An annual review and a major biennial update of the TIP are scheduled, with off-schedule amendments considered as needed. The TIP is adopted by the OMPO Policy Committee and sent to the Governor for approval. Upon approval, the TIP is incorporated as the Oahu element of the Statewide TIP (STIP).

The TIP lists several rockfall mitigation projects as shown in Table 11-4. These majority of the projects listed have successfully been implemented and significantly improve the rockfall mitigation practices in place on Oahu. The ongoing Waimea Bay project has since been deferred in a later amendment to the TIP, and is receiving a feasibility study for alternatives as of 2018.

Additional mitigation projects for Class A slopes are recommended to further improve safety along Oahu's roads. Prioritization of these projects is dependent on a number of factors, including: construction cost, funding availability, the type of mitigation technique to be employed and whether a secondary access road is necessary and available.

The Pali Highway is currently undergoing a $20 million landslide/rockfall prevention and protection project. In addition to Department of Transportation projects, other organizations are also active in rockfall and landslide mitigation including private landowners, the State Department of Land and Natural Resources (DNLR), and the various branches of the military. DLNR conducts assessments, evaluations, responses, and mitigation projects related to landslides and rock falls on state-owned lands (with exceptions, e.g., DOT lands).

The following is a list of some examples of mitigation projects that are either ongoing or recently completed outside the Department of Transportation jurisdiction, mostly from the City and County of Honolulu (C&C):

- March 2013 – C&C rockfall mitigation project finishes along Sierra Drive.
- November 2014 – C&C rockfall mitigation projects finish along Pupukea Road.
- October 2015 – DLNR reopens Aiea Loop Trail after a landslide blocked the path.
- October 2015 – DLNR constructs rockfall impact resistant fencing in Lanikai under the popular "Lanikai Pillboxes" hike.
- March 2016 – C&C rockfall mitigation projects at Hanauma Bay finish.
- August 2016 – C&C rockfall mitigation project for Booth Road began.
- October 2016 – C&C rockfall mitigation project along Mokapu Saddle Road finishes.
- January 2017 – Rockfall mitigation project finishes at HPHA Puahala Homes.
- December 2018 – DNLR finishes rockfall mitigation project at Diamond Head State Monument.

Table 11-4 . TIP Rockfall Mitigation Related Projects

Oahu Transportation Improvement Program - FY 2015 through FY 2018

Project	Total Amount Programmed						Estimated Total Project Cost (1$1000)
	FFY 2015 (1$1000)	FFY 2016 (1$1000)	FFY 2017 (1$1000)	FFY 2018 (1$1000)	(For Information Only) FFY 2019 (1$1000)	(For Information Only) FFY 2020 (1$1000)	
Kamehameha Highway, Rockfall Protection, Waimea Bay	470			10,080		8,000	19,800

Oahu Transportation Improvement Program - FY 2011 through FY 2014

Project	Total Amount Programmed						Estimated Total Project Cost (1$1000)
	FFY 2011 (1$1000)	FFY 2012 (1$1000)	FFY 2013 (1$1000)	FFY 2014 (1$1000)	(For Information Only) FFY 2015 (1$1000)	(For Information Only) FFY 2016 (1$1000)	
Kamehameha Highway, Rockfall Protection, Waimea Bay		50			470	9,690	11,100

Oahu Transportation Improvement Program - FY 2008 through FY 2011

Project	Total Amount Programmed						Estimated Total Project Cost (1$1000)
	FFY 2008 (1$1000)	FFY 2009 (1$1000)	FFY 2010 (1$1000)	FFY 2011 (1$1000)	(For Information Only) FFY 2012 (1$1000)	(For Information Only) FFY 2013 (1$1000)	
Kalanianole Highway (Route 72) Improvements, Retaining Wall at Makapuu	11,923						13,000
Kamehameha Highway, Rockfall Protection, Waimea Bay	1,510					9,500	11,010

Oahu Transportation Improvement Program - FY 2006 through FY 2008

Project	Phase	FY 2006			FY 2007			FY 2008			TEA-21 Funding Category
		Total (1$1000)	Federal (1$1000)	Local (1$1000)	Total (1$1000)	Federal (1$1000)	Local (1$1000)	Total (1$1000)	Federal (1$1000)	Local (1$1000)	
Kalanianole Highway Improvements, Retaining Wall at Makapuu. The scope of work will consist of constructing and/or repairing a retaining wall along Kalanianiole Highway in the vicinity of Makapuu Point, including subsurface investigation and slope protection. This project is deemed necessary to qualify for Federal-Aid financing and/or reimbursement.	CON							9,990	7,920	1,980	National Highway System
Kamehameha Highway, Rockfall Protection Vicinity of Kahuku. Rockfall mitigation measures along Kamehameha Highway in the vicinity of Kahuku.	DES							1,000	800	300	STP Flexible
Kamehameha Highway, Rockfall Protection at Waimea Bay MP 5.4 to MP5.52. Rockfall mitigation measures along Kamehameha Highway at Waimea Bay.	DES							1,500	1,200	300	STP Optional Safety

11.4 Future Landslide and Rock Fall Hazard Mitigation Projects

Proposed mitigation projects to reduce rockfall and debris flow hazards are:

- Incorporate all-hazard assessments in land development application process. DNLR recommended that Buffer Zones should be developed or at least incorporated into new developments between high-hazard rock fall areas and homes. This requires implementation into planning policy documentation and further planning projects to create mapping to identify the hazard areas for regulatory purposes, and include rockfall mitigation in the project approval process.
- Continue the process of rockfall mitigation projects along Class “A” slopes.

Further details of the proposed project are provided in Chapter 19.



12. Drought

12. DROUGHT

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
Droughts, drought impacts for the various sectors, drought management, and advancements in drought monitoring are described. The 2005 Hawaii Drought Plan is discussed in detail.	• Drought hazard considered three sectors impacted by drought: the water supply sector, agriculture and commerce sector, and the environment, public health and safety sector. • Drought monitoring, prediction, communication and mitigation is managed through the Hawaii Drought Plan steered by the Hawaii drought council. The Hawaii Drought Plan received an update in 2017. • The integrated water system on Oahu effectively minimizes water supply risks to any particular area on Oahu although continued development in the drier leeward areas will put future pressure on the system. • A relatively small portion of the island is used for agriculture, therefore, the commercial sector is not as severely affected by drought as more extensive agricultural counties. Central Oahu has the most vulnerable agricultural areas. • The primary environmental safety concern from drought is the wildfire hazard which is exacerbated during drought conditions, particular at the urban wildland interfaces in the Mililani/Waipio areas. • The status of recent drought mitigation is discussed • New drought mitigation activities are included. • The Hawaii Rainfall Atlas (Giambelluca, et al. 2013) has been updated

Summary of Mitigation Projects for the City and County of Honolulu

Refer to Section 12.13 for the list of other proposed mitigation activities for drought. Drought mitigation comprises a broad range of proactive measures. "Risk management" using a proactive approach to drought management is a better mitigation tool than the nominal reactive or "crisis management" approach. Recommended mitigation actions have been clustered into the following categories:

- Statewide Water Resources Monitoring and Impact Assessments;
- Development of New or Alternative Water Sources;
- Water Conservation Practices;
- Public Education Awareness and Outreach;
- Watershed Protection Partnerships;
- Legislation, and;
- Land Use Planning

12.1 Hazard Description

A drought, which is defined as a water shortage caused by a deficiency of rainfall, can be increased by other factors such as high temperatures, high winds, and low relative humidity. Drought can also result from human activities that increase demand for water. Expanding populations, irrigation, and environmental awareness all put pressure on water supplies. The severity of the drought depends not only on the duration, intensity, and geographic range, but also on the regional water supply demands made by human activities and vegetation.

Drought differs from other natural hazards in three significant ways. First, a drought's onset and end are difficult to determine since the effects accumulate slowly and may linger even after the apparent termination of an episode. Second, the absence of a precise and universally accepted definition adds to the confusion about whether a drought exists, and if it does, the degree of severity. Third, unlike most other natural hazards, drought impacts are less obvious and are spread over a larger geographic area. These characteristics have hindered the development of accurate, reliable, and timely estimates of drought severity and effects.

12.1.1 Average Rainfall

The climate, and hence the amount of rainfall, of the Hawaiian Islands is directly influenced by the northwesterly trade winds. Typically, leeward locations (south and west shores) are much drier and sunnier than windward locations (north and east shores). Within leeward and windward locations, however, rainfall varies considerably according to elevation. Figure 12-1 shows a map indicating the average annual precipitation for Oahu.

12.1.2 El Niño

A large-scale meteorological pattern governs temperature and precipitation trends in the Pacific Ocean. This pattern is called the Southern Oscillation and it is related to the pressure difference between a body of dry air (a high pressure system) located in the southeast Pacific over Easter Island and a body of wet air (a low pressure system) located over Indonesia in the southwest Pacific. Under normal conditions, air flows from the high pressure to the low pressure and creates the trade winds. These blow east to west across the surface of the equatorial Pacific and drive a warm surface current into the western Pacific. This water is replaced in the east by deep cold ocean water (a process called upwelling) that is rich in nutrients fueling an important fishing industry off the coast of South America.

On occasion, the pressure difference between the two centers decreases and the trade winds die. This is known as El Niño. As a result, the warm water of the west Pacific surges to the east and heats up the ocean surface in the central and eastern Pacific. Precipitation in the east increases because the warmer water evaporates more readily. Upwelling temporarily comes to an end. Torrential rains and damaging floods across the southern U.S. have resulted, and the Peruvian fishing industry falters, leading to nationwide economic hardship in that country. Most recently, major El Nino events were recorded in the years 1982–83, 1997–98, and 2014–16.

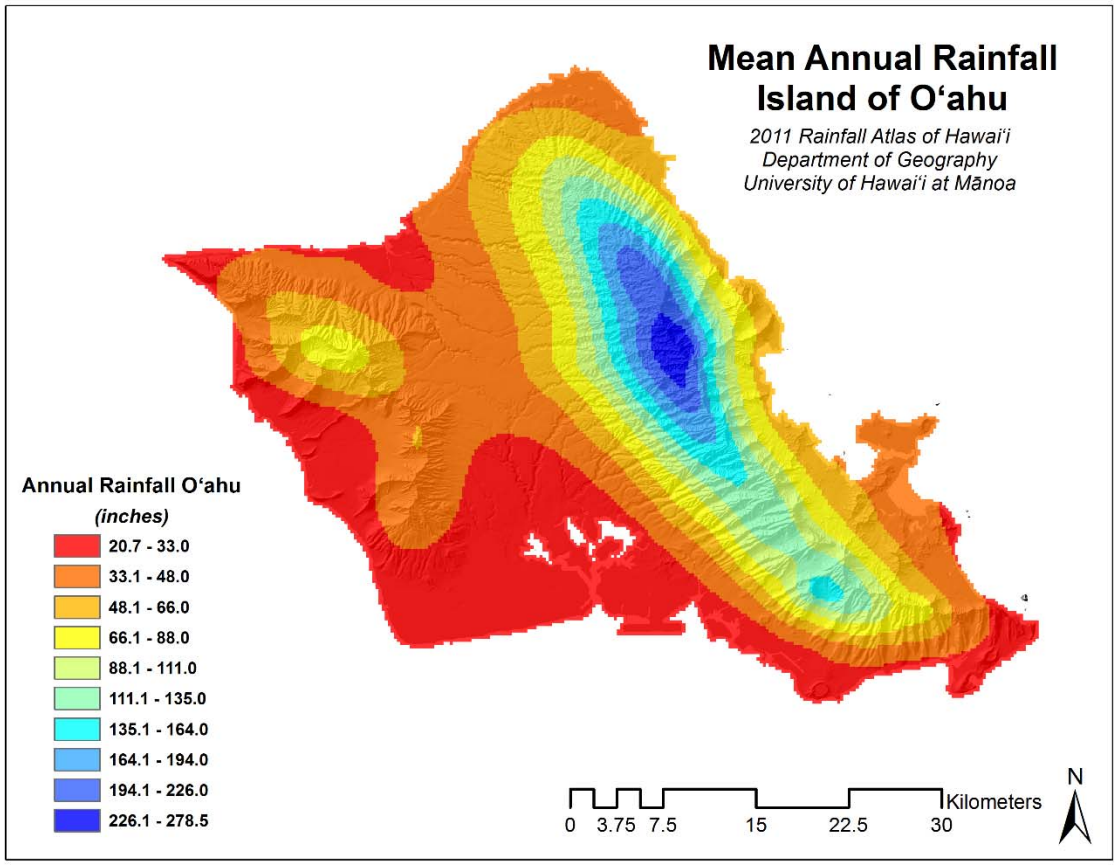


Figure 12-1 Average Annual Precipitation for Oahu 1978-2007 (Giambelluca, et al. 2013))

During an El Niño the Hawaiian Islands usually experience a decrease in rainfall. In fact, the ten driest years on record are all associated with El Niño years. Rainfall decreases because of a southerly shift in the atmospheric circulation system of the north Pacific, a feature called the Hadley Cell. The Hadley Cell is a large continuous belt of air that rises, moisture-laden, from the warm waters north of the equator at about 8° latitude, and moves north across the subtropics where the Hawaiian Islands are located. During its journey the air cools, losing its ability to hold moisture, and produces abundant rainfall. Eventually it descends back to Earth's surface as a column of dry, cool air and creates a pressure system known as the Pacific High. Under normal conditions the Hawaiian Islands experience a wet climate, while to the north and northeast, the Pacific High creates a dry climate. However, during El Niño the surface waters at the equator become significantly warmer and the rising motion of the Hadley Cell shifts to the south. This brings the Pacific High south as well, and the Hawaiian Islands experience a decrease in rainfall. Chu (1995) further refined the El Nino and Hawaiian rainfall relationship by compositing historical rainfall variations through an El Nino cycle. Based on 20 El Nino events since 1905, it shows that the chance of having a dry winter (spring) following an onset of El Nino is 90% for winter and 80% for spring. Deficient rainfall observed during an El Nino winter was statistically unlikely to have occurred by random chance.

12.2 Historic Occurrences

The most severe drought to affect the Hawaiian Islands since streamflow recordkeeping began extended from the late 1930's through most of the 1940's, and the effects were felt on all of the main islands. A moderate to severe drought affected the entire State from 1983 to 1986. Although not as intense on some islands as either the 1938-1947 or the 1970-1979 drought, nor as long, this drought caused cumulative streamflow deficits at some gaging stations that rank second for the period of record. El Nino conditions in the latter part of 2009 and into 2010 resulted in fewer winter storms putting the islands in severe drought conditions. Oahu also experienced drought in 2016, later resulting in wildfires on the slopes of Diamond Head. The drought recurrence intervals calculated from the streamflow deficits ranged from about 10 to more than 25 years, depending on locality.

Although Hawaii has experienced severe droughts, the most detrimental effects usually have been confined to limited areas. The areas most affected by drought are those that normally are dry and depend on winter rains and those that receive little rain from the trade winds. Also, greatly affected are the areas that have no ground-water supply or water supply from another area. Since the termination of sugar cane industry, which used to do the majority of the maintenance on the agricultural irrigation ditches and reservoirs, the reliability of irrigation water has declined around the state.

Monitoring of the Hawaiian climate over the last 50 to 60 years indicates that there has been trend towards an increase in temperature and decrease in statewide rainfall. (Chu et al., 2010) Therefore, future incidences and the intensity of drought may be expected to increase.

12.3 Drought Indices

There are two drought indices primarily used in Hawaii, the Standardized Precipitation Index (SPI), and the Percent of Normal Rainfall Index (PNRI). The SPI is based on the probability of precipitation for a given time scale by measuring the precipitation deviation from the long-term mean. The SPI can quantify the precipitation deficit over multiple time scales. Positive SPI values indicate above average precipitation, while negative values indicate below normal precipitation.

Because the SPI values are normalized, the wide range of rainfall conditions across Hawaii can be assessed on an equal basis. Furthermore, SPI values can be generated for multiple time scales. This is extremely useful for monitoring purposes because drought affects the various sectors over a wide range of time scales. Short-term drought duration (e.g., 3 months) may be important for agricultural practices while long-term duration (e.g., one year or longer) may be vital for water supply management interests. Here, 3-month and 12-month are considered. If 3-month events are desired, a moving average time series is constructed. The resulting time series is then used to compute the 3-month SPI. The 12-month SPI can be obtained in the same manner. Finally, since the SPI uses standard statistical principles, it can also be used to monitor other data such as stream flow, reservoir levels, and ground water levels. Table 12-1 describes the drought classification scheme with average times in which the different drought conditions occur based on SPI for the three different sectors described in Section 12.6. The Honolulu Forecast Office (HFO) of the National Weather Service (NWS) has tailored the SPI software for use in Hawaii.

Table 12-1. Drought Classification Based On SPI

SPI Values	Designation	Time in Category
0.00 to -0.99	Mild Drought	34.1%
-1.00 to -1.49	Moderate Drought	9.2%
-1.50 to -1.99	Severe Drought	4.4%
-2.00 or less	Extreme Drought	2.3%

PNRI is one of the simplest methods of comparing current precipitation amounts to historical averages and is most effective when used for a single region or a single season. PNRI is calculated by dividing the actual precipitation by normal precipitation- typically a 30-year mean- and multiplying by 100%. This index can be calculated for a variety of time scales. The network of rain gauges in Hawaii and the history of precipitation data available make the PNRI a useful indicator for Hawaii. It is also easily understood by the general public, giving it an advantage over other indices.

12.4 National Drought Mitigation Center

The U.S. Drought Monitor is an operational drought monitoring tool produced through a partnership with the National Drought Mitigation Center and the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. The U.S. Drought Monitor is a composite of indicators that classifies areas of the United States into drought categories. D1 represents the least intense drought conditions, with D4 being the most intense and D0 as drought watch areas that are abnormally dry. The drought monitor relies on local observations for localized information that is as site specific as possible, making it a unique tool that provides the best available data.

The U.S. Drought Monitor - Hawaii has been publically available since 2000 and is released every Thursday morning at 8:30am Eastern Time. The HDMA submits drought maps based on drought indices, hydrologic data, reports from local informants, and other drought impact information. The U.S. Drought Monitor is updated every week by one of the partner agencies (weekly rotation), and the U.S. Drought Monitor – Hawaii is updated as conditions change or as new data becomes available at: (http://droughtmonitor.unl.edu/).

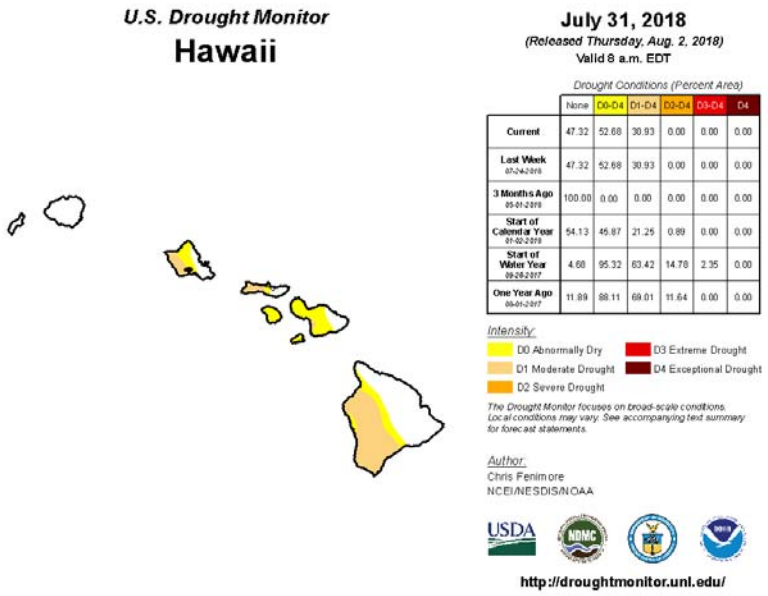


Figure 12-2. Federal Drought Monitoring Program: State of Hawaii **(Drought Monitor website 8/2/18, http://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?HI)**

12.5 Hawaii Drought Plan

The Hawaii Drought Plan (HDP) has been updated in 2017 for use by the Hawaii Drought Council to improve coordination and implementation of drought management strategies for the State of Hawaii. (DLNR CWRM, 2017) The revised plan is intended to serve as a "framework" through which State and local entities can work together to proactively implement mitigation measures and appropriate response actions during periods of drought. Effective coordination of these activities can help reduce and minimize the effects upon the people and natural resources of Hawaii.

The HDP was designed as an informative guide to help reduce the negative impacts that drought conditions cause for the State of Hawaii. It addresses an overview of drought in Hawaii along with the threat of future droughts, the coordination of Hawaii's Drought Program, methods for drought monitoring, forecasting, and impact assessment, and strategies for drought planning and mitigation. Drought mitigation has been emphasized in this plan as a proactive approach to lessen the intensity of dry periods.

Since the initial HDP in 2000, much progress has been made with drought planning, particularly with regard to implementation of specific recommended actions. In the future, continued implementation of recommended plan provisions will remain a key challenge to the Hawaii Drought Council and its member agencies and stakeholder representatives. Appropriate government and private sector resources will need to be identified to address the recommended priority mitigation actions identified in the plan. The success of the plan will ultimately be measured by the ability of government agencies, stakeholders, and the general public to function as a team in achieving the necessary goals and objectives for successful mitigation of drought impacts for the state.

This plan has been designed as a dynamic "living" document, which should be utilized and updated to reflect changing conditions, new information, and an evolving leadership structure encompassing the Hawaii Drought Council, Hawaii Drought Monitor Author, and the County/Local Drought Committees. The plan is available on the Hawaii Drought Website to facilitate public access and the review of future plan updates: http://dlnr.hawaii.gov/drought/planning/.

12.5.1 Scope

The HDP includes a description of historical occurrences, climatological statistics, risk assessments of susceptibility and vulnerability to drought, as well as the identification of potential impacts related to specific geographical locations. The HDP also emphasizes the identification of pre- and post-drought preparedness and mitigation measures for implementation by government agencies, stakeholders, and the general public.

The Hawaii Drought Plan establishes the following leadership structure:

- Hawaii Drought Council (HDC)
- State Drought Coordinator (SDC)
- Hawaii Drought Monitor Author (HDMA)
- County/ Local Drought Committees (CLDCs)

Participation in these groups is designed to include, but not be limited to, individuals and/or organizations that can best share their knowledge and experience regarding local issues, resources, and priorities for drought response and mitigation.

The plan also proposes development of a public outreach component consisting of drought-related projects, educational- based programs, and development and initiation of statewide water conservation measures. In addition, the drought plan makes several recommendations regarding performance of risk management assessments pertaining to potential drought impacts.

The State and County Multi-Hazard Mitigation Plans serve as integral components of an overall mitigation strategy, and together with the Hawaii Drought Plan, comprises a comprehensive strategy calling for a shift from emergency drought assistance to aggressive drought mitigation. Specific drought mitigation projects have been developed and will be updated by the CLDCs for future incorporation within each County Multi-Hazard Mitigation Plan (Figure 12-3).

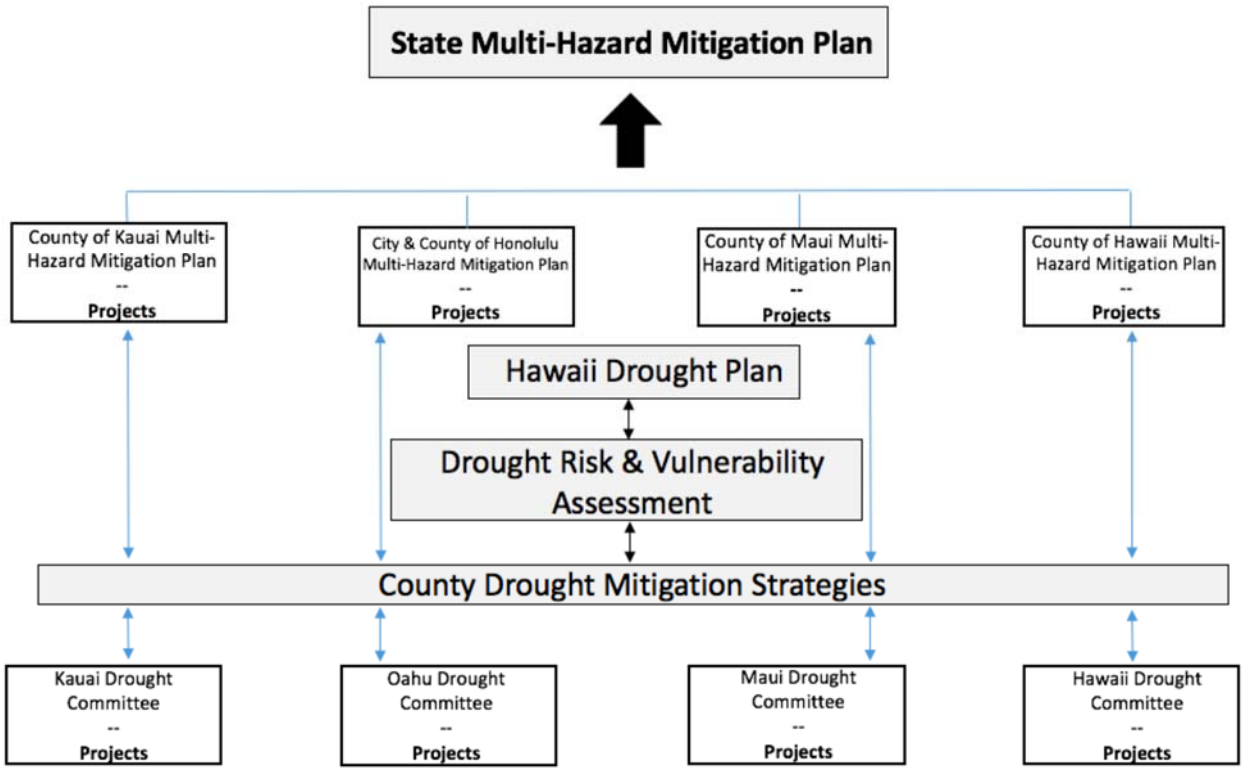


Figure 12-3. Drought plan role in the State & County Hazard Mitigation Plans (DLNR CWRM, 2017)

12.5.2 Goals and Objectives

The objective of the Hawaii Drought Plan is to be prepared for and mitigate against the impacts of future drought events in Hawaii. With that in mind the key components of the plan include:

- An overview of drought in Hawaii
- Details on Hawaii's drought program
- Monitoring and forecasting - Timely predictions and monitoring of drought conditions
- Impact assessments
- Risk assessment of drought-related impacts to the (1) agriculture and commerce (2) municipal water supply, and (3) environment, public health and safety sectors
- Communication and response actions - Detailed response measures for state and county agencies
- Mitigation and preparedness - Mitigation of drought impacts through effective planning actions during non-drought periods
- Recommendations and implementation actions

A key element of successful drought preparedness is public education. Educational programs such as workshops, newsletters, public service announcements, press releases, community meetings, school curricula, bill stuffers for utilities, and interactive participatory decision-making processes can increase awareness of the value of preparing and planning for droughts. As part of this effort,

the Hawaii Drought Council developed several public service announcements on drought awareness. Hands-on training and technical assistance programs can help stakeholders formulate and implement plans that incorporate drought planning and mitigation processes. Such programs can help farmers in Hawaii decide whether to include drought-resistant crops, on-farm wells, crop insurance, conservation systems, restoration of wetlands and wildlife habitat, and other important factors into their risk-management strategies. These measures can help farmers implement water management practices and gain a better understanding of the soils and climate conditions in their areas and the types of crops and plants suitable to mitigating adverse changing conditions. Such assistance can also help them understand (and plan for) complicated marketing options and other methods to manage risks.

Training and technical assistance programs can also help Hawaii communities as they determine their own priorities for incorporating drought concerns, protection of environmental resources, and land-use and community planning into comprehensive water management plans. USDA Natural Resources Conservation Service has several programs available to assist the agricultural sector in developing conservation plans for farmers and ranchers. The statewide strategy for promoting public education and awareness includes the following specific near-term and long-term actions:

- Continue to encourage and promote wildland fire awareness through the Firewise Program and the Wildfire and Drought Lookout Campaign. Continue cooperation with the county water departments and support public education, outreach, and awareness activities as appropriate (e.g., Halawa Xeriscape Garden Annual Unthirsty Plant Sale Event).
- Seek partnerships with private entities and community organizations to support and augment government outreach activities and to access different target audiences (e.g., Earth Day Event at the Waikiki Aquarium).
- Seek cooperative opportunities with agricultural agencies and organizations, such as the USDA Farm Services Agency and the Hawaii Farm Bureau, to develop educational workshops and training on technical assistance programs. Farmers should also continue to be provided with information to further their understanding of marketing options and other methods to manage risks, including conservation planning through the USDA Natural Resources Conservation Service.
- Help stakeholders formulate and implement plans that incorporate drought mitigation processes, such as the use of drought-resistant crops, crop insurance, conservation systems, grazing programs, restoration of wetlands and wildlife habitat, and other important factors into their risk-management strategies.
- Develop drought educational exercise and learning tools that may be incorporated into school science curriculums.
- Incorporate emerging natural resource conservation approaches, such as watershed-based management, into drought-related outreach activities. Promote the importance of considering drought risk at the local level in watershed-based planning activities.

12.5.3 Hawaii Drought Program Organization

The following Table 12-2 describes the groups responsible for the Hawaii Drought Program and their respective tasks.

Table 12-2. Hawaii Drought Program tasks and descriptions (Hawaii Drought Plan 2017)

HDP	Hawaii Drought Council (HDC)	State Drought Coordinator (SDC)	County Level Drought Committees (CLDCs)	Hawaii Drought Monitor Author (HDMA)
Purpose	Coordination at the highest levels of government to develop drought policy and implement the Hawaii Drought Plan.	Supports preparation and successful implementation of the Hawaii Drought Plan.	The first to identify, implement and respond to drought at a local level and to establish localized strategies and projects to implement county drought mitigation.	Collects and coordinates the dissemination of drought-related information, provides technical assessments, and analyzes drought forecast information. Provides input to the U.S. Drought Monitor Hawaii maps.
Membership/ Position Description	Governor's Office State DLNR (Co-Chair) State Department of Agriculture (Co-Chair) State HI-EMA Four (4) County Government Officials HI Association of Conservation Districts (Ex-Officio) Hawaii Farm Bureau(Ex-Officio) Hawaii Cattleman's Council(Ex-Officio) East Maui Irrigation Co., Ltd. (Ex-Officio) NOAA National Weather Service (Unofficial member)	This position resides within the Commission on Water Resource Management (CWRM) and provides coordination on other CWRM programs and projects.	Each CLDC should include representation from appropriate county government agencies, stakeholders, and the private sector. (See Appendix B for committee member list.) Members should also represent the three drought impact sectors.	The HDMA is currently an unfunded position provided in-kind by NWS. This position should be institutionalized to prevent lapse of this function if or when current staff transition. The administrator coordinates with HDC, CLDC, USGS, Water Utilities, CWRM, Emergency Management Agencies, Farm Bureau and others to assess drought conditions and impacts.
Responsibilities	• Informs Governor on drought related issues • Implements and maintains Hawaii Drought Plan • Supports and facilitates CLDCs • Reports drought monitoring information • Coordinates drought impact assessments • Promotes activities to mitigate impacts and reduce drought vulnerability • Proposes legislation to State and County legislative bodies for drought program activities • Facilitates access towards federal, State, and local assistance programs and assists with acquiring funding for program implementation • Acts as coordinating entity for application and disbursement of emergency aid/funding obtained from available sources • Promulgation of statutes and/or rules as necessary to implement mitigation measures	• Maintains the Hawaii Drought Plan and Hawaii Drought website • Provides coordination with Federal, State and local assistance programs and acquires funding for program implementation • Develops and implements projects to facilitate drought mitigation • Provides administrative support to the Hawaii Drought Council and County Level Drought Committees • Ensures timely distribution of drought forecasts to agencies, organizations and the public • Enhances public awareness and drought education	• Monitors, assesses, and reports drought conditions • Reports drought impacts • Executes drought mitigation and response actions • Identifies and prioritizes (in advance) emergency drought assistance projects • Develops long-term drought mitigation strategies to minimize the effects/impacts of drought.	• Contributes local knowledge and drought conditions to the Hawaii Drought Monitor based on monitoring of available data and drought impacts on a weekly basis • Communicates with local drought stakeholders and CLDCs to collect real time observations of drought conditions and impacts • Updates the Drought Information Statement as needed on the NWS website
Frequency	Meets at least once a year and more frequently during periods of drought or if drought funding becomes available.	Coordinates year-round/ facilitates meetings at least once a year for HDC and CLDC. More frequent communication during drought or as funding becomes available.	Meets at least once a year and more frequently during periods of drought or if drought funding becomes available.	Evaluates drought condition weekly and updates site as conditions change.

12.6 Drought Sectors

The impacts of drought can be categorized as economic, environmental, or social. Economic impacts can be observed as costs and losses to agricultural producers, costs and losses to livestock producers, and loss to the recreation and tourism industry. Environmental impacts can be categorized into damage to plant species, damage to animal species, and hydrological effects. Social impacts can be categorized as either health related, reduced quality of life and changes in lifestyle related, or even in increased conflicts regarding water use. Drought impact assessments begin by identifying direct consequences of the drought, such as reduced crop yields, livestock losses, and reservoir depletion.

Upon examining the possible impacts on Oahu, it was determined that the analysis should focus on the following sectors critical to the social, economic and environment aspects of drought impacts. The three sectors are:

1. Water Supply Sector;
2. Agriculture and Commerce Sector, and;
3. Environment, Public Health and Safety Sector.

12.6.1 Water Supply Sector

The water supply sector includes public and private urban and rural potable water systems, agriculture water systems, and other water networks. A public water system (PWS) is described by the Environmental Protection Agency (EPA) as a system that provides water to the public for human consumption through pipes or other constructed conveyances. To be considered a PWS, the system must support at least fifteen service connections or regularly serve at least twenty-five individuals. In the State of Hawai‘i, most PWS are supplied by groundwater sources. There are, however, a few surface water and catchment water systems that are considered public water systems by the State of Hawai‘i Department of Health.

The principal drought stage characteristics proposed for the Water Supply Sector is a 12-month SPI within watershed and demand regions (DLNR CWRM, 2017). The 12-month duration is considered because drought usually lasts for a long time and the response of ground water levels to drought is delayed by several months. To be categorized in a particular drought category the 12 month SPI for a given category, provided in Table 12-1, must persist for at least 2 consecutive months.

12.6.2 The Agriculture and Commerce Sector

The Statewide Agricultural Land Use Baseline 2015 was produced for the Department of Agriculture by the University of Hawaii at Hilo’s Spatial Data Analysis and Visualization Lab (SDAV) (Melrose, et al., 2015) Using a combination of satellite imagery, related geospatial datasets, and statewide farm interviews, they produced a new digital GIS layer to identify commercial agricultural crops grown in the state. SDAV also produced a report to accompany the digital data that contains a collection of maps and graphics to depict the current state of crop

production statewide. The 2015 Baseline dataset updates the 1980 Agricultural Land Use Map (ALUM), the previous statewide agricultural GIS layer. See Figure 12-4.

The Agriculture and Commerce Sector experiences negative drought impacts due to dependence upon both surface water and rainfall. Rainfall shortage-induced impacts are often exacerbated by the limits placed on ground water pumping during drought periods. Lack of rainfall and reduced irrigation water supplies can cause reduced yields, crop failure, and force farmers to delay planting or risk losing their crop. Drought can destroy pasture and deplete drinking water for livestock. Ranchers are forced to purchase feed and water and reduce herd sizes to cope with drought. For the commerce sector, ecotourism can suffer if drought negatively impacts popular destinations and electrical utilities can suffer from reduced stream flows used for hydroelectric power production.

For the Agriculture and Commerce Sector, the HDP recommends the use of a 3-month SPI because a short-term drought event would already have reduced crop yields and caused livestock losses. To be categorized within a given drought category (Table 12-1) the applicable 3-month SPI must persist for 2 consecutive months.

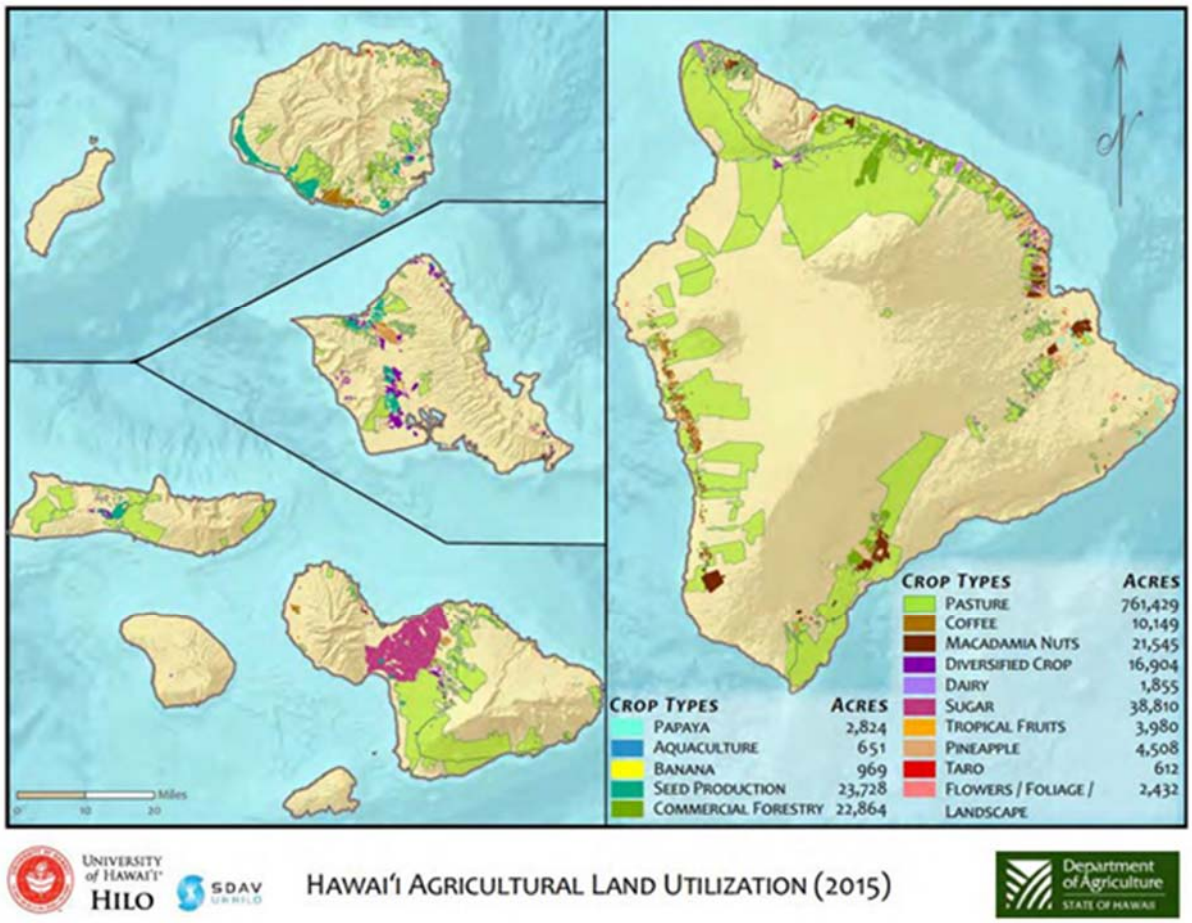


Figure 12-4. Hawaii Agricultural Land Utilization (Melrose et al., 2015)

12.6.3 The Environment, Public Health, and Safety Sector

This sector focuses mainly on wildfire incidence as drought conditions heighten the potential incidence and spread of wildfire. Continued economic growth and development in the wild land/urban interface areas has increased the risk to human life and property due to wildfires. Other concerns include the availability of sufficient fresh water reservoirs to combat wildfires and the looming threat of wildfire on former plantation lands no longer irrigated. Secondary and cumulative impacts of wildfires, such as erosion and pollution in near shore areas are also considered in this sector. Wildfires are discussed in detail in Chapter 13 – Wildfires. Other aspects of the environment, public health, and safety sector include impacts to habitat, water quality, endangered species, and other natural resources.

For the Environment, Public Health and Safety Sector, a 3-month SPI is considered most appropriate. To be categorized within a given drought category (Table 12-1) the applicable SPI must persist for 2 consecutive months.

12.7 Drought Impact Studies

In 2012 the Hazards, Climate, and Environment Program of University of Hawaii conducted a socioeconomic assessment on the impacts of drought using key informant interviews, surveys, and social mapping in the agricultural sector. The objective of this study was to analyze the full impacts of drought including impacts on communities, culture, and livelihoods surrounding the drought affected community. According to the study, the key findings included:

1. The effects of drought exacerbate a tenuous land management system for the agricultural community
2. Localized impacts are not merely financial and economic, but have emotional, legal, cultural, political, and social implications
3. Primary impacts to agricultural producers extend throughout the community and approaches to address drought risk requires local community engagement
4. Recovery periods, which may be several years, are not reflected in agricultural, relief assistance, and land use planning
5. Recovery and resilience are hampered by cascading hazards and cumulative impacts from extreme events that are considered separately rather than cyclically
6. Affected individual's stories provide key lessons for preparing and mitigating future drought risk

Solutions to help mitigate these impacts were listed in this report, including changing land use and lending policies, improving access to water, developing functional cooperatives through effective community organizing, creating access to training and technical support, and supporting innovative solutions.

12.8 Drought Risk and Vulnerability in Hawaii

The identification of areas that are vulnerable to drought impacts is especially difficult in the State of Hawaii due to the variations in microclimates and impact sectors. Understanding the threats

from potential drought hazards on population, infrastructure, and the environment along with understanding the vulnerabilities of drought allows for improved statewide planning in advance of drought scenarios. If areas at risk to drought are recognized, specific projects can be implemented prior to the onset of a drought to mitigate potential impacts. A better understanding of areas that are at risk of drought impacts will assist in proactive drought management practices that are more effective than reactive, crisis based methods.

The following maps were created to show general risks to the water supply sector, agriculture and commerce sector, and the environment, public health and safety sector. For water supply, residents who rely primarily on rainwater catchment are at the highest risk to drought (see red regions in Figure 12-6) since they could run out of water from a week or two of reduced rainfall. High-risk regions are estimated, further efforts to map areas utilizing rainwater catchment would be needed to accurately reflect all rainwater supplied areas. Water supply service areas that are supplied in part from surface water or rely on a vulnerable groundwater sources are at a medium risk to drought (see orange regions in Figure 12-7). These sources will only become more vulnerable with climate change, refer to Figures 12-5 and 12-6 for projected rainfall changes over the next century. The lowest risk to drought are those water supply areas that have adequate groundwater sources. Only a severe extended period of drought would affect these sources.

For agriculture, cultivated land and pastures were overlaid with agricultural water supply to identify agricultural areas that are more vulnerable to drought conditions (see Figure 12-8). If the water supply source for the region is groundwater, it has a lower risk during time of drought as it can most likely still withdraw from the groundwater to irrigate crops. Areas with surface water have a medium drought risk as they typically have some ability to store water, although sources can run out in an extended drought scenario. Unirrigated areas, mostly pastures, are at the highest risk to drought since they rely directly on rainfall for productivity. Note that Figures 12-7 and 12-8 were developed with the best available data and that drought risk may change in the future due to changes in land use and water access.

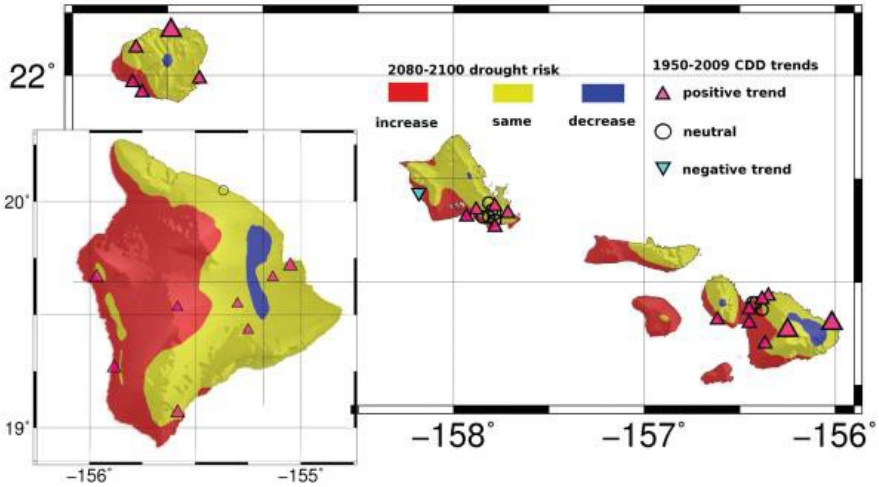


Figure 12-5 Future projections of drought based on historical data and future climate projections. **Source: Climate change and Pacific islands: Indicators and impacts (2012), figure courtesy of Oliver Elison Tim. (DLNR CWRM, 2017)**
https://www.cakex.org/sites/default/files/documents/NCA-PIRCA-FINAL-int-print-1.13-web.form_.pdf

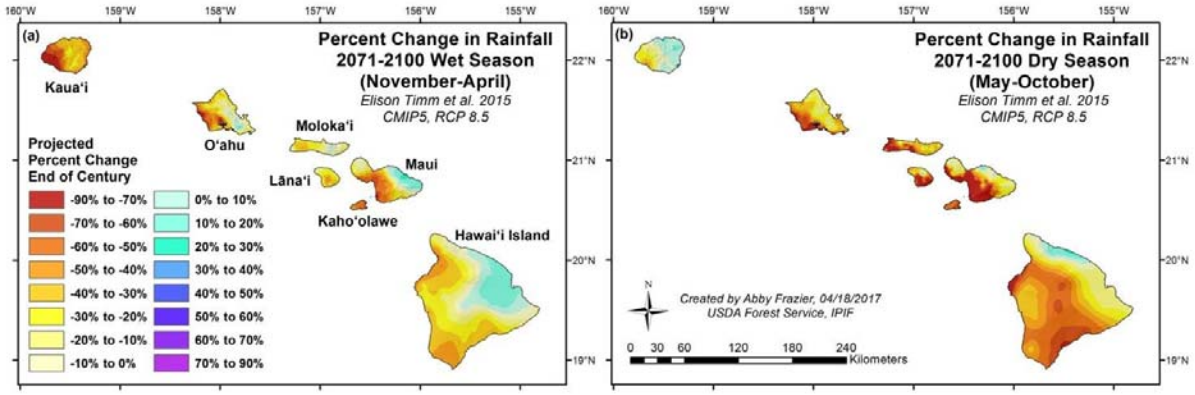


Figure 12-6**. Percent Change in Rainfall. Created by Abby Frazier.** Source: Elison Timm, O., T. W. Giambelluca, and H. F. Diaz (2015), Statistical downscaling of rainfall changes in Hawai‘i based on the CMIP5 global model projections, Journal of Geophysical Research: Atmospheres, 120(1), 92-112. (DLNR CWRM, 2017)
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014JD022059

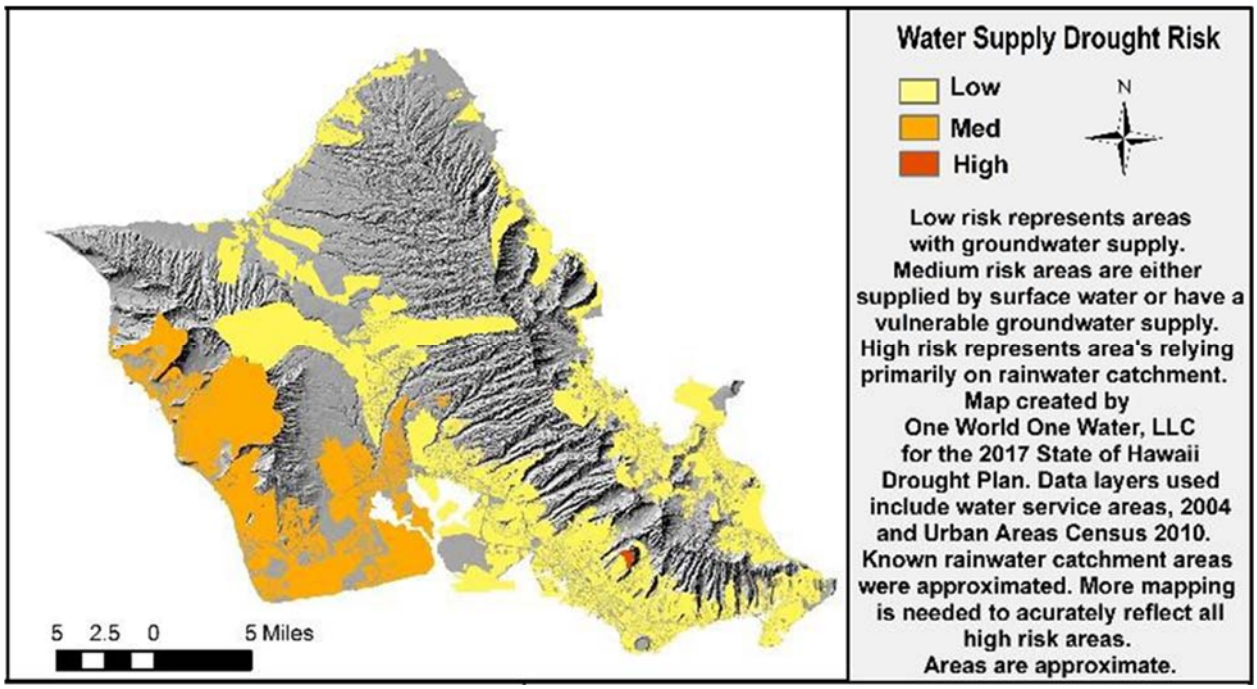


Figure 12-7. Water Supply Drought Risk, made by OWOW (DLNR CWRM, 2017)

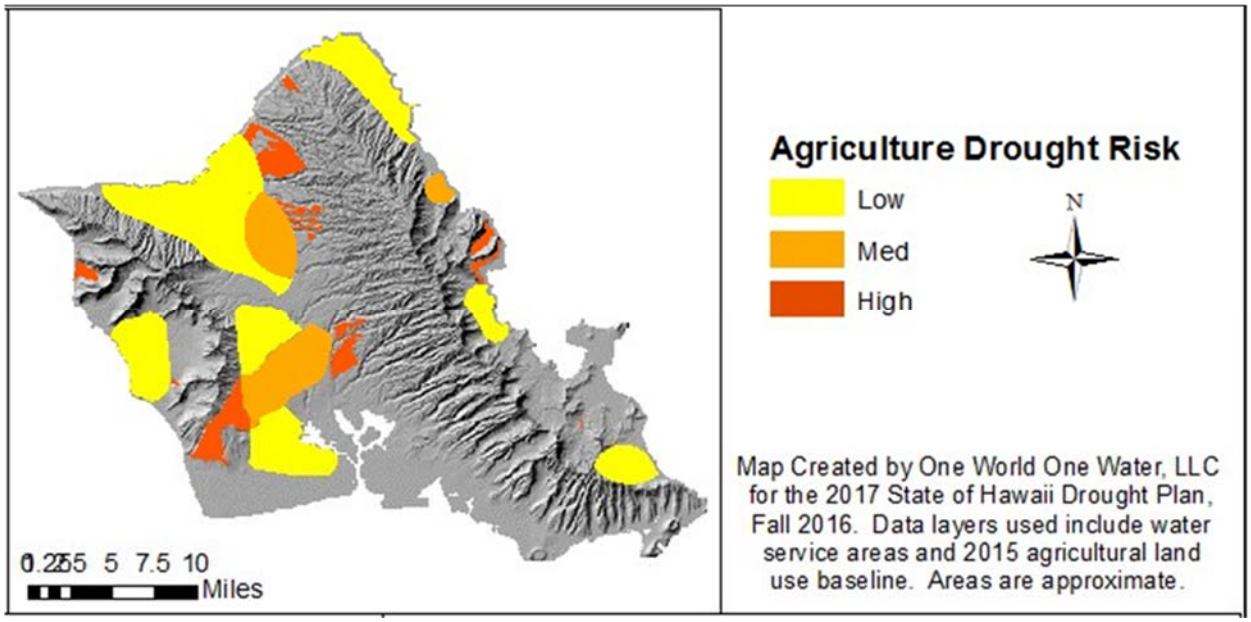


Figure 12-8. Agriculture Drought Risk, made by OWOW (DLNR CWRM, 2017)

12.9 Sector Risks and Vulnerability

In the HDP, Phase 1 (2000) a simplified analysis of sector vulnerability was used to describe local drought risk in terms of the three sectors. In 2003, the State Commission on Water Resource Management, on behalf of the Hawaii Drought Council and as part of the priority implementation actions recommended in Phase 1 of the HDP, completed a geographic and sector-based risk assessment and vulnerability analysis for the State of Hawaii. Based on the GIS mapping study, drought risk maps for all three sectors and the three different drought levels (moderate, severe and extreme), are shown for Oahu in Figures 12-9 through 12-20 (UH SOEST/SSRI, 2003). Higher resolution maps are available at: (http://files.hawaii.gov/dlnr/cwrm/planning/drva2003.pdf

The plan states that drought risk and vulnerability to the extent found on the islands of Hawaii and Maui does not exist on Oahu. With an integrated water system, a service area that covers the majority of the island, and groundwater as the primary source for potable water, the public water supply sector is not as vulnerable to minor drought conditions. If a severe drought persists for several years, the ground-water supply may be depleted to a large extent and the entire island could be affected despite the extensive ground-water integrated public water system. Other problems include the growing population occurring in the leeward or central portion of the island where rainfall is low.

In terms of risk to the agriculture and commerce sector, there is some risk within the central portion of the island near Kunia for moderate and severe drought stages. The Island of Oahu does not have as many lands devoted to this sector compared to other islands, making it less vulnerable. The environment, public health and safety sector is somewhat different from the other two sectors since fire is often human caused on Oahu. Based on the analysis, the area near the Mililani/Waipio region seems to be at high risk for moderate and severe drought stages. This area is in a wildland urban

interface where the highway passes through acres of open scrub land, creating a potential threat to the developed land and public transportation system in the area.

12.10 Drought Communication and Water Use Management

Four entities in the drought leadership structure are identified as having key communication responsibilities during normal, drought, and recovery periods. These entities are: the Hawaii Drought Council, the State Drought Coordinator, the Water Resources Committee, and the County/Local Drought Committees. Each of these entities has specific roles within the recommend communication protocol, which provides for the necessary coordination and dissemination of drought information to agencies, stakeholders, and the general public.

Various agencies are able to manage water use during droughts. The Commission on Water Resource Management provides statewide water management, issuing permits in designated water management areas, imposing restrictions, prioritizing water usage and dispute resolution through the Courts if necessary. The commission manages water with a resource protection mandate. Other State and county jurisdictions manage agricultural and municipal water usage on a supply and demand basis. The State Department of Agriculture operates irrigation systems with administrative rules for these systems for restriction or interruption of water supply as needed. The Honolulu Board of Water Supply manages municipal water supply with three levels of groundwater conditions to represent the severity of drought conditions. Voluntary or mandatory water use restrictions may be imposed depending on drought conditions.

12.11 Assessment of Drought Risks Relative to other Hazards

The average annualized losses due to drought may be estimated statewide by using the estimates of drought losses over the last two decades. Agricultural losses are considered the most significant losses as water supply is prioritized for municipal use during drought at the cost of irrigation systems. This is added to the losses sustained from reduced precipitation on agricultural land. Based on the estimates in the HDP the between the years of 1980 and 2002 statewide agricultural losses attributed largely to livestock losses summed to $26.4 million. Over a period of 23 years the statewide annualized losses are estimated at $1.1 million dollars, although most of these losses were not on Oahu. This loss estimate is conservative as it does not include all agricultural and environmental losses which are extremely difficult to quantify in terms of dollar value. More recently, agricultural disaster assistance programs payments reported in the 2017 HDP for losses due to drought statewide from 2005 and 2016 have amounted to over $47 million, or an annual loss of over $3.9 million per year. The cost of drought has increased, although those losses occurred mostly outside of Oahu.

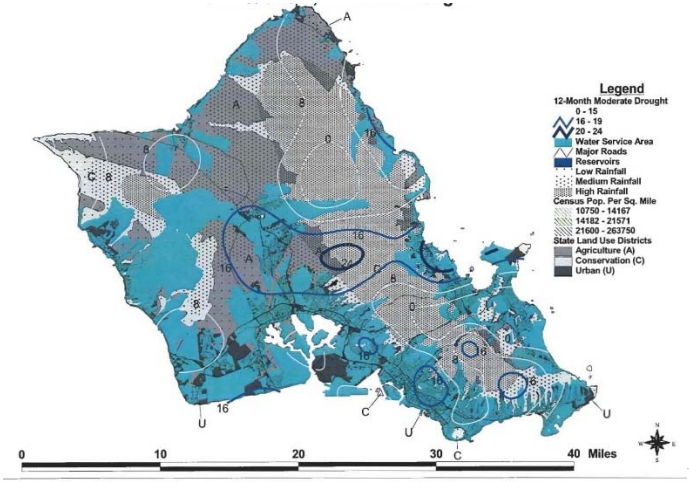


Figure 12-9. Water Supply Sector, 12 Month SPI, Moderate Drought (Left)

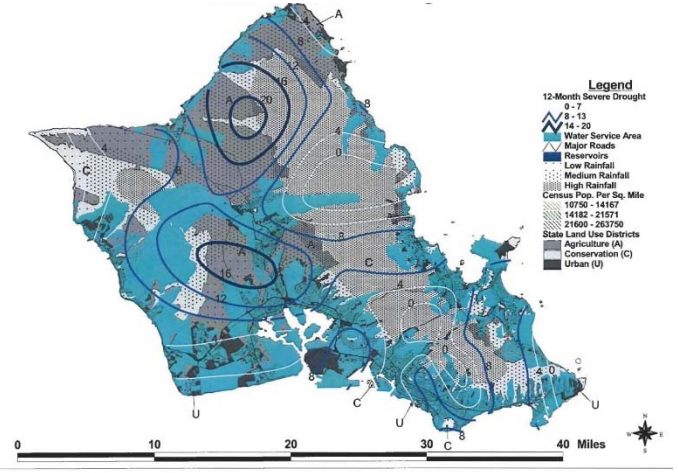


Figure 12-10. Water Supply Sector, 12 Month SPI, Severe Drought (Right)

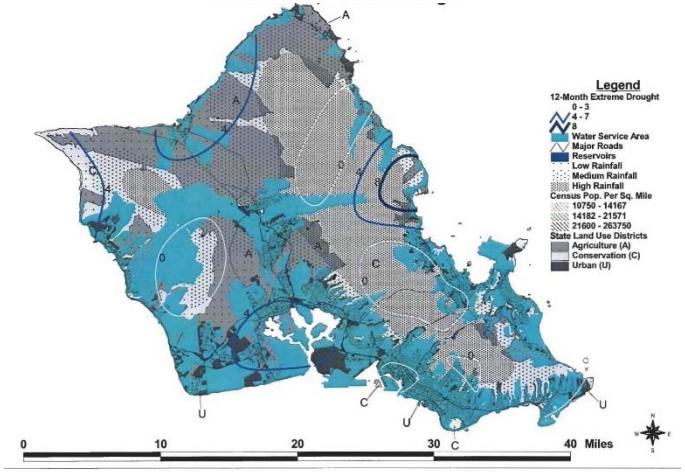


Figure 12-11. Water Supply Sector, 12 Month SPI, Extreme Drought

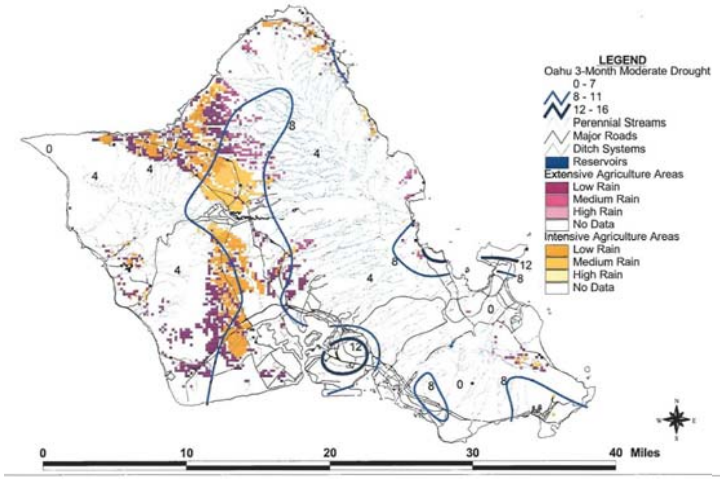


Figure 12-12. Agricultural Sector, 3 Month SPI, Moderate Drought (Left)

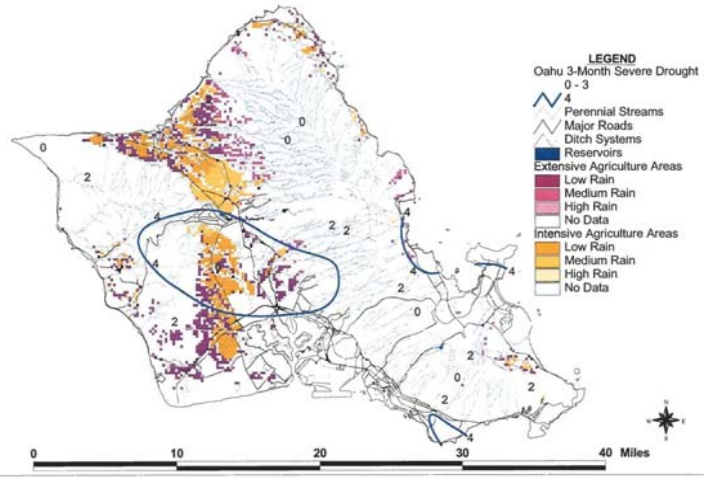


Figure 12-13. Agricultural Sector, 3 Month SPI, Severe Drought (Right)

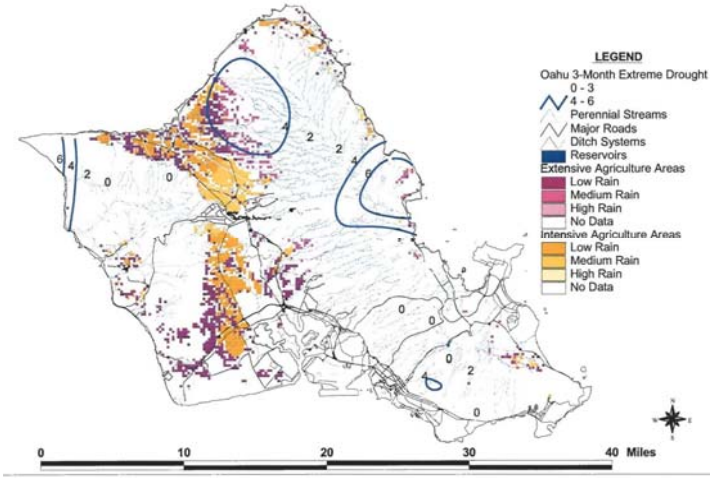


Figure 12-14. Agricultural Sector, 3 Month SPI, Extreme Drought

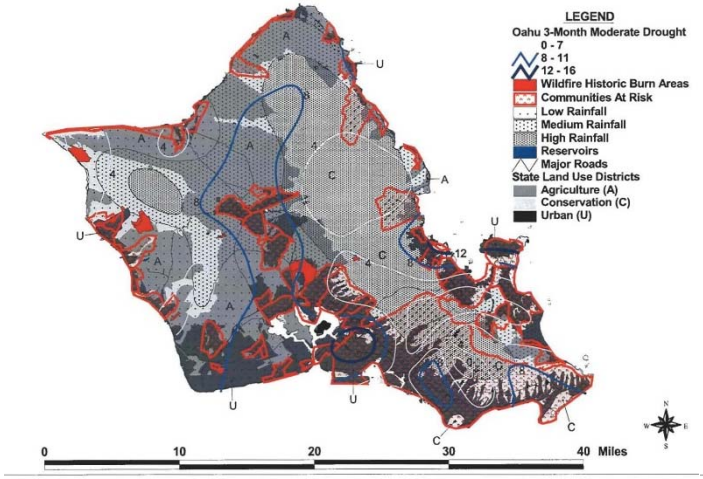


Figure 12-15. Environment, Public Health and Safety Sector, 3 Month SPI, Moderate Drought (Left)

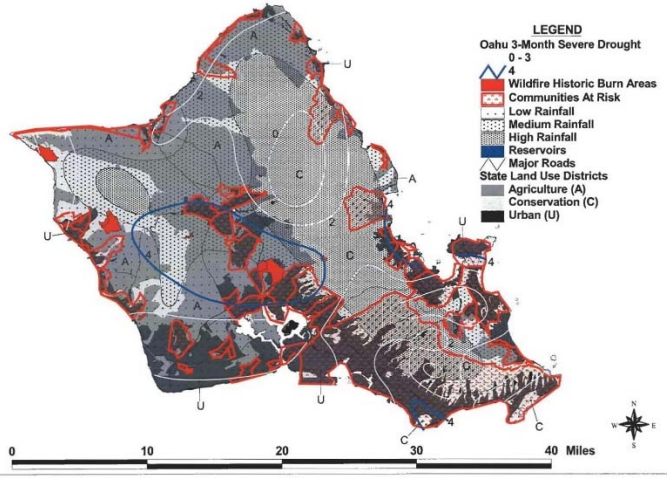


Figure 12-16. Environment, Public Health and Safety Sector, 3 Month SPI, Severe Drought (Right)

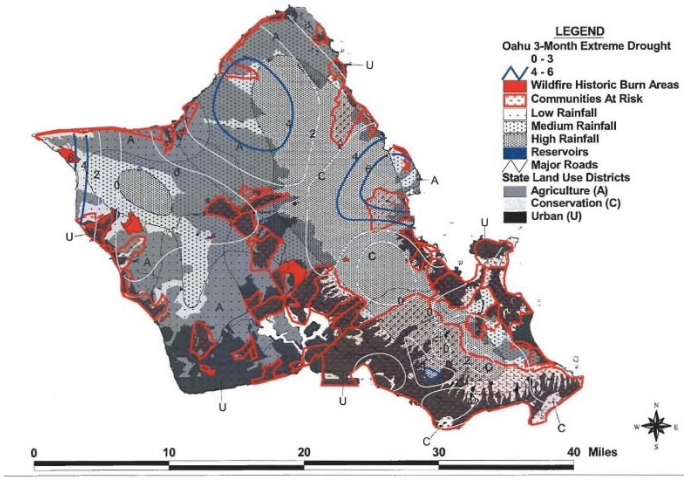


Figure 12-17. Environment, Public Health and Safety Sector, 3 Month SPI, Extreme Drought

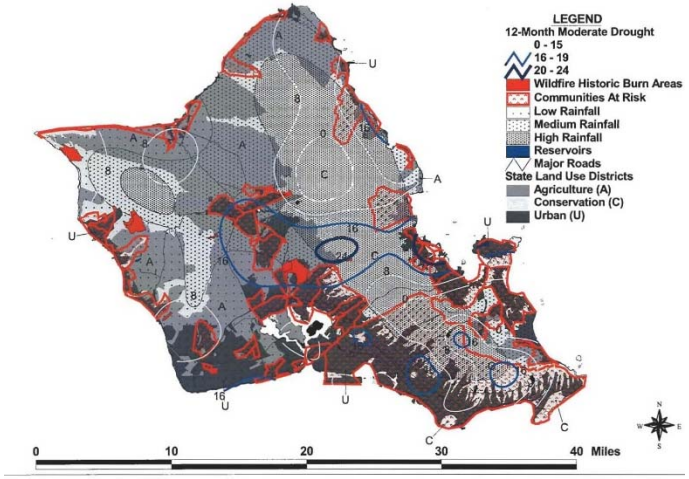


Figure 12-18. Environment, Public Health and Safety Sector, 12 Month SPI, Moderate Drought (Left)

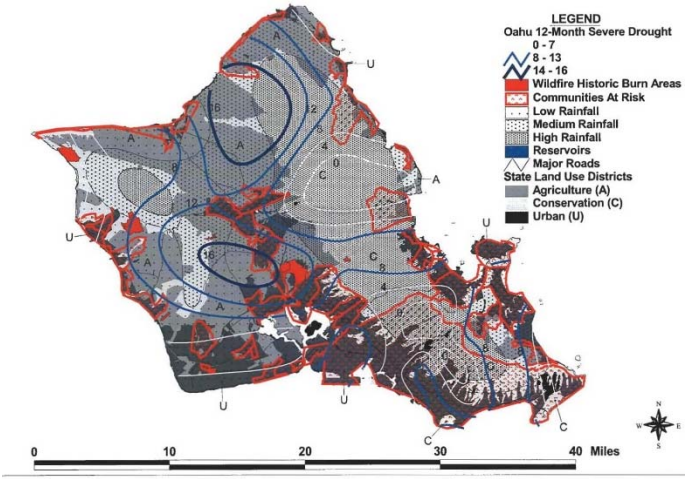


Figure 12-19. Environment, Public Health and Safety Sector, 12 Month SPI, Severe Drought (Right)

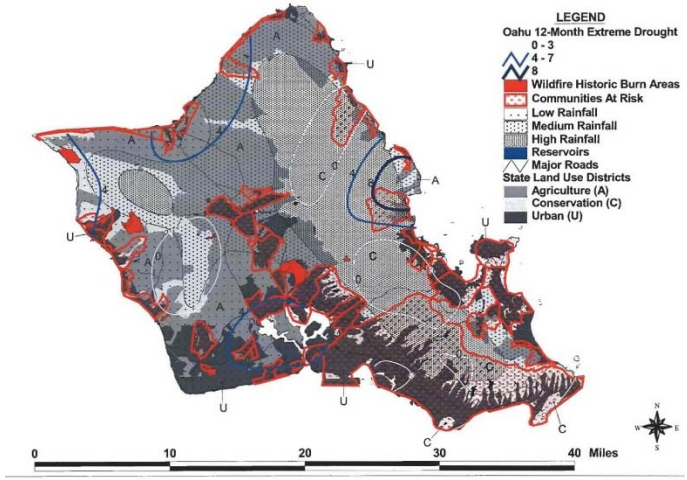


Figure 12-20. Environment, Public Health and Safety Sector, 12 Month SPI, Extreme Drought

12.12 Recent and Ongoing Mitigation Activities

Drought mitigation comprises a broad range of proactive measures. "Risk management" using a proactive approach to drought management is a better mitigation tool than the nominal reactive or "crisis management" approach. The key element to reducing impacts of drought on individuals, communities, and the environment is a coordinated drought preparedness program. If progress is to be made in improving our ability to manage drought, it will be the result of an integrated approach within and between levels of government, involving regional organizations and the private sectors where appropriate.

Recommended mitigation actions have been clustered into the following categories:

- Statewide Water Resources Monitoring and Impact Assessments;
- Development of New or Alternative Water Sources;
- Water Conservation Practices;
- Public Education Awareness and Outreach;
- Watershed Protection Partnerships;
- Legislation, and;
- Land Use Planning

In 2007 the Hawaii State Legislature passed House Bill 400 (HD1, SD2, CD1) appropriating $4,000,000 for drought mitigation projects and measures in each county. The mitigation projects in the City and County of Honolulu funded in 2007 are listed in Table 12-3.

Table 12-3. Oahu Drought Mitigation Projects – Funded 2007 (2017 Hawaii Drought Plan)

Sponsoring Agency	Sector	Project	Cost
Honolulu BWS	Env. Pub. Health & Safety	Inventory, maintain, and expand firefighting water sources (helicopter pads for dip tanks)	$350,000
Honolulu BWS	Water Supply	Drive By Leak Logger	$110,000
Honolulu BWS	Water Supply	Toilet Rebate Program	$100,000
West Oahu SWCD	Agriculture	Lower Kawailoa Drought Mitigation Planning Study	$45,000
CWRM	Water Supply	Ala Wai Boat Harbor Water Conservation	$100,000
CWRM	All	Documenting agricultural and other Commercial Losses	$100,000
DOFAW	Env. Pub. Health & Safety	Fuel hazard reduction in the wildland urban interface	$100,000
DOFAW	All	Installation of Remote Automated Weather Stations	$50,000
DOFAW	Env. Pub. Health & Safety	Fuel reduction equipment purchase	$45,000

12.13 Future Proposed Mitigation Actions

Future mitigation projects proposed by the Hawaii Drought Plan, the Oahu Drought Committee, or the aforementioned Integrating Socioeconomic Assessments to Build Community Resilience in Mitigating Drought in Hawai‘i Report:

- Long-term ecological research experimental forested watershed in Hawaii. Explore the use of forested watershed management tools to mitigate the effect of drought and improve ground and surface water management. Also develop monitoring tools to assess the impact of mitigating measures on water resources.
- Amend existing Federal and State laws to recognize drought as a natural disaster with a program for proactive mitigation and response.
- Further expand public education programs and implement measures for demand and resource conservation.
- Improve monitoring capability between responsible agencies, BWS, CWRM and USGS to collect and share hydrologic, groundwater and stream flow data as indicators prior to, during and after droughts. Develop a comprehensive operations plan that optimizes groundwater pumping among Oahu's primary aquifers and provides for sufficient aquifer recovery post drought to maintain aquifer health.
- Convene sector-based drought workshops to assist stakeholders in developing or improving their individual drought / water conservation plans. Includes retaining experts in respective sectors.
- Develop low-flow instream flow standards for environmental protection (native aquatic fauna) during drought. Have an alternate standard to keep water in streams. With drought and the loss of habitat, native species will return, and alien/invasive species may be eliminated.
- Expand agricultural and commerce education and outreach for water conservation practices including roadside vegetation management, composting of soils, etc.
- Establish funding sources and technical assistance available for farmers and ranchers to take advantage of advances in drought coping methods to enable the agriculture sector to become more resilient to impacts of drought and disasters.
- Develop cooperative organizations to encourage skill exchange, land swaps, equipment sharing and collaboration between farmers affected by drought.
- Explore combining drought forecasting with economic models for improved farmer decision-making. This could be built from elements of present federal water management practices, but more Hawaii-specific adaptation is needed for local crops and conditions.
- Explore potential use of the current storage capacity contained in Lake Wilson for emergency drought purposes. Also explore the use of Nuuanu Reservoir No. 4.
- Create water storage systems and increase distribution lines for agricultural use.
- Expand rebate program for new water-saving technologies
- Study the feasibility of installing bulkheads in windward water development tunnels to increase water storage and stream flow.
- The Hawaii Drought Council and the State Drought Coordinator should work with State and county agencies to develop legislation to facilitate the implementation of drought mitigation projects and activities.
- Provision of tax credits for agricultural losses due to drought.

- Agricultural loans or grants covering drought impacts, damages, or losses.
- Modifications in eligibility for Relief Assistance to assist those farmers and ranchers at most risk from the impacts of droughts and hazards.
- Further clarification regarding the use of reclaimed water over potable water sources, including the use of greywater for agricultural and livestock purposes during drought declaration emergency.



13. Wildfire

13. WILDFIRE

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan established wildfire as its own chapter for the first time. It focused upon the threat of developing near wildlands without sufficient defensible space.	• With the decline of production agriculture and associated irrigation, an increase in grass and shrub lands together with a warming, drying climate and year round fire season, greatly increase the incidence of larger fires, especially in leeward areas • The wildfire risk is increasing as development encroaches on wildlands and former agricultural lands without sufficient defensible space at the wildland/urban interface. To date building property damage on Oahu due to wildfires is minimal although many thousands of acres of wildlands have been burnt in recent years. The Honolulu Fire Department is responsible for mitigation and control of urban fires, while the DNLR, Division of Forestry and Wildlife is responsible for forest reserves, with a co-response in intermediate area. • Added discussion of the hazard and example statistics of acres burned and accounts of recent wildfire events are now included. • West Oahu now has a Community Wildfire Protection Plan • The status of ongoing projects is updated • A new list of future mitigation projects is proposed.

Summary of Mitigation Projects for the City and County of Honolulu

Project	Priority
Fire Break Maintenance - Various fuel breaks/fire roads throughout Oahu are maintained by DOFAW. These roads need to be maintained with heavy equipment to stop advancing fire, provide access to firefighters.	Medium
Assist Oahu communities to become Firewise Communities.	Medium
Establish water tanks at the fringes of threatened communities that can serve as dip tanks for fire suppression	Medium
Complete more detailed wildfire hazard analysis, including consideration of risk/hazard/value relationships. Inventory potential areas for harvesting guinea grass and forage prior to drought to reduce fire danger.	Low

13.1 Description of Hazard

Wildfires can threaten life and property, but they can also harm the environment and threaten important natural resources such as endangered species. While sometimes caused by lightning, nine out of ten wildfires are human-caused. Put simply, "wildfire" is the term applied to any unwanted and unplanned fire burning in forest, shrub or grass regardless of whether it is naturally or human induced.

On a global basis, the number of wildfires has significantly increased in the last decades. Such increase can be explained by four key factors:

1. Past fire suppression policies, including one of "total suppression," which allowed for the accumulation of fuel in the form fallen leaves, branches, and excessive plant overgrowth in forest and wild land areas.

2. Increasingly dry, hot weather.

3. Changing weather patterns.

4. Increased residential development in the wild land/urban interface.

Wildfires destroy wilderness, property, and lives. As more homes are built in and around brushy and forested areas, and as more people take to our country's wild land areas, wildfires are also on the rise. Through discarded smoking products, sparks from equipment in operation, arced power lines, campfires, arson, debris burning and other careless means, wildfires are often ignited.

Wildfires can be classified into several varieties. According to the National Oceanic Atmospheric Administration (NOAA), there are four types of wildfires: Ground Fires, Surface Fires, Crown Fires, and Spotting Fires as illustrated in Figure 13-1.

All the Hawaiian Islands are susceptible to wildland fires, especially during prolonged drought and high winds. In recent years, the average annual cost to suppress wildland fires in Hawaii is about $1,100,000 - making it a statewide risk. The greatest danger of fire is where the wildland borders urban areas. The amount of natural fuel (trees and brush) in close proximity to human populations contributes to increasing the risk to life and property. Wild land-urban interface fires tend to be more damaging than urban structural fires, are often more difficult to control, and behave differently from structural fires. When these fires erupt, people and structures must take priority, often at a devastating expense to natural resources. People who live in these areas often come directly from urban areas, and may bring with them careless habits and little understanding of wild land fire cycles and dangers. Homes and other structures are built and maintained in a manner that leaves them and their occupants vulnerable. Thus, fire becomes a significant threat to both humans and natural resources. Other threatened locations include agricultural areas that are adjacent to wildlands where downed trees and flammable brush are prevalent.

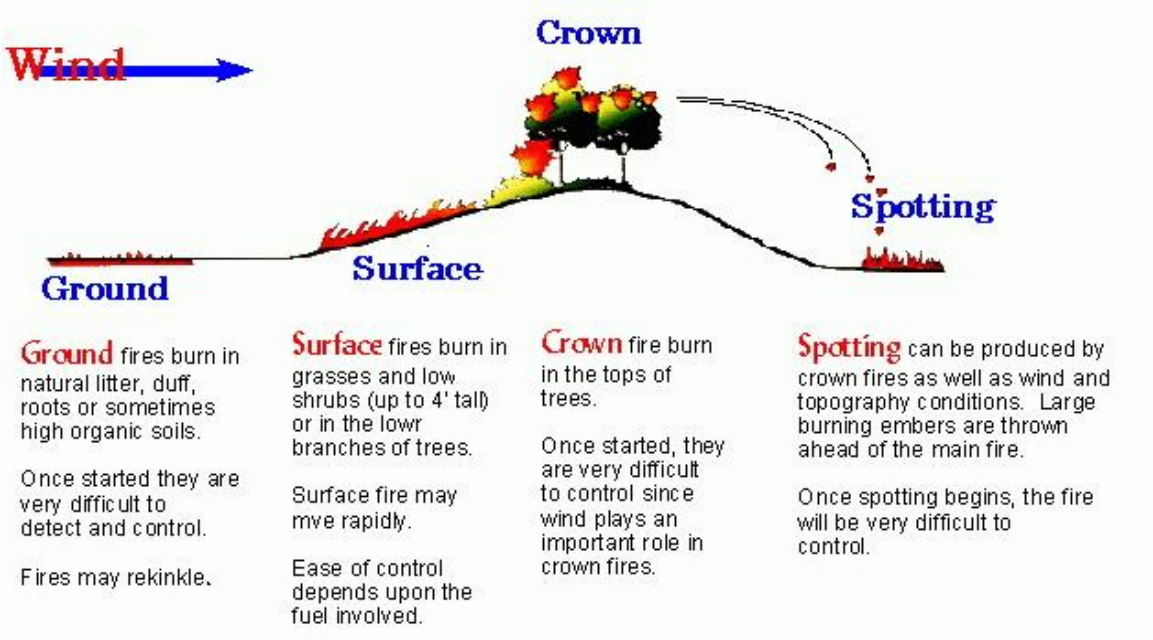


Figure 13-1. Wildfire types and risks (NOAA, National Fire Danger Rating System (NFDRS) http://www.seawfo.noaa.gov/fire/olm/firetype.htm)

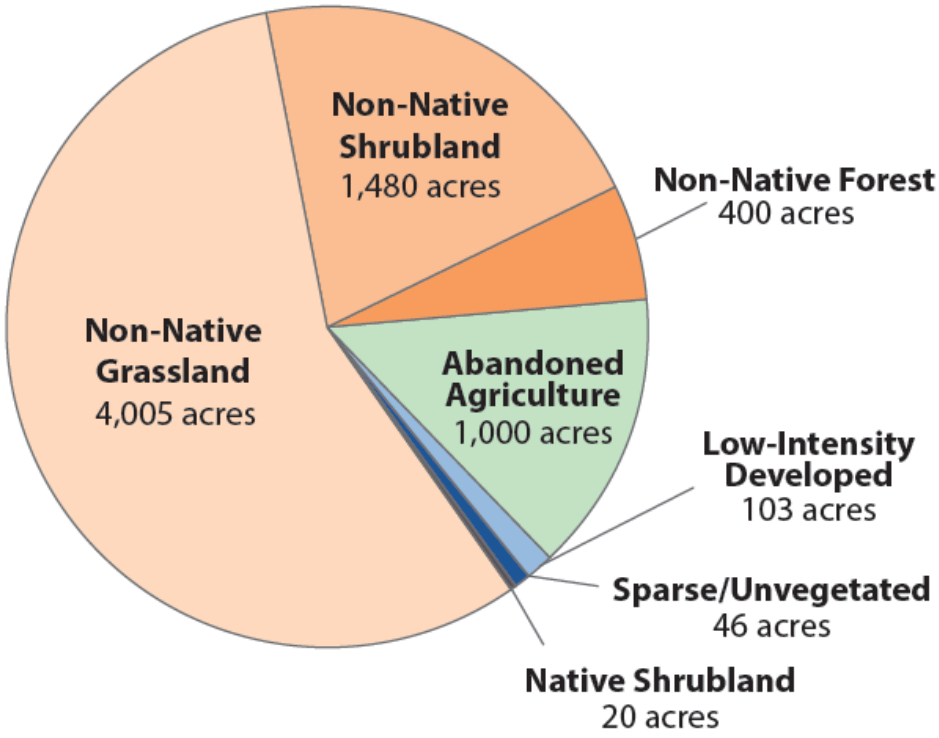
Each year, the State of Hawaii is endangered by hundreds of wildland fires. Wildland fires are associated with periods of little or no rainfall, (see Chapter 12 Drought), and are typically the highest with the months associated with severe drought conditions in Hawaii. "Over the past decade, an average of >1000 wildfires burned >17,000 acres each year in Hawai‘i…. Humans have caused much of the increase in wildfire threat by increasing the abundance of ignitions and introducing nonnative, fire-prone grasses and shrubs. Nonnative grasslands and shrublands now cover nearly one quarter of Hawaii's total land area and, together with a warming, drying climate and year round fire season, greatly increase the incidence of larger fires, especially in leeward areas” (Trauernicht, et al., 2014)

On March 17th, 2016, one of the larger wildfires in Western O‘ahu’s history burned 2,500 acres in Nanakuli Valley. The wildfire began atop a steep cliff on the southeastern edge of the valley and headed downslope toward homes and burned right to the edge of homes, prompting voluntary evacuations. Steep, inaccessible terrain and windy conditions made the wildfire a difficult one for firefighters to suppress. Starting on August 22, 2015, the 1,000-acre Makakilo fire began near homes and up toward Honouliuli Forest Reserve, which is home to the endangered O‘ahu elepaio and kahuli tree snails. On August 13-14, 2007 an estimated 3000 acres were consumed in a wildfire, causing people to evacuate and burning down utility poles. During August 4-6, 2018, nearly 9000 acres were consumed in the Waianae and Makaha wildfires. Through August, 2018, wildfires in Hawaii have burned 30,000 acres, (about double the *annual* average), An electronic map of wildfire locations is shown in Figure 13-2. An example photo of a fire on Oahu is shown in Figures 13-3.

With the decline of production agriculture, grasslands and shrublands have taken their place, increasing the wildland fire risk. These grass-dominated landscapes allow wildfires to propagate

rapidly from areas of high ignition frequencies. Historically, the majority of these fires have been directly caused by humans, either directly or by negligence. There are multiple solutions for reducing risk in these fuels: fuel breaks, targeted grazing, prescribed fire, and the restoration of agricultural and native ecosystems. Communities can become "firewise" and organize to take actions such as increasing access for firefighters and reducing hazardous fuels near homes.

Table 13-1. Annual Wildfire Summary Report – Statewide 2017 (Pacific Fire Exchange, PFX Annual Summary 2017)



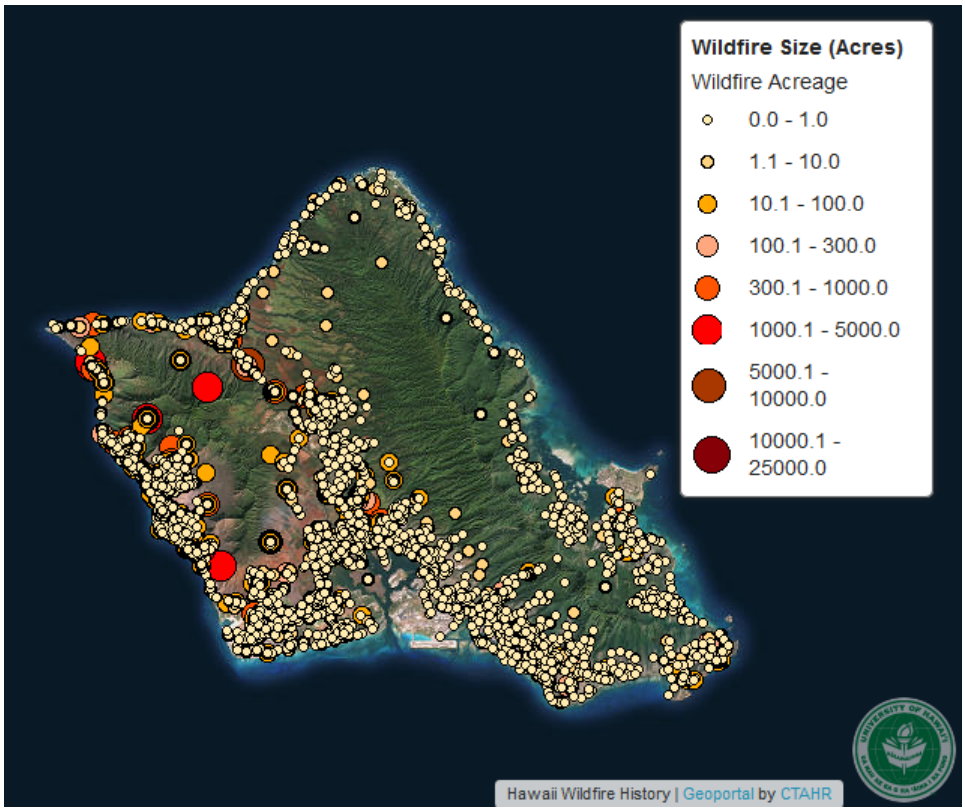


Figure 13-2. UH CTAHR Interactive Map of Oahu Wildfire History up through 2011 available at (http://gis.ctahr.hawaii.edu/WildfireHistory)



Figure 13-3. Waiawa Ridge fire shuts down H-2 Freeway (Hawaii News Now, 09/11/09 , http://www.hawaiinewsnow.com/)

Fortunately, wildland fires have not caused extensive damage or destruction to buildings nor injury to people on Oahu. However, as residential development expands or encroaches into relatively untouched wildlands, people living in these communities will be at greater risk of encountering a wildland fire. A concern within the wildfire community is that new housing developments are being constructed without adequate "defensible space" between the homeowners' property and the wildland areas. The boundaries between developed and undeveloped lands are referred to as the wildland-urban interface. Changes to development policies could help to mitigate the risk of wildfires to residential areas.

13.2 Risk Assessment

Currently there is no measure in place to quantify the potential economic impacts due to wildfires besides historical data. Similarly to the drought hazard, the risk of wildfires is measured in terms of the hazard's economic, environmental, or social impacts. Economic impacts due to wildfires include costs and losses due to burned agricultural crops, damaged public infrastructure and private property, interrupted transportation corridors, and disrupted communication lines. Economic impacts also include diminished real property values and thus tax revenues, loss of retail sales, and relocation expenses of temporarily or permanently displaced residents.

In terms of environmental impacts, wildfires in Hawai‘i pose a serious risk to endemic and introduced flora and fauna. Environmental impacts, therefore, include damage to plant species, damage to animal species, and contamination of hydrological resources.

Lastly, social impacts due to wildfires include health related problems related to smoke inhalation, disruption of activities related to the tourist industry, and damage to archeological sites.

Although the risks cannot currently be quantified in terms of financial losses or other measures, the relative wildfire risks can be assessed by the drought risk area maps for the environmental, public health and safety sector shown in Chapter 12. The areas of high risk primarily in the central Oahu region are illustrated at the different drought levels. In a typical representative year, 2007, DOFAW was involved in 3 fires on Oahu (1,076 acres). This wildfire activity would be expected to continue as long as drought conditions persist. Figure 13-4 shows the communities most at risk to wildfires.

Burn acreage could be mitigated with the mitigation actions listed in this chapter.

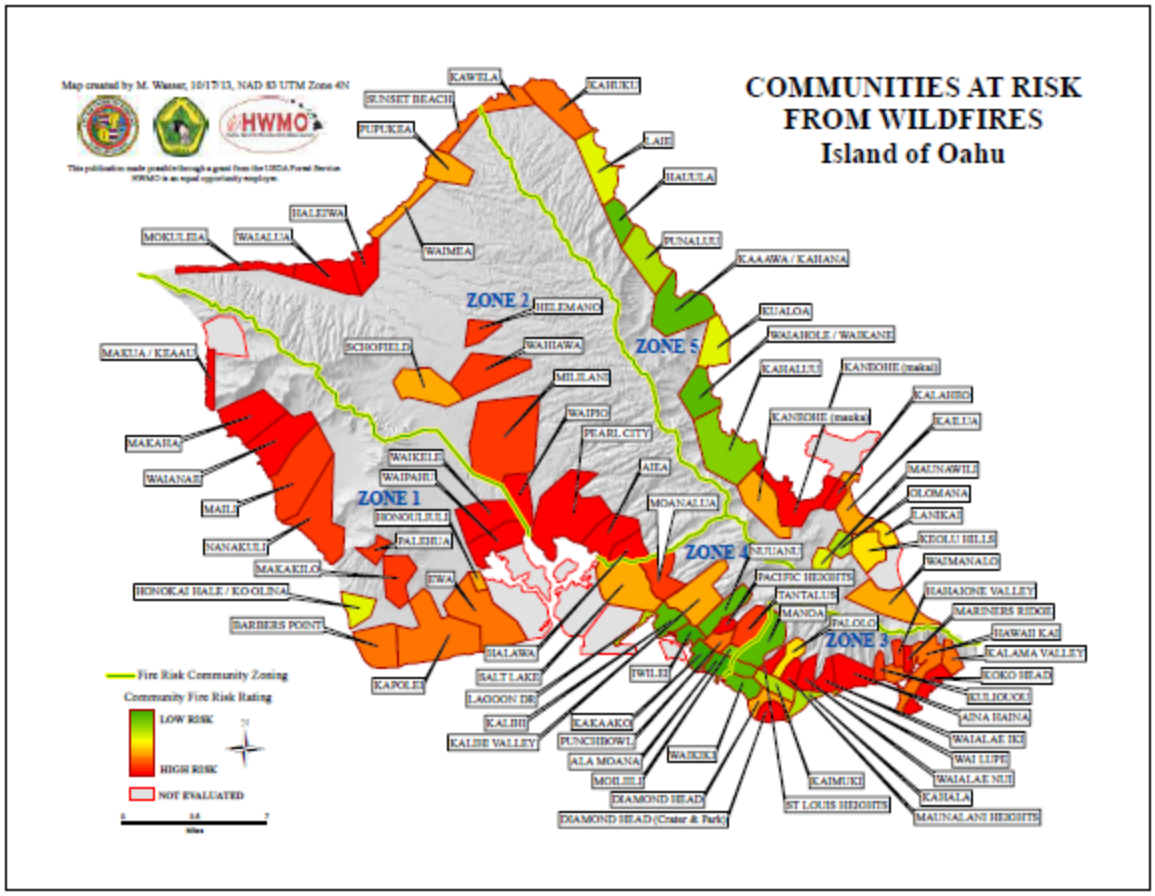


Figure 13-4. Burn Areas and Community Areas at Risk to Wildfires (Trauernicht, 2014)

13.3 The Department of Land and Natural Resources, Division of Forestry and Wildlife

DLNR has the authority under Chapter 185, Hawaii Revised Statutes, Land Fire Protection Law, for the prevention, pre-suppression, and suppression of wildfires forest reserves, public hunting areas, and natural area reserves. It also has the authority to cooperate with established fire control agencies for the protection of other wildlands not with the department's protection areas. The following are existing programs or organized efforts for wildfire prevention and mitigation in the community:

- Division of Forestry and Wildlife (DOFAW) Fire Management Program
- Oahu Wildland Coordinating Group (Federal, State, County, and private firefighting agencies)
- Wildland Urban Interface Grant Program (USDA Forest Service grant administered by DOFAW)
- Establishment and maintenance of fire breaks
- Installation of Remote Automated Weather Stations in high-risk areas
- NWS Fire Weather Products
- Established education and outreach program (Smokey Bear, HFD, etc.)
- National Firewise Communities program

- Community Wildfire Protection Plans

Combined with cooperative zones, DLNR's Division of Forestry and Wildlife (DOFAW) is involved with each of the four counties in the protection of 3,360,000 acres statewide, which approximately 81% of the state's land area. The remainder is managed by various military fire departments and Department of Interior (National Park Service and the Fish & Wildlife Service) and The Nature Conservancy of Hawaii.

In pursuit of this responsibility, DOFAW has adopted a Fire Management Handbook, which specifies its standards for prevention, pre-suppression, and suppression. The document provides a structured approach in providing for public/firefighter safety and minimizing damage to Hawaii's environment. Funding for the fire management program is provided by the State's general fund and federal cost share programs through the U.S. Forest Service. These programs include the Rural Community Fire Protection (RCFP) and Rural Fire Protection and Control (RFPC) programs. Additionally, the Division is a key agency within the State who can trigger provisions of the Stafford Act (Fire Suppression Assistance) which provides for Federal Emergency Management Agency (FEMA) funding assistance in situations where forest and grass fires on public or private lands threaten a major disaster to communities and economies.

Historically, the Division relied on a system of district fire wardens to help suppress fires in rural settings. Because of their location and distribution throughout the islands, many plantations and ranchers served an effective network of partners who could respond with their manpower and equipment to extinguish wildland fires in a timely fashion. Decline in these industries saw the demise of this special partnership within the past decade. In the meantime, local fire departments improved their capabilities by increasing the number of stations and firemen principally in response to the growth of the islands' population and the resultant urban sprawl. The improved fire protection served to provide extended coverage to rural and wildland areas as well. However, there was a need to clarify these relationships because DOFAW, which has no full-time firefighters like the dedicated fire services, was often requested to respond to fire situations outside its legal jurisdiction. The consequence was the rapid depletion of its own fire suppression funding and subsequent inability to address fire threats on land under its own jurisdiction. To still meet its legal fire protection mandate for state-owned lands and honor its partnership with other fire services, DOFAW negotiated with its local fire departments and established a cooperative mechanism for prevention, pre-suppression and suppression measures by way of the current Memorandum of Agreements. Fire Maps were also drawn to delineate agency fire responsibilities.

13.4 Wildland Fire Maps

The mission of the DOFAW Fire Management Program is to provide protection to forest reserves, natural area reserves, wildlife and plant sanctuaries and public hunting areas. In the early 1980s a map of each county, shown for Oahu in Figure 13-5, was delineated to depict areas where DOFAW has primary fire responsibility, areas where it could respond mutually with other firefighting agencies, and areas that are out of its jurisdiction. According to the Chapter 185, Land Fire Law, DOFAW will respond to fires in the green area as the green response zones represent lands managed by DOFAW. The pink areas generally are those areas which are adjacent to the green areas. DOFAW responds to fires in the pink response zone to prevent fires from entering DOFAW lands. If fires are in these areas, DOFAW could respond and assist HFD if the request came

directly from the county fire department. In these areas, DOFAW is an assisting agency and will provide fire suppression resources as funds and resources allow. It was agreed that DOFAW would be able to respond to fires in the white response zone only under specific conditions, i.e. extreme threats to public safety, local resources fully committed, extreme fire behavior, etc., and through the appropriate channels and only if its resources are available. Requests for DOFAW assistance in white areas must be routed from HFD to DEM to HIEMA and finally to DOFAW.

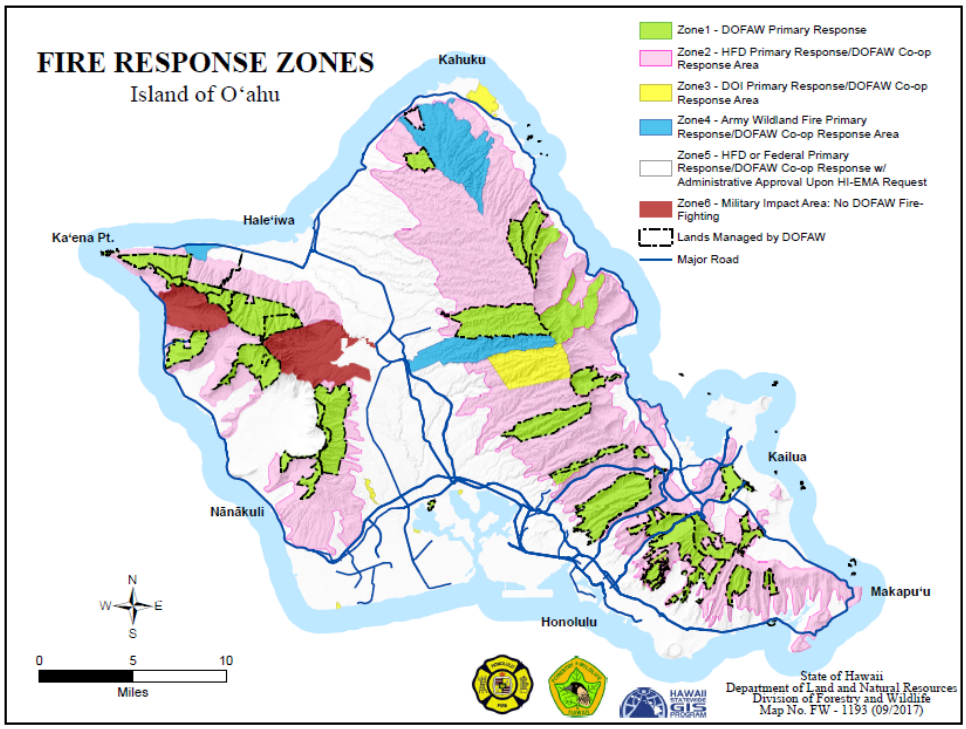


Figure 13-5. Wildland fire response map for Oahu

13.5 Recent and Ongoing Mitigation Activities

1. **Hawaii State Legislature Grant-in-aid (GIA) Program**
   - •During the Regular Legislative Session of 2016, the Hawaii State Legislature appropriated $158,000 for an Operating GIA to support wildfire prevention and hazardous fuel reduction measures.
   - •As the expending agency, DOFAW is working with the Hawaii Wildfire Management Organization and other partners to:
     - Create all-agency unified wildfire prevention messaging, related materials, and a public awareness campaign to maximize public protection and preparedness; and
     - Develop cross-boundary fuel reduction priorities, maps, and projects for all four counties in Hawaii.

2. **Firewise USA** is a voluntary mitigation program that encourages residents to work with neighbors to protect their homes from wildfire. No Oahu communities are Firewise yet.

3. **West Oahu Community Wildfire Protection Plan (2016)**

The State of Hawai‘i Department of Land and Natural Resources- Division of Forestry and Wildlife (DLNR-DOFAW), Honolulu Fire Department (HFD), and O‘ahu Wildfire Information and Education Coordinating Group (OWIE) were the primary partners in developing this plan. This plan addresses elements of fire protection, hazard assessment, wildfire mitigation priorities, and community outreach and education. It identifies and prioritizes areas for hazardous fuel reduction treatments and recommends the types and methods of treatment on federal and non-federal land that will protect one or more atrisk communities and essential infrastructure. It includes recommended measures to reduce structural ignitability throughout the at-risk community.

> “Steep slopes, rough terrain, strong winds, and a large percentage of highly ignitable invasive grasses characterize the Western O‘ahu landscape. This, coupled with warm weather, recurring drought conditions, and a history of human-caused fire starts puts the area at increased risk of wildfire. The proximity of development to fire-prone wildlands present hazardous conditions that now threaten Western O‘ahu communities and natural resources.”

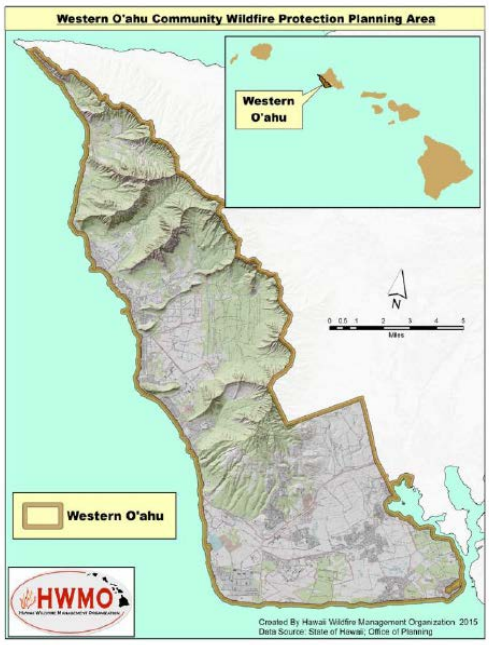


Figure 13-6 – the Western Oahu Wildfire Planning Area

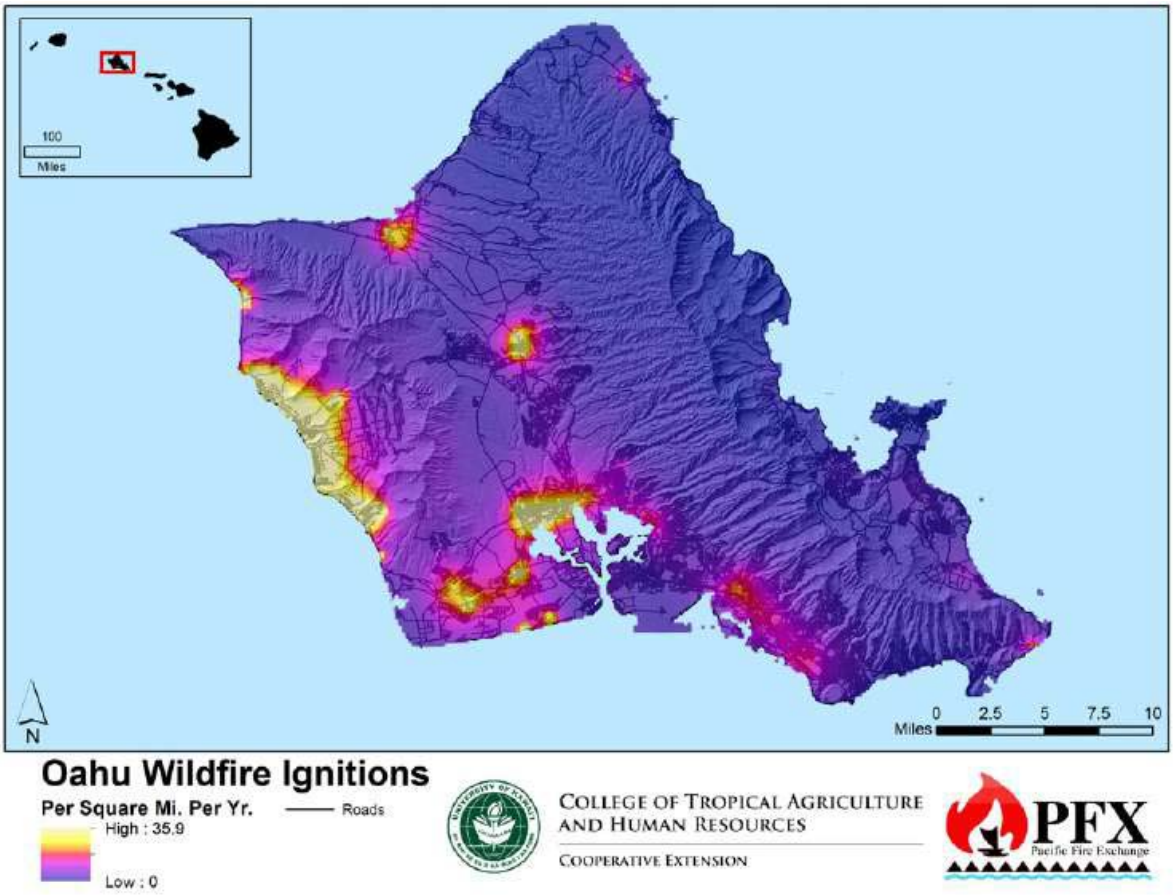


Figure 13-7. Oahu Wildfire Ignition Density Map
(2000-2011 data – wildfire ignitions per sq. mi. / year)

Table 13-2. Western Oahu CWPP Action Plan – Near-Term Projects

1-5 Year Projects			
Proposed and/or Planned Project	**Anticipated Cost**	**When**	**Lead**
Wai'anae Kai Forest Reserve – Green Break: breaking the grass fire cycle by replacing guinea grass with mostly native shrubs and trees that will shade out the grass. Weed mat is also laid down to inhibit grass growth. Education is a strong component of this project. Thousands of volunteer hours by school kids have been logged for this project.	$100,000/ year	Ongoing	Wai'anae Mountains Watershed Partnership, DLNR-DOFAW
Wai'anae Kai Forest Reserve Fuels Conversion– Honua Riparian Project: Restore and reestablish abandoned lo'i to create a riparian area in the FR. This riparian area will be a living fire break to inhibit fire spread.	$50,000/ year	In Initial Phases	DLNR-DOFAW
Wai'anae Kai Forest Reserve Fuel break: Maintenance of approximately ¾ of a mile to prevent fire from hitting the FR from neighboring ranch.	$40,000/y ear	Ongoing	DLNR-DOFAW
Wai'anae Kai Forest Reserve: Retardant treatment- Spraying retardant along roads and plantings to inhibit fire spread.	$30,000/ year	Ongoing	DLNR-DOFAW
Honouliuli Forest Reserve – Fuel break and access: maintenance of roads for firebreaks and fire access.	$20,000/ year	Ongoing	DLNR-DOFAW
Makua Keaau Forest Reserve - Fuel break and access: maintenance of roads for firebreaks and fire access. Approx $20K per year	$20,000/ year	Ongoing	DLNR-DOFAW
Kuaokala Game Management Area - Fuel break and access: Maintenance of roads for firebreaks and fire access. Approx $15K per year	$15,000/ year	Ongoing	DLNR-DOFAW
Nanakuli Ranch - Fuel break and access: maintenance of roads for firebreaks and fire access.	$10,000/ year	Ongoing	DLNR-DOFAW
Smokey Bear and other signage – Install and maintain "Smokey Bear, Prevent Wildfire Signs" throughout project area.	$10,000/ year	ASAP	DLNR-DOFAW
Assist interested communities in completing Firewise Communities certification process	$5,000/ community	Ongoing	HWMO
Provide outreach to students at schools in fire-prone communities	Varies, part of broader workplan and set of expenses	Ongoing	HWMO, OWIE
Develop wildfire prevention and drought awareness and preparedness materials	Variable	In Initial Phases	HWMO, OWIE
Launch wildfire and drought awareness campaign	Variable, depending on strategies employed	In Initial Phases	HWMO, OWIE, DLNR-DOFAW
Host wildfire preparedness information and materials for residents and decision makers on website	Variable	Ongoing	HWMO, DLNR-DOFAW
Utilize social media to promote wildfire awareness	Variable	Ongoing	HWMO, OWIE
Consult county land use planners regarding wildfire issues and input	Variable	ASAP, as part of CWPP process	HWMO

Table 13-3 Western Oahu CWPP Action Plan – Long-Term Recommendations

Longer-Term Projects		
Proposed Project	Anticipated Cost	Lead
Continue and expand all-agency unified wildfire outreach campaign, such as Wildfire & Drought Lookout	TBD	HWMO, OWIE
Improve national reporting of wildfires in Hawai'i	TBD	DLNR-DOFAW, USFS, HWMO
Improve initial attack capacity	Project dependent	TBD
Work to appropriately graze fallow areas where fuels are building, Fund fencing and water troughs to make lease areas more economically feasible to graze	200,000 for fencing multiple areas	DLNR-DOFAW
Install water tanks around margins of communities to serve as dip tanks for helicopter fire suppression. Have tanks double as water troughs for ranching and conservation/restoration efforts	$20-60,000 per diptank	TBD
Increase outreach to community associations (workshops, presentations)	Variable	HWMO, OWIE
Increase K-12 wildfire-focused outreach and education	TBD	HWMO, OWIE
Provide wildfire education for decision makers	TBD	HWMO, OWIE
Seed collection and storage for post-fire replanting	TBD	DLNR-DOFAW
Create fuelbreak maps (existing and desired)	$50,000	HWMO
Work with large landowners to encourage fuels management	TBD	OWIE, HWMO
Develop plan for increased water to areas such as Yokohama Bay	TBD	OWIE, DOFAW
Maintain and add RAWS	TBD	DLNR-DOFAW, OWIE
Work with partners and residents to garner support for increasing DOFAW's budget for fire response	TBD	HWMO
Extend successes in Wai'anae Kai to other Forest Reserves and Makaha (Honolulu Board of Water Supply)	TBD	DLNR-DOFAW
Increase DOFAW nursery capacity (i.e., add a horticulturalist position)	TBD	DLNR-DOFAW
Submit WUI proposals for projects in the CWPP area	TBD	DLNR-DOFAW
Work with state and federal land-owner assistance programs to incorporate wildland fire concerns	TBD	DLNR-DOFAW
Develop fire-specific situational awareness and evacuation plans, education, and resources for communities	TBD	TBD
Increase community and agency fire danger and fuels monitoring capacity	TBD	HWMO, UH

13.6 Future Proposed Mitigation Projects

Further activities that could reduce the vulnerability to wildfire are categorized in Table 13-4.

Table 13-4. General Types of Mitigation Actions to Reduce Wildfire Vulnerability

Impacts	Response and Mitigation Actions	Response Agency
Accessibility	• Under normal fire events and workload, utilize existing fire suppression mechanisms of local, state, military and federal assets • Provide additional helicopter assets during critical drought periods	DOFAW State CD County CD County Fire Depts. HARNG
Reduced Water Supply	• Utilize local government and private water tenders • Limit the use of salt water in suppression activities • Consider fire fighting needs when upgrading water systems • Inventory water sources statewide and seek agreements to maintain these water sources • Develop a policy for the use of salt water for fire fighting	DOFAW County Public Works County Planning Dept. County Fire Depts. County Water Depts. State Highways Div. CWRM
Fuel Loading	• Under normal workload, exercise thinning, pruning, grazing, and limited use of prescribed fire • Expand grazing program	DOFAW Private Ranchers U.S. Army
Fire Fighting Resources	• Utilize existing fire suppression mechanisms of local, state, military, and federal assets • Modernize fire fighting agencies with new or specialized equipment to the extent fiscally possible • Purchase all-terrain fire fighting vehicles such as humvees. Acquire supplemental equipment such as pumps, hoses, and water buckets • Investigate the feasibility of purchasing new and innovative technology that would enhance the capability of fire response agencies • Acquisition of communications gear (air and ground) to ensure proper lines of communication are always available during fire suppression activities	DOFAW County Fire Depts. State CD County CD U.S. Army Federal Fire Dept. HARNG Private Entities

Mitigation projects proposed by the 2017 Hawaii Drought Plan include:

- Complete more detailed wildfire hazard analysis, including consideration of risk/hazard/value relationships.
- Inventory potential areas for harvesting guinea grass and forage prior to drought to reduce fire danger.
- Review the fire code for mitigative provisions and talk with construction personnel and insurance companies about fire mitigation.
- Develop recommendations for new regulations requiring registration and use of off-road vehicles, dirt bikes – trespassing, fire hazard, and nuisance issues.

Further details of the proposed projects are provided in Chapter 19.



14. Hazardous Materials

14. HAZARDOUS MATERIALS

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The HAZMAT hazard is described in the 2012 plan along with the HSERC and LEPC. HAZMAT sites are listed and HAZMAT team equipment is inventoried.	• This is an optional chapter not required by FEMA. • A major Superfund Amendments and Reauthorization Act (SARA) provision is Title III, also referred to as Emergency Planning and Community Right-to-Know Act (EPCRA). EPCRA established guidelines for Federal, State and local governments, and industry regarding emergency planning and providing communities with information on hazardous chemicals within their jurisdiction. • The Hawaii Emergency Planning and Community Right-to-Know Act became law in 1993 (HRS 128E). A Hawaii State Emergency Response Commission (HSERC) was formed and Local Emergency Planning Committee (LEPC) was established in each county. Functions of the LEPC include preparing a hazardous material emergency response plan, reviewing the plan annually, evaluating resources to mitigate an emergency, receiving emergency response notifications, and receiving and processing requests for information from the general public • Further background for the legislative structure and organizations that govern the management of hazardous materials is provided along with their roles and responsibilities. • The KLEAN local emergency action network is included. • An Oahu Response Program Site List is described • HAZMAT sites are mapped and discussed. • Recent and ongoing mitigation and preparedness activities are listed.

14.1 History

The Superfund Amendments and Reauthorization Act or SARA became law in 1986 (PL 99-499). A major SARA provision is Title III, or SARA Title III, also referred to as Emergency Planning and Community Right-to-Know Act (EPCRA). EPCRA established guidelines for Federal, State and local governments, and industry regarding emergency planning and providing communities with information on hazardous chemicals within their jurisdiction. The Hawaii Emergency Planning and Community Right-to-Know Act became law in 1993 (HRS 128E), and promulgated SARA Title III in the State of Hawaii.

The State of Hawai‘i Department of Health (DOH) Office of Hazard Evaluation and Emergency Response (HEER) is responsible for implementing Hawai‘i Revised Statutes Chapters 128D (Environmental Response Law) and 128E, Hawai‘i Emergency Planning and Community Right to Know Act.

Chapter 128D, Environmental Response Law, Section 7, HRS, mandates that a Statewide List of Sites be published annually listing the sites with potential or known hazardous substances or pollutants or contaminants. HEER Sites of Interest includes only those facilities, sites and areas where assessment has been initiated by the Site Discovery, Assessment and Remediation Section (SDAR section).

The DOH Hawai‘i Site Rehabilitation Prioritization (SRP) List of Priority Sites in the state shows 572 active non-military sites with potential or known hazardous substances or pollutants or contaminants. The Hawai‘i SRP List of Priority Sites is sorted in order of Island, Locality, the Program Area, and the Facility/Site Name. The site Status and Potential Hazard are also identified for each Facility/Site.

Chapter 128E, HRS, Hawai‘i Emergency Planning and Community Right to Know Act, (HEPCRA) governs the threshold quantities of hazardous chemical material subject to inventory, reporting, and emergency response plans required to be filed by the facility owner/operator. HEPCRA requires that facilities must report annually on hazardous substances stored on their premises if the amounts stored exceed specified threshold planning quantities. HEPCRA also requires that an owner or operator of a facility that stores, uses, or manufactures above defined thresholds, any hazardous substance, or extremely hazardous substance, is required to file a notification of such “Tier II” activity, and to pay a filing fee.

A Hawaii State Emergency Response Commission (HSERC) was formed and each of the four counties in Hawaii was designated as an emergency planning district. A Local Emergency Planning Committee (LEPC) was established in each county. Functions of the LEPC include preparing a hazardous material emergency response plan, reviewing the plan annually, evaluating resources to mitigate an emergency, receiving emergency response notifications, and receiving and processing requests for information from the general public.

14.2 Organization of the State and Local Emergency Planning

14.2.1 Hawaii State Emergency Response Commission

The Hawai‘i State Emergency Response Commission, is placed within the Department of Health for administrative purposes and to carry out the requirements of HRS 128-E. The commission shall consist of the following members, who shall be appointed by the governor as provided in section 26-34:

(1) The director of health;

(2) The chairperson of the board of agriculture;

(3) The adjutant general;

(4) The director of labor and industrial relations;

(5) The chairperson of the board of land and natural resources;

(6) The director of the office of environmental quality control;

(7) The director of business, economic development, and tourism;

(8) The director of transportation;

(9) The dean of the University of Hawai‘i school of public health or the dean of the University of Hawai‘i school of medicine, as determined by the governor;

(10) The director of the environmental center of the University of Hawai‘i;

(11) One representative from each committee designated by the mayor of each respective county; and

(12) Other persons appointed by the governor to meet the minimum requirements of the Emergency Planning and Community Right-to-Know Act of 1986.

14.2.2 Local Emergency Planning Committee (LEPC)

The Honolulu Local Emergency Planning Committee (LEPC) is a volunteer organization charged with bringing together local government, communities, academia, and industries as a resource for enhanced hazardous materials (HAZMAT) preparedness, planning and emergency response within the City and County of Honolulu. The Committee was established on November 24, 1987 to meet Federal (40 CFR) and State (Title 10 HRS Chapter 128E) Emergency Planning and Community Right-to-Know regulatory obligations.

The Local Emergency Planning Committee shall be composed of at least one person from each of the following groups:

(1) Elected state and county officials;

(2) Law enforcement, first aid, health, environmental, hospital, and transportation personnel;

(3) Firefighting personnel;

(4) Civil defense and emergency management personnel;

(5) Broadcast and print media personnel;

(6) Community groups not affiliated with emergency service groups;

(7) Owners and operators of facilities subject to the requirements of the Emergency Planning and Community Right-to-Know Act of 1986; and

(8) Other groups recommended by the mayor and appointed by the commission.

The Local Emergency Planning Committee is to take appropriate actions to ensure the preparation, implementation, and annual update and review of the local emergency response plan required by this chapter and the Emergency Planning and Community Right-to-Know Act of 1986. The local emergency response plans shall include, but not be limited to, the following:

(A) Identification of each facility subject to the requirements of section 303 of the Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. §11003 and within the emergency planning district; identification of routes likely to be used for the transportation of substances on the list of extremely hazardous substances; and identification of additional facilities contributing or subjected to additional risk due to their proximity to facilities subject to the requirements of this section, such as hospitals or natural gas facilities;

(B) Methods and procedures to be followed by facility owners and operators and local emergency and medical personnel in responding to any release of these substances;

(C) Designation of a community emergency coordinator and facility emergency coordinators, who shall make determinations necessary to implement the plan;

(D) Procedures providing reliable, effective, and timely notification by facility emergency coordinators and the community emergency coordinator to persons designated in the emergency plan, and the public, that a release has occurred, consistent with the notification requirements of this chapter and section 304 of the Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. §11004;

(E) Methods for determining the occurrence of a release, and the area or population likely to be affected by the release;

(F) A description of emergency equipment and facilities in the county and at each facility in the county subject to the requirements of this section, and the identification of the persons responsible for the equipment and facilities;

(G) Evacuation plans, including provisions for precautionary evacuation and alternate traffic routes;

(H) Training programs, including schedules for training of local emergency response and medical personnel; and

(I) Methods and schedules for exercising the emergency plan;

The Local Emergency Planning Committee shall be responsible for, but not limited, to the following:

(1) Request additional information from the facilities, if necessary, to develop emergency response plans;

(2) Submit local emergency response plans to the commission for review, and to other affected agencies upon request;

(3) Report to the commission on alleged violations of this chapter;

(4) Prepare reports, recommendations, and other information related to the implementation of this chapter, as requested by the commission;

(5) Have the primary responsibility for receiving, processing, and managing hazardous chemical information forms and data, trade secrets, and public information requests pursuant to this chapter;

(6) Accept and deposit into the state treasury any grants, gifts, or other funds received for the purpose of carrying out this chapter; and

(7) Evaluate the need for resources necessary to develop, implement, and exercise the emergency plan, and make recommendations with respect to additional resources that may be required and the means for providing these additional resources.

14.2.3 Kapolei Local Emergency Action Network (KLEAN)

The Kapolei Local Emergency Action Network (KLEAN) was formed in early 1996 (formerly Campbell Local Emergency Action Network (CLEAN)) to analyze potential vulnerabilities, determine emergency planning requirements, and address public safety and health for Campbell Industrial Park (CIP) businesses and their neighboring communities. KLEAN is a non-profit organization whose membership includes residents from neighboring communities, CIP businesses, and government agencies including the Honolulu LEPC.

14.3 Emergency Planning and Community Right to Know Act

The Hawai‘i State Legislature enacted an update to Hawai‘i Revised Statutes 128 (D - Environmental Response Law and E - Hawai‘i Emergency Planning and Community Right to Know Act), clarifying and affecting the threshold quantities of hazardous chemical material subject to inventory, reporting, and emergency response plans by the facility owner/operator.

§128E-6 Reporting requirements. (a) The owner or operator of a facility in the state that stores, uses, or manufactures any hazardous substance shall comply with the following requirements:

(1) Each owner or operator of a facility in the state shall comply with the emergency planning and notification requirements of sections 302 and 303 of the Emergency Planning and Community

Right-to-Know Act of 1986, 42 United States Code sections 11002 and 11003, if an extremely hazardous substance is present at the facility in an amount in excess of the threshold planning quantity established for the substance;

(2) Each owner or operator of a facility in this state that is required to prepare or have available a material safety data sheet for a hazardous chemical under the Occupational Safety and Health Act of 1970, as amended, 15 United States Code section 651 et seq., and regulations promulgated under that Act, for:

(A) All hazardous substances, except for extremely hazardous substances, present at the facility in amounts not less than ten thousand pounds; and

(B) All extremely hazardous substances present at the facility in amounts not less than five hundred pounds, or the threshold planning quantity for that substance, whichever is less,

shall comply with the following reporting requirements:

(i) Complete a chemical list by March 1 of each year and submit material safety data sheets not more than thirty days after a request;

(ii) Complete the state chemical inventory form by March 1 of each year; provided that a Tier II list shall be used until a state form is available;

(iii) Submit facility diagrams and location area maps by March 1 of each year, and update the maps annually as needed; and

(iv) Submit emergency response plans required under state or federal law.

The documents required in clauses (i) through (iv) shall be submitted by March 1 of each year to the commission, the respective committee, and the respective fire department;

(3) Each owner or operator of a facility in this state that is subject to section 313 of the Emergency Planning and Community Right-to-Know Act of 1986, 42 United States Code section 11023, shall comply with the toxic chemical release form requirements of section 323 of the Emergency Planning and Community Right-to-Know Act of 1986 by July 1 of each year; and

(4) Each owner or operator of a facility in this state covered under section 304 of the Emergency Planning and Community Right-to-Know Act of 1986, 42 United States Code section 11004, shall comply with the notification requirements of section 304 of the Emergency Planning and Community Right-to-Know Act of 1986, and section 128E-7, if a release of an extremely hazardous substance occurs from the facility.

(b) The commission shall adopt rules in accordance with chapter 91 establishing the specific information required on the state chemical inventory form. The chemical inventory form shall facilitate ease in complying with the requirements of [this chapter] by consolidating the necessary information into one form. The chemical inventory form may include, but is not limited to:

(1) The chemical name;
(2) Quantity stored on the site;
(3) Hazardous components;
(4) Health and physical hazards; and
(5) Storage information. [L 1993, c 300, pt of §1; am L 2008, c 87, §2]

14.4 Oahu Response Program Site List

Chapter 128D, HRS, Environmental Response Law requires that the department publish an annual report to the Legislature (Department of Health, 2017), listing Hawaii sites eligible for remedial

action under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA).

There are currently three sites on Oahu listed on EPA's National Priority List (NPL) for cleanup, a as listed in Table 14-1 below. Costs for site investigation and cleanup are being borne by the responsible parties :

Table 14-1. EPA's CERCLA National Priority List (NPL)

Island	Locality	Facility Site Name
Oahu	Kunia	Del Monte Oahu Plantation NPL Site
Oahu	Pearl Harbor	Naval Computer and Telecommunication Area Master Station (NCTAMS)
Oahu	Pearl Harbor	Pearl Harbor Naval Complex

Sites that are potential hazardous waste sites which are being or have been evaluated using the U.S. EPA's Hazard Ranking System, may be eligible for possible listing under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). These are presented below and managed by the Hazard Evaluation and Emergency Response (HEER) Office Preliminary Assessment/Site Inspection (PA/SI) Program Remedial Project Managers (RPMs) (Table 14-2). These sites are no longer being considered for NPL listing.

Table 14-2. HEER Office PA/SI Program Sites

Island	Locality	Facility Site Name
Oahu	Waialua	Waialua Sugar Company Inc and Waialua Sugar Mill Settling Ponds
Oahu	Kailua	Kapaa Landfill – Kapaa Quarry Road
Oahu	Honolulu	Kapalama Incinerator
Oahu	Kailua	Honolulu Skeet Club
Oahu	Honolulu	Pukoloa Wood Treating Site

In addition the State of Hawaii has a list of sites with potential or known hazards. Sites are managed within the Hazard Evaluation and Emergency Response (HEER) Office. HEER Sites of Interest includes only those facilities, sites and areas where follow up oversight has been initiated by the Site Discovery, Assessment and Remediation Section (SDAR section) under HRS 128D (including CERCLIS sites). This list includes all sites for which the SDAR section has an environmental interest, including military sites and older, inactive sites that have insufficient

available information to make regulatory determinations about closure. Over time a site may be managed within HEER Office under one or more program areas starting with the site assessment phase and if required by the State, through to cleanup completion. There are over 2000 sites http://eha-web.doh.hawaii.gov/eha-cma/Leaders/HEER/public-records , that have been subject to assessment. Many of those were determined to have no hazard; although there are over 2000 sites on this list, most are closed sites and are safe for the current land use. However, contamination may remain at closed sites and could be a problem if land use changes or if natural or man-made events like erosion, sea level rise, construction, or utility work impact the property.

Many HAZMAT sites of significance around the island are mapped in Figure 14-1.

The Hawaii State Response Program lists of all chemical and petroleum release notifications received by the HEER Office emergency response team during the fiscal year. These are shown in the iHEER_Hazard Evaluation and Emergency Response System online map that is available at http://eha-web.doh.hawaii.gov/eha-cma/Leaders/HEER/public-records

14.5 Hazmat Units

There are two hazardous materials units in separate companies, Hazmat 1 serves downtown Honolulu and east Oahu. Hazmat 2 is located in the Campbell Industrial Park near Kapolei to serve west Oahu. Both units have model year 2000 Pierce Lance HAZMAT Fire Apparatuses. The vehicles are powered by a 470 horsepower Detroit turbo diesel, contain a 25kw electric generator that can provide 18,000 watts of lighting, and have a built- in command center with weather station and computer. The vehicles are equipped to outfit a 5 man response team to Level A/B PPE capability and have detection equipment, leak and spill equipment, and decontamination equipment and supplies. The hazardous materials response companies are staffed by 5 HazMat technicians each and the department maintains 300+ HazMat technicians among the 1100+ uniform members. Level A & B chemical protective clothing, detection equipment, technical reference & spill mitigation response equipment is maintained in the HazMat response inventory.

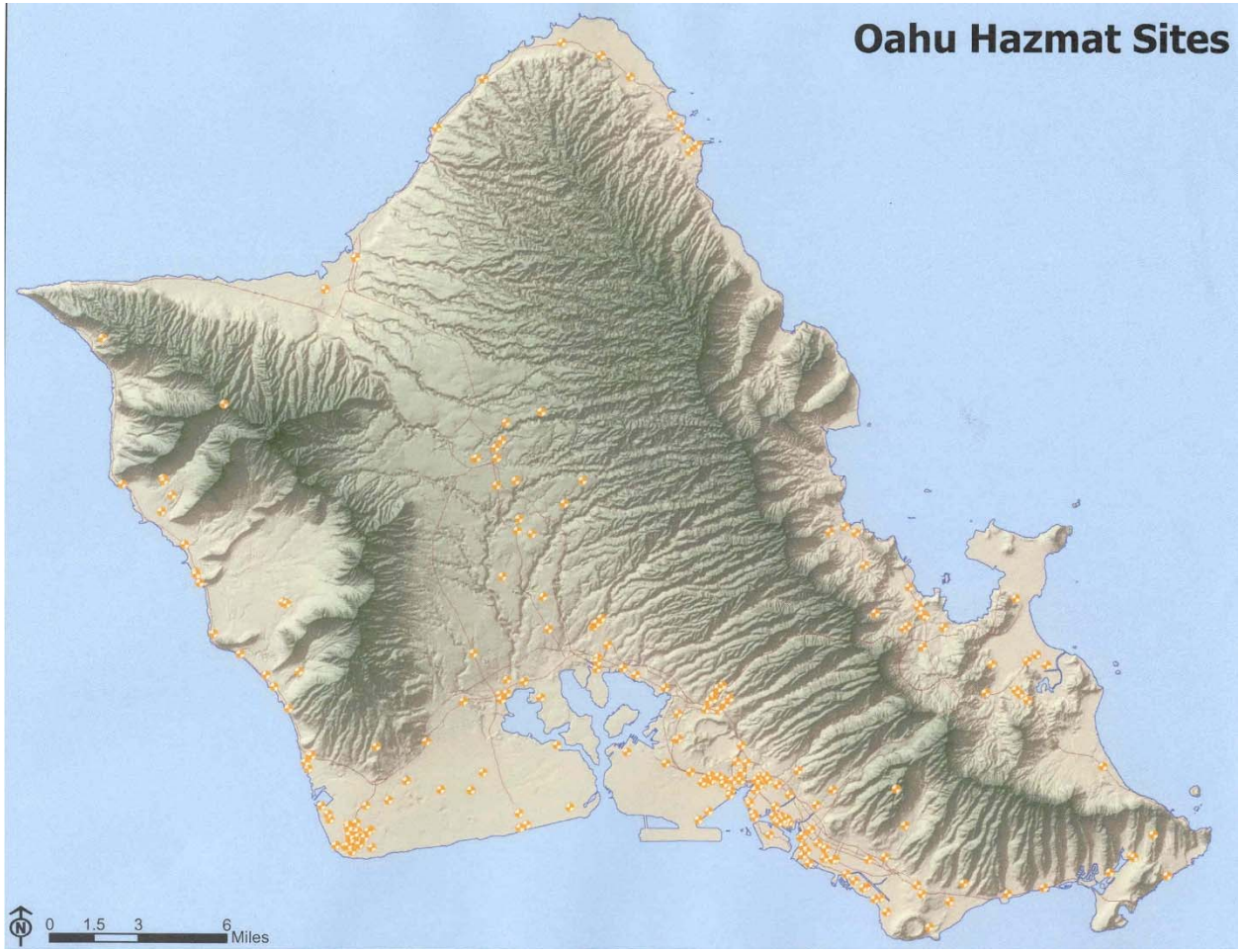


Figure 14-I - HAZMAT sites on the Island of Oahu

14.6 Recent and Ongoing Hazard Mitigation Activities

14.6.1 Projects

Risk Management Program guidelines are used to assess off-site consequences of a release, and are fully integrated into the softwares of Cameo, Marplot and Aloha.

14.6.2 Emergency Response Capabilities in the City & County of Honolulu

The various first response emergency activities & disciplines (Law Enforcement, Fire, Emergency Services, Emergency Management) needed to mitigate and stabilize a hazardous materials emergency are well handled and maintained by the City & County of Honolulu and as authorized by the Honolulu City Charter.

The Honolulu Fire Department is the lead incident command department for such events that are non-terrorist related. HFD maintains 43 fire stations, 6 water tankers, 2 helicopters, 2 technical rescue, & 2 hazardous materials response companies. Two of the fire companies are also fully staffed with HM technicians to facilitate a quick response of additional certified personnel.

Additional mutual aid is available from the Federal Fire Department who also maintains a Level A emergency response capability. The Hawaii National Guard Civilian Support Team maintains a 23 member team to assist and support civil authority with terrorism/Weapons of Mass Destruction events.

Normally, once emergency conditions are mitigated to a controlled state, events are turned over either to responsible parties or the State Department of Health, Hazard Evaluation & Emergency Response (HEER) On-Scene Coordinators (OSCs) as defined in the Hawaii Environment Emergency Response Law, HRS Chapter 128.

Interoperability between agencies is coordinated and incidents managed by utilizing national recognized Incident Management System/National Incident Management System protocols & procedures. Communications interoperability between organizations is well practiced with various drills and exercises.

14.6.3 Training and Exercise

Training activities over the last decade have primarily been focused at training fire fighters to the Hazardous Materials Technician Level for manning the Honolulu Fire Department's Hazardous Materials Emergency Response Program. Law Enforcement and State Health Department personnel have also participated in the program. Funding for this activity has been provided by a Federal Department of Transportation grant.



15. Dams

15. DAMS

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
A general description of the dam failure hazard and dam locations was given in the 2012 plan. A description of the seismic evaluation of dams was provided.	• All of the Oahu dam sites are mapped in GIS and their properties listed. • Emergency Action Plan (EAP) requirements are described. • All dams now have EAPs and it is now possible for dam owners to create their EAP online. • Dam evacuation zones are now available to the public

15.1 Dams on Oahu

A dam is defined as a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water. A dam impounds water in the upstream area, or reservoir. The amount of water impounded is measured in acre-feet referring to the volume of water that covers an acre of land to a depth of one foot. (FEMA, 1997b)

In Hawaii, a "Dam" is defined in Chapter 190 of the Hawaii Administrative Rules (http://www.state.hi.us/dlnr/lmd/rules/CHAP190.pdf) as any artificial barrier, including appurtenant works, which impounds or diverts water, and which:

1. Is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to a maximum water storage elevation; or
2. Has an impounding capacity at maximum water storage elevation of fifty acre-feet or more. This chapter does not apply to any artificial barrier that is less than six feet in height regardless of storage capacity or which has a storage capacity at maximum water storage elevation less than fifteen acre-feet regardless of height

Lake Wilson and Nuuanu Reservoir on Oahu may be some familiar local dams. All of the Oahu dam sites are mapped in Figure 15-1 and their properties listed in Table 15-1. There are three types of dams: detention, storage, and diversion. Detention dams are constructed to retard and minimize the effects of flood runoff. These types of dams are used to store all or a portion of an anticipated flood runoff. The floodwater stored by the dam is released at a rate that does not exceed the carrying capacity of the channel downstream. Dams are most efficient for flood control in deeper valleys where there is more room to store water. Storage dams are constructed to impound water during periods of surplus supply for use during periods of drought. This water is for crop irrigation, livestock watering, municipal and industrial water supply. Diversion dams are constructed to provide hydraulic head for diverting water from streams and rivers into ditches, canals, or other water conveyance. The lake created by a dam may provide recreational benefits, such as Lake Wilson does for fishing. Wet or dry basins can serve multiple uses by doubling as parks or other open space uses. All dams on Oahu are earthen dams.

As with other structural projects, man-made dams and reservoirs have several impacts to be managed, in that they:

- Are expensive
- May remove productive land
- Require periodic maintenance
- May fail to prevent damage from floods that exceed their design levels
- May create a flash flood hazard to properties downstream of the dam
- May eliminate beneficial functions of the natural floodplain

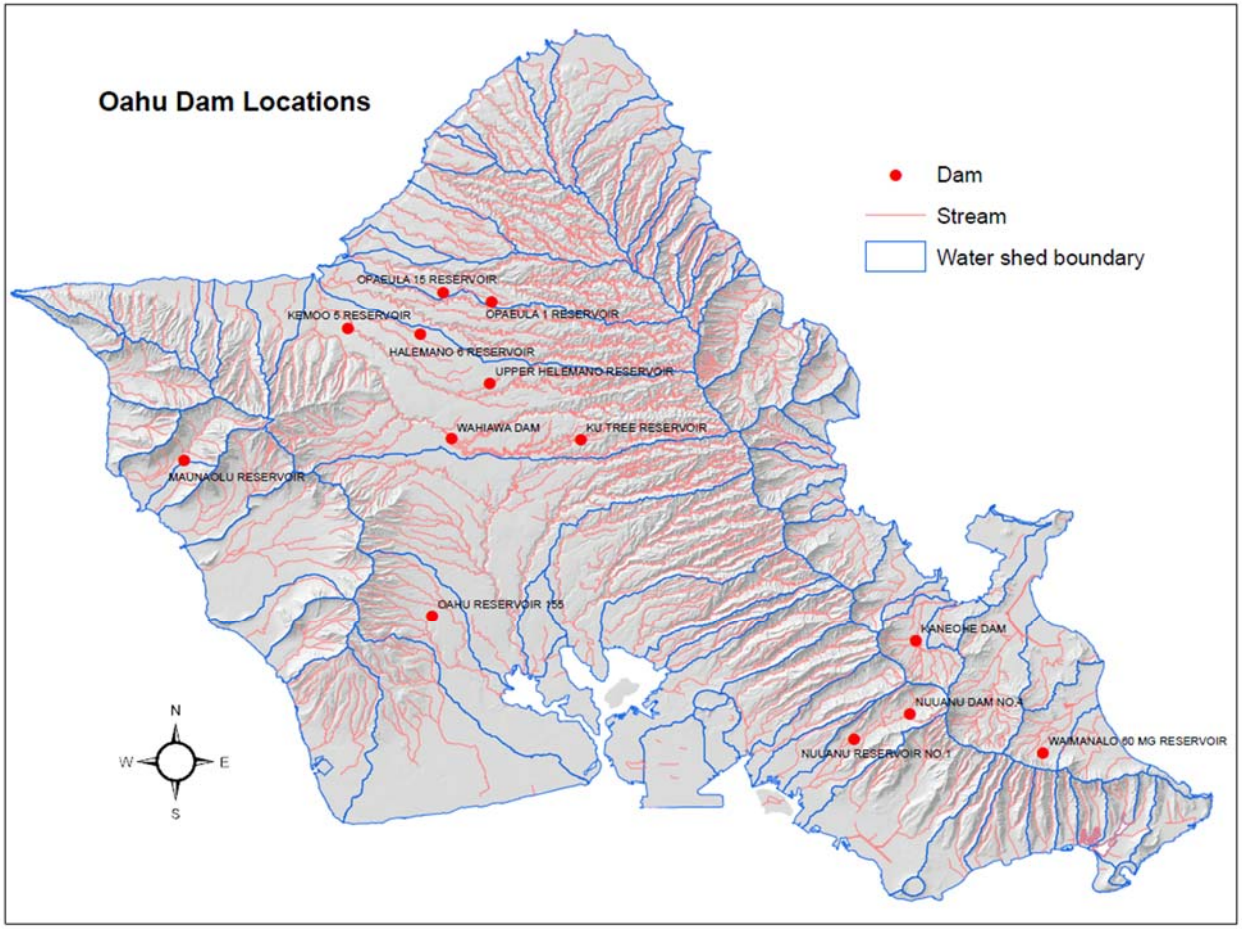


Figure 15-1. Oahu Dam Sites

Table 15-1. City and County of Honolulu Dams (DLNR Dam Inventory)

DAM NAME	STATE ID	NAT ID	NEAR TOWN	OWNER	PURPOSE	LENGTH (ft)	HEIGHT (ft)	MAXSTOR (acre-ft)	HAZARD	LAT	LONG	YEAR CREATED	YEAR LAST MODIFIED
HALEMANO 6 RESERVOIR	OA-0023	HI00023	KEMOO CAMP 4	DOLE FOOD CO. HAWAII	IRRIGATION	250.0000	36.0000	80.0000	HIGH	21.5528	-158.0656	1915	1915
KANEOHE DAM	OA-0124	HI00124	KANEOHE	C&C DFM	FLOOD CONTROL / RECREATION	2200.0000	83.0000	4500.0000	HIGH	21.3912	-157.8048	1980	1980
KEMOO 5 RESERVOIR	OA-0021	HI00021	THOMPSON CORNER	DOLE FOOD CO. HAWAII	IRRIGATION	650.0000	21.0000	63.0000	HIGH	21.5561	-158.1037	1920	1920
KU TREE RESERVOIR	OA-0025	HI00025	WAHIAWA	U.S. ARMY DOD	OTHER	550.0000	98.0000	1085.0000	HIGH	21.4976	-157.9811	1925	1925
MAUNAOLU RESERVOIR	OA-0149	HI00149	MAKAHA	HBWS	IRRIGATION	800.0000	27.0000	23.0000	HIGH	21.4862	-158.1899	1966	2014
NUUANU DAM NO.4	OA-0001	HI00001	HONOLULU	HBWS	FLOOD CONTROL / RECREATION	2120.0000	66.0000	3600.0000	HIGH	21.3526	-157.8078	1910	1910
NUUANU RESERVOIR NO.1	OA-0154	HI00154	NA	HBWS	FLOOD CONTROL / WATER SUPPLY	588.0000	33.5000	NA	HIGH	21.3397	-157.8374	1905	1905
OAHU RESERVOIR 155	OA-0137	HI00137	WAIPAHU	MONSANTO CO.	IRRIGATION	900.0000	25.0000	37.0000	HIGH	21.4046	-158.0593	1916	1916
OPAEULA 1 RESERVOIR	OA-0018	HI00018	HALEIWA	KAMEHAMEHA SCHOOLS	IRRIGATION	250.0000	66.0000	400.0000	HIGH	21.5704	-158.0280	1910	2011
OPAEULA 15 RESERVOIR	OA-0020	HI00020	HALEIWA	KAMEHAMEHA SCHOOLS	IRRIGATION	2200.0000	21.0000	85.0000	HIGH	21.5754	-158.0534	1910	1910
UPPER HELEMANO RESERVOIR	OA-0022	HI00022	WAIALUA	DOLE FOOD CO. HAWAII	IRRIGATION	530.0000	46.0000	700.0000	HIGH	21.5267	-158.0290	1912	1912
WAHIAWA DAM	OA-0017	HI00017	WAIALUA	DOLE FOOD CO. HAWAII	IRRIGATION	660.0000	88.0000	9200.0000	HIGH	21.4977	-158.0492	1906	1906
WAIMANALO 60 MG RESERVOIR	OA-0129	HI00129	WAIMANALO	HDOA	IRRIGATION	2118.0000	65.0000	182.0000	HIGH	21.33218	-157.7378	1993	1993

15.2 Dam Failures

Dam failures cause another type of flash flood. The sudden release of the impounded water can occur during a flood that overtops or damages a dam or it can occur on a clear day if the dam has not been properly constructed or maintained.

An example of a dam failure in the State of Hawaii occurred on Kauai in 2006, as shown in Figure 15-2. Beginning around February 20, 2006, the Hawaiian Islands experienced unusually severe rain showers that caused severe flooding throughout the State. On March 14, 2006, the privately-owned Kaloko Dam on the island of Kaua‘i failed, sending a wall of water downstream that overtopped the Morita Dam, damaged Kuhio Highway, swept away homes, and killed seven people.



Figure 15-2. Failure of Kaloko Dam on Kauai

Dam failures can occur anywhere there is a dam. The threat from dam failures increases as existing dams get older and more are being built for retention basins and amenity ponds in new developments. Many are on smaller streams that are not mapped as floodplains or subject to floodplain regulations. Even when the stream is mapped, the floodplain is usually not based on a dam breach inundation map, leaving downstream residents unaware of the potential dangers.

Two factors influence the potential severity of a full or partial dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream.

Dam failures typically occur when spillway capacity is inadequate and excess flow overtops the dam, or when internal erosion (piping) through the dam or foundation occurs. Complete failure occurs if internal erosion or overtopping results in a complete structural breach, releasing a high-velocity wall of debris-laden water that rushes downstream, damaging or destroying everything in its path.

Dam failures can result from anyone or a combination of the following causes:

- Prolonged periods of rainfall and flooding, which cause most failures
- Inadequate spillway capacity, resulting in excess overtopping flows
- Internal erosion caused by embankment or foundation leakage or piping
- Improper maintenance, including failure to remove trees, repair internal seepage problems, replace lost material from the cross section of the dam and abutments, or maintain gates, valves, and other operational components
- Improper design, including the use of improper construction materials and construction practices
- Negligent operation, including failure to remove or open gates or valves during high flow periods
- Failure of upstream dams on the same waterway
- Landslides into reservoirs, which cause surges that result in overtopping
- Earthquakes, which typically cause longitudinal cracks at the tops of embankments that weaken entire structures

The Dam Safety Program was started in 1988 where the rules, statues, and Hawaii Administrative Rules were set up by the Department of Land and Natural Resources (HAR, Title 13, Subtitle 7, Chapter 190, Dams and Reservoirs). A majority of existing dams were built by private plantation owners in the early 1900's for irrigation and not flood control; there were no standards at that time. According to the Hawaii NFIP CFM, during that historical period, when they built the embankment, they had carts filled with rocks that were pulled by horse or mule, which then ran back and forth over the embankment to provide some compaction. Now, the Department of Land and Natural Resources (DLNR), Engineering Branch administers the Hawaii Dam Safety Program (DSP). The DLNR reviews and approves plans and specifications for the construction of new dams or for the enlargement, alteration, repair, or removal of existing dams.

Common practice among federal and state dam safety offices is to classify a dam according to the potential impact a dam failure (breach) or mis-operation (unscheduled release) would have on upstream and/or downstream areas or at locations remote from the dam.

The hazard potential classification system categorizes dams based on the probable loss of human life and the impacts on economic, environmental, and lifeline interests. Improbable loss of life exists where persons are only temporarily in the potential inundation area. The hazard potential categories are listed below and summarized in Table 15-2.

Low Hazard Potential: Dams assigned the low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

Significant Hazard Potential: Dams assigned the significant hazard potential classification are those dams where failure or mis-operation results in no probable loss of human life but can cause/economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in the predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

High Hazard Potential: Dams assigned the high hazard potential are those where failure or mis-operation will likely cause the loss of human life.

Table 15-2. Dam Hazard Potential Classification

Category	Loss of Life	Property Damage
Low	None expected	Minimal (undeveloped to occasional structures or agriculture)
Significant	Few (no urban structures) or inhabitable	Appreciable (notable developments and no more than a small number of inhabitable structures, agriculture, industry
High	More than five	Excessive (extensive community, industry, or agriculture)

Designs for reservoirs built for water supply, recreation, or other purposes should include flood protection measures. Flood pools and flood protection measures should be considered when existing reservoirs are rehabbed or retrofitted.

During Tropical Storm Olivia in September of 2018, Nuuanu Reservoir Dam no. 1, built in 1905 and having a capacity of 21 million gallons, needed to be pumped by the Honolulu Fire Department and the Board of Water Supply in a precautionary measure to prevent overtopping of its spillway. Water levels in the dam had risen 4 to 5 feet (nearly 1.5 meters) overnight as heavy rains from a storm dumped 7.3 inches (18 centimeters) of rain in the area. The water reached 5 feet below the top of the dam at midday September 13. It also reached just 18 inches (45 centimeters) below a spillway.

Areas downstream would have flooded if water went over the spillway, said Ernie Lau, the agency's chief engineer. The Board of Water Supply, the agency that manages the dam, said Emergency Action Plans call for a mandatory evacuation if the water reaches 1 foot (30 centimeters) under the top of the dam. If such an evacuation had become necessary, 10,000 residents would have been affected.

15.3 The National Dam Safety Program Act

On October 12, 1996, the Water Resources Development Act of 1996 (Public Law 104-303) was signed into law. Section 215 of Public Law 104-303 established a National Dam Safety Program and named the Director of the Federal Emergency Management Agency (FEMA) as its coordinator.

15.3.1 Purpose

The purpose of the National Dam Safety Program, as expressed in Section 215(a) of Public Law 104-303, is to "reduce the risks to life and property from dam failure in the United States through the establishment and maintenance of an effective national dam safety program to bring together the expertise and resources of the federal and non-federal communities in achieving national dam safety hazard reduction."

15.3.2 Overview

The state assistance program is intended to help states bring the necessary resources to bear on inspection, classification, and emergency planning for dam safety. Public Law 104-303 provides for the assistance program described below.

For a state to be eligible for primary assistance under the National Dam Safety Program, the state dam safety program must be working toward meeting the following criteria, as listed in Public Law 104-303:

- The authority to review and approve plans and specifications to construct, enlarge, modify, remove, and abandon dams;
- The authority to perform periodic inspections during dam construction to ensure compliance with approved plans and specifications;
- A requirement that state approval be given on completion of dam construction and before operation of the dam;
- The authority to require or perform the inspection at least once every 5 years of all dams and reservoirs that would pose a significant threat to human life and property in case of failure to determine the continued safety of the dams and reservoirs, and a procedure for more detailed and frequent safety inspections;
- A requirement that all inspections be performed under the supervision of a state-registered professional engineer with experience in dam design and construction;
- The authority to issue notices, when appropriate, to require owners of dams to perform necessary maintenance or remedial work, revise operating procedures, or take other actions, including breaching dams when necessary;
- Regulations for carrying out the legislation of the state;
- The provision for funds to ensure timely repairs or other changes to or removal of a dam to protect human life and property, and if the owner of the dam does not take the action described above, to take appropriate action as expeditiously as possible;
- A system of emergency procedures to be used if a dam fails or if the failure of a dam is imminent; and

- An identification of each dam whose failure could be reasonably expected to endanger human life, the maximum area that could be flooded if the dam failed, and public facilities that would be affected by the flooding.

The State's dam safety program should continue to review plans for new dams, monitor the condition of existing dams, and publicize the potential hazards to downstream residents. Structural evaluation of dams shall include a seismic evaluation. Post-earthquake inspections of dams should also be done after seismic events. Flood protection plans that consider new reservoirs should clearly explain their full costs and impacts to the affected local officials and residents.

The DLNR maintains a database of regulated structures, including classifications of each in regard to size, hazard potential and overall condition. Following the Kaloko dam failure, many dam inspections were done. The DLNR verified and updated their inventory of regulated dams in 2006. In coordination with the State of Hawai‘i Department of Land and Natural Resources (DLNR), the U.S. Army Corps of Engineers (Corps) provided assistance with emergency visual dam inspections under the Emergency Flood Protection Act of 1965 (PL 84-99). This assistance was limited to inspections on the island of Kaua‘i and for a limited duration following the Kaloko disaster. In view of limited Federal funding, the DLNR enlisted the Corps to provide technical assistance with dam inspections on the islands of Maui, O‘ahu, Hawai‘i, and Moloka‘i under the Corps' Interagency and International Services (IIS) program. Inspections performed under the IIS program were done on a reimbursable basis with State funds in conjunction with Federal Emergency Management funds.

A report was generated for each dam. The visual assessments yielded condition ratings that ranged from "poor" (may not fulfill intended function; maintenance or repairs are necessary) to "satisfactory" (expected to fulfill intended function) condition. Most of the facilities falling in the "fair" (expected to fulfill intended function, but maintenance is recommended) to "poor" category. The limitations of the findings were based on the visual availability of the features, access to the features, and the conditions as of early April 2006. Recommendations for the facilities inspected range from removing vegetation to facilitate further inspections to requiring the owners to take immediate actions to restore the integrity of the facilities.

Hazard potential classifications were updated and assigned by the department as a product of their statewide dam break modeling analysis conducted between 2007 and 2011. Subsequent updates to the hazard classifications have been made for newly added facilities or those with new data affecting this classification. The overall condition assessment classification is a field which the Dam and Reservoir Safety Program is working to consistently apply across the state based on the condition assessments conducted on all regulated dams. All regulated dams were assessed and assigned an overall condition assessment classification during phase I inspections conducted statewide in 2007-2009. These condition assessment classifications are being updated based on ongoing inspection findings. Visit the Dam Inventory System at: http://132.160.239.52/daminventory/. The Department of Land and Natural Resources makes annual reports on the Hawaii Dam and Reservoir Safety Program to the Legislature. (DLNR, 2017).

15.4 Recent and Ongoing Hazard Mitigation Activities

15.4.1 Training and Outreach

The DLNR provides technical assistance to the dam owners, operators and consultants, as well as to the broader community of hazard mitigation partners and agencies. The DLNR works closely with the Association of State Dam Safety Officials, (ASDSO) to collaborate on public outreach and national awareness of the importance of dam and reservoir safety programs. Recent training seminars included Operation and Maintenance Training and Emergency Action Planning Training.

In March and April of 2017, the DLNR sponsored three overview workshops on Oahu, Maui and Kauai, detailing the rehabilitation improvements for embankment dams and one technical training class. This overview workshop was focused on providing dam owners with insight on how to procure and scope professional services for investigations and rehabilitation work on their facilities. An additional two-day advanced technical training class was conducted to provide continuing education for the local dam safety technical community. Almost 200 people attended the various training events and over 20 different consulting firms and partner agencies were present.

The DLNR has also retained a consultant to train and assist their staff in performing Probable Failure Mode Analysis on several dams to aid the DLNR better managing the risks of the current regulated dam portfolio.

15.4.2 Dam Safety Construction Permits

A permit from the Board of Land and Natural Resources (Board) is required for all dam construction, alteration, enlargement, modifications or removal work. Dams are uniquely engineered structures that require knowledge and experience in dam safety, particularly how to safely handle water flows in and out of the structure through appurtenant features, as well as mitigating the hazards of water passing through the dam embankment itself (seepage). Dams sustain high hydrostatic water loads, which can result in failure of the embankment if they are not properly designed. Dam safety permits allow the DLNR to review and check proposed improvements for concurrence with current dam safety practices and guidelines. Work that is not considered routine maintenance requires prior approval from the Board. Detailed procedures and requirements for this permitting process are provided in HAR Chapter 190.1. The DLNR also has developed additional guidance documents for dam owners and designers as well as a standard set of general permit requirements. All of the following permits have been closed prior to Fiscal Year 2017, except for the Nuuanu No. 4, Mauanaolu, and Opaeula Resevoir 1. Those dam improvements are listed are ongoing as of the end of FY 2017.

Table 15-3. Board Issued Permits for Oahu Dams (FY 2009-2017)

Dam Name	Description of Improvements	Date Issued
Helemano 11	Dam removal	FY 2011
Opaeula Reservoir No. 2	Dam removal	09/09/11
Maunaolu Reservoir	Spillway improvements	11/14/12
Oahu Reservoir 545A Removal	Dam removal	9/14/12

Oahu Reservoir 530 Removal	Dam removal	9/14/12
Oahu Reservoir 510 Removal	Dam removal	9/14/12
Nuuanu No. 4 Reservoir	Repair and improvement	4/8/15
Helemano 16 Reservoir	Dam removal	9/9/15
Opaeula Reservoir 1	Outlet Work Repair	FY 2017

15.4.3 Certificate of Approval to Impound

The Certificate of Approval to Impound (CAI) water requirement was included in the Hawaii Dam and Reservoir Safety Act of 2007. Issuance of this certificate will be dependent on dam and reservoir owners ensuring their structures are remedied of critical deficiencies and meet minimum operational criteria.

The DLNR has developed guidelines and procedures for this certificate in coordination with dam owners on the implementation of this new requirement. The DLNR sent out notices to complete and submit CAI applications, to all owners of regulated dams and reservoirs in the state in Fiscal Year 2014. The DLNR received CAI applications for most of the regulated structures.

Understanding that many of these dams are over 80 years old, and almost all were constructed before the development of any modern dam safety standards, the DLNR is working with owners to establish a reasonable improvement schedule for these facilities to meet current regulations. In the interim period, the department is working with owners to mitigate these deficiencies through operational restrictions or other types of mitigation actions.

15.4.4 Emergency Action Plans

HRS Chapter 179D requires that all dam owners of High and Significant Hazard Potential dams complete and submit an Emergency Action Plan (EAP) to the DLNR. The DLNR developed guidelines and an EAP template for dam owners to utilize in formulating and executing a plan of action should a possible threat or deficiency occur on their dam facilities. The DLNR provides training and technical assistance to dam owners and emergency management officials to assist them in the completion and execution of the EAPs. Additionally, the DLNR is identified as a technical advisor during dam safety emergencies where an EAP is activated.

The EAP should establish the following procedure for an unusual or emergency event:

1. Detect by observation or inspection,
2. Determine event level,
3. Activate notification plan,
4. Follow pre-planned actions, including an evacuation plan upon indication of an impending dam failure or unsafe condition,
5. Terminate event.

Early identification of hazardous conditions will permit prompt implementation of emergency procedures outlined in the EAP. The Dam Owner should be capable of identifying specific types of potential failure modes such as overtopping and piping, and be trained in implementing remedial procedures to prevent or mitigate dam failure.

In April 2015, the DLNR coordinated EAP training and table top exercises on Oahu and Maui. Over 150 dam owners, operators, emergency managers, first responders and representative from supporting agencies participated in the event. The major objectives for this event was to provide training on basic technical understanding of typical dam failure modes and need of an EAP to mitigate these potential failures, run through several EAP test scenarios, and gain feedback from all participants on revising the current EAP template. Additional training exercises were conducted on Hawaii and Kauai in September 2015, with approximately 130 participants attending those exercises.

In 2018, the DLNR has an EAP for every regulated dam on Oahu. The DLNR released a new online EAP tool, which simplifies the creation and routine updates of the EAP process. The tool allows the department to easily update the statewide template quickly and users can process revisions to EAPs almost instantly. Owners have responded with positive feedback regarding this new tool. In 2017, many EAPs have been processed and are available online via the EAP tool. The DLNR's goal is to have all owners migrate over to the new online tool and update their EAPs annually.

15.4.5 Oahu Dam Visual Conditions Survey

By Hawai‘i Revised Statutes Chapter 179D, and Hawai‘i Administrative Rules Title 13, Chapter 190, "Dams and Reservoirs", the State of Hawai‘i Department of Land and Natural Resources (DLNR) is authorized to conduct dam safety inspections throughout the State of Hawai‘i to assure public safety.

Since 2006, DLNR has increased their number of inspections. In 2011, a dam was required to be inspected only once every five years, and the DLNR inspected high risk dams every 6 months. Since 2012, the DLNR began inspecting each dam once every two years, but have reported that a lack of funding and staff can make even this frequency difficult to achieve. Table 15-4 contains all of the visual dam safety inspection for each of the 13 Oahu dams, as well as some additional inspections, from fiscal years 2014-2017. The Hawaii Dam and Reservoir Safety Act of 2007 authorized the DLNR to take enforcement action for both emergencies and any other violations of the act. The DLNR has established enforcement action procedures that are initiated by the following general deficiencies:

- Failure of dam and reservoir owners to comply with general requirements and responsibilities
- Non-compliance with dam safety permit general terms and special conditions
- Non-compliance with certificate to impound terms and conditions

The DLNR has not used any enforcement action procedures against any Oahu dams, but did issue a penalty fine for delinquent submissions to the Helemano Reservoir owner in FY 2015.

Table 15-4. Most Recent Inspections of Oahu Dams (FY 2014-2017)

State ID	Dam Name	Inspection Type	Date of Inspection
OA-0001	Nuuanu Dam No. 4	Visual Dam Safety	13-Nov-14
OA-0017	Wahiawa Reservoir	Visual Dam Safety	5-Aug-15
OA-0017	Wahiawa Reservoir	Informal	1-Sep-16
OA-0018	Opaeula 01 Reservoir	Visual Dam Safety	29-Oct-15
OA-0018	Opaeula 01 Reservoir	Informal – LEVEL 1	3-Feb-16
OA-0018	Opaeula 01 Reservoir	Informal UHSLC	17-Feb-16
OA-0018	Opaeula 01 Reservoir	Informal UHSLC	24-Mar-16
OA-0018	Opaeula 01 Reservoir	Informal UHSLC	1-Jun-16
OA-0020	Opaeule 15 Reservoir	Visual Dam Safety	29-Oct-15
OA-0021	Kemoo 5 Reservoir	Visual Dam Safety	28-Jan-15
OA-0021	Kemoo 5 Reservoir	Informal – USGS Elevation	3-Nov-15
OA-0022	Upper Helemano Reservoir	Visual Dam Safety	5-Aug-15
OA-0022	Upper Helemano Reservoir	Informal – Grass/Spillway Gage	12-Oct-15
OA-0023	Helemano Reservoir	Visual Dam Safety	5-Aug-15
OA-0025	Ku Tree Reservoir	Visual Dam Safety	3-Nov-15
OA-0124	Kaneohe Dam	Visual Dam Safety	24-Nov-14
OA-0129	Waimanalo 60 MG Reservoir	Visual Dam Safety	5-May-16
OA-0129	Waimanalo 60 MG Reservoir	Informal	8-March-17
OA-0129	Waimanalo 60 MG Reservoir	Informal	3-May-17
OA-0137	Oahu Reservoir 155	Visual Dam Safety	14-Dec-15
OA-0149	Maunaolu Reservoir	Construction	21-Oct-15
OA-0149	Maunaolu Reservoir	Const- Base Prep Meeting	29-Jan-16
OA-0149	Mauanolu Reservoir	Construction	1-Jul-16
OA-0149	Mauanolu Reservoir	Construction	22-Jul-16
OA-0149	Mauanolu Reservoir	Construction	4-Aug-16
OA-0149	Mauanolu Reservoir	Construction	23-Aug-16
OA-0149	Mauanolu Reservoir	Construction	23-Aug-16
OA-0149	Mauanolu Reservoir	Construction	7-Sep-16
OA-0149	Mauanolu Reservoir	Visual Dam Safety	3-Aug-17
OA-0154	Nuuanu Reservoir No. 1	Informal UHSLC	19-Jan-16
OA-0154	Nuuanu Reservoir No. 1	Informal UHSLC	19-Jan-16
OA-0154	Nuuanu Reservoir No. 1	Informal UHSLC	3-Feb-16
OA-0154	Nuuanu Reservoir No. 1	Informal UHSLC	27-Jul-15
OA-0154	Nuuanu Reservoir No. 1	Informal	25-Jul-16
OA-0154	Nuuanu Reservoir No. 1	Visual Dam Safety	2-Aug-17

15.5 Proposed Mitigation Actions

Several dams on Oahu have been removed; however the remaining dams are all high hazard. The risk of dam failure will be lessened by the continuation of routine dam safety inspections and encouraging dam owners to update their EAPs annually.



16. VOG (Volcanic Gas) Hazard

16. VOG (Volcanic Gas) HAZARD

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 Plan described vog, its effect on the population on Oahu, and concluded that no mitigation projects are currently necessary on Oahu.	• Vog is used to describe hazy conditions caused by gaseous emissions from three primary sources from Kilauea volcano. The chemistry of these emissions is given. • Vog impacts to Oahu are described, in which sulfur dioxide levels are greatly reduced as the gas goes through several chemical reactions to form ammonium sulfate which settles out of the atmosphere. The direct volcanic hazard from gaseous emission is minimal on Oahu that is 200 miles away. • The 2018 Lower East Rift Zone eruptions on the island of Hawai‘i renewed concerns of VOG on Oahu during that period of 2018. The effects are discussed and the chapter is updated accordingly. • No mitigation projects are currently considered necessary on Oahu due to the research on chemical transformation from the Center for the Study of Active Volcanoes at the University of Hawaii at Hilo.

16.1 Hazard Description

The island of Oahu is formed from two principal volcanoes: Waianae and Koolau about 2.2-3.8 million years and 1.8-2.6 million years ago respectively. These two principal volcanoes are considered extinct. The island is also riddled with a number of more recent smaller "rejuvenation" vents such as Diamond Head, Koko head, Punchbowl and many others, which are believed to have occurred between 70,000 and 500,000 years ago. They are now considered inactive and the probability of eruption on Oahu is negligible. Therefore, only neighboring volcanoes on the Island of Hawaii and possibly Haleakalā on Maui, which last erupted in the 1700's, are expected to have any impact on Oahu.

The Island of Hawai`i is composed of five volcanoes, two of which (Mauna Loa and Kilauea) have been very active in the past 100 years and pose the most immediate threat to life and property. A third volcano, Hualalai, last erupted in 1801 and has the potential to erupt again within our lifetime. The other two are dormant. Mauna Kea last erupted approximately 3,500 years ago and is considered dormant but not extinct. Kohala, considered extinct, is the oldest volcano on the island and last erupted approximately 60,000 years ago. Hawaiian volcanoes are not as explosive as continental margin volcanoes (e.g. Rainier, Mt. St. Helens, Mt. Shasta) and are characterized by relatively quiet outflow of relatively fluid lava, therefore the probability of harmful volcanic rock debris and ashfall on Oahu from the volcanoes on Maui and Hawaii is negligible. Consequently, the only credible volcanic hazard on Oahu is "VOG," short for "volcanic gas" or "volcanic smog," resulting from ongoing eruptions on Hawaii.

Vog is a term used in Hawai'i to describe hazy conditions caused by gaseous emissions from Kilauea volcano. Vog is created when volcanic gases react with sunlight, oxygen, and moisture. The vog plumes from Kilauea contain a variety of compounds, at varying concentrations, that could have adverse impacts on the downwind communities and environment. There are three primary sources of volcanic gases from Kilauea: Halema'uma'u, at the summit of Kilauea, Pu'u O'o, located on the middle Kilauea East Rift Zone (KERZ). The recent 2018 Lower East Rift Zone Fissure 8 eruption and its ocean entry plume along the Puna shoreline produced vog, but that event has now ceased and is no longer an emission source. The compositions of each are generally different, and the compositions can vary depending on local and temporal conditions.

16.1.1 Halema'uma'u

During the last several decades, the Halema'uma'u discharge consisted of carbon dioxide (CO_2), water vapor (H_2O), sulfur dioxide (SO_2), sulfur trioxide (SO_3) and smaller amounts of hydrogen sulfide (H_2S), hydrochloric acid (HCl), and hydrofluoric acid (HF), as well as a number of trace gases. Although most of the gases discharged are the result of degassing of magma (within or below the recently formed pit) there can also be contributions (of water vapor, hydrogen sulfide, and sulfur trioxide) from lower temperature hydrothermal systems that surround the magma conduit below and around Halema'uma'u. The constituent of greatest concern to air quality is the sulfur containing species dominated by sulfur dioxide. During the last decade, emissions of sulfur dioxide from Halema'uma'u have ranged from as low as a few hundred metric tons per day to as high as 10,000 to 15,000 tons per day after an explosive event unroofed the magma conduit in 2008. However 2018 activity at Kilauea, in particular the draining of the lava lake and progressive

collapse of the summit caldera, has reduced sulfur dioxide emissions to a few tens of tons and similarly reduced other gas discharges from the summit region. The 2018 conditions at the Kilauea summit were extremely dynamic, with intermittent subsidence events occurring at intervals of approximately once per day.

16.1.2 Kilauea East Rift Zone

Prior to the mid-2018 phase of Kilauea's eruption, a long-lived vent (or sequence of vents) formed on Kilauea's Middle Rift Zone, approximately 18 km SE of the Kilauea Summit at a site referred to as Pu'u O'o. Those vents were intermittently to continuously active over a period of more than 35 years and discharged sulfur dioxide at rates ranging from approximately 10,000 metric tons per day to 3,000 metric tons per day after the summit vent formed in 2008. The 2018 eruptive activity was marked by a drain-out of lava from beneath this event, and eventual collapse of the vent, with the nearly complete elimination of discharge of gases from this site in 2018.

The onset of the 2018 phase of Kilauea's eruption was marked by the following factors: falling lava lake levels at Kilauea's summit and at the Pu'u O'o vent, an intense swarm of seismic activity trending down the Kilauea East Rift Zone (KERZ), the formation of more than 20 individual fissures discharging magmatic gases (sulfur dioxide, sulfur trioxide, carbon dioxide, and steam), and varying amounts of lava discharge from the individual fissures. The eruptive activity on the Kilauea's Lower East Rift Zone (LERZ) quickly focused on Fissure 8, located within the Leilani Estates subdivision. That vent discharged lava at a rate substantially higher than the Pu'u O'o vent has historically generated, and might have been as much as a factor of ten or more times higher than previous eruption rates. The USGS estimated that Fissure 8 had a volumetric output of up to 26,000 gallons per second. Magmatic gas emissions from the then active vent and flow were estimated at about 60,000+/- 20,000 metric tons per day of sulfur dioxide. The following Figure shows the locations of the fissures and demonstrates the area affected by the mid-2018 volcanic activity up to July 27, 2018.

However, since the cessation of the 2018 LERZ eruption, total VOG emissions from Kilauea have dropped to levels not recorded since 2007, at less than 1,000 metric tons per day.

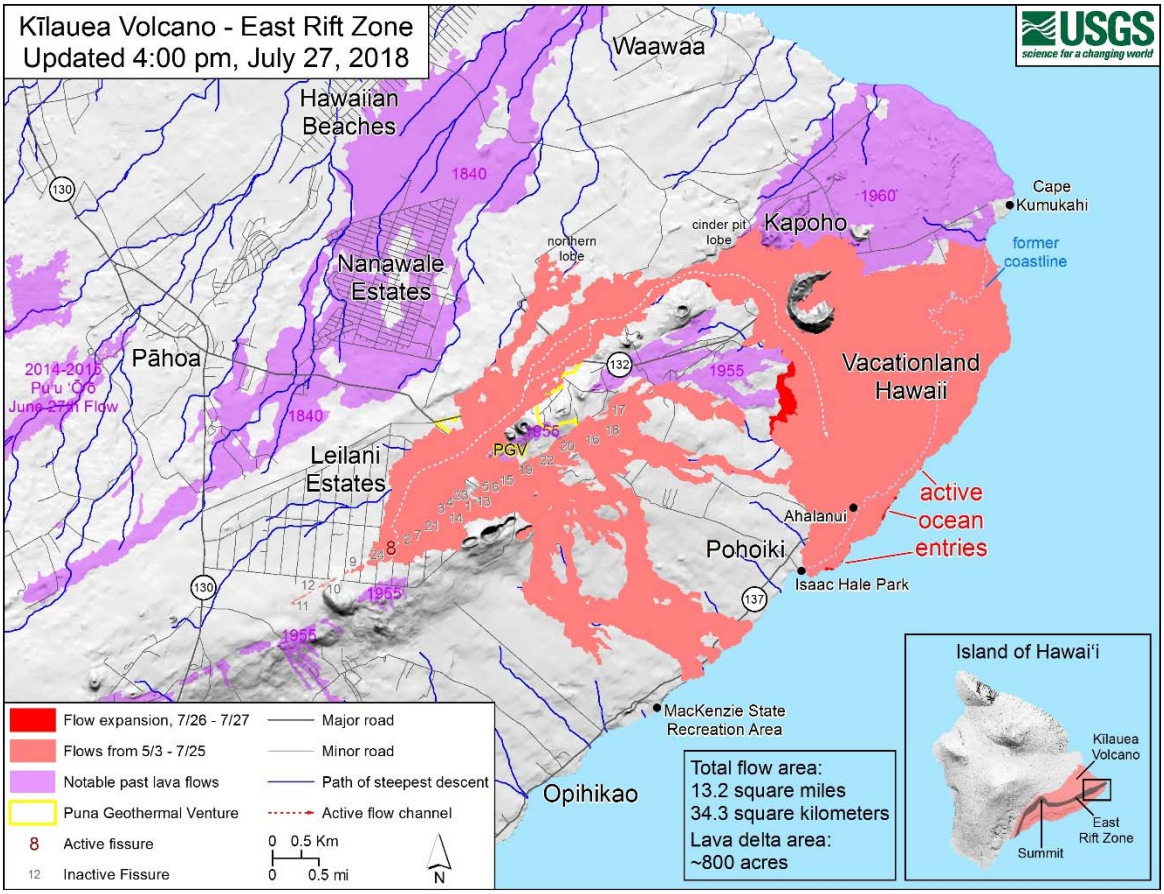


Figure 16-1. Map as of 4:00 p.m. HST, July 27, 2018 Kīlauea's lower East Rift Zone.

Given the dynamic nature of Kīlauea's lower East Rift Zone eruption, with changing vent locations, fissures starting and stopping, and varying rates of lava effusion, map details shown here are accurate as of the date/time noted. Shaded purple areas indicate lava flows erupted in 1840, 1955, 1960, and 2014-2015. This map was produced by USGS and is updated on a weekday basis during the mid-2018 volcanic activity. For a current map, visit: https://volcanoes.usgs.gov/volcanoes/kilauea/multimedia_maps.html.

16.1.3 Chemical Reactions of the Gases

Over time, the gases released from volcanic activity can have significant, adverse effects upon the surrounding area. The following pages (16-5 and 16-6) contain technical details of the chemical reactions, none of which will occur to any significant extent on Oahu:

Soon after the gases discharge from the magma or the conduit surfaces, they begin to cool and undergo a variety of internal reactions and reactions with the atmosphere. While in the gas phase, all the above compounds are transparent but, with cooling, sulfur trioxide will rapidly combine with water vapor (from the plume or the atmosphere) to form a sulfuric acid (H_2SO_4) aerosol. Under relatively dry conditions, the sulfuric acid aerosol can be distinguished by its bluish cast; when abundant water is present, a dense white plume is formed. HCl and HF will also condense onto solid particulates, if the latter are present, or form aerosol droplets by combining with condensing water vapor. Under dry atmospheric conditions, the plume will drift downwind and mix with the air column which will decrease the dew point in the discharge plume and the aerosol droplets will dehydrate and disperse. Under moist conditions, the plume will remain hydrated and the aerosols will remain much more visible.

Mixing with air will also lead to reactions between atmospheric oxygen and the sulfur compounds sulfur dioxide and hydrogen sulfide. Sulfur dioxide is the more reactive of the two, with a reported half-life as short as a few tens of minutes to as long as several days depending on the chemical constituents in the air mass (e.g. urban air pollution, marine air), as well as the intensity of ultraviolet radiation. Given the observed near absence of significant sulfur dioxide in the vog plume by the time it reaches Kona, it's likely that the half-life in the Hawaii air mass is no more than a few hours. The oxidation of any hydrogen sulfide present in the plume occurs at a much slower rate where the half-life of H_2S in the atmosphere may be a day or more.

The oxidation of sulfur dioxide will result in the formation of additional sulfur trioxide/sulfuric acid aerosol (because sulfur trioxide is extremely hygrosocopic, it will extract nearly any and all available water vapor from the atmosphere to form the acid aerosol) to contribute to the dry haze in the downwind plume. The oxidation process will continue until all of the sulfur dioxide is converted to sulfuric acid.

Mixing of the plume with the atmosphere also brings the plume constituents into contact with ammonia that is derived from biogenic decay processes occurring in tropical soils. In the presence of water, ammonia (NH_3) forms a weak base (NH_4OH) that will react very rapidly with the sulfuric acid aerosols to form ammonium sulfate [$(NH_4)_2SO_4$], and with the hydrochloric and hydrofluoric acids to form ammonium chloride (NH_4Cl) and ammonium fluoride (NH_4F) respectively. Although these ammonia salts are not as hygroscopic as sulfur trioxide, they are sensitive to atmospheric moisture levels and the optical density of the plume will vary depending on the relative humidity in the ambient air.

Whereas the non-reactive gas phase components of the plume (e.g. carbon dioxide) will gradually disperse, the aerosols are subject to both gravitational settling, through a process called dry deposition, as well as scrubbing from the atmosphere by rainfall. Although the aerosols can serve as a source of condensation nuclei for raindrop formation, some studies have suggested that the plume may be providing an overabundance of nuclei that have inhibited drop growth resulting in a decline in rainfall rates in Ka'u and South Kona during prior phases of Kilauea's activity. The sulfur dioxide, as well as the dry deposition of the plume aerosols, can cause a variety of adverse impacts on the downwind environment and communities:

1) Sulfur dioxide and residual acid aerosols (that haven't reacted with ammonia) have been found to have broad detrimental impacts on non-native and agricultural crop biota. (There is some evidence that native plants have developed a degree of resistance to sulfur dioxide and/or the acid constituents in the plume.) The farming communities in Ka'u and HOVE have seen extensive defoliation and leaf damage to both edible crops as well as flowering and ornamental plants (tomatoes, lettuce, roses, protea, etc.). In the current eruption phase, such massive quantities of sulfuric acid aerosol were discharged during the early phases of the eruption in Leilani Estates, a broad area of plant death extends for up to hundreds of meters around some of the gas-rich vents.

2) The acid aerosols have been found to substantially lower the pH of rainfall. In locations with limited rainfall (e.g. HOVE, Leilani Estates) the combined effect of dry deposition of acid aerosols onto roofs, along with acid rainfall, substantially lowers the pH (becoming more acid) of domestic rainwater catchment systems. The likely consequences of the acidified domestic water are increased corrosion of the metallic constituents of both the roof and the plumbing equipment, as well as potential adverse health impacts from consuming the water (e.g. weakened dental enamel, poor uptake of dietary minerals). Increased acidity of the rainfall also has the potential to increase heavy metal exposure from leaching lead from paint (manufactured prior to 1978 when lead oxide was banned from paint) or plumbing systems that have used tin-lead alloys in their solder.

The acid will likewise increase corrosion to any exposed metal along the path of the downwind plume including fencing, water lines, water tanks, farm equipment, etc. Even in relatively dry downwind areas, severe corrosion will generate significant economic losses. The most likely process driving the corrosion is dew formation rather than the rainfall: during the evening hours, as the dew point temperature is approached, the hygroscopic acid aerosols will form an extremely corrosive film, with pH as low as 1, on metallic surfaces. With daily replenishment of fresh acid from dry deposition, and nightly condensation of moisture it's reasonable to anticipate substantially more rapid deterioration of exposed metal surfaces than would occur in similar environments not exposed to the plume acids.

A further effect of the increased loading of acid onto agricultural lands in the downwind areas will be accelerated leaching of minerals from the soil column. To date, this process has not been fully researched and, hence, it's difficult to offer an assessment of the long-term impacts of acidification of rainfall on the agriculture communities downwind of Kilauea.

3) The dry deposition of the acid aerosols and ammonia salts will increase the exposure of the downwind environment and communities to chloride, sulfate, and fluoride ions. Whereas moderate dietary intake of chloride and sulfate ion are relatively benign, fluoride ion is both an essential element, at low rates of intake, but can be extremely toxic at excessive levels of consumption. Surveys of domestic catchment systems in the area of HOVE and Volcano Village after the Haleme'uma'u vent opened up in 2008 showed that plume constituents were contributing chloride, sulfate and fluoride ions to catchment waters. HOVE water samples showed the higher concentrations of these ions, by factors of four to ten above those of Volcano, and reflect a higher integrated exposure to plume deposition than did the Volcano community. (The higher rainfall rates and flow through the catchment systems in Volcano is also likely to contribute to the lower values there.) The median values of all ions for both communities were considerably lower than drinking water standards but some samples from both the HOVE and Volcano areas did show values that were substantially higher than the median values and were much closer to drinking water limits. With the increase in rates of emission of magmatic gases in Lower Puna, and much closer proximity of residential catchments in the downwind environment, it is possible that much higher concentrations of these ions can accumulate in domestic catchment systems near these vents. To date, no studies have been undertaken to assess the degree of threat that exists in the Lower Puna communities.

   Of potentially greater concern is the deposition of fluoride salts onto forage crops. The scientific literature has documented a number of events where sheep, cattle, and horses have suffered significant losses as a result of both acute exposure as well as chronic exposure and accumulation of fluoride salts by grazing animals. Research conducted on forage crops shortly after the increase in degassing at the Kilauea Summit in 2008 did find fluoride levels that exceeded recommended limits; and farm animals did exhibit symptoms of fluorosis. Elevated sulfate concentrations in the forage crops were also found to affect mineral uptake by the farm animals that, subsequently, were treated with mineral supplements to reduce the adverse sulfate impacts.

16.1.4 Ocean Entry Plume

The steam and gas plume generated when lava flows into the ocean has a substantially different composition from that of the land-based eruptive vents. Whereas in the latter, sulfur dioxide is a major contributor to the acid aerosols present in their plumes, the ocean entry plume contains only minor amounts of sulfur dioxide but much higher concentrations of hydrochloric acid. The latter is generated by the reactions occurring when seawater is boiled to near dryness by its interaction with the lava. The ocean entry plume is also rich in steam and aerosolized seawater, the hydrochloric acid tends to precipitate out more rapidly and, hence, poses a greater threat only in close proximity to the source and a much lesser threat further downwind. In all cases, the threat posed by the ocean entry plume to the land-based environment will be controlled by the location of the ocean entry and the direction of the prevailing winds in relation to the shoreline.

16.2 VOG Impacts

VOG impacts are highly dependent on both proximity of the source to the affected area as well as the day to day climatic conditions. During trade-wind weather, vog is carried from the Kilauea vents is carried toward the SW around the southern tip of the island where some is trapped within an eddy system in the lee of the island. Hence, during normal trade-wind conditions the southern and Kona communities on Hawaii Island are most heavily impacted by vog. During slack or southerly winds the entire island chain can be blanked in vog. However, due to the short half-life of sulfur dioxide and sulfuric acid in the environment, Oahu is not expected to experience the elevated SO_2 levels that may be experienced on Hawaii island (Hawaii State Department of Health, FAQ). SO_2 levels are greatly reduced further away or upwind from the vents as the gas disperses and reacts with water to form sulfuric acid and then with ammonia to form ammonium sulfate which is eventually washed or settles out of the atmosphere. The visible “hazy” appearance of vog is often intensified when the gases and particulate matter combine with high humidity due to the warmer tropical temperatures when brought up from the south. The vog is most prevalent in the winter when Kona winds are most frequent.

Informational resources on vog distributions can be found at this website, which provides modeled vog plume trajectories based on current and projected weather conditions: http://mkwc.ifa.hawaii.edu/vmap/ Other informational resources on vog and mitigation actions that the public can take to reduce the impacts of vog can be found at these websites: https://vog.ivhhn.org/ & https://hilo.hawaii.edu/natural-hazards/vog/

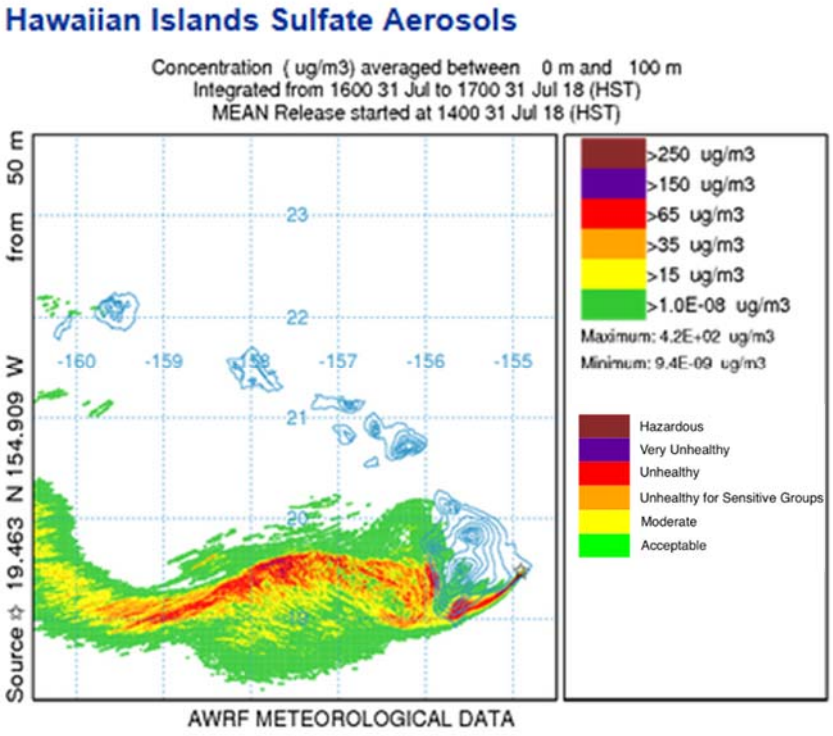


Figure 16-2. Hawaiian Islands Sulfate Aerosols forecast 7/31/18 from the Vog Measurement and Prediction Project (visit http://mkwc.ifa.hawaii.edu/vmap/ for current version)

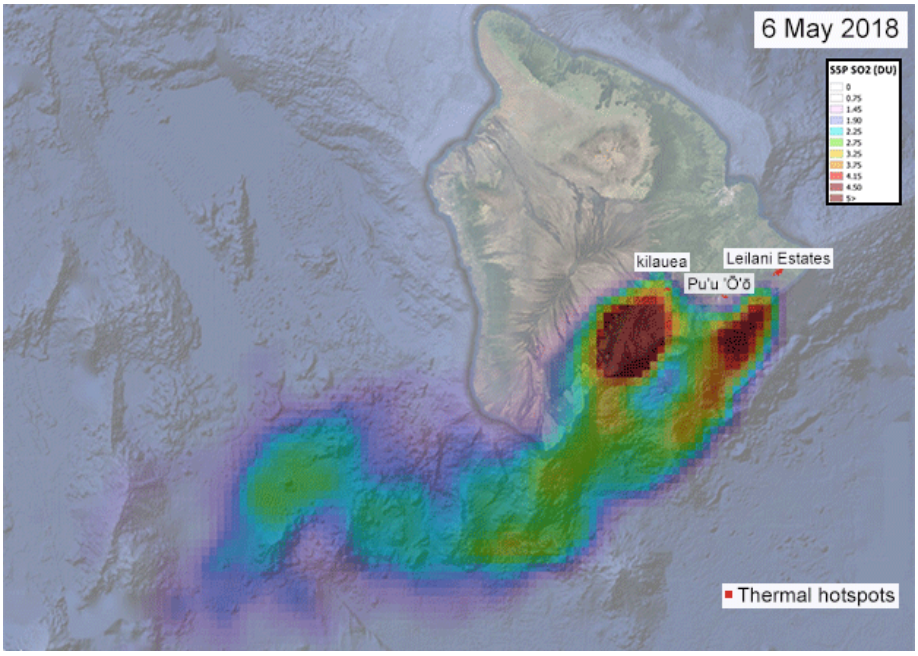


Figure 16-3. Satellite imagery differentiates between the sources of SO2 from the mid-2018 eruption. (Satellite S5P-Tropomi, Copernicus data 2018/Tropomi/BIRA-IASB/DLR)

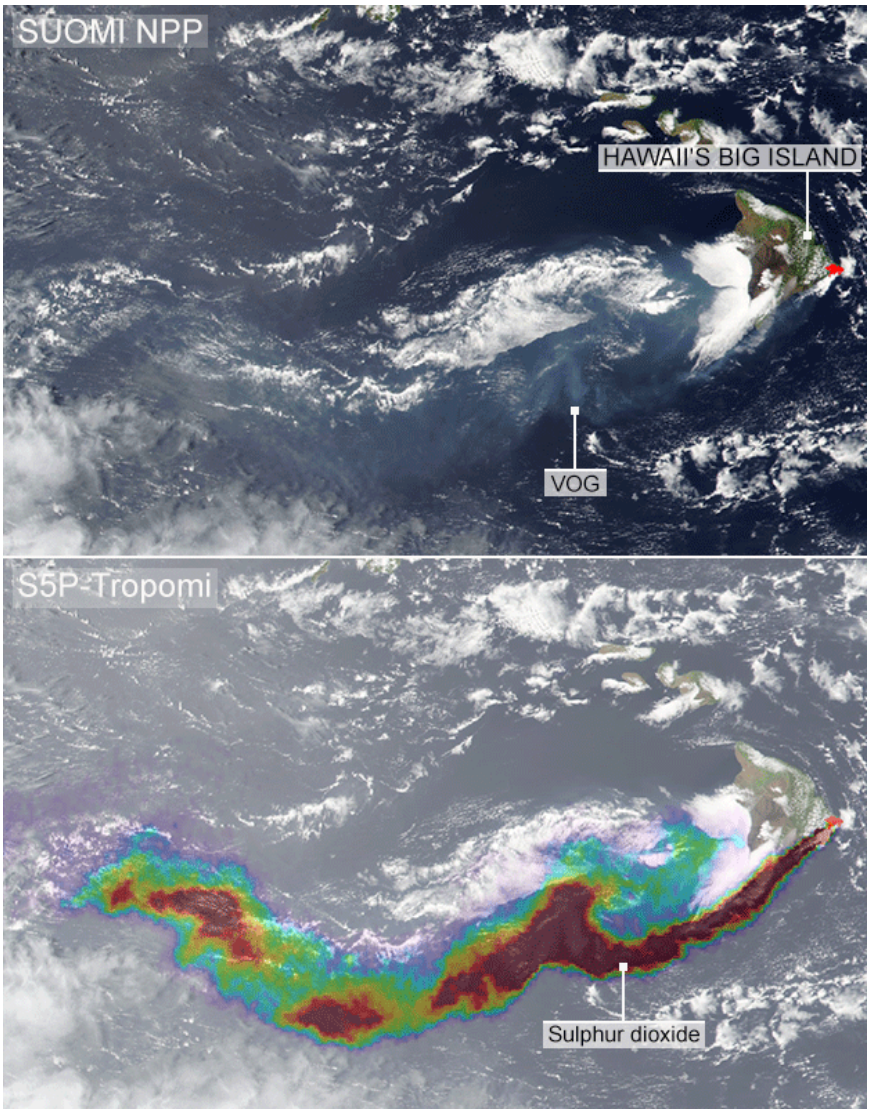


Figure 16-4. Satellite imagery of vog and sulfur dioxide plumes generated by the mid-2018 eruption of Kilauea.

During prevailing trade wind conditions, the nearly constant stream of vog produced by Kilauea Volcano on the Island of Hawai`i is blown to the southwest and west. These images were taken during a period of normal trade-winds by two satellites: SUOMI NPP (top) and S5P-Tropomi (bottom). (Copernicus data 2018/Tropomi/BIRA-IASB/DLR)

16.2.1 Health Effects

The health impacts from vog on Oahu are very minor as there are no elevated levels of SO_2 which is the main contributor to adverse health effects. Where SO_2 levels are elevated, it can be irritating to the eyes, nose, throat and respiratory tract. Short-term exposure to elevated levels of SO_2 may cause inflammation and irritation, resulting in burning of the eyes, coughing, difficulty in breathing, and a feeling of chest tightness. “Sensitive groups” are children and those with pre-existing respiratory conditions such as asthma, emphysema, bronchitis, and chronic lung or heart disease. These people are especially sensitive to SO_2 and may respond to very low levels in the

air. Prolonged or repeated exposure to higher levels may increase the danger. Other common symptoms of vog exposure include the following:

- Headaches
- Breathing difficulties
- Increased susceptibility to respiratory ailments
- Watery eyes
- Sore throat

The American Heart and Lung Association recommend that those sensitive when impacted by unusually high vog levels may take the following precautions:

- Stay indoors and use air conditioning, if possible
- Drink plenty of warm fluids
- Have medications close at hand
- Avoid strenuous outdoor activity

Any individuals concerned about vog affecting their health can use the previously mentioned vog prediction model to anticipate when vog may affect them (Figure 16-2, available at: http://mkwc.ifa.hawaii.edu/vmap/). Figure 16-4 shows the photographs of two satellites that are over Hawaii at nearly the same time, which could be used to provide the real-time status of vog, however the technology is not yet available to do so.

16.2.2 Effects on Plants

The sulfuric acid or sulfur dioxide in vog may have some effects on plants. Sulfuric acid has the potential to burn plants if in high enough concentrations or upset the pH balance of the soil. Where SO_2 levels are sufficiently elevated, the SO_2 can enter leaf mesophyll tissue, through stomata (natural openings in leaf surfaces that regulate gas exchange), to cause plant injury (Nelson and Sewake, 2008). Once SO_2 enters the moist mesophyll tissue, it combines with water and is converted to sulfuric acid which burns plant tissue. The general effects of SO_2 exposure to plants may vary and depend upon plant species, age, and the SO_2 dosage; these effects may include:

- reduced seed germination
- enhanced susceptibility to diseases
- foliar necrosis (spots, blight)
- epicuticular wax erosion
- rupture of epidermis, plasmolysis
- reduced chlorophyll content
- increased membrane permeability of plant leaves
- decreased plant growth
- plant organ or entire plant death

On Oahu, SO_2 levels are not elevated; there is no evidence that concentrations are high enough to have an impact on Oahu. Therefore, it is unlikely that SO_2 with have any direct effect on plants.

16.3 Future Mitigation Activities

There is not currently sufficient evidence that vog generates significant impacts on Oahu to warrant expenditure on hazard mitigation activities. If, in the future, there is evidence of significant impacts, a monitoring and mitigation program may be considered.



17. Emergency Shelters

17. EMERGENCY SHELTERS

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan described a list of hurricane shelters and an analysis of the shelter needs. Shelter information was consolidated in this chapter.	• An updated list of available shelter locations on Oahu is provided. Circumstances of a particular storm would dictate which of these are actually announced to be opened for use. • Hurricanes are the hazard with the greatest need for sheltering. There is an estimated capacity of 200,000 shelter spaces at the designated shelters in public schools, which excludes potential additional spaces in the Hawaii Convention Center and Neil Blaisdell Center. This could meet the projected needs for sheltering during a "strong" storm. • Structural inspections of all hurricane shelters have been deemed necessary. SEAOH created a catalog of shelters on Oahu of the shelters that engineers have evaluated.

Summary of Mitigation Projects for the City and County of Honolulu

Project	Priority
The principal issue with hurricane shelter spaces is having structural integrity: Perform all-hazard assessments of Hurricane Shelters. Structural evaluations of existing hurricane shelters should be done according to the 2014 *Scope of Services and Procedure for Structural Assessment of Buildings for Hurricane Shelter Classification*.	Medium-High
Adopt 2012 IBC and then the 2018 IBC and related codes per HRS 107 Part II. The State code will then have the latest information for the design of Enhanced Hurricane Protective Areas in high-occupancy public buildings.	Medium-High
Re-assess the structural integrity of the Hawaii Convention Center and Neil Blaisdell Center according to the 2014 *Scope of Services and Procedure for Structural Assessment of Buildings for Hurricane Shelter Classification.* There are potentially 34,000 spaces just in these two facilities.	Medium-High
Incentives for homeowners and businesses to retrofit their structures, thereby reducing the demand on shelter spaces..	Medium-High
Retrofit public shelter buildings to increase capacity and refine actual evacuation demand and update policies when advising the public, to decrease sheltering deficit.	Medium-High
Identify the types of buildings more suitable for self-sheltering: Perform a comprehensive screening evaluation of private sector candidate building types for possible hurricane refuge use and create a voluntary\certification system for private shelter refuges.	Medium
The University of Hawaii at Manoa has a wind cannon used for the testing of commonly used local materials and building styles. More materials should be tested.	Low

17.1 Introduction

Sheltering is required for a number of disasters, leading up to and during an event when some warning is possible for events such as hurricanes or tropical storms. Hurricanes have the potential to result in the greatest number of people requiring sheltering at any one time on Oahu, and

therefore, the focus of this chapter is on hurricane shelters. For some disasters certain shelters cannot be used, for example designated shelters located in the potential inundation zone during a tsunami event cannot be used unless they are specifically designed for vertical evacuation to upper levels of the structure. Similarly, buildings located in a flood zone cannot be used for flood shelters, nor should they be used for hurricane shelters.

In Hawaii, residents and visitors cannot relocate away from a storm's impact, as they do on the U.S. mainland, to reduce the life-threatening effects of a hurricane. They must remain in-place and have immediately available hurricane resistant homes, businesses, hotels, public shelters, etc. in which to seek refuge. In that regard, government in Hawaii has a more difficult responsibility to provide for the health, safety, and welfare of its citizens. Two important aspects of this responsibility as it pertains to the hurricane hazard is the adoption of building codes that afford hurricane protection to both public and private sector property, and the provision of sufficient, reasonably provisioned hurricane-resistant public shelters and identification of reasonably hurricane-resistant buildings that can function as refuges during the storm.

The "All-Hazards Preparedness Improvement Action Plan and Report" from Hawaii Emergency Management Agency (HI-EMA) in February, 2018 (Hara, 2018) explains the situation for shelters in Hawaii: "Hurricane evacuation shelters are a last resort option for residents and visitors who do not have a safer place to stay. There are insufficient hurricane evacuation shelters to meet the estimated demand of the population and these shelters have no supplies. The designated hurricane evacuation shelters and the post-impact sheltering systems are in need of retrofitting and improvement."

A list of hurricane shelters in each district provided by HIEMA and Honolulu DEM, is given in summary form in Table 17-1 with the published shelter capacity for each shelter. The total shelter capacity for hurricanes is around 200,000 shelter spaces at the designated shelters in public schools, which excludes spaces in the Hawaii Convention Center and the Neil Blaisdell Center. These two excluded facilities have a potential of offering 34,000 shelter spaces, but State and City engineers have expressed some doubts about public safety several years ago. They should probably be re-assessed.

With the expected adoption of the Hawaii State Building Code based on the 2012 IBC, residential structures not fitted with debris impact resistant glazing or shutters will require a residential safe room in some part of the structure. Therefore, the future hurricane sheltering needs should diminish as the housing stock is upgraded to new design provisions.

Table 17-1. **List of Potential Shelter Locations and Shelter Capacities**

Location	Shelter Capacity
North Shore (Kaena Pt.-Kahuku)	
Waialua High and Intermediate	1,223
	1,223
Leeward Coast (Makua-Waipahu and Vicinity)	
August Ahrens Elementary	**3,437**
Barbers Point Elementary	**2,863**
Campbell High	**7,278**
Ewa Beach Elementary	**1,966**
Holomua Elementary	**1,309**
Honowai Elementary	**465**
Ilima Intermediate	**2,685**
Kaimiloa Elementary	**1,807**
Kaleiopuu Elementary	**2,629**
Kamaile Elementary	**2,343**
Kanoelani Elementary	**1,451**
Kapolei Elementary	**1,467**
Kapolei Middle	**164**
Kapolei High	**458**
Leihoku Elementary	**2,754**
Makaha Elementary	**341**
Makakilo Elementary	**1,746**
Nanakuli Elementary	**1,394**
Nanakuli High & Intermediate	**2,292**
Pohakea Elementary	**647**
Waianae Elementary	**1,468**
Waipahu Elementary	**2,337**
Waipahu High	**4,152**
Waipahu Intermediate	**4,022**
	51,475
Central Oahu (Wahiawa-Mililani and Vicinity)	
Helemano Elementary	**481**
Iliahi Elementary	**1,529**
Kaala Elementary	**711**
Kipapa Elementary	**1,236**
Leilehua High	**944**
Mililani High	**3,326**
Mililani Waena Elementary	**405**
Mililani Middle	**1,009**
Mililani-Uka Elementary	**1,777**
Wahiawa Elementary	**1,738**
Wahiawa Middle	**249**
	13,405
Pearl City-Aiea and Salt Lake	
Aiea Elementary	**932**
Aiea Intermediate	**2,280**
Aiea High	**1,760**

Aliamanu Middle	**2,474**
Highlands Intermediate	**2,708**
Lehua Elementary	**1,457**
Makalapa Elementary	**1,962**
Moanalua High	**4,661**
Momilani Elementary	**189**
Palisades Elementary	**1,541**
Pearl City District Park	**43**
Pearl City Elementary	**330**
Pearl City High	**4,954**
Pearl City Highlands Elementary	**376**
Pearl Harbor Elementary	**472**
Pearl Harbor Kai Elementary	**206**
Radford High	**2,748**
Red Hill Elementary	**439**
Salt Lake Elementary	**1,068**
Waiau Elementary	**1,609**
Waimalu Elementary	**744**
Webling Elementary	**1,700**
	34,653
Salt Lake-Punchbowl and Downtown	
Central Middle	**618**
Dole Middle	**2,614**
Farrington High	**6,766**
Fern Elementary	**1,805**
Kaahumanu Elementary	**420**
Kaewai Elementary	**176**
Kaiulani Elementary	**2,015**
Kalakaua Middle	**3,038**
Kalihi Elementary	**2,082**
Kalihi-Kai Elementary	**1,357**
Kalihi-Uka Elementary	**817**
Kalihi Valley District Park	**350**
Kalihi-Waena Elementary	**1,680**
Kapalama Elementary	**1,595**
Kauluwela Elementary	**1,420**
Kawananakoa Middle	**2,093**
Lanakila Elementary	**1,955**
Likelike Elementary	**1,585**
Linapuni Elementary	**1,317**
Maemae Elementary	**1,558**
Nuuanu Elementary	**285**
Puuhale Elementary	**580**
Roosevelt High	**2,597**
Royal Elementary	**1,195**
Stevenson Middle	**2,697**
	42,615
Punchbowl-Waialae and Vicinity	
Aliiolani Elementary	**1,748**
Jarrett Middle	**327**

Kaimuki High	**3,697**
Kaimuki Middle	**1,607**
Kuhio Elementary	**1,528**
Liholiho Elementary	**326**
Manoa Elementary	**1,904**
McKinley High	**1,607**
Noelani Elementary	**42**
Palolo Elementary	**990**
Waialae Elementary	**1,186**
Waikiki Elementary	**1,298**
Wilson Elementary	**1,146**
	17,406
Aina Haina-Hawaii Kai and Vicinity	
Aina Haina Elementary	**1,492**
Hahaione Elementary	**674**
Kaiser High	**3,478**
Kalani High	**2,487**
Kamiloiki Elementary	**1,147**
Koko Head Elementary	**10**
Niu Valley Middle	**2,360**
	11,648
Windward Coast (Kahuku-Waimanalo)	
Ahuimanu Elementary	**3,152**
Benjamin Parker Elementary	**237**
Brigham Young University of Hawaii	**540**
Castle High	**3,750**
Enchanted Lake Elementary	**1,118**
Heeia Elementary	**1,585**
Kahaluu Elementary	**1,039**
Kailua Elementary	**659**
Kailua High	**526**
Kailua Intermediate	**292**
Kainalu Elementary	**478**
Kalaheo High	**3,938**
Kaneohe Elementary	**552**
Kapunahala Elementary	**1,164**
Keolu Elementary	**648**
King Intermediate	**3,076**
Lanikai Elementary	**580**
Pope Elementary	**1,582**
Puohala Elementary	**1,679**
Waiahole Elementary	**317**
Waimanalo Elementary and Inter.	**1,168**
	28,080
Total Shelter Capacity	**200,505**

– Includes limited capacity for Special Needs persons
– Includes limited capacity for pets in a separate area

Any shelters susceptible to flooding should be used with caution for hurricane sheltering if

associated heavy rain is expected to potentially lead to flooding. None on the above list are in the storm surge inundation zone.

17.2 Design and Assessment Criteria

As previously stated in the hurricane hazard chapter, the State adoption of the 2012 International Building Code provides State specific criteria for the design of new structures that could potentially act as hurricane shelters. Appendix U of the State Building Code provides Hawaii Hurricane Sheltering Provisions for New Construction. Certain types of new buildings that are state- or county-owned built after the adoption of the 2006 IBC (which also included these criteria) must be designed as shelters for Enhanced Hurricane Protection Area standards (surviving hurricanes to Category 3), as well as many other requirements detailed in the aforementioned Appendix U. This requires wind borne debris protection of glazed openings along with other criteria that will result in significant improvement in hurricane shelter performance. The new buildings that this will be applied to are:

- Enclosed and partially enclosed structures whose primary occupancy is assembly with an occupant load greater than 300.
- Health care facilities with and occupant load of 50 or more resident patients, but not having surgery or emergency treatment facilities.
- Any other state- and county-owned enclosed of partially enclosed building with an occupant load great than 5,000.
- Hospitals and other health care facilities having surgery or emergency treatment facilities.

The current State and County lists of hurricane shelters are not currently based on evaluations of the buildings' structural capacity to withstand hurricanes. For existing hurricane shelters, evaluations should be an ongoing process to confirm the safety of every building deemed to be suitable as a shelter. In 2005, Statewide Public Hurricane Shelter Criteria were created in order for hurricane shelter evaluations and retrofits to be done in a uniform fashion. Due to some lack of consistency in reporting, the criteria and report requirements were updated in 2014 to create a completely uniform method of evaluation and retrofitting.

17.3 Shelter Evaluations and Retrofits

The State has been in the process of updating the status of hurricane shelters by doing structural inspections of shelters according to the 2014 Statewide Public Hurricane Shelter Criteria (Chock, 2014) in order to assure the safety of the structure during a hurricane. The Structural Engineers Association of Hawaii (SEAOH) compiled a list of the evaluations and results from the engineers who performed the inspections. The primary objective of these evaluations was to identify whether the structures substantially meet the wind load criteria for a Shelter rating of Type B or better. The evaluations also identified recommendations for any further incremental structural or nonstructural retrofits to achieve substantial compliance with the four standardized hurricane shelter classifications of incrementally increasing protective integrity, Shelter Types B, A, EHPA, and

EFCOOP, where economically feasible. The shelter classifications and performance objectives are summarized in Table 17-2.

Of the 182 SEAOH-reported buildings in the State of Hawaii that were evaluated for structural safety and integrity of their window protection, 56 of those reports were done after the updated 2014 criteria. It was reported that statewide only 5 structures met the standards for Enhanced Hurricane Protection Area, 9 were evaluated to be Type A, 33 were Type B, and 12 were marked "infeasible" for ever being used as hurricane shelters. The remaining 123 shelters did not meet the criteria for a Type B shelter (the lowest classification) but could be retrofitted to achieve that level of safety. Usually, these structures need window protection against windborne debris in addition to structural upgrading. On Oahu, there are 4 EHPA buildings, 2 Type A Shelters, and 13 Type B Shelters

Table 17-2 **Hurricane Shelter Performance Objectives**

Shelter Classification	Expected Performance Objective	Hurricane Category
Type B Hurricane Shelter	Life Safety, with significant structural and nonstructural damage permitted	Category 1 Hurricane
Type A Hurricane Shelter	Life Safety, with significant non-structural damage and low to moderate structural damage permitted	Category 2 Hurricane
Enhanced Hurricane Protection Area	Operational during and after a 500 to 1,000-year event	Category 3 Hurricane
Essential Facility for Continuity of Operations	Near-Absolute Protection and Continuity of Operations during and after a hurricane of maximum considered intensity	Category 4 Hurricane

17.4 Shelter Capacity and Needs

In previous years, shelter capacity estimates were created based on the assumption that every person at the shelter will receive the use of an area of about 10 square feet each. This was deemed to be too small of an area, so the 2014 update to the Statewide Public Hurricane Shelter Criteria changed the required space per person to be 15 square feet. This number increases the safety and quality while individuals are inside of the shelter and is more in line with the suggestions of the American Red Cross. It reduces the previously estimated shelter space in Hawaii, which essentially was over-estimated. As more buildings suitable to be hurricane shelters are structurally evaluated, retrofitted, or built, the amount of estimate shelter space in Hawaii will increase.

An Oahu survey (SMS 2009) found that around 60% of residents on Oahu surmised they would evacuate to some other location if it was recommended by local emergency management officials for an approaching hurricane. Not all residents who evacuate will go to a public shelter; according to the survey, on average 40% of residents would go to a public shelter with the highest local percentage of 52% in the Pearl City area and lowest percentage of 21% in the coastal Waikiki region. Based on the 2014 Hawaii Mass Care Council, it was assumed that up to 30% of the population might go to a shelter in the event of a hurricane. However, this percentage has never

been observed to occur in past disasters in Hawaii. Moreover, since that time, state and city emergency management agencies have explicitly advised to shelter in place.

Table 17-3 demonstrates the very approximate nature of estimating shelter spaces needed versus the survey of ten years ago. The HAZUS model used to analyze hurricane risk estimated that a Category II hurricane would temporarily displace about 52,000 households. The hurricane is estimated to potentially cause 60,000 to 70,000 residential buildings to become uninhabitable, and 31,000 individuals are unable to go back immediately so they must continue to stay in the shelter for awhile longer after the event. The evacuating number of persons would probably become a function of what emergency managers tell the public. Presently, they advise the public to stay in place unless in a flood zone. So, it is likely that the principal issue with hurricane shelter spaces lacking structural integrity for high winds, rather than numbers.

Table 17-3. **Public Shelter Space and Longer-Term Requirements, Oahu Residents Only, Greater than Hurricane Category II Landfall**

Resident Population (2010)	Residents Evacuating Hurricane per 2009 survey (~30% max)	Post-Hurricane Alternative Short-Term Shelter Space Needs
953,000	285,000	31,000

17.5 Visitor Sheltering

Hawaii Emergency Management Agency and Department of Emergency Management planners have, for several years, assisted hotel and resort managers in identifying, within their own facilities, hurricane-resistant shelter space for their guests. As an incentive, liability coverage for private shelters, as outlined in Hawaii Revised Statute 128-19, was offered to those facilities who either had created suitable guest shelter space, or agreed to mitigate portions of their facilities to make them hurricane-resistant. This was and continues to be an important initiative. Based on 2016 figures from the State of Hawaii Data Book (available at http://dbedt.hawaii.gov/economic/databook/), there is an average of 217,675 tourists at any given time that would require sheltering during an extreme event affecting all islands in Hawaii at once. Based on 2010 figures from the same source, approximately 97,000 of those visitors would be in Waikiki alone.

17.6 Disabled Sheltering

It is anticipated that the population of persons with special needs is about 10-13% of the total population. The American Red Cross and National Organization on Disability have prepared information providing guidance on sheltering for people and caregivers of those with different forms of disabilities, including sensory disabilities, cognitive disabilities and mobility disabilities. These are available on the Red Cross website: (http://www.redcross.org/get-help/how-to-prepare-for-emergencies/disaster-safety-for-people-with-disabilities). People with sensory disabilities and some mobility disabilities are generally able to shelter with the general population, with some assistance as may be required depending on the disability and the resources of each shelter. While typical pets are confined to pet friendly shelters, service animals are legally able to shelter with a

disabled individual in any shelter. People with cognitive disabilities and certain mobility disabilities typically require special needs shelters with additional resources and accessibility features. A large proportion of the shelters listed in Table 17-1 have a special needs designated area.

17.7 Legislative Requirements

The Legislature should provide funds to retrofit selected facilities with hurricane shutters and other improvements, such as emergency power generation equipment, adequate to fulfill the needs of a hurricane resistant shelter.

The Legislature now encourages all hotels and resorts to house their own guests and worker families during hurricanes and other major natural disasters. In Hawaii, there is legislation that enables private facilities to house the public with relief for negligence liability.

Hawaii Revised Statutes (HRS) 127A-20 provides relief for negligence liability to private sector owners who volunteer the use of their facilities as an emergency shelter. The immunity protection that may be provided applies when an owner or controller of the facility meets the following criteria: (1) Their actions relating to the sheltering of people are voluntary; (2) They receive no compensation for the use of the property as a shelter; (3) They grant a license or privilege, or permit the property to be used to shelter people.
Furthermore, per Hawaii Revised Statutes 663-10.7 (here paraphrased), Any owner of private property who provides emergency access to land, shelter, or subsistence, including food and water, to a person during a disaster without remuneration, shall be exempt from civil liability for any injury or damage suffered by the person, unless the injury or damage was caused by the gross negligence or intentional or wanton acts or omissions of the owner.

17.8 Future Proposed Mitigation Projects

Future mitigation projects required for ensuring adequate and safe shelters for hurricanes and other natural disasters are:

- Honolulu should adopt 2012 IBC and related codes per HRS 107 Part II.
- Structural evaluations of existing hurricane shelters should be done according to the 2014 *Scope of Services and Procedure for Structural Assessment of Buildings for Hurricane Shelter Classification*.
- Re-assess the structural integrity of the Hawaii Convention Center and Neil Blaisdell Center
- Based on a structural evaluation, retrofit public shelter buildings to increase capacity and refine actual evacuation demand and update policies to decrease sheltering deficit.
- Identify the types of buildings more suitable for self-sheltering: Perform a comprehensive screening evaluation of private sector candidate building types for possible hurricane refuge use and create a certification system for private shelter refuges.
- Incentives for homeowners and businesses to retrofit their structures.
- The University of Hawaii at Manoa has a wind cannon used for the testing of commonly used local materials and building styles. Further testing of components for windborne

debris protection of glazing is required for use in the construction of residential safe rooms. Further devices that need testing in the SCD wind cannon include wood louvers, vinyl louvers, and security meshes that are presently used for school repair and maintenance projects.



18. Risk Assessment

18. RISK ASSESSMENT

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 plan created the first risk assessment chapter and contained analyses for all hazards. A risk analysis of the University of Hawaii System campus buildings was given with facility vulnerability rankings.	• This new chapter updates a summary of risk assessments for all hazards. Here, risk is defined as the potential losses associated with a hazard, defined in terms of expected annual loss, resulting from the probability of occurrence, magnitude and severity, asset exposure and vulnerability, and consequences. This is an objective method for evaluating the economic risk associated with each specific hazard. • The Site-Specific portion of the Building Inventory is expanded to 80,000 properties based on footprints and parcel data; more accurate building floor areas and valuations increased the net total exposure • Risk assessment AAL's are updated for Hurricane, Earthquake, Floods, Tsunamis, and the other significant hazards. • A risk analysis of all critical facility buildings in the County for earthquakes and hurricanes is described that identified the most vulnerability facilities. • The relative hazard severity of the hazards treated in this plan based on average annualized losses is determined. • The completed and ongoing projects that are expected to reduce vulnerability to the different hazards are discussed. • Critical facilities are identified and listed. The most vulnerable facilities are identified.

Annualized loss estimates were used to establish a measure of negative economic impacts of particular natural hazards and to determine and prioritize potentially effective mitigation actions insofar as benefits from reduced annual losses.

Relative Hazard Severity to the City & County of Honolulu
Based on Average Annual Loss Estimates

Hurricane Winds	$410 Million / Year
Tsunamis	$81 Million / Year
Floods	$41 Million / Year
Earthquakes	$21 Million / Year
Debris Flows and Rockfalls	$1 to $5 Million / Year
Coastal Erosion (sand replenishment)	$3 Million / Year
Wildfire	$1 Million / Year
Dam Failure	less than $1 Million / Year
High Surf	less than $0.5 Million / Year
HAZMAT	less than $0.10 Million / Year

Summary of Risk Analysis Related Mitigation Projects for Honolulu

Project	Priority
Develop guideline criteria for designation of Critical Facilities, which are defined as Buildings and structures that provide services that are designated by federal, state, or local governments to be essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations. Critical facilities comprise all public and private facilities deemed by a community to be essential for the delivery of vital services, protection of special populations, and the provision of other services of importance for that community.	High

18.1 Overview

In order to prioritize hazard mitigation measures, the relative risk of the natural hazards needs to be evaluated. This can be done through a quantitative risk assessment. The steps in a risk assessment to a given natural hazard are:

1. Construct an inventory of the assets within an analysis boundary that are vulnerable to a given hazard.
2. Determine fragility functions for different categories of assets that predict the amount of damage to the inventory due to hazard events of different intensities.
3. Calculate points along the hazard probability curve that predicts the frequency of hazard events of different intensities.
4. Perform an analysis that combines the inventory, fragilities functions for that inventory and the hazard probabilities to determine the average annual losses expected as a consequence of a given hazard.

Average Annualized Loss (AAL) is an objective measure of future losses averaged on an annual basis. The benefits of hazard mitigation may be then be assessed by calculating the reduction in the annual losses as a result of a mitigation activity. By calculating the AAL for different natural hazards, the need for mitigation measures for the different hazards may be assessed on a relative basis, although AAL is not the only measure for assessing the relative merits of mitigation activities, as other non quantifiable factors must also be considered.

The AAL is calculated from the following expression:

$$AAL = \sum L_i \times P_i$$

L_i = Estimated Loss for Event *i*

P_i = Annual Probability of Event *i*

Description: Sum of the expected loss for each event (i.e., sum of the products of the estimated loss from each event and that event's rate of occurrence)

The fragility of a building or structure is dependent on the design basis used for its original design and construction. Older structures designed under older codes are typically more vulnerable than modern structures designed under later building codes and standards. Also, the design criteria for one hazard may differ from another. A prime example of disparate criteria for related hazards is the case of hurricane winds and flooding (in which flooding by storm rainfall and storm surge and waves is concurrent with high wind). However, the application of current design standards result in different failure probabilities. See Figure 18-1.

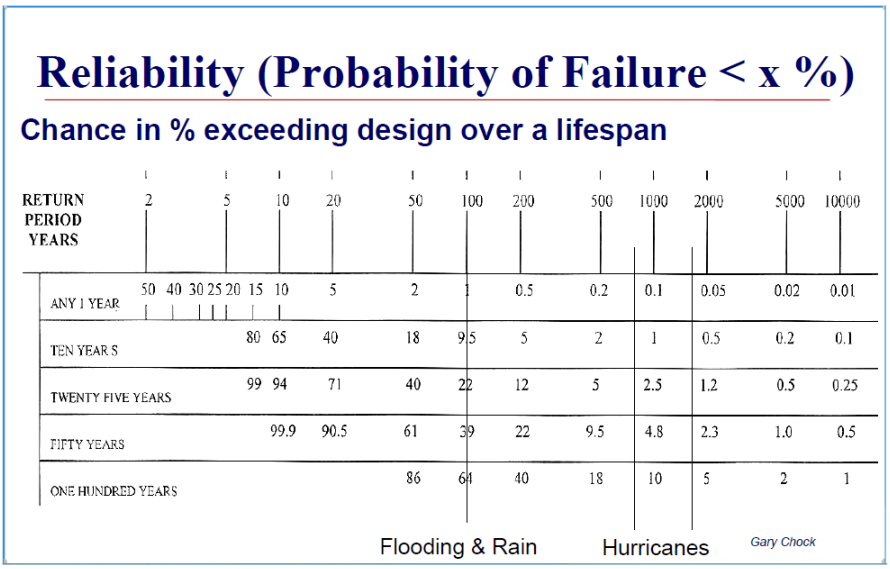


Figure 18-1. Failure Probabilities inherent in the Flood and Hurricane Provisions of the current Building Code

18.2 City and County of Honolulu Inventory of Assets

18.2.1 Critical Facilities

Critical facilities include facilities that provide emergency services to the community, i.e. police and fire stations, hospitals, the emergency operations center, and shelters (primarily school buildings), and other facilities providing services to the public that are necessary to preserve public welfare, such as water and wastewater systems, power, and major transportation highways. Critical facilities are the assets for which loss would have the greatest impact during a hazard event. These may be temporarily disrupted during disaster, but would have priority for initial recovery efforts. Due to large impact of their disruption it is beneficial to get an accurate assessment of the inventory of critical facilities.

Figures 18-2 through 18-8 show the locations of different categories of critical facilities, including:

- 7 Emergency Operation Center sites (State and County) locations (Figure 18-2)
- 80 Hospitals and other Medical Centers (Figure 18-3)
- 43 Fire stations (Figure 18-4)
- 14 Police Stations (Figure 18-5)
- 162 Shelter locations that are a subset of 784 School Buildings (see Chapter 17 for a complete shelter list) (Figure 18-6)
- 588 Bridges (Figure 18-7)
- 17 Dams and Reservoirs (See Chapter 15 for a description of dams) (Figure 18-8)

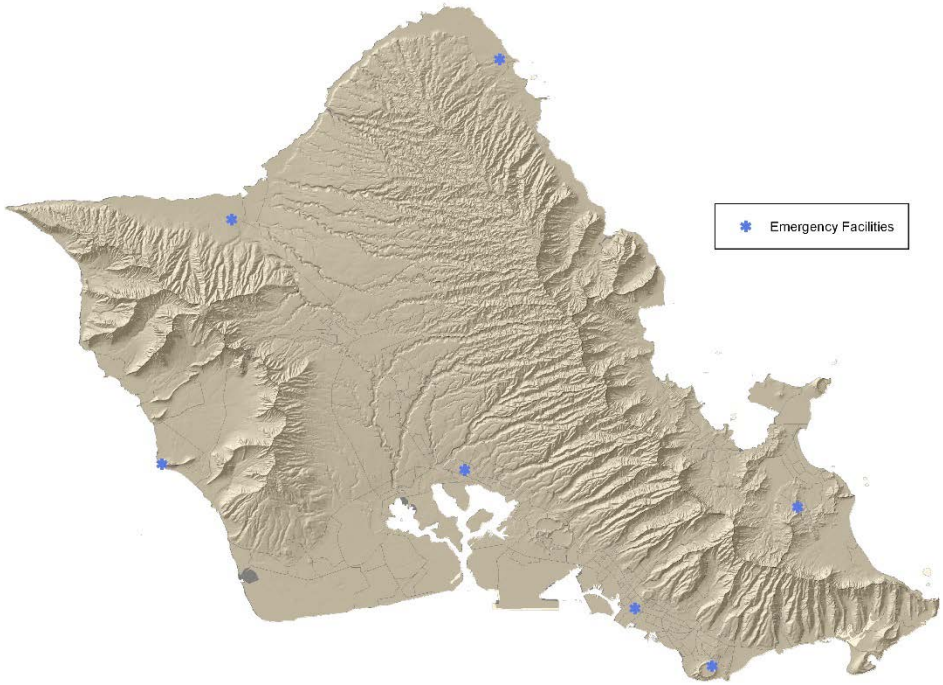


Figure 18-2. Map of Emergency Operations Centers

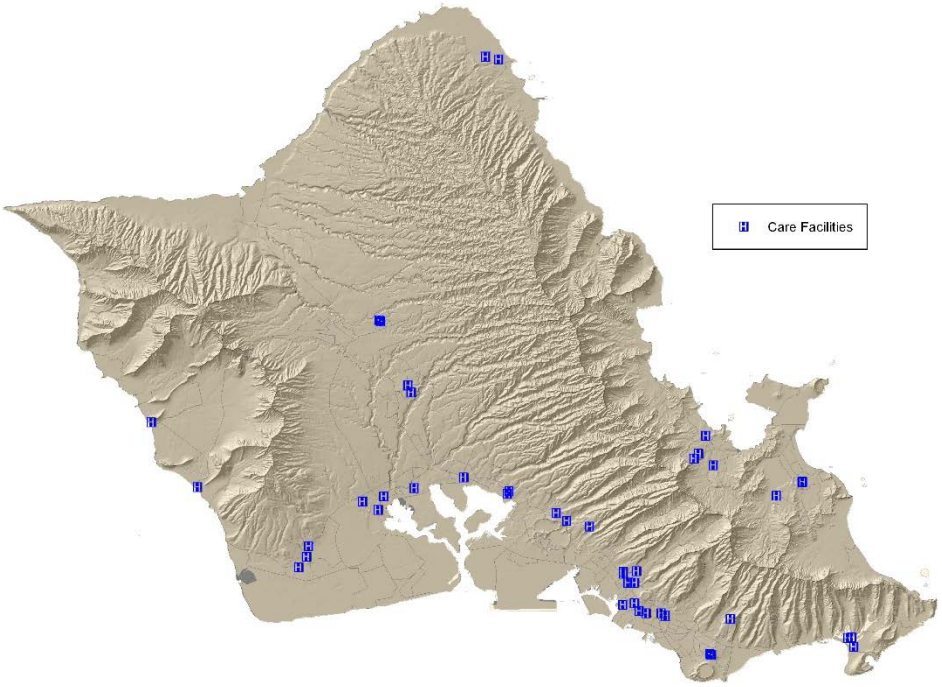


Figure 18-3. Map of Care Facilities

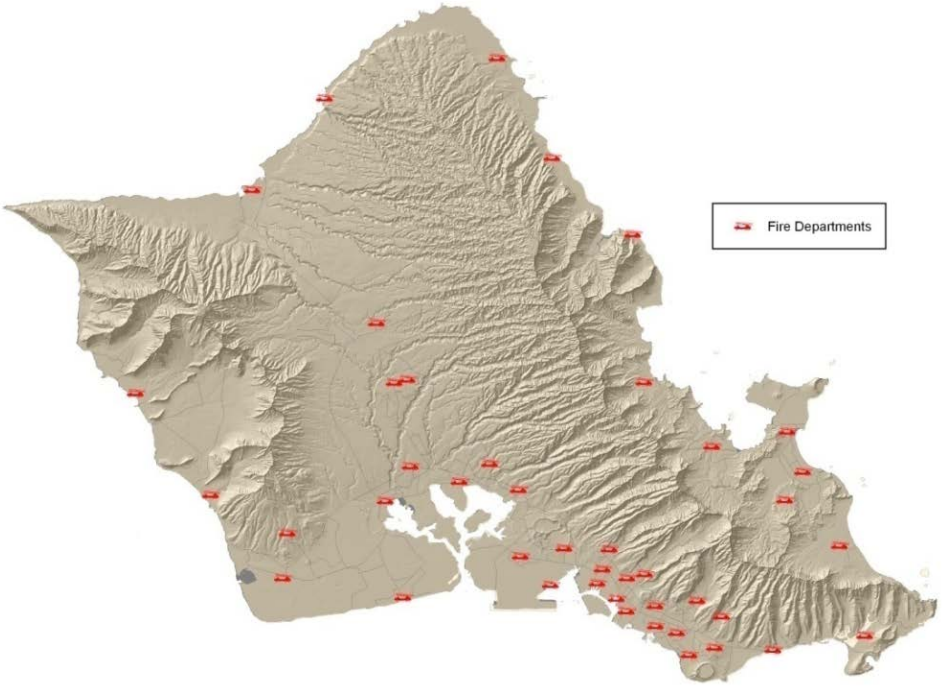


Figure 18-4. Map of Fire Departments

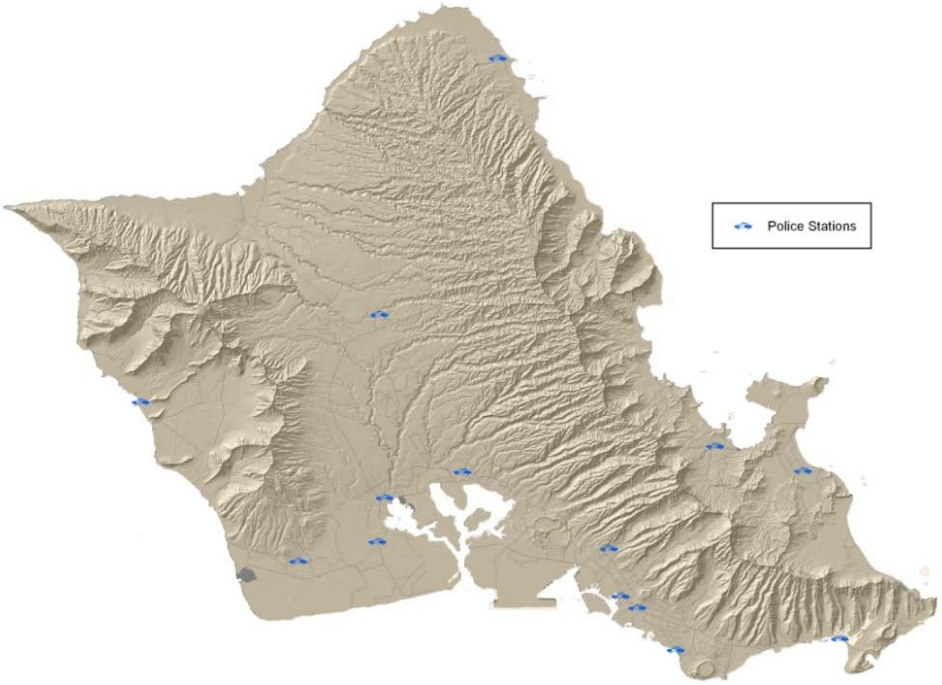


Figure 18-5. Map of Police Stations

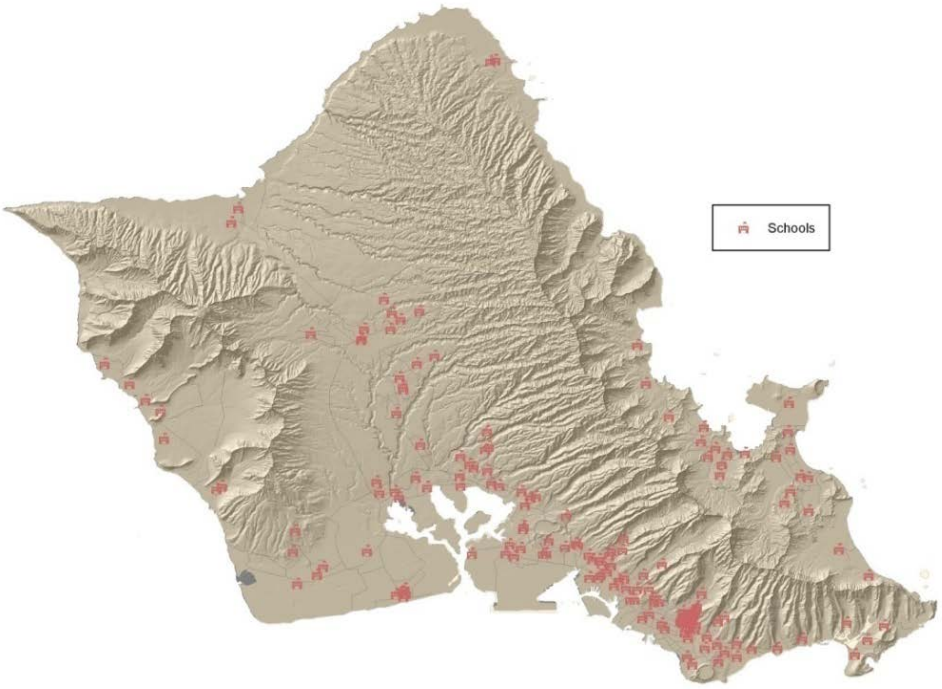


Figure 18-6. Map of School Campuses

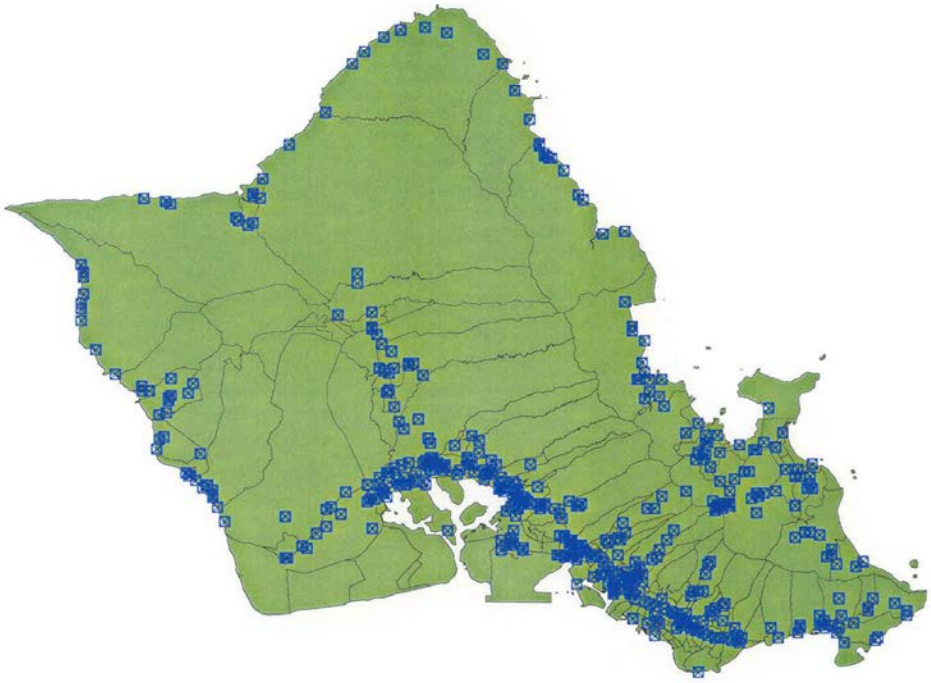


Figure 18-7. Map of Bridges

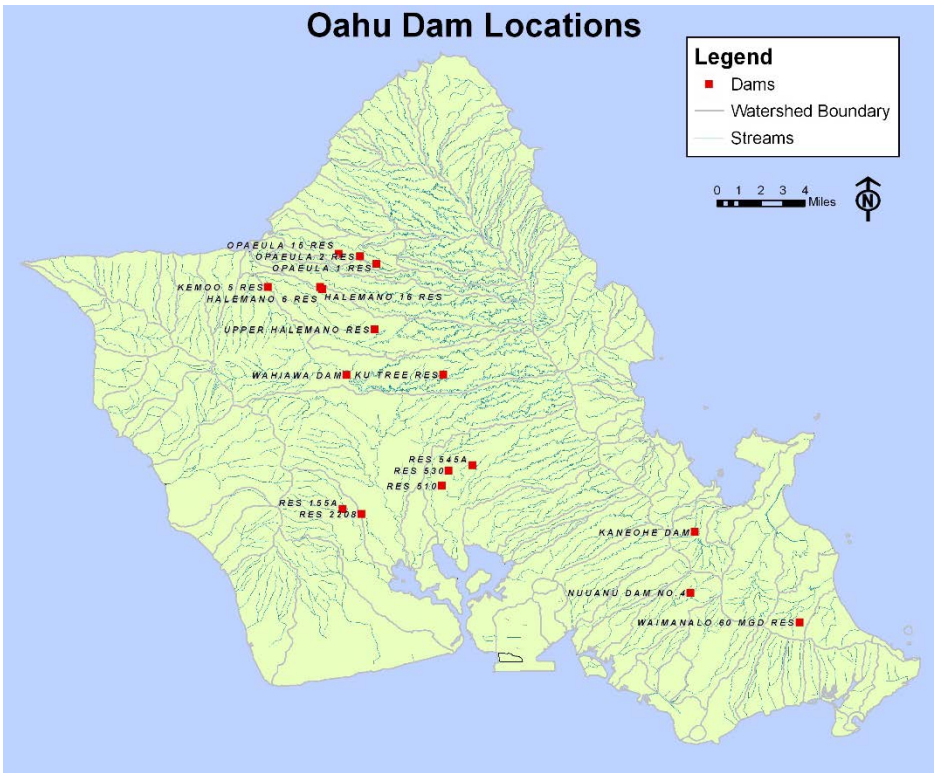


Figure 18-8. Map of Dam Locations

Lists of the emergency operations centers, hospitals and medical centers, fire stations, police stations and schools are provided in this chapter. A list of dam locations is provided in Chapter 15.

Other critical facilities not specifically mapped or listed include:

- Water & Wastewater Plants
- Sewage Pumping Stations
- Power Plants and Power Stations
- Communications Facilities
- Facilities that produce, use, or store highly volatile, flammable, explosive, toxic or water-reactive materials

Data for the majority of these critical facilities was collected including asset valuations and structural building properties, which allowed an assessment of their fragility functions for use in risk assessments in five separate studies. In the first study a HAZUS®MH analysis of critical facilities including the Emergency Operations Centers, Hospitals and Medical Centers, Fire Stations, Police Stations, School Buildings and University of Hawaii facilities was completed in January 2010 (RMTC / URS Joint Venture, 2010). The additional data was used to enhance the default HAZUS®MH data for a more accurate loss estimation and prioritization of the most vulnerable facilities for deterministic hurricane and earthquake and three probabilistic flood scenarios. The second study provided further data on State facilities, included the airports, state hospitals and healthcare facilities, pier facilities, courthouses, libraries and other miscellaneous state facilities as well as City and County of Honolulu schools that are designated as hub shelters during emergencies. These additional facilities were prioritized for retrofit based on probabilistic hurricane and earthquake scenarios. Thirdly, the Department of Land and Natural Resources

produced site-specific building data for the coastal zone subject to sea level rise. We also utilized publically available parcel data on building area and zoning occupancy combined with GIS building footprints to deterMmine the heights of buildings and their occupancy mapping scheme for building type. In general, ore accurate building floor areas and valuations increased the building exposure at risk over the default HAZUS®MH data.

18.2.2 University of Hawaii

A separate hazard mitigation study was performed for the University of Hawaii system. This accounts for around 885 buildings of which around 63% are located on Oahu. The total value of buildings is estimated at around 4.96 billion dollars of which around 83% is located on Oahu. The number of buildings and valuations of buildings at each campus is shown in Figures 18-9 and 18-10 respectively. The building types and structural fragilities were assessed in order to include the vulnerabilities of the University of Hawaii system to different hazards.

18.2.3 General Building Inventory

The breakdown of the asset categories is given in Table 18-1. A complete analysis of the tax appraiser records has not been previously done for Oahu, but is recommended since it would allow a more precise assessment of building inventory exposure.

Table 18-1. Default General Building Stock Inventory Exposure for Oahu

Occupancy	**Percent of Total**
Residential	81.9%
Commercial	13.3%
Industrial	1.7%
Agricultural	0.4%
Religious	1.1%
Government	0.7%
Education	0.9%
Total	**100%**

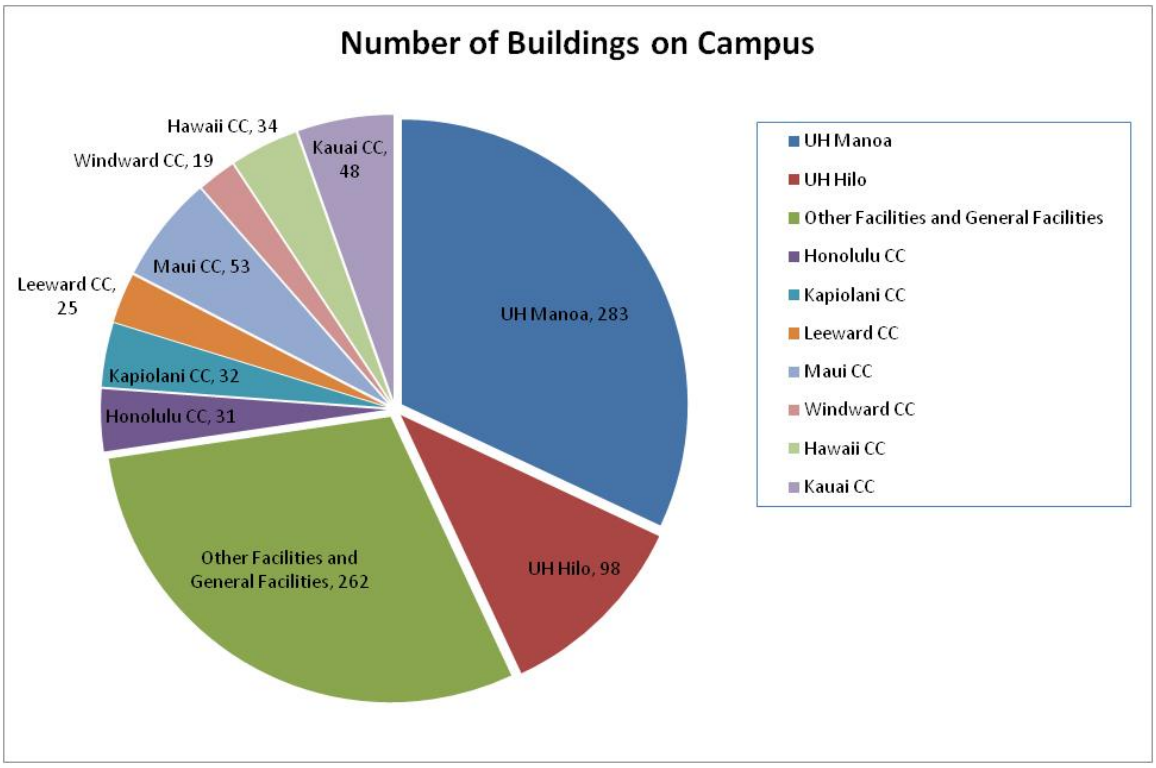


Figure 18-9. Building counts for each UH campus

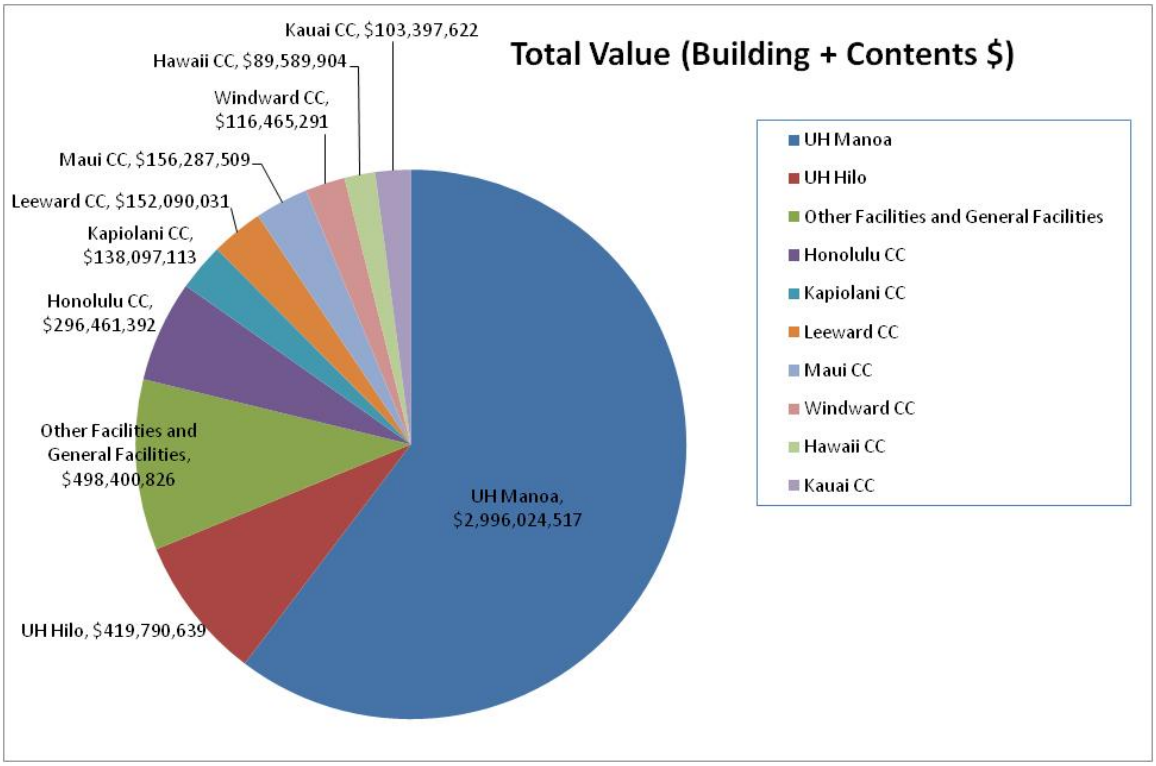


Figure 18-10. Building Valuation for each UH campus

18.3 Assessment of Relative Risks of Natural Hazards

18.3.1 Strong Winds

High winds from trade winds, which blow 70% of the time, Kona winds 30% of the time, passing through Hawaiian waters all affect the island of Oahu. These seasonal winds are typically not severely damaging, although the high wind storms are generally linked to flooding therefore the storms result in both wind damage and flood damage. No data exists to quantify the annual damage from strong non-tropical cyclone winds except that 60% of respondents from the survey described in Chapter 2, had experienced some level of damage to their homes from strong wind storms. This was well ahead of the hazard that had affected the next largest proportion of people that is flooding at 29%. While strong wind storm damage is more frequent the level of damage is generally minor compared to tropical cyclone, including hurricane, damage. Any mitigation for the tropic cyclone hazard also has benefits for the other wind hazards.

18.3.2 Tropical Cyclones

To calculate Average Annualized Losses, a probabilistic simulation of tropical cyclones over the central Pacific was conducted for the present-day climate. Fifty 20-year downscaled simulations representative of the 1980-1999 period were performed using the NCAR-CCSM4 model, generating a catalog of 2436 tropical cyclones for evaluation of storms with up to a 1000-year mean recurrence interval (Table 18-2). This model has better representation of the El Niño Southern Oscillation (ENSO) and atmospheric feedback as shown by Bellenger et al. (2014). Each 20-year period captures several cycles of the ENSO, which strongly influences the storm and wave activities in the Pacific. Each storm track includes time histories of the central pressure, radius of maximum winds, maximum sustained wind speed, and forward velocity at two-hour intervals. This quasi-stationary dataset of 1000 years provides the basis for probabilistic analysis.

Table 18-2. Number and percentage of hurricanes by intensity from 50 downscaling simulations of the 1980-1999 period.

Storm Category	1980 - 1999	
Tropical Storm	779	32.0%
Category 1	648	26.6%
Category 2	332	13.6%
Category 3	321	13.2%
Category 4	266	10.9%
Category 5	90	3.7%
Total	2436	100%

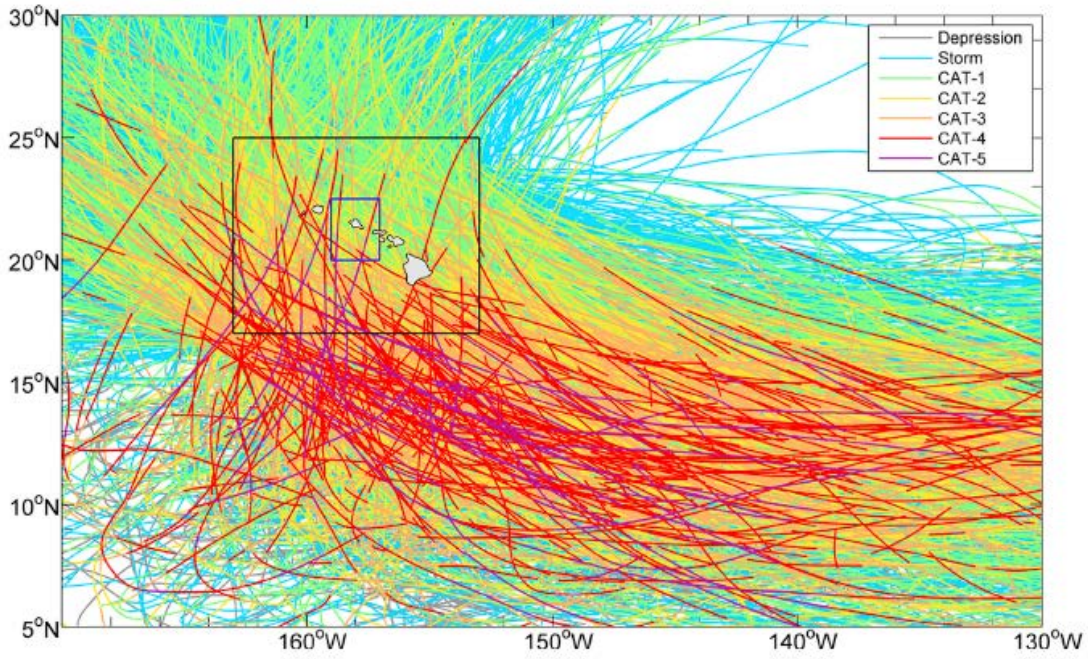


Figure 18-11. Simulated tropical storms and hurricanes passing through the Hawaii region from 50 downscaling computations of the period from 1980 to 1999.
The black and blue boxes indicate the Hawaii region and the potential impact zone around Oahu

From this representative catalog, the top 20 storms entering the local region around Oahu were ranked, and the parametric Holland windfield was used to determine the 10-minute sustained windspeeds on Oahu as each storm had its closest approach. From this, the 1st, 2nd, and 10th ranked storms were identified that yields the 1000-year, 500-year, and 100-year windspeed scenarios from the 1000-year catalog. Then, the directional windfields were converted to peak gust windspeeds at 10 m height above ground and the topographic speed-ups were determined over a grid of reference points based on the modeling by Chock that had been previously implemented in the Hurrevac/MMS model. Thus, the topographically amplified peak gust windspeeds were interpolated to calculate the windfields over the entire island for the probabilistic 1000-year, 500-year, and 100-year mean return periods.

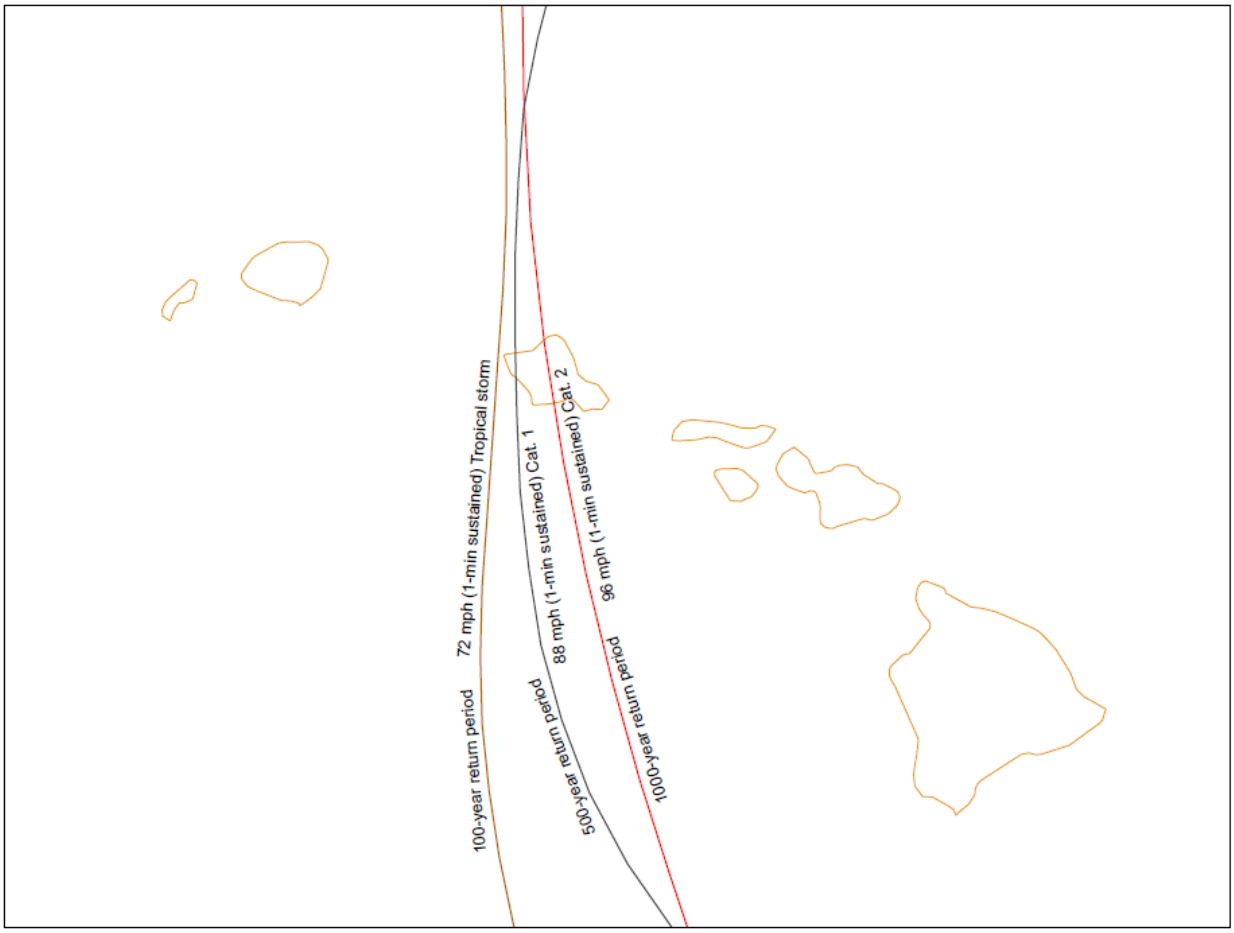


Figure 18-12. Probabilistic Storm Tracks for the 1000-year, 500-year, and 100-year windspeed storms.

The resulting peak gust wind speeds around the island are shown in Figures 18-13 and 18-14.

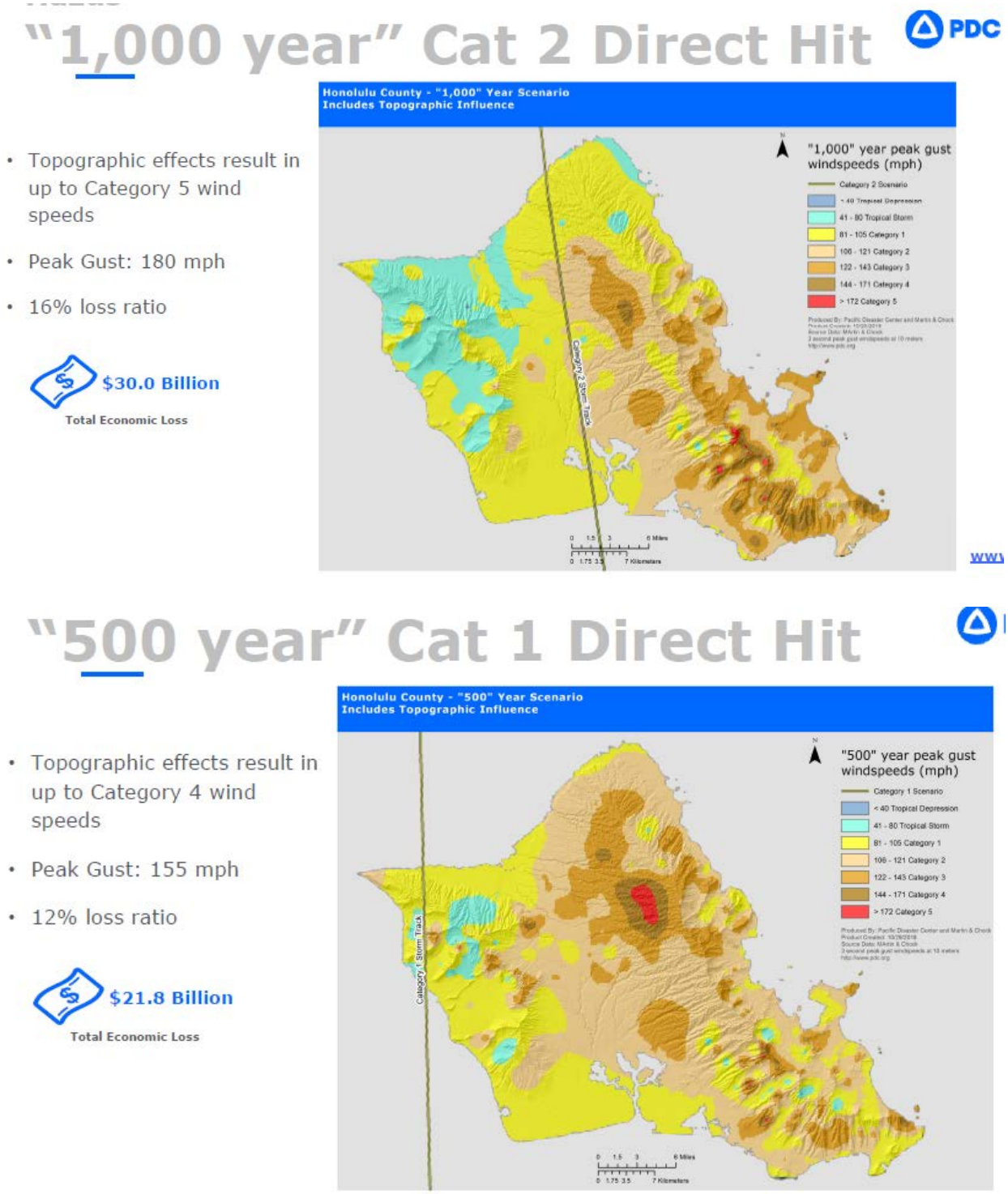


Figure 18-13. 1000-year and 500-year hurricane scenario tracks and peak wind gusts including topography

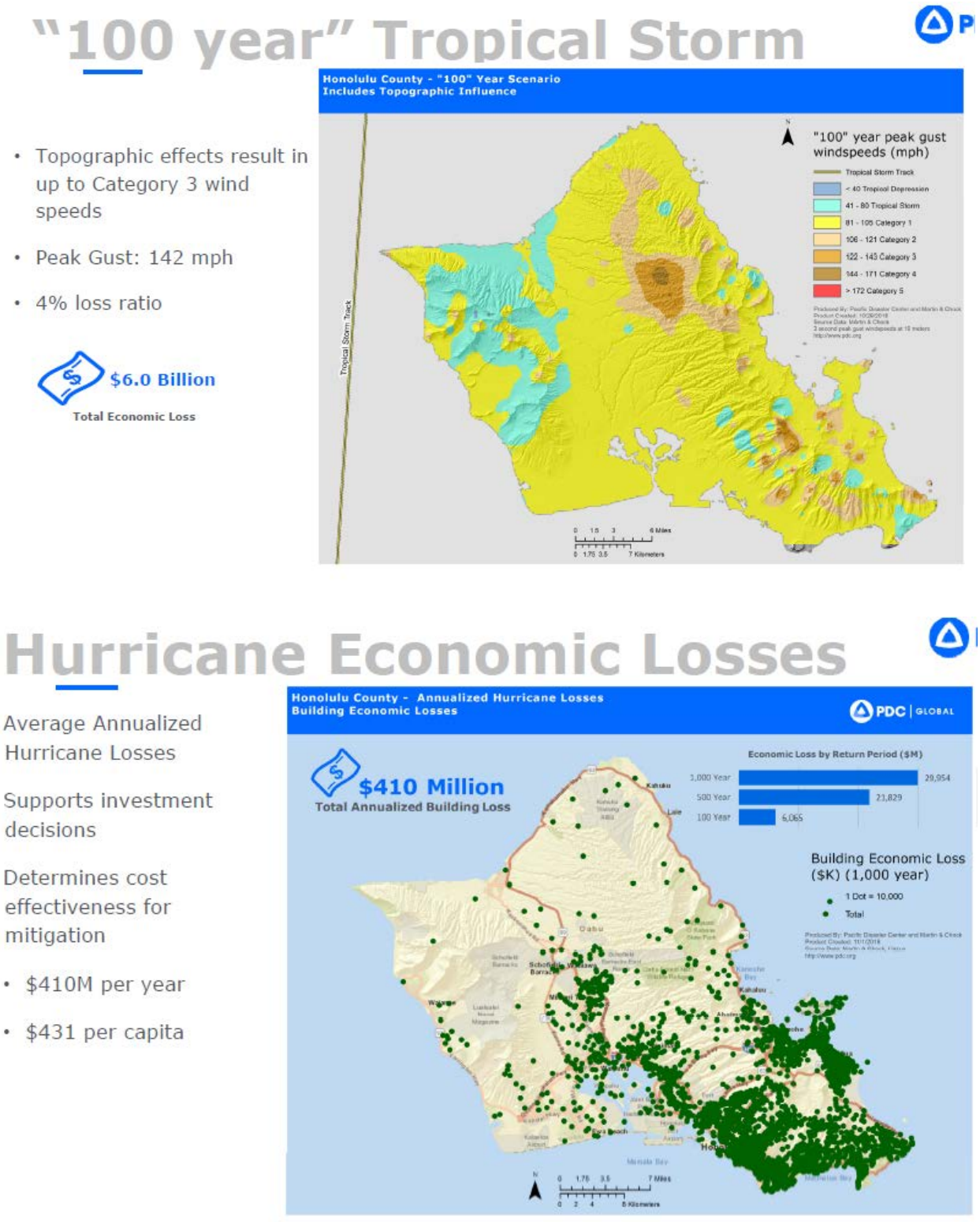
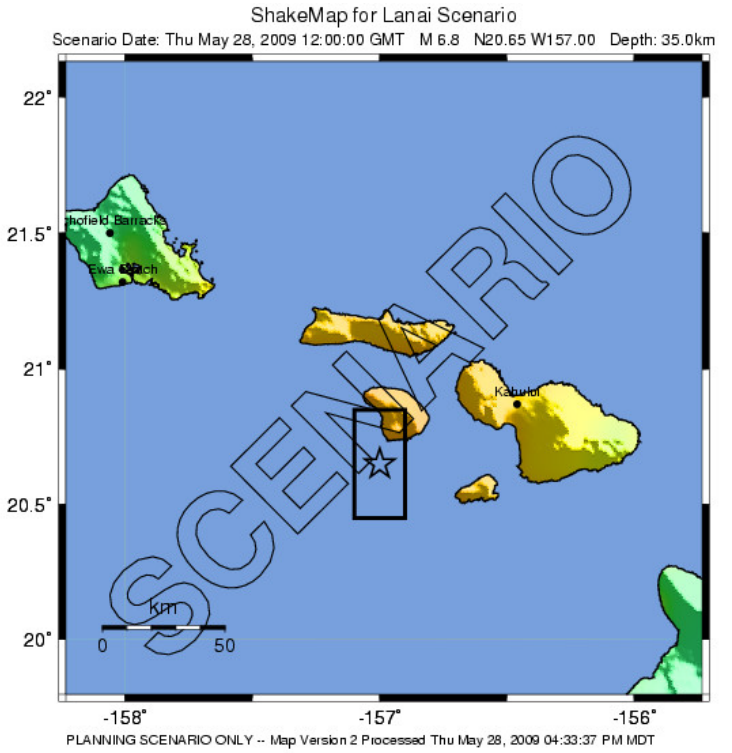


Figure 18-14. 100-year hurricane scenario track and peak wind gusts including topography and economic losses

18.3.3 Earthquakes

For loss estimation and building vulnerability ranking a magnitude 6.8 earthquake scenario with an epicenter near the Island of Lanai was analyzed within the HAZUS model (RMTC / URS JV, 2010). Shake maps prepared by David Wald of USGS for peak ground acceleration, velocity, and spectral accelerations were imported into the model for this study. This is a deep lithospheric earthquake with a similar seismogenic mechanism as the Kiholo Bay earthquake, i.e., plate flexural failure. A shakemap of the scenario is shown in Figure 18-13. Maximum peak ground accelerations on Oahu were about 12% gravity at the southeastern most point of the island, with values elsewhere of between 2% to 10% as shown in Figure 18-15 and Figure 18-16.

Building type benchmark years used in the HAZUS analysis are listed in Table 18-3. The fragility of post and pier residential light-frame construction utilized the Hawaii-specific damage functions developed for HAZUS MH in 2008 after the 2006 Kiholo Bay Earthquake. Overall direct losses to general building stock (property losses only) were estimated to be $75 Million. A breakdown of these losses per occupancy type and type of loss is included in Table 18-4. The distribution of residential damage and losses is shown in Figure 18-17. The damage is most severe in the southern end of the island corresponding to the highest peak ground accelerations. The losses from this earthquake scenario is less than 1% of the damage estimated based on the Category 2 hurricane scenario, although the earthquake scenario is considered to be a more frequent event than the hurricane scenario considered.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 18-15. Shakemap of event used for earthquake vulnerability ranking

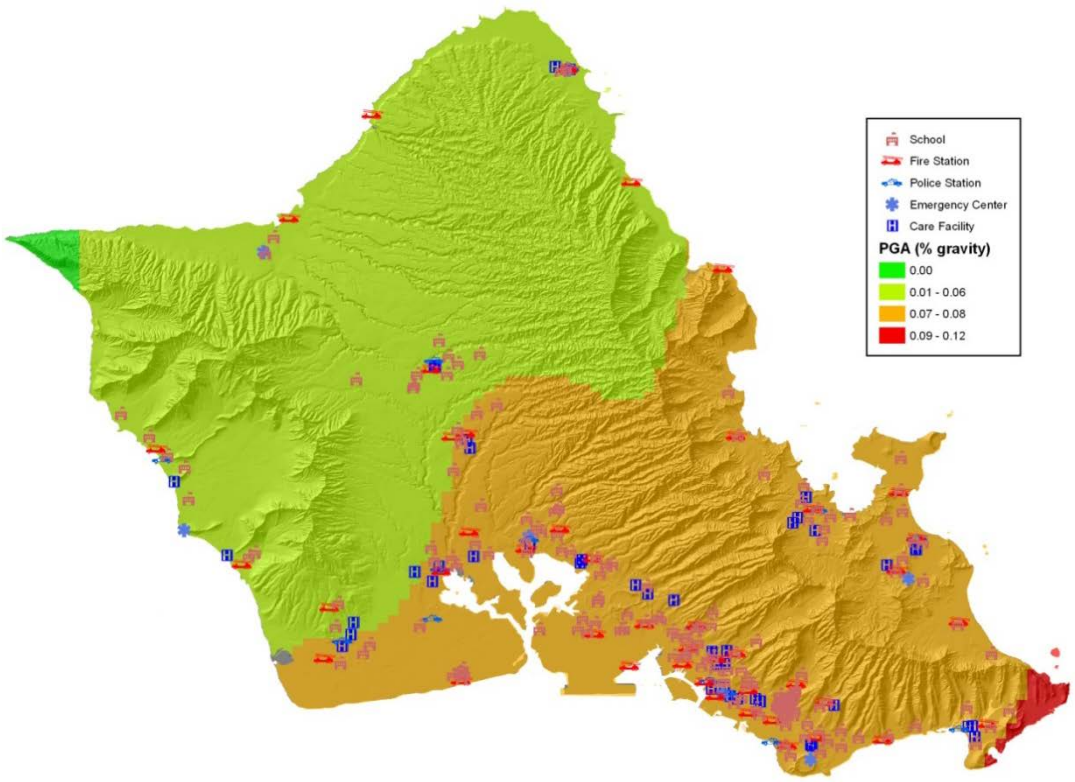


Figure 18-16. HAZUS modeled Peak Ground Accelerations on Oahu for Lanai Earthquake scenario

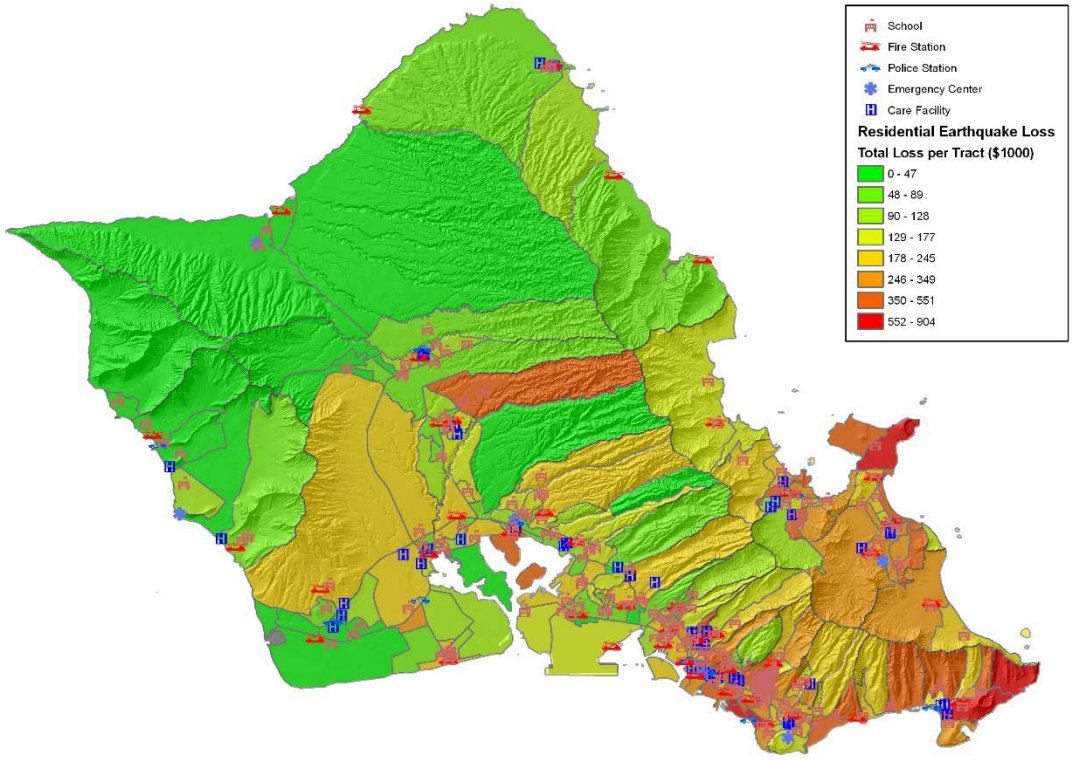


Figure 18-17. Residential earthquake losses per census tract for modeled event

Table 18-3. Benchmark Buildings UBC Dates

Building Type[1]	Building Seismic Design Provisions
	UBC
Wood Frame, Wood Shear Panels(TypeW1&W2)	1976
Wood Frame, Wood Shear Panels (Type W1A)	1976
Steel Moment Resisting Frame (Type Sl & SlA)	1994[2]
Steel Braced Frame (Type S2 & S2A)	1988
Light Metal Frame (Type S3)	*
Steel Frame w/ Concrete Shear Walls (Type S4)	1976
Reinforced Concrete Moment Resisting Frame (Type C1)	1976
Reinforced Concrete Shear Walls(TypeC2& C2A)	1976
Steel Frame with URM Infill (Type S5, S5A)	*
Concrete Frame with URM Infill (Type C3 & C3A)	*
Tilt-up Concrete (Type PC1 & PCIA)	1997
Precast Concrete Frame (Type PC2 & PC2A)	*
Reinforced Masonry (Type RM1)	1997
Reinforced Masonry (Type RM2)	1976
Unreinforced Masonry (Type URM)	1991[3]
Unreinforced Masonry (Type URMA)	*

[1] Building Type refers to one of the Common Building Types defined in FEMA 310

[2] Steel Moment-Resisting Frames shall comply with the 1994 UBC Emergency Provisions.

[3] Refers to the UCBC Section of the UBC.

* No benchmark year

UBC - International Conference of Building Officials, *Uniform Building Code.*

Table 18-4. General Building Stock Economic Losses Per Occupancy Due To Earthquake Scenario

	Occupancy - *losses in millions of dollars*					
Income Loses	**Single Family**	**Other Residential**	**Commercial**	**Industrial**	**Others**	**Total**
Wage	0.00	0.03	0.42	0.01	0.06	0.52
Capital-Related	0.00	0.01	0.43	0.00	0.01	0.46
Rental	0.05	0.34	0.41	0.00	0.02	0.82
Relocation	0.00	0.00	0.01	0.00	0.00	0.02
Subtotal	**0.05**	**0.38**	**1.28**	**0.02**	**0.09**	**1.82**
Capital Stock Loses						
Structural	0.94	0.80	0.75	0.09	0.15	2.74
Non Structural	13.88	14.79	12.72	2.10	2.65	46.15
Content	7.41	5.41	9.34	1.42	2.07	25.66
Inventory	0.00	0.00	0.19	0.23	0.03	0.45
Subtotal	**22.23**	**21.01**	**23.01**	**3.85**	**4.90**	**75.00**
Total	**22.28**	**21.39**	**24.29**	**3.87**	**4.98**	**76.82**

In the independent probabilistic HAZUS analysis by Martin & Chock, the Average Annualized Losses due to seismic events is estimated at $21 million per year. As with the hurricane analysis, this analysis could be improved with a more complete study of building inventory on Oahu. Compared to the Average Annual Losses due to hurricanes, seismic losses are around 10% of the hurricane losses. Therefore, on Oahu, hurricane mitigation is of significantly higher priority than earthquake mitigation.

The effects of the Lanai earthquake scenario on the essential facilities data set of the Island of Oahu were, in general, low. Estimated losses to all essential facilities combined were under $3 million, again at very low level (0.5%) compared to the hurricane scenario.

Damage levels to the individual buildings were slight to none (typical damage conditions may include damaged ceiling tiles, wall finishes, or other non-structural acceleration sensitive components), resulting in a maximum loss of functionality of up to 7 days with many buildings experiencing no loss of functionality.

18.3.4 Landslide / Debris Flows

Annualized losses due to landslides and debris flow cannot be accurately determined. Risk assessment and mitigation is performed based on historic occurrences and the impacts of these occurrences, such as injuries or financial impacts resulting from road closures or property damage. Annualized losses, based on a historical assessment, are estimated at between $1 and $5 million, similar to flood, but much less than hurricane and earthquake losses. Active rockfall and debris flow areas should continue to be monitored and addressed on a case-by-case basis.

18.3.5 Tsunamis

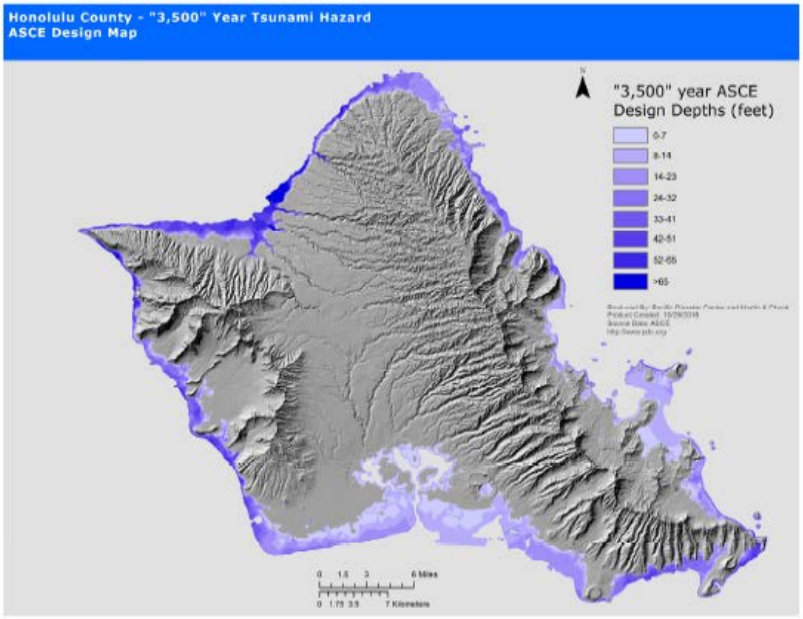
The Hawaiian Islands have a long history of destruction due to tsunamis and are particularly vulnerable to tsunamis originating in the north and the southeast Pacific Ocean. It potentially provides the greatest risk of all hazards to residents and properties located within a projected tsunami inundation zone. Average Annualized Losses were based on three scenarios that have estimated probabilities:

- The ASCE 7-16 Tsunami Design Geodatabase, which is estimated to have a mean hazard level equivalent to 3500 year mean recurrence interval based on a fully probabilistic tsunami hazard analysis.
- The City of Honolulu Extreme Tsunami inundation zone, which is estimated to have a mean hazard level equivalent to 1500 year mean recurrence interval
- The City of Honolulu inundation zone based on historical flooding, which is estimated to have a mean hazard level equivalent ot 400 year mean recurrence interval

"3,500 year" Tsunami

- $1.8 Billion Essential Facility Losses
- Population Exposed:
  - Day: 404K
  - Night: 294K

$41.5 Billion
Total Building Economic Loss



"1,500 year" Great Aleutian Tsunami

- Extreme Evacuation Zone
- $396 Million Essential Facility Building Losses
- Population Exposed:
  - Day: 298K
  - Night: 217K

$18.2 Billion
Total Building Economic Loss

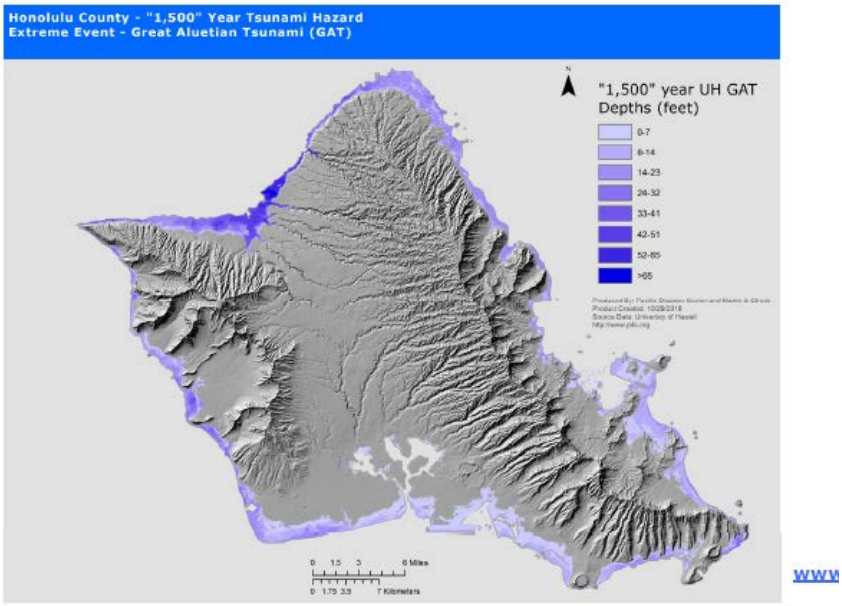


Figure 18-18. 3000-year and 1500-year Tsunami Inundation Zones

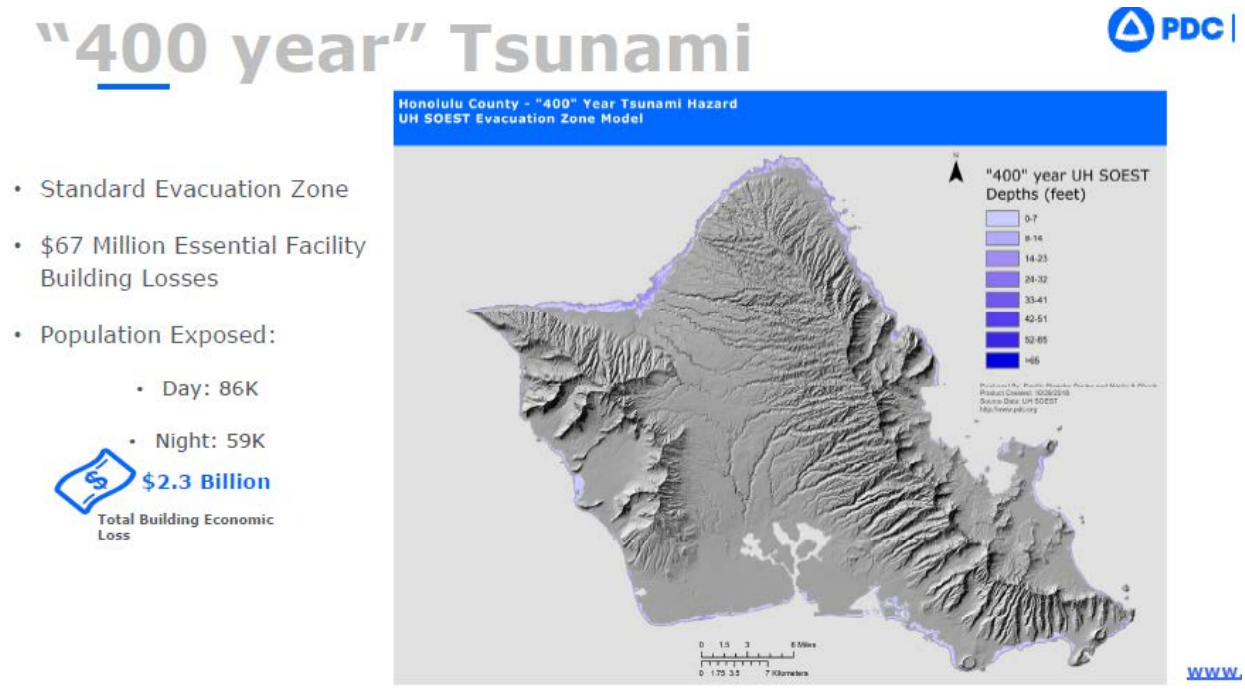


Figure 18-19. 400-year tsunami scenario

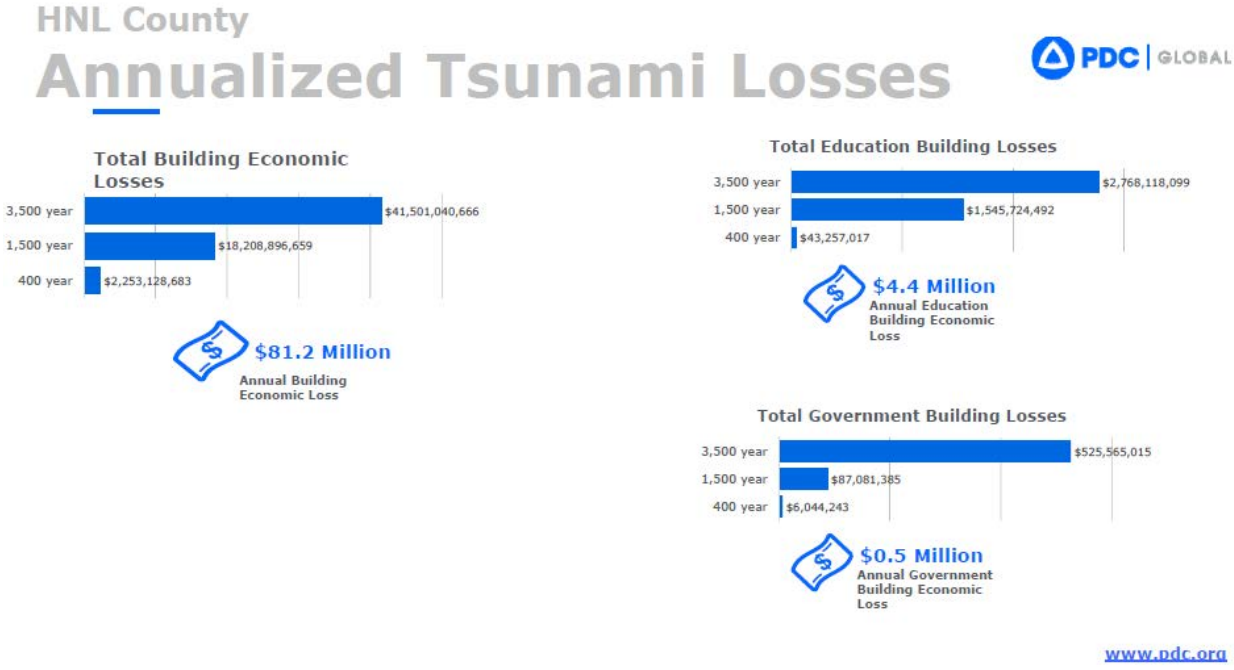


Figure 18-20. Tsunami Average Annualized Losses

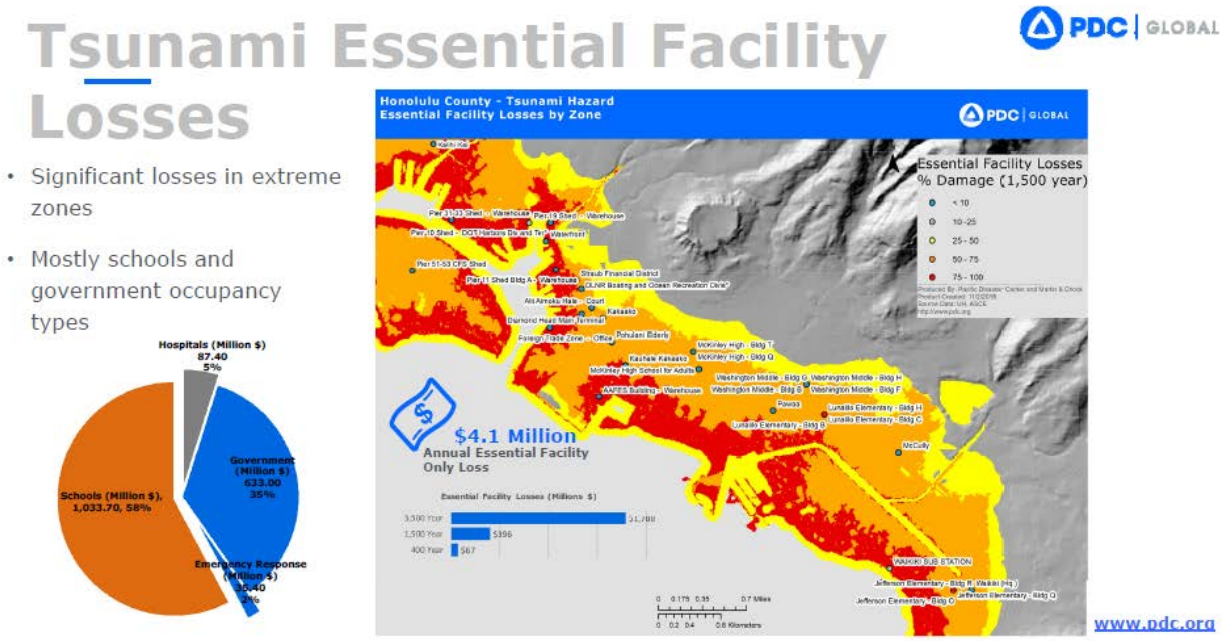


Figure 18-21. Tsunami Essential Facility Losses

*18.3.6 **Floods***

The risk assessment on the City and County of Honolulu examined the impacts of three different floods on essential facilities and general building stock in the county – a 100-year flood with the existing certified levee system in the county intact, a 100-year flood without consideration of these levees, and a 500-year (0.2% chance per year) flood (RMTC / URS JV, 2010). Depth grids, that were derived from DFIRMs, for all three scenarios were imported into HAZUS®MH flood model for analysis. The flood depths around the island of Oahu for the three different flood scenarios are shown in Figures 18-22 through 18-24. For the 500 year flood event the levees were assumed to remain intact but were overwhelmed as they are not typically designed to contain this level of flood event. The estimated flood losses could have been considered high for three reasons, which were addressed as follows:

1. By use of an island-wide flood map, it is inherently assumed that all riverine and coastal flooding experience the flood hazard of interest at the same time, which is highly unlikely to occur. All the streams, tributaries, and coastlines modeled in the county would not experience the flood hazard of interest simultaneously. In reality, only portions of the county will experience this level of flooding at a given time. Therefore, we separated the losses by coastline area and so that we need not take this assumption.
2. The without levees scenario assume that all levees fail simultaneously. However, the only area significantly affected by levee failure was Kailua area on the east side of the island where there was widespread flooding.
3. There is no accounting for emergency management measures to reduce the impacts of a flood, which is conservative. For coastal flooding, there is not much that can be done to reduce this affected area.

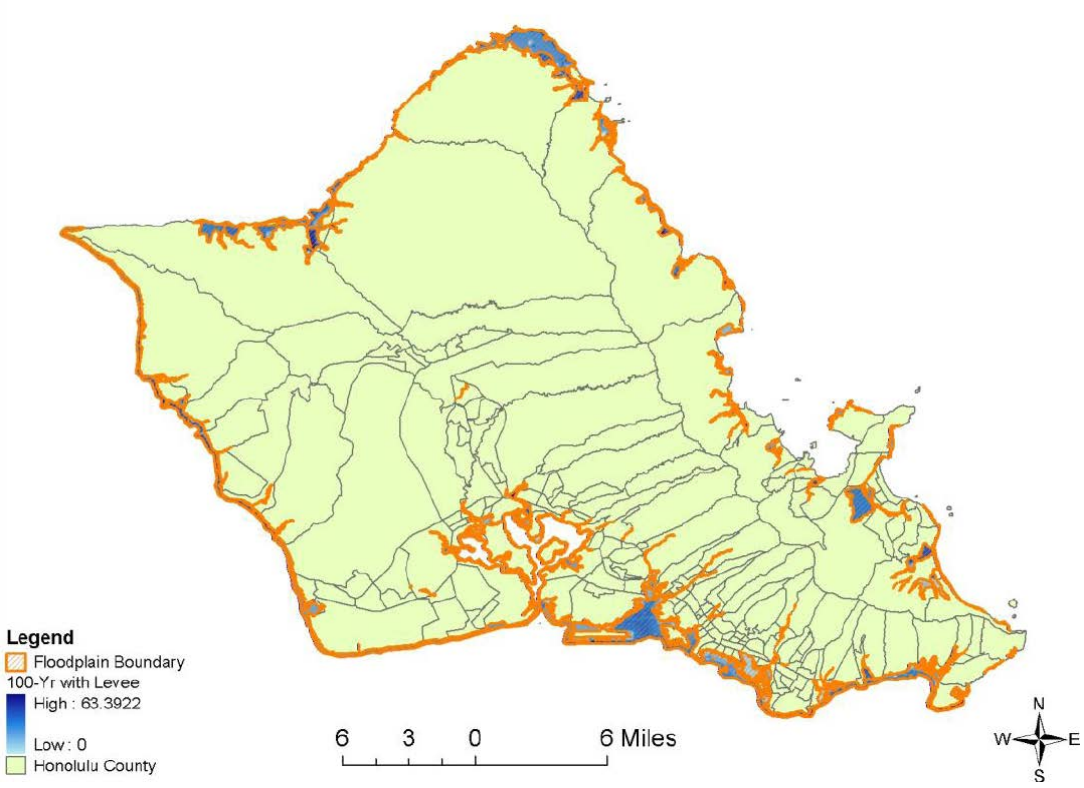


Figure 18-22. 100 year floodplain with levees

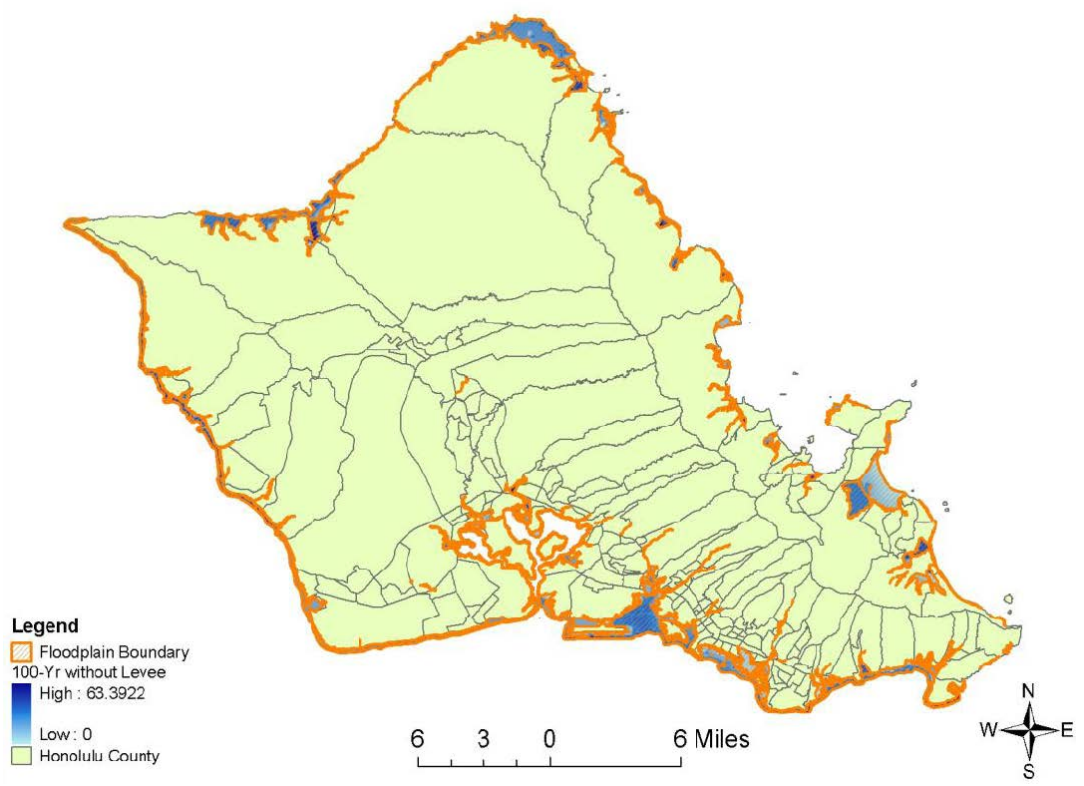


Figure 18-23. 100 year floodplain without levees (see Kailua area difference)

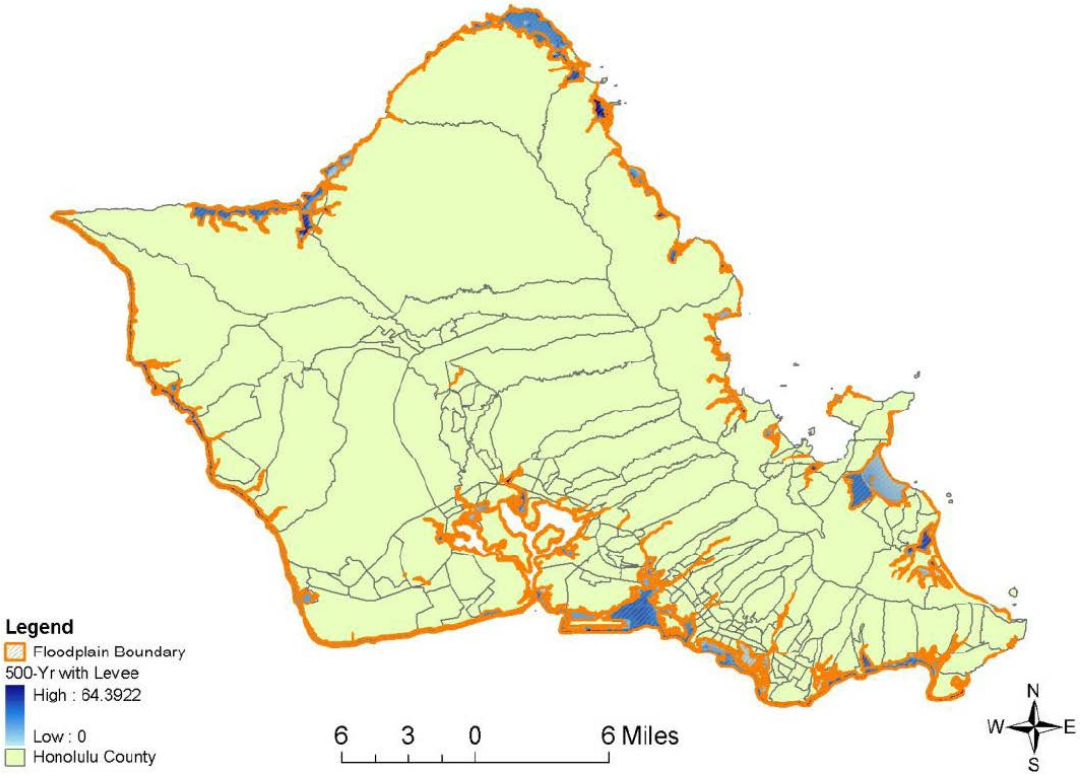


Figure 18-24. 500 year floodplain

Table 18-5. Disaggregated 100-year Losses to General Building Stock by Coastline

FEMA 100-year			Counts	Building Loss	Content Loss	Inventory Loss	Total Loss
North Oahu			3,832	$ 630,652,169	$497,030,292	$4,486,422	**$1,132,168,882**
East Oahu			1,126	$ 121,626,669	$88,578,519	$2,163,682	**$212,368,870**
South Oahu			5,174	$1,137,355,800	$1,386,595,447	$45,700,033	**$2,569,651,280**
West Oahu			339	$ 87,349,215	$58,550,841	$ 697,645	**$146,597,701**
							$4,060,786,732

Table 18-6. 100-year Losses to Essential Facilities (Primarily South Oahu)

Essential Facility Losses	Building Loss	Content Loss	Total Loss
Schools	**$14,195,959**	**$ 126,019,798**	**$140,215,758**
Hospitals	**$ 4,448,399**	**$ 7,893,001**	**$12,341,400**
Government	**$ 61,171,597**	**$191,302,500**	**$252,474,097**
Emergency Services	**$ 736,966**	**$ 3,370,888**	**$ 4,107,854**
			$409,139,109

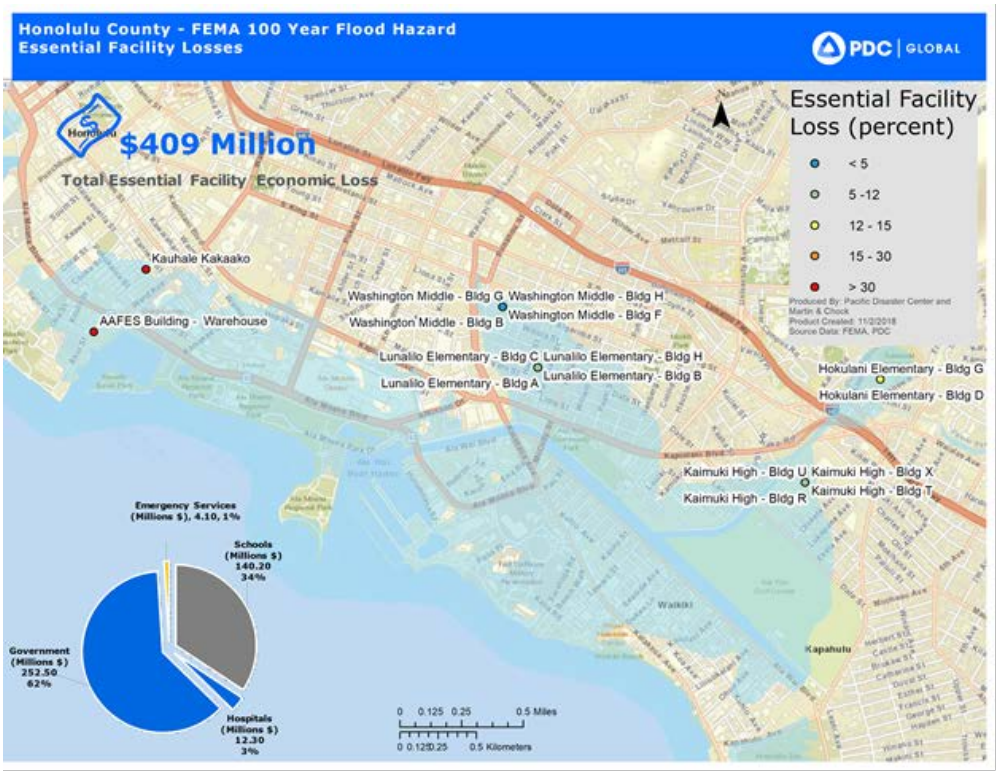


Figure 18-25 Flood Losses to Essential Facilities (example)

Based on the calculated losses, it is evident that the governing area is south Oahu. For average annualized loss, purposes, we utilize the combination of south and east Oahu as being a probable simultaneous occurrence. For the 100-year flood this equates to $212,368,870 and $2,569,651,280 for general buildings and an additional $409,139,109 for essential facilities, which sums to $3,191,159,259. The average annualized loss contribution based on an analysis of coastal and riverine flooding is thus estimated at $ 31.9 million. Flood Losses were $4.41 billion for the 500-year flood with levees scenario, yielding an average annualized loss contribution of $8.8 million. Accordingly, the net Average Annualized Loss for Flooding is $40.7 million per year. This is very significant but less than the estimated hurricane wind or tsunami flooding damage.

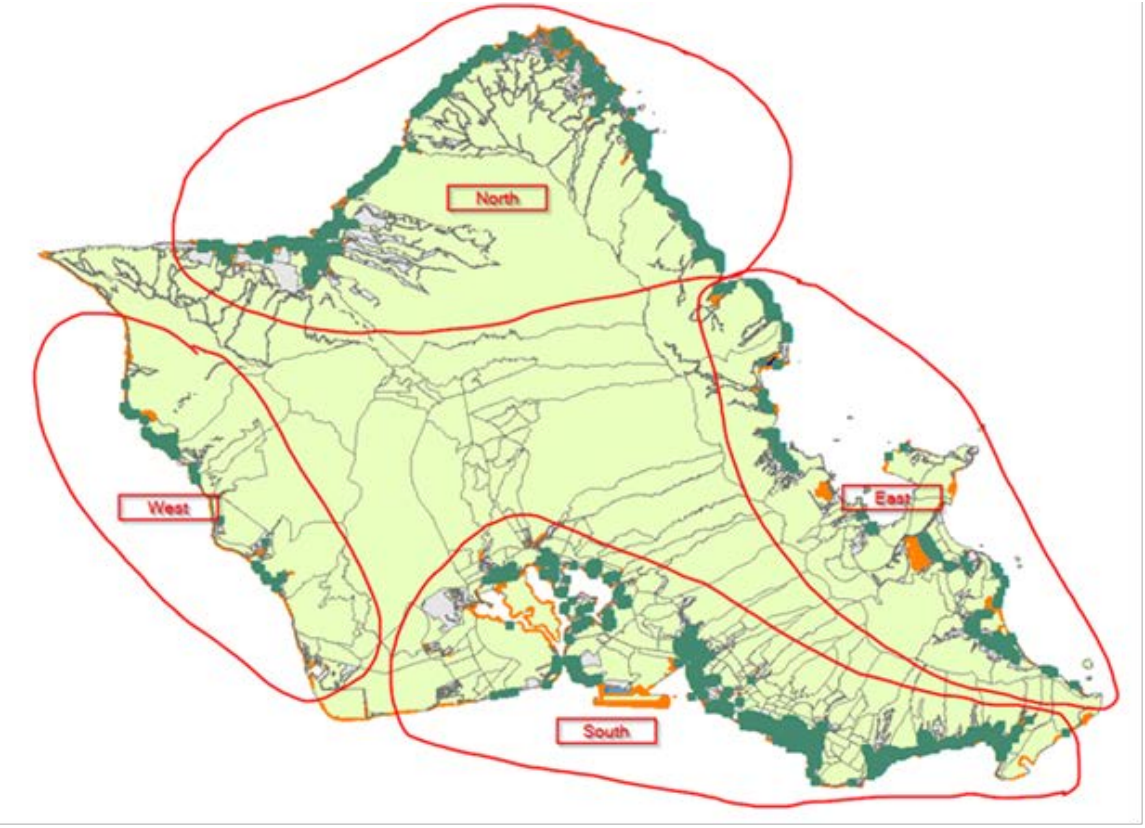


Figure 18-26. Subdivided Area Regions for Risk Analysis

18.3.7 Coastal Erosion

Recent studies (Coyne 1999) on Oahu have shown that nearly 24% or 17 miles of an original 72 miles of sandy shoreline (1940s) has been either significantly narrowed or lost. The cost of the beach loss at Waikiki has been estimated would be about $1 million per year, in order to maintain the beach in its current state. Extrapolating this islandwide, it is estimated that beach erosion costs $3 million per year.

18.3.8 Drought

Drought vulnerability is a complex issue with a number of contributing factors relating to the different sectors: water supply; agriculture and commerce, and; environment, public health and safety. The City and County of Honolulu has an extensive integrated public water system that provides water to nearly the entire island, thus decreasing vulnerability of the public water supply to drought impacts. However, if a severe drought persisted for over one or two years, the groundwater supply would be depleted to a large extent and the entire island would be affected despite the extensive groundwater integrated public water system. For moderate drought based on 12-month SPI, the most at risk areas for drought impacts include the area of central Oahu, including Mililani and Waipio. Quantified annual losses due to drought are not available, as there is a wide spectrum of drought conditions and it is difficult to provide a baseline for non-drought conditions.

18.3.9 Dams

Two factors influence the potential severity of a full or partial dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream. The consequences of dam failure could be severe in a localized area, however, the probability of occurrence is relatively rare. Based on the draft inundation maps, we estimate the relative hazard to be less than debris flows and rockfalls. A principal reason is that dam imposed levels are purposely lowered during high rainfall to lessen flood risk, such as was done for Nuuanu Reservoir during the April 2018 rainfall event.

18.3.10 Other Hazards

The annual losses due to VOG on Oahu have not been quantified. VOG from the Island of Hawaii source is vastly different by the time it reaches Oahu. SO_2 levels are not elevated on Oahu because the gas has occasionally reacted with water vapor to form ammonium sulfate, which then settles out of the atmosphere. Therefore, health and plant effects are not significant on Oahu even though the residual haze is visible (but without $SO_{2)}$. The other hazards have been rated in accordance with response costs (wildfire control, dam maintenance, high surf evacuation procedures, and HAZMAT cleanup training and exercises). These are considered to be significantly lower than the main hazards: hurricanes, tsunamis, earthquakes and floods.

18.3.11 Summary of Risk Assessment

AAL's for each of the significant natural hazards on Oahu are summarized in Table 18-5. Annualized loss estimates were used to establish a measure of relative economic importance of particular natural hazards and to determine and prioritize potentially effective mitigation actions insofar as benefits from reduced annual loss costs.

Table 18-7. Relative Hazard Severity to the City & County of Honolulu Based on Average Annual Loss Estimates

Hurricane Winds	**$410 Million / Year**
Tsunamis	**$81 Million / Year**
Floods	**$41 Million / Year**
Earthquakes	**$21 Million / Year**
Debris Flows and Rockfalls	**$1 to $5 Million / Year**
Coastal Erosion (sand replenishment)	**$3 Million / Year**
Wildfire	**$1 Million / Year**
Dam Failure	**less than $1 Million / Year**
High Surf	**less than $0.5 Million / Year**
HAZMAT	**less than $0.10 Million / Year**

18.4 Changes in Vulnerability since Adoption of the 2012 Mitigation Plan

This new chapter updates a summary of risk assessments for all hazards. Here, risk is defined as the potential losses associated with a hazard, defined in terms of expected annual loss, resulting from the probability of occurrence, magnitude and severity, asset exposure and vulnerability, and consequences. This is an objective method for evaluating the economic risk associated with each specific hazard.

The Site-Specific portion of the Building Inventory has been expanded to 80,000 properties based on footprints and parcel data; more accurate building floor areas and valuations increased the net total exposure.

Risk assessment AAL's are updated for Hurricane, Earthquake, Floods, Tsunamis, and the other significant hazards. The average annualized losses have increased due to an increased valuation of the building stock and greater detail in the loss analysis.

18.5 Critical Government Facilities on Oahu

From the study of critical facilities on Oahu, the most vulnerable critical facilities and University of Hawaii Manoa buildings were determined and are ranked in Table 18-8 for hurricanes and earthquakes, and Table 18-9 for floods, based on the enhanced building dataset. The facilities with the highest monetary losses as well as the buildings with the longest loss of functionality are listed.

A similar ranking of the buildings studied in the state critical facility study are ranked in Table 18-10 The Honolulu International Airport is the largest asset and subject to the highest dollar losses for both earthquakes and hurricanes, although the percentage dollar loss and loss of functionality is relatively low. Leahi Hospital, the Diamond Head Main Port Terminal and the Foreign Trade Zone Office are the only other facilities included in the top ten ranking for either hurricanes or earthquakes. In fact no Oahu facilities make the top ten most vulnerable statewide list in loss of functionality for either hurricanes or earthquakes. For the most vulnerable buildings it is recommended that more detailed structural analyses be performed in order to determine feasible retrofit strategies or make decisions on future uses.

Table 18-8. Most Vulnerable City and County of Honolulu Essential Facility and UH Manoa Building Rankings for Hurricanes and Earthquakes

Honolulu County Essential Facilities - Vulnerability List		Total Number of Modeled Buildings =				985	Category 2 - Ewa Hurricane Event Vulnerability			Lanai Earthquake Scenario Vulnerability		
		Description										
	Building Name	Facility Classification	Year Built	EQ Bldg Type	Design Level	Soil Type	Wind Building Type	Modeled Building $ Loss	$ Loss Rank*	Loss of Functionality (Num. of Days)	Modeled Building $ Loss	$ Loss Rank	Loss of Functionality (Num. of Days)
High Modeled Losses	Hurricane												
	Stevenson Middle - Bldg A	School	1951	W1	PC	D	**WSF2**	**$ 5,106,629**	**17**	**417**	$ 5,469	83	0
	Queens Medical Center	CareFlty	UNK	**C2H**	**PC**	**B**	**CERBH**	**$ 4,291,043**	**22**	263	**$ 241,760**	**1**	**7**
	Tripler Army Medical Center	CareFlty	1945	**C2H**	**PC**	**C**	**CERBH**	**$ 3,956,547**	**25**	247	**$ 66,863**	**8**	**5**
	St. Francis Medical Center	CareFlty	UNK	**C2H**	**PC**	**C**	**CERBH**	**$ 3,036,991**	**29**	208	**$ 66,863**	**8**	**5**
	Maluhia Elderly Care	CareFlty	1931	W2	PC	D	**WSF1**	**$ 2,310,999**	**36**	**478**	$ 2,115	250	0
	Lanakila Health Center	CareFlty	UNK	W2	PC	D	**WSF1**	**$ 2,310,999**	**36**	**478**	$ 2,115	250	0
	Leahi Hospital	CareFlty	UNK	**C2M**	**PC**	**B**	**CERBM**	**$ 2,204,617**	**39**	171	**$ 81,239**	**4**	**5**
	Solomon Elementary - Bldg B	School	1969	W1	PC	B	**WSF2**	**$ 2,074,460**	**42**	**528**	$ 69	847	0
	Hawaii State Hospital	CareFlty	UNK	W2	PC	D	**WSF1**	**$ 1,952,158**	**45**	148	$ 2,181	243	0
	Straub Kapolei Family Health	CareFlty	1999	W2	LS	C	**WSF2**	**$ 1,787,198**	**47**	346	$ 25	904	0
	Kaiser Kapolei Clinic	CareFlty	1999	W2	LS	B	**WSF2**	**$ 1,735,066**	**48**	332	$ 25	904	0
	Roosevelt High - Bldg A	School	1932	W1	PC	D	**WMUH3**	**$ 1,704,488**	**51**	235	$ 8,435	58	0
	Castle Medical Center	CareFlty	2002	C2L	LS	B	**CERBL**	**$ 1,611,063**	**52**	37	$ 1,252	367	0
	Campbell High - Bldg D	School	1975	RM1L	PC	C	**MERBL**	**$ 1,585,102**	**53**	57	$ 3,040	146	0
	Puuhale Elementary - Bldg A	School	1972	W1	PC	C	**WSF2**	**$ 1,583,254**	**54**	233	$ 3,558	116	0
	Earthquake												
	Straub Clinic & Hospital	CareFlty	1962	**C2H**	**PC**	**D**	CERBM	$ 652,487	228	53	**$ 60,733**	**10**	**7**
	Kapiolani Medical Center	CareFlty	1976	**C2H**	**PC**	**D**	WSF2	$ 670,830	217	164	**$ 60,733**	**10**	**7**
	Kaiser High - Bldg H	School	1973	**RM1L**	**PC**	**C**	MERBL	$ 651,101	232	13	**$ 34,754**	**17**	0
	Kuakini Medical Center	CareFlty	1968	**C2M**	**PC**	**D**	CERBH	$ 463,145	411	26	**$ 20,408**	**23**	**5**
	Kaiser Honolulu Clinic	CareFlty	UNK	**C2M**	**PC**	**D**	CERBM	$ 514,095	340	164	**$ 20,408**	**23**	**5**
	Kaiser High - Bldg L	School	1974	**RM1L**	**PC**	**C**	MERBL	$ 199,228	726	13	**$ 10,634**	**48**	0
	Kaiser High - Bldg A	School	1971	**RM1L**	**PC**	**C**	MERBL	$ 189,762	740	13	**$ 10,129**	**50**	0
	Wahiawa General Hospital	CareFlty	UNK	**RM1L**	**PC**	**C**	MERBL	$ 1,345,392	68	126	**$ 9,152**	**54**	0
	Kamiloiki Elementary - Bldg C	School	1971	**RM1L**	**PC**	**C**	MERBL	$ 318,603	555	28	**$ 8,731**	**55**	0
	Kamiloiki Elementary - Bldg A	School	1973	**RM1L**	**PC**	**C**	MERBL	$ 308,972	568	28	**$ 8,467**	**57**	0
High Loss of Functionality	Hurricane												
	Red Hill Elementary - Bldg A	School	1974	W1	PC	C	**WSF2**	$ 1,031,354	95	**499**	$ 269	744	0
	Solomon Elementary - Bldg P21	School	1994	W1	HC	B	**WSF1**	$ 87,581	884	**495**	$ 0	972	0
	Solomon Elementary - Bldg P22	School	1994	W1	HC	B	**WSF1**	$ 87,581	884	**495**	$ 0	972	0
	Solomon Elementary - Bldg P23	School	1994	W1	HC	B	**WSF1**	$ 87,581	884	**495**	$ 0	972	0
	Kawananakoa Middle - Bldg H	School	1939	W1	PC	D	**WSF2**	$ 1,272,343	72	**417**	$ 1,363	348	0
	Kawananakoa Middle - Bldg F	School	1960	W1	PC	D	**WSF2**	$ 611,415	260	**417**	$ 655	565	0
	Kawananakoa Middle - Bldg G	School	1960	W1	PC	D	**WSF2**	$ 582,491	278	**417**	$ 624	572	0
	Shafter Elementary - Bldg B	School	1966	W1	PC	C	**WSF2**	$ 1,057,209	91	**412**	$ 347	699	0
	Manoa Elementary - Bldg E	School	1952	W1	PC	D	**WSF1**	$ 565,843	298	**405**	$ 732	523	0
	Makakilo Elementary - Bldg K	School	1969	W1	PC	B	**WSF1**	$ 488,804	381	**395**	$ 194	781	0
	Kawananakoa Middle - Bldg D	School	1962	W1	PC	D	**WSF1**	$ 657,523	225	**394**	$ 891	458	0
	Stevenson Middle - Bldg C	School	1954	W1	PC	D	**WSF1**	$ 311,560	564	**394**	$ 422	652	0
	Pauoa Elementary - Bldg E	School	1969	W1	PC	C	**WSF1**	$ 600,274	266	**390**	$ 822	494	0
	Shafter Elementary - Bldg C	School	1968	W1	PC	C	**WSF1**	$ 354,980	517	**384**	$ 150	802	0
	Kaiulani Elementary - Bldg F	School	1970	W1	PC	C	**WSF2**	$ 526,769	328	**355**	$ 695	544	0
	Earthquake												
	Straub Hawaii Kai Family Health	CareFlty	UNK	**W2**	**PC**	**D**	WSF1	$ 155,651	803	53	$ 7,619	64	**4**
	Kaiser High - Bldg B	School	1971	**W1**	**PC**	**C**	WSF1	$ 49,047	925	53	$ 1,705	302	**4**
	Kamiloiki Elementary - Bldg E	School	1975	**W1**	**PC**	**C**	WSF1	$ 92,889	875	95	$ 1,581	317	**4**
	Koko Head Elementary - Bldg P3	School	1967	**W1**	**PC**	**C**	WSF1	$ 25,394	961	145	$ 255	753	**4**
	Koko Head Elementary - Bldg P4	School	1967	**W1**	**PC**	**C**	WSF1	$ 21,048	967	145	$ 212	772	**4**
	Koko Head Elementary - Bldg P5	School	1967	**W1**	**PC**	**C**	WSF1	$ 21,048	967	145	$ 212	772	**4**
	Koko Head Elementary - Bldg P6	School	1967	**W1**	**PC**	**C**	WSF1	$ 21,048	967	145	$ 212	772	**4**
High Modeled Losses - UH Manoa	Hurricane												
	Hamilton Library	School - UH Manoa	1968	**C2M**	**PC**	**D**	**CERBM**	$ 21,712,092	**1**	47	$ 168,574	**2**	1
	Pacific Ocean Science & Technology (POST)	School - UH Manoa	1995	**C2H**	**HC**	**D**	**CERBH**	$ 16,791,750	**2**	42	$ 23,850	**19**	0
	Biomedical Sciences Building	School - UH Manoa	1972	**C2H**	**LC**	**D**	**CERBH**	$ 13,776,101	**3**	42	$ 82,328	**3**	0
	St. John Laboratory Complex	School - UH Manoa	1969	**C2M**	**PC**	**D**	**CERBM**	$ 9,445,972	**4**	47	$ 73,339	**6**	1
	Stan Sheriff Center	School - UH Manoa	1994	C1L	HC	B	CERBL	$ 9,442,541	**5**	62	$ 5,472	82	0
	Agricultural Science Facility	School - UH Manoa	1995	**C2M**	**HC**	**D**	**CERBM**	$ 8,318,877	**6**	47	$ 15,067	**43**	0
	Marine Sciences Building	School - UH Manoa	1984	**C2M**	**HC**	**D**	**CERBM**	$ 8,246,716	**7**	47	$ 14,936	**44**	0
	Art Building	School - UH Manoa	1974	**C2L**	**LC**	**D**	**CERBL**	$ 7,825,481	**8**	62	$ 15,589	**40**	0
	Holmes Hall	School - UH Manoa	1972	C2M	LC	D	**CERBM**	$ 6,648,884	**9**	47	$ 9,563	51	0
	Saunders Hall	School - UH Manoa	1973	C2M	LC	B	**CERBM**	$ 6,566,527	**10**	47	$ 9,445	52	0
	Earthquake												
	Snyder Hall	School - UH Manoa	1962	**C1M**	**PC**	**D**	**CERBM**	$ 4,507,629	**21**	47	$ 73,903	**5**	**5**
	Sinclair Library	School - UH Manoa	1956	**C1L**	**PC**	**D**	**CERBL**	$ 6,146,937	**12**	62	$ 70,724	**7**	**4**
	Gartley Hall	School - UH Manoa	1921	**URMM**	**PC**	**D**	MMUH3	$ 752,593	181	161	$ 48,484	**12**	**7**
	Hawaii Institute of Geophysics (Geophysics Institute Building)	School - UH Manoa	1963	**C2M**	**PC**	**D**	**CERBM**	$ 5,708,672	**14**	47	$ 44,322	**13**	1
	Moore Hall	School - UH Manoa	1969	**C2M**	**PC**	**D**	**CERBM**	$ 4,998,264	**18**	47	$ 38,807	**14**	1
	Kuykendall Hall	School - UH Manoa	1964	**C2M**	**PC**	**D**	**CERBM**	$ 4,934,513	**20**	47	$ 38,312	**15**	1
	Dean Hall	School - UH Manoa	1929	**URMM**	**PC**	**D**	MMUH3	$ 576,681	282	161	$ 37,152	**16**	**7**
	Keller Hall	School - UH Manoa	1959	**C2L**	**PC**	**D**	**CERBL**	$ 4,070,480	**23**	62	$ 23,883	**18**	0
	Auxiliary Services	School - UH Manoa	1962	**C1L**	**PC**	**D**	**CERBL**	$ 2,015,734	**43**	62	$ 23,192	**20**	**4**
	Bilger Hall	School - UH Manoa	1952	**C2L**	**PC**	**D**	**CERBL**	$ 3,722,647	**28**	62	$ 21,843	**21**	0
High Loss of Functionality - UH Manoa	Hurricane												
	HECO Substation	School - UH Manoa	1998	RM2L	HC	B	**MSF2**	$ 498,840	357	**243**	$ 121	814	0
	Miller Hall	School - UH Manoa	1939	RM1L	PC	D	**MMUH3**	$ 592,198	269	**161**	$ 4,672	90	0
	Maintenance Warehouse	School - UH Manoa	1963	S1L	PC	D	**SPMBS**	$ 1,120,167	83	**156**	$ 833	492	0
	Hawaii Hall	School - UH Manoa	1912	S2L	PC	D	**SERBL**	**$ 1,828,815**	**46**	**89**	$ 8,626	56	0
	Kennedy Theatre	School - UH Manoa	1963	**RM2L**	**PC**	**D**	**MERBL**	**$ 2,137,175**	**40**	**88**	**$ 18,583**	**36**	0
	Bachman Hall	School - UH Manoa	1949	**RM2L**	**PC**	**D**	**MERBL**	$ 1,389,751	67	**88**	**$ 11,067**	**47**	0
	University Health Services	School - UH Manoa	1963	RM1L	PC	D	**MERBL**	$ 489,587	377	**88**	$ 2,616	177	0
	Physical Plant Building	School - UH Manoa	1963	RM1L	PC	D	**MMUH1**	$ 77,109	900	**71**	$ 608	577	0
	Earthquake												
	Auxiliary Services	School - UH Manoa	1962	**C1L**	**PC**	**D**	**CERBL**	**$ 2,015,734**	**43**	62	**$ 23,192**	**20**	**4**
	University High School #3	School - UH Manoa	1957	**C1L**	**PC**	**D**	CERBL	$ 963,962	106	36	**$ 15,576**	**41**	**4**
	Webster Hall	School - UH Manoa	1961	**C2M**	**PC**	**D**	**CERBM**	**$ 2,683,357**	**33**	47	**$ 20,834**	**22**	**1**
	Edmundson Hall	School - UH Manoa	1963	**C2M**	**PC**	**D**	**CERBM**	**$ 1,958,938**	**44**	47	**$ 15,209**	**42**	**1**
	Spalding Hall	School - UH Manoa	1961	**C2M**	**PC**	**D**	CERBM	$ 1,487,315	58	47	**$ 11,548**	**46**	**1**

* Note that numerous UH facilities have higher modeled losses than the public facilities (in large part due to more accurate building valuation data), the $ loss rank value is the rank of the losses of an individual building compared to the losses of all other public facilities and the core UH facilities

Table 18-9. Most Vulnerable City and County of Honolulu Essential Facilities and UH Manoa Building Rankings for Floods

HAZUS Updated Honolulu County Essential Facilities - Vulnerability List		Total Number of Modeled Buildings = 291 Description						100-Year with Levees Flood Scenario Vulnerability		100-Year without Levees Flood Scenario Vulnerability		500-Year with Levees Flood Scenario Vulnerability	
	Building	Facility Classification	Year Built	Design Level	Foundation Type	First Floor Height	Building Type	Modeled Building $ Loss	$ Loss Rank	Modeled Building $ Loss	$ Loss Rank	Modeled Building $ Loss	$ Loss Rank
High Modeled Losses	Kaiser Kahuku Clinic	CareFlty	1800	0	4	0	1	$ 2,000,480	1	$ 2,000,480	1	$ 2,097,766	1
	Kahuku High & Intermediate - Bldg W	School	1979	0	7	0	4	$ 1,131,042	2	$ 1,131,042	2	$ 1,378,544	2
	Straub Hawaii Kai Family Health	CareFlty	1800	0	4	0	1	$ 1,046,507	3	$ 1,046,507	3	$ 1,254,007	3
	Kalani High - Bldg C	School	1960	0	7	0	4					$ 1,098,859	4
	Kahuku High & Intermediate - Bldg V	School	1978	0	7	0	4	$ 892,506	4	$ 892,506	4	$ 1,087,810	5
	Kaiser Kailua Clinic	CareFlty	1989	0	4	0	1			$ 434,351	12	$ 1,063,087	6
	Kaiser Kailua Clinic	CareFlty	1989	0	4	0	1			$ 434,351	12	$ 1,063,087	6
	Kaiser Kailua Clinic	CareFlty	1989	0	4	0	1			$ 434,351	12	$ 1,063,087	6
	Kaiser Kailua Clinic	CareFlty	1989	0	4	0	1			$ 434,351	12	$ 1,063,087	6
	Straub Kailua Family Health Center	CareFlty	1960	0	4	0	4			$ 414,565	13	$ 1,058,141	7
	Building	Facility Classification	Year Built	Design Level	Foundation Type	First Floor Height	Building Type	Restoration Time	Restoration Rank	Restoration Time	Restoration Rank	Restoration Time	Restoration Rank
High Loss of Functionality	Kaiser Kahuku Clinic	CareFlty	1800	0	4	0	1	900	1	900	1	900	1
	Kahuku High & Intermediate - Bldg W	School	1979	0	7	0	4	720	2	720	2	720	2
	Straub Hawaii Kai Family Health	CareFlty	1800	0	4	0	1	720	2	720	2	720	2
	Kalani High - Bldg C	School	1960	0	7	0	4					720	2
	Kahuku High & Intermediate - Bldg V	School	1978	0	7	0	4	720	2	720	2	720	2
	Kaiser Kailua Clinic	CareFlty	1989	0	4	0	1			540	4	720	2
	Kaiser Kailua Clinic	CareFlty	1989	0	4	0	1			540	4	720	2
	Kaiser Kailua Clinic	CareFlty	1989	0	4	0	1			540	4	720	2
	Kaiser Kailua Clinic	CareFlty	1989	0	4	0	1			540	4	720	2
	Straub Kailua Family Health Center	CareFlty	1960	0	4	0	4			540	4	720	2

Table 18-10. Most Vulnerable State Essential Facility Rankings for Hurricanes and Earthquakes

		Building Name	Description					Hurricane Probabilistic Senario (1000 year return period)				EQ Probabilistic Scenario (750 year return period)			
			Facility Classification	EQ Building Type	Design Level	Soil type	Wind Building Type	Estimated % Loss	Estimated $ Loss	% Loss Rank	$ Loss Rank	Estimated % Loss	Estimated $ Loss	% Loss Rank	$ Loss Rank
High Modeled Losses	Hurricane	Honolulu International Airport	GOV1	C2M	MC	D	CECBM	16.1%	$319,980,322	214	1	9.3%	$183,917,250	215	1
		Hawaii State Hospital	COM6	W2	HC	D	MLRM1	28.4%	$46,729,356	68	2	4.9%	$8,071,422	236	16
		Kauhale Kakaako	RES3F	C2H	LC	D	CERBH	17.6%	$19,689,620	211	3	18.9%	$21,095,150	180	6
		Kula Hospital - Main Building	COM6	C1M	PC	C	CECBM	21.4%	$16,165,578	157	4	36.4%	$27,511,598	63	5
		Foreign Trade Zone - Office	COM4	S2L	PC	D	SECBM	23.9%	$16,135,416	101	5	29.5%	$19,945,574	86	7
		Leahi Hospital - Young Bldg - District Court	COM6	C2M	PC	B	CECBH	29.5%	$15,677,550	63	6	4.2%	$2,237,069	241	58
		Leahi Hospital Young Building - New Wards A&C	COM6	C2M	PC	B	CECBH	29.5%	$12,893,791	63	7	4.2%	$1,839,848	240	67
		Kauikeaouli Hale - State Court	GOV1	C2H	LC	D	CECBH	19.2%	$11,881,365	203	8	19.1%	$11,839,387	166	11
		Kahului Airport	GOV1	C2L	HC	C	CECBL	9.7%	$11,589,070	232	9	7.3%	$8,644,388	232	14
		Hilo Medical Center - Acute Care Facility	COM6	C2M	MC	D	CECBM	11.5%	$11,248,341	229	10	49.8%	$48,646,770	44	4
	Earthquake	Honolulu International Airport	GOV1	C2M	MC	D	CECBM	16.1%	$319,980,322	214	1	9.3%	$183,917,250	215	1
		Keahole/Kohala Airport - Passenger Terminal	GOV1	W2	PC	D	WMUH1	1.0%	$1,228,436	274	93	73.5%	$87,477,445	18	2
		Hilo Airport - Passenger Terminal	GOV1	RM1L	LC	C	MECBL	2.0%	$2,432,941	268	52	69.9%	$83,163,578	19	3
		Hilo Medical Center - Acute Care Facility	COM6	C2M	MC	D	CECBM	11.5%	$11,248,341	229	10	49.8%	$48,646,770	44	4
		Kula Hospital - Main Building	COM6	C1M	PC	C	CECBM	21.4%	$16,165,578	157	4	36.4%	$27,511,598	63	5
		Kauhale Kakaako	RES3F	C2H	LC	D	CERBH	17.6%	$19,689,620	211	3	18.9%	$21,095,150	180	6
		Foreign Trade Zone - Office	COM4	S2L	PC	D	SECBM	23.9%	$16,135,416	101	5	29.5%	$19,945,574	86	7
		Kona Community Hospital - Building 1 and 2	COM6	C1L	MC	B	CECBL	24.4%	$7,642,005	84	16	56.2%	$17,628,084	32	8
		State Office Building - Hilo	GOV1	C2L	LC	D	CECBL	5.5%	$1,193,707	254	97	78.5%	$17,050,131	15	9
		Diamond Head Main Terminal	COM2	S2L	PC	D	SECBL	23.7%	$10,478,318	103	13	29.5%	$13,064,352	85	10
High Loss of Functionality	Hurricane	Hoolehua Fire Station - Living Quarters	GOV2	W1	HC	B	WSF1	68.8%	$185,753	1	239	3.4%	$9,059	253	270
		Kona Community Hospital - Infusion Center	COM6	W1	MC	B	WSF1	62.7%	$501,779	2	175	33.7%	$269,512	74	210
		Lanai High School and Elementary School Gymnasium	EDU1	C1L	PC	D	MECBL	49.0%	$3,366,158	3	37	50.0%	$3,437,294	41	44
		Kaunakakai State Office Building	GOV1	RM1L	HC	B	MECBL	48.3%	$2,499,824	4	51	3.9%	$202,477	244	227
		Molokai District Court	GOV1	RM1L	HC	B	MECBL	48.3%	$1,616,352	4	75	3.9%	$130,919	245	237
		Kaunakakai Police Station	GOV2	RM1L	PC	C	MECBL	48.1%	$1,229,385	6	92	29.2%	$746,844	91	144
		Molokai General Hospital - Phase 2	COM6	RM2L	MC	C	MECBL	48.0%	$4,227,281	7	28	10.1%	$891,792	214	127
		Molokai General Hospital - Phase 1	COM6	RM1L	MC	C	MECBL	48.0%	$2,778,668	7	46	8.8%	$509,779	217	170
		Lanai Airport - Terminal	GOV1	W2	LC	D	MECBL	46.8%	$935,039	9	113	19.5%	$389,480	152	182
		Lanai Fire Station and Ambulence	GOV2	RM1L	PC	D	MECBL	46.6%	$607,072	10	159	43.5%	$567,388	53	165
	Earthquake	Kau Hospital and Rural Health Clinic	COM6	C2L	PC	D	CECBL	27.6%	$2,381,543	72	53	99.6%	$8,603,021	1	15
		Hilo Public Library	GOV1	C1L	PC	E	CECBL	6.9%	$513,201	252	173	97.2%	$7,254,572	2	23
		Hilo Harbor Pier 1 - Warehouse facility	COM2	S2L	PC	E	SECBL	2.1%	$163,633	266	244	96.1%	$7,328,769	3	21
		Hilo Harbor Pier 2 - Interisland warehouse facility	COM2	S2L	PC	E	SECBL	2.1%	$163,633	266	244	96.1%	$7,328,769	3	21
		Hilo Medical Center - Maintenance Bldg	COM3	RM2L	PC	D	MECBL	12.1%	$212,390	224	231	88.9%	$1,555,978	5	71
		Konawaena High School - Building G	EDU1	C3L	PC	B	CECBL	26.4%	$493,319	75	177	87.4%	$1,635,072	6	69
		Konawaena High School - Building F	EDU1	C3L	PC	B	CECBL	26.4%	$449,791	75	183	87.4%	$1,490,801	7	80
		Konawaena High School - Building A	EDU1	S5L	PC	B	SECBL	26.6%	$465,227	73	180	86.9%	$1,519,246	8	77
		Hilo Medical Center - Extended Care Facility	COM6	RM1L	PC	D	MECBL	12.1%	$1,077,813	226	106	86.6%	$7,723,634	9	19
		Keawe Health Center	COM7	C2L	PC	D	CECBL	6.8%	$52,831	253	266	86.4%	$668,930	10	154

18.6 Cost-Benefit Analysis

The purpose of the cost-benefit analysis is to evaluate the tradeoffs about reaching goals concerned with protection of the built and natural environments. The Whitehouse Office of Management and Budget Circular No. A-94 (Sections 6 and 6a) indicates that: "*Analyses should include comprehensive estimates of the expected benefits and costs to society based on established definitions and practices for program and policy evaluation. Social net benefits, and not the benefits and costs to the Federal Government, should be the basis for evaluating government programs or policies that have effects on private citizens or other levels of government.*" Social benefits and costs can differ from private benefits and costs as measured in the marketplace because of imperfections arising from external diseconomies, monopoly power and taxes or subsidies. Both intangible and tangible benefits and costs should be recognized.

18.6.1 Costs of Mitigation Efforts in the Community

The costs for mitigation will include FEMA, other federal agency, state, local, and private dollars spent on the mitigation activities. This "dollars-spent" assessment should include administrative and maintenance costs and indirect costs. Costs also should include relevant opportunity costs, i.e. the value of alternatives foregone to achieve the mitigation activity. The costs of mitigation include:

- Direct expenditures on relocation, construction and transportation
- Costs generated by rules and regulations setup in the name of hazard mitigation (e.g, possibly lower property values due to new zoning restrictions)
- Denial of access to economic resources due to zoning
- Increased business costs from mitigation-related safety regulations

18.6.2 Benefits of Mitigation Efforts in the Community

The benefits of mitigation activities are estimated. Expected benefits are the losses avoided because of a mitigation activity for hazard events of different intensities, multiplied by the probability of each of these events occurring. Most benefits of mitigation are costs and losses avoided through the reduction in loss probabilities and a reduction in loss amounts/value. The reduced costs and losses include:

- Loss of life and injury.
- Property destruction and damage.
- Impacts on environmental, social, and recreational values.
- Community and local infrastructure disruption.
- Business interruption, including closures, shutdowns and loss of employment.
- Loss of culturally and historically important items.
- Expenditure on disaster relief by both governments and private organizations.

Intangible benefits may include increased awareness by communities of hazards, their impacts and avoidance, leading to better decisions and future actions.

Summary of Potentially Critical Facilities

List of Emergency Response Centers

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000001	EmergencyCtr	15003000600	CIVIL DEFENSE	4204 DIAMOND HEAD RD	HONOLULU	96815	HI	CECBL	C2L	UNK	PC	1	$ 1,813,000	5,000	21.30406	-157.85475
HI000002	EmergencyCtr	15003011103	KAILUA EOC	42-377 KALANIANAOLE HWY	KAILUA	96734	HI	WSF1	W1	UNK	PC	1	$ 60,800	5,000	21.26492	-157.80263
HI000003	EmergencyCtr	15003010100	KAHUKU EOC	56-460 KAMEHAMEHA HWY	KAHUKU	96731	HI	WSF1	W1	UNK	PC	1	$ 1,203,500	5,000	21.37243	-157.74470
HI000004	EmergencyCtr	15003009901	WAIALUA EOC	67-170 FARRINGTON HWY	WAIALUA	96791	HI	WSF1	W1	UNK	PC	1	$ 465,200	5,000	21.67485	-157.94626
HI000005	EmergencyCtr	15003009604	WAIANAE EOC	87-1100 FARRINGTON HWY	WAIANAE	96792	HI	WSF1	W1	UNK	PC	1	$ 165,000	5,000	21.56666	-158.12761
HI000006	EmergencyCtr	15003008003	PEARL CITY EOC	1100 WAIMANO HOME ROAD	PEARL CITY	96782	HI	WMUH2	W1	UNK	PC	2	$ 1,844,200	33,700	21.39602	-157.96990
HI000007	EmergencyCtr	15003003900	HONOLULU EOC	1130 ALAPAI ST	HONOLULU	96813	HI	CECBL	C2L	UNK	PC	1	$ 1,180,000	5,000	21.30406	-157.85475

List of Care Facilities

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000001	CareFlty	15003006701	Tripler Army Medical Center	1250 ALA AOLANI	HONOLULU	96819	HI	CERBH	C2H	1945	PC	1	$ 16,520,000		21.35954	-157.88417
HI000002	CareFlty	15003006701	Kaiser Moanalua Medical Center	3288 MOANALUA RD	HONOLULU	96819	HI	CERBL	C2L	UNK	PC	1	$ 4,150,000		21.36341	-157.89951
HI000003	CareFlty	15003004800	Maluhia Elderly Care	1027 HALA DR	HONOLULU	96817	HI	WSF1	W2	1931	PC	1	$ 4,150,000		21.32917	-157.86134
HI000004	CareFlty	15003004800	Lanakila Health Center	1700 LANAKILA AVE	HONOLULU	96817	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.32790	-157.86134
HI000005	CareFlty	15003005000	Rehabilitation Hospital of the Pacific	234 N KUAKINI ST	HONOLULU	96817	HI	WSF1	W2	UNK	PC	1	$ 8,260,000		21.32169	-157.85383
HI000006	CareFlty	15003005000	Kuakini Medical Center	347 N KUAKINI ST	HONOLULU	96817	HI	CERBH	C2M	1968	PC	6	$ 4,150,000		21.32171	-157.85825
HI000007	CareFlty	15003005000	Kuakini Medical Center	347 N KUAKINI ST	HONOLULU	96817	HI	CERBH	C2H	1978	LC	9	$ 4,150,000		21.32171	-157.85825
HI000008	CareFlty	15003005000	Kuakini Medical Center	347 N KUAKINI ST	HONOLULU	96817	HI	CERBH	C2H	1979	LC	10	$ 4,150,000		21.32171	-157.85825
HI000009	CareFlty	15003005000	Kuakini Medical Center	347 N KUAKINI ST	HONOLULU	96817	HI	CERBL	C2M	1938	PC	2	$ 4,150,000		21.32171	-157.85825
HI000010	CareFlty	15003005000	Kuakini Medical Center	347 N KUAKINI ST	HONOLULU	96817	HI	CERBL	C2M	1955	PC	1	$ 4,150,000		21.32171	-157.85825
HI000011	CareFlty	15003005000	Kuakini Medical Center	347 N KUAKINI ST	HONOLULU	96817	HI	CERBL	C2M	1932	PC	1	$ 4,150,000		21.32171	-157.85825
HI000012	CareFlty	15003005000	Kuakini Medical Center	347 N KUAKINI ST	HONOLULU	96817	HI	CERBL	C2M	1937	PC	1	$ 4,150,000		21.32171	-157.85825
HI000013	CareFlty	15003005000	Kuakini Medical Center	347 N KUAKINI ST	HONOLULU	96817	HI	CERBL	C2M	1932	PC	1	$ 4,150,000		21.32171	-157.85825
HI000014	CareFlty	15003004700	St. Francis Medical Center	2230 LILIHA ST	HONOLULU	96817	HI	CERBH	C2H	UNK	PC	1	$ 16,520,000		21.32954	-157.85266
HI000015	CareFlty	15003004000	Straub Financial District	222 QUEEN ST	HONOLULU	96813	HI	MERBL	RM1L	1950	PC	1	$ 4,150,000		21.30682	-157.86179
HI000016	CareFlty	15003004100	Queens Medical Center	1236 LAUHALA ST	HONOLULU	96813	HI	CERBH	C2H	UNK	PC	1	$ 16,520,000		21.30782	-157.85394
HI000017	CareFlty	15003004100	Straub Clinic & Hospital	888 S KING ST	HONOLULU	96813	HI	CERBM	C2M	1933	PC	4	$ 4,150,000		21.30267	-157.85060
HI000018	CareFlty	15003004100	Straub Clinic & Hospital	888 S KING ST	HONOLULU	96813	HI	CERBM	C2M	1971	PC	4	$ 4,150,000		21.30267	-157.85060
HI000019	CareFlty	15003004100	Straub Clinic & Hospital	888 S KING ST	HONOLULU	96813	HI	CERBH	C2M	1970	PC	7	$ 4,150,000		21.30267	-157.85060
HI000020	CareFlty	15003004100	Straub Clinic & Hospital	888 S KING ST	HONOLULU	96813	HI	CERBM	C2M	1950	PC	4	$ 4,150,000		21.30267	-157.85060
HI000021	CareFlty	15003004100	Straub Clinic & Hospital	888 S KING ST	HONOLULU	96813	HI	CERBH	C2H	1962	PC	8	$ 4,150,000		21.30267	-157.85060
HI000022	CareFlty	15003003500	Kaiser Honolulu Clinic	1010 PENSACOLA ST	HONOLULU	96814	HI	CERBM	C2M	UNK	PC	1	$ 4,150,000		21.30111	-157.84615
HI000023	CareFlty	15003003500	Shriners Hospital	1310 PUNAHOU ST	HONOLULU	96814	HI	CERBL	C2L	UNK	PC	1	$ 4,150,000		21.30120	-157.83576
HI000024	CareFlty	15003002600	Kapiolani Medical Center	1637 BINGHAM ST	HONOLULU	96826	HI	WSF2	W2	1938	PC	2	$ 4,150,000		21.29941	-157.83281
HI000025	CareFlty	15003002600	Kapiolani Medical Center	1637 BINGHAM ST	HONOLULU	96826	HI	CERBM	C2M	1964	PC	5	$ 4,150,000		21.29941	-157.83281
HI000026	CareFlty	15003002600	Kapiolani Medical Center	1637 BINGHAM ST	HONOLULU	96826	HI	CERBH	C2H	1976	PC	12	$ 4,150,000		21.29941	-157.83281
HI000027	CareFlty	15003002600	Kapiolani Medical Center	1637 BINGHAM ST	HONOLULU	96826	HI	CERBM	C2M	1978	LC	5	$ 4,150,000		21.29941	-157.83281
HI000028	CareFlty	15003002600	Kapiolani Medical Center	1637 BINGHAM ST	HONOLULU	96826	HI	WSF2	W2	1951	PC	2	$ 4,150,000		21.29941	-157.83281
HI000029	CareFlty	15003002600	Kapiolani Medical Center	1637 BINGHAM ST	HONOLULU	96826	HI	WSF1	W2	1965	PC	1	$ 4,150,000		21.29941	-157.83281
HI000030	CareFlty	15003002600	Kapiolani Medical Center	1637 BINGHAM ST	HONOLULU	96826	HI	CERBH	C2M	1977	PC	7	$ 4,150,000		21.29941	-157.83281
HI000031	CareFlty	15003000800	Leahi Hospital	3675 KILAUEA AVE	HONOLULU	96816	HI	CERBM	C2M	UNK	PC	1	$ 16,520,000		21.27303	-157.80201
HI000032	CareFlty	15003000800	Diamond Head Health Center	3627 KILAUEA AVE	HONOLULU	96816	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.27375	-157.80286
HI000033	CareFlty	15003000902	Maunalani Hospital	5113 MAUNALANI CIR	HONOLULU	96816	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.29735	-157.78902
HI000034	CareFlty	15003008608	Queen's Health Care Center	377 KEAHOLE ST	HONOLULU	96825	HI	CERBL	C2L	1982	HC	2	$ 4,150,000		21.28503	-157.70682
HI000035	CareFlty	15003000108	Kaiser Hawaii Kai Clinic	6700 KALANIANAOLE HWY	HONOLULU	96824	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.28443	-157.70944
HI000036	CareFlty	15003000105	Straub Hawaii Kai Family Health	7192 KALANIANAOLE HWY	HONOLULU	96825	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.27849	-157.70543
HI000038	CareFlty	15003011105	Kaiser Kailua Clinic	201 HAMAKUA DR	KAILUA	96734	HI	WSF2	W2	1989	HC	2	$ 4,150,000		21.38997	-157.74049
HI000041	CareFlty	15003011000	Castle Medical Center	640 ULUKAHIKI ST	KAILUA	96734	HI	CERBL	C2L	2002	LS	3	$ 16,520,000		21.38039	-157.75774
HI000042	CareFlty	15003011105	Straub Kailua Family Health Center	641 KAILUA RD	KAILUA	96734	HI	MERBL	RM1L	1960	PC	2	$ 4,150,000		21.38957	-157.74005
HI000043	CareFlty	15003010503	Hawaii State Hospital	45-691 KEAAHALA RD	KANEOHE	96744	HI	WSF1	W2	UNK	PC	1	$ 16,520,000		21.40551	-157.81356
HI000044	CareFlty	15003010503	Windward Health Center	45-691 KEAAHALA RD	KANEOHE	96744	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.40874	-157.81053
HI000045	CareFlty	15003010602	Kaiser Koolau Clinic	46-602 KAMEHAMEHA HWY	KANEOHE	96744	HI	CERBL	C2L	1965	PC	1	$ 4,150,000		21.40100	-157.80033
HI000046	CareFlty	15003010506	Straub Kaneohe Family Health	46-56 KAMEHAMEHA HWY	KANEOHE	96744	HI	MERBL	RM1L	1982	HC	2	$ 4,150,000		21.42082	-157.80569
HI000047	CareFlty	15003010506	Straub Kaneohe Family Health	46-56 KAMEHAMEHA HWY	KANEOHE	96744	HI	MERBL	RM1L	1982	HC	1	$ 4,150,000		21.42082	-157.80569
HI000048	CareFlty	15003010100	Kahuku Hospital	56-117 PUALALEA ST	KAHUKU	96731	HI	MERBL	RM1L	1939	PC	1	$ 4,150,000		21.67654	-157.95450
HI000049	CareFlty	15003010100	Kahuku Hospital	56-117 PUALALEA ST	KAHUKU	96731	HI	MERBL	RM1L	1917	PC	1	$ 4,150,000		21.67654	-157.95450
HI000050	CareFlty	15003010100	Kahuku Hospital	56-117 PUALALEA ST	KAHUKU	96731	HI	MERBL	RM1L	1949	PC	2	$ 4,150,000		21.67654	-157.95450
HI000051	CareFlty	15003010100	Kahuku Hospital	56-117 PUALALEA ST	KAHUKU	96731	HI	MERBL	RM1L	1966	PC	1	$ 4,150,000		21.67654	-157.95450
HI000052	CareFlty	15003010100	Kahuku Hospital	56-117 PUALALEA ST	KAHUKU	96731	HI	MERBL	RM1L	1959	PC	1	$ 4,150,000		21.67654	-157.95450
HI000053	CareFlty	15003010100	Kahuku Hospital	56-117 PUALALEA ST	KAHUKU	96731	HI	MERBL	RM1L	1981	PC	1	$ 4,150,000		21.67654	-157.95450

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000054	CareFlty	15003009300	Wahiawa General Hospital	128 LEHUA ST	WAHIAWA	96786	HI	MERBL	RM1L	UNK	PC	1	$ 16,520,000		21.49885	-158.02643
HI000055	CareFlty	15003009300	Wahiawa Clinic	910 CALIFORNIA AVE	WAHIAWA	96786	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.49805	-158.02548
HI000056	CareFlty	15003009702	Waianae Health Center	86-234 FARRINGTON HWY	WAIANAE	96792	HI	WSF1	W2	1969	PC	1	$ 4,150,000		21.43005	-158.18080
HI000057	CareFlty	15003009601	Kaiser Nanaikeola Clinic	87-2116 FARRINGTON HWY	WAIANAE	96792	HI	WSF1	W2	1997	HC	1	$ 4,150,000		21.38622	-158.14940
HI000058	CareFlty	15003008605	Kahi Mohala	2301 FORT WEAVER RD	EWA BEACH	96706	HI	MERBL	RM1L	1983	HC	1	$ 4,150,000		21.37647	-158.03790
HI000059	CareFlty	15003008605	Kahi Mohala	2301 FORT WEAVER RD	EWA BEACH	96706	HI	MERBL	RM1L	1983	HC	1	$ 4,150,000		21.37647	-158.03790
HI000060	CareFlty	15003008605	Kahi Mohala	2301 FORT WEAVER RD	EWA BEACH	96706	HI	MERBL	RM1L	1983	HC	1	$ 4,150,000		21.37647	-158.03790
HI000061	CareFlty	15003008605	Kahi Mohala	2301 FORT WEAVER RD	EWA BEACH	96706	HI	MERBL	RM1L	1984	HC	1	$ 4,150,000		21.37647	-158.03790
HI000062	CareFlty	15003008605	Kahi Mohala	2301 FORT WEAVER RD	EWA BEACH	96706	HI	MERBL	RM1L	1983	HC	1	$ 4,150,000		21.37647	-158.03790
HI000063	CareFlty	15003008605	St. Francis Medical Center - West	2139 FORT WEAVER RD	EWA BEACH	96706	HI	CERBM	C2M	1989	HC	5	$ 4,150,000		21.37086	-158.02729
HI000064	CareFlty	15003008605	St. Francis Medical Center - West	2139 FORT WEAVER RD	EWA BEACH	96706	HI	CERBL	C2M	1990	HC	1	$ 4,150,000		21.37086	-158.02729
HI000065	CareFlty	15003008603	Kaiser Kapolei Clinic	91-599 FARRINGTON HWY	KAPOLEI	96707	HI	WSF2	W2	1999	LS	2	$ 4,150,000		21.34637	-158.07433
HI000066	CareFlty	15003000108	Queen's Health Care Center	91-599 FARRINGTON HWY	KAPOLEI	96707	HI	CERBL	C2L	1999	LS	1	$ 4,150,000		21.33215	-158.08104
HI000067	CareFlty	15003008608	Straub Kapolei Family Health	91-599 FARRINGTON HWY	KAPOLEI	96707	HI	WSF2	W2	1999	LS	2	$ 4,150,000		21.33922	-158.07581
HI000068	CareFlty	15003008702	Waipahu Clinic	94-275 MOKUOLA ST	WAIPAHU	96797	HI	CERBL	C2L	1993	HC	3	$ 4,150,000		21.38569	-158.00287
HI000069	CareFlty	15003008702	Waipahu Clinic	94-275 MOKUOLA ST	WAIPAHU	96797	HI	CERBL	C2L	1998	HC	1	$ 4,150,000		21.38569	-158.00287
HI000070	CareFlty	15003008914	Kaiser Punawai Clinic	94-235 LEOKU ST	WAIPAHU	96797	HI	CERBM	C2M	1970	PC	4	$ 4,150,000		21.37990	-158.02346
HI000071	CareFlty	15003008917	Kaiser Mililani Clinic	95-660 LANIKUHANA AVE	MILILANI	96789	HI	WSF1	W2	1991	HC	1	$ 4,150,000		21.45001	-158.00508
HI000072	CareFlty	15003008917	Straub Mililani Family Health	95-1249 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1987	HC	1	$ 4,150,000		21.45491	-158.00691
HI000073	CareFlty	15003008917	Straub Mililani Family Health	95-1249 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1987	HC	2	$ 4,150,000		21.45491	-158.00691
HI000074	CareFlty	15003008917	Straub Mililani Family Health	95-1249 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1987	HC	1	$ 4,150,000		21.45491	-158.00691
HI000075	CareFlty	15003008917	Straub Mililani Family Health	95-1249 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1987	HC	1	$ 4,150,000		21.45491	-158.00691
HI000076	CareFlty	15003008917	Straub Mililani Family Health	95-1249 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1988	HC	1	$ 4,150,000		21.45491	-158.00691
HI000077	CareFlty	15003008917	Straub Mililani Family Health	95-1249 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1993	HC	1	$ 4,150,000		21.45491	-158.00691
HI000078	CareFlty	15003008001	Leeward Health Center	860 4TH ST	PEARL CITY	96782	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.39284	-157.96950
HI000079	CareFlty	15003007808	Straub Pearl Ridge	98-151 PALI MOMI ST	AIEA	96701	HI	MERBL	RM1L	1977	PC	2	$ 4,150,000		21.38180	-157.93980
HI000080	CareFlty	15003007808	Straub Pearl Ridge	98-151 PALI MOMI ST	AIEA	96701	HI	MERBL	RM1L	1977	PC	1	$ 4,150,000		21.38180	-157.93980
HI000081	CareFlty	15003007808	Kapiolani Medical Center at Pali Momi	98-1079 MOANALUA RD	AIEA	96701	HI	CERBM	C2M	1989	HC	1	$ 4,150,000		21.38349	-157.93851
HI000082	CareFlty	15003006804	Kaiser Foundation Hospital	3288 MOANALUA ROAD	HONOLULU	96819	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.36863	-157.90677
HI000083	CareFlty	15003010100	Kaiser Kahuku Clinic	56-565 KAMEHAMEHA HWY	KAHUKU	96731	HI	WSF1	W2	UNK	PC	1	$ 4,150,000		21.67491	-157.94579

List of Fire Stations Included

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000001	FireStation	15003007100	Mokulele	890 VALKENBURGH ST	HICKAM AFB	96853	HI	MLRI	RM1L	UNK	PC	1	$ 708,000	0	21.33966	-157.93043
HI000002	FireStation	15003006805	Moanalua	2835 ALA ILIMA ST	Honolulu	96818	HI	MLRI	RM1L	UNK	PC	1	$ 336,000	0	21.34521	-157.90084
HI000003	FireStation	15003007200	Airport	120 KAPALULU PL	Honolulu	96819	HI	MLRI	RM1L	UNK	PC	1	$ 708,000	0	21.32053	-157.90988
HI000004	FireStation	15003006100	Kalihi	112 NAKOLO PL	Honolulu	96819	HI	MLRI	RM1L	UNK	PC	1	$ 29,000	0	21.33109	-157.87494
HI000005	FireStation	15003006301	Kalihi Uka	1861 KAMEHAMEHA IV RD	Honolulu	96819	HI	MLRI	RM1L	UNK	PC	1	$ 2,824,000	0	21.34453	-157.87013
HI000006	FireStation	15003005700	Kalihi Kai	1334 NIMITZ HWY	Honolulu	96819	HI	MLRI	RM1L	UNK	PC	1	$ 357,900	0	21.32161	-157.87832
HI000007	FireStation	15003004900	Kuakini	601 NORTH KUAKINI ST	Honolulu	96817	HI	MLRI	RM1L	UNK	PC	1	$ 298,000	0	21.32489	-157.85831
HI000008	FireStation	15003004700	Nuuanu	115 WYLLIE ST	Honolulu	96817	HI	MLRI	RM1L	UNK	PC	1	$ 81,700	0	21.32790	-157.84635
HI000009	FireStation	15003005200	Waterfront	111 N. NIMITZ HWY	Honolulu	96817	HI	MLRI	RM1L	UNK	PC	1	$ 708,000	0	21.31112	-157.86528
HI000010	FireStation	15003003900	Kakaako	1302 QUEEN EMMA ST	Honolulu	96813	HI	MLRI	RM1L	UNK	PC	1	$ 478,200	0	21.30274	-157.85871
HI000011	FireStation	15003003602	Pawaa	1610 MAKALOA ST	Honolulu	96814	HI	MLRI	RM1L	UNK	PC	1	$ 339,000	0	21.29272	-157.83907
HI000012	FireStation	15003003404	Makiki	1202 WILDER AVE	Honolulu	96822	HI	MLRI	RM1L	UNK	PC	1	$ 56,000	0	21.30635	-157.83916
HI000013	FireStation	15003002300	McCully	2425 DATE ST	Honolulu	96826	HI	MLRI	RM1L	UNK	PC	1	$ 138,100	0	21.28822	-157.82459
HI000014	FireStation	15003003000	Manoa	2850 EAST MANOA RD	Honolulu	96822	HI	MLRI	RM1L	UNK	PC	1	$ 292,200	0	21.30983	-157.81081
HI000015	FireStation	15003001700	Waikiki (Hq.)	381 KAPAHULU AVE	Honolulu	96815	HI	MLRI	RM1L	UNK	PC	1	$ 309,800	0	21.27325	-157.81619
HI000016	FireStation	15003000800	Kaimuki	971 KOKO HEAD AVE	Honolulu	96816	HI	MLRI	RM1L	UNK	PC	1	$ 37,900	0	21.27823	-157.79887
HI000017	FireStation	15003001100	Palolo	3345 KIWILA ST	Honolulu	96816	HI	MLRI	RM1L	UNK	PC	1	$ 233,300	0	21.29917	-157.79420
HI000018	FireStation	15003000302	Wailupe	5046 KALANIANAOLE HWY	Honolulu	96821	HI	MLRI	RM1L	UNK	PC	1	$ 95,000	0	21.27676	-157.75947
HI000019	FireStation	15003000105	Hawaii Kai	515 LUNALILO HOME RD	Honolulu	96825	HI	MLRI	RM1L	UNK	PC	1	$ 291,400	0	21.28616	-157.69728
HI000020	FireStation	15003011301	Waimanalo	41-1301 KALANIANAOLE HWY	WAIMANALO	96795	HI	MLRI	RM1L	UNK	PC	1	$ 486,500	0	21.34691	-157.71440
HI000021	FireStation	15003011000	Olomana	42-510 KALANIANAOLE HWY	KAILUA	96734	HI	MLRI	RM1L	UNK	PC	1	$ 1,711,400	0	21.37761	-157.75142
HI000022	FireStation	15003011105	Kailua	21 KAINALUA DR	KAILUA	96734	HI	MLRI	RM1L	UNK	PC	1	$ 3,828,200	0	21.39665	-157.73937
HI000023	FireStation	15003010901	Aikahi	45 KANEOHE BAY DR	KAILUA	96734	HI	MLRI	RM1L	UNK	PC	1	$ 1,700,000	0	21.42374	-157.74981
HI000024	FireStation	15003010503	Kaneohe (Hq.)	45-910 KAMEHAMEHA HWY	KANEOHE	96744	HI	MLRI	RM1L	UNK	PC	1	$ 1,783,000	0	21.41383	-157.80080
HI000025	FireStation	15003010303	Kahaluu	47-304 WAIHEE RD	KANEOHE	96744	HI	MLRI	RM1L	UNK	PC	1	$ 708,000	0	21.45704	-157.84667
HI000026	FireStation	15003010201	Kaaawa	51-518 KAMEHAMEHA HWY	KAAAWA	96730	HI	WMUH1	W1	1942	PC	2	$ 154,600	1476	21.55666	-157.85433
HI000027	FireStation	15003010201	Hauula	54-64 KAMEHAMEHA HWY	HAUULA	96717	HI	MLRI	RM1L	UNK	PC	1	$ 237,300	0	21.60808	-157.90880
HI000028	FireStation	15003010100	Kahuku	56-460 KAMEHAMEHA HWY	KAHUKU	96731	HI	MLRI	RM1L	UNK	PC	1	$ 1,203,500	0	21.67517	-157.94611
HI000029	FireStation	15003010100	Sunset	59-719 KAMEHAMEHA HWY	HALEIWA	96712	HI	MLRI	RM1L	UNK	PC	1	$ 893,000	0	21.64816	-158.06286
HI000030	FireStation	15003009902	Waialua	66-420 HALEIWA RD	HALEIWA	96712	HI	MLRI	RM1L	UNK	PC	1	$ 202,800	0	21.58649	-158.11186
HI000031	FireStation	15003009300	Wahiawa	640 CALIFORNIA AVE	WAHIAWA	96786	HI	MLRI	RM1L	2001	LS	1	$ 625,200	2736	21.49680	-158.02785
HI000032	FireStation	15003009701	Waianae	85-645 FARRINGTON HWY	WAIANAE	96892	HI	MLRI	RM1L	UNK	PC	1	$ 416,900	0	21.44948	-158.19073
HI000033	FireStation	15003009601	Nanakuli	89-334 NANAKULI AVE	WAIANAE	96792	HI	MLRI	RM1L	UNK	PC	1	$ 195,900	0	21.38096	-158.13989
HI000034	FireStation	15003008402	Ewa Beach	673 FORT WEAVER RD	EWA BEACH	96706	HI	MLRI	RM1L	UNK	PC	1	$ 1,011,900	0	21.31189	-158.00977
HI000035	FireStation	15003008500	Kapolei (Hq.)	107 UU PL	KAPOLEI	96707	HI	MLRI	RM1L	UNK	PC	1	$ 708,000	0	21.32503	-158.09127
HI000036	FireStation	15003008603	Makakilo	92-885 MAKAKILO DR	KAPOLEI	96707	HI	MLRI	RM1L	UNK	PC	1	$ 359,400	0	21.35539	-158.08800
HI000037	FireStation	15003008922	Waikele	840 LUMIAINA ST	WAIPAHU	96797	HI	MLRI	RM1L	UNK	PC	1	$ 1,920,000	0	21.40021	-158.00490
HI000038	FireStation	15003008703	Waipahu	94-121 LEONUI ST	WAIPAHU	96797	HI	MLRI	RM1L	UNK	PC	1	$ 360,600	0	21.37696	-158.02165
HI000039	FireStation	15003008907	Mililani	95-269 KIPAPA DR	MILLANI	96789	HI	MLRI	RM1L	UNK	PC	1	$ 295,700	0	21.45669	-158.01558
HI000040	FireStation	15003008916	Mililani Mauka (Hq.)	1990 MEHEULA PKWY	MILLANI	96789	HI	MLRI	RM1L	UNK	PC	1	$ 2,020,000	0	21.45867	-158.00700
HI000041	FireStation	15003008001	Pearl City	880 FIRST ST PC	PEARL CITY	96782	HI	MLRI	RM1L	1979	PC	2	$ 471,300	33700	21.39002	-157.97162
HI000042	FireStation	15003007702	Aiea	98-1239 ULUNE ST	AIEA	96701	HI	MLRI	RM1L	UNK	PC	1	$ 252,400	0	21.38447	-157.93164
HI000043	FireStation	15003007810	Waiau	98-1109 KOMO MAI DR	PEARL CITY	96782	HI	MLRI	RM1L	UNK	PC	1	$ 646,800	0	21.40200	-157.95114

List of Police Stations Included

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000001	PoliceStation	15003006301	KALIHI STATION	1861 KAM IV RD	HONLULU	96819	HI	MERBL	RM1L	UNK	PC	1	$ 2,824,000	1000	21.34404	-157.87067
HI000002	PoliceStation	15003005200	CHINATOWN STATION	61 HOTEL ST	HONLULU	96817	HI	MMUH3	RM2L	1909	PC	3	$ 620,800	18870	21.31201	-157.86279
HI000003	PoliceStation	15003004100	ALAPAI STATION	801 BERETANIA ST	HONLULU	96713	HI	MERBL	RM1L	UNK	PC	1	$ 1,652,000	1000	21.30427	-157.85149
HI000004	PoliceStation	15003001901	WAIKIKI SUB STATION	2425 KALAKAUA AVE	HONLULU	96815	HI	MERBL	RM1L	UNK	PC	1	$ 1,652,000	1000	21.27566	-157.82562
HI000005	PoliceStation	15003000108	HAWAII KAI STATION	6600 KALANIANAOLE HWY	HONLULU	96825	HI	MERBM	RM2M	1987	HC	6	$ 7,701,200	307968	21.28330	-157.71442
HI000006	PoliceStation	15003011105	KAILUA STATION	21 KAINALU DR	KAILUA	96734	HI	MERBL	RM1L	UNK	PC	1	$ 3,828,200	1000	21.39673	-157.73945
HI000007	PoliceStation	15003010504	KANEOHE STATION	260 WAIKALUA RD	KANEOHE	96744	HI	MERBL	RM1L	UNK	PC	1	$ 106,200	1000	21.41338	-157.79876
HI000008	PoliceStation	15003010100	KAHUKU STATION	470 KAM HWY	KAHUKU	96731	HI	MERBL	RM1L	UNK	PC	1	$ 1,203,500	1000	21.67538	-157.94589
HI000009	PoliceStation	15003009300	WAHIAWA STATION	330 CANE ST	WAIHIAWA	96786	HI	MERBL	RM1L	UNK	PC	1	$ 2,601,300	1000	21.50219	-158.02597
HI000010	PoliceStation	15003009701	WAIANAE STATION	939 FARRINGTON HWY	WAIANAE	96792	HI	MERBL	RM1L	UNK	PC	1	$ 292,100	1000	21.44326	-158.18743
HI000011	PoliceStation	15003008605	EWA STOREFRONT	1669 FORT WEAVER RD	EWA BEACH	96706	HI	MERBL	RM1L	UNK	PC	1	$ 1,918,000	1000	21.34879	-158.02739
HI000012	PoliceStation	15003008608	KAPOLEI STATION	1100 KAMOKILA BLVD	KAPOLEI	96707	HI	MERBL	RM1L	UNK	PC	1	$ 6,754,700	1000	21.33554	-158.08078
HI000013	PoliceStation	15003008914	WAIPAHU STATION	144 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1969	PC	1	$ 9,987,700	157460	21.37854	-158.02244
HI000014	PoliceStation	15003008003	PEARL CITY STATION	1100 WAIMANO HOME RD	PEARL CITY	96782	HI	MERBL	RM1L	1979	PC	2	$ 1,844,200	33700	21.39596	-157.96969

List of Schools

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000001	School	15003010306	Ahuimanu Elementary - Bldg A	47-470 HUI AEKO PL	KANEOHE	96744	HI	WSF1	W1	1976	PC	1	$ 1,115,975	6,377	21.43503	-157.83037
HI000002	School	15003010306	Ahuimanu Elementary - Bldg C	47-470 HUI AEKO PL	KANEOHE	96744	HI	MERBL	RM1L	1977	PC	1	$ 2,201,400	7,338	21.43503	-157.83037
HI000003	School	15003010306	Ahuimanu Elementary - Bldg D	47-470 HUI AEKO PL	KANEOHE	96744	HI	MERBL	RM1L	1977	PC	1	$ 1,511,100	5,037	21.43503	-157.83037
HI000004	School	15003010306	Ahuimanu Elementary - Bldg E	47-470 HUI AEKO PL	KANEOHE	96744	HI	MERBL	RM1L	1973	PC	2	$ 4,893,600	16,312	21.43503	-157.83037
HI000005	School	15003007504	Aiea Elementary - Bldg A	99-350 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1965	PC	2	$ 2,742,300	9,141	21.37568	-157.92773
HI000006	School	15003007504	Aiea Elementary - Bldg B	99-350 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1965	PC	2	$ 2,791,800	9,306	21.37568	-157.92773
HI000007	School	15003007504	Aiea Elementary - Bldg C	99-350 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1967	PC	2	$ 2,791,800	9,306	21.37568	-157.92773
HI000008	School	15003007504	Aiea Elementary - Bldg E	99-350 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1951	PC	1	$ 898,500	2,995	21.37568	-157.92773
HI000009	School	15003007702	Aiea High - Bldg A	98-1276 ULUNE ST	AIEA	96701	HI	MERBL	RM1L	1961	PC	2	$ 3,816,600	12,722	21.38489	-157.93004
HI000010	School	15003007702	Aiea High - Bldg B	98-1276 ULUNE ST	AIEA	96701	HI	MERBL	RM1L	1961	PC	2	$ 3,816,600	12,722	21.38489	-157.93004
HI000011	School	15003007702	Aiea High - Bldg C	98-1276 ULUNE ST	AIEA	96701	HI	MERBL	RM1L	1962	PC	2	$ 3,917,100	13,057	21.38489	-157.93004
HI000012	School	15003007702	Aiea High - Bldg D	98-1276 ULUNE ST	AIEA	96701	HI	MERBL	RM1L	1962	PC	2	$ 4,017,000	13,390	21.38489	-157.93004
HI000013	School	15003007702	Aiea High - Bldg G	98-1276 ULUNE ST	AIEA	96701	HI	MERBL	RM1L	1964	PC	2	$ 3,958,200	13,194	21.38489	-157.93004
HI000014	School	15003007702	Aiea High - Bldg H	98-1276 ULUNE ST	AIEA	96701	HI	MERBL	RM1L	1964	PC	1	$ 1,832,700	6,109	21.38489	-157.93004
HI000015	School	15003007702	Aiea High - Bldg J	98-1276 ULUNE ST	AIEA	96701	HI	MERBL	RM1L	1962	PC	2	$ 4,321,800	14,406	21.38489	-157.93004
HI000016	School	15003007702	Aiea High - Bldg Q	98-1276 ULUNE ST	AIEA	96701	HI	WSF2	W1	1967	PC	2	$ 2,503,025	14,303	21.38489	-157.93004
HI000017	School	15003007702	Aiea High - Bldg R	98-1276 ULUNE ST	AIEA	96701	HI	MERBL	RM1L	1970	PC	2	$ 3,439,200	11,464	21.38489	-157.93004
HI000018	School	15003007702	Aiea High - Bldg T	98-1276 ULUNE ST	AIEA	96701	HI	MERBL	RM1L	1991	HC	2	$ 6,495,900	21,653	21.38489	-157.93004
HI000019	School	15003007503	Aiea Intermediate - Bldg A	99-600 KULAWEA ST	AIEA	96701	HI	MERBL	RM1L	1964	PC	2	$ 6,548,400	21,828	21.38037	-157.92377
HI000020	School	15003007503	Aiea Intermediate - Bldg B	99-600 KULAWEA ST	AIEA	96701	HI	MERBL	RM1L	1964	PC	1	$ 1,536,300	5,121	21.38037	-157.92377
HI000021	School	15003007503	Aiea Intermediate - Bldg E	99-600 KULAWEA ST	AIEA	96701	HI	MERBL	RM1L	1967	PC	2	$ 3,263,100	10,877	21.38037	-157.92377
HI000022	School	15003007503	Aiea Intermediate - Bldg F	99-600 KULAWEA ST	AIEA	96701	HI	MERBL	RM1L	1965	PC	2	$ 3,493,800	11,646	21.38037	-157.92377
HI000023	School	15003010901	Aikahi Elementary - Bldg A	281 ILIHAU ST	KAILUA	96734	HI	MERBL	RM1L	1960	PC	1	$ 1,873,200	6,244	21.42508	-157.74968
HI000024	School	15003010901	Aikahi Elementary - Bldg B	281 ILIHAU ST	KAILUA	96734	HI	MERBL	RM1L	1960	PC	2	$ 4,988,400	16,628	21.42508	-157.74968
HI000025	School	15003010901	Aikahi Elementary - Bldg C	281 ILIHAU ST	KAILUA	96734	HI	MERBL	RM1L	1961	PC	2	$ 3,884,400	12,948	21.42508	-157.74968
HI000026	School	15003010901	Aikahi Elementary - Bldg E	281 ILIHAU ST	KAILUA	96734	HI	WSF1	W1	1964	PC	1	$ 1,357,125	7,755	21.42508	-157.74968
HI000027	School	15003000302	Aina Haina Elementary - Bldg C	827 HIND DR	HONOLULU	96821	HI	MERBL	RM1L	1951	PC	1	$ 2,793,300	9,311	21.27915	-157.75684
HI000028	School	15003000302	Aina Haina Elementary - Bldg D	827 HIND DR	HONOLULU	96821	HI	MERBL	RM1L	1951	PC	1	$ 2,793,300	9,311	21.27915	-157.75684
HI000029	School	15003000302	Aina Haina Elementary - Bldg E	827 HIND DR	HONOLULU	96821	HI	MERBL	RM1L	1951	PC	1	$ 1,941,600	6,472	21.27915	-157.75684
HI000030	School	15003000302	Aina Haina Elementary - Bldg G	827 HIND DR	HONOLULU	96821	HI	MERBL	RM1L	1951	PC	1	$ 1,048,200	3,494	21.27915	-157.75684
HI000031	School	15003000302	Aina Haina Elementary - Bldg P1	827 HIND DR	HONOLULU	96821	HI	MERBL	RM1L	1967	PC	1	$ 280,800	936	21.27915	-157.75684
HI000032	School	15003000302	Aina Haina Elementary - Bldg P2	827 HIND DR	HONOLULU	96821	HI	MERBL	RM1L	1967	PC	1	$ 270,000	900	21.27915	-157.75684
HI000033	School	15003000302	Aina Haina Elementary - Bldg P3	827 HIND DR	HONOLULU	96821	HI	MERBL	RM1L	1967	PC	1	$ 270,000	900	21.27915	-157.75684
HI000034	School	15003007000	Aliamanu Elementary - Bldg A	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1958	PC	1	$ 1,368,000	4,560	21.34294	-157.91337
HI000035	School	15003007000	Aliamanu Elementary - Bldg B	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1958	PC	1	$ 1,368,000	4,560	21.34294	-157.91337
HI000036	School	15003007000	Aliamanu Elementary - Bldg C	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1958	PC	1	$ 1,368,000	4,560	21.34294	-157.91337
HI000037	School	15003007000	Aliamanu Elementary - Bldg D	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1958	PC	1	$ 1,368,000	4,560	21.34294	-157.91337
HI000038	School	15003007000	Aliamanu Elementary - Bldg E	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1958	PC	1	$ 1,368,000	4,560	21.34294	-157.91337
HI000039	School	15003007000	Aliamanu Elementary - Bldg F	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1958	PC	1	$ 1,420,800	4,736	21.34294	-157.91337
HI000040	School	15003007000	Aliamanu Elementary - Bldg G	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1960	PC	1	$ 1,420,800	4,736	21.34294	-157.91337
HI000041	School	15003007000	Aliamanu Elementary - Bldg H	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1960	PC	1	$ 1,420,800	4,736	21.34294	-157.91337
HI000042	School	15003007000	Aliamanu Intermediate - Bldg A	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1959	PC	2	$ 1,648,800	5,496	21.34281	-157.91566
HI000043	School	15003007000	Aliamanu Intermediate - Bldg B	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1959	PC	2	$ 3,747,000	12,490	21.34281	-157.91566
HI000044	School	15003007000	Aliamanu Intermediate - Bldg C	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1959	PC	2	$ 3,292,200	10,974	21.34281	-157.91566
HI000045	School	15003007000	Aliamanu Intermediate - Bldg D	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1960	PC	2	$ 3,796,800	12,656	21.34281	-157.91566
HI000046	School	15003007000	Aliamanu Intermediate - Bldg E	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1960	PC	1	$ 3,529,800	11,766	21.34281	-157.91566
HI000047	School	15003007000	Aliamanu Intermediate - Bldg F	3271 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1962	PC	1	$ 1,769,100	5,897	21.34281	-157.91566
HI000048	School	15003007000	Aliamanu Intermediate - Bldg M	3271 SALT LAKE BLVD	HONOLULU	96819	HI	WSF1	W1	1962	PC	1	$ 806,225	4,607	21.34281	-157.91566
HI000049	School	15003001201	Aliiolani Elementary - Bldg A	1240 7TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1963	PC	2	$ 3,686,400	12,288	21.28664	-157.80476
HI000050	School	15003001201	Aliiolani Elementary - Bldg B	1240 7TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1951	PC	1	$ 1,198,200	3,994	21.28664	-157.80476
HI000051	School	15003001201	Aliiolani Elementary - Bldg C	1240 7TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1953	PC	1	$ 800,100	2,667	21.28664	-157.80476
HI000052	School	15003001201	Aliiolani Elementary - Bldg D	1240 7TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1951	PC	1	$ 1,008,300	3,361	21.28664	-157.80476
HI000053	School	15003001201	Aliiolani Elementary - Bldg F	1240 7TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1966	PC	2	$ 3,274,200	10,914	21.28664	-157.80476
HI000054	School	15003001201	Aliiolani Elementary - Bldg H	1240 7TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1967	PC	1	$ 1,962,900	6,543	21.28664	-157.80476

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000055	School	15003008912	August Ahrens Elementary - Bldg A	94-1170 WAIPAHU ST	WAIPAHU	96797	HI	MERBL	RM1L	1962	PC	2	$ 2,787,300	9,291	21.39393	-158.00179
HI000056	School	15003008912	August Ahrens Elementary - Bldg B	94-1170 WAIPAHU ST	WAIPAHU	96797	HI	MERBL	RM1L	1964	PC	2	$ 2,787,300	9,291	21.39393	-158.00179
HI000057	School	15003008912	August Ahrens Elementary - Bldg H	94-1170 WAIPAHU ST	WAIPAHU	96797	HI	MERBL	RM1L	1969	PC	2	$ 3,191,400	10,638	21.39393	-158.00179
HI000058	School	15003008912	August Ahrens Elementary - Bldg I	94-1170 WAIPAHU ST	WAIPAHU	96797	HI	MERBL	RM1L	1970	PC	1	$ 6,273,900	20,913	21.39393	-158.00179
HI000059	School	15003008912	August Ahrens Elementary - Bldg J	94-1170 WAIPAHU ST	WAIPAHU	96797	HI	MERBL	RM1L	1972	PC	1	$ 4,352,400	14,508	21.39393	-158.00179
HI000060	School	15003008912	August Ahrens Elementary - Bldg K	94-1170 WAIPAHU ST	WAIPAHU	96797	HI	WSF1	W1	1973	PC	1	$ 1,985,025	11,343	21.39393	-158.00179
HI000061	School	15003008500	Barbers Point Elementary - Bldg B	91-1001 BOXER ST BPNAS	BARBERS POINT	96862	HI	WSF1	W1	1954	PC	1	$ 1,610,700	9,204	21.32241	-158.08191
HI000062	School	15003011302	Blanche Pope Elementary - Bldg A	41-133 HULI ST WAIM	WAIMANALO	96795	HI	MERBL	RM1L	1965	PC	2	$ 3,596,100	11,987	21.32811	-157.69520
HI000063	School	15003011302	Blanche Pope Elementary - Bldg B	41-133 HULI ST WAIM	WAIMANALO	96795	HI	MERBL	RM1L	1969	PC	2	$ 3,402,000	11,340	21.32811	-157.69520
HI000064	School	15003011302	Blanche Pope Elementary - Bldg C	41-133 HULI ST WAIM	WAIMANALO	96795	HI	MERBL	RM1L	1975	PC	2	$ 4,614,900	15,383	21.32811	-157.69520
HI000065	School	15003011302	Blanche Pope Elementary - Bldg D	41-133 HULI ST WAIM	WAIMANALO	96795	HI	WSF1	W1	1965	PC	1	$ 1,081,675	6,181	21.32811	-157.69520
HI000066	School	15003008302	Campbell High - Bldg D	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1975	PC	3	$ 11,876,400	39,588	21.31578	-158.00835
HI000067	School	15003008302	Campbell High - Bldg E	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	WSF1	W1	1973	PC	1	$ 1,478,050	8,446	21.31578	-158.00835
HI000068	School	15003008302	Campbell High - Bldg F	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1973	PC	1	$ 1,282,500	4,275	21.31578	-158.00835
HI000069	School	15003008302	Campbell High - Bldg G	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1968	PC	2	$ 6,901,500	23,005	21.31578	-158.00835
HI000070	School	15003008302	Campbell High - Bldg H	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1976	PC	1	$ 7,053,300	23,511	21.31578	-158.00835
HI000071	School	15003008302	Campbell High - Bldg J	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1974	PC	1	$ 4,704,900	15,683	21.31578	-158.00835
HI000072	School	15003008302	Campbell High - Bldg K	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1968	PC	1	$ 5,042,400	16,808	21.31578	-158.00835
HI000073	School	15003008302	Campbell High - Bldg L	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1972	PC	1	$ 1,940,700	6,469	21.31578	-158.00835
HI000074	School	15003008302	Campbell High - Bldg N	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	WSF1	W1	1971	PC	1	$ 3,893,400	22,248	21.31578	-158.00835
HI000075	School	15003008302	Campbell High - Bldg O	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1963	PC	2	$ 6,375,900	21,253	21.31578	-158.00835
HI000076	School	15003008302	Campbell High - Bldg I	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1974	PC	1	$ 4,704,900	15,683	21.31578	-158.00835
HI000077	School	15003010602	Castle High - Bldg BB	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1980	PC	1	$ 6,997,200	23,324	21.40314	-157.79458
HI000078	School	15003010602	Castle High - Bldg C	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1955	PC	1	$ 1,140,000	3,800	21.40314	-157.79458
HI000079	School	15003010602	Castle High - Bldg CC	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	WSF1	W1	1990	HC	1	$ 1,169,525	6,683	21.40314	-157.79458
HI000080	School	15003010602	Castle High - Bldg D	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1955	PC	1	$ 1,338,000	4,460	21.40314	-157.79458
HI000081	School	15003010602	Castle High - Bldg DD	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	WSF1	W1	1991	HC	1	$ 1,100,400	6,288	21.40314	-157.79458
HI000082	School	15003010602	Castle High - Bldg E	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1955	PC	1	$ 2,034,300	6,781	21.40314	-157.79458
HI000083	School	15003010602	Castle High - Bldg EE	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1997	HC	1	$ 6,699,300	22,331	21.40314	-157.79458
HI000084	School	15003010602	Castle High - Bldg F	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1950	PC	1	$ 2,016,900	6,723	21.40314	-157.79458
HI000085	School	15003010602	Castle High - Bldg FF	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	WSF1	W1	1999	LS	1	$ -	-	21.40314	-157.79458
HI000086	School	15003010602	Castle High - Bldg K	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1958	PC	1	$ 1,390,500	4,635	21.40314	-157.79458
HI000087	School	15003010602	Castle High - Bldg L	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1958	PC	1	$ 625,200	2,084	21.40314	-157.79458
HI000088	School	15003010602	Castle High - Bldg M	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1958	PC	1	$ 1,287,300	4,291	21.40314	-157.79458
HI000089	School	15003010602	Castle High - Bldg Q	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1950	PC	1	$ 2,118,900	7,063	21.40314	-157.79458
HI000090	School	15003010602	Castle High - Bldg S	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1960	PC	1	$ 2,326,200	7,754	21.40314	-157.79458
HI000091	School	15003010602	Castle High - Bldg U	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	WSF1	W1	1963	PC	1	$ 1,306,025	7,463	21.40314	-157.79458
HI000092	School	15003010602	Castle High - Bldg Y	45-386 KANEOHE BAY DR	KANEOHE	96744	HI	MERBL	RM1L	1967	PC	1	$ 1,080,000	3,600	21.40314	-157.79458
HI000093	School	15003004200	Central Intermediate / Middle - Bldg A	1302 QUEEN EMMA ST	HONOLULU	96813	HI	WSF2	W1	1930	PC	2	$ 2,903,425	16,591	21.31167	-157.85658
HI000094	School	15003006301	Dole Middle - Bldg A	1715 KINO ST	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	2	$ 2,666,400	8,888	21.34239	-157.87087
HI000095	School	15003006301	Dole Middle - Bldg B	1715 KINO ST	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	2	$ 2,822,400	9,408	21.34239	-157.87087
HI000096	School	15003006301	Dole Middle - Bldg C	1715 KINO ST	HONOLULU	96819	HI	MERBL	RM1L	1957	PC	2	$ 2,672,400	8,908	21.34239	-157.87087
HI000097	School	15003006301	Dole Middle - Bldg D	1715 KINO ST	HONOLULU	96819	HI	MERBL	RM1L	1957	PC	2	$ 2,889,000	9,630	21.34239	-157.87087
HI000098	School	15003006301	Dole Middle - Bldg E	1715 KINO ST	HONOLULU	96819	HI	MERBL	RM1L	1957	PC	2	$ 2,843,700	9,479	21.34239	-157.87087
HI000099	School	15003006301	Dole Middle - Bldg F	1715 KINO ST	HONOLULU	96819	HI	MERBL	RM1L	1958	PC	2	$ 2,352,000	7,840	21.34239	-157.87087
HI000100	School	15003008402	Ewa Beach Elementary - Bldg C	91-740 PAPIPI RD	EWA BEACH	96706	HI	MERBL	RM1L	1959	PC	2	$ 3,820,800	12,736	21.31544	-158.01503
HI000101	School	15003008402	Ewa Beach Elementary - Bldg E	91-740 PAPIPI RD	EWA BEACH	96706	HI	MERBL	RM1L	1961	PC	1	$ 1,449,600	4,832	21.31544	-158.01503
HI000102	School	15003008402	Ewa Beach Elementary - Bldg G	91-740 PAPIPI RD	EWA BEACH	96706	HI	MERBL	RM1L	1962	PC	1	$ 569,400	1,898	21.31544	-158.01503
HI000103	School	15003008402	Ewa Beach Elementary - Bldg I	91-740 PAPIPI RD	EWA BEACH	96706	HI	MERBL	RM1L	1997	HC	1	$ 2,576,100	8,587	21.31544	-158.01503
HI000104	School	15003008605	Ewa Elementary - Bldg C	91-1280 RENTON RD	EWA BEACH	96706	HI	MERBL	RM1L	1954	PC	1	$ 1,290,000	4,300	21.34450	-158.03469
HI000105	School	15003008605	Ewa Elementary - Bldg D	91-1280 RENTON RD	EWA BEACH	96706	HI	MERBL	RM1L	1957	PC	1	$ 1,473,000	4,910	21.34450	-158.03469
HI000106	School	15003008605	Ewa Elementary - Bldg I	91-1280 RENTON RD	EWA BEACH	96706	HI	MERBL	RM1L	1965	PC	2	$ 2,817,600	9,392	21.34450	-158.03469
HI000107	School	15003008605	Ewa Elementary - Bldg J	91-1280 RENTON RD	EWA BEACH	96706	HI	WSF2	W1	1967	PC	2	$ 1,654,625	9,455	21.34450	-158.03469
HI000108	School	15003008605	Ewa Elementary - Bldg K	91-1280 RENTON RD	EWA BEACH	96706	HI	WSF1	W1	1979	LC	1	$ 1,119,125	6,395	21.34450	-158.03469

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000109	School	15003008605	Ewa Elementary - Bldg L	91-1280 RENTON RD	EWA BEACH	96706	HI	MERBL	RM1L	1990	HC	1	$ 2,890,200	9,634	21.34450	-158.03469
HI000110	School	15003008605	Ewa Elementary - Bldg M	91-1280 RENTON RD	EWA BEACH	96706	HI	MERBL	RM1L	1994	HC	2	$ 2,890,200	9,634	21.34450	-158.03469
HI000111	School	15003005600	Farrington High - Bldg A	1101 KALIHI ST	HONOLULU	96817	HI	WMUH3	W1	1939	PC	3	$ 11,689,300	66,796	21.33072	-157.87242
HI000112	School	15003005600	Farrington High - Bldg H	1101 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1968	PC	1	$ 4,428,900	14,763	21.33072	-157.87242
HI000113	School	15003005600	Farrington High - Bldg I	1101 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1964	PC	3	$ 6,345,900	21,153	21.33072	-157.87242
HI000114	School	15003005600	Farrington High - Bldg J	1101 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1965	PC	3	$ 7,407,900	24,693	21.33072	-157.87242
HI000115	School	15003005600	Farrington High - Bldg O	1101 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1965	PC	2	$ 3,050,400	10,168	21.33072	-157.87242
HI000116	School	15003005600	Farrington High - Bldg Q	1101 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1965	PC	1	$ 6,905,100	23,017	21.33072	-157.87242
HI000117	School	15003005600	Farrington High - Bldg R	1101 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1958	PC	1	$ 4,738,200	15,794	21.33072	-157.87242
HI000118	School	15003005600	Farrington High - Bldg U	1101 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1975	PC	2	$ 2,840,400	9,468	21.33072	-157.87242
HI000119	School	15003006201	Fern Elementary - Bldg I	1121 MIDDLE ST	HONOLULU	96819	HI	MERBL	RM1L	1971	PC	2	$ 2,620,200	8,734	21.33878	-157.88198
HI000120	School	15003000106	Hahaione Elementary - Bldg A	595 PEPEEKEO ST	HONOLULU	96825	HI	MERBL	RM1L	1967	PC	1	$ 1,323,300	4,411	21.29623	-157.71017
HI000121	School	15003000106	Hahaione Elementary - Bldg B	595 PEPEEKEO ST	HONOLULU	96825	HI	MERBL	RM1L	1967	PC	1	$ 1,323,300	4,411	21.29623	-157.71017
HI000122	School	15003000106	Hahaione Elementary - Bldg C	595 PEPEEKEO ST	HONOLULU	96825	HI	MERBL	RM1L	1967	PC	1	$ 1,323,300	4,411	21.29623	-157.71017
HI000123	School	15003000106	Hahaione Elementary - Bldg H	595 PEPEEKEO ST	HONOLULU	96825	HI	MERBL	RM1L	1972	PC	1	$ 3,258,000	10,860	21.29623	-157.71017
HI000124	School	15003000106	Hahaione Elementary - Bldg I	595 PEPEEKEO ST	HONOLULU	96825	HI	WSF1	W1	1967	PC	1	$ 1,176,350	6,722	21.29623	-157.71017
HI000125	School	15003010506	Heeia Elementary - Bldg B	46-202 HAIKU RD	KANEOHE	96744	HI	MERBL	RM1L	1960	PC	1	$ 4,022,400	13,408	21.41825	-157.80859
HI000126	School	15003010506	Heeia Elementary - Bldg C	46-202 HAIKU RD	KANEOHE	96744	HI	MERBL	RM1L	1961	PC	1	$ 4,022,400	13,408	21.41825	-157.80859
HI000127	School	15003010506	Heeia Elementary - Bldg F	46-202 HAIKU RD	KANEOHE	96744	HI	MERBL	RM1L	1971	PC	1	$ 1,411,500	4,705	21.41825	-157.80859
HI000128	School	15003010506	Heeia Elementary - Bldg P1	46-202 HAIKU RD	KANEOHE	96744	HI	WSF1	W1	1994	HC	1	$ 142,100	812	21.41825	-157.80859
HI000129	School	15003010506	Heeia Elementary - Bldg P2	46-202 HAIKU RD	KANEOHE	96744	HI	WSF1	W1	1996	HC	1	$ 142,100	812	21.41825	-157.80859
HI000130	School	15003009100	Helemano Elementary - Bldg F	1001 IHIIHI AVE	WAHIAWA	96786	HI	MERBL	RM1L	1992	HC	2	$ 2,386,800	7,956	21.51417	-158.02331
HI000131	School	15003009100	Helemano Elementary - Bldg G	1001 IHIIHI AVE	WAHIAWA	96786	HI	MERBL	RM1L	1996	HC	2	$ 2,581,500	8,605	21.51417	-158.02331
HI000132	School	15003009100	Helemano Elementary - Bldg P12	1001 IHIIHI AVE	WAHIAWA	96786	HI	WSF1	W1	1994	HC	1	$ 142,100	812	21.51417	-158.02331
HI000133	School	15003009100	Helemano Elementary - Bldg P13	1001 IHIIHI AVE	WAHIAWA	96786	HI	WSF1	W1	1994	HC	1	$ 142,100	812	21.51417	-158.02331
HI000134	School	15003009100	Helemano Elementary - Bldg P14	1001 IHIIHI AVE	WAHIAWA	96786	HI	WSF1	W1	1994	HC	1	$ 142,100	812	21.51417	-158.02331
HI000135	School	15003007300	Hickam Elementary - Bldg F	MANZELMAN ST	HICKAM AFB	96853	HI	MERBL	RM1L	1950	PC	1	$ 1,224,300	4,081	21.34249	-157.96369
HI000136	School	15003007300	Hickam Elementary - Bldg G	MANZELMAN ST	HICKAM AFB	96853	HI	WSF1	W1	1950	PC	1	$ 956,550	5,466	21.34249	-157.96369
HI000137	School	15003007300	Hickam Elementary - Bldg H	MANZELMAN ST	HICKAM AFB	96853	HI	MERBL	RM1L	1950	PC	1	$ 1,426,800	4,756	21.34249	-157.96369
HI000138	School	15003007300	Hickam Elementary - Bldg I	MANZELMAN ST	HICKAM AFB	96853	HI	MERBL	RM1L	1950	PC	1	$ 775,800	2,586	21.34249	-157.96369
HI000139	School	15003007300	Hickam Elementary - Bldg K	MANZELMAN ST	HICKAM AFB	96853	HI	MERBL	RM1L	1965	PC	2	$ 3,396,000	11,320	21.34249	-157.96369
HI000140	School	15003007300	Hickam Elementary - Bldg P8	MANZELMAN ST	HICKAM AFB	96853	HI	WSF1	W1	1994	HC	1	$ 142,100	812	21.34249	-157.96369
HI000141	School	15003007300	Hickam Elementary - Bldg C	MANZELMAN ST	HICKAM AFB	96853	HI	MERBL	RM1L	1950	PC	1	$ 2,334,000	7,780	21.34249	-157.96369
HI000142	School	15003007300	Hickam Elementary - Bldg E	MANZELMAN ST	HICKAM AFB	96853	HI	MERBL	RM1L	1950	PC	1	$ 621,000	2,070	21.34249	-157.96369
HI000143	School	15003008007	Highlands Intermediate - Bldg A	1460 HOOLAULEA ST	PEARL CITY	96782	HI	MERBL	RM1L	1959	PC	2	$ 4,601,400	15,338	21.40096	-157.96262
HI000144	School	15003008007	Highlands Intermediate - Bldg B	1460 HOOLAULEA ST	PEARL CITY	96782	HI	MERBL	RM1L	1959	PC	2	$ 3,836,400	12,788	21.40096	-157.96262
HI000145	School	15003008007	Highlands Intermediate - Bldg C	1460 HOOLAULEA ST	PEARL CITY	96782	HI	MERBL	RM1L	1961	PC	1	$ 1,899,300	6,331	21.40096	-157.96262
HI000146	School	15003008007	Highlands Intermediate - Bldg D	1460 HOOLAULEA ST	PEARL CITY	96782	HI	MERBL	RM1L	1961	PC	1	$ 4,083,600	13,612	21.40096	-157.96262
HI000147	School	15003008007	Highlands Intermediate - Bldg G	1460 HOOLAULEA ST	PEARL CITY	96782	HI	MERBL	RM1L	1963	PC	1	$ 1,939,800	6,466	21.40096	-157.96262
HI000148	School	15003008007	Highlands Intermediate - Bldg H	1460 HOOLAULEA ST	PEARL CITY	96782	HI	MERBL	RM1L	1963	PC	1	$ 1,292,400	4,308	21.40096	-157.96262
HI000149	School	15003008007	Highlands Intermediate - Bldg J	1460 HOOLAULEA ST	PEARL CITY	96782	HI	WSF1	W1	1959	PC	1	$ 1,499,925	8,571	21.40096	-157.96262
HI000150	School	15003008007	Highlands Intermediate - Bldg K	1460 HOOLAULEA ST	PEARL CITY	96782	HI	WSF1	W1	1967	PC	1	$ 1,503,775	8,593	21.40096	-157.96262
HI000151	School	15003002701	Hokulani Elementary - Bldg A	2940 KAMAKINI ST	HONOLULU	96816	HI	MERBL	RM1L	1957	PC	1	$ 1,531,800	5,106	21.29164	-157.81307
HI000152	School	15003002701	Hokulani Elementary - Bldg B	2940 KAMAKINI ST	HONOLULU	96816	HI	MERBL	RM1L	1958	PC	2	$ 3,012,300	10,041	21.29164	-157.81307
HI000153	School	15003002701	Hokulani Elementary - Bldg C	2940 KAMAKINI ST	HONOLULU	96816	HI	MERBL	RM1L	1960	PC	2	$ 3,012,300	10,041	21.29164	-157.81307
HI000154	School	15003002701	Hokulani Elementary - Bldg D	2940 KAMAKINI ST	HONOLULU	96816	HI	MERBL	RM1L	1964	PC	1	$ 1,872,900	6,243	21.29164	-157.81307
HI000155	School	15003002701	Hokulani Elementary - Bldg G	2940 KAMAKINI ST	HONOLULU	96816	HI	MERBL	RM1L	1971	PC	1	$ 387,600	1,292	21.29164	-157.81307
HI000156	School	15003008913	Honowai Elementary - Bldg A	94-660 HONOWAI ST	WAIPAHU	96797	HI	MERBL	RM1L	1968	PC	1	$ 1,408,800	4,696	21.38373	-158.02621
HI000157	School	15003008913	Honowai Elementary - Bldg B	94-660 HONOWAI ST	WAIPAHU	96797	HI	MERBL	RM1L	1968	PC	1	$ 1,219,200	4,064	21.38373	-158.02621
HI000158	School	15003008913	Honowai Elementary - Bldg C	94-660 HONOWAI ST	WAIPAHU	96797	HI	MERBL	RM1L	1968	PC	1	$ 1,629,600	5,432	21.38373	-158.02621
HI000159	School	15003008913	Honowai Elementary - Bldg D	94-660 HONOWAI ST	WAIPAHU	96797	HI	MERBL	RM1L	1968	PC	1	$ 2,652,000	8,840	21.38373	-158.02621
HI000160	School	15003008913	Honowai Elementary - Bldg F	94-660 HONOWAI ST	WAIPAHU	96797	HI	WSF1	W1	1968	PC	1	$ 1,503,600	8,592	21.38373	-158.02621
HI000161	School	15003008913	Honowai Elementary - Bldg G	94-660 HONOWAI ST	WAIPAHU	96797	HI	MERBL	RM1L	1968	PC	2	$ 1,612,800	5,376	21.38373	-158.02621
HI000162	School	15003008913	Honowai Elementary - Bldg H	94-660 HONOWAI ST	WAIPAHU	96797	HI	MERBL	RM1L	1968	PC	1	$ 1,075,200	3,584	21.38373	-158.02621

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000163	School	15003008913	Honowai Elementary - Bldg J	94-660 HONOWAI ST	WAIPAHU	96797	HI	MERBL	RM1L	1968	PC	1	$ 537,600	1,792	21.38373	-158.02621
HI000164	School	15003008913	Honowai Elementary - Bldg K	94-660 HONOWAI ST	WAIPAHU	96797	HI	WSF1	W1	1968	PC	1	$ 485,100	2,772	21.38373	-158.02621
HI000165	School	15003008913	Honowai Elementary - Bldg L	94-660 HONOWAI ST	WAIPAHU	96797	HI	MERBL	RM1L	1968	PC	1	$ 1,095,600	3,652	21.38373	-158.02621
HI000166	School	15003009200	Iliahi Elementary - Bldg A	2035 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1964	PC	2	$ 3,961,800	13,206	21.50623	-157.99909
HI000167	School	15003009200	Iliahi Elementary - Bldg C	2035 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1965	PC	2	$ 4,251,600	14,172	21.50623	-157.99909
HI000168	School	15003009200	Iliahi Elementary - Bldg D	2035 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1969	PC	1	$ 1,974,900	6,583	21.50623	-157.99909
HI000169	School	15003008302	Ilima Intermediate - Bldg A	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1962	PC	2	$ 3,160,200	10,534	21.31716	-158.01090
HI000170	School	15003008302	Ilima Intermediate - Bldg B	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1962	PC	2	$ 3,279,900	10,933	21.31716	-158.01090
HI000171	School	15003008302	Ilima Intermediate - Bldg C	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1962	PC	2	$ 4,520,400	15,068	21.31716	-158.01090
HI000172	School	15003008302	Ilima Intermediate - Bldg D	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1962	PC	2	$ 1,301,100	4,337	21.31716	-158.01090
HI000173	School	15003008302	Ilima Intermediate - Bldg E	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1962	PC	2	$ 3,900,600	13,002	21.31716	-158.01090
HI000174	School	15003008302	Ilima Intermediate - Bldg I	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1980	PC	1	$ 3,635,400	12,118	21.31716	-158.01090
HI000175	School	15003008302	Ilima Intermediate - Bldg J	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1963	PC	1	$ 1,575,300	5,251	21.31716	-158.01090
HI000176	School	15003001100	Jarrett Intermediate - Bldg A	3360 KALUA RD	HONOLULU	96816	HI	MERBL	RM1L	1956	PC	2	$ 2,703,900	9,013	21.29712	-157.79724
HI000177	School	15003001100	Jarrett Intermediate - Bldg B	3360 KALUA RD	HONOLULU	96816	HI	MERBL	RM1L	1956	PC	2	$ 2,685,300	8,951	21.29712	-157.79724
HI000178	School	15003001100	Jarrett Intermediate - Bldg C	3360 KALUA RD	HONOLULU	96816	HI	MERBL	RM1L	1957	PC	2	$ 4,860,300	16,201	21.29712	-157.79724
HI000179	School	15003001100	Jarrett Intermediate - Bldg D	3360 KALUA RD	HONOLULU	96816	HI	MERBL	RM1L	1958	PC	2	$ 2,304,000	7,680	21.29712	-157.79724
HI000180	School	15003001100	Jarrett Intermediate - Bldg E	3360 KALUA RD	HONOLULU	96816	HI	MERBL	RM1L	1960	PC	1	$ 3,573,900	11,913	21.29712	-157.79724
HI000181	School	15003001100	Jarrett Intermediate - Bldg G	3360 KALUA RD	HONOLULU	96816	HI	MERBL	RM1L	1956	PC	1	$ 3,145,800	10,486	21.29712	-157.79724
HI000182	School	15003001100	Jarrett Intermediate - Bldg I	3360 KALUA RD	HONOLULU	96816	HI	MERBL	RM1L	1957	PC	1	$ 2,017,800	6,726	21.29712	-157.79724
HI000183	School	15003001802	Jefferson Elementary - Bldg C	324 KAPAHULU AVE	HONOLULU	96815	HI	MERBL	RM1L	1951	PC	1	$ 1,900,800	6,336	21.27326	-157.81828
HI000184	School	15003001802	Jefferson Elementary - Bldg L	324 KAPAHULU AVE	HONOLULU	96815	HI	MERBL	RM1L	1973	PC	1	$ 2,437,200	8,124	21.27326	-157.81828
HI000185	School	15003001802	Jefferson Elementary - Bldg M	324 KAPAHULU AVE	HONOLULU	96815	HI	MERBL	RM1L	1973	PC	1	$ 1,429,200	4,764	21.27326	-157.81828
HI000186	School	15003001802	Jefferson Elementary - Bldg N	324 KAPAHULU AVE	HONOLULU	96815	HI	MERBL	RM1L	1973	PC	1	$ 1,429,200	4,764	21.27326	-157.81828
HI000187	School	15003001802	Jefferson Elementary - Bldg O	324 KAPAHULU AVE	HONOLULU	96815	HI	MERBL	RM1L	1973	PC	1	$ 1,429,200	4,764	21.27326	-157.81828
HI000188	School	15003001802	Jefferson Elementary - Bldg Q	324 KAPAHULU AVE	HONOLULU	96815	HI	MERBL	RM1L	1973	PC	1	$ 3,014,400	10,048	21.27326	-157.81828
HI000189	School	15003001802	Jefferson Elementary - Bldg R	324 KAPAHULU AVE	HONOLULU	96815	HI	WSF2	W1	1975	PC	2	$ 3,161,200	18,064	21.27326	-157.81828
HI000190	School	15003003500	Kaahumanu Elementary - Bldg C	1141 KINAU ST	HONOLULU	96814	HI	MERBL	RM1L	1967	PC	1	$ 2,384,400	7,948	21.30211	-157.84376
HI000191	School	15003009400	Kaala Elementary - Bldg A	130 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1958	PC	1	$ 1,857,300	6,191	21.49429	-158.03653
HI000192	School	15003009400	Kaala Elementary - Bldg D	130 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1959	PC	2	$ 3,795,300	12,651	21.49429	-158.03653
HI000193	School	15003006301	Kaewai Elementary - Bldg A	1929 KAM IV RD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	1	$ 998,400	3,328	21.34465	-157.86923
HI000194	School	15003006301	Kaewai Elementary - Bldg B	1929 KAM IV RD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	1	$ 998,400	3,328	21.34465	-157.86923
HI000195	School	15003006301	Kaewai Elementary - Bldg C	1929 KAM IV RD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	1	$ 998,400	3,328	21.34465	-157.86923
HI000196	School	15003006301	Kaewai Elementary - Bldg D	1929 KAM IV RD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	1	$ 1,102,800	3,676	21.34465	-157.86923
HI000197	School	15003006301	Kaewai Elementary - Bldg E	1929 KAM IV RD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	1	$ 1,069,500	3,565	21.34465	-157.86923
HI000198	School	15003006301	Kaewai Elementary - Bldg F	1929 KAM IV RD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	1	$ 1,069,500	3,565	21.34465	-157.86923
HI000199	School	15003006301	Kaewai Elementary - Bldg G	1929 KAM IV RD	HONOLULU	96819	HI	MERBL	RM1L	1963	PC	1	$ 1,257,300	4,191	21.34465	-157.86923
HI000200	School	15003006301	Kaewai Elementary - Bldg K	1929 KAM IV RD	HONOLULU	96819	HI	MERBL	RM1L	1970	PC	1	$ 910,200	3,034	21.34465	-157.86923
HI000201	School	15003000500	Kahala Elementary - Bldg A	4559 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1958	PC	1	$ 1,616,700	5,389	21.27322	-157.78448
HI000202	School	15003000500	Kahala Elementary - Bldg B	4559 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1955	PC	1	$ 1,070,400	3,568	21.27322	-157.78448
HI000203	School	15003000500	Kahala Elementary - Bldg C	4559 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1955	PC	1	$ 1,248,900	4,163	21.27322	-157.78448
HI000204	School	15003000500	Kahala Elementary - Bldg D	4559 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1954	PC	1	$ 1,713,600	5,712	21.27322	-157.78448
HI000205	School	15003000500	Kahala Elementary - Bldg E	4559 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1956	PC	1	$ 2,644,200	8,814	21.27322	-157.78448
HI000206	School	15003000500	Kahala Elementary - Bldg G	4559 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1956	PC	1	$ 2,152,800	7,176	21.27322	-157.78448
HI000207	School	15003010303	Kahaluu Elementary - Bldg A	47-248 WAIHEE RD	KANEOHE	96744	HI	MERBL	RM1L	1963	PC	1	$ 1,929,000	6,430	21.45738	-157.84587
HI000208	School	15003010303	Kahaluu Elementary - Bldg B	47-248 WAIHEE RD	KANEOHE	96744	HI	MERBL	RM1L	1967	PC	1	$ 3,928,800	13,096	21.45738	-157.84587
HI000209	School	15003010303	Kahaluu Elementary - Bldg C	47-248 WAIHEE RD	KANEOHE	96744	HI	MERBL	RM1L	1963	PC	1	$ 2,432,100	8,107	21.45738	-157.84587
HI000210	School	15003010303	Kahaluu Elementary - Bldg D	47-248 WAIHEE RD	KANEOHE	96744	HI	MERBL	RM1L	1963	PC	1	$ 1,902,600	6,342	21.45738	-157.84587
HI000211	School	15003010303	Kahaluu Elementary - Bldg E	47-248 WAIHEE RD	KANEOHE	96744	HI	MERBL	RM1L	1969	PC	1	$ 876,600	2,922	21.45738	-157.84587
HI000212	School	15003010100	Kahuku Elementary - Bldg C	56-170 PUALALEA ST	KAHUKU	96731	HI	WSF1	W1	1991	HC	1	$ 545,300	3,116	21.67433	-157.95109
HI000213	School	15003010100	Kahuku High & Intermediate - Bldg A	56-490 KAM HWY	KAHUKU	96731	HI	WSF1	W1	1993	HC	1	$ 3,426,675	19,581	21.67533	-157.94797
HI000214	School	15003010100	Kahuku High & Intermediate - Bldg D	56-490 KAM HWY	KAHUKU	96731	HI	MERBL	RM1L	1962	PC	1	$ 1,937,700	6,459	21.67533	-157.94797
HI000215	School	15003010100	Kahuku High & Intermediate - Bldg G	56-490 KAM HWY	KAHUKU	96731	HI	MERBL	RM1L	1968	PC	1	$ 2,786,400	9,288	21.67533	-157.94797
HI000216	School	15003010100	Kahuku High & Intermediate - Bldg O	56-490 KAM HWY	KAHUKU	96731	HI	WSF1	W1	1971	PC	1	$ 602,350	3,442	21.67533	-157.94797

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000217	School	15003010100	Kahuku High & Intermediate - Bldg R	56-490 KAM HWY	KAHUKU	96731	HI	MERBL	RM1L	1965	PC	1	$ 2,121,600	7,072	21.67533	-157.94797
HI000218	School	15003010100	Kahuku High & Intermediate - Bldg V	56-490 KAM HWY	KAHUKU	96731	HI	MERBL	RM1L	1978	PC	1	$ 5,612,400	18,708	21.67533	-157.94797
HI000219	School	15003010100	Kahuku High & Intermediate - Bldg W	56-490 KAM HWY	KAHUKU	96731	HI	MERBL	RM1L	1979	PC	3	$ 7,112,400	23,708	21.67533	-157.94797
HI000220	School	15003010100	Kahuku High & Intermediate - Bldg X	56-490 KAM HWY	KAHUKU	96731	HI	WSF1	W1	1980	LC	1	$ 2,255,400	12,888	21.67533	-157.94797
HI000221	School	15003010100	Kahuku High & Intermediate - Bldg Y	56-490 KAM HWY	KAHUKU	96731	HI	MERBL	RM1L	1987	HC	1	$ 4,738,200	15,794	21.67533	-157.94797
HI000222	School	15003010100	Kahuku High & Intermediate - Bldg Z	56-490 KAM HWY	KAHUKU	96731	HI	MERBL	RM1L	1985	HC	1	$ 3,264,000	10,880	21.67533	-157.94797
HI000223	School	15003011105	Kailua Elementary - Bldg C	315 KUULEI RD	KAILUA	96734	HI	MERBL	RM1L	1951	PC	1	$ 1,557,000	5,190	21.39507	-157.74136
HI000224	School	15003011105	Kailua Elementary - Bldg D	315 KUULEI RD	KAILUA	96734	HI	MERBL	RM1L	1951	PC	1	$ 1,379,700	4,599	21.39507	-157.74136
HI000225	School	15003011105	Kailua Elementary - Bldg E	315 KUULEI RD	KAILUA	96734	HI	MERBL	RM1L	1951	PC	1	$ 832,500	2,775	21.39507	-157.74136
HI000226	School	15003011105	Kailua Elementary - Bldg G	315 KUULEI RD	KAILUA	96734	HI	MERBL	RM1L	1951	PC	1	$ 832,500	2,775	21.39507	-157.74136
HI000227	School	15003011105	Kailua Elementary - Bldg H	315 KUULEI RD	KAILUA	96734	HI	WSF1	W1	1957	PC	1	$ 1,464,400	8,368	21.39507	-157.74136
HI000228	School	15003011105	Kailua Elementary - Bldg J	315 KUULEI RD	KAILUA	96734	HI	MERBL	RM1L	1951	PC	1	$ 799,800	2,666	21.39507	-157.74136
HI000229	School	15003011103	Kailua High - Bldg A	451 ULUMANU DR	KAILUA	96734	HI	MERBL	RM1L	1960	PC	2	$ 3,975,300	13,251	21.38481	-157.74818
HI000230	School	15003011103	Kailua High - Bldg B	451 ULUMANU DR	KAILUA	96734	HI	MERBL	RM1L	1958	PC	2	$ 3,884,400	12,948	21.38481	-157.74818
HI000231	School	15003011103	Kailua High - Bldg C	451 ULUMANU DR	KAILUA	96734	HI	MERBL	RM1L	1958	PC	2	$ 4,184,400	13,948	21.38481	-157.74818
HI000232	School	15003011103	Kailua High - Bldg D	451 ULUMANU DR	KAILUA	96734	HI	MERBL	RM1L	1959	PC	2	$ 5,250,000	17,500	21.38481	-157.74818
HI000233	School	15003011103	Kailua High - Bldg E	451 ULUMANU DR	KAILUA	96734	HI	MERBL	RM1L	1959	PC	2	$ 5,150,400	17,168	21.38481	-157.74818
HI000234	School	15003011103	Kailua High - Bldg F	451 ULUMANU DR	KAILUA	96734	HI	MERBL	RM1L	1962	PC	2	$ 3,001,200	10,004	21.38481	-157.74818
HI000235	School	15003011103	Kailua High - Bldg Q	451 ULUMANU DR	KAILUA	96734	HI	MERBL	RM1L	1962	PC	1	$ 1,361,400	4,538	21.38481	-157.74818
HI000236	School	15003011103	Kailua High - Bldg T	451 ULUMANU DR	KAILUA	96734	HI	WSF1	W1	1969	PC	1	$ 875,000	5,000	21.38481	-157.74818
HI000237	School	15003011105	Kailua Intermediate - Bldg A	211 KUULEI RD	KAILUA	96734	HI	WSF1	W1	1953	PC	1	$ 2,599,450	14,854	21.39406	-157.73619
HI000238	School	15003011105	Kailua Intermediate - Bldg B	211 KUULEI RD	KAILUA	96734	HI	MERBL	RM1L	1953	PC	1	$ 8,670,300	28,901	21.39406	-157.73619
HI000239	School	15003011105	Kailua Intermediate - Bldg C	211 KUULEI RD	KAILUA	96734	HI	MERBL	RM1L	1955	PC	1	$ 7,069,500	23,565	21.39406	-157.73619
HI000240	School	15003011105	Kailua Intermediate - Bldg H	211 KUULEI RD	KAILUA	96734	HI	MERBL	RM1L	1970	PC	1	$ 3,874,800	12,916	21.39406	-157.73619
HI000241	School	15003008302	Kaimiloa Elementary - Bldg B	91-1028 KAUNOLU ST	EWA BEACH	96706	HI	WSF1	W1	1978	LC	1	$ 1,131,375	6,465	21.31921	-158.00919
HI000242	School	15003008302	Kaimiloa Elementary - Bldg E	91-1028 KAUNOLU ST	EWA BEACH	96706	HI	MERBL	RM1L	1990	HC	2	$ 3,869,400	12,898	21.31921	-158.00919
HI000243	School	15003008302	Kaimiloa Elementary - Bldg F	91-1028 KAUNOLU ST	EWA BEACH	96706	HI	MERBL	RM1L	1975	PC	2	$ 5,339,700	17,799	21.31921	-158.00919
HI000244	School	15003008302	Kaimiloa Elementary - Bldg P25	91-1028 KAUNOLU ST	EWA BEACH	96706	HI	WSF1	W1	1968	PC	1	$ 156,800	896	21.31921	-158.00919
HI000245	School	15003002100	Kaimuki High - Bldg A	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1949	PC	2	$ 3,147,600	10,492	21.28597	-157.81747
HI000246	School	15003002100	Kaimuki High - Bldg B	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1949	PC	2	$ 3,147,600	10,492	21.28597	-157.81747
HI000247	School	15003002100	Kaimuki High - Bldg C	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1949	PC	2	$ 3,147,600	10,492	21.28597	-157.81747
HI000248	School	15003002100	Kaimuki High - Bldg E	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1951	PC	1	$ 2,009,100	6,697	21.28597	-157.81747
HI000249	School	15003002100	Kaimuki High - Bldg F	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1952	PC	2	$ 3,175,500	10,585	21.28597	-157.81747
HI000250	School	15003002100	Kaimuki High - Bldg G	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1952	PC	2	$ 3,043,200	10,144	21.28597	-157.81747
HI000251	School	15003002100	Kaimuki High - Bldg H	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1949	PC	2	$ 3,147,600	10,492	21.28597	-157.81747
HI000252	School	15003002100	Kaimuki High - Bldg R	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1965	PC	1	$ 616,800	2,056	21.28597	-157.81747
HI000253	School	15003002100	Kaimuki High - Bldg T	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1962	PC	1	$ 804,000	2,680	21.28597	-157.81747
HI000254	School	15003002100	Kaimuki High - Bldg U	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1982	HC	1	$ 1,518,600	5,062	21.28597	-157.81747
HI000255	School	15003002100	Kaimuki High - Bldg X	2705 KAIMUKI AVE	HONOLULU	96816	HI	MERBL	RM1L	1977	PC	1	$ 6,162,000	20,540	21.28597	-157.81747
HI000256	School	15003000700	Kaimuki Middle - Bldg B	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1963	PC	1	$ 1,103,100	3,677	21.26989	-157.79698
HI000257	School	15003000700	Kaimuki Middle - Bldg C	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1959	PC	2	$ 4,427,700	14,759	21.26989	-157.79698
HI000258	School	15003000700	Kaimuki Middle - Bldg H	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1957	PC	1	$ 2,157,600	7,192	21.26989	-157.79698
HI000259	School	15003000700	Kaimuki Middle - Bldg J	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1957	PC	2	$ 4,339,800	14,466	21.26989	-157.79698
HI000260	School	15003000700	Kaimuki Middle - Bldg K	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1960	PC	2	$ 3,019,200	10,064	21.26989	-157.79698
HI000261	School	15003000700	Kaimuki Middle - Bldg L	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1963	PC	1	$ 1,029,600	3,432	21.26989	-157.79698
HI000262	School	15003000700	Kaimuki Middle - Bldg N	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1956	PC	1	$ 1,808,400	6,028	21.26989	-157.79698
HI000263	School	15003000700	Kaimuki Middle - Bldg P1	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1967	PC	1	$ 268,800	896	21.26989	-157.79698
HI000264	School	15003000700	Kaimuki Middle - Bldg P2	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1967	PC	1	$ 268,800	896	21.26989	-157.79698
HI000265	School	15003000700	Kaimuki Middle - Bldg P3	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1967	PC	1	$ 268,800	896	21.26989	-157.79698
HI000266	School	15003000700	Kaimuki Middle - Bldg P4	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1967	PC	1	$ 268,800	896	21.26989	-157.79698
HI000267	School	15003000700	Kaimuki Middle - Bldg R	4031 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1969	PC	1	$ 1,737,300	5,791	21.26989	-157.79698
HI000268	School	15003010904	Kainalu Elementary - Bldg D	165 KAIHOLU ST	KAILUA	96734	HI	MERBL	RM1L	1955	PC	1	$ 1,768,800	5,896	21.41288	-157.74830
HI000269	School	15003010904	Kainalu Elementary - Bldg E	165 KAIHOLU ST	KAILUA	96734	HI	MERBL	RM1L	1955	PC	1	$ 1,768,800	5,896	21.41288	-157.74830
HI000270	School	15003010904	Kainalu Elementary - Bldg P1	165 KAIHOLU ST	KAILUA	96734	HI	WSF1	W1	1954	PC	1	$ 156,800	896	21.41288	-157.74830
HI000271	School	15003010904	Kainalu Elementary - Bldg P2	165 KAIHOLU ST	KAILUA	96734	HI	WSF1	W1	1954	PC	1	$ 156,800	896	21.41288	-157.74830

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000272	School	15003010904	Kainalu Elementary - Bldg P3	165 KAIHOLU ST	KAILUA	96734	HI	WSF1	W1	1954	PC	1	$ 156,800	896	21.41288	-157.74830
HI000273	School	15003010904	Kainalu Elementary - Bldg P4	165 KAIHOLU ST	KAILUA	96734	HI	WSF1	W1	1954	PC	1	$ 156,800	896	21.41288	-157.74830
HI000274	School	15003000105	Kaiser High - Bldg A	511 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1971	PC	3	$ 6,309,000	21,030	21.28478	-157.69600
HI000275	School	15003000105	Kaiser High - Bldg B	511 LUNALILO HOME RD	HONOLULU	96825	HI	WSF1	W1	1971	PC	1	$ 1,262,975	7,217	21.28478	-157.69600
HI000276	School	15003000105	Kaiser High - Bldg C	511 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1972	PC	3	$ 3,753,900	12,513	21.28478	-157.69600
HI000277	School	15003000105	Kaiser High - Bldg E	511 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1972	PC	3	$ 1,662,300	5,541	21.28478	-157.69600
HI000278	School	15003000105	Kaiser High - Bldg G	511 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1973	PC	2	$ 3,260,700	10,869	21.28478	-157.69600
HI000279	School	15003000105	Kaiser High - Bldg H	511 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1973	PC	3	$ 21,647,100	72,157	21.28478	-157.69600
HI000280	School	15003000105	Kaiser High - Bldg K	511 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1974	PC	2	$ 3,560,700	11,869	21.28478	-157.69600
HI000281	School	15003000105	Kaiser High - Bldg L	511 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1974	PC	1	$ 6,623,700	22,079	21.28478	-157.69600
HI000282	School	15003005700	Kaiulani Elementary - Bldg A	783 N KING ST	HONOLULU	96817	HI	MERBL	RM1L	1956	PC	2	$ 3,220,200	10,734	21.32121	-157.86760
HI000283	School	15003005700	Kaiulani Elementary - Bldg B	783 N KING ST	HONOLULU	96817	HI	MERBL	RM1L	1956	PC	2	$ 3,220,200	10,734	21.32121	-157.86760
HI000284	School	15003005700	Kaiulani Elementary - Bldg C	783 N KING ST	HONOLULU	96817	HI	MERBL	RM1L	1960	PC	2	$ 3,150,900	10,503	21.32121	-157.86760
HI000285	School	15003005700	Kaiulani Elementary - Bldg F	783 N KING ST	HONOLULU	96817	HI	WSF2	W1	1970	PC	2	$ 1,157,800	6,616	21.32121	-157.86760
HI000286	School	15003010901	Kalaheo High - Bldg A	730 ILIAINA ST	KAILUA	96734	HI	MERBL	RM1L	1968	PC	2	$ 2,841,600	9,472	21.40799	-157.75773
HI000287	School	15003010901	Kalaheo High - Bldg C	730 ILIAINA ST	KAILUA	96734	HI	MERBL	RM1L	1966	PC	2	$ 2,941,500	9,805	21.40799	-157.75773
HI000288	School	15003010901	Kalaheo High - Bldg D	730 ILIAINA ST	KAILUA	96734	HI	MERBL	RM1L	1968	PC	2	$ 3,543,600	11,812	21.40799	-157.75773
HI000289	School	15003010901	Kalaheo High - Bldg F	730 ILIAINA ST	KAILUA	96734	HI	MERBL	RM1L	1970	PC	2	$ 3,104,400	10,348	21.40799	-157.75773
HI000290	School	15003010901	Kalaheo High - Bldg G	730 ILIAINA ST	KAILUA	96734	HI	MERBL	RM1L	1974	PC	1	$ 6,899,700	22,999	21.40799	-157.75773
HI000291	School	15003010901	Kalaheo High - Bldg H	730 ILIAINA ST	KAILUA	96734	HI	WSF2	W1	1974	PC	2	$ 5,127,850	29,302	21.40799	-157.75773
HI000292	School	15003010901	Kalaheo High - Bldg I	730 ILIAINA ST	KAILUA	96734	HI	WSF1	W1	1966	PC	1	$ 1,771,875	10,125	21.40799	-157.75773
HI000293	School	15003010901	Kalaheo High - Bldg J	730 ILIAINA ST	KAILUA	96734	HI	WSF1	W2	1968	PC	1	$ 782,250	4,470	21.40799	-157.75773
HI000294	School	15003010901	Kalaheo High - Bldg K	730 ILIAINA ST	KAILUA	96734	HI	WSF2	W1	1966	PC	2	$ 3,610,425	20,631	21.40799	-157.75773
HI000295	School	15003010901	Kalaheo High - Bldg L	730 ILIAINA ST	KAILUA	96734	HI	MERBL	RM1L	1968	PC	2	$ 2,603,100	8,677	21.40799	-157.75773
HI000296	School	15003010901	Kalaheo High - Bldg M	730 ILIAINA ST	KAILUA	96734	HI	MERBL	RM1L	1975	PC	1	$ 3,069,900	10,233	21.40799	-157.75773
HI000297	School	15003005800	Kalakaua Middle - Bldg E	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1965	PC	2	$ 3,600,000	12,000	21.32832	-157.87662
HI000298	School	15003005800	Kalakaua Middle - Bldg F	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1961	PC	1	$ 2,821,500	9,405	21.32832	-157.87662
HI000299	School	15003005800	Kalakaua Middle - Bldg K	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1967	PC	1	$ 2,089,800	6,966	21.32832	-157.87662
HI000300	School	15003005800	Kalakaua Middle - Bldg L	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1963	PC	2	$ 3,768,000	12,560	21.32832	-157.87662
HI000301	School	15003005800	Kalakaua Middle - Bldg M	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1971	PC	1	$ 1,333,200	4,444	21.32832	-157.87662
HI000302	School	15003005800	Kalakaua Middle - Bldg N	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1971	PC	2	$ 2,876,400	9,588	21.32832	-157.87662
HI000303	School	15003005800	Kalakaua Middle - Bldg O	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1971	PC	2	$ 2,850,000	9,500	21.32832	-157.87662
HI000304	School	15003005800	Kalakaua Middle - Bldg R	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1973	PC	2	$ 2,864,100	9,547	21.32832	-157.87662
HI000305	School	15003005800	Kalakaua Middle - Bldg U	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1977	PC	1	$ 1,312,500	4,375	21.32832	-157.87662
HI000306	School	15003000402	Kalani High - Bldg A	4686 KALANIANAOLE HWY	HONOLULU	96821	HI	MERBL	RM1L	1958	PC	2	$ 3,402,300	11,341	21.27855	-157.77426
HI000307	School	15003000402	Kalani High - Bldg B	4686 KALANIANAOLE HWY	HONOLULU	96821	HI	MERBL	RM1L	1958	PC	2	$ 4,620,000	15,400	21.27855	-157.77426
HI000308	School	15003000402	Kalani High - Bldg C	4686 KALANIANAOLE HWY	HONOLULU	96821	HI	MERBL	RM1L	1960	PC	2	$ 5,931,600	19,772	21.27855	-157.77426
HI000309	School	15003000402	Kalani High - Bldg D	4686 KALANIANAOLE HWY	HONOLULU	96821	HI	MERBL	RM1L	1960	PC	2	$ 4,857,900	16,193	21.27855	-157.77426
HI000310	School	15003000402	Kalani High - Bldg E	4686 KALANIANAOLE HWY	HONOLULU	96821	HI	MERBL	RM1L	1963	PC	2	$ 4,359,000	14,530	21.27855	-157.77426
HI000311	School	15003000402	Kalani High - Bldg F	4686 KALANIANAOLE HWY	HONOLULU	96821	HI	MERBL	RM1L	1958	PC	1	$ 1,140,000	3,800	21.27855	-157.77426
HI000312	School	15003000402	Kalani High - Bldg K	4686 KALANIANAOLE HWY	HONOLULU	96821	HI	MERBL	RM1L	1960	PC	1	$ 1,376,400	4,588	21.27855	-157.77426
HI000313	School	15003000402	Kalani High - Bldg N	4686 KALANIANAOLE HWY	HONOLULU	96821	HI	MERBL	RM1L	1969	PC	2	$ 3,219,900	10,733	21.27855	-157.77426
HI000314	School	15003008905	Kaleiopuu Elementary - Bldg D	94-665 KAAHOLO ST	WAIPAHU	96797	HI	MERBL	RM1L	1989	HC	2	$ 2,511,600	8,372	21.39122	-158.02813
HI000315	School	15003008905	Kaleiopuu Elementary - Bldg E	94-665 KAAHOLO ST	WAIPAHU	96797	HI	MERBL	RM1L	1989	HC	2	$ 2,553,300	8,511	21.39122	-158.02813
HI000316	School	15003008905	Kaleiopuu Elementary - Bldg F	94-665 KAAHOLO ST	WAIPAHU	96797	HI	MERBL	RM1L	1989	HC	2	$ 2,524,800	8,416	21.39122	-158.02813
HI000317	School	15003008905	Kaleiopuu Elementary - Bldg G	94-665 KAAHOLO ST	WAIPAHU	96797	HI	MERBL	RM1L	1990	HC	2	$ 2,652,900	8,843	21.39122	-158.02813
HI000318	School	15003008905	Kaleiopuu Elementary - Bldg H	94-665 KAAHOLO ST	WAIPAHU	96797	HI	MERBL	RM1L	1993	HC	2	$ 3,120,000	10,400	21.39122	-158.02813
HI000319	School	15003008905	Kaleiopuu Elementary - Bldg P7	94-665 KAAHOLO ST	WAIPAHU	96797	HI	WSF1	W1	1994	HC	1	$ 142,100	812	21.39122	-158.02813
HI000320	School	15003006500	Kalihi Elementary - Bldg A	2471 KULA KOLEA DR	HONOLULU	96819	HI	WMUH3	W1	1954	PC	3	$ 3,414,950	19,514	21.35302	-157.86099
HI000321	School	15003006500	Kalihi Elementary - Bldg B	2472 KULA KOLEA DR	HONOLULU	96819	HI	WMUH3	W1	1954	PC	3	$ 2,572,150	14,698	21.35302	-157.86099
HI000322	School	15003005800	Kalihi Kai Elementary - Bldg B	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1964	PC	1	$ 1,256,100	4,187	21.32656	-157.87809
HI000323	School	15003005800	Kalihi Kai Elementary - Bldg C	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1958	PC	2	$ 2,630,400	8,768	21.32656	-157.87809
HI000324	School	15003005800	Kalihi Kai Elementary - Bldg H	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1961	PC	2	$ 2,780,400	9,268	21.32656	-157.87809
HI000325	School	15003005800	Kalihi Kai Elementary - Bldg I	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1965	PC	2	$ 2,780,400	9,268	21.32656	-157.87809

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000326	School	15003005800	Kalihi Kai Elementary - Bldg J	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1966	PC	2	$ 2,783,400	9,278	21.32656	-157.87809
HI000327	School	15003005800	Kalihi Kai Elementary - Bldg K	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1973	PC	2	$ 3,129,900	10,433	21.32656	-157.87809
HI000328	School	15003005800	Kalihi Kai Elementary - Bldg L	821 KALIHI ST	HONOLULU	96817	HI	MERBL	RM1L	1977	PC	1	$ 2,424,900	8,083	21.32656	-157.87809
HI000329	School	15003006402	Kalihi Uka Elementary - Bldg B	2411 KALIHI ST	HONOLULU	96819	HI	MERBL	RM1L	1961	PC	2	$ 3,813,600	12,712	21.34504	-157.86197
HI000330	School	15003006402	Kalihi Uka Elementary - Bldg A	2411 KALIHI ST	HONOLULU	96819	HI	MERBL	RM1L	1964	PC	1	$ 2,599,800	8,666	21.34504	-157.86197
HI000331	School	15003006402	Kalihi Uka Elementary - Bldg C	2411 KALIHI ST	HONOLULU	96819	HI	MERBL	RM1L	1968	PC	3	$ 5,371,800	17,906	21.34504	-157.86197
HI000332	School	15003006100	Kalihi Waena Elementary - Bldg D	1240 GULICK AVE	HONOLULU	96819	HI	MERBL	RM1L	1965	PC	2	$ 2,336,700	7,789	21.33628	-157.87578
HI000333	School	15003006100	Kalihi Waena Elementary - Bldg H	1240 GULICK AVE	HONOLULU	96819	HI	MERBL	RM1L	1973	PC	1	$ 1,527,300	5,091	21.33628	-157.87578
HI000334	School	15003009701	Kamaile Elementary PCCS - Bldg C	85-180 ALA AKAU ST	WAIANAE	96792	HI	WSF1	W1	1991	HC	1	$ 1,190,875	6,805	21.45709	-158.19539
HI000335	School	15003009701	Kamaile Elementary PCCS - Bldg D	85-180 ALA AKAU ST	WAIANAE	96792	HI	MERBL	RM1L	1989	HC	2	$ 2,772,900	9,243	21.45709	-158.19539
HI000336	School	15003009701	Kamaile Elementary PCCS - Bldg E	85-180 ALA AKAU ST	WAIANAE	96792	HI	MERBL	RM1L	1989	HC	2	$ 2,605,200	8,684	21.45709	-158.19539
HI000337	School	15003009701	Kamaile Elementary PCCS - Bldg F	85-180 ALA AKAU ST	WAIANAE	96792	HI	MERBL	RM1L	1993	HC	2	$ 2,973,900	9,913	21.45709	-158.19539
HI000338	School	15003009701	Kamaile Elementary PCCS - Bldg G	85-180 ALA AKAU ST	WAIANAE	96792	HI	MERBL	RM1L	1990	HC	2	$ 2,669,100	8,897	21.45709	-158.19539
HI000339	School	15003000109	Kamiloiki Elementary - Bldg A	7788 HAWAII KAI DR	HONOLULU	96825	HI	MERBL	RM1L	1973	PC	2	$ 5,274,000	17,580	21.29427	-157.68493
HI000340	School	15003000109	Kamiloiki Elementary - Bldg C	7788 HAWAII KAI DR	HONOLULU	96825	HI	MERBL	RM1L	1971	PC	2	$ 5,438,400	18,128	21.29427	-157.68493
HI000341	School	15003000109	Kamiloiki Elementary - Bldg E	7788 HAWAII KAI DR	HONOLULU	96825	HI	WSF1	W1	1975	PC	1	$ 1,171,275	6,693	21.29427	-157.68493
HI000342	School	15003010602	Kaneohe Elementary - Bldg C	45-495 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1956	PC	1	$ 2,370,900	7,903	21.39595	-157.79585
HI000343	School	15003010602	Kaneohe Elementary - Bldg D	45-495 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1956	PC	1	$ 2,370,900	7,903	21.39595	-157.79585
HI000344	School	15003010602	Kaneohe Elementary - Bldg E	45-495 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1956	PC	1	$ 1,493,100	4,977	21.39595	-157.79585
HI000345	School	15003010602	Kaneohe Elementary - Bldg F	45-495 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1958	PC	1	$ 1,493,100	4,977	21.39595	-157.79585
HI000346	School	15003008923	Kanoelani Elementary - Bldg A	94-1091 OLI LP	WAIPAHU	96797	HI	MERBL	RM1L	1982	HC	1	$ 2,656,500	8,855	21.41609	-157.99850
HI000347	School	15003008923	Kanoelani Elementary - Bldg B	94-1091 OLI LP	WAIPAHU	96797	HI	MERBL	RM1L	1982	HC	1	$ 2,640,000	8,800	21.41609	-157.99850
HI000348	School	15003008923	Kanoelani Elementary - Bldg C	94-1091 OLI LP	WAIPAHU	96797	HI	MERBL	RM1L	1984	HC	2	$ 2,029,800	6,766	21.41609	-157.99850
HI000349	School	15003008923	Kanoelani Elementary - Bldg D	94-1091 OLI LP	WAIPAHU	96797	HI	WSF1	W1	1987	HC	1	$ 989,625	5,655	21.41609	-157.99850
HI000350	School	15003008923	Kanoelani Elementary - Bldg F	94-1091 OLI LP	WAIPAHU	96797	HI	MERBL	RM1L	1987	HC	1	$ 1,347,900	4,493	21.41609	-157.99850
HI000351	School	15003005600	Kapalama Elementary - Bldg A	1601 N SCHOOL ST	HONOLULU	96817	HI	MERBL	RM1L	1965	PC	2	$ 2,886,600	9,622	21.33489	-157.86948
HI000352	School	15003005600	Kapalama Elementary - Bldg B	1601 N SCHOOL ST	HONOLULU	96817	HI	MERBL	RM1L	1966	PC	2	$ 2,821,200	9,404	21.33489	-157.86948
HI000353	School	15003005600	Kapalama Elementary - Bldg C	1601 N SCHOOL ST	HONOLULU	96817	HI	WSF2	W1	1970	PC	2	$ 2,091,600	11,952	21.33489	-157.86948
HI000354	School	15003005600	Kapalama Elementary - Bldg D	1601 N SCHOOL ST	HONOLULU	96817	HI	MERBL	RM1L	1954	PC	1	$ 1,927,200	6,424	21.33489	-157.86948
HI000355	School	15003005600	Kapalama Elementary - Bldg E	1601 N SCHOOL ST	HONOLULU	96817	HI	WSF1	W1	1967	PC	1	$ 1,423,975	8,137	21.33489	-157.86948
HI000356	School	15003005600	Kapalama Elementary - Bldg F	1601 N SCHOOL ST	HONOLULU	96817	HI	MERBL	RM1L	1957	PC	1	$ 4,043,100	13,477	21.33489	-157.86948
HI000357	School	15003008607	Kapolei Elementary - Bldg D	91-1119 KAMAAHA LP	KAPOLEI	96707	HI	MERBL	RM1L	1993	HC	2	$ 3,065,700	10,219	21.33389	-158.06433
HI000358	School	15003008607	Kapolei Elementary - Bldg E	91-1119 KAMAAHA LP	KAPOLEI	96707	HI	MERBL	RM1L	1993	HC	2	$ 2,793,600	9,312	21.33389	-158.06433
HI000359	School	15003008607	Kapolei Elementary - Bldg F	91-1119 KAMAAHA LP	KAPOLEI	96707	HI	MERBL	RM1L	1993	HC	2	$ 2,699,700	8,999	21.33389	-158.06433
HI000360	School	15003008607	Kapolei High - Bldg B	91-5007 KAPOLEI PKWY	KAPOLEI	96707	HI	WSF1	W1	2000	LS	1	$ 2,560,075	14,629	21.32859	-158.06851
HI000361	School	15003008607	Kapolei High - Bldg D	91-5007 KAPOLEI PKWY	KAPOLEI	96707	HI	WSF1	W1	2000	LS	1	$ 1,155,700	6,604	21.32859	-158.06851
HI000362	School	15003008607	Kapolei High - Bldg G	91-5007 KAPOLEI PKWY	KAPOLEI	96707	HI	WSF1	W1	2000	LS	1	$ 6,746,075	38,549	21.32859	-158.06851
HI000363	School	15003010302	Kapunahala Elementary - Bldg A	45-800 ANOI RD	KANEOHE	96744	HI	MERBL	RM1L	1962	PC	1	$ 2,224,200	7,414	21.40790	-157.80400
HI000364	School	15003010302	Kapunahala Elementary - Bldg B	45-800 ANOI RD	KANEOHE	96744	HI	MERBL	RM1L	1962	PC	2	$ 3,883,800	12,946	21.40790	-157.80400
HI000365	School	15003010302	Kapunahala Elementary - Bldg C	45-800 ANOI RD	KANEOHE	96744	HI	MERBL	RM1L	1963	PC	2	$ 3,883,800	12,946	21.40790	-157.80400
HI000366	School	15003010302	Kapunahala Elementary - Bldg D	45-800 ANOI RD	KANEOHE	96744	HI	WSF1	W1	1962	PC	1	$ 1,365,525	7,803	21.40790	-157.80400
HI000367	School	15003005300	Kauluwela Elementary - Bldg S	1480 AALA ST	HONOLULU	96817	HI	MERBL	RM1L	1973	PC	2	$ 3,195,600	10,652	21.31932	-157.85933
HI000368	School	15003004300	Kawananakoa Middle - Bldg C	49 FUNCHAL ST	HONOLULU	96813	HI	MERBL	RM1L	1964	PC	2	$ 1,356,300	4,521	21.31898	-157.85192
HI000369	School	15003004300	Kawananakoa Middle - Bldg D	49 FUNCHAL ST	HONOLULU	96813	HI	WSF1	W1	1962	PC	1	$ 1,485,050	8,486	21.31898	-157.85192
HI000370	School	15003004300	Kawananakoa Middle - Bldg F	49 FUNCHAL ST	HONOLULU	96813	HI	WSF2	W1	1960	PC	2	$ 1,091,300	6,236	21.31898	-157.85192
HI000371	School	15003004300	Kawananakoa Middle - Bldg G	49 FUNCHAL ST	HONOLULU	96813	HI	WSF2	W1	1960	PC	2	$ 1,039,675	5,941	21.31898	-157.85192
HI000372	School	15003004300	Kawananakoa Middle - Bldg H	49 FUNCHAL ST	HONOLULU	96813	HI	WSF2	W1	1939	PC	2	$ 2,270,975	12,977	21.31898	-157.85192
HI000373	School	15003004300	Kawananakoa Middle - Bldg J	49 FUNCHAL ST	HONOLULU	96813	HI	MERBL	RM1L	1970	PC	3	$ 5,100,300	17,001	21.31898	-157.85192
HI000374	School	15003004300	Kawananakoa Middle - Bldg K	49 FUNCHAL ST	HONOLULU	96813	HI	MERBL	RM1L	1970	PC	3	$ 4,041,600	13,472	21.31898	-157.85192
HI000375	School	15003010701	Ke Kula O Kamakau Lab PCS - Bldg D	45-35 KANEOHE BAY DR	KANEOHE	96744	HI	WSF1	W1	1947	PC	1	$ 34,300	196	21.41047	-157.77910
HI000376	School	15003010701	Ke Kula O Kamakau Lab PCS - Bldg D	45-35 KANEOHE BAY DR	KANEOHE	96744	HI	WSF1	W1	1949	PC	1	$ 34,300	196	21.41047	-157.77910
HI000377	School	15003011104	Keolu Elementary - Bldg A	1420 KEOLU DR	KAILUA	96734	HI	MERBL	RM1L	1961	PC	1	$ 1,972,800	6,576	21.37171	-157.73588
HI000378	School	15003011104	Keolu Elementary - Bldg B	1420 KEOLU DR	KAILUA	96734	HI	MERBL	RM1L	1961	PC	2	$ 3,402,000	11,340	21.37171	-157.73588
HI000379	School	15003011104	Keolu Elementary - Bldg C	1420 KEOLU DR	KAILUA	96734	HI	MERBL	RM1L	1962	PC	2	$ 3,449,400	11,498	21.37171	-157.73588
HI000380	School	15003011104	Keolu Elementary - Bldg D	1420 KEOLU DR	KAILUA	96734	HI	MERBL	RM1L	1961	PC	1	$ 2,385,300	7,951	21.37171	-157.73588
HI000381	School	15003010505	King Intermediate - Bldg A	46-155 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1965	PC	2	$ 2,693,100	8,977	21.42823	-157.80671

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000382	School	15003010505	King Intermediate - Bldg B	46-155 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1965	PC	3	$ 4,567,800	15,226	21.42823	-157.80671
HI000383	School	15003010505	King Intermediate - Bldg C	46-155 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1965	PC	3	$ 5,005,800	16,686	21.42823	-157.80671
HI000384	School	15003010505	King Intermediate - Bldg E	46-155 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1968	PC	3	$ 3,682,200	12,274	21.42823	-157.80671
HI000385	School	15003010505	King Intermediate - Bldg F	46-155 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1966	PC	1	$ 2,397,300	7,991	21.42823	-157.80671
HI000386	School	15003010505	King Intermediate - Bldg I	46-155 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1973	PC	1	$ 3,166,500	10,555	21.42823	-157.80671
HI000387	School	15003010505	King Intermediate - Bldg J	46-155 KAM HWY	KANEOHE	96744	HI	WSF1	W1	1966	PC	1	$ 2,456,825	14,039	21.42823	-157.80671
HI000388	School	15003010505	King Intermediate - Bldg K	46-155 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1969	PC	1	$ 6,285,900	20,953	21.42823	-157.80671
HI000389	School	15003010505	King Intermediate - Bldg L	46-155 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1965	PC	1	$ 4,853,100	16,177	21.42823	-157.80671
HI000390	School	15003008907	Kipapa Elementary - Bldg A	95-440 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1960	PC	1	$ 1,227,000	4,090	21.46139	-158.01264
HI000391	School	15003008907	Kipapa Elementary - Bldg C	95-440 KUAHELANI AVE	MILILANI	96789	HI	WSF1	W1	1961	PC	1	$ 1,333,500	7,620	21.46139	-158.01264
HI000392	School	15003008907	Kipapa Elementary - Bldg D	95-440 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1961	PC	2	$ 2,712,600	9,042	21.46139	-158.01264
HI000393	School	15003008907	Kipapa Elementary - Bldg H	95-440 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1966	PC	2	$ 2,669,400	8,898	21.46139	-158.01264
HI000394	School	15003008907	Kipapa Elementary - Bldg I	95-440 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1973	PC	1	$ 1,237,200	4,124	21.46139	-158.01264
HI000395	School	15003008907	Kipapa Elementary - Bldg L	95-440 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1976	PC	2	$ 2,624,400	8,748	21.46139	-158.01264
HI000396	School	15003000102	Koko Head Elementary - Bldg A	189 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1954	PC	1	$ 1,417,500	4,725	21.27465	-157.70448
HI000397	School	15003000102	Koko Head Elementary - Bldg B	189 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1954	PC	1	$ 1,584,000	5,280	21.27465	-157.70448
HI000398	School	15003000102	Koko Head Elementary - Bldg C	189 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1954	PC	1	$ 1,584,000	5,280	21.27465	-157.70448
HI000399	School	15003000102	Koko Head Elementary - Bldg D	189 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1955	PC	1	$ 1,417,500	4,725	21.27465	-157.70448
HI000400	School	15003000102	Koko Head Elementary - Bldg E	189 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1955	PC	1	$ 1,584,000	5,280	21.27465	-157.70448
HI000401	School	15003000102	Koko Head Elementary - Bldg F	189 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1962	PC	1	$ 1,485,000	4,950	21.27465	-157.70448
HI000402	School	15003000102	Koko Head Elementary - Bldg J	189 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1969	PC	1	$ 1,191,900	3,973	21.27465	-157.70448
HI000403	School	15003000102	Koko Head Elementary - Bldg K	189 LUNALILO HOME RD	HONOLULU	96825	HI	MERBL	RM1L	1976	PC	1	$ 1,516,800	5,056	21.27465	-157.70448
HI000404	School	15003000102	Koko Head Elementary - Bldg P3	189 LUNALILO HOME RD	HONOLULU	96825	HI	WSF1	W1	1967	PC	1	$ 189,175	1,081	21.27465	-157.70448
HI000405	School	15003000102	Koko Head Elementary - Bldg P4	189 LUNALILO HOME RD	HONOLULU	96825	HI	WSF1	W1	1967	PC	1	$ 156,800	896	21.27465	-157.70448
HI000406	School	15003000102	Koko Head Elementary - Bldg P5	189 LUNALILO HOME RD	HONOLULU	96825	HI	WSF1	W1	1967	PC	1	$ 156,800	896	21.27465	-157.70448
HI000407	School	15003000102	Koko Head Elementary - Bldg P6	189 LUNALILO HOME RD	HONOLULU	96825	HI	WSF1	W1	1967	PC	1	$ 156,800	896	21.27465	-157.70448
HI000408	School	15003002300	Kuhio Elementary - Bldg B	2759 S KING ST	HONOLULU	96826	HI	MERBL	RM1L	1950	PC	1	$ 1,100,400	3,668	21.28961	-157.81976
HI000409	School	15003002300	Kuhio Elementary - Bldg C	2759 S KING ST	HONOLULU	96826	HI	MERBL	RM1L	1963	PC	2	$ 2,545,800	8,486	21.28961	-157.81976
HI000410	School	15003002300	Kuhio Elementary - Bldg H	2759 S KING ST	HONOLULU	96826	HI	MERBL	RM1L	1976	PC	2	$ 4,127,400	13,758	21.28961	-157.81976
HI000411	School	15003004900	Lanakila Elementary - Bldg C	717 N KUAKINI ST	HONOLULU	96817	HI	MERBL	RM1L	1966	PC	2	$ 3,537,600	11,792	21.32644	-157.86070
HI000412	School	15003004900	Lanakila Elementary - Bldg D	717 N KUAKINI ST	HONOLULU	96817	HI	MERBL	RM1L	1967	PC	2	$ 3,537,600	11,792	21.32644	-157.86070
HI000413	School	15003004900	Lanakila Elementary - Bldg F	717 N KUAKINI ST	HONOLULU	96817	HI	WSF1	W1	1965	PC	1	$ 1,257,025	7,183	21.32644	-157.86070
HI000414	School	15003008100	Lehua Elementary - Bldg A	781 LEHUA AVE	PEARL CITY	96782	HI	MERBL	RM1L	1965	PC	2	$ 3,425,100	11,417	21.38870	-157.97117
HI000415	School	15003008100	Lehua Elementary - Bldg B	781 LEHUA AVE	PEARL CITY	96782	HI	MERBL	RM1L	1965	PC	2	$ 3,425,100	11,417	21.38870	-157.97117
HI000416	School	15003008100	Lehua Elementary - Bldg D	781 LEHUA AVE	PEARL CITY	96782	HI	WSF2	W1	1967	PC	2	$ 1,895,425	10,831	21.38870	-157.97117
HI000417	School	15003008100	Lehua Elementary - Bldg E	781 LEHUA AVE	PEARL CITY	96782	HI	WSF1	W1	1965	PC	1	$ 1,281,000	7,320	21.38870	-157.97117
HI000418	School	15003009702	Leihoku Elementary - Bldg C	86-285 LEIHOKU ST	WAIANAE	96792	HI	WSF1	W1	1987	HC	1	$ 1,177,400	6,728	21.43869	-158.17437
HI000419	School	15003009702	Leihoku Elementary - Bldg D	86-285 LEIHOKU ST	WAIANAE	96792	HI	MERBL	RM1L	1980	PC	2	$ 2,722,800	9,076	21.43869	-158.17437
HI000420	School	15003009702	Leihoku Elementary - Bldg E	86-285 LEIHOKU ST	WAIANAE	96792	HI	MERBL	RM1L	1980	PC	2	$ 2,722,800	9,076	21.43869	-158.17437
HI000421	School	15003009702	Leihoku Elementary - Bldg G	86-285 LEIHOKU ST	WAIANAE	96792	HI	WSF1	W1	1980	LC	1	$ 277,375	1,585	21.43869	-158.17437
HI000422	School	15003009702	Leihoku Elementary - Bldg H	86-285 LEIHOKU ST	WAIANAE	96792	HI	MERBL	RM1L	1985	HC	2	$ 2,527,200	8,424	21.43869	-158.17437
HI000423	School	15003009702	Leihoku Elementary - Bldg J	86-285 LEIHOKU ST	WAIANAE	96792	HI	MERBL	RM1L	1983	HC	2	$ 2,604,600	8,682	21.43869	-158.17437
HI000424	School	15003009200	Leilehua High - Bldg B	1515 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1949	PC	1	$ 1,327,200	4,424	21.50056	-158.01203
HI000425	School	15003009200	Leilehua High - Bldg EE	1515 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1970	PC	1	$ 2,219,400	7,398	21.50056	-158.01203
HI000426	School	15003009200	Leilehua High - Bldg N	1515 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1965	PC	2	$ 4,982,400	16,608	21.50056	-158.01203
HI000427	School	15003009200	Leilehua High - Bldg R	1515 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1968	PC	2	$ 7,943,100	26,477	21.50056	-158.01203
HI000428	School	15003009200	Leilehua High - Bldg Y	1515 CALIFORNIA AVE	WAHIAWA	96786	HI	WSF1	W1	1949	PC	1	$ 2,342,725	13,387	21.50056	-158.01203
HI000429	School	15003009200	Leilehua High - Bldg Z	1515 CALIFORNIA AVE	WAHIAWA	96786	HI	MERBL	RM1L	1964	PC	1	$ 1,176,000	3,920	21.50056	-158.01203
HI000430	School	15003001400	Liholiho Elementary - Bldg B	838 9TH AVE	HONOLULU	96816	HI	WSF1	W1	1940	PC	1	$ 781,550	4,466	21.27898	-157.80614
HI000431	School	15003001400	Liholiho Elementary - Bldg F	838 9TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1951	PC	1	$ 1,321,500	4,405	21.27898	-157.80614
HI000432	School	15003001400	Liholiho Elementary - Bldg G	838 9TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1968	PC	2	$ 2,557,500	8,525	21.27898	-157.80614
HI000433	School	15003001400	Liholiho Elementary - Bldg J	838 9TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1971	PC	3	$ 5,338,800	17,796	21.27898	-157.80614
HI000434	School	15003005600	Likelike Elementary - Bldg B	1618 PALAMA ST	HONOLULU	96817	HI	MERBL	RM1L	1965	PC	2	$ 3,916,200	13,054	21.32489	-157.86420
HI000435	School	15003005600	Likelike Elementary - Bldg C	1618 PALAMA ST	HONOLULU	96817	HI	MERBL	RM1L	1966	PC	2	$ 4,000,200	13,334	21.32489	-157.86420
HI000436	School	15003000800	Liliuokalani Elementary - Bldg B	3633 WAIALAE AVE	HONOLULU	96816	HI	MERBL	RM1L	1967	PC	3	$ 5,341,500	17,805	21.28147	-157.79777

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000437	School	15003000800	Liliuokalani Elementary - Bldg C	3633 WAIALAE AVE	HONOLULU	96816	HI	MERBL	RM1L	1965	PC	3	$ 4,964,700	16,549	21.28147	-157.79777
HI000438	School	15003000800	Liliuokalani Elementary - Bldg D	3633 WAIALAE AVE	HONOLULU	96816	HI	WSF1	W1	1968	PC	1	$ 850,325	4,859	21.28147	-157.79777
HI000439	School	15003000800	Liliuokalani Elementary - Bldg E	3633 WAIALAE AVE	HONOLULU	96816	HI	WSF2	W1	1970	PC	2	$ 1,238,125	7,075	21.28147	-157.79777
HI000440	School	15003006202	Linapuni Elementary - Bldg A	1434 LINAPUNI ST	HONOLULU	96819	HI	WSF2	W1	1965	PC	2	$ 1,699,775	9,713	21.33878	-157.87753
HI000441	School	15003006202	Linapuni Elementary - Bldg B	1434 LINAPUNI ST	HONOLULU	96819	HI	MERBL	RM1L	1965	PC	2	$ 2,926,500	9,755	21.33878	-157.87753
HI000442	School	15003006202	Linapuni Elementary - Bldg C	1434 LINAPUNI ST	HONOLULU	96819	HI	WSF1	W1	1965	PC	1	$ 896,000	5,120	21.33878	-157.87753
HI000443	School	15003004300	Lincoln Elementary - Bldg H	1202 PROSPECT ST	HONOLULU	96813	HI	WSF1	W1	1956	PC	1	$ 1,323,175	7,561	21.31289	-157.84054
HI000444	School	15003002500	Lunalilo Elementary - Bldg A	810 PUMEHANA ST	HONOLULU	96826	HI	MERBL	RM1L	1960	PC	2	$ 3,336,600	11,122	21.29230	-157.83316
HI000445	School	15003002500	Lunalilo Elementary - Bldg B	810 PUMEHANA ST	HONOLULU	96826	HI	MERBL	RM1L	1964	PC	2	$ 3,391,800	11,306	21.29230	-157.83316
HI000446	School	15003002500	Lunalilo Elementary - Bldg C	810 PUMEHANA ST	HONOLULU	96826	HI	MERBL	RM1L	1966	PC	2	$ 3,365,400	11,218	21.29230	-157.83316
HI000447	School	15003002500	Lunalilo Elementary - Bldg H	810 PUMEHANA ST	HONOLULU	96826	HI	WSF2	W1	1971	PC	2	$ 2,126,425	12,151	21.29230	-157.83316
HI000448	School	15003004700	Maemae Elementary - Bldg B	319 WYLLIE ST	HONOLULU	96817	HI	MERBL	RM1L	1953	PC	1	$ 1,458,300	4,861	21.32852	-157.84760
HI000449	School	15003004700	Maemae Elementary - Bldg D	319 WYLLIE ST	HONOLULU	96817	HI	MERBL	RM1L	1956	PC	2	$ 3,969,300	13,231	21.32852	-157.84760
HI000450	School	15003004700	Maemae Elementary - Bldg E	319 WYLLIE ST	HONOLULU	96817	HI	WSF1	W1	1956	PC	1	$ 1,415,750	8,090	21.32852	-157.84760
HI000451	School	15003004700	Maemae Elementary - Bldg F	319 WYLLIE ST	HONOLULU	96817	HI	MERBL	RM1L	1965	PC	2	$ 3,439,800	11,466	21.32852	-157.84760
HI000452	School	15003004700	Maemae Elementary - Bldg J	319 WYLLIE ST	HONOLULU	96817	HI	MERBL	RM1L	1950	PC	1	$ 1,516,800	5,056	21.32852	-157.84760
HI000453	School	15003004700	Maemae Elementary - Bldg K	319 WYLLIE ST	HONOLULU	96817	HI	MERBL	RM1L	1954	PC	1	$ 1,449,900	4,833	21.32852	-157.84760
HI000454	School	15003009603	Maili Elementary - Bldg A	87-360 KULAAUPUNI ST	WAIANAE	96792	HI	MERBL	RM1L	1963	PC	1	$ 1,843,200	6,144	21.42002	-158.17199
HI000455	School	15003009603	Maili Elementary - Bldg B	87-360 KULAAUPUNI ST	WAIANAE	96792	HI	MERBL	RM1L	1963	PC	1	$ 1,983,900	6,613	21.42002	-158.17199
HI000456	School	15003009603	Maili Elementary - Bldg C	87-360 KULAAUPUNI ST	WAIANAE	96792	HI	MERBL	RM1L	1963	PC	1	$ 1,983,900	6,613	21.42002	-158.17199
HI000457	School	15003009603	Maili Elementary - Bldg D	87-360 KULAAUPUNI ST	WAIANAE	96792	HI	MERBL	RM1L	1964	PC	2	$ 4,190,100	13,967	21.42002	-158.17199
HI000458	School	15003009603	Maili Elementary - Bldg F	87-360 KULAAUPUNI ST	WAIANAE	96792	HI	MERBL	RM1L	1972	PC	1	$ 1,569,000	5,230	21.42002	-158.17199
HI000459	School	15003009802	Makaha Elementary - Bldg A	84-224 ALA NAAUAO PL	WAIANAE	96792	HI	MERBL	RM1L	1961	PC	2	$ 3,910,800	13,036	21.47054	-158.21211
HI000460	School	15003009802	Makaha Elementary - Bldg B	84-224 ALA NAAUAO PL	WAIANAE	96792	HI	MERBL	RM1L	1961	PC	2	$ 3,885,600	12,952	21.47054	-158.21211
HI000461	School	15003009802	Makaha Elementary - Bldg C	84-224 ALA NAAUAO PL	WAIANAE	96792	HI	MERBL	RM1L	1961	PC	1	$ 2,369,700	7,899	21.47054	-158.21211
HI000462	School	15003009802	Makaha Elementary - Bldg D	84-224 ALA NAAUAO PL	WAIANAE	96792	HI	MERBL	RM1L	1962	PC	1	$ 1,937,700	6,459	21.47054	-158.21211
HI000463	School	15003008604	Makakilo Elementary - Bldg A	92-675 ANIPEAHI ST	KAPOLEI	96707	HI	MERBL	RM1L	1969	PC	1	$ 1,620,000	5,400	21.34431	-158.08478
HI000464	School	15003008604	Makakilo Elementary - Bldg B	92-675 ANIPEAHI ST	KAPOLEI	96707	HI	MERBL	RM1L	1969	PC	1	$ 1,080,000	3,600	21.34431	-158.08478
HI000465	School	15003008604	Makakilo Elementary - Bldg C	92-675 ANIPEAHI ST	KAPOLEI	96707	HI	MERBL	RM1L	1969	PC	1	$ 1,080,000	3,600	21.34431	-158.08478
HI000466	School	15003008604	Makakilo Elementary - Bldg F	92-675 ANIPEAHI ST	KAPOLEI	96707	HI	MERBL	RM1L	1971	PC	1	$ 1,080,000	3,600	21.34431	-158.08478
HI000467	School	15003008604	Makakilo Elementary - Bldg H	92-675 ANIPEAHI ST	KAPOLEI	96707	HI	MERBL	RM1L	1971	PC	1	$ 1,408,800	4,696	21.34431	-158.08478
HI000468	School	15003008604	Makakilo Elementary - Bldg K	92-675 ANIPEAHI ST	KAPOLEI	96707	HI	WSF1	W1	1969	PC	1	$ 1,078,700	6,164	21.34431	-158.08478
HI000469	School	15003007400	Makalapa Elementary - Bldg A	4435 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1973	PC	1	$ 1,844,400	6,148	21.36123	-157.92855
HI000470	School	15003007400	Makalapa Elementary - Bldg C	4435 SALT LAKE BLVD	HONOLULU	96819	HI	WSF1	W1	1971	PC	1	$ 808,150	4,618	21.36123	-157.92855
HI000471	School	15003007400	Makalapa Elementary - Bldg D	4435 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1971	PC	1	$ 2,854,200	9,514	21.36123	-157.92855
HI000472	School	15003007400	Makalapa Elementary - Bldg F	4435 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1971	PC	2	$ 2,854,200	9,514	21.36123	-157.92855
HI000473	School	15003007400	Makalapa Elementary - Bldg I	4435 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1973	PC	2	$ 2,854,200	9,514	21.36123	-157.92855
HI000474	School	15003007400	Makalapa Elementary - Bldg K	4435 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1971	PC	1	$ 1,991,700	6,639	21.36123	-157.92855
HI000475	School	15003008006	Manana Elementary - Bldg D	1147 KUMANO ST	PEARL CITY	96782	HI	WSF1	W1	1970	PC	1	$ 233,275	1,333	21.40835	-157.97137
HI000476	School	15003008006	Manana Elementary - Bldg O	1147 KUMANO ST	PEARL CITY	96782	HI	WSF1	W1	1974	PC	1	$ 536,550	3,066	21.40835	-157.97137
HI000477	School	15003003102	Manoa Elementary - Bldg B	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1953	PC	1	$ 1,267,500	4,225	21.31594	-157.80819
HI000478	School	15003003102	Manoa Elementary - Bldg C	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1952	PC	1	$ 752,400	2,508	21.31594	-157.80819
HI000479	School	15003003102	Manoa Elementary - Bldg D	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1953	PC	1	$ 1,267,500	4,225	21.31594	-157.80819
HI000480	School	15003003102	Manoa Elementary - Bldg E	3155 MANOA RD	HONOLULU	96822	HI	WSF1	W1	1952	PC	1	$ 1,220,625	6,975	21.31594	-157.80819
HI000481	School	15003003102	Manoa Elementary - Bldg H	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1953	PC	1	$ 1,267,500	4,225	21.31594	-157.80819
HI000482	School	15003003102	Manoa Elementary - Bldg I	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1953	PC	1	$ 1,276,500	4,255	21.31594	-157.80819
HI000483	School	15003003102	Manoa Elementary - Bldg J	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1952	PC	1	$ 752,400	2,508	21.31594	-157.80819
HI000484	School	15003003102	Manoa Elementary - Bldg K	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1952	PC	1	$ 752,400	2,508	21.31594	-157.80819
HI000485	School	15003003102	Manoa Elementary - Bldg L	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1952	PC	1	$ 752,400	2,508	21.31594	-157.80819
HI000486	School	15003003102	Manoa Elementary - Bldg M	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1952	PC	1	$ 748,800	2,496	21.31594	-157.80819
HI000487	School	15003003102	Manoa Elementary - Bldg N	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1952	PC	1	$ 752,400	2,508	21.31594	-157.80819
HI000488	School	15003003102	Manoa Elementary - Bldg O	3155 MANOA RD	HONOLULU	96822	HI	MERBL	RM1L	1952	PC	1	$ 752,400	2,508	21.31594	-157.80819
HI000489	School	15003008603	Mauka Lani Elementary - Bldg A	92-1300 PANANA ST	KAPOLEI	96707	HI	MERBL	RM1L	1973	PC	2	$ 5,388,000	17,960	21.35831	-158.08331
HI000490	School	15003008603	Mauka Lani Elementary - Bldg B	92-1300 PANANA ST	KAPOLEI	96707	HI	WSF1	W1	1973	PC	1	$ 1,379,350	7,882	21.35831	-158.08331
HI000491	School	15003008603	Mauka Lani Elementary - Bldg P11	92-1300 PANANA ST	KAPOLEI	96707	HI	WSF1	W1	1993	HC	1	$ 142,100	812	21.35831	-158.08331

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000492	School	15003011000	Maunawili Elementary - Bldg D	1465 ULUPII ST	KAILUA	96734	HI	MERBL	RM1L	1958	PC	1	$ 1,458,000	4,860	21.37698	-157.75213
HI000493	School	15003011000	Maunawili Elementary - Bldg F	1465 ULUPII ST	KAILUA	96734	HI	WSF1	W1	1958	PC	1	$ 1,458,100	8,332	21.37698	-157.75213
HI000494	School	15003003700	McKinley High - Bldg F	1039 S KING ST	HONOLULU	96814	HI	MERBL	RM1L	1959	PC	2	$ 5,227,500	17,425	21.29917	-157.84831
HI000495	School	15003003700	McKinley High - Bldg G	1039 S KING ST	HONOLULU	96814	HI	MERBL	RM1L	1970	PC	1	$ 2,743,200	9,144	21.29917	-157.84831
HI000496	School	15003003700	McKinley High - Bldg H	1039 S KING ST	HONOLULU	96814	HI	MERBL	RM1L	1963	PC	1	$ 2,798,700	9,329	21.29917	-157.84831
HI000497	School	15003003700	McKinley High - Bldg K	1039 S KING ST	HONOLULU	96814	HI	MERBL	RM1L	1939	PC	1	$ 3,229,800	10,766	21.29917	-157.84831
HI000498	School	15003003700	McKinley High - Bldg M	1039 S KING ST	HONOLULU	96814	HI	MERBL	RM1L	1964	PC	2	$ 5,618,100	18,727	21.29917	-157.84831
HI000499	School	15003003700	McKinley High - Bldg Q	1039 S KING ST	HONOLULU	96814	HI	WSF1	W1	1957	PC	1	$ 1,144,500	6,540	21.29917	-157.84831
HI000500	School	15003003700	McKinley High - Bldg T	1039 S KING ST	HONOLULU	96814	HI	MERBL	RM1L	1982	HC	2	$ 4,143,000	13,810	21.29917	-157.84831
HI000501	School	15003008907	Mililani High - Bldg B	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1973	PC	2	$ 7,644,000	25,480	21.45336	-158.00996
HI000502	School	15003008907	Mililani High - Bldg C	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1994	HC	2	$ 2,555,400	8,518	21.45336	-158.00996
HI000503	School	15003008907	Mililani High - Bldg E	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1987	HC	1	$ 6,649,500	22,165	21.45336	-158.00996
HI000504	School	15003008907	Mililani High - Bldg G	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1980	PC	2	$ 4,206,900	14,023	21.45336	-158.00996
HI000505	School	15003008907	Mililani High - Bldg I	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1980	PC	1	$ 567,300	1,891	21.45336	-158.00996
HI000506	School	15003008907	Mililani High - Bldg J	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1976	PC	1	$ 2,457,300	8,191	21.45336	-158.00996
HI000507	School	15003008907	Mililani High - Bldg K	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1975	PC	2	$ 3,766,200	12,554	21.45336	-158.00996
HI000508	School	15003008907	Mililani High - Bldg L	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1976	PC	2	$ 5,688,600	18,962	21.45336	-158.00996
HI000509	School	15003008907	Mililani High - Bldg N	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1981	PC	2	$ 3,359,100	11,197	21.45336	-158.00996
HI000510	School	15003008907	Mililani High - Bldg O	95-1200 MEHEULA PKWY	MILILANI	96789	HI	MERBL	RM1L	1991	HC	2	$ 3,180,600	10,602	21.45336	-158.00996
HI000511	School	15003008916	Mililani Mauka Elementary - Bldg TB1	95-1111 MAKAIKAI ST	MILILANI	96789	HI	WSF1	W1	1997	HC	1	$ 142,100	812	21.47097	-158.00090
HI000512	School	15003008916	Mililani Mauka Elementary - Bldg TB3	95-1111 MAKAIKAI ST	MILILANI	96789	HI	WSF1	W1	1998	HC	1	$ 142,100	812	21.47097	-158.00090
HI000513	School	15003008916	Mililani Mauka Elementary - Bldg TB4	95-1111 MAKAIKAI ST	MILILANI	96789	HI	WSF1	W1	1998	HC	1	$ 142,100	812	21.47097	-158.00090
HI000514	School	15003008916	Mililani Mauka Elementary - Bldg TB5	95-1111 MAKAIKAI ST	MILILANI	96789	HI	WSF1	W1	2001	LS	1	$ 142,100	812	21.47097	-158.00090
HI000515	School	15003008916	Mililani Mauka Elementary - Bldg TB6	95-1111 MAKAIKAI ST	MILILANI	96789	HI	WSF1	W1	2001	LS	1	$ 142,100	812	21.47097	-158.00090
HI000516	School	15003008916	Mililani Middle - Bldg C	95-230 KAILIULA PL	MILILANI	96789	HI	MERBL	RM1L	UNK	PC	1	$ 3,111,900	10,373	21.47583	-157.98893
HI000517	School	15003008909	Mililani Uka Elementary - Bldg C	94-380 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1990	HC	2	$ 2,794,200	9,314	21.43727	-158.01476
HI000518	School	15003008909	Mililani Uka Elementary - Bldg D	94-380 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1977	PC	2	$ 2,786,700	9,289	21.43727	-158.01476
HI000519	School	15003008909	Mililani Uka Elementary - Bldg E	94-380 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1977	PC	2	$ 2,814,600	9,382	21.43727	-158.01476
HI000520	School	15003008909	Mililani Uka Elementary - Bldg F	94-380 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1977	PC	2	$ 2,807,700	9,359	21.43727	-158.01476
HI000521	School	15003008909	Mililani Uka Elementary - Bldg H	94-380 KUAHELANI AVE	MILILANI	96789	HI	MERBL	RM1L	1977	PC	1	$ 1,359,300	4,531	21.43727	-158.01476
HI000522	School	15003008907	Mililani Waena Elementary - Bldg B	95-502 KIPAPA DR	MILILANI	96789	HI	MERBL	RM1L	1971	PC	1	$ 5,764,200	19,214	21.45550	-158.01053
HI000523	School	15003008907	Mililani Waena Elementary - Bldg D	95-502 KIPAPA DR	MILILANI	96789	HI	MERBL	RM1L	1973	PC	1	$ 5,764,200	19,214	21.45550	-158.01053
HI000524	School	15003006701	Moanalua Elementary - Bldg A	1337 MAHIOLE ST	HONOLULU	96819	HI	MERBL	RM1L	1961	PC	2	$ 3,415,800	11,386	21.34889	-157.89179
HI000525	School	15003006701	Moanalua Elementary - Bldg B	1337 MAHIOLE ST	HONOLULU	96819	HI	MERBL	RM1L	1961	PC	2	$ 3,415,800	11,386	21.34889	-157.89179
HI000526	School	15003006701	Moanalua Elementary - Bldg E	1337 MAHIOLE ST	HONOLULU	96819	HI	WSF1	W1	1961	PC	1	$ 1,500,275	8,573	21.34889	-157.89179
HI000527	School	15003006701	Moanalua Elementary - Bldg F	1337 MAHIOLE ST	HONOLULU	96819	HI	MERBL	RM1L	1971	PC	1	$ 1,562,100	5,207	21.34889	-157.89179
HI000528	School	15003006805	Moanalua High - Bldg F	2825 ALA ILIMA	HONOLULU	96819	HI	MERBL	RM1L	1975	PC	3	$ 5,051,700	16,839	21.34731	-157.90064
HI000529	School	15003006805	Moanalua High - Bldg G	2825 ALA ILIMA	HONOLULU	96819	HI	MERBL	RM1L	1976	PC	3	$ 5,542,800	18,476	21.34731	-157.90064
HI000530	School	15003006805	Moanalua High - Bldg H	2825 ALA ILIMA	HONOLULU	96819	HI	MERBL	RM1L	1980	PC	3	$ 4,145,400	13,818	21.34731	-157.90064
HI000531	School	15003006805	Moanalua High - Bldg I	2825 ALA ILIMA	HONOLULU	96819	HI	MERBL	RM1L	1993	HC	2	$ 3,178,200	10,594	21.34731	-157.90064
HI000532	School	15003006805	Moanalua High - Bldg L	2825 ALA ILIMA	HONOLULU	96819	HI	MERBL	RM1L	1980	PC	2	$ 1,915,200	6,384	21.34731	-157.90064
HI000533	School	15003006805	Moanalua High - Bldg M	2825 ALA ILIMA	HONOLULU	96819	HI	MERBL	RM1L	1972	PC	3	$ 5,503,200	18,344	21.34731	-157.90064
HI000534	School	15003006805	Moanalua High - Bldg Q	2825 ALA ILIMA	HONOLULU	96819	HI	MERBL	RM1L	1975	PC	2	$ 6,823,800	22,746	21.34731	-157.90064
HI000535	School	15003006805	Moanalua High - Bldg R	2825 ALA ILIMA	HONOLULU	96819	HI	MERBL	RM1L	1973	PC	3	$ 2,931,300	9,771	21.34731	-157.90064
HI000536	School	15003006805	Moanalua High - Bldg S	2825 ALA ILIMA	HONOLULU	96819	HI	MERBL	RM1L	1978	PC	1	$ 246,000	820	21.34731	-157.90064
HI000537	School	15003006701	Moanalua Middle - Bldg C	1289 MAHIOLE ST	HONOLULU	96819	HI	MERBL	RM1L	1968	PC	2	$ 3,086,700	10,289	21.34976	-157.89341
HI000538	School	15003006701	Moanalua Middle - Bldg D	1289 MAHIOLE ST	HONOLULU	96819	HI	MERBL	RM1L	1968	PC	2	$ 3,177,900	10,593	21.34976	-157.89341
HI000539	School	15003006701	Moanalua Middle - Bldg E	1289 MAHIOLE ST	HONOLULU	96819	HI	MERBL	RM1L	1969	PC	2	$ 3,141,000	10,470	21.34976	-157.89341
HI000540	School	15003006701	Moanalua Middle - Bldg F	1289 MAHIOLE ST	HONOLULU	96819	HI	MERBL	RM1L	1976	PC	2	$ 1,765,200	5,884	21.34976	-157.89341
HI000541	School	15003006701	Moanalua Middle - Bldg I	1289 MAHIOLE ST	HONOLULU	96819	HI	WSF1	W1	1968	PC	1	$ 2,057,475	11,757	21.34976	-157.89341
HI000542	School	15003006701	Moanalua Middle - Bldg K	1289 MAHIOLE ST	HONOLULU	96819	HI	MERBL	RM1L	1968	PC	1	$ 2,029,800	6,766	21.34976	-157.89341
HI000543	School	15003010802	Mokapu Elementary - Bldg A	800 MOKAPU RD KMCAS	KANEOHE	96863	HI	MERBL	RM1L	1960	PC	1	$ 1,562,400	5,208	21.44433	-157.74920
HI000544	School	15003010802	Mokapu Elementary - Bldg B	800 MOKAPU RD KMCAS	KANEOHE	96863	HI	WSF1	W1	1960	PC	1	$ 911,400	5,208	21.44433	-157.74920
HI000545	School	15003010802	Mokapu Elementary - Bldg C	800 MOKAPU RD KMCAS	KANEOHE	96863	HI	WSF1	W1	1960	PC	1	$ 588,000	3,360	21.44433	-157.74920
HI000546	School	15003010802	Mokapu Elementary - Bldg D	800 MOKAPU RD KMCAS	KANEOHE	96863	HI	WSF1	W1	1960	PC	1	$ 588,000	3,360	21.44433	-157.74920

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000547	School	15003010802	Mokapu Elementary - Bldg E	800 MOKAPU RD KMCAS	KANEOHE	96863	HI	WSF1	W1	1960	PC	1	$ 588,000	3,360	21.44433	-157.74920
HI000548	School	15003010802	Mokapu Elementary - Bldg F	800 MOKAPU RD KMCAS	KANEOHE	96863	HI	WSF1	W1	1960	PC	1	$ 541,800	3,096	21.44433	-157.74920
HI000549	School	15003010802	Mokapu Elementary - Bldg O	800 MOKAPU RD KMCAS	KANEOHE	96863	HI	MERBL	RM1L	1994	HC	1	$ 1,388,700	4,629	21.44433	-157.74920
HI000550	School	15003007200	Mokulele Elementary - Bldg A	3903 KAM HWY	HICKAM AFB	96853	HI	MERBL	RM1L	1960	PC	1	$ 1,348,800	4,496	21.34297	-157.94089
HI000551	School	15003007200	Mokulele Elementary - Bldg B	3903 KAM HWY	HICKAM AFB	96853	HI	MERBL	RM1L	1960	PC	1	$ 1,348,800	4,496	21.34297	-157.94089
HI000552	School	15003007200	Mokulele Elementary - Bldg C	3903 KAM HWY	HICKAM AFB	96853	HI	MERBL	RM1L	1961	PC	2	$ 3,444,000	11,480	21.34297	-157.94089
HI000553	School	15003007200	Mokulele Elementary - Bldg E	3903 KAM HWY	HICKAM AFB	96853	HI	WSF1	W1	1961	PC	1	$ 1,129,275	6,453	21.34297	-157.94089
HI000554	School	15003007200	Mokulele Elementary - Bldg F	3903 KAM HWY	HICKAM AFB	96853	HI	MERBL	RM1L	1967	PC	2	$ 3,459,600	11,532	21.34297	-157.94089
HI000555	School	15003007810	Momilani Elementary - Bldg B	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBL	RM1L	1972	PC	1	$ 5,154,000	17,180	21.41317	-157.95471
HI000556	School	15003009601	Nanakuli Elementary - Bldg B	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1980	PC	1	$ 2,970,600	9,902	21.38614	-158.13638
HI000557	School	15003009601	Nanakuli Elementary - Bldg C	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1978	PC	2	$ 5,358,300	17,861	21.38614	-158.13638
HI000558	School	15003009601	Nanakuli High & Intermediate - Bldg B	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1971	PC	1	$ 6,465,300	21,551	21.38825	-158.13276
HI000559	School	15003009601	Nanakuli High & Intermediate - Bldg C	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1979	PC	1	$ 6,269,700	20,899	21.38825	-158.13276
HI000560	School	15003009601	Nanakuli High & Intermediate - Bldg D	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1995	HC	1	$ 3,342,900	11,143	21.38825	-158.13276
HI000561	School	15003009601	Nanakuli High & Intermediate - Bldg E	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1972	PC	1	$ 7,327,200	24,424	21.38825	-158.13276
HI000562	School	15003009601	Nanakuli High & Intermediate - Bldg J	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1979	PC	2	$ 7,117,200	23,724	21.38825	-158.13276
HI000563	School	15003009601	Nanakuli High & Intermediate - Bldg Q	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1973	PC	1	$ 5,067,000	16,890	21.38825	-158.13276
HI000564	School	15003009601	Nanakuli High & Intermediate - Bldg R	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1971	PC	1	$ 2,207,700	7,359	21.38825	-158.13276
HI000565	School	15003009601	Nanakuli High & Intermediate - Bldg U	89-778 HALEAKALA AVE	WAIANAE	96792	HI	MERBL	RM1L	1973	PC	1	$ 1,498,800	4,996	21.38825	-158.13276
HI000566	School	15003007100	Nimitz Elementary - Bldg C	520 MAIN	HONOLULU	96819	HI	MERBL	RM1L	1954	PC	2	$ 6,183,000	20,610	21.34089	-157.93511
HI000567	School	15003000200	Niu Valley Middle - Bldg A	310 HALEMAUMAU ST	HONOLULU	96821	HI	MERBL	RM1L	1956	PC	2	$ 2,820,900	9,403	21.28529	-157.74027
HI000568	School	15003000200	Niu Valley Middle - Bldg B	310 HALEMAUMAU ST	HONOLULU	96821	HI	MERBL	RM1L	1956	PC	2	$ 2,835,600	9,452	21.28529	-157.74027
HI000569	School	15003000200	Niu Valley Middle - Bldg C	310 HALEMAUMAU ST	HONOLULU	96821	HI	MERBL	RM1L	1963	PC	2	$ 3,893,400	12,978	21.28529	-157.74027
HI000570	School	15003000200	Niu Valley Middle - Bldg I	310 HALEMAUMAU ST	HONOLULU	96821	HI	MERBL	RM1L	1958	PC	1	$ 612,000	2,040	21.28529	-157.74027
HI000571	School	15003002900	Noelani Elementary - Bldg A	2667 WOODLAWN DR	HONOLULU	96822	HI	MERBL	RM1L	1962	PC	2	$ 3,917,400	13,058	21.30575	-157.81180
HI000572	School	15003002900	Noelani Elementary - Bldg C	2667 WOODLAWN DR	HONOLULU	96822	HI	WSF1	W1	1962	PC	1	$ 1,392,475	7,957	21.30575	-157.81180
HI000573	School	15003002900	Noelani Elementary - Bldg D	2667 WOODLAWN DR	HONOLULU	96822	HI	WSF1	W1	1970	PC	1	$ 619,500	3,540	21.30575	-157.81180
HI000574	School	15003004500	Nuuanu Elementary - Bldg J	3055 PUIWA LN	HONOLULU	96817	HI	WSF1	W1	1960	PC	1	$ 1,244,775	7,113	21.33552	-157.83503
HI000575	School	15003008005	Palisades Elementary - Bldg A	2306 AUHUHU ST	PEARL CITY	96782	HI	MERBL	RM1L	1955	PC	2	$ 4,101,600	13,672	21.42521	-157.95345
HI000576	School	15003008005	Palisades Elementary - Bldg B	2306 AUHUHU ST	PEARL CITY	96782	HI	WSF2	W1	1955	PC	2	$ 2,343,600	13,392	21.42521	-157.95345
HI000577	School	15003008005	Palisades Elementary - Bldg C	2306 AUHUHU ST	PEARL CITY	96782	HI	MERBL	RM1L	1967	PC	2	$ 3,258,000	10,860	21.42521	-157.95345
HI000578	School	15003008005	Palisades Elementary - Bldg D	2306 AUHUHU ST	PEARL CITY	96782	HI	WSF2	W1	1955	PC	2	$ 2,096,850	11,982	21.42521	-157.95345
HI000579	School	15003001100	Palolo Elementary - Bldg A	2106 10TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1964	PC	1	$ 3,133,500	10,445	21.29957	-157.79282
HI000580	School	15003001100	Palolo Elementary - Bldg B	2106 10TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1951	PC	1	$ 2,560,500	8,535	21.29957	-157.79282
HI000581	School	15003001100	Palolo Elementary - Bldg C	2106 10TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1953	PC	1	$ 1,797,600	5,992	21.29957	-157.79282
HI000582	School	15003001100	Palolo Elementary - Bldg D	2106 10TH AVE	HONOLULU	96816	HI	WSF1	W1	1968	PC	1	$ 2,301,600	13,152	21.29957	-157.79282
HI000583	School	15003001100	Palolo Elementary - Bldg F	2106 10TH AVE	HONOLULU	96816	HI	WSF1	W1	1958	PC	1	$ 1,092,000	6,240	21.29957	-157.79282
HI000584	School	15003001100	Palolo Elementary - Bldg L	2106 10TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1970	PC	2	$ 2,589,900	8,633	21.29957	-157.79282
HI000585	School	15003010504	Parker Elementary - Bldg D	45-921 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1973	PC	2	$ 5,356,200	17,854	21.41377	-157.79892
HI000586	School	15003010504	Parker Elementary - Bldg H	45-921 KAM HWY	KANEOHE	96744	HI	MERBL	RM1L	1954	PC	2	$ 3,353,700	11,179	21.41377	-157.79892
HI000587	School	15003004400	Pauoa Elementary - Bldg D	2301 PAUOA	HONOLULU	96813	HI	MERBL	RM1L	1967	PC	2	$ 3,443,700	11,479	21.31862	-157.84400
HI000588	School	15003004400	Pauoa Elementary - Bldg E	2301 PAUOA	HONOLULU	96813	HI	WSF1	W1	1969	PC	1	$ 1,369,725	7,827	21.31862	-157.84400
HI000589	School	15003008003	Pearl City Elementary - Bldg I	1090 WAIMANO HOME RD	PEARL CITY	96782	HI	MERBL	RM1L	1956	PC	1	$ 1,828,200	6,094	21.39522	-157.97196
HI000590	School	15003007810	Pearl City High - Bldg A	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBM	RM1M	1971	PC	4	$ 4,662,900	15,543	21.41483	-157.95227
HI000591	School	15003007810	Pearl City High - Bldg B	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBM	RM1M	1971	PC	4	$ 6,940,500	23,135	21.41483	-157.95227
HI000592	School	15003007810	Pearl City High - Bldg C	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBL	RM1L	1972	PC	3	$ 4,936,500	16,455	21.41483	-157.95227
HI000593	School	15003007810	Pearl City High - Bldg D	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBL	RM1L	1972	PC	3	$ 4,167,300	13,891	21.41483	-157.95227
HI000594	School	15003007810	Pearl City High - Bldg E	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBL	RM1L	1972	PC	2	$ 4,987,800	16,626	21.41483	-157.95227
HI000595	School	15003007810	Pearl City High - Bldg F	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBL	RM1L	1972	PC	1	$ 1,114,500	3,715	21.41483	-157.95227
HI000596	School	15003007810	Pearl City High - Bldg G	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	WSF1	W1	1972	PC	1	$ 2,287,775	13,073	21.41483	-157.95227
HI000597	School	15003007810	Pearl City High - Bldg H	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBL	RM1L	1972	PC	1	$ 7,827,900	26,093	21.41483	-157.95227
HI000598	School	15003007810	Pearl City High - Bldg I	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBL	RM1L	1976	PC	1	$ 2,041,200	6,804	21.41483	-157.95227
HI000599	School	15003007810	Pearl City High - Bldg K	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBL	RM1L	1973	PC	1	$ 2,811,600	9,372	21.41483	-157.95227
HI000600	School	15003007810	Pearl City High - Bldg L	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBM	RM1M	1973	PC	4	$ 4,977,600	16,592	21.41483	-157.95227
HI000601	School	15003007810	Pearl City High - Bldg M	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBM	RM1M	1973	PC	4	$ 2,811,600	9,372	21.41483	-157.95227

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000602	School	15003007810	Pearl City High - Bldg O	2100 HOOKIEKIE ST	PEARL CITY	96782	HI	MERBL	RM1L	1979	PC	2	$ 7,134,600	23,782	21.41483	-157.95227
HI000603	School	15003008007	Pearl City Highlands Elementary - Bldg A	1419 WAIMANO HOME RD	PEARL CITY	96782	HI	MERBL	RM1L	1958	PC	1	$ 1,941,300	6,471	21.40309	-157.96547
HI000604	School	15003008007	Pearl City Highlands Elementary - Bldg B	1419 WAIMANO HOME RD	PEARL CITY	96782	HI	MERBL	RM1L	1958	PC	1	$ 1,941,300	6,471	21.40309	-157.96547
HI000605	School	15003008007	Pearl City Highlands Elementary - Bldg C	1419 WAIMANO HOME RD	PEARL CITY	96782	HI	MERBL	RM1L	1960	PC	1	$ 1,941,300	6,471	21.40309	-157.96547
HI000606	School	15003008007	Pearl City Highlands Elementary - Bldg D	1419 WAIMANO HOME RD	PEARL CITY	96782	HI	MERBL	RM1L	1960	PC	1	$ 1,941,300	6,471	21.40309	-157.96547
HI000607	School	15003008007	Pearl City Highlands Elementary - Bldg E	1419 WAIMANO HOME RD	PEARL CITY	96782	HI	MERBL	RM1L	1958	PC	1	$ 1,776,900	5,923	21.40309	-157.96547
HI000608	School	15003008007	Pearl City Highlands Elementary - Bldg F	1419 WAIMANO HOME RD	PEARL CITY	96782	HI	WSF1	W1	1958	PC	1	$ 1,350,475	7,717	21.40309	-157.96547
HI000609	School	15003007000	Pearl Harbor Elementary - Bldg A	3801 SALT LAKE	HONOLULU	96818	HI	MERBL	RM1L	1956	PC	1	$ 1,075,200	3,584	21.34638	-157.93051
HI000610	School	15003007000	Pearl Harbor Elementary - Bldg B	3801 SALT LAKE	HONOLULU	96818	HI	MERBL	RM1L	1956	PC	1	$ 1,075,200	3,584	21.34638	-157.93051
HI000611	School	15003007000	Pearl Harbor Elementary - Bldg D	3801 SALT LAKE	HONOLULU	96818	HI	MERBL	RM1L	1956	PC	1	$ 1,075,200	3,584	21.34638	-157.93051
HI000612	School	15003007000	Pearl Harbor Elementary - Bldg E	3801 SALT LAKE	HONOLULU	96818	HI	MERBL	RM1L	1956	PC	1	$ 1,075,200	3,584	21.34638	-157.93051
HI000613	School	15003007000	Pearl Harbor Elementary - Bldg F	3801 SALT LAKE	HONOLULU	96818	HI	MERBL	RM1L	1956	PC	1	$ 1,075,200	3,584	21.34638	-157.93051
HI000614	School	15003007000	Pearl Harbor Elementary - Bldg G	3801 SALT LAKE	HONOLULU	96818	HI	MERBL	RM1L	1956	PC	1	$ 1,075,200	3,584	21.34638	-157.93051
HI000615	School	15003007000	Pearl Harbor Elementary - Bldg H	3801 SALT LAKE	HONOLULU	96818	HI	MERBL	RM1L	1956	PC	1	$ 1,162,200	3,874	21.34638	-157.93051
HI000616	School	15003007000	Pearl Harbor Elementary - Bldg I	3801 SALT LAKE	HONOLULU	96818	HI	MERBL	RM1L	1956	PC	1	$ 1,162,200	3,874	21.34638	-157.93051
HI000617	School	15003007000	Pearl Harbor Elementary - Bldg J	3801 SALT LAKE	HONOLULU	96818	HI	MERBL	RM1L	1956	PC	1	$ 1,008,000	3,360	21.34638	-157.93051
HI000618	School	15003007400	Pearl Harbor Kai Elementary - Bldg B	99-659 KAM HWY	HONOLULU	96818	HI	MERBL	RM1L	1960	PC	2	$ 3,607,200	12,024	21.34907	-157.93815
HI000619	School	15003007400	Pearl Harbor Kai Elementary - Bldg C	99-659 KAM HWY	HONOLULU	96818	HI	MERBL	RM1L	1959	PC	2	$ 3,895,200	12,984	21.34907	-157.93815
HI000620	School	15003007400	Pearl Harbor Kai Elementary - Bldg E	99-659 KAM HWY	HONOLULU	96818	HI	WSF1	W1	1963	PC	1	$ 1,492,050	8,526	21.34907	-157.93815
HI000621	School	15003007400	Pearl Harbor Kai Elementary - Bldg I	99-659 KAM HWY	HONOLULU	96818	HI	MERBL	RM1L	1968	PC	2	$ 2,586,300	8,621	21.34907	-157.93815
HI000622	School	15003007807	Pearl Ridge Elementary - Bldg C	98-940 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1974	PC	1	$ 2,707,500	9,025	21.38859	-157.94498
HI000623	School	15003007807	Pearl Ridge Elementary - Bldg D	98-940 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1991	HC	1	$ 814,500	2,715	21.38859	-157.94498
HI000624	School	15003007807	Pearl Ridge Elementary - Bldg E	98-940 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1991	HC	1	$ 814,500	2,715	21.38859	-157.94498
HI000625	School	15003007807	Pearl Ridge Elementary - Bldg G	98-940 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1976	PC	1	$ 1,329,900	4,433	21.38859	-157.94498
HI000626	School	15003007807	Pearl Ridge Elementary - Bldg H	98-940 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1972	PC	1	$ 1,898,100	6,327	21.38859	-157.94498
HI000627	School	15003007807	Pearl Ridge Elementary - Bldg J	98-940 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1972	PC	1	$ 2,380,500	7,935	21.38859	-157.94498
HI000628	School	15003008302	Pohakea Elementary - Bldg A	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1965	PC	2	$ 3,590,700	11,969	21.31372	-158.00991
HI000629	School	15003008302	Pohakea Elementary - Bldg B	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1965	PC	2	$ 3,373,500	11,245	21.31372	-158.00991
HI000630	School	15003008302	Pohakea Elementary - Bldg C	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	MERBL	RM1L	1965	PC	2	$ 3,304,200	11,014	21.31372	-158.00991
HI000631	School	15003008302	Pohakea Elementary - Bldg D	91-950 NORTH RD EWA BCH	EWA BEACH	96706	HI	WSF1	W1	1965	PC	1	$ 1,249,150	7,138	21.31372	-158.00991
HI000632	School	15003010601	Puohala Elementary - Bldg A	45-235 KULAULI ST	KANEOHE	96744	HI	MERBL	RM1L	1967	PC	2	$ 3,537,900	11,793	21.40975	-157.79101
HI000633	School	15003010601	Puohala Elementary - Bldg B	45-235 KULAULI ST	KANEOHE	96744	HI	MERBL	RM1L	1967	PC	2	$ 3,624,000	12,080	21.40975	-157.79101
HI000634	School	15003010601	Puohala Elementary - Bldg C	45-235 KULAULI ST	KANEOHE	96744	HI	MERBL	RM1L	1967	PC	2	$ 3,962,100	13,207	21.40975	-157.79101
HI000635	School	15003005900	Puuhale Elementary - Bldg A	336 MOKAUEA ST	HONOLULU	96819	HI	WSF2	W1	1972	PC	2	$ 5,929,700	33,884	21.32680	-157.88415
HI000636	School	15003005900	Puuhale Elementary - Bldg B	336 MOKAUEA ST	HONOLULU	96819	HI	WSF1	W1	1973	PC	1	$ 1,175,650	6,718	21.32680	-157.88415
HI000637	School	15003005900	Puuhale Elementary - Bldg P5	336 MOKAUEA ST	HONOLULU	96819	HI	WSF1	W1	1966	PC	1	$ 156,800	896	21.32680	-157.88415
HI000638	School	15003005900	Puuhale Elementary - Bldg P6	336 MOKAUEA ST	HONOLULU	96819	HI	WSF1	W1	1966	PC	1	$ 156,800	896	21.32680	-157.88415
HI000639	School	15003007400	Radford High - Bldg B	4361 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	2	$ 2,944,200	9,814	21.35943	-157.92909
HI000640	School	15003007400	Radford High - Bldg C	4361 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	2	$ 4,029,000	13,430	21.35943	-157.92909
HI000641	School	15003007400	Radford High - Bldg D	4361 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	2	$ 3,999,600	13,332	21.35943	-157.92909
HI000642	School	15003007400	Radford High - Bldg F	4361 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1956	PC	1	$ 2,701,800	9,006	21.35943	-157.92909
HI000643	School	15003007400	Radford High - Bldg I	4361 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1980	PC	2	$ 1,997,700	6,659	21.35943	-157.92909
HI000644	School	15003007400	Radford High - Bldg L	4361 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1957	PC	2	$ 2,431,200	8,104	21.35943	-157.92909
HI000645	School	15003007400	Radford High - Bldg M	4361 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1957	PC	2	$ 4,029,000	13,430	21.35943	-157.92909
HI000646	School	15003007400	Radford High - Bldg N	4361 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1963	PC	2	$ 4,666,800	15,556	21.35943	-157.92909
HI000647	School	15003007400	Radford High - Bldg O	4361 SALT LAKE BLVD	HONOLULU	96819	HI	MERBL	RM1L	1993	HC	2	$ 4,062,600	13,542	21.35943	-157.92909
HI000648	School	15003006702	Red Hill Elementary - Bldg A	1265 ALA KULA PL	HONOLULU	96819	HI	WSF2	W1	1974	PC	2	$ 1,495,025	8,543	21.36834	-157.90010
HI000649	School	15003006702	Red Hill Elementary - Bldg B	1265 ALA KULA PL	HONOLULU	96819	HI	MERBL	RM1L	1969	PC	2	$ 2,961,000	9,870	21.36834	-157.90010
HI000650	School	15003006702	Red Hill Elementary - Bldg C	1265 ALA KULA PL	HONOLULU	96819	HI	MERBL	RM1L	1969	PC	2	$ 2,994,900	9,983	21.36834	-157.90010
HI000651	School	15003003300	Roosevelt High - Bldg A	1120 NEHOA ST	HONOLULU	96822	HI	WMUH3	W1	1932	PC	3	$ 14,057,925	80,331	21.31055	-157.83732
HI000652	School	15003003300	Roosevelt High - Bldg C	1120 NEHOA ST	HONOLULU	96822	HI	MERBL	RM1L	1959	PC	2	$ 2,957,400	9,858	21.31055	-157.83732
HI000653	School	15003003300	Roosevelt High - Bldg D	1120 NEHOA ST	HONOLULU	96822	HI	MERBL	RM1L	1956	PC	1	$ 1,101,900	3,673	21.31055	-157.83732
HI000654	School	15003003300	Roosevelt High - Bldg F	1120 NEHOA ST	HONOLULU	96822	HI	MERBL	RM1L	1963	PC	1	$ 2,202,300	7,341	21.31055	-157.83732
HI000655	School	15003003300	Roosevelt High - Bldg G	1120 NEHOA ST	HONOLULU	96822	HI	MERBL	RM1L	1965	PC	2	$ 5,560,200	18,534	21.31055	-157.83732
HI000656	School	15003003300	Roosevelt High - Bldg J	1120 NEHOA ST	HONOLULU	96822	HI	MERBL	RM1L	1935	PC	1	$ 3,777,600	12,592	21.31055	-157.83732

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000657	School	15003003300	Roosevelt High - Bldg N	1120 NEHOA ST	HONOLULU	96822	HI	MERBL	RM1L	1970	PC	2	$ 1,858,800	6,196	21.31055	-157.83732
HI000658	School	15003004100	Royal Elementary - Bldg A	1519 QUEEN EMMA ST	HONOLULU	96813	HI	MERBL	RM1L	1967	PC	2	$ 3,656,100	12,187	21.31175	-157.85378
HI000659	School	15003004100	Royal Elementary - Bldg B	1519 QUEEN EMMA ST	HONOLULU	96813	HI	MERBL	RM1L	1965	PC	2	$ 3,561,300	11,871	21.31175	-157.85378
HI000660	School	15003004100	Royal Elementary - Bldg C	1519 QUEEN EMMA ST	HONOLULU	96813	HI	MERBL	RM1L	1951	PC	1	$ 1,248,000	4,160	21.31175	-157.85378
HI000661	School	15003006805	Salt Lake Elementary - Bldg A	1131 ALA LILIKOI	HONOLULU	96819	HI	WSF1	W1	1972	PC	1	$ 1,125,250	6,430	21.35171	-157.91178
HI000662	School	15003006805	Salt Lake Elementary - Bldg C	1131 ALA LILIKOI	HONOLULU	96819	HI	MERBL	RM1L	1973	PC	1	$ 2,587,200	8,624	21.35171	-157.91178
HI000663	School	15003006805	Salt Lake Elementary - Bldg F	1131 ALA LILIKOI	HONOLULU	96819	HI	MERBL	RM1L	1973	PC	2	$ 5,005,200	16,684	21.35171	-157.91178
HI000664	School	15003006600	Shafter Elementary - Bldg A	2508 KAUA ST	FORT SHAFTER	96858	HI	MERBL	RM1L	1966	PC	2	$ 3,470,100	11,567	21.34191	-157.88470
HI000665	School	15003006600	Shafter Elementary - Bldg B	2508 KAUA ST	FORT SHAFTER	96858	HI	WSF2	W1	1966	PC	2	$ 1,927,975	11,017	21.34191	-157.88470
HI000666	School	15003006600	Shafter Elementary - Bldg C	2508 KAUA ST	FORT SHAFTER	96858	HI	WSF1	W1	1968	PC	1	$ 834,925	4,771	21.34191	-157.88470
HI000667	School	15003009501	Solomon Elementary - Bldg A	1701 *WILIKINA DR	SCHOFIELD BARRACKS	96857	HI	MERBL	RM1L	1969	PC	2	$ 1,752,000	5,840	21.49106	-158.07250
HI000668	School	15003009501	Solomon Elementary - Bldg B	1701 *WILIKINA DR	SCHOFIELD BARRACKS	96857	HI	WSF2	W1	1969	PC	2	$ 2,891,350	16,522	21.49106	-158.07250
HI000669	School	15003009501	Solomon Elementary - Bldg C	1701 *WILIKINA DR	SCHOFIELD BARRACKS	96857	HI	MERBL	RM1L	1969	PC	2	$ 4,223,400	14,078	21.49106	-158.07250
HI000670	School	15003009501	Solomon Elementary - Bldg E	1701 *WILIKINA DR	SCHOFIELD BARRACKS	96857	HI	MERBL	RM1L	1976	PC	2	$ 3,713,400	12,378	21.49106	-158.07250
HI000671	School	15003009501	Solomon Elementary - Bldg P21	1701 *WILIKINA DR	SCHOFIELD BARRACKS	96857	HI	WSF1	W1	1994	HC	1	$ 142,100	812	21.49106	-158.07250
HI000672	School	15003009501	Solomon Elementary - Bldg P22	1701 *WILIKINA DR	SCHOFIELD BARRACKS	96857	HI	WSF1	W1	1994	HC	1	$ 142,100	812	21.49106	-158.07250
HI000673	School	15003009501	Solomon Elementary - Bldg P23	1701 *WILIKINA DR	SCHOFIELD BARRACKS	96857	HI	WSF1	W1	1994	HC	1	$ 142,100	812	21.49106	-158.07250
HI000674	School	15003004300	Stevenson Middle - Bldg A	1202 PROSPECT ST	HONOLULU	96813	HI	WSF2	W1	1951	PC	2	$ 9,114,700	52,084	21.31033	-157.84024
HI000675	School	15003004300	Stevenson Middle - Bldg B	1202 PROSPECT ST	HONOLULU	96813	HI	MERBL	RM1L	1954	PC	1	$ 2,130,300	7,101	21.31033	-157.84024
HI000676	School	15003004300	Stevenson Middle - Bldg C	1202 PROSPECT ST	HONOLULU	96813	HI	WSF1	W1	1954	PC	1	$ 703,675	4,021	21.31033	-157.84024
HI000677	School	15003004300	Stevenson Middle - Bldg E	1202 PROSPECT ST	HONOLULU	96813	HI	MERBL	RM1L	1954	PC	1	$ 1,648,800	5,496	21.31033	-157.84024
HI000678	School	15003004300	Stevenson Middle - Bldg F	1202 PROSPECT ST	HONOLULU	96813	HI	MERBL	RM1L	1954	PC	1	$ 2,154,000	7,180	21.31033	-157.84024
HI000679	School	15003009200	Wahiawa Elementary - Bldg B	1390 GLEN AVE	WAHIAWA	96786	HI	MERBL	RM1L	1950	PC	1	$ 1,827,600	6,092	21.50488	-158.01781
HI000680	School	15003009200	Wahiawa Elementary - Bldg C	1390 GLEN AVE	WAHIAWA	96786	HI	MERBL	RM1L	1950	PC	1	$ 1,827,600	6,092	21.50488	-158.01781
HI000681	School	15003009200	Wahiawa Elementary - Bldg D	1390 GLEN AVE	WAHIAWA	96786	HI	MERBL	RM1L	1955	PC	1	$ 1,845,600	6,152	21.50488	-158.01781
HI000682	School	15003009200	Wahiawa Elementary - Bldg E	1390 GLEN AVE	WAHIAWA	96786	HI	MERBL	RM1L	1950	PC	1	$ 318,000	1,060	21.50488	-158.01781
HI000683	School	15003009200	Wahiawa Elementary - Bldg F	1390 GLEN AVE	WAHIAWA	96786	HI	MERBL	RM1L	1950	PC	1	$ 1,827,600	6,092	21.50488	-158.01781
HI000684	School	15003009200	Wahiawa Elementary - Bldg G	1390 GLEN AVE	WAHIAWA	96786	HI	MERBL	RM1L	1950	PC	1	$ 1,827,600	6,092	21.50488	-158.01781
HI000685	School	15003009200	Wahiawa Elementary - Bldg H	1390 GLEN AVE	WAHIAWA	96786	HI	MERBL	RM1L	1950	PC	1	$ 1,827,600	6,092	21.50488	-158.01781
HI000686	School	15003009000	Wahiawa Middle - Bldg A	275 ROSE ST WAHI	WAHIAWA	96786	HI	MERBL	RM1L	1961	PC	2	$ 3,405,600	11,352	21.49405	-158.01864
HI000687	School	15003009000	Wahiawa Middle - Bldg B	275 ROSE ST WAHI	WAHIAWA	96786	HI	MERBL	RM1L	1963	PC	2	$ 3,397,200	11,324	21.49405	-158.01864
HI000688	School	15003009000	Wahiawa Middle - Bldg C	275 ROSE ST WAHI	WAHIAWA	96786	HI	MERBL	RM1L	1963	PC	2	$ 3,397,200	11,324	21.49405	-158.01864
HI000689	School	15003009000	Wahiawa Middle - Bldg H	275 ROSE ST WAHI	WAHIAWA	96786	HI	MERBL	RM1L	1963	PC	1	$ 1,500,300	5,001	21.49405	-158.01864
HI000690	School	15003010303	Waiahole Elementary - Bldg G	48-215 WAIAHOLE VALLEY RD	KANEOHE	96744	HI	MERBL	RM1L	1957	PC	1	$ 1,469,700	4,899	21.48329	-157.85165
HI000691	School	15003010303	Waiahole Elementary - Bldg P1	48-215 WAIAHOLE VALLEY RD	KANEOHE	96744	HI	WSF1	W1	1966	PC	1	$ 156,800	896	21.48329	-157.85165
HI000692	School	15003010303	Waiahole Elementary - Bldg P2	48-215 WAIAHOLE VALLEY RD	KANEOHE	96744	HI	WSF1	W1	1966	PC	1	$ 156,800	896	21.48329	-157.85165
HI000693	School	15003000700	Waialae Elementary PCS - Bldg A	1045 19TH AVE	HONOLULU	96816	HI	WSF2	W1	1964	PC	2	$ 2,435,475	13,917	21.27611	-157.79256
HI000694	School	15003000700	Waialae Elementary PCS - Bldg B	1045 19TH AVE	HONOLULU	96816	HI	MERBL	RM1L	1965	PC	2	$ 3,819,900	12,733	21.27611	-157.79256
HI000695	School	15003009901	Waialua Elementary - Bldg A	67-20 WAIALUA BEACH RD	WAIALUA	96791	HI	WSF2	W1	1966	PC	2	$ 2,677,675	15,301	21.57549	-158.12164
HI000696	School	15003009901	Waialua Elementary - Bldg D	67-20 WAIALUA BEACH RD	WAIALUA	96791	HI	MERBL	RM1L	1993	HC	2	$ 2,812,500	9,375	21.57549	-158.12164
HI000697	School	15003009901	Waialua High & Intermediate - Bldg C	67-595A KAHUI ST	WAIALUA	96791	HI	MERBL	RM1L	1972	PC	1	$ 2,562,300	8,541	21.56583	-158.12646
HI000698	School	15003009901	Waialua High & Intermediate - Bldg F	67-595A KAHUI ST	WAIALUA	96791	HI	WSF1	W1	1955	PC	1	$ 1,896,125	10,835	21.56583	-158.12646
HI000699	School	15003009901	Waialua High & Intermediate - Bldg L	67-595A KAHUI ST	WAIALUA	96791	HI	MERBL	RM1L	1965	PC	1	$ 1,316,100	4,387	21.56583	-158.12646
HI000700	School	15003009901	Waialua High & Intermediate - Bldg S	67-595A KAHUI ST	WAIALUA	96791	HI	MERBL	RM1L	1978	PC	2	$ 3,767,700	12,559	21.56583	-158.12646
HI000701	School	15003009901	Waialua High & Intermediate - Bldg T	67-595A KAHUI ST	WAIALUA	96791	HI	MERBL	RM1L	1980	PC	2	$ 8,297,100	27,657	21.56583	-158.12646
HI000702	School	15003009901	Waialua High & Intermediate - Bldg U	67-595A KAHUI ST	WAIALUA	96791	HI	MERBL	RM1L	1985	HC	1	$ 1,998,300	6,661	21.56583	-158.12646
HI000703	School	15003009901	Waialua High & Intermediate - Bldg V	67-595A KAHUI ST	WAIALUA	96791	HI	MERBL	RM1L	1993	HC	1	$ 1,831,200	6,104	21.56583	-158.12646
HI000704	School	15003009901	Waialua High & Intermediate - Bldg W	67-595A KAHUI ST	WAIALUA	96791	HI	MERBL	RM1L	1971	PC	1	$ 2,217,600	7,392	21.56583	-158.12646
HI000705	School	15003009701	Waianae Elementary - Bldg B	85-220 MCARTHUR ST	WAIANAE	96792	HI	MERBL	RM1L	1950	PC	1	$ 1,342,500	4,475	21.44589	-158.18453
HI000706	School	15003009701	Waianae Elementary - Bldg C	85-220 MCARTHUR ST	WAIANAE	96792	HI	WSF1	W1	1949	PC	1	$ 659,400	3,768	21.44589	-158.18453
HI000707	School	15003009701	Waianae Elementary - Bldg D	85-220 MCARTHUR ST	WAIANAE	96792	HI	MERBL	RM1L	1950	PC	1	$ 1,239,600	4,132	21.44589	-158.18453
HI000708	School	15003009701	Waianae Elementary - Bldg F	85-220 MCARTHUR ST	WAIANAE	96792	HI	MERBL	RM1L	1965	PC	1	$ 927,000	3,090	21.44589	-158.18453
HI000709	School	15003009701	Waianae Elementary - Bldg G	85-220 MCARTHUR ST	WAIANAE	96792	HI	MERBL	RM1L	1982	HC	2	$ 3,253,500	10,845	21.44589	-158.18453
HI000710	School	15003009701	Waianae Elementary - Bldg L	85-220 MCARTHUR ST	WAIANAE	96792	HI	MERBL	RM1L	1969	PC	1	$ 1,545,900	5,153	21.44589	-158.18453
HI000711	School	15003007805	Waiau Elementary - Bldg D	98-450 HOOKANIKE ST	PEARL CITY	96782	HI	MERBL	RM1L	1974	PC	2	$ 5,241,900	17,473	21.39887	-157.95331

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000712	School	15003007805	Waiau Elementary - Bldg F	98-450 HOOKANIKE ST	PEARL CITY	96782	HI	MERBL	RM1L	1979	PC	2	$ 2,921,400	9,738	21.39887	-157.95331
HI000713	School	15003001700	Waikiki Elementary - Bldg B	3710 LEAHI AVE	HONOLULU	96815	HI	MERBL	RM1L	1964	PC	2	$ 3,047,400	10,158	21.26795	-157.81448
HI000714	School	15003001700	Waikiki Elementary - Bldg C	3710 LEAHI AVE	HONOLULU	96815	HI	MERBL	RM1L	1964	PC	2	$ 3,047,400	10,158	21.26795	-157.81448
HI000715	School	15003008002	Waimalu Elementary - Bldg A	98-825 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1961	PC	1	$ 1,679,400	5,598	21.38998	-157.95039
HI000716	School	15003008002	Waimalu Elementary - Bldg B	98-825 MOANALUA RD	AIEA	96701	HI	WSF1	W1	1961	PC	1	$ 1,200,325	6,859	21.38998	-157.95039
HI000717	School	15003008002	Waimalu Elementary - Bldg D	98-825 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1961	PC	2	$ 4,057,800	13,526	21.38998	-157.95039
HI000718	School	15003008002	Waimalu Elementary - Bldg E	98-825 MOANALUA RD	AIEA	96701	HI	MERBL	RM1L	1961	PC	2	$ 4,008,600	13,362	21.38998	-157.95039
HI000719	School	15003011301	Waimanalo Elem & Inter - Bldg C	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	MERBL	RM1L	1950	PC	1	$ 993,900	3,313	21.34553	-157.71525
HI000720	School	15003011301	Waimanalo Elem & Inter - Bldg D	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	MERBL	RM1L	1952	PC	1	$ 1,187,700	3,959	21.34553	-157.71525
HI000721	School	15003011301	Waimanalo Elem & Inter - Bldg N	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	MERBL	RM1L	1955	PC	1	$ 1,511,100	5,037	21.34553	-157.71525
HI000722	School	15003011301	Waimanalo Elem & Inter - Bldg O	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	MERBL	RM1L	1961	PC	1	$ 1,336,800	4,456	21.34553	-157.71525
HI000723	School	15003011301	Waimanalo Elem & Inter - Bldg Q	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	MERBL	RM1L	1962	PC	1	$ 3,460,500	11,535	21.34553	-157.71525
HI000724	School	15003011301	Waimanalo Elem & Inter - Bldg R	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	WSF1	W1	1975	PC	1	$ 778,750	4,450	21.34553	-157.71525
HI000725	School	15003011301	Waimanalo Elem & Inter - Bldg S	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	WSF1	W1	1976	PC	1	$ 1,455,475	8,317	21.34553	-157.71525
HI000726	School	15003011301	Waimanalo Elem & Inter - Bldg T	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	MERBL	RM1L	1972	PC	1	$ 539,700	1,799	21.34553	-157.71525
HI000727	School	15003011301	Waimanalo Elem & Inter - Bldg U	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	MERBL	RM1L	1972	PC	1	$ 1,416,600	4,722	21.34553	-157.71525
HI000728	School	15003011301	Waimanalo Elem & Inter - Bldg V	41-1312 KALANIANAOLE HWY	WAIMANALO	96795	HI	MERBL	RM1L	1972	PC	1	$ 986,400	3,288	21.34553	-157.71525
HI000729	School	15003008703	Waipahu Elementary - Bldg B	94-465 WAIPAHU ST	WAIPAHU	96797	HI	WSF1	W1	1967	PC	1	$ 1,334,025	7,623	21.38495	-158.01592
HI000730	School	15003008703	Waipahu Elementary - Bldg D	94-465 WAIPAHU ST	WAIPAHU	96797	HI	MERBL	RM1L	1969	PC	2	$ 2,591,400	8,638	21.38495	-158.01592
HI000731	School	15003008703	Waipahu Elementary - Bldg E	94-465 WAIPAHU ST	WAIPAHU	96797	HI	MERBL	RM1L	1964	PC	2	$ 4,096,800	13,656	21.38495	-158.01592
HI000732	School	15003008703	Waipahu Elementary - Bldg F	94-465 WAIPAHU ST	WAIPAHU	96797	HI	MERBL	RM1L	1955	PC	1	$ 777,600	2,592	21.38495	-158.01592
HI000733	School	15003008703	Waipahu Elementary - Bldg I	94-465 WAIPAHU ST	WAIPAHU	96797	HI	MERBL	RM1L	1970	PC	2	$ 2,830,500	9,435	21.38495	-158.01592
HI000734	School	15003008701	Waipahu High - Bldg A	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1968	PC	1	$ 710,400	2,368	21.38759	-157.99397
HI000735	School	15003008701	Waipahu High - Bldg B	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1971	PC	1	$ 2,538,600	8,462	21.38759	-157.99397
HI000736	School	15003008701	Waipahu High - Bldg C	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1967	PC	1	$ 2,574,900	8,583	21.38759	-157.99397
HI000737	School	15003008701	Waipahu High - Bldg D	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1967	PC	1	$ 919,200	3,064	21.38759	-157.99397
HI000738	School	15003008701	Waipahu High - Bldg E	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1969	PC	2	$ 2,919,600	9,732	21.38759	-157.99397
HI000739	School	15003008701	Waipahu High - Bldg F	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1969	PC	2	$ 4,133,700	13,779	21.38759	-157.99397
HI000740	School	15003008701	Waipahu High - Bldg G	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	WSF2	W1	1968	PC	2	$ 1,931,475	11,037	21.38759	-157.99397
HI000741	School	15003008701	Waipahu High - Bldg H	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1967	PC	2	$ 3,011,400	10,038	21.38759	-157.99397
HI000742	School	15003008701	Waipahu High - Bldg I	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1967	PC	2	$ 6,015,600	20,052	21.38759	-157.99397
HI000743	School	15003008701	Waipahu High - Bldg J	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1967	PC	1	$ 3,859,800	12,866	21.38759	-157.99397
HI000744	School	15003008701	Waipahu High - Bldg M	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	WSF1	W1	1967	PC	1	$ 2,139,725	12,227	21.38759	-157.99397
HI000745	School	15003008701	Waipahu High - Bldg N	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1977	PC	1	$ 6,944,700	23,149	21.38759	-157.99397
HI000746	School	15003008701	Waipahu High - Bldg Q	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1988	HC	2	$ 3,604,500	12,015	21.38759	-157.99397
HI000747	School	15003008701	Waipahu High - Bldg U	94-1211 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1988	HC	2	$ 5,113,800	17,046	21.38759	-157.99397
HI000748	School	15003008703	Waipahu Intermediate - Bldg C	94-427 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1987	HC	2	$ 3,226,200	10,754	21.38056	-158.01288
HI000749	School	15003008703	Waipahu Intermediate - Bldg E	94-427 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1996	HC	2	$ 3,313,500	11,045	21.38056	-158.01288
HI000750	School	15003008703	Waipahu Intermediate - Bldg J	94-427 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1985	HC	2	$ 3,822,000	12,740	21.38056	-158.01288
HI000751	School	15003008703	Waipahu Intermediate - Bldg L	94-427 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1975	PC	1	$ 2,668,800	8,896	21.38056	-158.01288
HI000752	School	15003008703	Waipahu Intermediate - Bldg M	94-427 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1980	PC	2	$ 4,121,400	13,738	21.38056	-158.01288
HI000753	School	15003008703	Waipahu Intermediate - Bldg S	94-427 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1957	PC	1	$ 1,732,200	5,774	21.38056	-158.01288
HI000754	School	15003008703	Waipahu Intermediate - Bldg Y	94-427 FARRINGTON HWY	WAIPAHU	96797	HI	MERBL	RM1L	1962	PC	2	$ 3,846,000	12,820	21.38056	-158.01288
HI000755	School	15003002500	Washington Middle - Bldg A	1710 WAIOLA ST	HONOLULU	96826	HI	MERBL	RM1L	1952	PC	2	$ 3,788,400	12,628	21.29564	-157.83522
HI000756	School	15003002500	Washington Middle - Bldg B	1710 WAIOLA ST	HONOLULU	96826	HI	MERBL	RM1L	1952	PC	2	$ 3,532,800	11,776	21.29564	-157.83522
HI000757	School	15003002500	Washington Middle - Bldg F	1710 WAIOLA ST	HONOLULU	96826	HI	MERBL	RM1L	1939	PC	2	$ 5,374,800	17,916	21.29564	-157.83522
HI000758	School	15003002500	Washington Middle - Bldg G	1710 WAIOLA ST	HONOLULU	96826	HI	MERBL	RM1L	1963	PC	1	$ 1,432,800	4,776	21.29564	-157.83522
HI000759	School	15003002500	Washington Middle - Bldg H	1710 WAIOLA ST	HONOLULU	96826	HI	MERBL	RM1L	1967	PC	2	$ 4,196,400	13,988	21.29564	-157.83522
HI000760	School	15003002500	Washington Middle - Bldg P2	1710 WAIOLA ST	HONOLULU	96826	HI	WSF1	W1	1966	PC	1	$ 156,800	896	21.29564	-157.83522
HI000761	School	15003002500	Washington Middle - Bldg P3	1710 WAIOLA ST	HONOLULU	96826	HI	WSF1	W1	1966	PC	1	$ 156,800	896	21.29564	-157.83522
HI000762	School	15003002500	Washington Middle - Bldg P4	1710 WAIOLA ST	HONOLULU	96826	HI	WSF1	W1	1966	PC	1	$ 156,800	896	21.29564	-157.83522
HI000763	School	15003007503	Webling Elementary - Bldg A	99-600 KULAWEA ST	AIEA	96701	HI	MERBL	RM1L	1967	PC	2	$ 3,440,700	11,469	21.38125	-157.92032
HI000764	School	15003007503	Webling Elementary - Bldg B	99-600 KULAWEA ST	AIEA	96701	HI	MERBL	RM1L	1967	PC	2	$ 3,361,800	11,206	21.38125	-157.92032
HI000765	School	15003007503	Webling Elementary - Bldg C	99-600 KULAWEA ST	AIEA	96701	HI	MERBL	RM1L	1970	PC	1	$ 1,954,500	6,515	21.38125	-157.92032
HI000766	School	15003007503	Webling Elementary - Bldg D	99-600 KULAWEA ST	AIEA	96701	HI	WSF1	W1	1968	PC	1	$ 977,900	5,588	21.38125	-157.92032

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000767	School	15003009000	Wheeler Elementary - Bldg A	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1966	PC	2	$ 3,608,100	12,027	21.48780	-158.03806
HI000768	School	15003009000	Wheeler Elementary - Bldg B	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1971	PC	2	$ 4,722,000	15,740	21.48780	-158.03806
HI000769	School	15003009000	Wheeler Elementary - Bldg C	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1988	HC	2	$ 2,593,800	8,646	21.48780	-158.03806
HI000770	School	15003009000	Wheeler Elementary - Bldg G	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1991	HC	1	$ 2,412,300	8,041	21.48780	-158.03806
HI000771	School	15003009000	Wheeler Middle - Bldg A	1 WILIKINA DR	WAHIAWA	96786	HI	WSF2	W1	1970	PC	2	$ 2,671,900	15,268	21.48661	-158.03881
HI000772	School	15003009000	Wheeler Middle - Bldg B	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1970	PC	1	$ 1,511,700	5,039	21.48661	-158.03881
HI000773	School	15003009000	Wheeler Middle - Bldg C	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1969	PC	2	$ 3,827,400	12,758	21.48661	-158.03881
HI000774	School	15003009000	Wheeler Middle - Bldg D	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1970	PC	2	$ 5,301,600	17,672	21.48661	-158.03881
HI000775	School	15003009000	Wheeler Middle - Bldg E	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1969	PC	2	$ 7,369,500	24,565	21.48661	-158.03881
HI000776	School	15003009000	Wheeler Middle - Bldg F	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1970	PC	2	$ 2,318,700	7,729	21.48661	-158.03881
HI000777	School	15003009000	Wheeler Middle - Bldg G	1 WILIKINA DR	WAHIAWA	96786	HI	WSF1	W1	1970	PC	1	$ 1,654,625	9,455	21.48661	-158.03881
HI000778	School	15003009000	Wheeler Middle - Bldg H	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1969	PC	1	$ 3,380,100	11,267	21.48661	-158.03881
HI000779	School	15003009000	Wheeler Middle - Bldg I	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1978	PC	1	$ 550,200	1,834	21.48661	-158.03881
HI000780	School	15003009000	Wheeler Middle - Bldg J	1 WILIKINA DR	WAHIAWA	96786	HI	MERBL	RM1L	1978	PC	1	$ 1,128,000	3,760	21.48661	-158.03881
HI000781	School	15003000901	Wilson Elementary - Bldg B	4901 KILAUEA AVE	HONOLULU	96816	HI	WSF1	W1	1961	PC	1	$ 1,346,800	7,696	21.28241	-157.78472
HI000782	School	15003000901	Wilson Elementary - Bldg C	4901 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1965	PC	2	$ 2,799,900	9,333	21.28241	-157.78472
HI000783	School	15003000901	Wilson Elementary - Bldg D	4901 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1967	PC	2	$ 2,487,600	8,292	21.28241	-157.78472
HI000784	School	15003000901	Wilson Elementary - Bldg F	4901 KILAUEA AVE	HONOLULU	96816	HI	MERBL	RM1L	1970	PC	2	$ 2,547,300	8,491	21.28241	-157.78472
HI000785	School - UH Manoa	15003002701	Hawaii Hall	2500 Campus Road	HONOLULU	96848	HI	SERBL	S2L	1912	PC	3	$ 10,946,700	36,489	21.29994	-157.81900
HI000786	School - UH Manoa	15003002900	Astronomy, Institute for	2680 Woodlawn Drive	HONOLULU	96848	HI	CERBL	C2L	1976	PC	2	$ 16,620,000	55,400	21.30730	-157.81158
HI000787	School - UH Manoa	15003002701	Saunders Hall	2424 Maile Way	HONOLULU	96848	HI	CERBM	C2M	1973	PC	7	$ 43,724,610	126,738	21.30057	-157.81913
HI000788	School - UH Manoa	15003002701	Gartley Hall	2430 Campus Road	HONOLULU	96848	HI	MMUH3	URMM	1921	PC	3	$ 7,347,900	24,493	21.29954	-157.82018
HI000789	School - UH Manoa	15003002701	Architecture Building	2410 Campus Road	HONOLULU	96848	HI	CERBL	C2L	1996	HC	3	$ 17,400,000	58,000	21.29984	-157.82068
HI000790	School - UH Manoa	15003002701	Shidler College of Business	2404 Maile Way	HONOLULU	96848	HI	CERBM	C2M	1972	PC	5	$ 42,900,000	143,000	21.30110	-157.82029
HI000791	School - UH Manoa	15003002701	George Hall	2560 Campus Road	HONOLULU	96848	HI	CERBL	C2L	1922	PC	3	$ 17,184,795	49,811	21.30043	-157.82019
HI000792	School - UH Manoa	15003002701	Queen Liliuokalani Center For Student Se	2600 Campus Road	HONOLULU	96848	HI	CERBL	C1L	1996	HC	3	$ 30,900,000	103,000	21.30050	-157.81839
HI000793	School - UH Manoa	15003002701	Dean Hall	2450 Campus Road	HONOLULU	96848	HI	MMUH3	URMM	1929	PC	3	$ 5,630,400	18,768	21.29955	-157.81951
HI000794	School - UH Manoa	15003002702	Wist Hall	1776 University Ave	HONOLULU	96848	HI	MERBL	RM1L	1930	PC	2	$ 7,377,300	24,591	21.29856	-157.82177
HI000795	School - UH Manoa	15003002701	Sakamaki Hall	2530 Dole street	HONOLULU	96848	HI	CERBM	C2M	1976	PC	4	$ 26,161,800	87,206	21.29751	-157.81706
HI000796	School - UH Manoa	15003002701	Art Building	2535 The Mall	HONOLULU	96848	HI	CERBL	C2L	1974	PC	3	$ 47,238,600	157,462	21.29925	-157.81749
HI000797	School - UH Manoa	15003002701	Hemenway Hall	2445 Campus Road	HONOLULU	96848	HI	CERBL	C2L	1939	PC	2	$ 10,458,300	34,861	21.29879	-157.81969
HI000798	School - UH Manoa	15003002701	Crawford Hall	2550 Campus Road	HONOLULU	96848	HI	CERBL	C2L	1938	PC	3	$ 8,508,390	24,662	21.30026	-157.81956
HI000799	School - UH Manoa	15003002701	Miller Hall	2515 Campus Road	HONOLULU	96848	HI	MMUH3	RM1L	1939	PC	3	$ 5,781,900	19,273	21.29935	-157.81816
HI000800	School - UH Manoa	15003002702	Castle Memorial Hall	1776 University Ave	HONOLULU	96848	HI	WMUH1	W1	1941	PC	1	$ 5,127,120	28,484	21.29746	-157.82281
HI000801	School - UH Manoa	15003002701	Korean Studies, Center for	1881 East West Road	HONOLULU	96848	HI	CERBL	C1L	1980	LC	2	$ 4,970,700	16,569	21.30113	-157.81418
HI000802	School - UH Manoa	15003002702	KHET TV (ETV Production Building)	2350 Dole Street	HONOLULU	96848	HI	CERBL	C2L	1973	PC	2	$ 5,820,000	19,400	21.29713	-157.82195
HI000803	School - UH Manoa	15003002702	Everly Hall	1776 University Ave	HONOLULU	96848	HI	MERBL	RM1L	1979	PC	2	$ 6,187,500	20,625	21.29891	-157.82176
HI000804	School - UH Manoa	15003002701	Gilmore Hall	3050 Maile Way	HONOLULU	96848	HI	CERBM	C2M	1978	LC	7	$ 25,247,100	73,180	21.30164	-157.81669
HI000805	School - UH Manoa	15003002701	Sherman Laboratory	1910 East West Road	HONOLULU	96848	HI	CERBL	C2L	1985	HC	3	$ 24,521,000	49,042	21.30227	-157.81507
HI000806	School - UH Manoa	15003002701	Music Building Complex	2411 Dole Street	HONOLULU	96848	HI	CERBL	C2L	1973	PC	2	$ 13,491,000	44,970	21.29572	-157.82065
HI000807	School - UH Manoa	15003002701	Marine Sciences Building	1000 Pope Road	HONOLULU	96848	HI	CERBM	C2M	1984	HC	6	$ 54,912,500	95,500	21.29794	-157.81570
HI000808	School - UH Manoa	15003002701	Bachman Hall	2444 Dole Street	HONOLULU	96848	HI	MERBL	RM2L	1949	PC	2	$ 8,421,000	28,070	21.29722	-157.81998
HI000809	School - UH Manoa	15003002701	Physical Education/Athletic Complex (HPE	1337 Lower Campus Road	HONOLULU	96848	HI	CERBL	C2L	1982	HC	3	$ 35,760,000	119,200	21.29475	-157.81816
HI000810	School - UH Manoa	15003002701	HECO Substation	1311 Lower Campus Road	HONOLULU	96848	HI	MSF2	RM2L	1998	HC	2	$ 1,635,904	4,500	21.29198	-157.81611
HI000811	School - UH Manoa	15003002701	Stan Sheriff Center	1337 Lower Campus Road	HONOLULU	96848	HI	CERBL	C1L	1994	HC	1	$ 57,000,000	190,000	21.29429	-157.81889
HI000812	School - UH Manoa	15003002701	Bilger Hall	2445 The Mall	HONOLULU	96848	HI	CERBL	C2L	1952	PC	3	$ 22,471,800	74,906	21.29938	-157.81670
HI000813	School - UH Manoa	15003002701	Bilger Addition	2445 The Mall	HONOLULU	96848	HI	CERBM	C2M	1972	PC	4	$ 36,665,000	73,330	21.29893	-157.81672
HI000814	School - UH Manoa	15003002701	Hawaiian Studies, Center for	2645 Dole Street	HONOLULU	96848	HI	CERBL	C2L	1997	HC	2	$ 6,600,000	22,000	21.29513	-157.81213
HI000815	School - UH Manoa	15003002701	Sinclair Library	2425 Campus Road	HONOLULU	96848	HI	CERBL	C1L	1956	PC	3	$ 37,106,055	117,797	21.29842	-157.82044
HI000816	School - UH Manoa	15003002701	Law School	2515 Dole Street	HONOLULU	96848	HI	CERBL	C1L	1985	HC	2	$ 15,957,000	53,190	21.29647	-157.81873
HI000817	School - UH Manoa	15003002701	Law Library	2525 Dole Street	HONOLULU	96848	HI	CERBL	C1L	1982	HC	1	$ 10,472,175	33,245	21.29635	-157.81733
HI000818	School - UH Manoa	15003002702	University High School #3	1776 University Ave	HONOLULU	96848	HI	CERBL	C1L	1957	PC	2	$ 8,172,300	27,241	21.29796	-157.82179
HI000819	School - UH Manoa	15003002701	Keller Hall	2565 The Mall	HONOLULU	96848	HI	CERBL	C2L	1959	PC	3	$ 24,571,500	49,143	21.29972	-157.81578
HI000820	School - UH Manoa	15003002701	Physical Science Building	2565 The Mall	HONOLULU	96848	HI	CERBL	C2L	1960	PC	3	$ 12,861,900	42,873	21.29918	-157.81601
HI000821	School - UH Manoa	15003002701	Watanabe Hall	2505 Correa Road	HONOLULU	96848	HI	CERBM	C2M	1972	PC	4	$ 33,083,500	66,167	21.29839	-157.81576

ID	Facility Type	Tract	Name	Address	City	ZipCode	State	Hurricane SBT	EQ SBT	YearBuilt	DesignLevel	NumStories	Cost	Area	Latitude	Longitude
HI000822	School - UH Manoa	15003002701	Pacific Ocean Science & Technology (POST	1686 East West Road	HONOLULU	96848	HI	CERBH	C2H	1995	HC	9	$ 112,500,000	225,000	21.29752	-157.81630
HI000823	School - UH Manoa	15003002701	Holmes Hall	1540 Dole Street	HONOLULU	96848	HI	CERBM	C2M	1972	PC	4	$ 44,273,000	88,546	21.29697	-157.81604
HI000824	School - UH Manoa	15003002701	Edmundson Hall	2538 The Mall	HONOLULU	96848	HI	CERBM	C2M	1963	PC	4	$ 13,044,000	43,480	21.30051	-157.81669
HI000825	School - UH Manoa	15003002701	Hawaii Institute of Geophysics (Geophysi	2525 Correa Road	HONOLULU	96848	HI	CERBM	C2M	1963	PC	4	$ 38,012,400	126,708	21.29820	-157.81663
HI000826	School - UH Manoa	15003002701	Webster Hall	2528 The Mall	HONOLULU	96848	HI	CERBM	C2M	1961	PC	4	$ 17,867,700	59,559	21.30061	-157.81773
HI000827	School - UH Manoa	15003002701	Spalding Hall	2540 Maile Way	HONOLULU	96848	HI	CERBM	C2M	1961	PC	4	$ 9,903,600	33,012	21.30083	-157.81738
HI000828	School - UH Manoa	15003002701	Pope Laboratory	3190 Maile Way	HONOLULU	96848	HI	CERBL	C2L	1973	PC	1	$ 17,904,000	35,808	21.30263	-157.81515
HI000829	School - UH Manoa	15003002701	Biomedical Sciences Building	1960 East West Road	HONOLULU	96848	HI	CERBH	C2H	1972	PC	8	$ 92,296,000	184,592	21.30343	-157.81466
HI000830	School - UH Manoa	15003002701	Moore Hall	1890 East West Road	HONOLULU	96848	HI	CERBM	C2M	1969	PC	5	$ 33,282,000	110,940	21.30098	-157.81507
HI000831	School - UH Manoa	15003002701	Snyder Hall	2538 The Mall	HONOLULU	96848	HI	CERBM	C1M	1962	PC	5	$ 30,015,000	60,030	21.30029	-157.81716
HI000832	School - UH Manoa	15003002701	Kennedy Theatre	1770 East West Road	HONOLULU	96848	HI	MERBL	RM2L	1963	PC	2	$ 14,190,600	47,302	21.29928	-157.81495
HI000833	School - UH Manoa	15003003000	College Hill	2334 Kamehameha Ave	HONOLULU	96848	HI	WMUH2	W1	1963	PC	2	$ 3,525,900	10,220	21.30378	-157.82106
HI000834	School - UH Manoa	15003002701	Auxiliary Services	1951 East West Road	HONOLULU	96848	HI	CERBL	C1L	1962	PC	1	$ 12,168,000	24,336	21.30233	-157.81411
HI000835	School - UH Manoa	15003002701	University Health Services	1710 East West Road	HONOLULU	96848	HI	MERBL	RM1L	1963	PC	1	$ 3,237,600	10,792	21.29836	-157.81526
HI000836	School - UH Manoa	15003002701	Kuykendall Hall	1773 Donagho Road	HONOLULU	96848	HI	CERBM	C2M	1964	PC	4	$ 32,857,500	87,620	21.29839	-157.81760
HI000837	School - UH Manoa	15003002701	Physical Plant Building	2002 East West Road	HONOLULU	96848	HI	MMUH1	RM1L	1963	PC	1	$ 752,850	4,302	21.30356	-157.81333
HI000838	School - UH Manoa	15003002701	Maintenance Warehouse	2002 East West Road	HONOLULU	96848	HI	SPMBS	S1L	1963	PC	2	$ 3,180,625	25,445	21.30370	-157.81280
HI000839	School - UH Manoa	15003002701	St. John Laboratory Complex	3190 Maile Way	HONOLULU	96848	HI	CERBM	C2M	1969	PC	7	$ 62,898,000	125,796	21.30166	-157.81532
HI000840	School - UH Manoa	15003002701	Hamilton Library	2540 The Mall	HONOLULU	96848	HI	CERBM	C2M	1968	PC	4	$ 144,574,560	401,596	21.30073	-157.81617
HI000841	School - UH Manoa	15003002701	Agricultural Science Facility	1955 East West Road	HONOLULU	96848	HI	CERBM	C2M	1995	HC	4	$ 55,393,000	110,786	21.30278	-157.81382

Number		ID	Location			Year Built	# spans
1	159	003843001100001	HUIPA DR/MAKAHA STRM	HUIPA DR	TMK=8-4-02-5(MAKAHA)	1970	002
2	159	003000610400022	H1 RAMP TO PALI HWY	SCHOOL ST	0.22MI NE/VINEYARD BLVD	1960	001
3	159	003000631100418	BURMEISTER OP-LIKELIKE H	PRIVATE RD	1.25MI NE/VALLEY VIEW DR	1959	004
4	159	003000H11100048	FAI-H1(FARR SEP)	FARR HWY	0.42MI E/KALAELOA BLVD	1966	004
5	159	003000H11100112	FAI-H1(MAKAKILO SEP)	MAKAKILO DR	1.06MI E/KALAELOA BLVD	1966	004
6	159	003000H11100633	FAI-H1(MILITARY RD OP)	MILITARY RD	0.96MI E/KUNIA RD	1967	004
7	159	003000H11100677	FAI-H1(LUMIAINA ST OP)	LUMIAINA ST.	0.43MI E/NAVAL ACC RD	1968	002
8	159	003000H11100817	FAI-H1(WAIAWA IC #12)	WAIPAHU ST	1.41MI E/MANAGERS DR	1968	004
9	159	003000H11100913	WAIAWA IC #1 FAI-H1	WAIAWA RD	0.96MI E/WAIPAHU ST SEP	1969	002
10	159	003000H11101095	AUSTIN BISHOP SEP-FAI-H1	AUSTIN BISHOP	0.65MI E/KAM HWY	1971	002
11	159	003000H11101178	KAONOHI ST SEP-FAI-H1	KAONOHI ST	1.48MI E/KAM HWY	1970	002
12	159	003000H11101241	KAAMILO ST SEP FAI-H1	KAAMILO ST	2.11MI E/KAM HWY	1970	002
13	159	003000H11101278	AIEA HTS DR SEP(FAI-H1)	AIEA HTS DR	0.37MI E/KAAMILO ST SEP	1970	002
14	159	003000H11101303	KAIMAKANI ST SEP(FAI-H1)	KAIMAKANI ST	0.33MI E/AIEA HTS DR SEP	1970	002
15	159	003000H11102157	FAI-H1(AALA ST EXT SEP)	AALA ST	0.23MI E/LILIHA ST	1964	002
16	159	003000H11201522	FAI-H1 UP-PH INT #2	MAUKA FRONTAGE RD	0.33MI S/PLT DR SEP	1975	003
17	159	003000H11201552	FAI-H1-PH INT #6	RAMP "NW"	0.67MI S/PLT DR SEP	1974	008
18	159	003000H11201948	FAI-H1	OLA LANE	0.11MI E/MIDDLE ST	1961	003
19	159	003000H11201990	FAI-H1	GULICK AVE	0.45MI E/OLA LANE	1959	002
20	159	003000H11202591	7TH AVE SEP(FAI-H1)	7TH AVE	0.08MI E/6TH AVE SEP	1964	002
21	159	003000H11202669	16TH AVE SEP(FAI-H1)	16TH AVE	0.26MI E/KOKOHEAD AVE SEP	1966	002
22	159	003000610000045	PALI HWY(KUAKINI PED OP)	PEDESTRIAN	0.27MI NE/SCH ST	1962	002
23	159	003000610300568	PALI TUNN 1A OB(MTN)	PALI HWY	0.10MI NE/PALI LKOT RD	1959	001
24	159	003000610300569	PALI TUNN 1 IB(MTN)	PALI HWY	0.10MI NE/PALI LKOT RD	1957	001
25	159	003000610300591	PALI BR 1 IB(PART'L)	PALI HWY	0.32MI NE/PALI LKOT RD	1956	001
26	159	003000610300592	PALI BR 2 IB(PART'L)	PALI HWY	0.33MI NE/PALI LKOT RD	1956	001
27	159	003000610300593	PALI BR 3 IB(PART'L)	PALI HWY	0.34MI NE/PALI LKOT RD	1956	002
28	159	003000610300595	PALI TUNN 2A OB(MTN)	PALI HWY	0.36MI NE/PALI LKOT RD	1961	001
29	159	003000610300596	PALI TUNN 2 IB(MTN)	PALI HWY	0.36MI NE/PALI LKOT RD	1957	001
30	159	003000610300613	PALI BR 4A OB(PART'L)	PALI HWY	0.54MI NE/PALI LKOT RD	1961	004
31	159	003000610300615	PALI BR 4B OB(PART'L)	PALI HWY	0.56MI NE/PALI LKOT RD	1961	002
32	159	003000610300616	PALI BR 4 IB	PALI HWY	0.57MI NE/PALI LKOT RD	1956	004
33	159	003000610300619	PALI BR 4C OB	PALI HWY	0.605MI NE/PALI LKOT RD	1961	002
34	159	003000610300621	PALI BR 5 IB	PALI HWY	0.62MI NE/PALI LKOT RD	1956	004
35	159	003000610300623	PALI BR 5A OB	PALI HWY	0.64MI NE/PALI LKOT RD	1961	002
36	159	003000610300629	PALI BR #6 IB	PALI HWY	0.70MI NE/PALI LKOT RD	1956	005
37	159	003000610300631	PALI BR #7A OB	PALI HWY	0.72MI NE/PALI LKOT RD	1961	002
38	159	003000610300632	PALI BR #7 IB	PALI HWY	0.73MI NE/PALI LKOT RD	1956	004
39	159	003000610300638	PALI BR #8A OB	PALI HWY	0.79MI NE/PALI LKOT RD	1961	002
40	159	003000610300640	PALI BR #8 IB	PALI HWY	0.81MI NE/PALI LKOT RD	1956	004
41	159	003000610300877	KAHANAIKI STRM	KAL HWY	0.04MI E/KAPAA QUARRY RD	1951	002
42	159	003000610400014	FAI-H1(STRUCT #1 OB)	PALI HWY	0.14MI NE/VINEYARD BLVD	1960	002
43	159	003000610400015	FAI-H1(STRUCT #1 IB)	PALI HWY	0.14MI NE/VINEYARD BLVD	1960	002
44	159	003000610400019	FAI-H1(STRUCT #2 IB)	RAMP IB	0.19MI NE/VINEYARD BLVD	1960	005
45	159	003000610400044	PAUOA STRM CULV'T	PALI HWY	0.26MI NE/SCH ST	1925	001
46	159	003000610400064	PAUOA RD	PALI HWY	0.46MI NE/SCH ST	1961	001
47	159	003000610400090	PARTIAL BR #8(GULCH)	PALI HWY	0.26MI NE/PAUOA RD	1962	002
48	159	003000610400112	NUUANU STRM KAPENA FALLS	PALI HWY	0.48MI NE/PAUOA RD	1962	001
49	159	003000610400912	MAUNAWILI STRM	KAL HWY	0.18MI E/AULOA RD	1951	003
50	159	003000610401060	KAWAINUI STRM OB	KAILUA RD	0.70MI E/ULUMANU ST	1940	003

List of Bridges

51	159	003000610401061	KAWAINUI STRM IB	KAILUA RD	0.70MI E/ULUMANU ST	1940	003
52	159	003000611100124	PALI HWY(WYLLIE OP)	WYLLIE ST	0.60MI NE/PAUOA RD	1961	002
53	159	003000H10402194	FAI-H1(PALI HWY OP IB)	PALI HWY	0.15MI E/NUUANU AVE SEP	1960	002
54	159	003000H10402198	FAI-H1(PALI HWY OP OB)	PALI HWY	0.19MI E/NUUANU AVE SEP	1960	002
55	159	003000630000087	KALIHI PED OP	PEDESTRIAN	0.13MI NE/BECKLEY ST	1959	003
56	159	003000630000234	KULAKOLEA PED OP	PEDESTRIAN	0.01MI NE/KULAKOLEA DR	1960	002
57	159	003000630400081	K2-KALIHI OP #2	LIKELIKE HWY	0.08MI NE/BECKLEY ST	1960	001
58	159	003000630400087	FAI-H1-KALIHI OP #1	LIKELIKE HWY	0.13MI NE/BECKLEY ST	1959	003
59	159	003000630400095	FAI-H1-KALIHI OP #3	RAMP K-2	0.21MI NE/BECKLEY ST	1959	003
60	159	003000630400166	KALIHI STRM	LIKELIKE HWY OB	0.51MI NE/SCHOOL ST	1957	003
61	159	003000630400167	KALIHI STRM	LIKELIKE HWY IB	0.51MI NE/SCHOOL ST	1957	003
62	159	003000630400557	KALIHI STRM 3 CELL CBC	LIKELIKE HWY	0.18MI W/WILSON TUNN	1954	003
63	159	003000630400575	JOHN H WILSON TUNN OB	LIKELIKE HWY	2.82MI NE/VALLEY VIEW DR	1959	001
64	159	003000630400576	JOHN H WILSON TUNN IB	LIKELIKE HWY	2.82MI NE/VALLEY VIEW DR	1958	001
65	159	003000H10402009	FAI-H1(STRUCT #3 KALIHI)	LIKELIKE HWY	0.19MI E/GULICK AVE	1959	003
66	159	003000H10402016	FAI-H1(KALIHI OP #1)	LIKELIKE HWY	0.26MI E/GULICK AVE	1959	003
67	159	003000H10402017	FAI-H1(KALIHI OP #2)	LIKELIKE HWY	0.26MI E/GULICK AVE	1959	001
68	159	003000640400149	HARBOR (BRIDGE #2)	SAND ISL ROAD	.22 MI S/S HARBOR ACC	1987	005
69	159	003000640400150	HARBOR (HNL(BASCULE BR)	SAND ISLAND RD	0.22MI S/S HARBOR ACC RD	1962	001
70	159	003063000000155	KANEOHE BAY DR-KOKOKAHI	KOKOKAHI PED OP	0.04MI W/KOKOKAHI PL	1952	001
71	159	003063001400065	KAWA STRM	KANEOHE BAY DR	0.01MI E/PUAAE RD	1939	001
72	159	003000720000030	KAL HWY(ULUPII PED OP)	PEDESTRIAN	0.15MI SE/ULUPUNI ST	1967	001
73	159	003000720300574	30X10 RCB CULVT	KAL HWY WAIMANALO	WAIMANALO DRAINAGE DITCH	1978	001
74	159	003000720401307	KULIOUOU STRM	KAL HWY	0.02MI W/BAY ST	1936	001
75	159	003000720401418	NIU STRM	KAL HWY	0.11MI W/NIUIKI CIRCLE	1934	003
76	159	003000720401504	WAILUPE STRM IB	KAL HWY	0.08MI W/EAST HIND DR	1930	002
77	159	003000720401505	WAILUPE STRM OB	KAL HWY	0.08MI W/EAST HIND DR	1955	002
78	159	003000720700285	KAHAWAI STRM(EAST)	KAL HWY	0.05MI NW/FLAMINGO ST	1924	002
79	159	003000720700329	WAIMANALO STRM	KAL HWY	0.13MI NE/KUMUNIKI ST	1924	001
80	159	003074000000432	KAL HWY-LUNALILO HM RD	PEDESTRIAN OP	0.35MI S/NAWILIWILI ST	1968	001
81	159	003074001400058	WAWAMALU STREAM	KAL HWY	0.72MI S/MAKAPUU LT HS RD	1972	001
82	159	003074001400083	WAWAMALU CANAL	KAL HWY	0.96MI E/MAKAPUU LT HS RD	1941	001
83	159	003074001400256	KAWAIAKAIEA STRM	KAL HWY	0.41MI SW/BLOW HOLE	1931	004
84	159	003074001400274	IHIIHILAUAKEA STRM	KAL HWY	0.59MI SW/BLOW HOLE	1931	001
85	159	003074001400490	KUAPA PD-HI KAI MARINER	KAL HWY	0.25MI NW/PORTLOCK RD	1969	006
86	159	003074001400545	KUAPA PD-MAUNALUA	KAL HWY	0.09MI NW/HAWAII KAI DR	1936	006
87	159	003076001400436	CANE HAUL ROAD	FT WEAVER RD(NB)	0.37MI N/RENTON RD	1983	001
88	159	003076001400437	CANE HAUL ROAD	FT WEAVER RD(SB)	0.38MI N/RENTON RD	1983	001
89	159	003076001400518	HONOULIULI STRM (S.B.)	FORT WEAVER RD	0.58MI N/MANGO TREE RD	1982	005
90	159	003076001400519	HONOULIULI STRM (N.B.)	FORT WEAVER RD	0.58MI N/MANGO TREE RD	1982	005
91	159	003076001400601	FARR HWY (S.B.)	FORT WEAVER RD	0.63MI S/INT/H1	1980	001
92	159	003076001400602	FARR HWY (N.B.)	FORT WEAVER RD	0.63MI S/INT/H1	1980	001
93	159	003000780000049	MOANALUA RD AIEA IC PED	PEDESTRIAN	0.29MI E/LAULIMA ST	1966	003
94	159	003000780400001	KAM HWY AIEA IC #2	MOANALUA RD	0.25MI E/MCGREW LOOP	1966	010
95	159	003000780400065	MOANALUA RD&STRM HIC #3	RAMP WE	0.16MI E/AIEA IC PED OP	1974	020
96	159	003000780400074	FAI-H1(HIC #2)	MOANALUA RD	0.25MI E/AIEA IC PED OP	1974	002
97	159	003000780400090	HALAWA STRM HIC STRUC #9	RAMP 78EB 1A	0.02MI SE/STRUCT #3A	1974	002
98	159	003000780400097	MOANALUA RD(HIC #7)	RAMP EW	0.46MI E/AIEA IC PED OP	1974	002
99	159	003000780400178	SOUTH HALAWA STREAM	RAMP N	220'N ULUNE ST EXTENSION	1973	002
100	159	003000800300071	NF KAUKONAHUA(K THOT)	KAM HWY	0.18MI N/KILANI AVE	1932	001

101	159	003000800400003	WAHIAWA RSVR(WILSON BR)	KAM HWY	0.11MI S/AVACADO ST	1984	003
102	159	003000830004118	ANOI PED O'PASS	PEDESTRIAN	0.03MI S/ANOI RD	1969	002
103	159	003000830004187	KANEOHE SCH PED O'PASS	PEDESTRIAN	0.09MI S/DUNCAN DR	1968	002
104	159	003000830300041	WAIALUA TWN A (HELEMANO)	KAM HWY	0.37MI N/WAIALUA BCH RD	1928	001
105	159	003000830300043	OPAELUA WAIALUA TWN B	KAM HWY	0.39MI N/WAIALUA BCH RD	1928	001
106	159	003000830300339	LAUHULU STRM	KAM HWY	0.14MI NE/MEADOWGOLD RD	1937	002
107	159	003000830300456	KAWAILOA STRM	KAM HWY	0.62MI NE/ASHLEY RD	1929	001
108	159	003000830300573	WAIMEA STRM	KAM HWY	0.04MI NE/WAIMEA BH PAV R	1930	006
109	159	003000830300869	PAUMALU STRM	KAM HWY	0.19MI NE/KENUI RD	1930	005
110	159	003000830300939	KAUNALA STRM	KAM HWY	0.11MI NE/WEHIWA ST	1929	001
111	159	003000830301059	WAIALEE STRM	KAM HWY	1.07MI NE/KAUNALA ST	1931	001
112	159	003000830301140	KAWELA STRM	KAM HWY	0.13MI W/HANOPU ST	1931	001
113	159	003000830301255	KUILIMA-OIO STRM	KAM HWY	0.04MI E/KUILIMA HOTEL RD	1931	001
114	159	003000830301357	HOOLAPA STRM-NANAHU	KAM HWY	0.09MI W/RCA COM CTR RD	1931	001
115	159	003000830301523	KII DITCH	KAM HWY	0.35MI W/HOSPITAL RD	1937	001
116	159	003000830301638	MALAEKAHANA STRM	KAM HWY	0.50MI E/KAHUKU HI SCH RD	1932	001
117	159	003000830301785	KAHAWAINUI STRM-LAIEWAI	KAM HWY	0.17MI NW/NANILOA LP	1933	005
118	159	003000830301851	LAIELOA STRM	KAM HWY	0.09MI SE/HALELAA BLVD	1932	001
119	159	003000830301970	KOLOA STRM-LAIEMALOO	KAM HWY	0.46MI N/POLYN CTR RD	1933	005
120	159	003000830302021	KOKOLOLIO STRM-LAIE	KAM HWY	0.42MI NW/KAHIKOLO PL	1932	001
121	159	003000830302099	KAIPAPAU STRM	KAM HWY	0.01MI SE/PIPILANI PL	1932	002
122	159	003000830302112	WAIPILOPILO STRM	KAM HWY	0.03MI SE/MUA PL	1932	001
123	159	003000830302151	MAAKUA STRM-MULIWAI	KAM HWY	0.21MI SE/HAUULA HMSTD RD	1932	006
124	159	003000830302169	HAUULA STRM	KAM HWY	0.06MI SE/KUKUNA RD	1932	001
125	159	003000830302186	PAPAU STRM-WAIPUHI	KAM HWY	0.23MI SE/KUKUNA RD	1932	001
126	159	003000830302196	MAHEIWI STRM	KAM HWY	0.06MI SE/HAUULA HMSTD RD	1926	003
127	159	003000830302242	WAIMANANA STRM	KAM HWY	0.02MI SE/POKIWAI PL	1926	004
128	159	003000830302282	KALUANUI STRM	KAM HWY	0.23MI SE/SCRD FALLS RD	1926	007
129	159	003000830302412	N PUNALUU STRM	KAM HWY	1.53MI SE/SCRD FALLS RD	1926	002
130	159	003000830302442	S PUNALUU STRM	KAM HWY	1.83MI SE/SCRD FALLS RD	1926	007
131	159	003000830302624	N KAHANA STRM	KAM HWY	3.65MI SE/SCRD FALLS RD	1927	005
132	159	003000830302637	S KAHANA STRM	KAM HWY	3.78MI SE/SCRD FALLS RD	1927	005
133	159	003000830302791	MAKAUA STRM	KAM HWY	0.23MI W/HIAKA RD	1927	001
134	159	003000830302903	KAAAWA STRM	KAM HWY	0.10MI SE/POHUEHUE RD	1927	007
135	159	003000830303252	HAKIPUU STRM	KAM HWY	0.10MI S/JOHNSON RD	1922	001
136	159	003000830303377	WAIKANE STRM	KAM HWY	1.35MI S/JOHNSON RD	1928	001
137	159	003000830303396	UNMD STRM(N WAIAHOLE)	KAM HWY	0.59MI N/WAIAHOLE VLLY RD	1928	003
138	159	003000830303459	WAIAHOLE STRM(COUNTY)	KAM HWY	0.04MI S/WAIAHOLE VLLY RD	1922	002
139	159	003000830303575	KAALAEA STRM	KAM HWY	0.01MI S/KAALAEA ST	1923	002
140	159	003000830303604	UNMD STRM(DBL 10X5 CBC)	KAM HWY	0.10MI S/WAILEHUA RD	1922	002
141	159	003000830303639	KAHALUU STRM	KAM HWY	0.14MI S/WAIHEE RD	1980	003
142	159	003000830303738	AHUIMANU STRM	KAHEKILI HWY	0.22MI N/AHUIMANU PL BR	1971	001
143	159	003000830303803	AHUIMANU STRM	KAHEKILI HWY	45'KAILUA OF HUI IWA ST	1963	002
144	159	003000830303972	HEEIA STRM	KAHEKILI HWY	526'KAHUKU OF HAIKU RD	1963	002
145	159	003000830304273	KAMOOALII STRM (O.B)	KAM HWY	0.13MI S/KAHIKO ST	1968	003
146	159	003000830304369	DBL 12X10 RCB	KAM HWY	0.17MI NW/PALI GC ACC RD	1933	002
147	159	003000830404094	KANEOHE STR DBL 10X8 CBC	LIKELIKE HWY	0.08MI E/KAHEKILI HWY	1959	002
148	159	003000830404123	KAMOOALII STRM TPL 12X13	LIKELIKE HWY	0.13MI E/ANOI RD	1959	003
149	159	003000920000014	MOKULELE PED O.P.	MOKULELE PED OP	INTERS/RAMP R-HI&R-IH	1979	004
150	159	003000920000054	NIMITZ HWY FAP 92	PEDESTRIAN	INTERS/NIMITZ HWY&MAIN ST	1978	002

151	159	003000920400012	RAMP/HICKAM R-PW	NIMITZ HWY R-PW	INTERS/RAMP R-PW&R-IH	1979	004
152	159	003000920400013	RAMP/HICKAM R-N-PI	NIMITZ HWY N-PI	INTERS/RAMP N-PI/R-HI	1979	006
153	159	003000920400088	PH MAKAI FR-PH INT #7	RAMP 92 EB1A	0.70MI S/PLT DR SEP	1975	003
154	159	003000920400363	KALIHI STRM	NIMITZ HWY	0.02MI SE/MIDDLE ST	1945	007
155	159	003000920400480	KAPALAMA CANAL (E.B)	NIMITZ HWY	0.25MI SE/WAIAKAMILO RD	1949	007
156	159	003000920400481	KAPALAMA CANAL (W.B)	NIMITZ HWY	0.25MI SE/WAIAKAMILO RD	1949	007
157	159	003000920400580	SLIP COVER HON HARBOR	NIMITZ HWY	0.25MI E/PACIFIC ST	1952	006
158	159	003000920400587	NUUANU STRM (E.B)	NIMITZ HWY	0.06MI E/AWA ST	1952	008
159	159	003000920400588	NUUANU STRM (W.B)	NIMITZ HWY	0.06MI E/AWA ST	1932	005
160	159	003000920400592	SLIP COVER #1 HON HBR	NIMITZ HWY	0.11MI E/AWA ST	1952	010
161	159	003000920400603	SLIP COVER #2 HON HBR	NIMITZ HWY	0.22MI E/AWA ST	1952	010
162	159	003000920400609	SLIP COVER #3 HON HBR	NIMITZ HWY	0.28MI E/AWA ST	1952	012
163	159	003000920400617	SLIP COVER #4 HON HBR	NIMITZ HWY	0.36MI E/AWA ST	1952	003
164	159	003000920400796	PENSACOLA RELIEF DRAIN	ALA MOANA BLVD	0.12MI W/PIIKOI ST.	1973	002
165	159	003000920400861	ALA WAI CANAL	ALA MOANA BLVD	0.21MI N/HOBRON LANE	1939	003
166	159	003000930300071	AWAWANUI STREAM	OLD FARRINGTON HWY	.83 MI W KALAELOA BLVD	1927	001
167	159	003000930300083	PALAILAI STREAM	OLD FARRINGTON HWY	.95 MI W KALAELOA BLVD	1927	001
168	159	003000930300345	KEANANOIO STRM (O.B)	FARR HWY	0.07MI W/H.E.CO RDWY	1967	002
169	159	003000930300346	KEANANOIO STRM (I.B)	FARR HWY	0.07MI W/H.E.CO RDWY	1967	002
170	159	003000930300420	PILI-O-KOE STRM	FARR HWY	0.17MI E/POHAKUNUI AVE	1969	001
171	159	003000930300481	NANAKULI STRM	FARR HWY	0.07MI W/LAUMANIA AVE	1947	002
172	159	003000930300832	MAIPALAOA STRM	FARR HWY	0.05MI W/MAIPALAOA RD	1967	002
173	159	003000930300970	MAILIILII STRM	FARR HWY	0.20MI W/ALAPAKI ST	1949	006
174	159	003000930301128	KAUPUNI STRM	FARR HWY	0.04MI W/KAUPUNI ST	1937	003
175	159	003000930301253	UNMD STRM(MAKAHA #2)	FARR HWY	0.14MI W/MAIUU RD	1989	002
176	159	003000930301279	UNMD STRM(MAKAHA #2A)	FARR HWY	0.03MI W/ORANGE ST	1937	002
177	159	003000930301404	UNMD STRM(MAKAHA #3)	FARR HWY	0.12MI W/UPENA ST	1937	003
178	159	003000930301412	UNMD STRM(MAKAHA #3A)	FARR HWY	0.20MI W/UPENA ST	1937	004
179	159	003000930400536	NANAIKAPONO STRM	FARR HWY	0.29MI NW/NANAKULI AVE	1969	002
180	159	003000930400640	ULEHAWA STRM	FARR HWY	0.08MI W/MOHIHI RD	1963	002
181	159	003009300500010	WAIKOMO STRM-MAKAHA #3B	FARR HWY	0.10MI N/BEG OF ROUTE	1994	003
182	159	003009300500070	KEAAU STRM-MAKAHA #4	FARR HWY	0.60MI N/MAKAHA BR #3B	1995	007
183	159	003009300500088	NA OHI KILOLO STRM #5	FARR HWY	0.18MI N/MAKAHA BR #4	1995	002
184	159	003009300500138	OHI KILOLO STR #5A BR.	FARR HWY	0.50MI N/MAKAHA BR #5	1995	001
185	159	003009300500221	KAIAHI STRM(MAKUA)DBL B	FARR HWY	0.83MI N/MAKAHA BR #5A	1964	002
186	159	003009300500242	MAKUA STRM(TPL CBC)	FARR HWY	1.45MI S/SATELLITE TRK ST	1964	003
187	159	003000H11100006	FAI-H1(PALAILAI IC)	KALAELOA BLVD	0.06MI E/BEG H1	1966	004
188	159	003000H10402220	LUNA-VINE ON(FAI-H1)	VINEYARD BLVD	0.39MI E/QUEEN EMMA ST	1968	002
189	159	003000H10402248	LUNA-VINE OFF(FAI-H1)	VINEYARD BLVD	0.38MI E/QUEEN EMMA ST	1969	004
190	159	003098001400077	NUUANU STRM	VINEYARD BLVD	0.03MI E/AALA ST	1959	003
191	159	003098001400116	VINEYARD BLVD(CENTL INT)	PEDESTRIAN	0.05MI E/PALI HWY	1957	002
192	159	003098001400160	RAMP B1(VINE-LUNA #2) ON	VINEYARD BLVD	0.11MI E/LUSITANA ST	1968	002
193	159	003098001400161	FAI-H1(LUNA-VINE #1) OFF	VINEYARD BLVD	0.11MI E/LUSITANA ST	1969	004
194	159	003098001400168	LUNA-VINE(ALAPAI PED)	ALAPAI PED XING	0.18MI E/LUSITANA ST	1969	004
195	159	003000990001381	MILILANI TOWN PED OP	PEDESTRIAN	0.14MI S/U KIPAPA MIL RD	1974	003
196	159	003000990001492	KAM HWY (FLUME OP)	WATER	0.08MI N/MILILANI MEMO RD	1933	003
197	159	003000990300562	UP POAMOHO STRM-BRODIE 2	KAM HWY	0.01MI S/PUPUKEA RD	1937	001
198	159	003000990300626	UP POAMOHO STRM	KAM HWY	0.18MI N/POAMOHO RD	1936	004
199	159	003000990300787	KAUKONAHUA STRM	WILIKINA DR	0.06MI N/MCNAIR GATE	1944	003
200	159	003000990301164	WAIKAKALAUA STRM (I.B)	KAM HWY	0.67MI S/LEHUA AVE	1936	003

201	159	003000990301165	WAIKAKALAUA STRM (O.B)	KAM HWY	0.12MI N/WAIAKALANI ST	1950	003
202	159	003000990301447	KIPAPA STRM	KAM HWY	0.03MI S/DAIRY RD	1933	016
203	159	003000990401678	CANE HAUL RD (O.B)	KAM HWY	0.11MI S/BEG DIVIDED HWY	1953	001
204	159	003000990401679	CANE HAUL RD (I.B)	KAM HWY	0.11MI S/BEG DIVIDED HWY	1953	001
205	159	003000990401688	FAI-H1 WAIAWA IC #4B	KAM HWY	0.05MI S/RD TO WAIPAHU	1968	005
206	159	003000990401689	FAI-H1 WAIAWA IC #4A	KAM HWY	0.05MI S/RD TO WAIPAHU	1968	005
207	159	003000990401724	FARR HWY-WAIAWA IC #10A	KAM HWY	0.08MI S/RAMP E	1969	002
208	159	003000990401725	FARR HWY-WAIAWA IC #10B	KAM HWY	0.08MI S/RAMP D-1	1969	002
209	159	003000990401745	WAIAWA STRM (E.B)	OLD KAM HWY	0.39MI W/FARR HWY	1949	007
210	159	003000990401746	WAIAWA STRM (W.B)	OLD KAM HWY	0.39MI W/FARR HWY	1953	007
211	159	003000990401761	WAIAWA IC STRUCT #3B	FARR HWY	1.20MI E/BEG DIVIDED HWY	1969	005
212	159	003000990401762	WAIAWA IC STRUCT #3A	FARR HWY	1.20MI E/BEG DIVIDED HWY	1969	005
213	159	003000990401802	WAIAWA STRM(WEST BN)	FARR HWY	0.12MI E/LEEWARD COLL ACC	1933	006
214	159	003000990401804	WAIAWA STRM(EAST BN)	FARR HWY	0.04MI E/LEEWARD COLL ACC	1952	003
215	159	003000990401815	WAIAWA SEP(HWY UP)	KAM HWY	0.25MI E/LEEWARD COLL ACC	1953	003
216	159	003000990401871	PEARL CITY STRM(EAST BN)	KAM HWY	0.10MI E/LEHUA AVE	1936	001
217	159	003000990401872	PEARL CITY STRM(WEST BN)	KAM HWY	0.10MI E/LEHUA AVE	1945	001
218	159	003000990401986	WAIMALU STRM(EAST BN)	KAM HWY	0.13MI E/P.H.PARK RD	1936	003
219	159	003000990401987	WAIMALU STRM(WEST BN)	KAM HWY	0.13MI E/P.H.PARK RD	1945	003
220	159	003000990402053	KALAUAO SPRING (E.B)	KAM HWY	0.11MI E/LIPOA PL	1936	001
221	159	003000990402054	KALAUAO SPRING (W.B)	KAM HWY	0.11MI E/LIPOA PL	1945	001
222	159	003000990402074	KALAUAO STRM (E.B)	KAM HWY	0.05MI W/AIEA KAI PL	1936	001
223	159	003000990402075	KALAUAO STRM (W.B)	KAM HWY	0.10MI W/KIHALE ST	1945	002
224	159	003000990402120	AIEA STRM	KAM HWY	0.24MI E/HONOMANU ST	1938	001
225	159	003000990402129	AIEA IC STRUCT #2	MOANALUA RD	0.33MI E/MCGREW LOOP	1966	010
226	159	003000990402211	HALAWA STRM (E.B)	KAM HWY	0.06MI S/KALALOA ST	1934	003
227	159	003000990402212	HALAWA STRM (W.B)	KAM HWY	0.06MI S/KALALOA ST	1945	006
228	159	003000990402336	PH RAMP WN-PH I.C. #3	99SB 23A	0.35 MI S/PLT DR SEP	1975	002
229	159	003000991201785	WAIAWA IC STRUCT #2	RAMP C	1.44MI E/BEG DIVIDED HWY	1969	003
230	159	003000991202143	AIEA IC STRUCT #4	AIEA HTS ACC RD	0.47MI E/MCGREW LOOP	1965	004
231	159	003000H10300830	FAI-H1(WAIAWA IC #4A)	KAM HWY	1.53MI E/MANAGERS DR	1968	005
232	159	003000H10400831	FAI-H1(WAIAWA IC #4B)	KAM HWY	1.54MI E/MANAGERS DR	1968	005
233	159	003000H10400875	WAIAWA IC #3A FAI-H1	FARR HWY	0.58MI E/WAIPAHU ST SEP	1969	005
234	159	003000H10400877	WAIAWA IC #3B FAI-H1	FARR HWY	0.60MI E/WAIPAHU ST SEP	1969	005
235	159	003000H10002233	MILLER PED OP(FAI-H1)	PEDESTRIAN	0.24MI E/QUEEN EMMA ST	1969	001
236	159	003000H10002255	ALAPAI PED OP(FAI-H1)	PEDESTRIAN	0.38MI E/QUEEN EMMA ST	1969	004
237	159	003000H10002442	ISENBERG PED OP(FAI-H1)	PEDESTRIAN	0.34MI E/MCCULLY ST SEP	1956	003
238	159	003000H10002549	2ND AVE PED OP(FAI H1)	PEDESTRIAN	0.33MI W/6TH AVE SEP	1965	002
239	159	003000H10002563	4TH AVE PED OP(FAI H1)	PEDESTRIAN	0.19MI W/6TH AVE SEP	1965	002
240	159	003000H10002687	19TH AVE PED OP(FAI-H1)	PEDESTRIAN	0.17MI E/16TH AVE SEP	1968	003
241	159	003000H10100132	CANEHAUL RD(25X21 CBC)	FAI-H1	0.20MI E/MAKAKILO DR	1966	001
242	159	003000H10100316	PALEHUA SEP IB	FAI-H1	2.03MI E/MAKAKILO DR	1966	001
243	159	003000H10100317	PALEHUA SEP OB	FAI-H1	2.03MI E/MAKAKILO DR	1966	001
244	159	003000H10100345	STRM-DBL 12X12 CBC	FAI-H1	0.29MI E/PALEHUA RD	1966	002
245	159	003000H10100451	HONOULIULI STRM IB	FAI-H1	1.35MI E/PALEHUA RD	1966	002
246	159	003000H10100452	HONOULIULI STRM OB	FAI-H1	1.35MI E/PALEHUA RD	1966	002
247	159	003000H10100537	KUNIA SEP IB	FAI-H1	2.21MI E/PALEHUA RD	1967	002
248	159	003000H10100538	KUNIA SEP OB	FAI-H1	2.21MI E/PALEHUA RD	1967	002
249	159	003000H10100586	STRM-TRPL 168" STL PL	FAI-H1	0.49MI E/KUNIA RD	1967	003
250	159	003000H10100604	HOAEAE RD SEP IB	FAI-H1	0.67MI E/KUNIA RD	1967	001

251	159	003000H10100605	HOAEAE RD SEP OB	FAI-H1	0.67MI E/KUNIA RD	1967	001
252	159	003000H10100635	WAIKELE STRM IB	FAI-H1	0.97MI E/KUNIA RD	1968	009
253	159	003000H10100636	WAIKELE STRM OB	FAI-H1	0.97MI E/KUNIA RD	1968	009
254	159	003000H10100707	CANE HAUL RD 414 IB	FAI-H1	0.30MI E/MANAGERS DR	1968	004
255	159	003000H10100708	CANE HAUL RD 414 OB	FAI-H1	0.30MI E/MANAGERS DR	1968	004
256	159	003000H10100775	CANE HAUL RD 451 IB	FAI-H1	0.98MI E/MANAGERS DR	1968	003
257	159	003000H10100776	CANE HAUL RD 451 OB	FAI-H1	0.98MI E/MANAGERS DR	1968	003
258	159	003000H10101678	PAIEA ST/RAMP AW,IF	RAMP IF/H1	ABOVE PAIEA ST HON HI	1980	007
259	159	003000H10101679	PAIEA ST	RAMP AE/H1	ABOVE PAIEA ST	1980	015
260	159	003000H10200024	PH RAMP EN-PH INT #4	MAKAI FRONTAGE RD	0.63MI S/PLT DR SEP	1974	001
261	159	003000H10200832	WAIAWA IC #8 FAI-H2	FAI-H1	1.55MI E/MANAGERS DR	1970	001
262	159	003000H10200854	WAIAWA IC #5 FAI-H1	FAI-H2	1.77MI E/MANAGERS DR	1971	003
263	159	003000H10200865	WAIAWA IC #6 OLD KAM HWY	FAI-H1	1.89MI E/MANAGERS DR	1971	001
264	159	003000H10200922	PEARL CITY VIADUCT	FAI-H1	1.05MI E/WAIPAHU ST SEP	1969	006
265	159	003000H10201059	WAIAU IC-MOANALUA RD	FAI-H1	0.28MI E/KAM HWY	1970	002
266	159	003000H10201116	3-162" SECTL PL CULVT	FAI-H1	0.21MI E/AUSTIN BISHOP	1970	003
267	159	003000H10201125	WAIMALU VIA-STRM/HWY	FAI-H1	0.95MI E/KAM HWY	1970	012
268	159	003000H10201231	2-180IN SECTL PL CULVT	FAI-H1	0.53MI E/KAONOHI ST SEP	1970	002
269	159	003000H10201256	MAHIKO PED OP FAI-H1	PEDESTRIAN	0.15MI E/KAAMILO ST SEP	1970	002
270	159	003000H10201287	AIEA STRM 15X12 TWN CULV	FAI-H1	0.08MI E/AIEA HTS DR SEP	1970	002
271	159	003000H10201333	FAI-H1(HALAWA IC #2)	MOANALUA RD	0.317MI E/KAIMAKANI SEP	1974	002
272	159	003000H10201340	FAI-H1(HALAWA IC #6)	RAMP ES	0.074MI S/STRUCT #2	1974	008
273	159	003000H10201344	HIC STRUCT #3A	RAMP H1EB 13AA	0.02MI NW/STRUCT #9	1974	006
274	159	003000H10201349	FAI-H1(HALAWA IC #3)	RAMP WE	0.476MI SE/KAIMAKANI SEP	1974	020
275	159	003000H10201352	FAI-H1(HALAWA IC #8)STRM	FAI-H1	0.192MI S/STRUCT #2	1974	002
276	159	003000H10201370	FAI-H1(N LEG VIA)	FAL-H1(N LEG VIA)	0.27MI S/HIC STRUCT #8	1975	021
277	159	003000H10201425	FAI-H1 UP-MAKALAPA PED	PEDESTRIAN	0.71MI S/HIC STRUCT #8	1974	004
278	159	003000H10201550	RAMP MN EN-PH INT #5	FAI-H1(O.B.)	0.65MI S/PLT DR SEP	1974	001
279	159	003000H10201551	TRISQUITMN PH INT#5-I.B.	RAMP KE FAI-H1	0.65MI S/PLT DR SEP	1974	001
280	159	003000H10201581	VALKBGH,CATLIN,OHOHIA ST	AIRPT VIA (W.B),H1	.04 MILE E OF VALKENBURGH	1981	107
281	159	003000H10201582	LAGN DR,CATLIN,OHOHIA ST	AIRPT VIA (E.B),H1	.04 MILE E OF VALKENBURGH	1981	107
282	159	003000H10201641	FAI-H1/RAMP WA WI	RAMP ED/H1	AT RODGERS BLVD	1979	003
283	159	003000H10201650	RODGERS BLVD RAMPS/H1	RAMPS WA WD WI	RODGERS BLVD HON HI	1981	058
284	159	003000H10201675	PAIEA ST RAMPS/H1	RAMP IW AW PF	ABOVE PAIEA ST HON HI	1980	039
285	159	003000H10201758	MOANALUA STREAM	NIMITZ CONN,H1(WB)	200'S KAKOI ST	1981	025
286	159	003000H10201764	MOANALUA STREAM	MAKAI FRONTAGE RD	350'S KAKOI ST	1982	022
287	159	003000H10201765	MOANALUA STREAM	NIMITZ CONN,H1(EB)	300'S KAKOI ST	1981	018
288	159	003000H10201767	MOANALUA STREAM	KEEHI IC VIA (W.B)	100' EAST OF LAGOON DR.	1981	047
289	159	003000H10201768	MOANALUA STREAM	KEEHI IC VIA (E.B)	100' EAST OF LAGOON DR.	1984	046
290	159	003000H10201784	KAKOI ST,DRAIN CHANNEL	MAUKA FRONT'G ROAD	.019M E AHUA ST.	1981	034
291	159	003000H10201805	MOANALUA STREAM	H.O.V.RAMP,H1(E.B)	450'S KAKOI ST	1981	014
292	159	003000H10201808	NIMITZ HWY,MOANALUA STM	RAMP G,FAI-H1(W.B)	400' WEST OF MOANALUA STM		021
293	159	003000H10201816	KEEHI I.C. NIMITZ CONN	RAMP C (E.B),H1	200' EAST OF MOANALUA STM	1984	009
294	159	003000H10201817	NIMITZ HWY, MOANALUA STM	RAMP F,FAI-H1(W.B)	100' WEST OF MOANALUA STM	1980	006
295	159	003000H10201820	MOANALUA STREAM,RAMP E	RAMP D,NIMITZ HWY	150' WEST OF MOANALUA STM	1979	004
296	159	003000H10201822	MOANALUA STREAM	BIKEWAY,WATERMAIN	400'E KAKOI ST	1976	007
297	159	003000H10201828	KEEHI I.C. NIMITZ CONN	RAMP B (E.B),H1	100' WEST OF MOANALUA STM	1984	001
298	159	003000H10201830	MOANALUA STRM,KEEHI IC	RAMP A (E.B),H-1	380' EAST OF MOANALUA STM	1984	029
299	159	003000H10201908	MOANALUA RD/MIDDLE ST	FAI-H1(STRUCT B)	0.12MI W/OLA LANE	1963	002
300	159	003000H10201978	RICHARD LN/KALIHI STRM	FAI-H1	0.30MI E/OLA LANE	1962	001

301	159	003000H10202043	HOUGHTAILING SEP	FAI H1	0.53MI E/GULICK AVE	1964	001
302	159	003000H10202075	KAPALAMA CANAL	HALONA ST	0.29MI E/HOUGHTAILING ST	1938	005
303	159	003000H10202076	KAPALAMA CANAL	OLOMEA ST	0.29MI E/HOUGHTAILING ST	1965	003
304	159	003000H10202077	KAPALAMA CANAL	FAI-H1	0.29MI E/HOUGHTAILING ST	1965	003
305	159	003000H10202091	PALAMA ST(HWY OP)	FAI-H1	0.47MI E/HOUGHTAILING ST	1965	007
306	159	003000H10202161	NUUANU STREAM	FAI-H1	0.03MI E/AALA ST EXT SEP	1964	003
307	159	003000H10202217	PUNCHBOWL ST SEP(HWY OP)	FAI-H1	0.08MI E/QUEEN EMMA ST	1960	001
308	159	003000H10202293	MAKIKI VIA(PIIKOI ST)	FAI-H1(HWY OP)	0.24MI E/WARD AVE SEP	1969	015
309	159	003000H10202463	UNIVERSITY AVE SEP	FAI-H1	0.55MI E/MCCULLY ST SEP	1953	002
310	159	003000H10202464	UNIVERSITY RAMP U-1	FAI-H1	0.56MI E/MCCULLY ST SEP	1954	008
311	159	003000H10202483	KALO LN SEP	FAI-H1	0.20MI E/UNIVER AVE SEP	1953	001
312	159	003000H10202512	MANOA PALOLO STRM	FAI-H1	0.09MI E/OLD WAIALAE RD	1967	002
313	159	003000H10202513	MANOA PALOLO STRM(KING)	KING ST	0.10MI E/OLD WAIALAE RD	1948	003
314	159	003000H10202514	KAP OFF RAMP(HWY UP)	RAMP H1-I	0.11MI E/OLD WAIALAE RD	1969	015
315	159	003000H10202524	KAP GRADE SEP	FAI-H1	0.21MI E/OLD WAIALAE RD	1967	011
316	159	003000H10202615	10TH AVE SEP	FAI-H1	0.24MI E/7TH AVE SEP	1964	001
317	159	003000H10202704	WAIALAE AVE(OFF RAMP)	FAI-H1(OFF RAMP)	0.14MI E/INTS/WAIALAE AVE	1968	004
318	159	003000H10202705	WAIALAE VIA OB-HWY OP	FAI-H1	0.14MI E/WAIALAE AVE SEP	1969	029
319	159	003000H10202706	WAIALAE VIA IB-HWY OP	FAI-H1	0.14MI E/WAIALAE AVE SEP	1969	029
320	159	003000H10202750	WAIALAE NUI STRM	FAI-H1	0.59MI E/WAIALAE AVE SEP	1968	001
321	159	003000H10202761	KAPAKAHI STRM	FAI-H1	0.71MI E/WAIALAE AVE SEP	1969	001
322	159	003000H20100103	PANAKAUAHI 4-144" CULVT	FAI-H2	0.63MI N/URBAN BOUNDARY	1973	004
323	159	003000H20100124	PANAKAUAHI 3-144" CULVT	FAI-H2	0.84MI N/URBAN BOUNDARY	1973	003
324	159	003000H20100425	KIPAPA STRM	FAI-H2	0.35MI N/PINEAPPLE RD SEP	1975	008
325	159	003000H20100528	2-120" STRUC P DRN CULVT	MEHEULA ST	STRUC ON RAMP B	1975	002
326	159	003000H20100531	2-132" STRUC.P DRN CULVT	FAI-H2	0.04MI E/MEHEULA SEP	1975	002
327	159	003000H20100624	WAIKAKALAUA STRM	FAI-H2(O.B.)	0.97MI N/MEHEULA PKWY BR	1975	005
328	159	003000H20100625	WAIKAKALAUA STRM	FAI-H2(I.B.)	0.97MI N/MEHEULA PKWY BR	1975	005
329	159	003000H20200021	CANEHAUL RD & STRM #16	FAI-H2 WIC #16	0.19MI S/URBAN BOUNDARY	1973	006
330	159	003000H20200022	CANEHAUL RD&STRM #13	FAI-H2 WIC #13	0.19MI S/URBAN BOUNDARY	1974	006
331	159	003000H20200023	WAIAWA STRM & RD #14	FAI-H2 WIC #14	0.19MI S/URBAN BOUNDARY	1974	006
332	159	003000H20200024	CANEHAUL RD & STRM #15	FAI-H2 WIC #15	0.19MI S/URBAN BOUNDARY	1974	008
333	159	003000H20200745	E RANGE RD WAHIAWA IC #3	FAI-H2	0.60MI S/END H2	1973	001
334	159	003000H20200746	E RANGE RD WAHIAWA IC #4	FAI-H2	0.60MI S/END H2	1973	001
335	159	003000H20200771	KAM HWY-WAHIAWA IC #1	FAI-H2	0.35MI S/END H2	1973	002
336	159	003000H20200772	KAM HWY-WAHIAWA IC #2	FAI-H2	0.35MI S/END H2	1974	002
337	159	003000H21100392	FAI-H2(PINEAPPLE RD)	PINEAPPLE RD	1.67MI N/MILILANI ACC RD	1973	002
338	159	003000H21100698	FAI-H2(GOLF COURSE RD)	GOLF COUSE RD)	0.76MI N/WAIKAKALAUA STRM	1973	002
339	159	003000H21200223	FAI-H2(MILILANI ACC RD)	MILILANI MEM PK RD	1.85MI N/URBAN BOUNDARY	1972	002
340	159	003000H21200527	FAI-H2(MEHEULA PKWY RD)	MEHEULA PKWY RD	1.03MI N/KIPAPA STRM BR	1973	002
341	159	003000H30200022	HALAWA STRM(HIC #13)	RAMP "M"	0.22MI W/BEG RAMP"M"	1973	001
342	159	003000H30200030	HALAWA STRM(HIC #15)	RAMP "P"	0.305MI W/BEG RAMP"P"	1974	001
343	159	003000H30200075	HALAWA STRM(HIC #5)(OB)	FAI-H3	0.759MI E/BEG H3	1974	001
344	159	003000H30200076	HALAWA STRM(HIC @5)(IB)	FAI-H3(IB)	0.76MI E/BEG H3	1974	001
345	159	003000H30200082	FAI-H3(HIC STRUCT #16)	ULUNE EXTENSION	0.82MI E/BEG H3	1973	007
346	159	003000H30200087	HALAWA STRM HIC #12	RAMP HIWB 13B	0.76MI SE/STRUCT #1	1974	002
347	159	003000H30201242	3-84"RCP CULVT	QUARRY ACCESS RD	KAPAA QUARRY ACC RD A-1	1976	003
348	159	003000H30201243	KAPAA QUARRY RD SEP#2 IB	FAI-H3	2.23MI S/KANEOHE B LO RD	1977	003
349	159	003000H30201244	KAPAA QUARRY RD SEP#2 OB	FAI-H3	2.24MI S/KANEOHE B LO RD	1977	003
350	159	003000H30201268	KAPAA QUARRY RD SEP#1 OB	FA1-H3	2.0MI S/KANEOHE BAY LO RD	1977	003

351	159	003000H30201269	KAPAA QUARRY RD SEP#1 IB	FAI-H3	2.0MI S/KANEOHE BAY LO RD	1977	003
352	159	003000H30201373	KAILUA I C (I B)	FAI-H3	0.95MI S/KANEOHE B LO RD	1971	003
353	159	003000H30201374	KAILUA I C (O B)	FAI-H3	0.96MI S/KANEOHE B LO RD	1971	003
354	159	003000H30201525	MOKAPU IC	FAI-H3	0.57MI N/KANEOHE BAY LO	1967	003
355	159	003000H30201589	TWIN 21.5'X6.0' RCB	FAI-H3	1.21MI N/KANEOHE B LO RD	1967	002
356	159	003000H30311320	H3 FREEWAY	BRIDGE #3/SERVICE	.19 MILE SW OF ROUTE 83	1988	002
357	159	003000H30311410	SERVICE ROAD & RAMP	H3 FRWY	30' SW 0F KAMOOALII STRM	1988	002
358	159	003000H30311510	KAM HWY #83	BRIDGE #1/H3	.04MI SE/KAMOOALII STREAM	1988	002
359	159	003000H30311520	KAM HWY RT #83	BRIDGE #2/H3	200' SE KAMOOALII STREAM	1988	002
360	159	003000H31011430	SERVICE ROAD	H3 FRWY/RAMP	.076MI W/BRIDGE #1	1988	002
361	159	003009300500272	PUNAPOHAKU STRM-DBL CBC	FARR HWY	1.15MI S/SATELLITE TRK ST	1964	002
362	159	003009300501254	KAWAIHAPAI STRM	FARR HWY	0.08MI N/EXT-MOKULEIA B P	1941	001
363	159	003009300501315	POLIPOLI STRM	FARR HWY	0.48MI N/HOOMANA PL	1940	002
364	159	003009300501414	KAPALAAU STRM	FARR HWY	0.29MI S/HOOMANA PL	1940	003
365	159	003009300501436	MAKALENA STRM	FARR HWY	0.51MI S/HOOMANA PL	1940	002
366	159	003009300501748	KAUKONAHUA STRM	FARR HWY	0.02MI S/NALUAHI ST	1940	002
367	159	003009300501794	WAIALUA PLT RD	FARR HWY	0.41MI S/KAUPE RD	1941	001
368	159	003009300501823	NORTH POAMOHO STRM	KAUKONAHUA RD	0.05MI S/HUKILAU LOOP	1934	003
369	159	003009301101728	FARR HWY-WAIALUA PLT RD	WAIALUA PLT-RD	0.26MI S/KUHI ST	1940	001
370	159	003062071400018	KALIHI STRM /OB	KAM HWY/KEEHI IC	500'E/MIDDLE ST/KAM HWY	1943	006
371	159	003062071400019	KALIHI STRM	KAM HWY	500'E/MIDDLE ST/KAM HWY	1926	006
372	159	003000H11201935	KING ST(FAI-H1 OFF RAMP)	KING ST	0.14MI W/OLA LANE	1962	001
373	159	003062081400560	MANOA-PALOLO STRM	S KING ST	450'W/KAP BLVD/HARDING AV	1948	003
374	159	003000H11102209	FAI-H1(QUEEN EMMA SEP)	QUEEN EMMA ST	0.30MI E/NUUANU AVE SEP	1961	004
375	159	003000H11202269	WARD AVE SEP(FAI-H1)	WARD AVE	0.60MI E/QUEEN EMMA ST	1968	002
376	159	003000H11202340	KEEAUMOKU SEP(FAI-H1)	KEEAUMOKU ST	0.70MI E/WARD AVE SEP	1960	007
377	159	003090001400038	DBL SECTL PL CULVT-STRM	FARR HWY	0.18MI E/LEOKU ST	1965	002
378	159	003090001400108	WAIKELE CANAL IB	FARR HWY	0.22MI E/WAIKELE RD	1939	003
379	159	003090001400113	WAIKELE CANAL OB	FARR HWY	0.22MI E/WAIKELE RD	1963	002
380	159	003090001400114	RR XING(HWY OP)	FARR HWY	0.28MI E/WAIKELE RD	1939	001
381	159	003090001400136	KAPAKAHI STRM	FARR HWY	0.08MI W/WAIPAHU DEPOT RD	1964	001
382	159	003090001400174	WAIPAHU CANAL	FARR HWY	0.01MI E/MOKUOLA ST	1964	002
383	159	003090001400245	OAHU SUGAR CO RD	FARR HWY	0.23MI E/KAHUALII ST	1952	001
384	159	003090001400270	WAIAWA IC STRUCT #10B	KAM HWY CONN	0.48MI E/KAHUALII ST	1969	002
385	159	003090001400271	WAIAWA IC STRUCT #10A	KAM HWY CONN	0.49MI E/KAHUALII ST	1969	002
386	159	003071001400113	RAMP WE&ES&HA STRM #11	HALAWA HTS RD	0.85MI SE/STRUCT #1	1974	006
387	159	003071001400130	MOANALUA FWY #10	HALAWA HTS RD	0.17MI E/STRUCT #11	1971	003
388	159	003071001400224	FORMER HALAWA RDG RD	HALAWA HTS RD	0.02MI N/KAAKAU PL	1952	001
389	159	003066000000094	RAMP G&H(PUULOA IC)	PED O'PASS	0.23MI N/PELTIER ST	1974	004
390	159	003066001400010	MOANALUA STRM @ PUULOA	PUULOA IC RAMP B	0.04MI/BEG RAMP "B"	1974	007
391	159	003066001400012	MOANALUA PK RD	PUULOA IC RAMP"C"	0.12MI/BEG RAMP C	1974	006
392	159	003000H11201485	FAI-H1 UP-PH INT #1	PLANTATION DR	1.31MI S/HIC STRUCT #8	1974	002
393	159	003000H11102129	FAI-H1(LILIHA ACC RD)	LILIHA ACC RD	0.29MI E/PALAMA ST SEP	1965	002
394	159	003000H11102134	FAI-H1(LILIHA ST SEP)	LILIHA ST	0.34MI E/PALAMA ST SEP	1965	002
395	159	003000H11201934	MIDDLE ST(FAI-H1)TUNNEL	MIDDLE ST	0.14MI W/OLA LANE	1964	001
396	159	003000H11201937	FAI-H1 OB(MIDDLE ST)	MIDDLE ST	0.12MI W/OLA LANE	1964	003
397	159	003000H11202476	WAIALAE RD SEP(FAI-H1)	OLD WAIALAE RD	0.40MI E/UNIVER AVE SEP	1953	001
398	159	003000H11202486	MANOA PALOLO STRM	OLD WAIALAE RD	0.09MI E/OLD WAIALAE RD	1953	002
399	159	003000H11202503	WAIALAE RD SEP(FAI-H1)	OLD WAIALAE RD	0.40MI E/UNIVER AVE SEP	1967	002
400	159	003000H11202672	HARDING AVE(FAI-H1)	HARDING AVE	0.29MI E/KOKOHEAD AVE SEP	1967	002

401	159	003000H11202642	KOKOHEAD SEP(FAI-H1)	KOKOHEAD AVE	0.51MI E/7TH AVE SEP	1964	002
402	159	003000H11202407	MCCULLY ST SEP(FAI-H1)	MCCULLY ST	0.36MI E/PUNAHOU ST SEP	1956	007
403	159	003000H11102179	FAI-H1(NUUANU AVE SEP)	NUUANU AVE	0.21MI E/AALA ST EXT SEP	1961	002
404	159	003000H11202370	PUNAHOU ST SEP(FAI-H1)	PUNAHOU ST	0.30MI E/KEEAUMOKU ST SEP	1955	002
405	159	003000H11102199	RAMP TO PALI HWY(SCH ST)	SCHOOL ST	0.20MI E/NUUANU AVE SEP	1960	001
406	159	003000H11202690	WAIALAE AVE SEP(FAI-H1)	WAIALAE AVE	0.21MI E/6TH AVE SEP	1967	002
407	159	003000H11202582	6TH AVE SEP(FAI-H1)	6TH AVE	0.08MI W/7TH AVE SEP	1964	002
408	159	003000780200147	FAI-H3(HIC #4)	MOANALUA RD	0.73MI E/H1	1974	002
409	159	003000780400010	HALAWA STRM HIC #14	RAMP"O"	0.103MI W/BEG RAMP"O"	1974	001
410	159	003000780400115	MOANALUA RD(HIC #10)	HALAWA HTS RD	0.41MI E/H1	1972	003
411	159	003000780400145	NORTH HALAWA STREAM	MOANALUA RD	0.30MI E/HALAWA HTS RD	1937	001
412	159	003000780400157	S HALAWA STRM-TWN RC BOX	MOANALUA RD	0.12MI E/HIC STRUCT #4	1973	002
413	159	003000780400223	MOANALUA RD-RED HILL SEP	ALA KAPUNA ST	0.31MI E/RD TO HALAWA JL	1973	002
414	159	003000780400277	LAKESIDE #1-ALA AOLANI	MOANALUA RD	0.55MI E/ALA KAPUNA RD	1973	003
415	159	003000780400278	LAKESIDE #2-ALA AOLANI	NORTH FRONTAGE RD	0.55MI E/ALA KAPUNA RD	1974	003
416	159	003000780400279	MOANALUA STRM	ALA AOLANI ST	0.55MI E/ALA KAPUNA RD	1973	003
417	159	003000780400359	MOANALUA RD-PUULOA SEP	PUULOA RD	0.81MI E/LAKESIDE STR #1	1974	013
418	159	003000780400366	MOANALUA RD-PUULOA IC"A"	PUULOA RAMP A	0.88MI E/LAKESIDE STR #2	1974	017
419	159	003000780400392	MOANALUA STR KAUA TRESTL	MOANALUA RD	0.22MI E/OFF RAMP PAA ST	1980	002
420	159	003000780400393	MOANALUA STRM	MOANALUA RD OB	0.23MI E/OFF RAMP PAA ST	1981	001
421	159	003000780400394	MOANALUA STRM	MOANALUA RD IB	0.23MI E/OFF RAMP PAA ST	1981	001
422	159	003000780400395	MOANALUA STR EC TRESTL#1	MOANALUA RD	0.25MI E/OFF RAMP PAA ST	1979	004
423	159	003000780400397	MOANALUA STR EC TRESTL#2	MOANALUA RD	0.27MI E/RAMP PAA ST	1978	013
424	159	003000780400438	KAHAUIKI STRM	MOANALUA RD	0.68MI E/OFF RAMP PAA ST	1960	003
425	159	003000780400443	RAMP J MOANALUA RD	RAMP I	0.73MI E/OFF RAMP PAA ST	1984	003
426	159	003000781200034	MOANALUA RD AIEA IC #1	AIEA HTS ACC RD	0.14MI E/LAULIMA ST	1965	004
427	159	003000781200400	DAMON OP-MOANALUA RD UP	AHUA ST ACC RD	0.30MI E/OFF RAMP PAA ST	1980	004
428	159	003000781200427	FT SHAFTER-MOANALUA RD	FT SHAFTER RD	0.57MI E/OFF RAMP PAA ST	1979	002
429	159	00300C291100137	ANAHULU STRM	KAM HWY	0.052MI NE/INT HALEIWA/K	1921	002
430	159	00300C301100152	LOKOEA STRM-SUNKEN CNTY	KAM HWY	0.07MI N/LOKOEA RD	1923	002
431	159	003083051400001	GULLY(DIAMOND HEAD)	DIAMOND HEAD RD	950'W/POKI ST/DIA HD RD	1930	001
432	159	003083681400001	WAIOLANI STRM	WYLLIE ST	1200'W/NUUANU A/WYLLIE ST	1931	001
433	159	003109001200001	KALIHI BR#2/KALIHI STRM	KALIHI ST.	TMK=1-4-13	1969	001
434	159	003123001200001	N KUKUI ST/NUUANU STRM	NORTH KUKUI ST	TMK=1-7-06	1966	003
435	159	003124001200001	LAULANI ST/KAMANAIKI STR	LAULANI ST	TMK=1-4-03	1973	001
436	159	003128001200001	ALA AOLANI #3/MOANALUA S	ALA AOLANI	TMK=1-1-43	1963	001
437	159	003129001200001	NUMANA RD/KALIHI STRM	NUMANA RD	TMK=1-4-08	1969	002
438	159	003131001200001	ALA AOLOA LP/MOANALUA ST	ALA AOLANI LOOP	TMK=1-1-12	1965	001
439	159	003138001100001	MANAIKI STREAM	PINEAPPLE PLACE	TMK=1-1-12	1976	001
440	159	003148001200001	KALIHI ST BR#3/KALIHI ST	KALIHI ST	TMK=1-4-20	1942	003
441	159	003154001200001	NAIO AVE/NUHELEWAI STRM	NAIO AVE	TMK=1-6-17	1927	001
442	159	003209001100001	FERN ST/MAKIKI STRM	FERN ST.	TMK=2-3-23	1931	001
443	159	003211001200001	KAHALOA DR/MANOA STRM	KAHALOA DR.	TMK=2-9-36,37	1954	001
444	159	003219001200001	KOALI RD/PALOLO STRM	KOALI RD	TMK=2-8-27	1972	001
445	159	003226001200001	MAKIKI ST/MAKIKI STRM	MAKIKI ST.	TMK=2-4-23	1912	001
446	159	003232001200001	PAWAINA ST/MANOA STRM	PAWAINA ST.	TMK=2-9-69	1961	001
447	159	003237001200001	WAALOA WY BR#1/MANOA STR	WAALOA WAY	TMK=2-9-54	1967	001
448	159	003244001200001	WAALOA BR#3/WAIAKEAKUA S	WAALOA WAY	TMK=2-9-54	1967	001
449	159	003245001200001	WAALOA BR#4/WAIAKEAKUA S	WAALOA WAY	TMK=2-9-54	1963	002
450	159	003253001200001	KAPULEI ST/PAUOA STRM	KAPULEI ST.	TMK=2-2-25	1951	003

451	159	003257001200001	PUIWA RD/NUUANU STRM	PUIWA RD.	TMK=2-2-42,43	1964	003
452	159	003260001200001	KIMO DR/NUUANU STRM	KIMO DR.	TMK=2-2-50	1900	003
453	159	003261001200001	LAIMI RD/NUUANU STRM	LAIMI RD.	TMK=2-2-35	1920	001
454	159	003262001200001	MAKIKI STRM/LIHOLIHO	LIHOLIHO ST	TMK:2-4-29	1967	001
455	159	003265001200001	NUUANU PALI DR/NUUANU ST	NUUANU PALI DR.	TMK=2-2-54	1931	001
456	159	003267001200001	PELEKANE DR/NUUANU STRM	PELEKANE DR.	TMK=2-2-46		001
457	159	003268001200001	WAALOA WY BR#2/MANOA STR	WAALOA WAY	TMK=2-9-54	1965	001
458	159	003284001200001	KAAMALIO DR/MANOA STRM	KAAMALIO DR	TMK=2-9-38(MANOA)	1976	002
459	159	003292001200001	WOODLAWN DR/MANOA STRM	WOODLAWN DR.	TMK=2-9-26	1974	001
460	159	003306001200001	HALEMAUMAU PL/NIU STRM	HALEMAUMAU PL	TMK=3-7-10	1960	003
461	159	003312001200001	KAHALA AVE/KAPAKAHI STRM	KAHALA AVE	TMK=3-5-08(KAHALA)	1927	003
462	159	003314001200001	KALUA RD BR/PALOLO STRM	KALUA RD.	TMK=3-4-01(PALOLO VLLY)	1953	001
463	159	003326001200001	PAALEA ST/PALOLO STRM	PAALEA ST.	TMK=3-3-38	1952	001
464	159	003340001200001	MALIA ST/WAIALAE NUI D C	MALIA ST.	TMK=3-5-17	1961	001
465	159	003343001200001	KIWILA ST/PALOLO STRM	KIWILA ST.	TMK=3-4-02	1961	001
466	159	003345001200001	HIIKALA PL/WAIALAE NUI C	HIIKALA PL.	TMK=3-5-18	1962	001
467	159	003346001200001	KAMILOIKI STREAM	HAWAII KAI DR.	TMK=3-9-14	1967	001
468	159	003347001200001	KAMILOIKI STREAM	MANINIHOLO ST.	TMK=3-9-10	1969	001
469	159	003349001200001	KAMILOIKI STREAM	WAINIHA ST.	TMK=3-9-10,14	1967	001
470	159	003350001200001	KULIOUOU STRM	SUMMER ST.	TMK=3-8-03	1969	001
471	159	003351001200001	KULIOUOU STREAM	KULIOUOU RD.	TMK=3-8-06	1968	001
472	159	003370001200001	AHE ST/PUKELE STRM	AHE ST.	TMK=3-4-07	19	001
473	159	003371001200001	KAPAKAHI STRM/ALIIKOA	ALIIKOA ST	TMK:3-5-19	1954	001
474	159	003376001200001	HALELOA PL/KULIOUOU STRM	HALELOA PL.	TMK=3-8-06	1973	001
475	159	003382001200001	10TH AVE PL/WAIOMAO STRM	10TH AVENUE PL	TMK=3-4-03	1930	001
476	159	003392001200001	KALAMA VALLEY	MOKUHANO ST.	TMK=3-9-10,15,18	1972	
477	159	003393001200001	KAHULUI ST/DRAINAGE CNL	KAHULUI ST.	TMK=3-9-10,15,16	1972	001
478	159	003401001100001	KAHALUU WPP A-1 CHANNEL	AHAOLELO RD	TMK 4-7-28	1965	001
479	159	003401401200001	WAIMANALO STRM	MAHIKU PL	TMK=4-1-35	1983	001
480	159	003401601100001	DRAINAGE DITCH	ALAWIKI ST.	TMK:4-7-065 BRYAN 36E2	1980	001
481	159	003402001100001	MAKAKALO ST/4 CELL RCB	MAKAKALO ST.	TMK=4-1-24	1955	004
482	159	003403001100001	AHILAMA RD/N WAIHEE STRM	AHILAMA RD.	TMK=4-7-33	1977	001
483	159	003405001100001	KAHALUU WPP A-1 CHANNEL	AHUIMANU RD	TMK 4-7-25	1985	001
484	159	003406001100001	AULOA RD/KAHANAIKI STRM	AULOA RD	TMK=4-2-07	1921	001
485	159	003407001100001	AULOA RD/MAUNAWILI STRM	AULOA RD		1921	006
486	159	003429001100001	WAIMANALO STREAM	KUMUHAU ST.	TMK=4-1-18	1963	001
487	159	003430001100001	AHIKI ST/DRAINAGE DITCH	AHIKI ST	TMK=4-1-25	1955	004
488	159	003431001100001	AHIKI ST/4 CELL RCS #2	AHIKI ST	TMK=4-1-25	1955	004
489	159	003432001200001	MULIWAI OLENA CHANNEL	NAKINI STREET	TMK:4-1-08	1990	001
490	159	003435001100001	WAIMANALO STREAM	WAIKUPANAHA ST.	BRYAN 23A3	1983	001
491	159	003437001100001	MAUNAWILI STREAM	MAUNAWILI RD	TMK=4-2-67	1937	002
492	159	003438001200001	WAIMANALO DRAINAGE CNL	HULI STREET	TMK=4-1-24	1976	001
493	159	003440001100001	ALALOA ST/HEEIA STRM	ALALOA ST.	TMK=4-6-34	1972	003
494	159	003447001100001	KAPOO ST/KAPUNAHALA STRM	KAPOO ST	TMK=4-5-68(KANEOHE)	1969	001
495	159	003448001100001	KAPUNAHALA STREAM	KANEKE ST	TMK=4-5-68	1970	001
496	159	003460001200001	DRAINAGE CHANNEL	AHUIMANU PLACE	TMK=4-7-52	1965	001
497	159	003466001100001	HUI AEKO ST/DRAIN CHNL	HUI AEKO ST	TMK=4=7-51(AHUIMANU)	1971	001
498	159	003485001100001	KAHALUU-STRM	MELEKULA RD	TMK=4-7-46	1956	001
499	159	003495001200001	WAIHEE STRM	AHILAMA RD	MWY BET WAIHEE&MAPELE RD	1965	001
500	159	003514001100001	HAUULA HMSTD RD/HAHAIMOA	HAUULA HMSTD RD	TMK=5-4-13	19	002

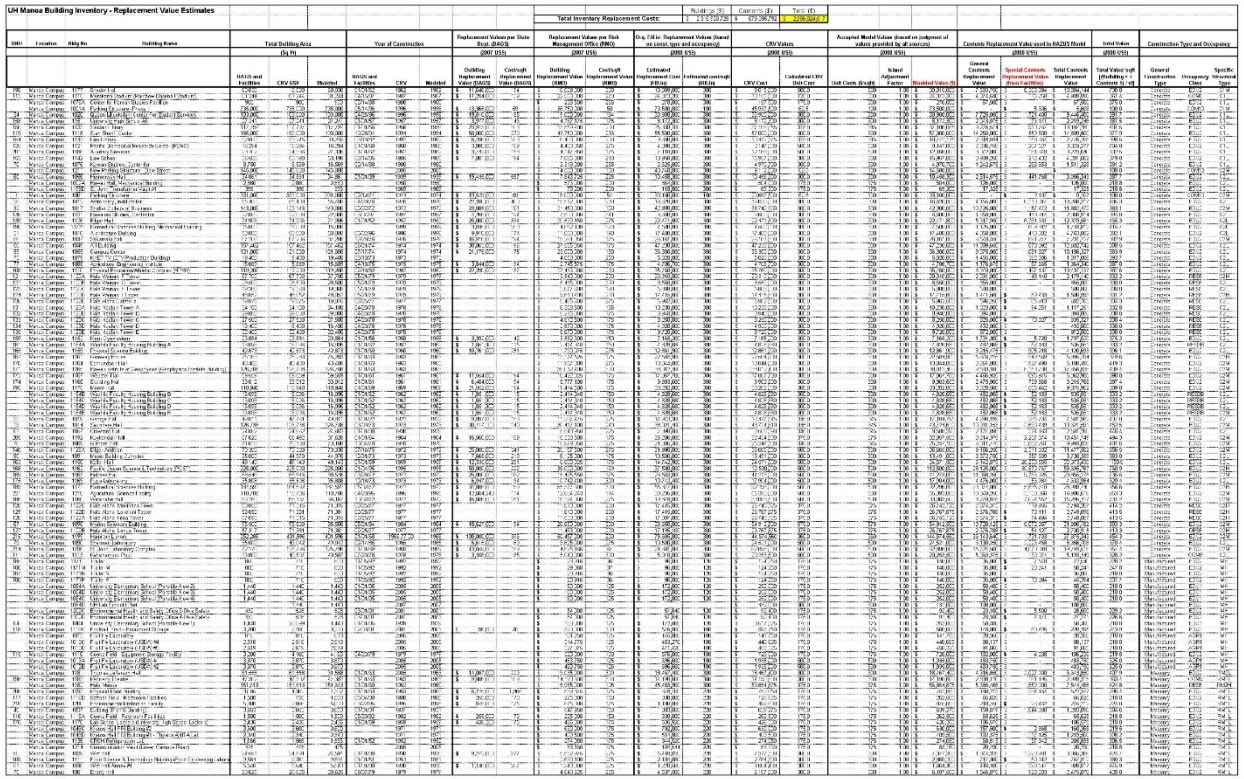
501	159	003600001100001	IRRIGATION DITCH	CANE HAUL ROAD	TMK=6-6-12=2	1983	001
502	159	003800001100001	KAUPUNI STRM	KANEAKI ST	0.95MI/FARR HWY/WAIANAE V	1974	001
503	159	003801001100001	ULEHAWA CHANNEL	AUYONG HMSTD RD	TMK=8-7-26	1964	001
504	159	003804001100001	KAHAU PL/ULEHAWA CHL U-3	KAHAU PL	TMK=8-7-26(NANAKULI)	1964	001
505	159	003806001100001	ULEHAWA CHL U-3	MAALOA ST	TMK=8-7-31	1964	001
506	159	003807001100001	MALIONA ST/MAILI CHL M-4	MAALOA ST	TMK=8-7-02	1967	001
507	159	003808001100001	ULEHAWA CHL U-3	MOHIHI ST	TMK=8-7-07(MAILI)	1964	001
508	159	003814001100001	SAINT JOHN'S RD/M-4	ST JOHN'S RD	TMK=8-7-02	1967	001
509	159	003825001100001	KAWILI ST/KAUPUNI CHL K3	PLT RD	TMK=8-5-03	1968	002
510	159	003833001100001	MAILI C M-5	KULAAUPUNI ST	TMK=8-7-10	1973	002
511	159	003834001100001	MAILIILII CHANNEL	MAILIILII RD	TMK=8-6-13	1970	002
512	159	003835001100001	LUALUALEI HMSTD RD/M-2	LUALUALEI HMSTD RD	TMK=8-6-13	1970	001
513	159	003836001100001	HALONA RD/MAILIILII(M-2)	HALONA RD	TMK=8-6-12	1970	001
514	159	003837001100001	23+68 BR/MAILIILII M-2		TMK=8-6-11	1970	001
515	159	003838001100001	PUUHULU RD/MAILIILII M-2	PUUHULU RD	TMK=8-6-10	1970	001
516	159	003844001100001	PUUHULU RD/PUUHULU STRM	PUUHULU RD	TMK=8-6-07,08	1977	001
517	159	003845001100001	KUWALE RD/LUALUALEI STRM	KUWALE RD	TMK=8-6-06	1980	001
518	159	003846001100001	DRAINAGE CANAL	HAKIMO RD	1.25MI NE OF INTERS FARR	1980	001
519	159	003850001100001	NANAKULI DRAINAGE CHNL	MANO AVE.	WAIANAE TMK 8-9-02:1	1979	001
520	159	003903001100001	WAIPIO ACC RD/RR R/W	WAIPIO ACC RD	TMK=9-4-50		003
521	159	003904001100001	MAKAKILO GULCH	FARR. HWY	TMK:9-1-16 BRYAN 104F2	1995	002
522	159	003905001100001	ANANIA DR/WAIAHOLE DITCH	ANANIA DR		1973	007
523	159	003928001100001	KIHALE ST/KALAUAO STRM	KIHALE ST	TMK=9-8-17	1956	002
524	159	003944001100001	PEARL CITY DRAINAGE DTH	HOOLAULEA ST	TMK=9-7-32	1980	001
525	159	003949001100001	LEOKANE ST/WAIPAHU STRM	LEOKANE ST.	TMK=9-4-01	1965	003
526	159	003950001100001	LEONUI ST/WAIPAHU STRM	LEONUI ST.	TMK=9-4-49	1965	003
527	159	003955001100001	WAIHAU ST/WAIPIO CHL #1	WAIHAU ST.	TMK=9-5-09	1957	002
528	159	003956001100001	WAIPUKA PL/WAIPIO CHL #1	WAIPUKA PL.	TMK=9-5-08	1957	002
529	159	003960001100001	KALOI GULCH	RENTON RD	BRYAN 97B1	1994	002
530	159	003967001100001	WAINIHI ST/WAIPIO CHL #1	WAINIHI ST.	TMK=9-5-06		002
531	159	003968001100001	HONOWAI ST/WAIPAHU STRM	HONOWAI ST.	TMK=9-4-52	1967	001
532	159	003970001100001	PEARL CITY DD	NOELANI ST.	TMK=9-7-38	1956	001
533	159	003971001100001	WAILANI STREAM	WAIPIO PT. ACC RD	TMK=9-3-02-9-4-19,20	1967	003
534	159	003975001100001	WAIAHOLE DITCH	MEHEULA PKWY	TMK=9-5-01	1974	001
535	159	003976001100001	KUAHEALANI AVE/DRAIN CNL	KUAHEALANI AVE.	TMK=9-5-01	1974	001
536	159	003980001100001	WAIHONA PL/WAIAWA STRM	WAIHONA PL.	TMK=9-6-08	1974	001
537	159	003983001100001	HIAPO ST/CANE HAUL RD	HIAPO ST.	TMK=9-4-02	1975	003
538	159	003991001100001	AWANUI STREAM	PALAHIA STREET EXT	TMK=9-2-03	1989	003
539	159	003995001100001	HALAWA STREAM	HALAWA CRUSHER RD.	TMK:9-9-72	1987	003
540	159	003996001100001	DRAINAGE CHANNEL	MANAGERS DR.	TMK:9-4-02	1990	001
541	159	003426001100001	KAWAINUI STRM	HAMAKUA DR	KOOLAUPOKO TMK4-2-01	1985	003
542	159	003083761400197	KAWAINUI CANAL	N KALAHEO AVE	300'N/INT/KAILUANA PL	1952	006
543	159	003425001100001	KEOLU DR/KAELEPULU STRM	KEOLU DR	TMK=4-2-40	1961	002
544	159	003427001100001	KEOLU DR/HELU DRAIN CHL	KEOLU DR	TMK=4-2-24	1957	002
545	159	003488001100001	KEOLU DR/KEOLU HILL CHL	KEOLU DR	TMK=4-2-04	1970	001
546	159	003083761400001	KAWAINUI CANAL	ONEAWA ST	170'E/KAINUI/ONEAWA ST	1967	003
547	159	003083821400052	KAELEPULU STRM	WANAAO	200'S/AUWINA ST/WANAAO RD	1971	003
548	159	003408001100001	KAWAINUI STREAM	KAAWAKEA RD	TMK=4-2-75(ENCHANTED LK)	1961	004
549	159	003411001100001	KAELEPULU STREAM	KAWAILOA ST	TMK=4-3-11	1925	010
550	159	003455001100001	AKUMU ST/VIENNEY DITCH	AKUMU ST	TMK=4-2-50	1961	004

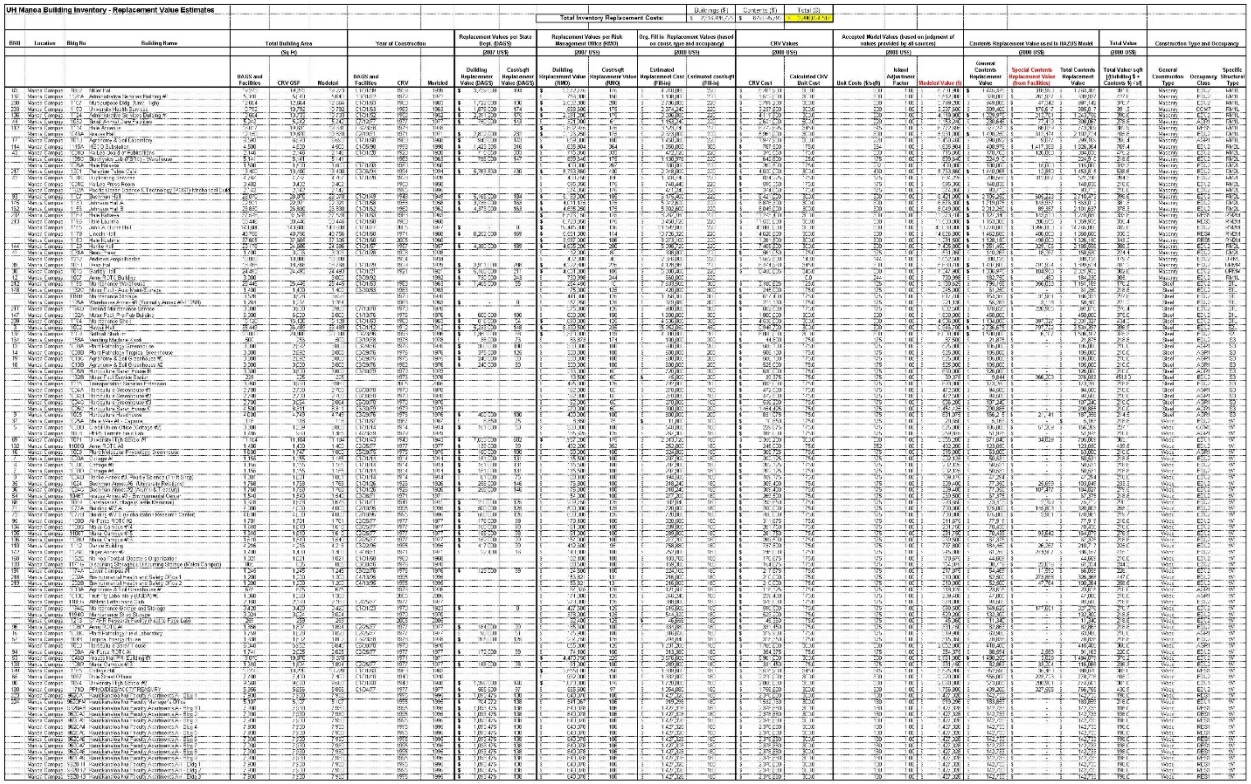
551	159	003444001100001	KAMAKALEPO STREAM	MAUNAWILI RD.	TMK=4-2-09	1966	001
552	159	003083601400059	KANEOHE STRM	KAM HWY	0.59MI W/LIKELIKE HWY	1953	002
553	159	003083601400098	KEAAHALA STRM	KAM HWY	0.02MI W/PAHIA RD	1918	001
554	159	003008360800242	HEEIA STRM	KAM HWY	0.39MI S/ULUMAU VILLAGE	1921	052
555	159	003443001100001	WAILELE RD/KEEAHALA STRM	WAILELE RD.	TMK=4-5-02	1967	001
556	159	003484001100001	LULUKU RD/KANEOHE STRM	LULUKU RD	TMK=4-5-85	1962	003
557	159	003994001100001	WAIAHOLE DITCH	LANIKUHANA AVENUE	TMK=9-5-41	1987	001
558	159	003083661400001	DRAINAGE CANAL #1	WAIPAHU ST	250'W/HIANAKIU ST	1971	001
559	159	003083661400002	DRAINAGE CANAL #3	WAIPAHU ST	250'E/LEOKU ST/WAIPAHU ST	1967	001
560	159	003083661400104	WAIKELE STRM	WAIPAHU ST	3300'E/WAIKELE/WAIPAHU ST	1905	001
561	159	003076001400581	HONOULIULI STRM	FT WEAVER RD	0.84MI NW/TONGG RANCH RD	1927	001
562	159	003072000000001	MOANALUA RD(PED OP)	PEDESTRIAN	AT WAIMANO HOME RD	1969	003
563	159	003072000000024	MOANALUA RD(PED OP)	PEDESTRIAN	AT HOOLAULEA ST	1969	003
564	159	003072001400041	WAIMANO STRM	MOANALUA RD	0.16MI SE/HOOLAULEA ST	1969	001
565	159	003072001400140	PUNANANI CHANNEL	MOANALUA RD	0.23MI W/HEKAHA ST	1969	001
566	159	003072001400159	WAIMALU STRM	MOANALUA RD	0.04MI W/HEKAHA ST	1965	002
567	159	003072001400235	KAONOHI STRM	MOANALUA RD	0.23MI E/KAONOHI ST	1966	001
568	159	003072001400258	KALAUAO STRM	MOANALUA RD	0.03MI W/HALE MOMI PL	1935	001
569	159	003072001400318	AIEA STRM	MOANALUA RD	0.04MI S/AIEA HTS DR	1951	001
570	159	003933001100001	ANOUNOU ST/AIEA STRM	ULUNE ST.	TMK=9-9-42	1954	002
571	159	003067001400301	HALAWA STRM	SALTLAKE BLVD	0.08MI SE/HALE ST	1968	003
572	159	003083261400006	MOANALUA STRM	KIKOWAENA ST	250'E/AHUA/KIKOWAENA ST	1961	004
573	159	003122001200001	ALA AOLANI/MOANALUA STRM	ALA-AOLANI ST.	TMK=1-1-39	1962	001
574	159	003126001200001	ALA AOLANI #1/MOANALUA S	ALA AOLANI	TMK=1-1-45	1965	002
575	159	003127001200001	ALA AOLANI #2/MOANALUA S	ALA AOLANI	TMK=1-1-44	1965	001
576	159	003062071400140	KAPALAMA CANAL	DILLINGHAM BLVD	BETWN KOHOU ST/KOKEA ST	1930	005
577	159	003062081400037	KALIHI STRM	N KING ST	300'W//GULICK AV/N KING ST	1933	001
578	159	003062081400134	KAPALAMA CANAL	N KING ST	INT/KOKEA ST/N KING ST	1938	004
579	159	003062081400218	NUUANU STRM	N KING ST	INT/RIVER ST/N KING ST	1922	004
580	159	003062081400252	FORT ST MALL	SOUTH KING ST	BET BISHOP ST/BETHEL ST	1968	001
581	159	003105001200001	HOUGHTAILG/KAPALAMA CHNL	HOUGHTAILING ST.	TMK=1-6-25	1937	001
582	159	003083631400093	KALIHI STRM	N SCHOOL ST	550'N/GULICK AVE/N SCH ST	1927	001
583	159	003083631400271	NUUANU STRM	N SCHOOL ST	225'S/STILLMAN/N SCH ST	1932	003
584	159	003083211400072	KAMANAIKI STRM	KALIHI ST	200'N/MONTE ST/KALIHI ST	1938	001
585	159	003083220000049	KAM IV RD	PEDESTRIAN	540'E/HIHIO PL/KAM IV RD	1961	001
586	159	003083451400011	KALIHI STRM	NALANIEHA ST	250'W/KALIHI/NALANIEHA ST	1955	003
587	159	003062091400213	NUUANU STRM	BERETANIA ST	INT/RIVER/BERETANIA ST	1967	003
588	159	003062020000001	KAPIOLANI BLVD	PEDESTRIAN	INT/MAHIAI PL/KAP BLVD	1971	001
589	159	003062021400052	MAKIKI DITCH	KAPIOLANI BLVD	320'E/KALAKAUA/KAP BLVD	1931	001
590	159	003062021400168	MANOA-PALOLO STRM	KAPIOLANI BLVD	400'W/KAIMUKI/KAP BLVD	1950	004
591	159	003083381400047	PAUOA STRM	LUSITANA ST	350'N/AUWAIOLIMU/LUSITANA	1932	001
592	159	003083461400067	MAKIKI STRM	NEHOA ST	100'E/NEHOA/MAKIKI ST	1920	001
593	159	003083471400113	NUUANU STRM	NUUANU AVE	200'E/PAUOA RD/NUUANU AVE	1933	001
594	159	003083321400019	WAIOLANI STRM	N KUAKINI ST	100'N/HUNA/N KUAKINI ST	1934	001
595	159	003083321400031	NUUANU STRM	N KUAKINI ST	450'N/NUUANU/N KUAKINI ST	1934	001
596	159	003083981400003	NUUANU STRM	N HOTEL ST	INT/RIVER ST/N HOTEL ST	1936	003
597	159	003202001200001	BOOTH RD/PAUOA STRM	BOOTH RD	TMK=2-2-27	1973	001
598	159	003236001200001	PUOWAINA DR/AUWAIOLIMU S	PUOWAINA DR.	TMK=2-2-15	1936	003
599	159	003083041400055	MANOA PALOLO STRM	DATE ST	INT/LAAU ST/DATE ST	1937	003
600	159	003083061400076	MANOA STRM	DOLE ST	2650'W/UNIV AVE/DOLE ST	1953	003

601	159	003083061400136	PALOLO STRM	ST LOUIS DR	100'N/WAIA AVE/ST LOUIS D	1929	001
602	159	003083181400074	ALA WAI CANAL	KALAKAUA AVE	INT/ALA WAI/KALAKAUA AVE	1929	003
603	159	003083401400011	ALA WAI CANAL	MCCULLY ST	INT/ALAWAI BLVD/MCCULLY	1959	007
604	159	003234001200001	PHILIP ST/MAKIKI STRM	PHILIP ST.	TMK=2-3-24	1938	001
605	159	003083071400092	MANOA STRM	E MANOA RD	400'E/LOWREY/E MANOA RD	1950	002
606	159	003208001200001	E MANOA RD/MANOA PK DITC	EAST MANOA RD	TMK=2-9-06	1938	001
607	159	003083371400092	MANOA STRM	LOWREY AVE	160'W/E MANOA/LOWREY AVE	1953	001
608	159	003311001200001	KAHALA AVE/MULIWAI DITCH	KAHALA AVE.	TMK=3-5-07	1947	001
609	159	003083531400001	PUKELE STRM	PALOLO AVE	50' E/PALOLO PL/PALOLO AV	1928	001
610	159	003083531400155	PALOLO STRM	PALOLO AVE	IK/'N/KAAU ST/PALOLO AVE	1949	001
611	159	003364001200001	10TH AVE/WAIOMAO STRM	10TH AVENUE	TMK=3-4-03	1962	002
612	159	003300001200001	ANI ST BR/WAILUPE STRM	ANI ST.	TMK=3-6-20	1954	001
613	159	003309001200001	E HIND DR/WAILUPE STRM	EAST HIND DR.	TMK=3-6-05	1949	001
614	159	003353001200001	HALEMAUMAU ST/NIU E FORK	HALEMAUMAU ST.	TMK=3-7-07	1969	001
615	159	003354001200001	HALEMAUMAU ST/NIU W FORK	HALEMAUMAU ST.	TMK=3-7-07	1969	001
616	159	003303001200001	HAWAII KAI DR/HAHAIONE C	HAWAII KAI DR.	TMK=3-9-38	1962	002
617	159	003304001200001	HAWAII KAI DR/KUAPA POND	HAWAII KAI DR.	TMK=3-9-09	1967	003
618	159	003394001200001	AINAPO BR/HAHAIONE CHL	AINAPO ST.	TMK=3-9-08	1972	001
619	159	003352001200001	KEAHOLE ST/KUAPA POND	KEAHOLE ST.	TMK=3-9-08	1971	004
620	159	003342001200001	WAILUA ST/KUAPA POND	WAILUA ST.	TMK=3-9-08	1970	005
621	159	003331001200001	PEPEEKEO ST/HAHAIONE CHL	PEPEEKEO ST.	TMK=3-9-38	1962	002
622	159	003083660000003	WAIPAHU RD	PEDESTRIAN	350'E/WAIKELE/WAIPAHU ST	1963	001
623	159	003810001100001	PLT RD/KAUPUNI CHL K-2	PLANTATION RD	TMK=8-5-03	1968	001
624	159	003830001100001	WAIANAE V RD/KAUPUNI CHL	WAIANAE VALLEY RD	TMK=8-5-19	1971	001
625	159	003902001100001	FARR HWY/PALEHUA STRM	FARR HWY	TMK=9-1-16	1922	001
626	159	003922001100001	FARR HWY/HONOULIULI STRM	FARR HWY	TMK=9-1-17	1939	001
627	159	003923001100001	FARR HWY/KALOI GULCH	FARR HWY	TMK=8-1-17	1941	001
628	159	003924001100001	FARR HWY/HUNEHUNE STRM	FARR HWY	TMK=8-1-17		001
629	159	003605001100001	KIIKII STREAM	WAIALUA BEACH RD	TMK=6-7-01	1950	004
630	159	003602001100001	PAUKAUILA STREAM	HALEIWA RD	TMK=6-6-21	1971	013
631	159	003601001100001	PAALAA RD/UNKNOWN STRM	PAALAA RD	TMK=6-6-12	1968	001
632	159	003809001100001	PAAKEA RD/MAILIILII CNL	PAAKEA RD	TMK=8-6-02	1966	003
633	159	003918001100001	KOMO MAI DR/WAIMANO STRM	KOMO MAI DR	TMK=9-7-25	1961	001
634	159	003929001100001	KOMO MAI DR/PC DRAIN CNL	KOMO MAI DR	TMK=9-8-86	1969	001
635	159	003953001100001	PAIWA ST/WAILANI STRM	PAIWA ST.	TMK=9-4-77	1963	003
636	159	003973001100001	KOMO MAI DR/DRAINAGE CNL	KOMO MAI DR	TMK=9-8-2-09	1975	002
637	159	003974001100001	KOMO MAI DR/DRAINAGE CNL	KOMO MAI DR	TMK=9-8-2-2	1972	001
638	159	003982001100001	HALAWA CORR FAC ACC RD		TMK=9-9-10		003
639	159	003378001200001	LA-I RD #1/PUKELE STRM				002
640	159	003379001200001	LA-I RD #2/PUKELE STRM				002
641	159	003380001200001	LA-I RD #3/PUKELE STRM				001
642	159	003461001100001	AHUIMANU RD BR #2/K STRM	AHUIMANU RD	TMK=4-7-32		001
643	159	003843001100001	HUIPA DR/MAKAHA STRM	HUIPA DR	TMK=8-4-02-5(MAKAHA)	1970	002

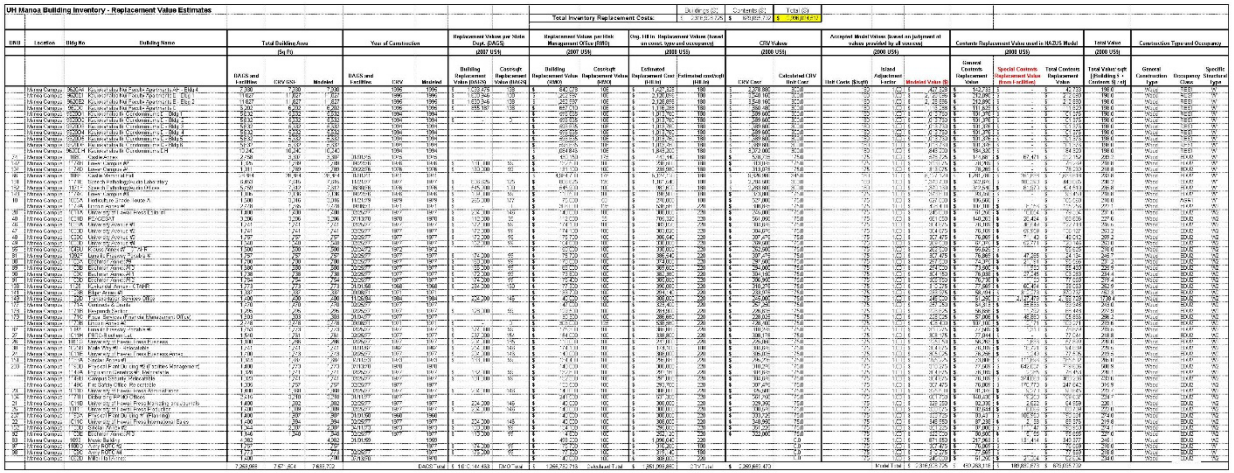
University of Hawaii
System-wide Building Exposures to Risk

University of Hawaii at Manoa (1 of 3)





University of Hawaii at Manoa (3 of 3)



Other Facilities

Other Facilities Building Inventory - Replacement Value Estimates

	Buildings ($)	Contents ($)	Total ($)
Total Inventory Replacement Costs:	$ 308,359,210	$ 69,264,804	$ 377,624,014

BNU	Location	Bldg No	Building Name	Total Building Area (Sq Ft)			Year of Construction			Replacement Values per State Dept. (DAGS) (2007 US$)		Replacement Values per Risk Management Office (RMO) (2007 US$)		Org. Fill in Replacement Values (based on const. type and occupancy) (2008 US$)		CRV Values (2008 US$)		Accepted Model Values (based on judgment of values provided by all sources) (2008 US$)			Contents Replacement Value used in HAZUS Model (2008 US$)			Total Value (2008 US$)	Construction Type and Occupancy		
				DAGS and Facilities	CRV GSF	Modeled	DAGS and Facilities	CRV	Modeled	Building Replacement Value (DAGS)	Cost/sqft Replacement Value (DAGS)	Building Replacement Value (RMO)	Cost/sqft Replacement Value (RMO)	Estimated Replacement Cost (Fill-in)	Estimated cost/sqft (Fill-in)	CRV Cost	Calculated CRV Unit Cost	Unit Costs ($/sqft)	Island Adjustment Factor	Modeled Value ($) (if sqft unk. Use max of DAGS & RMO)	General Contents Replacement Value	Special Contents Replacement Value (from Facilities)	Total Contents Replacement Value	Total Value/ sqft [(Building $ + Contents $) / sf]	General Construction Type	Occupancy Class	Specific Structural Type
LYON ARBORETUM																											
	Lyon Arboretum	9618A	LYON ARBORETUM-OFFICE/LIBRARY	842	842	842	1979	1979	1979	$ 123,000	146	$ 4,567	5	$ 151,560	180	147,350	175.00	175	1.00	$ 147,350	$ 29,470		$ 29,470	210.0	Wood	EDU1	W1
	Lyon Arboretum	9618B	LYON ARBORETUM-COTTAGE B-RENT	950	950	950	1979	1979	1979	$ 139,000	146	$ 4,000	4	$ 171,000	180	166,250	175.00	175	1.00	$ 166,250	$ 16,625		$ 16,625	192.5	Wood	RES4	W1
	Lyon Arboretum	9618C	LYON ARBORETUM-COTTAGE C-RENT	672	672	672	1979	1979	1979	$ 98,000	146	$ 3,500	5	$ 120,960	180	117,600	175.00	175	1.00	$ 117,600	$ 11,760		$ 11,760	192.5	Wood	RES4	W1
	Lyon Arboretum	9618D	Arboretum Seed Culture Research Lab	528	528	528	1979	1979	1979	$ 77,000	146	$ 3,500	7	$ 105,600	200	92,400	175.00	175	1.00	$ 92,400	$ 18,480		$ 18,480	210.0	Steel	AGR1	S3
	Lyon Arboretum	9618E	LYON ARBORETUM-REPRINT COLLECT	571	571	571	1979	1979	1979	$ 83,000	145	$ 3,500	6	$ 102,780	180	99,925	175.00	175	1.00	$ 99,925	$ 19,985		$ 19,985	210.0	Wood	AGR1	W1
	Lyon Arboretum	9618F	LYON ARBORETUM-COTTAGE F-RENT	922	922	922	1979	1979	1979	$ 135,000	146	$ 3,500	4	$ 165,960	180	161,350	175.00	175	1.00	$ 161,350	$ 16,135		$ 16,135	192.5	Wood	RES4	W1
	Lyon Arboretum	9618G	LYON ARBORETUM-COTTAGE G-RENT	1,412	1,412	1,412	1979	1979	1979	$ 206,000	146	$ 3,800	3	$ 254,160	180	247,100	175.00	175	1.00	$ 247,100	$ 24,710		$ 24,710	192.5	Wood	RES4	W1
	Lyon Arboretum	9618H	Arboretum Reception Center	2,854	2,854	2,854	1979	1979	1979	$ 417,000	146	$ 226,882	79	$ 513,720	180	499,450	175.00	175	1.00	$ 499,450	$ 99,890		$ 99,890	210.0	Wood	AGR1	W1
	Lyon Arboretum	9618I	Aboretum Greenhouse 1	2,604	1,400	2,604	1979	1979	1979	$ 7,000	3	$ 34,124	13	$ 520,800	200	245,000	175.00	175	1.00	$ 455,700	$ 91,140		$ 91,140	210.0	Steel	AGR1	S3
	Lyon Arboretum	9618J	Arboretum Greenhouse 4	722	722	722	1979	1979	1979	$ 2,000	3	$ 2,772	4	$ 144,400	200	126,350	175.00	175	1.00	$ 126,350	$ 25,270		$ 25,270	210.0	Steel	AGR1	S3
	Lyon Arboretum	9618K	Arboretum Garage	396	396	396	1979	1979	1979	$ 46,000	116	$ 1,000	3	$ 79,200	200	69,300	175.00	175	1.00	$ 69,300	$ -		$ -	175.0	Steel	COM10	S3
	Lyon Arboretum	9618L	LYON ARBORETUM-RAIN SHELTER	96	96	96	1979	1979	1979	$ 11,000	115	$ 5,000	52	$ 17,280	180	16,800	175.00	175	1.00	$ 16,800	$ 3,360		$ 3,360	210.0	Wood	AGR1	W1
	Lyon Arboretum	9618M	Arboretum Greenhouse 2	1,536	1,536	1,536	1979	1983	1979	$ 4,000	3	$ 3,092	2	$ 307,200	200	268,800	175.00	175	1.00	$ 268,800	$ 53,760		$ 53,760	210.0	Steel	AGR1	S3
	Lyon Arboretum	9618N	Arboretum Greenhouse 3		2,747	2,747	1979	1997	1979	$ 3,000		$ 162,700		$ -	200	480,725	175.00	175	1.00	$ 480,725	$ 96,145		$ 96,145	210.0	Steel	AGR1	S3
	Lyon Arboretum	9618O	Arboretum Workshop		500	500	1979	1979	1979			$ -		$ -	200	87,500	175.00	175	1.00	$ 87,500	$ 17,500		$ 17,500	210.0	Steel	AGR1	S3
	Lyon Arboretum	9681P	Classroom-Children's Learning Center	1,500		1,500	1979		1979			$ -	0	$ 270,000	180		0.00	175	1.00	$ 262,500	$ 52,500		$ 52,500	210.0	Wood	EDU1	W1
	Lyon Arboretum	9618Q	Aboretum Snail Greenhouse 1		500	500	1979	1979	1979			$ -		$ -	200	87,500	175.00	175	1.00	$ 87,500	$ 17,500		$ 17,500	210.0	Steel	AGR1	S3
	Lyon Arboretum	9618R	Aboretum Snail Greenhouse 2		500	500	1979	1979	1979			$ -		$ -	200	87,500	175.00	175	1.00	$ 87,500	$ 17,500		$ 17,500	210.0	Steel	AGR1	S3
KAKAAKO FACILITY																											
	Kakaako		Medical Education & Administration	136,581	136,581	136,581	2005	2002	2002	$ 31,200,000	228	$ 39,435,032	289	$ 40,974,300	300	40,974,300	300.00	300	1.00	$ 40,974,300	$ 6,146,145		$ 6,146,145	345.0	Concrete	EDU2	C2M
	Kakaako		Biosciences (Research)	181,028	181,028	181,028	2005	2005	2005	$ 67,900,000	375	$ 62,532,502	345	$ 54,308,400	300	90,514,000	500.00	500	1.00	$ 90,514,000	$ 22,628,500		$ 22,628,500	625.0	Concrete	IND5	C2L
	Kakaako		Ancillary	8,176	8,176	8,176	2005	2005	2005			$ 2,121,508	259	$ 1,798,720	220	2,452,800	300.00	300	1.00	$ 2,452,800	$ 367,920		$ 367,920	345.0	Masonry	EDU2	RM1L
	Kakaako		Central Plant	11,629	11,629	11,629	2005	2005	2005			$ 15,557,044	1,338	$ 3,488,700	300	3,488,700	300.00	300	1.00	$ 3,488,700	$ 523,305		$ 523,305	345.0	Concrete	EDU2	C2L
OUT CAMPUS FACILITIES (CTAHR AND OTHERS)																											
386	Waimanalo, Oahu	9628A	WAIMANALO FARM-OFFICE & SHOP	1,127	1,127	1,127	1977	1977	1977	$ 165,000	146	$ 4,138	4	$ 202,860	180	226,809	201.25	175	1.00	$ 197,225	$ 39,445		$ 39,445	210.0	Wood	AGR1	W1
387	Waimanalo, Oahu	9628B	WAIMANALO FARM-WHSE & GARAGE	4,158	4,158	4,158	1977	1977	1977	$ 254,000	61	$ 4,478	1	$ 748,440	180	836,798	201.25	175	1.00	$ 727,650	$ 145,530		$ 145,530	210.0	Wood	AGR1	W1
388	Waimanalo, Oahu	9628C	WAIMANALO FARM-FOREMAN COTTAGE	875	875	875	1977	1977	1977	$ 120,000	137	$ 4,088	5	$ 157,500	180	176,094	201.25	175	1.00	$ 153,125	$ 15,313		$ 15,313	192.5	Wood	RES4	W1
389	Waimanalo, Oahu	9628D	WAIMANALO FARM-HOTHSE/STORERM	2,160	600	2,160	1977	1977	1977	$ 5,000	2	$ 2,000	1	$ 388,800	180	120,750	201.25	175	1.00	$ 378,000	$ 75,600		$ 75,600	210.0	Wood	AGR1	W1
390	Waimanalo, Oahu	9628E	WAIMANALO FARM-GREENHOUSE #2			1,500	1977		1977	$ -		$ 600		$ -	180				1.00	$ 600	$ 120		$ 120	0.5	Wood	AGR1	W1
391	Waimanalo, Oahu	9628G	WAIMANALO FARM-TRACTOR GARAGE	3,534	500	3,534	1977	1977	1977	$ 216,000	61	$ 100	0	$ 636,120	180	100,625	201.25	175	1.00	$ 618,450	$ 123,690		$ 123,690	210.0	Wood	AGR1	W1
392	Waimanalo, Oahu	9628H	WAIMANALO FARM-OFFCLAB/CLSRM	2,040	2,040	2,040	1977	1977	1977	$ 306,000	150	$ 56,748	28	$ 367,200	180	410,550	201.25	175	1.00	$ 357,000	$ 71,400		$ 71,400	210.0	Wood	AGR1	W1
393	Waimanalo, Oahu	9628J	WAIMANALO FARM-SEED PROC LAB	1,612	2,400	2,400	1983	1983	1983	$ 248,000	154	$ 122,980	76	$ 290,160	180	483,000	201.25	175	1.00	$ 420,000	$ 84,000		$ 84,000	210.0	Wood	AGR1	W1
394	Waimanalo, Oahu	9628K	WAIMANALO FARM-GREENHSE 30X96	2,880	3,000	3,000	1996	1996	1996	$ -	0	$ 103,373	36	$ 518,400	180	603,750	201.25	175	1.00	$ 525,000	$ 105,000		$ 105,000	210.0	Wood	AGR1	W1
398	Pearl City Hawaii	9645B	PEARL CITY FARM-COMPD ANNEX 2	4,000		4,000	1977		1977	$ 584,000	146	$ 9,000	2	$ 720,000	180		0.00	175	1.00	$ 700,000	$ 140,000		$ 140,000	210.0	Wood	AGR1	W1
399	Pearl City Hawaii	9645C	PEARL CITY FARM-PUMP HOUSE			1,500	1977		1977	$ -		$ 4,000		$ -	180				1.00	$ 4,000	$ 800		$ 800	3.2	Wood	AGR1	W1
400	Pearl City Hawaii	9645D	PEARL CITY FARM-MGR RESIDENCE	1,700	1,700	1,700	1977	1977	1977	$ 233,000	137	$ 43,980	26	$ 306,000	180	342,125	201.25	175	1.00	$ 297,500	$ 29,750		$ 29,750	192.5	Wood	RES1	W1
401	Pearl City Hawaii	9645E	PEARL CITY FARM-CLASSROOM	1,000	1,000	1,000	1977	1977	1977	$ 160,000	160	$ 38,950	39	$ 180,000	180	201,250	201.25	175	1.00	$ 175,000	$ 26,250		$ 26,250	201.3	Wood	EDU2	W1
402	Pearl City Hawaii	9645F	PEARL CITY FARM-OFFC/STORAGE	1,500	1,500	1,500	1980	1980	1980	$ 219,000	146	$ 17,263	12	$ 270,000	180	301,875	201.25	175	1.00	$ 262,500	$ 52,500		$ 52,500	210.0	Wood	AGR1	W1
403	Pearl City Hawaii	9645G	PEARL CITY FARM-CLASSROOM #2			1,500	1980		1980	$ -		$ 17,263		$ -	180				1.00	$ 17,263	$ 2,589		$ 2,589	13.2	Wood	EDU2	W1
404	Pearl City Hawaii	9645H	PEARL CITY FARM-RESTROOMS		300	300	1977	1980	1977	$ 50,000		$ 17,629		$ -	180	60,375	201.25	175	1.00	$ 52,500	$ 10,500		$ 10,500	210.0	Wood	AGR1	W1
407	Waialee Hawaii	9657	WAIALEE EXPERIMENTAL FARM		1,100	1,100		1959	1959	$ -		$ 942,453		$ -	180	221,375	201.25	175	1.00	$ 192,500	$ 38,500		$ 38,500	210.0	Wood	AGR1	W1
408		9666	PRI-WHITMORE VILLAGE			1,500	1959		1959	$ -		$ 50,000		$ -	180				1.00	$ 50,000	$ 5,000		$ 5,000	36.7	Wood	RES3B	W1
409		9670A	POAMOHO FARM-FOREMAN RESIDENCE	1,400	1,400	1,400	1977	1977	1977	$ 192,000	137	$ 4,285	3	$ 252,000	180	281,750	201.25	175	1.00	$ 245,000	$ 24,500		$ 24,500	192.5	Wood	RES1	W1
410		9670B	POAMOHO FARM-GARAGE & STORAGE	1,500	1,500	1,500	1977	1977	1977	$ 74,000	49	$ 81,430	54	$ 270,000	180	301,875	201.25	175	1.00	$ 262,500	$ 52,500		$ 52,500	210.0	Wood	AGR1	W1
411		9670G	POAMOHO FARM-GREENHOUSE			1,500	1977		1977	$ -		$ 2,976		$ -	180				1.00	$ 2,976	$ 595		$ 595	2.4	Wood	AGR1	W1
412		9670H	POAMOHO FARM-OFFICE/LAB/CLSRM	2,000	2,000	2,000	1977	1977	1977	$ 300,000	150	$ 56,748	28	$ 360,000	180	402,500	201.25	175	1.00	$ 350,000	$ 70,000		$ 70,000	210.0	Wood	AGR1	W1
413	Kaneohe Bay	9684	HAWAII INST MARINE BIOLOGY		46,700	46,700	1963	1963	1963	$ -		$ 1,527,745		$ -	180	23,350,000	500.00	500	1.00	$ 23,350,000	$ 5,837,500		$ 5,837,500	625.0	Wood	EDU2	W1
414	Kaneohe Bay	9685	COCONUT ISLAND MARINE RSCH LAB		22,000	22,000	1998	1998	1998			$ 9,345,745		$ -	180	11,000,000	500.00	500	1.00	$ 11,000,000	$ 2,750,000		$ 2,750,000	625.0	Wood	EDU2	W1
345	Kaimuki, Oahu	9600B	LEAHI HOSP-YOUNG BLDG	132,685		132,685	1970		1970			$ 26,153,800	197	$ 29,190,700	220		0.00	300	1.00	$ 39,805,500	$ 9,951,375		$ 9,951,375	375.0	Masonry	COM6	RM1L
346	Kaimuki, Oahu	9600C	LEAHI HOSP-ATHERTON BLDG	25,284		25,284	1970		1970	$ -	0	$ 5,498,000	217	$ 5,562,480	220		0.00	300	1.00	$ 7,585,200	$ 1,896,300		$ 1,896,300	375.0	Masonry	COM6	RM1L
347	Kaimuki, Oahu	9600H	LEAHI HOSP-TROTTER BLDG	30,754		30,754	1980		1980			$ 3,982,000	129	$ 6,765,880	220		0.00	300	1.00	$ 9,226,200	$ 2,306,550		$ 2,306,550	375.0	Masonry	COM6	RM1L
348	Kaimuki, Oahu	9600N	LEAHI HOSP-PSYCHIATRY BLDG	6,220		6,220	1980		1980	$ 1,014,000	163	$ 870,800	140	$ 1,368,400	220		0.00	175	1.00	$ 1,088,500	$ 272,125		$ 272,125	218.8	Wood	COM6	W2
349	Kaimuki, Oahu	9601A	LEAHI HOSP-NURSE QTR #1 WILCOX	20,880		20,880	1980		1980			$ 3,326,400	159	$ 4,593,600	220		0.00	300	1.00	$ 6,264,000	$ 1,566,000		$ 1,566,000	375.0	Masonry	COM6	RM1L
350	Kaimuki, Oahu	9601B	LEAHI HOSP-MED RES QTR #3	1,990		1,990	1980		1980			$ 278,600	140	$ 358,200	180		0.00	175	1.00	$ 348,250	$ 87,063		$ 87,063	218.8	Wood	COM6	W1
351	Kaimuki, Oahu	9601C	LEAHI HOSP-STAFF RES #4	1,780		1,780	1980		1980			$ 249,200	140	$ 320,400	180		0.00	175	1.00	$ 311,500	$ 77,875		$ 77,875	218.8	Wood	COM6	W1
352	Kaimuki, Oahu	9601D	LEAHI HOSP-STAFF RES #5	1,800		1,800	1980		1980			$ 181,900	101	$ 324,000	180		0.00	175	1.00	$ 315,000	$ 78,750		$ 78,750	218.8	Wood	COM6	W1
353	Kaimuki, Oahu	9601E	LEAHI HOSP-STAFF RES #6	1,080		1,080	1980		1980			$ 151,200	140	$ 194,400	180		0.00	175	1.00	$ 189,000	$ 47,250		$ 47,250	218.8	Wood	COM6	W1
354	Kaimuki, Oahu	9601F	LEAHI HOSP-STAFF RES #7	1,100		1,100	1980		1980			$ 154,000	140	$ 198,000	180		0.00	175	1.00	$ 192,500	$ 48,125		$ 48,125	218.8	Wood	COM6	W1
355	Kaimuki, Oahu	9601G	LEAHI HOSP-STAFF RES STUDIO#7	340		340	1980		1980			$ 47,600	140	$ 61,200	180		0.00	175	1.00	$ 59,500	$ 14,875		$ 14,875	218.8	Wood	COM6	W1
356	Kaimuki, Oahu	9601H	LEAHI HOSP-STAFF RES #9	1,110		1,110	1980		1980			$ 155,400	140	$ 199,800	180		0.00	175	1.00	$ 194,250	$ 48,563		$ 48,563	218.8	Wood	COM6	W1
357	Kaimuki, Oahu	9601I	LEAHI HOSP-STAFF RES #10	1,110		1,110	1980		1980			$ 155,400	140	$ 199,800	180		0.00	175	1.00	$ 194,250	$ 48,563		$ 48,563	218.8	Wood	COM6	W1
358	Kaimuki, Oahu	9601J	LEAHI HOSP-STAFF RES #11	1,770		1,770	1980		1980			$ 247,800	140	$ 318,600	180		0.00	175	1.00	$ 309,750	$ 77,438		$ 77,438	218.8	Wood	COM6	W1
359	Kaimuki, Oahu	9601K	LEAHI HOSP-STAFF RES #12	1,870		1,870	1980		1980			$ 261,800	140	$ 336,600	180		0.00	175	1.00	$ 327,250	$ 81,813		$ 81,813	218.8	Wood	COM6	W1
360	Kaimuki, Oahu	9601L	LEAHI HOSP-NURSES QTRS #14	9,220		9,220	1980		1980			$ 1,290,800	140	$ 1,659,600	180		0.00	175	1.00	$ 1,613,500	$ 403,375		$ 403,375	218.8	Wood	COM6	W1
361	Kaimuki, Oahu	9601R	LEAHI HOSP-NURSES QTRS/GARAGE	580		580	1980		1980			$ 60,200	104	$ 104,400	180		0.00	175	1.00	$ 101,500	$ 25,375		$ 25,375	218.8	Wood	COM6	W1
362	Kaimuki, Oahu	9601S	LEAHI HOSP-STAFF RES	1,280		1,280	1980		1980			$ 179,200	140	$ 230,400	180		0.00	175	1.00	$ 224,000	$ 56,000		$ 56,000	218.8	Wood	COM6	W1
395	Kakaako, Oahu	9631	LOOK LABORATORY			5,000	1964		1964	$ 697,296		$ 697,296		$ -	220				1.00	$ 697,296	$ 174,324		$ 174,324	174.3	Masonry	COM6	RM1L
396	Kakaako, Oahu	9631A	HYPERBARIC FACILITY			2,000	1970		1970	$ -		$ 40,787		$ -	220				1.00	$ 40,787	$ 10,197		$ 10,197	25.5	Masonry	COM6	RM1L
405		9650C	QUEEN'S HOSP-UNIV TOWERS			16,000	1983		1983	$ 4,421,571		$ 4,421,571		$ -	220				1.00	$ 4,421,571	$ 1,105,393		$ 1,105,393	345.4	Masonry	COM6	RM1L
406		9656A	KAPIOLANI CHILDREN'S HOSPITAL			5,000	1980		1980	$ -		$ 548,140		$ -	180				1.00	$ 548,140	$ 137,035		$ 137,035	137.0	Wood	COM6	W1
415		9952C	KUAKINI-HALE PULAMA MAU			5,000	1980		1980	$ -		$ 692,594		$ -	180				1.00	$ 692,594	$ 173,149		$ 173,149	173.1	Wood	COM7	W1
364	Honolulu, Oahu	9605	KEWALO MARINE LAB			10,000	1972		1972	$ 1,383,050		$ 1,383,050		$ -	180				1.00	$ 1,383,050	$ 345,763		$ 345,763	172.9	Wood	IND2	W1
365	Honolulu, Oahu	9612	MARINE EXPEDITIONARY CTR-SNUG			10,000	1976		1976	$ 2,483,697		$ 2,483,697		$ -	180				1.00	$ 2,483,697	$ 620,924		$ 620,924	310.5	Wood	IND2	W1
366	Honolulu, Oahu	9612A	MARINE EX CTR-WAREHOUSE-SNUG			3,000	1976		1976	$ -		$ 274,825		$ -	180				1.00	$ 274,825	$ 68,706		$ 68,706	114.5	Wood	IND2	W1
367	Honolulu, Oahu	9612B	MARINE EX CTR-MACHINE SHOP #1			5,000	1976		1976	$ 473,926		$ 473,926		$ -	180				1.00	$ 473,926	$ 118,482		$ 118,482	118.5	Wood	IND2	W1
368	Honolulu, Oahu	9612C	MARINE EX CTR-CORE STORAGE			10,000	1984		1984	$ 1,201,090		$ 1,201,090		$ -	180				1.00	$ 1,201,090	$ 300,273		$ 300,273	150.1	Wood	IND2	W1
369	Honolulu, Oahu	9615	CANCER CENTER OF HAWAII			16,000	1982		1982	$ 5,064,436		$ 5,064,436		$ -	180				1.00	$ 5,064,436	$ 1,266,109		$ 1,266,109	395.7	Wood	COM7	W1
397	Waikiki, Oahu	9640	WAIKIKI AQUARIUM	33,905		33,905	1955		1955	$ 4,833,951	143	$ 4,833,951	143	$ 7,459,100	220		0.00	220	1.00	$ 7,459,100	$ 1,491,820		$ 1,491,820	264.0	Masonry	COM8	RM1L
				671,658	589,644	1,025,649			DAGS Total	$ 133,204,076	RMO Total	$ 202,754,300	Calculated Total	$ 171,456,280	CRV Total	$ 210,861,674			Model Total	$ 308,359,210	$ 69,264,804	$ -	$ 69,264,804				

Honolulu Community College

Honolulu CC Building Inventory - Replacement Value Estimates

	Buildings ($)	Contents ($)	Total ($)
Total Inventory Replacement Costs:	$ 223,307,590	$ 73,153,802	$ 296,461,392

BNU	Location	Bldg No	Building Name	Total Building Area (Sq Ft)			Year of Construction			Replacement Values per State Dept. (DAGS) (2007 US$)		Replacement Values per Risk Management Office (RMO) (2007 US$)		Orig. Fill in Replacement Values (based on const. type and occupancy) (2008 US$)		CRV Values (2008 US$)		Accepted Model Values (based on judgment of values provided by all sources) (2008 US$)			Contents Replacement Value used in HAZUS Model (2008 US$)			Total Value (2008 US$)	Construction Type and Occupancy		
				DAGS and Facilities	CRV GSF	Modeled	DAGS and Facilities	CRV	Modeled	Building Replacement Value (DAGS)	Cost/sqft Replacement Value (DAGS)	Building Replacement Value (RMO)	Cost/sqft Replacement Value (RMO)	Estimated Replacement Cost (Fill-in)	Estimated cost/sqft (Fill-in)	CRV Cost	Calculated CRV Unit Cost	Unit Costs ($/sqft)	Island Adjustment Factor	Modeled Value ($)	General Contents Replacement Value	Special Contents Replacement Value (from Facilities)	Total Contents Replacement Value	Total Value/ sqft [(Buildiing $ + Contents $) / sf]	General Construction Type	Occupancy Class	Specific Structural Type
541	Honolulu	8827	HCC-CLASSROOM #2 (COSMOTOLOGY)	33,460	33,460	33,460	07/05/72	1972	1972	$ 6,926,000	207	$ 5,855,500	175	$ 10,038,000	300	10,038,000	300.0	300	1.00	$ 10,038,000	$ 1,505,700	$ 700,000	$ 2,205,700	365.9	Concrete	EDU2	C1L
526	Honolulu	8806	HCC-ADMINISTRATION BLDG	17,380	17,380	17,380	05/23/74	1974	1974	$ 3,198,000	184	$ 2,676,500	154	$ 5,214,000	300	5,214,000	300.0	300	1.00	$ 5,214,000	$ 1,042,800	$ 400,000	$ 1,442,800	383.0	Concrete	EDU1	C2L
522	Honolulu	8802	HCC-CAMPUS CENTER/CLASSROOM	81,636	81,636	81,636	02/23/79	1979	1979	$ 18,286,000	224	$ 15,061,600	184	$ 24,490,800	300	28,164,420	345.0	345	1.00	$ 28,164,420	$ 4,224,663	$ 5,500,000	$ 9,724,663	464.1	Concrete	EDU2	PC2M
527	Honolulu	8807	HCC-LIBRARY/CLASSROOM BLDG	103,272	103,272	103,272	12/20/73	1974	1973	$ 21,945,000	212	$ 19,053,800	185	$ 30,981,600	300	37,177,920	360.0	360	1.00	$ 37,177,920	$ 5,576,688	$ 3,000,000	$ 8,576,688	443.0	Concrete	EDU2	PC2M
525	Honolulu	8805	HCC-GENERAL CLASSROOM BLDG	32,409	32,409	32,409	01/01/63	1963	1963	$ 6,709,000	207	$ 5,671,600	175	$ 9,722,700	300	9,722,700	300.0	300	1.00	$ 9,722,700	$ 1,458,405	$ 400,000	$ 1,858,405	357.3	Concrete	EDU2	C2L
533	Honolulu	8814	HCC-INDUSTRIAL TRADE COMPLEX	81,838	81,838	81,838	10/05/76	1977	1976	$ 15,958,000	195	$ 11,130,000	136	$ 24,551,400	300	24,551,400	300.0	300	1.00	$ 24,551,400	$ 3,682,710	$ 5,000,000	$ 8,682,710	406.1	Concrete	EDU2	C3L
537	Honolulu	8820	HCC-ELECTRONICS SHOP	11,203	11,203	11,203	01/01/62	1962	1962	$ 2,185,000	195	$ 1,752,300	156	$ 3,360,900	300	3,360,900	300.0	300	1.00	$ 3,360,900	$ 504,135	$ 200,000	$ 704,135	362.9	Concrete	EDU2	C3L
540	Honolulu	8824	HCC-ELECTRICAL SHOP	6,964	6,964	6,964	01/01/66	1966	1966	$ 1,358,000	195	$ 1,072,500	154	$ 2,089,200	300	2,089,200	300.0	300	1.00	$ 2,089,200	$ 313,380	$ 200,000	$ 513,380	373.7	Concrete	EDU2	C3L
531	Honolulu	8812	HCC-PIPEFITTER SHOP (CARPENTRY)	5,912	5,912	5,912	01/01/51	1951	1951	$ 863,000	146	$ 697,600	118	$ 1,478,000	250	1,773,600	300.0	300	1.00	$ 1,773,600	$ 443,400	$ 200,000	$ 643,400	408.8	Steel	IND2	S1L
532	Honolulu	8813	HCC-MACHINE SHOP	5,901	5,901	5,901	01/01/51	1951	1951	$ 862,000	146	$ 696,300	118	$ 1,475,250	250	1,770,300	300.0	300	1.00	$ 1,770,300	$ 442,575	$ 400,000	$ 842,575	442.8	Steel	IND2	S1L
529	Honolulu	8810	HCC-AIR CONDITIONING PLANT	2,396	2,396	2,396	11/20/85	1947	1947	$ 192,000	80	$ 468,447	196	$ 527,120	220	419,300	175.0	175	1.00	$ 419,300	$ 104,825	$ 1,000,000	$ 1,104,825	636.1	Masonry	IND2	RM1L
543	Honolulu	8844A	HCC-STORAGE	146	146	146	01/01/66	1988	1966			$ 6,600	45	$ 32,120	220	25,550	175.0	175	1.00	$ 25,550	$ 6,388	$ 50,000	$ 56,388	561.2	Masonry	IND2	RM1L
546	Honolulu	8851	HCC-AQUATIC FACILITY	1,387	1,387	1,387	09/15/95	1995	1995	$ 287,000	207	$ 62,400	45	$ 305,140	220	242,725	175.0	175	1.00	$ 242,725	$ 36,409	$ 100,000	$ 136,409	273.3	Masonry	EDU2	RM1L
548	Honolulu	8852A	HCC-MECHANICAL BLDG	1,067	1,067	1,067	01/01/94	1995	1994			$ 48,000	45	$ 234,740	220	186,725	175.0	175	1.00	$ 186,725	$ 28,009	$ 50,000	$ 78,009	248.1	Masonry	EDU2	RM1L
549	Honolulu	8857	HCC-PACIFIC AEROSPACE TRAING CTR	105,000	105,000	105,000	01/01/01	1941	1941	$ 17,535,000	167	$ 105,000	1	$ 21,000,000	200	52,500,000	500.0	300	1.00	$ 31,500,000	$ 4,725,000	$ 600,000	$ 5,325,000	350.7	Steel	EDU2	S1L
542	Honolulu	8843	HCC-AUTOMOTIVE TECHNOLOGY	48,545	48,545	48,545	01/01/86	1986	1986	$ 9,466,000	195	$ 7,476,000	154	$ 14,563,500	300	14,563,500	300.0	300	1.00	$ 14,563,500	$ 3,640,875	$ 1,500,000	$ 5,140,875	405.9	Steel	IND2	S1L
544	Honolulu	8844	HCC-HEAVY EQMT MAINT/REPAIR	15,919	15,919	15,919	11/03/88	1988	1988	$ 6,731,000	423	$ 2,451,500	154	$ 4,775,700	300	4,775,700	300.0	300	1.00	$ 4,775,700	$ 1,193,925	$ 1,000,000	$ 2,193,925	437.8	Steel	IND2	S1L
547	Honolulu	8852	HCC-AIRPORT TRAINING CENTER	38,980	38,980	38,980	01/01/94	1995	1994	$ 8,290,000	213	$ 6,003,000	154	$ 11,694,000	300	11,694,000	300.0	300	1.00	$ 11,694,000	$ 1,754,100	$ 1,200,000	$ 2,954,100	375.8	Steel	EDU2	S1L
545	Honolulu	8850	HCC-MARINE EDUCATION & TRAINING CENTER	36,626	36,626	36,626	09/15/95	1995	1995	$ 7,142,000	195	$ 5,237,500	143	$ 10,987,800	300	10,987,800	300.0	300	1.00	$ 10,987,800	$ 1,648,170	$ 7,000,000	$ 8,648,170	536.1	Masonry	EDU2	RM1L
523	Honolulu	8803	HCC-AUTO BODY/MECHANIC BLDG (AUTOMOTIVE)	30,903	30,903	30,903	01/01/62	1962	1962	$ 4,512,000	146	$ 4,202,800	136	$ 9,270,900	300	9,270,900	300.0	300	1.00	$ 9,270,900	$ 2,317,725	$ 1,500,000	$ 3,817,725	423.5	Steel	IND2	S1L
524	Honolulu	8804	HCC-CAFETERIA/BAKERY BLDG	18,790	18,790	18,790	01/01/58	1958	1958	$ 2,612,000	139	$ 2,893,700	154	$ 4,697,500	250	5,637,000	300.0	300	1.00	$ 5,637,000	$ 1,409,250	$ 1,100,000	$ 2,509,250	433.5	Steel	IND3	S5L
534	Honolulu	8816	HCC-PRINTDUPLICATING SHOP (SHEET METAL)	6,449	6,449	6,449	01/01/51	1951	1951	$ 940,000	146	$ 761,000	118	$ 1,612,250	250	1,934,700	300.0	300	1.00	$ 1,934,700	$ 290,205	$ 1,800,000	$ 2,090,205	624.1	Steel	EDU2	S1L
535	Honolulu	8817	HCC-SHEETMETAL SHOP (WELDING)	6,264	6,264	6,264	01/01/51	1964	1951	$ 915,000	146	$ 762,488	122	$ 1,568,000	250	1,879,200	300.0	300	1.00	$ 1,879,200	$ 469,800	$ 500,000	$ 969,800	454.8	Steel	IND2	S1L
536	Honolulu	8818	HCC-OPERATIONS MAINTENANCE (REFRIGERATION)	6,493	6,493	6,493	01/01/74	1947	1947	$ 396,000	61	$ 766,200	118	$ 1,623,250	250	1,947,900	300.0	300	1.00	$ 1,947,900	$ 486,975	$ 1,000,000	$ 1,486,975	529.0	Steel	IND2	S5L
530	Honolulu	8811A	HCC-CHILDCARE #1	3,505	3,505	3,505	01/16/70	1969	1969	$ 347,000	99	$ 357,500	102	$ 630,900	180	613,375	175.0	175	1.00	$ 613,375	$ 122,675	$ 300,000	$ 422,675	295.6	Wood	COM3	W1
551	Honolulu	8871A	ETC-HCC CLASSRM/OFFICE A	1,834	1,834	1,834	02/25/77	1969	1969	$ 177,000	97	$ 201,700	110	$ 330,120	180	320,950	175.0	175	1.00	$ 320,950	$ 48,143	$ 90,000	$ 138,143	250.3	Wood	EDU2	W1
552	Honolulu	8871B	ETC-HCC CLASSRM/OFFICE B	1,784	1,784	1,784	02/25/77	1969	1969	$ 172,000	96	$ 196,200	110	$ 321,120	180	312,200	175.0	175	1.00	$ 312,200	$ 46,830	$ 90,000	$ 136,830	251.7	Wood	EDU2	W1
553	Honolulu	8871C	ETC-HCC CLASSRM/OFFICE C	1,742	1,742	1,742	02/25/77	1969	1969	$ 300,000	172	$ 191,600	110	$ 313,560	180	304,850	175.0	175	1.00	$ 304,850	$ 45,728	$ 90,000	$ 135,728	252.9	Wood	EDU2	W1
554	Honolulu	8871D	ETC-HCC CLASSRM/OFFICE D	3,035	3,035	3,035	02/25/77	1990	1977	$ 182,000	60	$ 333,800	110	$ 546,300	180	531,125	175.0	175	1.00	$ 531,125	$ 79,669	$ 90,000	$ 169,669	230.9	Wood	EDU2	W1
		8828	HCC PALAMA STATION		5,200	5,200		1930	1930							1,794,000	345.0	345	1.00	$ 1,794,000	$ 269,100		$ 269,100		Masonry	EDU2	RM1L
528	Honolulu	8808	HCC-OFFICE/STORAGE OPS MAINT	2,878	2,878	2,878	01/01/47	1995	1947	$ 420,000	146	$ 207,200	72	$ 633,160	220	503,650	175.0	175	1.00	$ 503,650	$ 75,548	$ 100,000	$ 175,548	236.0	Wood	EDU2	W2
				713,718	718,918	718,918				$ 138,906,000	RMO Total	$ 96,400,336	Calculated Total	$ 199,067,030	CRV Total	$ 244,307,590			Model Total	$ 223,307,590	$ 37,993,802	$ 35,160,000	$ 73,153,802				

Kapiolani Community College

Kapiolani CC Building Inventory - Replacement Value Estimates

	Buildings ($)	Contents ($)	Total ($)
Total Inventory Replacement Costs:	$ 120,040,605	$ 18,056,508	$ 138,097,113

BNU	Location	Bldg No	Building Name	Total Building Area (Sq Ft)			Year of Construction			Replacement Values per State Dept. (DAGS) (2007 US$)		Replacement Values per Risk Management Office (RMO) (2007 US$)		Org. Fill in Replacement Values (based on const. type and occupancy) (2008 US$)		CRV Values (2008 US$)		Accepted Model Values (based on judgment of values provided by all sources) (2008 US$)			Contents Replacement Value used in HAZUS Model (2008 US$)			Total Value (2008 US$)	Construction Type and Occupancy		
				DAGS and Facilities	CRV GSF	Modeled	DAGS and Facilities	CRV	Modeled	Building Replacement Value (DAGS)	Cost/sqft Replacement Value (DAGS)	Building Replacement Value (RMO)	Cost/sqft Replacement Value (RMO)	Estimated Replacement Cost (Fill-in)	Estimated cost/sqft (Fill-in)	CRV Cost	Calculated CRV Unit Cost	Unit Costs ($/sqft)	Island Adjustment Factor	Modeled Value ($)	General Contents Replacement Value	Special Contents Replacement Value (from Facilities)	Total Contents Replacement Value	Total Value/ sqft [(Building $ + Contents $) / sf]	General Construction Type	Occupancy Class	Specific Structural Type
565	Kaimuki	6922A	KCC-KOA (ART) A	3,764	3764	3,764	11/03/88	1986	1986	$ 952,041	253	$ 692,600	184	$ 1,129,200	300	658,700	175.0	300	1.00	$ 1,129,200	$ 169,380	$ -	$ 169,380	345.0	Masonry	EDU2	RM1L
579	Kaimuki	6936	KCC-ALANI (CHILD CARE)	5,102	5102	5,102	10/03/97	1992	1992	$ 1,023,000	201	$ 647,954	127	$ 1,530,600	300	1,530,600	300.0	300	1.00	$ 1,530,600	$ 229,590	$ -	$ 229,590	345.0	Masonry	EDU2	RM1L
580	Kaimuki	6937	KCC-MANELE (COMMUNITY SVC)	5,256	5256	5,256	10/10/97	1992	1992	$ 1,088,000	207	$ 1,328,043	253	$ 1,576,800	300	1,576,800	300.0	300	1.00	$ 1,576,800	$ 236,520	$ -	$ 236,520	345.0	Masonry	EDU2	RM1L
581	Kaimuki	6938	KCC-MANONO (COMMUNITY SVC)	6,787	6787	6,787	10/10/97	1992	1992	$ 1,405,000	207	$ 1,045,200	154	$ 2,036,100	300	2,036,100	300.0	300	1.00	$ 2,036,100	$ 305,415	$ -	$ 305,415	345.0	Masonry	EDU2	RM1L
564	Kaimuki	6921D	KCC-ILIAHI (MECHANICAL ROOM)	315	315	315	10/13/87	1986	1986	$ 72,229	229	$ 58,000	184	$ 94,500	300	55,125	175.0	175	1.00	$ 55,125	$ 8,269	$ -	$ 8,269	201.3	Masonry	EDU2	RM1L
584	Kaimuki	6939C	KCC-KOPIKO COMPLEX	571	571	571	10/15/97	1994	1994	$ 118,198	207	$ 105,100	184	$ 171,300	300	99,925	175.0	175	1.00	$ 99,925	$ 14,989	$ -	$ 14,989	201.3	Masonry	EDU2	RM1L
558	Kaimuki	6919A	KCC-KAUILA (ALLIED HEALTH) A	18,577	18577	18,577	05/04/88	1984	1984	$ 3,811,177	205	$ 3,352,000	180	$ 5,573,100	300	5,573,100	300.0	300	1.00	$ 5,573,100	$ 835,965	$ -	$ 835,965	345.0	Masonry	EDU2	RM1L
559	Kaimuki	6919B	KCC-KAUILA (ALLIED HEALTH) B	21,573	21573	21,573	05/04/88	1984	1984	$ 4,425,823	205	$ 3,969,400	184	$ 6,471,900	300	6,471,900	300.0	300	1.00	$ 6,471,900	$ 970,785	$ -	$ 970,785	345.0	Masonry	EDU2	RM1L
561	Kaimuki	6921A	KCC-ILIAHI (CLASSROOMS) A	15,711	15711	15,711	10/13/87	1986	1986	$ 3,599,991	229	$ 2,890,800	184	$ 4,713,300	300	4,713,300	300.0	300	1.00	$ 4,713,300	$ 706,995	$ -	$ 706,995	345.0	Masonry	EDU2	RM1L
562	Kaimuki	6921B	KCC-ILIAHI (CLASSROOMS) B	6,081	6081	6,081	10/13/87	1986	1986	$ 1,393,521	229	$ 1,119,000	184	$ 1,824,300	300	1,824,300	300.0	300	1.00	$ 1,824,300	$ 273,645	$ -	$ 273,645	345.0	Masonry	EDU2	RM1L
563	Kaimuki	6921C	KCC-ILIAHI (CLASSROOMS) C	13,072	13072	13,072	10/13/87	1986	1986	$ 2,995,260	229	$ 2,405,200	184	$ 3,921,600	300	3,921,600	300.0	300	1.00	$ 3,921,600	$ 588,240	$ -	$ 588,240	345.0	Masonry	EDU2	RM1L
566	Kaimuki	6922B	KCC-KOA (ART) B	13,197	13197	13,197	11/03/88	1986	1986	$ 3,337,959	253	$ 2,428,200	184	$ 3,959,100	300	3,959,100	300.0	300	1.00	$ 3,959,100	$ 593,865	$ -	$ 593,865	345.0	Masonry	EDU2	RM1L
567	Kaimuki	6927A	KCC-ILIMA (ADMINISTRATION) A	8,443	8443	8,443	10/03/97	1988	1988	$ 3,886,000	460	$ 1,443,800	171	$ 2,532,900	300	2,532,900	300.0	300	1.00	$ 2,532,900	$ 379,935	$ -	$ 379,935	345.0	Masonry	EDU2	RM1L
568	Kaimuki	6927B	KCC-ILIMA (ADMINISTRATION) B	6,306	6306	6,306	10/03/97	1988	1988	$ 1,349,802	214	$ 1,078,300	171	$ 1,891,800	300	1,891,800	300.0	300	1.00	$ 1,891,800	$ 283,770	$ -	$ 283,770	345.0	Masonry	EDU2	RM1L
569	Kaimuki	6927C	KCC-ILIMA (ADMINISTRATION) C	6,373	6373	6,373	10/03/97	1988	1988	$ 1,364,198	214	$ 1,089,800	171	$ 1,911,900	300	1,911,900	300.0	300	1.00	$ 1,911,900	$ 286,785	$ -	$ 286,785	345.0	Masonry	EDU2	RM1L
570	Kaimuki	6928	KCC-OHIA (CAMPUS CENTER)	38,579	38579	38,579	07/10/86	1990	1986	$ 8,642,000	224	$ 7,600,411	197	$ 11,573,700	300	11,573,700	300.0	300	1.00	$ 11,573,700	$ 1,736,055	$ -	$ 1,736,055	345.0	Masonry	EDU2	RM1L
571	Kaimuki	6929	KCC-NAIO (MEDIA CENTER)	19,235	19235	19,235	10/03/97	1990	1990	$ 3,982,000	207	$ 3,876,257	202	$ 5,770,500	300	5,770,500	300.0	300	1.00	$ 5,770,500	$ 865,575	$ -	$ 865,575	345.0	Masonry	EDU2	RM1L
572	Kaimuki	6930	KCC-OHELO (FINE DINING)	32,904	32904	32,904	10/03/97	1990	1990	$ 7,370,000	224	$ 7,524,497	229	$ 9,871,200	300	9,871,200	300.0	300	1.00	$ 9,871,200	$ 1,480,680	$ -	$ 1,480,680	345.0	Masonry	EDU2	RM1L
576	Kaimuki	6932	KCC-KALIA	16,852	16852	16,852	10/14/97	1991	1991	$ 3,488,000	207	$ 3,900,935	231	$ 5,055,600	300	5,055,600	300.0	300	1.00	$ 5,055,600	$ 758,340	$ -	$ 758,340	345.0	Masonry	EDU2	RM1L
577	Kaimuki	6934	KCC-OLONA	14,934	14934	14,934	10/14/97	1991	1991	$ 3,091,000	207	$ 3,565,969	239	$ 4,480,200	300	4,480,200	300.0	300	1.00	$ 4,480,200	$ 672,030	$ -	$ 672,030	345.0	Masonry	EDU2	RM1L
582	Kaimuki	6939A	KCC-KOPIKO (NURSING) A	24,622	24622	24,622	10/15/97	1994	1994	$ 5,096,807	207	$ 4,530,400	184	$ 7,386,600	300	7,386,600	300.0	300	1.00	$ 7,386,600	$ 1,107,990	$ -	$ 1,107,990	345.0	Masonry	EDU2	RM1L
583	Kaimuki	6939B	KCC-KOPIKO (NURSING) B	13,338	13338	13,338	10/15/97	1994	1994	$ 2,760,995	207	$ 2,454,200	184	$ 4,001,400	300	4,001,400	300.0	300	1.00	$ 4,001,400	$ 600,210	$ -	$ 600,210	345.0	Masonry	EDU2	RM1L
585	Kaimuki	6940	KCC-OLAPA (HOTEL OPERATIONS)	23,840	23840	23,840	10/15/97	1993	1993	$ 4,934,000	207	$ 6,250,934	262	$ 7,152,000	300	7,152,000	300.0	300	1.00	$ 7,152,000	$ 1,072,800	$ -	$ 1,072,800	345.0	Masonry	EDU2	RM1L
578	Kaimuki	6935	KCC-LAMA (LIBRARY)	49,412	49412	49,412	10/06/97	1991	1991	$ 1,112,000	23	$ 9,684,800	196	$ 14,823,600	300	15,564,780	315.0	315	1.00	$ 15,564,780	$ 2,334,717	$ -	$ 2,334,717	362.3	Masonry	EDU2	RM1L
560	Kaimuki	6920	KCC-KOKO (SCIENCE)	19,395	19395	19,395	05/04/88	1984	1984	$ 4,752,000	245	$ 3,568,700	184	$ 5,818,500	300	5,818,500	300.0	300	1.00	$ 5,818,500	$ 872,775	$ -	$ 872,775	345.0	Masonry	EDU2	RM1L
573	Kaimuki	6931	KCC-OLOPUA (MAINTENANCE)	5,400	5400	5,400	10/06/97	1991	1991	$ 1,118,000	207	$ 637,200	118	$ 1,350,000	250	1,620,000	300.0	200	1.00	$ 1,080,000	$ 162,000	$ -	$ 162,000	230.0	Masonry	EDU2	RM1L
574	Kaimuki	6931A	KCC-GREENHOUSE	1,386	1386	1,386	10/01/91	1991	1991			$ 27,700	20	$ 277,200	200	242,550	175.0	175	1.00	$ 242,550	$ 48,510	$ -	$ 48,510	210.0	Steel	AGR1	S1L
575	Kaimuki	6931B	KCC-STORAGE	131	131	131	10/01/91	1991	1991			$ 5,900	45	$ 26,200	200	22,925	175.0	175	1.00	$ 22,925	$ 3,439	$ -	$ 3,439	201.3	Masonry	EDU2	RM1L
555	Kaimuki	6916	KCC-MAILE (DRAMA STUDIO)	4,352	4352	4,352	10/13/97	1983	1983	$ 901,000	207	$ 639,700	147	$ 957,440	220	761,600	175.0	175	1.00	$ 761,600	$ 114,240	$ -	$ 114,240	201.3	Wood	EDU2	W2
586	Kaimuki	6946	KCC-CHAPEL	3,829	3829	3,829	10/07/97	1925	1925	$ 593,000	155	$ 398,700	104	$ 842,380	220	770,586	201.3	200	1.00	$ 765,800	$ 153,160	$ -	$ 153,160	240.0	Wood	RE1	W2
557	Kaimuki	6918	KCC-MOKIHANA (CLASSROOMS)	3,488	3488	3,488	10/13/97	1983	1983	$ 722,000	207	$ 550,400	158	$ 767,360	220	1,046,400	300.0	175	1.00	$ 610,400	$ 91,560	$ -	$ 91,560	201.3	Wood	EDU2	W2
556	Kaimuki	6917	KCC-MAMANE (COMPUTER CTR)	3,744	3744	3,744	10/13/97	1983	1983	$ 775,000	207	$ 512,700	137	$ 823,680	220	1,872,000	500.0	175	1.00	$ 655,200	$ 98,280	$ -	$ 98,280	201.3	Wood	EDU2	W2
				406,569	406,569	406,569				$ 80,160,000	RMO Total	$ 79,382,800	Calculated Total	$ 120,315,960	CRV Total	$ 121,767,691			Model Total	$ 120,040,605	$ 18,056,508	$ -	$ 18,056,508				

Leeward Community College

Leeward CC Building Inventory - Replacement Value Estimates

	Buildings ($)	Contents ($)	Total ($)
Total Inventory Replacement Costs:	$ 129,443,370	$ 22,646,661	$ 152,090,031

BNU	Location	Bldg No	Building Name	Total Building Area (Sq Ft)			Year of Construction			Replacement Values per State Dept. (DAGS) (2007 US$)		Replacement Values per Risk Management Office (RMO) (2007 US$)		Org. Fill in Replacement Values (based on const. type and occupancy) (2008 US$)		CRV Values (2008 US$)		Accepted Model Values (based on judgment of values provided by all sources) (2008 US$)			Contents Replacement Value used in HAZUS Model (2008 US$)			Total Value (2008 US$)	Construction Type and Occupancy		
				DAGS and Facilities	CRV GSF	Modeled	DAGS and Facilities	CRV	Modeled	Building Replacement Value (DAGS)	Cost/sqft Replacement Value (DAGS)	Building Replacement Value (RMO)	Cost/sqft Replacement Value (RMO)	Estimated Replacement Cost (Fill-in)	Estimated cost/sqft (Fill-in)	CRV Cost	Calculated CRV Unit Cost	Unit Costs ($/sqft)	Island Adjustment Factor	Modeled Value ($)	General Contents Replacement Value	Special Contents Replacement Value (from Facilities)	Total Contents Replacement Value	Total Value/ sqft [(Buildiing $ + Contents $) / sf]	General Construction Type	Occupancy Class	Specific Structural Type
588	Pearl City	7876	LCC-ADMINISTRATION (B)	19,523	19523	19,523	06/15/70	1970	1970	3,592,000	184	2,694,200	138	$ 5,856,900	300	5,856,900	300.0	300	1.00	$ 5,856,900	$ 878,535	$ -	$ 878,535	345.0	Concrete	EDU2	C1L
589	Pearl City	7877	LCC-PHYSICAL-SCIENCES (C-1)	23,708	23708	23,708	01/01/68	1968	1968	5,808,000	245	4,148,900	175	$ 7,112,400	300	7,112,400	300.0	300	1.00	$ 7,112,400	$ 1,066,860	$ -	$ 1,066,860	345.0	Concrete	EDU2	C1L
591	Pearl City	7879	LCC-MATH-SCIENCES (C-3)	20,106	20106	20,106	04/20/78	1977	1977	4,926,000	245	3,518,500	175	$ 6,031,800	300	6,031,800	300.0	300	1.00	$ 6,031,800	$ 904,770	$ -	$ 904,770	345.0	Concrete	EDU2	C1L
592	Pearl City	7880	LCC-GENERAL TECHNOLOGY (D-1)	23,472	23472	23,472	02/18/71	1971	1971	4,577,000	195	4,107,600	175	$ 7,041,600	300	7,041,600	300.0	300	1.00	$ 7,041,600	$ 1,056,240	$ -	$ 1,056,240	345.0	Concrete	EDU2	C1L
590	Pearl City	7878	LCC-BIOLOGICAL SCIENCES (C-2)	23,701	23701	23,701	01/01/68	1968	1968	5,807,000	245	4,147,700	175	$ 7,110,300	300	11,850,500	500.0	500	1.00	$ 11,850,500	$ 2,962,625	$ -	$ 2,962,625	625.0	Concrete	EDU2	C1L
593	Pearl City	7881	LCC-DRAFTING TECHNOLOGY (D-2)	27,651	27651	27,651	02/18/71	1971	1971	5,392,000	195	4,276,000	155	$ 8,295,300	300	8,295,300	300.0	300	1.00	$ 8,295,300	$ 1,244,295	$ -	$ 1,244,295	345.0	Concrete	EDU2	C2L
594	Pearl City	7882	LCC-STUDENT CENTER BLDG (E)	43,323	43323	43,323	10/31/72	1973	1972	10,571,000	244	5,686,600	131	$ 12,996,900	300	12,996,900	300.0	300	1.00	$ 12,996,900	$ 1,949,535	$ -	$ 1,949,535	345.0	Concrete	EDU2	C2L
595	Pearl City	7883	LCC-ARTS & MUSIC BLDG (F-1)	14,591	14591	14,591	05/18/72	1972	1972	3,283,000	225	2,553,400	175	$ 4,377,300	300	4,377,300	300.0	300	1.00	$ 4,377,300	$ 656,595	$ -	$ 656,595	345.0	Concrete	EDU2	C2L
596	Pearl City	7884	LCC-FINE ARTS BLDG (F-2)	23,815	23815	23,815	12/20/73	1974	1973	5,358,000	225	4,167,600	175	$ 7,144,500	300	7,144,500	300.0	300	1.00	$ 7,144,500	$ 1,071,675	$ -	$ 1,071,675	345.0	Concrete	EDU2	C2L
597	Pearl City	7885	LCC-THEATER (F-3)	53,557	53557	53,557	02/13/75	1974	1974	14,139,000	264	9,589,400	179	$ 16,067,100	300	16,067,100	300.0	300	1.00	$ 16,067,100	$ 3,213,420	$ -	$ 3,213,420	360.0	Concrete	COM9	C2L
598	Pearl City	7886	LCC-BUSINESS EDUCATION (G)	23,564	23564	23,564	05/02/72	1972	1972	4,878,000	207	4,123,700	175	$ 7,069,200	300	7,069,200	300.0	300	1.00	$ 7,069,200	$ 1,060,380	$ -	$ 1,060,380	345.0	Concrete	EDU2	C2L
600	Pearl City	7889	LCC-LANGUAGE ARTS (J-1)	27,747	27747	27,747	05/18/72	1972	1972	5,744,000	207	4,855,700	175	$ 8,324,100	300	8,324,100	300.0	300	1.00	$ 8,324,100	$ 1,248,615	$ -	$ 1,248,615	345.0	Concrete	EDU2	C2L
599	Pearl City	7887	LCC-BUS SHELTER	444	444	444	04/07/77	1976	1976	33,000	74	19,760	45	$ 97,680	220	77,700	175.0	175	1.00	$ 77,700	$ 11,655	$ -	$ 11,655	201.3	Masonry	EDU2	RM1L
606	Pearl City	7895	LCC-ELECTRIC POWER VAULT	560	560	560	05/04/88	1974	1974	42,000	75	25,200	45	$ 123,200	220	98,000	175.0	175	1.00	$ 98,000	$ 24,500	$ -	$ 24,500	218.8	Masonry	IND2	RM1L
611	Pearl City	7899B	LCC-OBSERVATORY 2	523	600	600	10/26/98	1998	1998	117,000	224	35,280	67	$ 115,060	220	105,000	175.0	175	1.00	$ 105,000	$ 15,750	$ -	$ 15,750	201.3	Masonry	EDU2	RM1L
601	Pearl City	7890	LCC-AUTOMOTIVE SHOP	41,065	41065	41,065	11/21/79	1979	1979	8,008,000	195	5,584,800	136	$ 9,034,300	220	12,319,500	300.0	300	1.00	$ 12,319,500	$ 3,079,875	$ -	$ 3,079,875	375.0	Masonry	IND5	RM1L
587	Pearl City	7875	LCC-LIBRARY	40,663	40663	40,663	12/22/70	1970	1970	8,865,000	218	6,058,800	149	$ 8,945,860	220	12,808,845	315.0	315	1.00	$ 12,808,845	$ 1,921,327	$ -	$ 1,921,327	362.3	Masonry	EDU2	RM1L
610	Pearl City	7899A	LCC-OBSERVATORY1	80	144	144	05/13/98	2001	1998	18,000	225	7,100	89	$ 17,600	220	25,200	175.0	175	1.00	$ 25,200	$ 3,780	$ -	$ 3,780	201.3	Masonry	EDU2	RM1L
604	Pearl City	7894A	LCC-MAINT & OPERATIONS FACILIT A	3,600	3600	3,600	05/29/75	1975	1975	205,000	57	489,600	136	$ 792,000	220	630,000	175.0	175	1.00	$ 630,000	$ 94,500	$ -	$ 94,500	201.3	Masonry	EDU2	RM2L
602	Pearl City	7891A	LCC-RELOCATABLE-MENS SHOWER	373	373	373	01/01/69	1969	1969	37,000	99	32,800	88	$ 82,060	220	65,275	175.0	175	1.00	$ 65,275	$ 9,791	$ -	$ 9,791	201.3	Wood	EDU2	W2
603	Pearl City	7891B	LCC-RELOCATABLE-WOMENS SHOWER	373	373	373	01/01/69	1969	1969	37,000	99	32,800	88	$ 82,060	220	65,275	175.0	175	1.00	$ 65,275	$ 9,791	$ -	$ 9,791	201.3	Wood	EDU2	W2
605	Pearl City	7894B	LCC-MAINT & OPERATIONS FACILIT B	717	717	717	05/29/75	1975	1975	44,000	61	32,300	45	$ 157,740	220	125,475	175.0	175	1.00	$ 125,475	$ 18,821	$ -	$ 18,821	201.3	Masonry	EDU2	RM2L
607	Pearl City	7896	LCC-OCET PORTABLE (ADMIN)	1,820	1820	1,820	01/01/99	1999	1999	180,000	99	-	0	$ 400,400	220	318,500	175.0	175	1.00	$ 318,500	$ 47,775	$ -	$ 47,775	201.3	Wood	EDU2	W2
608	Pearl City	7897	LCC-OCET PORTABLE (CR) 1	1,820	1820	1,820	01/01/99	1998	1998	180,000	99	-	0	$ 400,400	220	318,500	175.0	175	1.00	$ 318,500	$ 47,775	$ -	$ 47,775	201.3	Wood	EDU2	W2
609	Pearl City	7898	LCC-OCET PORTABLE (CR) 2	1,820	1820	1,820	01/01/99	1998	1998	180,000	99	-	0	$ 400,400	220	318,500	175.0	175	1.00	$ 318,500	$ 47,775	$ -	$ 47,775	201.3	Wood	EDU2	W2
				418,616	418,757	418,757				$ 92,021,000	RMO Total	$ 66,187,740	Calculated Total	$ 118,076,160	CRV Total	$ 129,443,370			Model Total	$ 129,443,370	$ 22,646,661	$ -	$ 22,646,661				

Windward Community College

Windward CC Building Inventory - Replacement Value Estimates

	Buildings ($)	Contents ($)	Total ($)
Total Inventory Replacement Costs:	$ 99,373,190	$ 17,092,101	$ 116,465,291

BNU	Location	Bldg No	Building Name	Total Building Area (Sq Ft)			Year of Construction			Replacement Values per State Dept. (DAGS) (2007 US$)		Replacement Values per Risk Management Office (RMO) (2007 US$)		Org. Fill in Replacement Values (based on const. type and occupancy) (2008 US$)		CRV Values (2008 US$)		Accepted Model Values (based on judgment of values provided by all sources) (2008 US$)			Contents Replacement Value used in HAZUS Model (2008 US$)			Total Value (2008 US$)	Construction Type and Occupancy		
				DAGS and Facilities	CRV GSF	Modeled	DAGS and Facilities	CRV	Modeled	Building Replacement Value (DAGS)	Cost/sqft Replacement Value (DAGS)	Building Replacement Value (RMO)	Cost/sqft Replacement Value (RMO)	Estimated Replacement Cost (Fill-in)	Estimated cost/sqft (Fill-in)	CRV Cost	Calculated CRV Unit Cost	Unit Costs ($/sqft)	Island Adjustment Factor	Modeled Value ($)	General Contents Replacement Value	Special Contents Replacement Value (from Facilities)	Total Contents Replacement Value	Total Value/ sqft [(Buildiing $ + Contents $) / sf]	General Construction Type	Occupancy Class	Specific Structural Type
710	Kaneohe	5979	WCC-MAHI BLDG	8,062	8062	8,062	06/26/73	1930	1930	1,532,000	190	145,425	18	$ 2,418,600	300	2,781,390	345.0	300	1.00	$ 2,418,600	$ 362,790		$ 362,790	345.0	Concrete	EDU2	C2L
711	Kaneohe	5980	WCC-JUDD BLDG	7,694	7694	7,694	06/26/73	1930	1930	1,462,000	190	234,695	31	$ 2,308,200	300	2,654,430	345.0	300	1.00	$ 2,308,200	$ 346,230		$ 346,230	345.0	Concrete	EDU2	C2L
712	Kaneohe	5981	WCC-IOLANI BLDG	16,113	16113	16,113	11/03/76	1930	1930	3,061,000	190	379,611	24	$ 4,833,900	300	5,558,985	345.0	300	1.00	$ 4,833,900	$ 725,085		$ 725,085	345.0	Concrete	EDU2	C2L
713	Kaneohe	5982	WCC-ECKERDT BLDG	34,333	34333	34,333	11/03/76	1930	1930	6,523,000	190	517,659	15	$ 10,299,900	300	11,844,885	345.0	300	1.00	$ 10,299,900	$ 1,544,985		$ 1,544,985	345.0	Concrete	EDU2	C2L
714	Kaneohe	5983	WCC-WAIPA BLDG	10,831	10831	10,831	01/04/77	1930	1930	2,058,000	190	411,355	38	$ 3,249,300	300	3,736,695	345.0	300	1.00	$ 3,249,300	$ 487,395		$ 487,395	345.0	Concrete	EDU2	C2L
719	Kaneohe	5987	WCC-HALE KUHINA (OCET)	11,295	11295	11,295	01/01/96	1930	1930	2,338,000	207	-	0	$ 3,388,500	300	3,896,775	345.0	300	1.00	$ 3,388,500	$ 508,275		$ 508,275	345.0	Concrete	EDU2	C2L
724	Kaneohe	5991	WCC-HALE PALANAKILA (HUMANITIES)	82,759	82759	82,759	01/01/01	2002	2001	15,713,000	190	-	0	$ 24,827,700	300	28,551,855	345.0	300	1.00	$ 24,827,700	$ 3,724,155		$ 3,724,155	345.0	Concrete	EDU2	C2L
726	Kaneohe	5993	WCC-HALE AWA	11,612	11612	11,612	01/02/70	1950	1950	2,404,000	207	-	0	$ 3,483,600	300	4,006,140	345.0	300	1.00	$ 3,483,600	$ 522,540		$ 522,540	345.0	Concrete	EDU2	C2L
708	Kaneohe	5977	WCC-KANALOA BLDG	8,031	8031	8,031	06/26/73	1930	1930	1,526,000	190	219,085	27	$ 2,409,300	300	2,909,230	362.3	315	1.00	$ 2,529,765	$ 379,465		$ 379,465	362.3	Concrete	EDU2	C2L
720	Kaneohe	5988	WCC-HALE IMILOA (NATURAL SCIENCE)	32,359	32359	32,359	01/01/97	1997	1997	6,698,000	207	-	0	$ 9,707,700	300	18,606,425	575.0	500	1.00	$ 16,179,500	$ 4,044,875		$ 4,044,875	625.0	Concrete	EDU2	C2L
722	Kaneohe	5989	WCC-HALE HOKULANI (PLANETARIUM)	4,438	4438	4,438	01/01/00	2001	2000	994,000	224	-	0	$ 1,331,400	300	2,551,850	575.0	500	1.00	$ 2,219,000	$ 554,750		$ 554,750	625.0	Concrete	EDU2	C2L
709	Kaneohe	5978	WCC-LONO BLDG	8,034		8,034	06/26/73		1973	1,526,000	190	233,056	29	$ 2,410,200	300		0.0	300	1.00	$ 2,410,200	$ 361,530		$ 361,530	345.0	Concrete	EDU2	C2L
717	Kaneohe	5986A	WCC-AGRICULTURE FACILITY	800	800	800	01/01/88	1996	1988	-	0	-	0	$ 176,000	220	161,000	201.3	175	1.00	$ 140,000	$ 21,000		$ 21,000	201.3	Masonry	EDU2	RM1L
721	Kaneohe	5988A	WCC-EQUIPMENT STORAGE	192	192	192	01/01/97	1997	1997	14,000	73	-	0	$ 42,240	220	38,640	201.3	175	1.00	$ 33,600	$ 5,040		$ 5,040	201.3	Masonry	EDU2	RM2L
		5994	WCC-Lanihuli Observatory	1,400	1400	1,400		2005	2005	-		-	0	$ 308,000	220	805,000	575.0	500	1.00	$ 700,000	$ 175,000		$ 175,000	625.0	Masonry	EDU2	RM2L
716	Kaneohe	5985	WCC-MAINTENANCE SHOP	7,332	7434	7,434	01/01/88	1988	1988	549,000	75	-	0	$ 2,199,600	300	2,564,730	345.0	300	1.00	$ 2,230,200	$ 557,550		$ 557,550	375.0	Steel	IND2	S1L
723	Kaneohe	5990	WCC-HALE AKOAKOA (CAMPUS CNTR)	55,052	55052	55,052	01/01/02	2002	2002	12,332,000	224	-	0	$ 16,515,600	300	18,992,940	345.0	300	1.00	$ 16,515,600	$ 2,477,340		$ 2,477,340	345.0	Steel	EDU2	S2L
718	Kaneohe	5986B	WCC-HALE ULUWEHI (GREEN HOUSE)	6,086	6086	6,086	01/01/88	1996	1988	310,000	51	-	0	$ 1,217,200	200	2,099,670	345.0	175	1.00	$ 1,065,050	$ 213,010		$ 213,010	210.0	Steel	AGR1	S3
725	Kaneohe	5992	WCC-WHITE HOUSE (HAWAIIAN STUDS.)	3,089	3089	3,089	01/01/70	1920	1920	494,000	160	-	0	$ 556,020	180	621,661	201.3	175	1.00	$ 540,575	$ 81,086		$ 81,086	201.3	Wood	EDU2	W1
				309,512	301,580	309,614				$ 59,534,000	RMO Total	$ 2,140,886	Calculated Total	$ 91,682,960	CRV Total	$ 112,382,301			Model Total	$ 99,373,190	$ 17,092,101	$ -	$ 17,092,101				



19. Mitigation Strategy and Implementation Actions

19. MITIGATION STRATEGY AND IMPLEMENTATION ACTIONS

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 Plan discussed mitigation strategy, goals and the planning process. It also described a benefit-cost analysis process and provides a list of prioritized proposed mitigation projects.	• The planning information was moved into the mitigation planning Chapter 2. • The status of the past prioritized list of mitigation projects from the 2012 plan is reported with most of these completed. • This chapter then focuses on the prioritized mitigation actions recommended moving forward as confirmed through an All Departmental workshop. • An updated list of proposed actions is included and categorized by type of mitigation activity and hazard. Since the individual mitigation actions proposed were developed in each hazard section previously, this chapter can be succinct in a compilation and prioritization of those projects. • A prioritized summary of all the projects is provided, ranked by public survey and workshops, the Honolulu Planning Advisory Committee of collaborating public and private sector stakeholders starting with the highest priority groups of projects and highest priority projects within each type of mitigation activity • Honolulu's Mitigation Goals and Objectives are revised and updated.

19.1 Status of Past Mitigation Projects from the 2012 Plan

The prioritized past project list from the 2012 Hazard Mitigation Plan is shown in Table 19-1; the status of these projects is provided as a record of progress. Their priority as evaluated in 2012 is also indicated. Of the 44 projects, 23 have been completed or are ongoing. Many of those ongoing projects are very long term and thus are continued. 16 of the projects were not initiated since the 2012 Plan. Five were superseded. 12 have been carried forward into the current mitigation plan. A few have not been included in the 2018 plan: an electronic Post-Disaster Technical Clearinghouse for researcher input and use was determined to be unnecessary since an alternative electronic disaster response collaborative system is already in place for emergency responders; incorporating Honolulu bridge data into HAZUS for earthquake damage modeling was determined to be a low priority given the lower hazard of ground shaking for Oahu; equipment-specific needs for firebreak and water storage in one particular area were consolidated into a more strategic generic description.

Table 19-1 Progress Summary of 2012 Plan Mitigation Projects for the City and County of Honolulu

	Project	Status	Lead Agencies	2012 Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
Policy	Natural hazard policies integration into the General Plan & Community Development Plans.	Coordination / Integration beginning in this plan update. See Chapter 3.	DEM / DPP	High	1	2	2
	DNLR recommended that Buffer Zones should be developed or at least incorporated into new developments between high-hazard rock fall areas and homes. This requires implementation into planning policy documentation and establishment of mapping to identify the hazard areas.	Requires technical development and feasibility study.	DPP	Medium-High	1	2	
	Incorporate all-hazard assessments in land development application process	Policies need to be developed.	DEM /DPP	Medium	1	2	2
	Consider adopting coastal erosion setbacks per historical rates and require disclosure of erosion rate during real estate transactions. Disclose Hazard Risks as Mandatory Seller Disclosures in Real Estate Transactions Act.	Policies need to be implemented per guidance in State Office of Planning report, *Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability To Coastal Hazards and Climate Impacts In the City and County of Honolulu*	DPP / DEM	Medium	1	2	2
	Conservation land setback rules to establish the setback line about 40 feet from the certified shoreline, plus 70 times the average annual coastal erosion rate.	**Completed**. Conservation Land Use Rules, Chapter 13-5 of the Hawaii Administrative Rules have established that for DLNR Conservation land, the previously suggested policy is now law.	DNLR	Medium	1	2	2
Infrastructure Facilities	Hardening of critical facilities, utilities, and port facilities.	Requires funding for study of inventory of non-building infrastructure facilities to prioritize the most vulnerability facilities.	DEM HIEMA	High	2	3, 4	9
	Establish further upgrades to the electrical transmission and distribution design standards to incorporate Hawaii specific topographical, directionality and exposure information for the design of above ground utility using effective wind speed maps consistent with the state building code.	Needs similar process as HRS 107 Part II State Building Code and Design Standards, but more efficient and not identical participants.	PUC	High	1	4	1
	Improve emergency communication reliability during disasters.	**Ongoing.** Coordinated through HIEMA.	HIEMA / SEC	High	5	3	11
	Improve resiliency of fuel supplies during disasters through the Disaster Preparedness through the Hawaii State Energy Council and the Hawaii Emergency Preparedness Executive Consortium.	**Ongoing.** Need to include specific structural evaluation of the containment walls at the fuel tank farms at Honolulu Harbor and vicinity, for tsunami inundation damage, per the USGS study, *Honolulu Port Analyses for the Hawaii Tsunami.*	DEM / HDOT	High	6	4	

Table 19-1 Progress Summary of 2012 Plan Mitigation Projects for the City and County of Honolulu

	Project	Status	Lead Agencies	2012 Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
	Update design and construction standards for utility lifelines.	Needs similar process as HRS 107 Part II State Building Code and Design Standards, but more efficient and not identical participants.	PUC	Medium	1	4	1
	Increase capacity from HECO generator plants.	**Ongoing** development of new technologies and additional capacity	PUC / HECO	Medium	6	4	5, 11
	Replace weathered wood poles with NESC-conforming poles.	Costs and funding sources need to be evaluated.	PUC / HECO	Medium	6	4	11
Building Facilities	Hazard Mitigation Retrofits of City of Honolulu Essential Facility Inventory. Honolulu County All-Hazard Assessment of Critical Facilities ranked the 80 most vulnerable facilities. Detailed evaluations of these selected buildings would result in designs ready for cost estimation and grant application, and more importantly, would identify specific mitigation measures to reduce vulnerabilities and improve expected building performance.	Funding required to do engineering studies, design retrofits and prepare construction documentation for retrofits of most vulnerable facilities.	DEM / DDC / HIEMA	High	2	2	9
	Hazard Mitigation Retrofits of the State Essential Facility Inventory on Oahu based on BCA. State of Hawaii Critical Facilities Risk Assessment has ranked most critical facilities. Detailed evaluations of these selected buildings to result in designs ready for cost estimation and grant application, and more importantly, will identify specific mitigation measures to reduce vulnerabilities and improve expected building performance.	Funding required to do engineering studies, design retrofits and prepare construction documentation for retrofits of most vulnerable facilities. [See ranked vulnerabilities – HNL and Honolulu Harbor, State and Leahi Hospitals]	HIEMA	High	2	2	9
	Adopt 2012 and 2018 IBC and related codes per HRS 107 Part II	**Ongoing. DPP to adopt IBC 2012 by 2019**.	DPP	Medium	1	2	1, 9
	Testing of the Seismic (and Wind Performance) of Single Wall Construction. Wind Cannon tests of single wall panels should also be included	Funding required	HIEMA	Medium	2	2	
Hurricane	Identify the types of buildings more suitable for self-sheltering: Perform a comprehensive screening evaluation of private sector candidate building types for possible hurricane refuge use and create a voluntary\certification system for private shelter refuges.	Requires estimated funding of $125,000 to develop screening, engineering analysis and certification guidelines.	DEM	High	5	5	8, 11
	Develop a Hawaii certification program for residential safe room assemblies.	**Completed.** Embodied in the State Building Code local amendment to the 2012 IBC, Section 425.5.4 Approved Debris Impact Resistant Wall Assemblies.	NOAA / CZM				

Table 19-1 Progress Summary of 2012 Plan Mitigation Projects for the City and County of Honolulu

	Project	Status	Lead Agencies	2012 Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
	Emergency shelter evaluation: All-Hazard Assessment of Hurricane Shelters. Retrofit public shelter buildings to increase capacity.	**Ongoing.** Requires annual funding of about $500,000 required to do engineering, design retrofits and prepare construction documentation for retrofits of most vulnerable facilities.	HIEMA	High	2	5	9
	Refine actual evacuation demand and update policies to decrease sheltering deficit.	**Ongoing.** DEM public policy has been updated to utilize shelters as a last resort for those in the coastal flood zone or in weaker homes, or those in ridge areas	DEM	High	2	5	9
	Incentives or rebates for homeowners and businesses to retrofit their structures.	Funding for program required from the state legislature.	DEM	Medium	2	2	
	Include topographic wind effects into the output of the Hurrevac model, to allow identification of the topographically-amplified wind speeds for any individually defined storm scenario. Estimated peak gust wind speeds would be calculated at each "zone" at representative sites selected for planning and emergency response purposes within Hurrevac/MMS.	**This work was completed**, however, subsequently the MMS module was discontinued by the USCOE and no longer exists. Therefore, topographic effects on windspeed are still not considered in emergency planning.	DEM	Medium	5	1	8
	Improve assessments of hurricane risks to communities: assemble a Honolulu building inventory database by acquiring the Honolulu tax assessor building stock data for classification and census block group aggregation into an Enhanced Data Hurricane Loss Estimation Model for Oahu using HAZUS MH. Benefits include explicit quantification of wind-hazard and its mitigation through the identification of the severity of wind risk for planners and emergency management.	**Completed**. In 2018, enhanced Honolulu Building Inventory updates included new site-specific building inventory, and additionally including site-specific essential City and State buildings and all the buildings in the University of Hawaii system on Oahu. This enhanced data was incorporated into the HAZUS model of PDC.	PDC	Medium	2	1	
	Develop post & pier/single wall hurricane retrofit guide and Expert Tool for internet application, similar to what was done for earthquake retrofits by the University of Hawaii.	**Completed.** A homeowner hurricane retrofit online guide was developed by DCCA.	DCCA	Medium	2	5	
	Establish a policy for strengthening of critical public facility enclosure integrity for wind and windborne debris	Policies would need to be developed.	DEM	Low	2	3	9
Earthquake	Update the HAZUS MH model to incorporate detailed data on State and County Bridges and determine seismic risk of collapse/outage.	Funding required	DEM	Medium	2	1	
	Update the MCE maps to MCE_R	**Completed** in the ASCE 7-10 Standard. USGS now working on an updated seismic hazard analysis of Hawaii.					
Ts un	Update tsunami evacuation maps.	**Completed.** "Extreme Tsunami Maps" have been completed as well.	DEM	High	3	1, 6	11, 12

Table 19-1 Progress Summary of 2012 Plan Mitigation Projects for the City and County of Honolulu

	Project	Status	Lead Agencies	2012 Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
	Preliminary engineering of tsunami and coastal flood mitigation retrofit of critical infrastructure.	Funding required for master planning engineering study.	DEM	High	2	4	2
	Identify and retrofit critical BWS pumping stations in the tsunami inundation zone.	**Ongoing**	BWS	High	2	4	2
	UHM SOEST to produce high-resolution tsunami hazard maps (runup) for building code design provisions.	**Ongoing**. NOAA funded project underway at the DBEDT Office of Planning 2018-2019.	DEM	Medium	1	2	2
	Adopt tsunami design provisions for buildings for new design and construction and for evaluating existing buildings.	**Ongoing. Adopted in the State Building Code** amending the 2012 IBC, SECTION 1615 TSUNAMI LOADS. **This section needs to be further refined for the Honolulu Building Code.**	DPP	Medium	1	2	2
Flooding	Adopt new DFIRM flood maps that are hurricane-based for south and west shores.	**Completed**.	DEM	Medium	3	1	2
	Develop rainfall and streamflow gauging system suitable to flood monitoring.	**Completed**. Embodied in Hydronet, AMBER, and StreamStats data systems	DEM / DBEDT	Medium	5	1	11
	Develop policies for repetitive loss structures.	Repetitive loss analysis completed	DNLR / DEM	Medium	1	2	3
	Establish additional flood and debris-flow warning systems on Oahu.	**Ongoing** enhancement of rainfall and streamflow gauging system.	DEM / DBEDT	Low	5	1	3
	Consider participating in the Community Rating System.	Participation currently being contemplated.	DNLR / DEM	Low	1	2	3
Drought and Wildfire	Update the Hawaii Rainfall Atlas	**Completed.**	DEM / UH / NOAA / NWS	Medium	3	1	
	Fire Break Maintenance - Various fuel breaks/fire roads throughout Oahu are maintained by DOFAW. These roads need to be maintained with heavy equipment to stop advancing fire, provide access to firefighters, and escape routes for the public.	Estimated $30,000 annually annual funding required.	DEM / DOFAW	Medium	5	8	7
	Waianae Mountain Fuel Reduction Bulldozer Equipment purchase.	Estimated $200,000 in funding required.	DEM / DOFAW	Medium	5	8	7
	Waianae Watershed Fire Protection – Four 1000-gallon water tanks for rainfall catchment and storage for fire suppression.	Estimated $12,000 in funding required.	DEM / DOFAW	Medium	5	8	7
Other	Waikiki Beach Sand Restoration to 1985 width (State Office of Conservation and Coastal Lands, DLNR).	**Completed**.	DNLR / DEM	Medium	4	8	

Table 19-1 Progress Summary of 2012 Plan Mitigation Projects for the City and County of Honolulu

	Project	Status	Lead Agencies	2012 Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
	Conduct public information preparedness workshops, especially regarding: *Hurricane Awareness, Hurricane Retrofits, Hurricanes, Tsunamis and Flooding.* Multi-government agency crisis exercise 2-3 times per year.	**Ongoing** follow up from survey responses.	DEM	High	3	6	12
	Establish an electronic Post-Disaster Technical Clearinghouse for researchers data	**No longer considered**; alternative all-hazard emergency management system used	DEM	Medium	5	1	
	Disaster preparedness education for immigrant minority groups on Oahu.	**Ongoing.** Programs developed in addition to the general public information workshops.	DEM	Low	3	6	12

19.2 Mitigation of Risk and Proposed Actions

Mitigation of risk involves selecting various approaches that, when applied to the risk area, will reduce its vulnerability. Various actions and policies to reduce vulnerability were compiled from stakeholder and public group input. A summary of 2018 ongoing and proposed future City and County of Honolulu mitigation actions are presented in Table 19-2. A description each action along with any status is given. The actions are categorized in the table as:

- Policy and Processes
    - Supporting efforts to this category include assessing hazards, vulnerability and risk; conducting planning, policies and practices and set priorities; educating decision-makers and building constituencies and political will.
- Infrastructure Facility projects that may apply to multiple hazards
- Building Facilities projects that may apply to multiple hazards
- Projects specific to each of the different hazards:
    - Climate Change Adaptation
    - Flooding
    - Tropical Cyclones and Hurricanes
    - Earthquake
    - Tsunami
    - Drought/Wildfire
    - Others

19.3 Mitigation Action Categories

Mitigation actions can also be grouped into six broad categories:

1. *Prevention:* Government administrative and regulatory actions or processes that influence the way land and buildings are developed and built (e.g., incorporation of hazards in planning and zoning, building codes, drainage standards).
2. *Property Protection:* Actions that involve the modification of existing structures to protect them from a hazard, or removal from the hazard area (e.g., retrofit of facilities, relocation, integrity of enclosure protection).
3. *Public Education and Outreach:* Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigate them (e.g., outreach projects, real estate disclosure, hazard information fairs, and education programs, loss mitigation incentives).
4. *Natural Resource Protection:* Actions that minimize hazard losses while also preserving or restoring the functions of natural systems (e.g., erosion control, stream restoration, watershed management, wetland restoration and preservation).
5. *Essential Services:* Actions that protect people and property during and immediately after a disaster or hazard event and hasten recovery (e.g., warning systems, emergency response services, protection of critical facilities and networks).
6. *Structural Projects:* Actions that involve the construction of structures or improvement of infrastructure to reduce the impact of a hazard (e.g., flood control).

The actions listed in Table 19-2 were broadly categorized into the different mitigation action categories listed above.

19.4 Mitigation Goals

Based on the All-Departmental Stakeholders Meetings of February 2019, the updated mitigation goals and objectives of this plan are to eliminate or reduce risk through the following:

1. **Continually strive to improve the state of the art for the identification of hazard areas, risk assessment capabilities, warning systems, and effective response and recovery.**

    1.1. Prepare GIS maps for all hazards with the best available information and formulate a strategy to maintain/upgrade the data.
    1.2. Improve applicability of modeling systems for hazard mapping, mitigation planning, and scenario training purposes.
    1.3. Improve flood prediction and field-monitoring systems.
    1.4. Establish a warning system that is cognizant of warning siren gaps that require supplemental field warning, which strives to fill those gaps based on population, that is routinely tested and maintained, and that educates the public on proper response.
    1.5. Establish a rigorous reporting system after each major event to document the extent and cause of damage, lessons learned, and actions required to improve hazard mitigation, preparedness, response, or recovery.

2. **Plan, design, and construct future development and retrofit existing structures within hazard areas to become resilient and minimize losses.**

    2.1. Update building codes to cost-effectively reduce vulnerability to high wind storms, tropical cyclones, earthquakes, floods, tsunamis, and climate change effects.
    2.2. Periodically review the effectiveness of current land-use-related plans, codes, and standards for appropriate future development within hazard areas, and amend them as necessary to account for climate change effects.
    2.3. Develop incentives, such as tax deductions and insurance discounts, to encourage retrofitting of existing structures to reduce susceptibility to high wind storms, tropical cyclone, earthquakes, and floods.

3. **Ensure that all emergency response critical facilities, communication systems, information technology data networks, and broadband internet connectivity remain operational during and after hazard events.**

    3.1. Harden essential emergency facilities and communication systems to withstand high wind storm, tropical cyclone, tsunamis, and earthquakes
    3.2. Ensure road access to essential facilities can remain clear, and no emergency facilities should be located in the 100-year flood-prone areas.

4. **Ensure that all lifeline and information technology infrastructures are able to withstand hazard events or have contingency plans to quickly recover after a disaster.**

    4.1. Harden airports and ports to enable post-disaster operations.

4.2. Improve major highway and roadways that have no alternate bypass to remain operable during 100-year floods, and avoid rockfalls/landslide closures.
4.3. Harden fuel storage facilities and ensure adequate distribution networks to critical facilities.
4.4. Reduce vulnerability of electrical systems to all hazards.
4.5. Develop water systems that resist damage to all hazards and make contingency plans for alternate water supply systems.

5. Develop public guidance for the need to shelter in residences that are strengthened as necessary and outside of areas that are subject to flooding, or in alternative resilient structures. Provide pre- and post-disaster emergency shelters to accommodate residents and visitors that are not able to shelter in place.

5.1. Identify and harden selected shelters to withstand tropical cyclones.
5.2. Establish a standardized due diligence procedure for qualifying buildings for private self-sheltering.

6. Develop a high level of awareness among the general public and businesses, particularly the visitor industry, that results in calm and efficient evacuations, self-sufficient survival skills, and willingness to abide by preventive or property protection requirements.

6.1. Develop a broad-based public information program that utilizes a diversity of communication media.
6.2. Develop special public information programs targeted to vulnerable populations.
6.3. Develop a community-based network that provides input into mitigation planning.
6.4 Educate businesses on business interruption planning.

7. Minimize post-disaster recovery disruption by developing systems for efficient clean-up, documentation of damage and injury, and processing of appropriate aid to rebuild businesses and the economy.

8. Protect natural and cultural resources that buffer hazard effects to the extent practicable.

19.5 The City and County of Honolulu General Plan Public Safety Objective

The Public Safety Objectives of the City General Plan is to protect the people of Oahu and their property against natural disasters and other emergencies, traffic and fire hazards, and unsafe conditions. This hazard mitigation plan needs to be consistent with these policies:

Policy 1: Keep up-to-date and enforce all City and County safety regulations.

Policy 2: Require all developments in areas subject to floods and tsunamis to be located and constructed in a manner that will not create any health or safety hazard.

Policy 3: Participate with State and Federal agencies in the funding and construction of flood-control projects.

Policy 4: Cooperate with State and Federal agencies to provide tsunami warning and protection for Oahu.

Policy 5: Cooperate with State and Federal agencies to provide protection from war, civil disruptions, and other major disturbances.

Policy 6: Reduce hazardous traffic conditions.

Policy 7: Provide adequate fire protection and effective fire prevention programs.

Policy 8: Provide adequate search and rescue and disaster response services.

Policy 9: Design safe and secure public buildings.

Policy 10: Provide adequate staff to supervise activities at public facilities.

Policy 11: Develop civil defense plans and programs to protect and promote public health, safety and welfare of the people.

Policy 12: Provide educational materials on civil defense preparedness, fire protection, traffic hazards and other unsafe conditions.

The applicable General Plan public safety objective policies are listed for each of the hazard mitigation projects in Table 19-2.
(*For some projects no specific policies are applicable, while other projects are only relatively loosely aligned with a policy. This is indicative of the need to update the General Plan policies to incorporate a wider range of hazards and mitigation activities and better align with current federal and state strategies. The policies specifically include certain hazards such as: floods, tsunamis, war, traffic incidences, and fire. However other hazards are only covered by more general policies.*)

19.6 Prioritization Criteria

Mitigation actions were selected for implementation based on community acceptance criteria referred to as the STAPLEE criteria (Social, Technical, Administrative, Political, Legal, Economic, and Environmental) before they were prioritized. The STAPLEE evaluation criteria analyze the appropriateness of alternative mitigation actions by considering the following questions, which generally address checking for conflicts with other community goals, technical merit, consideration of cost-benefit, consistency with state and local environmental regulations.

1. *Social*
   a) Will the proposed action adversely affect one segment of the population?
   b) Is the proposed action culturally sensitive?
2. *Technical*
   a) Is the proposed action technically feasible?
   b) Is the proposed action a long term solution or a short term "band-aid"?
   c) Are there secondary effects resulting from the proposed action?
3. *Administrative*
   a) Does the proposed action require additional training?
   b) Does the proposed action require ongoing maintenance?
4. *Political*
   a) Is the proposed action controversial?
   b) Does the proposed action require legislative approval?
   c) Does the proposed action affect multiple stakeholders and have they all had an opportunity to be involved?
5. *Legal*
   a) Does the County have jurisdiction to implement the proposed action?
   b) Are new laws required to implement the proposed action?
   c) Are liability risks involved with the proposed action?
6. *Economic*
   a) What are the costs involved to implement the action?
   b) Is the proposed action eligible for outside funding?
   c) Is the burden of the choice of funding borne by those who benefit?
   d) Is a more detailed cost-benefit analysis warranted?
7. *Environmental*
   a) Does the proposed action protect or restore the environment?
   b) Does the proposed action have potentially negative effects on the environment?
   c) Is and Environmental Assessment (EA) or Environmental Impact Statement (EIS) required?

The selected actions that passed the STAPLEE criteria were then prioritized in consideration of the following factors:

1. *Critical to public health or safety:* Actions that would significantly protect essential and critical facilities and services.

2. *Hazard severity:* Actions that mitigate severe hazards based on loss estimation analyses.
3. *Long-Term Effectiveness*: Actions that may be comprehensive and impactful towards achieving community resilience. How much beneficial impact will the action have for the community's resilience?
4. *Multi-objectives:* Actions that meet multiple objectives or address multiple hazards.
5. *Ease of implementation:* Actions that can be readily established; actions that generally have less cost and/or require less prolonged effort to achieve initial success. When should the action take place to become effective? Is it possible to implement in suitable timeframe within funding or other constraints.

The actions were prioritized as High, Medium or Low based on the priority-setting methodology described in Chapter 2. The resulting priorities are shown in Table 19-2.

Table 19-2 Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
Mitigation Policies and Processes	1	**Integrate natural hazard policies into the General Plan & Community Development Plans**	Coordination / Integration beginning in this plan update**.**	DEM / DPP	High	Prevention	1, 2, 6	2
	2	**Plan and determine how to execute public works to protect or defend existing critical facilities, infrastructure and utility services, supply chain, and vital economic assets at risk to climate change effects.**	Planning and preliminary engineering feasibility studies should proceed on the coastal defense options for: Honolulu Harbor and particularly Pier 1, Kewalo Basin-Kakaako, Honolulu International (HNL) Airport reef runway, Sand Island access, Ala Wai Canal flood control, and Waikiki	MAY / DDC	High	Structural Projects	2, 4	2, 11
	3	**Utilize an adaptive engineering approach to all current and future projects near the shoreline. Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly the Ala Wai Watershed Flood Control project.**	Policies need to be implemented per the ***Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability To Coastal Hazards and Climate Impacts In the City and County of Honolulu***	MAY	High	Prevention	2, 6	2
	4	**HRS 205A Certified Shoreline For planning purposes, include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years. ROH Chapter 23 Establish the setback line about 25 feet from the certified shoreline plus 50 times the average annual coastal erosion rate, or to a minimum of 40 feet. The local geology and soil conditions should be taken in to account.**		DPP / DEM / State	Medium-High	Prevention	2, 6	2
	5	**HRS Chapter 484 - Uniform Land Sales Practices Act:** Require specific disclosure of an explicitly defined list hazards during real estate transactions per revision of the Disclose Hazard Risks as Mandatory Seller Disclosures in Real Estate Transactions Act. **HRS Chapter 508D Mandatory Seller Disclosures in Real Estate Transactions**: Make mandatory seller disclosure apply to vacant lots as well.		State	Medium	Public Education	6	12
	6	**Develop strategic master plans for implementation of new resilient and sustainable designs for communities that may need to be rebuilt post-disaster. Update the Land Use Ordinance.**	Action introduced in the 2019 Resilient Oahu Strategy	CCSR/N DPTC	High	Prevention	2, 4, 7	2, 11

Table 19-2 Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
Climate Change Adaptation	**7**	**ROH Chapter 25 SMA: Amend the Special Management Area permit requirements to include consideration of climate change effects for major developments. Adopt coastal flooding maps that account for future climate change.** Amend the Special Management Area requirements to: 1) Create a Coastal Construction Control Zone to account for 50-years of erosion, climate change and 2 ft. of Relative Sea Level Rise, and 500-year flooding 2) For Major Permits within the Coastal Construction Control Zone, require that those effects on the functionality of the development and land use be mitigated.	Update City and County of Honolulu regulations to implement the recommendations selected from the State Office of Planning 2017 report titled: Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability to Coastal Hazards and Climate Impacts in the City and County of Honolulu.	DPP	Medium-High	Prevention	1, 2	1, 2
	8	**Produce regulatory (100-year and 500-year) coastal flooding maps that account for future climate change effects on storm intensities and sea level rise. (associated with high priority Action #10)**	Use Numerical Wave Run-up and Storm Surge Models to develop improved coastal flood zones with consideration of climate change effects for 100-year and 500-year mean return periods per the methodology as detailed in Probabilistic mapping of storm-induced coastal inundation for climate change adaptation (Li, N., et al., 2017).	City	Medium-High	Prevention	1, 2, 3, 4,	1, 2, 3,9,11, 12
	9	**Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities.** Re-evaluate storm water flood control practices that address requirements for storm runoff quantities for flood control for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs.	Update City and County of Honolulu regulations to implement the recommendations from the State Office of Planning 2017 report titled: Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability to Coastal Hazards and Climate Impacts in the City and County of Honolulu.	DPP	Medium	Prevention	1	2

Table 19-2 Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
Flooding	10	**Revise and update the Flood Hazard Area, ROH Chapter 21A to enable the use of the ASCE 24-14 Standard, Flood Resistant Design and Construction. For Critical and Essential Facilities, this standard would require 500-year flood elevations be used for design. Incorporate the requirements of the ASCE 24-14 Standard, and revise regulations to require explicit building design for climate change adaptation. Incorporate climate change effects on the storm-generating environment, per the methodology as detailed in *Probabilistic mapping of storm-induced coastal inundation for climate change adaptation* (Li, N., et al., 2017).**	Use Numerical Wave Run-up and Storm Surge Models to develop improved coastal flood zones with consideration of climate change effects for 100-year and 500-year mean return periods for the entire coastline	.MAY / DPP	High	Prevention	1, 2	2
	11	**Revise the Honolulu Electrical Code, ROH Chapter 17: For Essential and Critical Facilities, the Electrical Code should require placement of electrical transformers, switchgear, and emergency generators above the 500-year flood elevation, or alternatively, protected by dry floodproofing.**		MAY	High	Prevention	2	2
	12	**Re-evaluate critical inland and stream flooding DFIRMs to account for a) watershed details and the floodway, its extent of urbanization, and b) assess from a policy standpoint whether the frequency of flood overtopping in heavily developed areas is really acceptable.** Include rainfall intensification. Develop a drainage system plan for future conditions		DPP	Medium	Prevention	1	2
	13	**Participate in the NFIP Community Rating System to reduce flood losses and lower flood insurance premiums.**		DNLR / DEM	Medium	Prevention	2	1, 3
	14	**Develop Flood Maps that go beyond FEMA requirements and consider both rainfall and coastal surge flooding, concentrating on areas with critical infrastructure**		DPP	Medium-High	Prevention	1, 2, 3, 4	2
	15	**Plan for flood control public works for the defense of critical facilities and major economic assets. Harden critical facilities, utilities, power and communication networks, and port facilities.**		DDC	High	Structural Projects	2, 3, 4	2
	16	**Pursue the Ala Wai Watershed Flood Mitigation project with the US Army Corps of Engineers; include resilience, visual appeal, water quality, and infrastructure improvements; create a watershed district to coordinate infrastructure projects, resilience planning and regulations, watershed data collection, and community engagement.**		DDC	Medium-High	Structural Projects	2	2, 3
	17	**Install flood barriers at HPD facilities at areas with habitual flooding**		HPD	Low	Essential Services	2, 3	2

Table 19-2 Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
Infrastructure Facilities	18	**Evaluate risks and prioritize protective measures for existing infrastructure faciliites.**	Requires funding for study of inventory of non-building infrastructure facilities to prioritize the most vulnerability facilities and identify the appropriate measures for each condition.	DEM	High	Essential Services	3, 4	9
	19	**Relocate or locally defend/reinforce vital infrastructure such as roads in coastal eroding regions.** Improve the materials and construction practices of roadways for greater resiliency.	Public Works projects need to proceed	DDC	High	Property Protection	4	2, 5, 6
	20	**PUC should adopt the 2017 National Electric Safety Code for power transmission and distribution, to include an amendment with the ASCE topographic windspeed maps. The PUC should update the NESC requirements periodically. Strategically plan with HECO for a disaster-resilient network. Establish further upgrades to the electrical transmission and distribution design standards to incorporate Hawaii specific topographical, directionality and exposure information for the design of above ground utility using effective wind speed maps consistent with the state building code.**	In order to maintain technical standard requirements, a PUC process analogous to HRS 107 Part II State Building Code and Design Standards is needed, but more efficient. Needs to be periodically updated every 5 years.	PUC	Medium-High	Prevention	4	1
	21	**Update the design and construction standards of the City for utility lifelines to improve the disaster resilience of essential services.**	Needs similar process as HRS 107 Part II State Building Code and Design Standards, but more efficient and not identical participants.	PUC	Medium	Prevention	4	1
	22	**Increase resiliency of post-disaster power plant capacity and achieve greater redundancy/reliability of the supply network.**	**Ongoing** development of new technologies and additional capacity, such as solar and wind.	PUC / HECO	Medium	Structural Project	4	5, 11
	23	**Replace weathered wood poles with National Electric Safety Code conforming poles, upgrading them rather than replacing them with the same type as existing.**	Costs and funding sources need to be evaluated.	PUC	Medium	Structural Project	4	11
	24	**Improve the resiliency of fuel supplies during and after disasters through the Hawaii State Energy Council and the Hawaii Emergency Preparedness Executive Consortium**.	**Ongoing.** Need to include specific structural evaluation of the containment walls at the fuel tank farms at Honolulu Harbor and vicinity, for tsunami inundation damage, per the USGS study, *Honolulu Port Analyses for the Hawaii Tsunami.*	DEM	Medium-High	Essential Services	4	8

Table 19-2 Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
Building Facilities	25	**Rockfall buffer zones should be defined and incorporated into new developments between high-hazard rock fall areas and homes and critical facilities; this requires regulatory mapping.** This requires implementation into planning policy documentation and establishment of mapping to identify the hazard areas.	Requires technical development and feasibility study. Continue the process of rockfall mitigation projects along Class "A" slopes.	DPP	Medium	Prevention	1, 2	5, 11
	26	**ROH Chapter 16 Building-Code - Adopt 2012 and 2018 IBC and related codes per HRS 107 Part II. (Honolulu is presently using the 2006 IBC, which is obsolete by four editions of the national model code.)**	**Ongoing. DPP to adopt IBC 2012 by 2019.** **Need to adopt 2018 IBC thereafter by 2021.**	DPP	Medium-High	Prevention	2	1, 9
	27	**Test Seismic and Wind Performance to develop Single Wall Construction retrofit techniques.**	Funding required for wind cannon tests and single wall seismic and wind performance. **Post and pier seismic tests completed.**	HIEMA	Low	Property Protection	2	11
	28	**Start hazard mitigation retrofits for the protection of essential facilities.of the City of Honolulu**. Honolulu County All-Hazard Assessment of Critical Facilities ranked the 80 most vulnerable facilities. Detailed evaluations of these selected buildings would result in designs ready for cost estimation, and more importantly, would identify specific mitigation measures to improve expected building performance. (Continued from 2012 Plan)	Funding required to do engineering studies, design retrofits and prepare construction documentation for retrofits of most vulnerable facilities.	DDC / DEM	High	Property Protection	2, 3	8, 9
	29	**Establish regulatory policy to identify critical facilities during planning and design. CRITICAL FACILITY: Buildings and structures provide services that are essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations.**		DDC	High	Prevention	2, 3, 4	8, 9
	30	**Create strengthening requirements for a building upgrade for hazard resistance whenever the owner does a major remodeling alteration of the structure.**		DPP	Low	Property Protection	2	11
	31	**Harden DFM and DRM Base Yards in Wahiawa and Kaneohe to provide viable pre-hurricane staging of debris clearing equipment and personnel**		DFM/DRM	Medium	Property Protection	7	8
	32	**Install mobile emergency generator switches at all HPD stations; increase emergency generator fuel capacity to more than 16 hours at Kaneohe, Kailua, Kahuku, and Pearl City stations; upgrade Alapai HQ emergency generator per USCOE recommendation and provide automatic start-up**		HPD	Low	Essential Services	3	8, 11

Table 19-2 Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
Tropical Cyclones and Hurricane	33	**Identify the types of buildings more suitable for self-sheltering as alternatives to public shelters. Perform a comprehensive screening evaluation of private sector candidate building types for possible hurricane refuge use and create a voluntary\certification system for private shelter refuges.**	Requires estimated funding of $150,000 to perform screening, engineering analysis and develop certification guidelines.	DEM	Medium	Essential Services	5	8, 11
	34	**Perform all-hazard structural safety assessments of hurricane shelters.**	**Ongoing.** Requires annual funding of at least $500,000. Follow the 2014 Scope of Services and Procedure for Structural Assessment of Buildings for Hurricane Shelter Classification.	HIEMA	Medium-High	Property Protection	5	8, 9,11
	35	**Retrofit public shelter buildings to increase capacity, refine actual evacuation demand, and update City policies on evacuation to decrease sheltering deficit.**	**DEM public policy has been updated to utilize shelters as a last resort for those in the coastal flood zone or in weaker homes.** Funding required to do engineering, design retrofits and prepare construction documentation for retrofits of most vulnerable facilities.	HIEMA	Medium-High	Property Protection	5	8, 9, 11
	36	**Create incentives for homeowners and businesses to retrofit their buildings.**	Online Guidelines already exist for Hawaii construction at the DCCA. Funding for a grant program required from the state legislature.	DCCA	Medium	Public Education	2, 6	11, 12
	37	**Require hurricane safe rooms in all new residential construction outside of flood zones**		DPP	Medium-High	Prevention	2	2
	38	**Establish a policy for strengthening of critical public facility enclosure integrity for wind and windborne debris**	Policies and approved criteria and protective techniques would need to be adopted. The University of Hawaii at Manoa has a wind cannon used for the testing of commonly used local materials and building styles. More protective systems should be tested.	MAY	Low	Property Protection	3	9

Table 19-2 Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
Tsunami	39	**Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects to enable their use as refuges of safety during extreme tsunamis.** Produce a workshop seminar on this procedure for the visitor industry.	Funding required	DEM/HI EMA	Medium-High	Property Protection / Public Outreach	2	4, 9
	40	**Perform preliminary engineering of tsunami and coastal flood mitigation defense of critical infrastructure.**	Funding required for engineering study.	MAY	Medium	Property Protection	4	2, 4
	41	**ROH Chapter 16 Building-Code Produce higher resolution probabilistic tsunami hazard maps (of run-up) for use with the ASCE-2016 and IBC-2018 building code design provisions**	**Ongoing**. NOAA funded project underway at the DBEDT Office of Planning 2018-2019.	DEM	Medium	Prevention	1, 2	2, 4
	42	**Adopt the ASCE national standard for tsunami design of new construction for critical, essential, and certain occupancy types of multi-story buildings in ROH Chapter 16 Building-Code.**)	**Adopted in the State Building Code** amendment to the 2012 IBC, SECTION 1615 TSUNAMI LOADS. However, this section needs to be further refined for adoption in the Honolulu Building Code.	DPP	Medium	Prevention	2	2, 4
	43	**Evaluate fuel storage tank farm containment walls in Honolulu Harbor for the capability to withstand tsunami and hurricane flooding.**		SDOT	High	Essential Services	2, 4	4
	44	**Board of Water Supply to continue to identify and retrofit critical pumping stations in the tsunami inundation zone**	**Ongoing**	BWS	High	Property Protection	4	2
Drought and Wildfire	45	**Develop low-flow instream flow standards for environmental protection (native aquatic fauna) during drought. Have an alternate standard to keep water in streams.**		DLNR	Low	Natural Resource Protection	8	11
	46	**Expand rebate program for new water-saving technologies**		MAY	Low	Natural Resource Protection	8	11
	47	**ROH Chapter 20 Fire Code:. Due to anticipated increases in drought conditions associated with wildfires, the City should utilize maps of historic burn areas as issued in the High Fire Risk Map Zones of the Hawaii Wildfire Management Organization for these regulations based on NFPA-1**.		HFD	Low	Prevention		7
	48	**Fire Break and Fire Road Maintenance by DOFAW to stop advancing fire and provide access to firefighters.**	Estimated $30,000 annually annual funding required.	HFD / DOFAW	Medium	Essential Services	8	7
	49	**Assist Oahu communities to become Firewise Communities.**	Ongoing.	HFD / DOFAW	Medium	Public Education	8	7

Table 19-2 Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Mitigation Action Category	Mitigation Goals	Public Safety Objective
	50	**Establish water tanks at the fringes of threatened communities that can serve as dip tanks for fire suppression**		DOFAW	Medium	Structural Projects	8	7
	51	**Complete more detailed wildfire hazard analysis, including consideration of risk/hazard/value relationships. Inventory potential areas for harvesting guinea grass and forage prior to drought to reduce fire danger.**		HFD / DOFAW	Low	Natural Resource Protection	8	7
	52	**Increase setbacks from property lines near wildland fire areas and require fire lanes and vegetation control measures**		DPP/ HFD	Low	Prevention	2	7
Public Information	53	**Enhance the public availability of disaster resilience information that can be quickly understood, especially regarding hurricane awareness, hurricane retrofits, hurricanes, tsunamis and flooding.**	**Ongoing**; Follow up on demand based on public survey responses.	DEM	High	Public Education	6	12
	54	**Provide culturally appropriate disaster preparedness education for immigrant minority groups, limited English proficiency individuals, individuals with access and functional needs, etc.**	**Ongoing.** Programs developed in addition to the general public information workshops.	DEM	Medium	Public Education	6	12
	55	**Create financial incentives for business and individuals to invest in building resiliency**. **Seek insurance industry involvement in encouraging building and retrofitting resilient structures**.		DCCA	Medium	Public Education	2, 6	12

19.7 Hazard Mitigation Actions Ranked by Priority

The prioritized summary of all the actions considered is provided below, ranked starting with the highest priority projects. The process by which these actions were prioritized is developed in Chapter 2, Mitigation Planning Process:

Table 19-3 Ranked Mitigation Actions

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
Policies and Processes	2	**Plan and determine how to execute public works to protect or defend existing critical facilities, infrastructure and utility services, supply chain, and vital economic assets at risk to climate change effects..**	**1**	**High**
Flooding	15	**Plan for flood control public works for the defense of critical facilities and major economic assets. Hardenf critical facilities, utilities, power and communication networks, and port facilities.**	**2**	**High**
Policies and Processes	1	**Integrate natural hazard policies into the General Plan & Community Development Plans.**	**3**	**High**
Building Facilities	29	**Establish regulatory policy to identify critical facilities during planning and design. CRITICAL FACILITY: Buildings and structures provide services that are essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations.**	**4**	**High**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
Public Information	53	**Enhance the public availability of disaster resilience information that can be quickly understood, especially regarding hurricane awareness, hurricane retrofits, hurricanes, tsunamis and flooding.**	**5**	**High**
Policies and Processes	6	**Develop strategic master plans for implementation of new resilient and sustainable designs for communities that may need to be rebuilt post-disaster. Update the Land Use Ordinance.**	**6**	**High**
Infrastructure Facilities	19	**Relocate or locally defend/reinforce vital infrastructure such as roads in coastal eroding regions. Improve the materials and construction practices of roadways for greater resiliency.**	**7**	**High**
Infrastructure Facilities	18	**Evaluate risks and prioritize protective measures for existing infrastructure faciliites.**	**8**	**High**
Building Facilities	28	**Start hazard mitigation retrofits for the protection of essential facilities.of the City of Honolulu. Honolulu County All-Hazard Assessment of Critical Facilities ranked the 80 most vulnerable facilities. Detailed evaluations of these selected buildings would result in designs ready for cost estimation, and more importantly, would identify specific mitigation measures to improve expected building performance.**	**9**	**High**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
Tsunami	43	**Evaluate fuel storage tank farm containment walls in Honolulu Harbor for the capability to withstand tsunami and hurricane flooding.**	**10**	**High**
Tsunami	44	**Board of Water Supply to continue to identify and retrofit critical pumping stations in the tsunami inundation zone**	**11**	**High**
Flooding	10	**Revise and update the Flood Hazard Area, ROH Chapter 21A to enable the use of the ASCE 24-14 Standard, Flood Resistant Design and Construction. For Critical and Essential Facilities, this standard would require 500-year flood elevations be used for design. Incorporate the requirements of the ASCE 24-14 Standard, and revise regulations to require explicit building design for climate change adaptation. Incorporate climate change effects on the storm-generating environment, per the methodology as detailed in *Probabilistic mapping of storm-induced coastal inundation for climate change adaptation* (Li, N., et al., 2017)**	**12**	**High**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
Flooding	11	**Revise the Honolulu Electrical Code, ROH Chapter 17*: For Essential and Critical Facilities, the Electrical Code should require placement of electrical transformers, switchgear, and emergency generators above the 500-year flood elevation, or alternatively, protected by dry floodproofing.**	**13**	**High**
Policies and Processes	3	**Utilize an adaptive engineering approach to all current and future projects near the shoreline. Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly the Ala Wai Watershed Flood Control project**	**14**	**High**
Policies and Processes	4	**HRS 205A Certified Shoreline For planning purposes, include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years. ROH Chapter 23 Establish the setback line about 25 feet from the certified shoreline plus 50 times the average annual coastal erosion rate, or to a minimum of 40 feet. The local geology and soil conditions should be taken in to account.**	**15**	**Medium-High**
Infrastructure Facilities	24	**Improve the resiliency of fuel supplies during and after disasters through the Hawaii State Energy Council and the Hawaii Emergency Preparedness Executive Consortium.**	**16**	**Medium-High**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
Tropical Cyclones and Hurricane	34	**Perform all-hazard structural safety assessments of hurricane shelters.**	**17**	**Medium-High**
Flooding	16	**Pursue the Ala Wai Watershed Flood Mitigation project with the US Army Corps of Engineers; include resilience, visual appeal, water quality, and infrastructure improvements; create a watershed district to coordinate infrastructure projects, resilience planning and regulations, watershed data collection, and community engagement.**	**18**	**Medium-High**
Tropical Cyclones and Hurricane	36	**Create incentives for homeowners and businesses to retrofit their buildings**	**19**	**Medium-High**
Tsunami	39	**Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects to enable their use as refuges of safety during extreme tsunamis. Produce a workshop seminar on this procedure for the visitor industry.**	**20**	**Medium-High**
Tropical Cyclones and Hurricane	35	**Retrofit public shelter buildings to increase capacity, refine actual evacuation demand, and update City policies on evacuation to decrease sheltering deficit.**	**21**	**Medium-High**
Flooding	14	**Develop Flood Maps that go beyond FEMA requirements and consider both rainfall and coastal surge flooding, concentrating on areas with critical infrastructure**	**22**	**Medium-High**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
Infrastructure Facilities	20	**PUC should adopt the 2017 National Electric Safety Code for power transmission and distribution, to include an amendment with the ASCE topographic windspeed maps. The PUC should update the NESC requirements periodically. Strategically plan with HECO for a disaster-resilient network. Establish further upgrades to the electrical transmission and distribution design standards to incorporate Hawaii specific topographical, directionality and exposure information for the design of above ground utility using effective wind speed maps consistent with the state building code.**	**23**	**Medium-High**
Public Information	55	**Investigate financial incentives for business and individuals to invest in building resiliency. Seek insurance industry involvement in encouraging building and retrofitting resilient structures.**	**24**	**Medium**
Tsunami	40	**Perform preliminary engineering of tsunami and coastal flood mitigation defense of critical infrastructure..**	**25**	**Medium**
Tropical Cyclones and Hurricane	33	**Identify the types of buildings more suitable for self-sheltering as alternatives to public shelters. Perform a comprehensive screening evaluation of private sector candidate building types for possible hurricane refuge use and create a voluntary\certification system for private shelter refuges.**	**26**	**Medium**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
Climate Change Adaptation	7	**ROH Chapter 25 SMA: Amend the Special Management Area permit requirements to include consideration of climate change effects for major developments. Adopt coastal flooding maps that account for future climate change.**	**27**	**Medium-High**
Building Facilities	26	**ROH Chapter 16 Building-Code - Adopt 2012 and 2018 IBC and related codes per HRS 107 Part II. (Honolulu is presently using the 2006 IBC, which is obsolete by four editions of the national model code.)***	**28**	**Medium-High**
Drought and Wildfire	48	**Fire Break and Fire Road Maintenance by DOFAW to stop advancing fire and provide access to firefighters**	**29**	**Medium**
Climate Change Adaptation	8	**Produce regulatory (100-year and 500-year) coastal flooding maps that account for future climate change effects on storm intensities and sea level rise. (associated with high priority Action #10)**	**30**	**Medium-High**
Infrastructure Facilities	25	**Rockfall buffer zones should be defined and incorporated into new developments between high-hazard rock fall areas and homes and critical facilities; this requires regulatory mapping. This requires implementation into planning policy documentation and establishment of mapping to identify the hazard areas.**	**31**	**Medium**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
Flooding	13	**Participate in the NFIP Community Rating System to reduce flood losses and lower flood insurance premiums.**	**32**	**Medium**
Climate Change Adaptation	9	**Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities. Re-evaluate storm water flood control practices that address requirements for storm runoff quantities for flood control for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs.**	**33**	**Medium**
Public Information	54	**Provide culturally appropriate disaster preparedness education for immigrant minority groups, limited English proficiency individuals, individuals with access and functional needs, etc.**	**34**	**Medium**
Infrastructure Facilities	21	**Update the design and construction standards of the City for utility lifelines to improve the disaster resilience of essential services.**	**35**	**Medium**
Tsunami	42	**Adopt the ASCE national standard for tsunami design of new construction for critical, essential, and certain occupancy types of multi-story buildings in ROH Chapter 16 Building-Code.)**	**36**	**Medium**
Drought and Wildfire	49	**Assist Oahu communities to become Firewise Communities.**	**37**	**Medium**
Hurricane	38	**Establish a policy for strengthening of critical public facility enclosure**	**38**	**Medium**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
		integrity for wind and windborne debris.		
Drought and Wildfire	50	**Establish water tanks at the fringes of threatened communities that can serve as dip tanks for fire suppression**	**39**	**Medium**
Building Facilities	31	**Harden DFM and DRM Base Yards in Wahiawa and Kaneohe to provide viable pre-hurricane staging of debris clearing equipment and personnel**	**40**	**Medium**
Flooding	12	**Re-evaluate critical inland and stream flooding DFIRMs* to account for a) the details of the watershed and the floodway, and b) from a policy standpoint whether the frequency of flood overtopping is really acceptable in heavily developed areas. Include rainfall intensification. Develop a drainage system plan for future conditions**	**41**	**Medium**
Infrastructure Facilities	23	**Replace weathered wood poles with National Electric Safety Code conforming poles, upgrading them rather than replacing them with the same type as existing**	**42**	**Medium**
Policies and Processes	5	**HRS Chapter 484 - Uniform Land Sales Practices Act: Require specific disclosure of an explicitly defined list hazards during real estate transactions per revision of the Disclose Hazard Risks as Mandatory Seller Disclosures in Real Estate Transactions Act. HRS Chapter 508D Mandatory Seller Disclosures in Real Estate Transactions: Make mandatory**	**43**	**Medium**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
		seller disclosure apply to vacant lots as well.		
Infrastructure Facilities	22	**Increase HECO power plant capacity and the redundancy/reliability of the supply network**	**44**	**Medium**
Tsunami	41	**ROH Chapter 16 Building-Code Produce higher resolution probabilistic tsunami hazard maps (of run-up) for use with the ASCE-2016 and IBC-2018 building code design provisions**	**45**	**Medium**
Drought and Wildfire	47	**ROH Chapter 20 Fire Code: Due to anticipated increases in drought conditions associated with wildfires, the City should utilize maps of historic burn areas as issued in the High Fire Risk Map Zones of the Hawaii Wildfire Management Organization for these regulations based on NFPA-1.**	**46**	**Low**
Flooding	17	**Install flood barriers at HPD facilities at areas with habitual flooding**	**47**	**Low**
Drought and Wildfire	52	**Increase setbacks from property lines near wildland fire areas and require fire lanes and vegetation control measures**	**48**	**Low**
Drought and Wildfire	46	**Expand rebate program for new water-saving technologies**	**49**	**Low**
Building Facilities	30	**Create strengthening requirements for a building upgrade for hazard resistance whenever the owner does**	**50**	**Low**

Hazard Mitigation Area	Action #	Action	Overall Rank	Priority
		a major remodeling alteration of the structure.		
Drought and Wildfire	**51**	**Complete more detailed wildfire hazard analysis, including consideration of risk/hazard/value relationships. Inventory potential areas for harvesting guinea grass and forage prior to drought to reduce fire danger.**	**51**	**Low**
Drought and Wildfire	**45**	**Develop low-flow instream flow standards for environmental protection (native aquatic fauna) during drought. Have an alternate standard to keep water in streams.**	**52**	**Low**
Hurricane	**37**	**Require hurricane safe rooms in all new residential construction outside of flood zones**	**53**	**Low**
Building Facilities	**32**	**Install mobile emergency generator switches at all HPD stations; increase emergency generator fuel capacity to more than 16 hours at Kaneohe, Kailua, Kahuku, and Pearl City stations; upgrade Alapai HQ emergency generator per USCOE recommendation and provide automatic start-up**	**54**	**Low**
Building Facilities	**27**	**Test Seismic and Wind Performance to develop Single Wall Construction retrofit techniques.**	**55**	**Low**

19.8 Hazard Mitigation Actions – Summarized with Implementation Metrics

The mitigation actions are shown with feasible timeframes, estimated magnitude of costs, and potential funding sources in Table 19-4

Table 19-4Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Feasible Timeframe	Estimated Magnitude of Cost	Potential Funding Source
Mitigation Policies and Processes	1	**Integrate natural hazard policies into the General Plan & Community Development Plans**	Coordination / Integration beginning in this plan update**.**	DEM / DPP	High	Long-Term	$25,000 annually	DPP
	2	**Plan and determine how to execute public works to protect or defend existing critical facilities, infrastructure and utility services, supply chain, and vital economic assets at risk to climate change effects.**	Planning and preliminary engineering feasibility studies should proceed on the coastal defense options for: Honolulu Harbor and particularly Pier 1, Kewalo Basin-Kakaako, Honolulu International (HNL) Airport reef runway, Sand Island access, Ala Wai Canal flood control, and Waikiki	MAY / DDC	High	Medium-Term	$100,000 annually	BFS
	3	**Utilize an adaptive engineering approach to all current and future projects near the shoreline. Incorporate mitigation of the effects of climate change into large infrastructure projects in close proximity to shoreline, particularly the Ala Wai Watershed Flood Control project.**	Policies need to be implemented per the ***Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability To Coastal Hazards and Climate Impacts In the City and County of Honolulu***	MAY	High	Medium-Term	$100,000 annually	CCSR
	4	**HRS 205A Certified Shoreline For planning purposes, include a new map of the Expected Shoreline, taking into account shoreline erosion and relative sea level rise over the next 50 years. ROH Chapter 23 Establish the setback line about 25 feet from the certified shoreline plus 50 times the average annual coastal erosion rate, or to a minimum of 40 feet. The local geology and soil conditions should be taken in to account.**		DPP / DEM / State	Medium-High	Long-Term	$500,000	Legislature / NOAA
	5	**HRS Chapter 484 - Uniform Land Sales Practices Act:** Require specific disclosure of an explicitly defined list hazards during real estate transactions per revision of the Disclose Hazard Risks as Mandatory Seller Disclosures in Real Estate Transactions Act. **HRS Chapter 508D Mandatory Seller Disclosures in Real Estate Transactions**: Make mandatory seller disclosure apply to vacant lots as well.		State	Medium	Medium-Term	$50,000	Legislature

Table 19-4Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Feasible Timeframe	Estimated Magnitude of Cost	Potential Funding Source
	6	**Develop strategic master plans for implementation of new resilient and sustainable designs for communities that may need to be rebuilt post-disaster. Update the Land Use Ordinance.**	Action introduced in the 2019 Resilient Oahu Strategy	CCSR /NDPTC	High	Medium-Term	$250,000	CCSR
Climate Change Adaptation	7	**ROH Chapter 25 SMA: Amend the Special Management Area permit requirements to include consideration of climate change effects for major developments. Adopt coastal flooding maps that account for future climate change.** Amend the Special Management Area requirements to: 1) Create a Coastal Construction Control Zone to account for 50-years of erosion, climate change and 2 ft. of Relative Sea Level Rise, and 500-year flooding 2) For Major Permits within the Coastal Construction Control Zone, require that those effects on the functionality of the development and land use be mitigated.	Update City and County of Honolulu regulations to implement the recommendations selected from the State Office of Planning 2017 report titled: Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability to Coastal Hazards and Climate Impacts in the City and County of Honolulu.	DPP	Medium-High	Long-Term	$250,000	DPP
	8	**Produce regulatory (100-year and 500-year) coastal flooding maps that account for future climate change effects on storm intensities and sea level rise. (associated with high priority Action #10)**	Use Numerical Wave Run-up and Storm Surge Models to develop improved coastal flood zones with consideration of climate change effects for 100-year and 500-year mean return periods per the methodology as detailed in Probabilistic mapping of storm-induced coastal inundation for climate change adaptation (Li, N., et al., 2017).	City	Medium-High	Medium-Term	$500,000	NOAA
	9	**Address rainfall intensification in the standards used for flood control and storm drainage works and wastewater facilities.** Re-evaluate storm water flood control practices that address requirements for storm runoff quantities for flood control for achieving better target reliabilities, and to accommodate rainfall intensification and urbanization effects on watershed runoffs.	Update Honolulu regulations to implement the report Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability to Coastal Hazards and Climate Impacts in the City and County of Honolulu.	DPP	Medium	Medium-Term	$250,000	FEMA

Table 19-4Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Feasible Timeframe	Estimated Magnitude of Cost	Potential Funding Source
Flooding	**10**	**Revise and update the Flood Hazard Area, ROH Chapter 21A to enable the use of the ASCE 24-14 Standard, Flood Resistant Design and Construction. For Critical and Essential Facilities, this standard would require 500-year flood elevations be used for design. Incorporate the requirements of the ASCE 24-14 Standard, and revise regulations to require explicit building design for climate change adaptation. Incorporate climate change effects on the storm-generating environment, per the methodology as detailed in *Probabilistic mapping of storm-induced coastal inundation for climate change adaptation* (Li, N., et al., 2017).**	Use Numerical Wave Run-up and Storm Surge Models to develop improved coastal flood zones with consideration of climate change effects for 100-year and 500-year mean return periods for the entire coastline (associated with Action #8)	.MAY / DPP	High	Medium-Term	$250,000	FEMA
	11	**Revise the Honolulu Electrical Code, ROH Chapter 17: For Essential and Critical Facilities, the Electrical Code should require placement of electrical transformers, switchgear, and emergency generators above the 500-year flood elevation, or alternatively, protected by dry floodproofing.**		MAY	High	Medium-Term	$25,000	Legislature
	12	**Re-evaluate critical inland and stream flooding DFIRMs to account for a) watershed details and the floodway, its extent of urbanization, and b) assess from a policy standpoint whether the frequency of flood overtopping in heavily developed areas is really acceptable. Include rainfall intensification. Develop a drainage system plan for future conditions**		DPP	Medium	Long-Term	$750,000	FEMA
	13	**Participate in the NFIP Community Rating System to reduce flood losses and lower flood insurance premiums.**		DNLR / DEM	Medium	Short-Term	$100,000 annually	BFS
	14	**Develop Flood Maps that go beyond FEMA requirements and consider both rainfall and coastal surge flooding, concentrating on areas with critical infrastructure**		DPP	Medium-High	Medium-Term	$500,000	FEMA
	15	**Plan for flood control public works for the defense of critical facilities and major economic assets. Harden critical facilities, utilities, power and communication networks, and port facilities.**		DDC	High	Medium-Term	$1,000,000 annually	BFS
	16	**Pursue the Ala Wai Watershed Flood Mitigation project with the US Army Corps of Engineers; include resilience, visual appeal, water quality, and infrastructure improvements; create a watershed district to coordinate infrastructure projects, resilience planning and regulations, watershed data collection, and community engagement.**		DDC	Medium-High	Medium-Term	$125M	Legislature
	17	**Install flood barriers at HPD facilities at areas with habitual flooding**		HPD	Low	Short-Term	$50,000	FEMA

Table 19-4Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Feasible Timeframe	Estimated Magnitude of Cost	Potential Funding Source
Infrastructure Facilities	**18**	**Evaluate risks and prioritize protective measures for existing infrastructure faciliites.**	Requires funding for study of inventory of non-building infrastructure facilities to prioritize the most vulnerability facilities and identify the appropriate measures for each condition.	DEM	High	Short-Term	$250,000	HIEMA
	19	**Relocate or locally defend/reinforce vital infrastructure such as roads in coastal eroding regions.** Improve the materials and construction practices of roadways for greater resiliency.	Public Works projects need to proceed	DDC	High	Long-Term	$2,000,000 annually	FHA
	20	**PUC should adopt the 2017 National Electric Safety Code for power transmission and distribution, to include an amendment with the ASCE topographic windspeed maps. The PUC should update the NESC requirements periodically. Strategically plan with HECO for a disaster-resilient network. Establish further upgrades to the electrical transmission and distribution design standards to incorporate Hawaii specific topographical, directionality and exposure information for the design of above ground utility using effective wind speed maps consistent with the state building code. (associated with Action #22)**	In order to maintain technical standard requirements, a PUC process analogous to HRS 107 Part II State Building Code and Design Standards is needed, but more efficient. Needs to be periodically updated every 5 years.	PUC	Medium-High	Short-Term	$25,000	PUC
	21	**Update the design and construction standards of the City for utility lifelines to improve the disaster resilience of essential services.**	Needs similar process as HRS 107 Part II State Building Code and Design Standards, but more efficient and not identical participants.	PUC	Medium	Medium-Term	$100,000	PUC
	22	**Increase resiliency of post-disaster power plant capacity and achieve greater redundancy/reliability of the supply network. (associated with Action #20)**	**Ongoing** development of new technologies and additional capacity, such as solar and wind.	PUC / HECO	Medium	Long-Term	$1,000,000 annually	HECO
	23	**Replace weathered wood poles with National Electric Safety Code conforming poles, upgrading them rather than replacing them with the same type as existing. (associated with Actions # 20 and 22)**	Costs and funding sources need to be evaluated.	PUC	Medium	Short-Term	TBD	HECO

Table 19-4Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Feasible Timeframe	Estimated Magnitude of Cost	Potential Funding Source
	24	**Improve the resiliency of fuel supplies during and after disasters through the Hawaii State Energy Council and the Hawaii Emergency Preparedness Executive Consortium**.	**Ongoing.** Include structural evaluation of containment walls at the fuel tank farms at Honolulu Harbor for tsunami damage, per *Honolulu Port Analyses for the Hawaii Tsunami.*	DEM	Medium-High	Medium-Term	TBD	State
Building Facilities	**25**	**Rockfall buffer zones should be defined and incorporated into new developments between high-hazard rock fall areas and homes and critical facilities; this requires regulatory mapping.** This requires implementation into planning policy documentation and establishment of mapping to identify the hazard areas.	Requires technical development and feasibility study. Continue the process of rockfall mitigation projects along Class "A" slopes.	DPP	Medium	Long-Term	TBD	FHA / FEMA
	26	**ROH Chapter 16 Building-Code - Adopt 2012 and 2018 IBC and related codes per HRS 107 Part II. (Honolulu is presently using the 2006 IBC, which is obsolete by four editions of the national model code.)**	**Ongoing. DPP to adopt IBC 2012 by 2019**. **Need to adopt 2018 IBC thereafter by 2021**.	DPP	Medium-High	Short-Term	$50,000	DPP
	27	**Test Seismic and Wind Performance to develop Single Wall Construction retrofit techniques.**	Funding required for wind cannon tests and single wall seismic and wind performance. **Post and pier seismic tests completed.**	HIEMA	Low	Short-Term	$100,000	FEMA
	28	**Start hazard mitigation retrofits for the protection of essential facilities.of the City of Honolulu**. Honolulu County All-Hazard Assessment of Critical Facilities ranked the 80 most vulnerable facilities. Detailed evaluations of these selected buildings would result in designs ready for cost estimation, and more importantly, would identify specific mitigation measures to improve expected building performance. (Continued from 2012 Plan)	Funding required to do engineering studies, design retrofits and prepare construction documentation for retrofits of most vulnerable facilities.	DDC / DEM	High	Medium--Term	$500,000 annually	TBD
	29	**Establish regulatory policy to identify critical facilities during planning and design. CRITICAL FACILITY: Buildings and structures provide services that are essential for the implementation of the response and recovery management plan or for the continued functioning of a community, such as facilities for power, fuel, water, communications, public health, major transportation infrastructure, and essential government operations.**		DDC	High	Short-Term	$75,000	BFS

Table 19-4Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Feasible Timeframe	Estimated Magnitude of Cost	Potential Funding Source
	30	**Create strengthening requirements for a building upgrade for hazard resistance whenever the owner does a major remodeling alteration of the structure.**		DPP	Low	Long-Term	$20,000	DPP
	31	**Harden DFM and DRM Base Yards in Wahiawa and Kaneohe to provide viable pre-hurricane staging of debris clearing equipment and personnel**		DFM /DRM	Medium	Medium-Term	TBD	DFM
	32	**Install mobile emergency generator switches at all HPD stations; increase emergency generator fuel capacity to more than 16 hours at Kaneohe, Kailua, Kahuku, and Pearl City stations; upgrade Alapai HQ emergency generator per USCOE recommendation and provide automatic start-up**		HPD	Low	Medium-Term	$75,000 each	HPD
Tropical Cyclones and Hurricane	**33**	**Identify the types of buildings more suitable for self-sheltering as alternatives to public shelters. Perform a comprehensive screening evaluation of private sector candidate building types for possible hurricane refuge use and create a voluntary\certification system for private shelter refuges.**	Perform screening, engineering analysis and develop certification guidelines.	DEM	Medium	Short-Term	$125,000	TBD
	34	**Perform all-hazard structural safety assessments of hurricane shelters.**	**Ongoing.**. Follow the 2014 Scope of Services and Procedure for Structural Assessment of Buildings for Hurricane Shelter Classification.	HIEMA	Medium-High	Long-Term	At least $500,000 annually	Legislature
	35	**Retrofit public shelter buildings to increase capacity, refine actual evacuation demand, and update City policies on evacuation to decrease sheltering deficit.**	**DEM public policy has been updated to utilize shelters as a last resort for those in the coastal flood zone or in weaker homes.** Funding required to do engineering, design retrofits and prepare construction documentation for retrofits of most vulnerable facilities.	HIEMA	Medium-High	Long-Term	$1,000,000 annually	Legislature
	36	**Create incentives for homeowners and businesses to retrofit their buildings.**	Online Guidelines already exist for Hawaii construction at the DCCA. Funding for a grant program required from the state legislature.	DCCA	Medium	Medium-Term	$250,000 annually	Legislature

Table 19-4Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Feasible Timeframe	Estimated Magnitude of Cost	Potential Funding Source
	37	**Require hurricane safe rooms in all new residential construction outside of flood zones**		DPP	Medium-High	Medium-Term	$15,000 each	Developers
	38	**Establish a policy for strengthening of critical public facility enclosure integrity for wind and windborne debris**	Policies and approved criteria and protective techniques would need to be adopted. The University of Hawaii at Manoa has a wind cannon used for the testing of commonly used local materials and building styles. More protective systems should be tested.	MAY	Low	Short-Term	TBD	TBD
Tsunami	**39**	**Develop a procedure for evaluating the structural integrity of existing buildings for tsunami effects to enable their use as refuges of safety during extreme tsunamis. Produce a workshop seminar on this procedure for the visitor industry.**	Funding required	DEM/HIEMA	Medium-High	Short-Term	$100,000	DBEDT / Office of Planning
	40	**Perform preliminary engineering of tsunami and coastal flood mitigation defense of critical infrastructure.**	Funding required for engineering study.	MAY	Medium	Medium-Term	$500,000	DDC
	41	**ROH Chapter 16 Building-Code Produce higher resolution probabilistic tsunami hazard maps (of run-up) for use with the ASCE-2016 and IBC-2018 building code design provisions**	**Ongoing**. Project underway at the DBEDT Office of Planning 2018-2019.	DEM	Medium	Short-Term	$500,000	NOAA funded
	42	**Adopt the ASCE national standard for tsunami design of new construction for critical, essential, and certain occupancy types of multi-story buildings in ROH Chapter 16 Building-Code.**)	**Adopted in the State Building Code** amendment to the 2012 IBC, SECTION 1615 TSUNAMI LOADS. However, this section needs to be further refined for adoption in the Honolulu Building Code.	DPP	Medium	Short-Term	$10,000	SBCC
	43	**Evaluate fuel storage tank farm containment walls in Honolulu Harbor for the capability to withstand tsunami and hurricane flooding.**		SDOT	High	Short-Term	$50,000	HDOT Harbors
	44	**Board of Water Supply to continue to identify and retrofit critical pumping stations in the tsunami inundation zone**	**Ongoing**	BWS	High	Medium-Term	TBD	BWS

Table 19-4Summary of Mitigation Actions for the City and County of Honolulu

	Action #	Action Description	Status	Lead Agencies	Priority	Feasible Timeframe	Estimated Magnitude of Cost	Potential Funding Source
Drought and Wildfire	45	**Develop low-flow instream flow standards for environmental protection (native aquatic fauna) during drought. Have an alternate standard to keep water in streams.**		DLNR	Low	Short-Term	TBD	DLNR
	46	**Expand rebate program for new water-saving technologies**		MAY	Low	Medium-Term	TBD	DLNR
	47	**ROH Chapter 20 Fire Code:. Due to anticipated increases in drought conditions associated with wildfires, the City should utilize maps of historic burn areas as issued in the High Fire Risk Map Zones of the Hawaii Wildfire Management Organization for these regulations based on NFPA-1**.		HFD	Low	Medium-Term	$250,000	DOFAW
	48	**Fire Break and Fire Road Maintenance by DOFAW to stop advancing fire and provide access to firefighters.**		HFD / DOFAW	Medium	Long-Term	$50,000 annually	DOFAW
	49	**Assist Oahu communities to become Firewise Communities.**	Ongoing.	HFD / DOFAW	Medium	Medium-Term	$25,000	DOFAW
	50	**Establish water tanks at the fringes of threatened communities that can serve as dip tanks for fire suppression**		DOFAW	Medium	Medium-Term	TBD	DOFAW
	51	**Complete more detailed wildfire hazard analysis, including consideration of risk/hazard/value relationships. Inventory potential areas for harvesting guinea grass and forage prior to drought to reduce fire danger.**		HFD / DOFAW	Low	Medium-Term	TBD	DOFAW
	52	**Increase setbacks from property lines near wildland fire areas and require fire lanes and vegetation control measures**		DPP/ HFD	Low	Long-Term	TBD	DPP
Public Outreach	53	**Enhance the public availability of disaster resilience information that can be quickly understood, especially regarding hurricane awareness, hurricane retrofits, hurricanes, tsunamis and flooding.**	**Ongoing**; Follow up on demand based on public survey responses.	DEM	High	Short-Term	$50,000 annually	DEM
	54	**Provide culturally appropriate disaster preparedness education for immigrant minority groups, limited English proficiency individuals, individuals with access and functional needs, etc.**	**Ongoing.** Programs developed in addition to the general public information workshops.	DEM	Medium	Medium-Term	$50,000 annually	DEM
	55	**Create financial incentives for business and individuals to invest in building resiliency**. **Seek insurance industry involvement in encouraging building and retrofitting resilient structures**.		DCCA	Medium	Medium-Term	TBD	TBD

19.9 Hazard Mitigation Assistance Programs

There are five programs funded by FEMA that provide funds for Hazard Mitigation Assistance (HMA). These programs are

1. Hazard Mitigation Grant Program (HMGP)
2. Pre-Disaster Mitigation (PDM)
3. Flood Mitigation Assistance (FMA)
4. Repetitive Flood Claims (RFC)
5. Severe Repetitive Loss (SRL)

The different programs are summarized below.

19.9.1 Hazard Mitigation Grant Program (HMGP)

The Hazard Mitigation Grant Program (HMGP) may provide funds to States, Territories, Indian Tribal governments, local governments, and eligible private non-profits following a Presidential major disaster declaration. Under Section 404 of the Stafford Act, and public assistance mitigation activities are appropriated in amounts proportional to the cost of post-disaster response and repair efforts through the Hazard Mitigation Grant Program (HMGP). It is the largest source of funds for mitigation activities, and the one with the greatest potential to reduce future disaster losses. Section 404 provides that 15 percent (and in some cases 20 percent) of the funds spent for Public Assistance and Individual and Family Grants may be spent for a wide variety of mitigation activities. Funds are granted to the state as the "grantee" and are spent by qualified "sub grantees" on eligible projects located within the state. Priorities are set by the state and projects can be used to mitigate against losses from any hazard. Projects must be cost-effective and a non-federal match of at least 25 percent is required.

In conjunction with the repair of damaged facilities, Section 406 public assistance of the Stafford Act allows for a more narrow selection of mitigation activities - physical projects on damaged facilities - than FEMA's other programs. Hazard mitigation is defined as cost-effective action taken to prevent or reduce the threat of future damage to a facility. A non-federal match of 25 percent is required. Mitigation funded by Section 406 only applies to buildings and infrastructure damaged by a Presidentially-declared disaster and is above and beyond the work required to return the damaged facility to its pre-disaster design. Section 406 mitigation is addressed by 44CFR 206.226 and by Response and Recovery Policy 9526.1 (FEMA 1998b). Section 7(c) of the FEMA policy provides that mitigation measures must be determined to be cost-effective. Anyone of the following means may be used to determine cost-effectiveness:

i. Measures may amount to up to 15 percent of the total eligible cost of the eligible repair work on a particular project.

   i. Certain mitigation measures will be determined to be cost-effective, as long as the mitigation measure does not exceed the eligible cost of the eligible repair work on the project.
   ii. For measures that exceed the above costs, the Grantee or Subgrantee must demonstrate through an acceptable benefit/cost analysis that the measure is cost-effective.

Appendix A of the policy defines mitigation measures as being cost-effective if they:

- Do not exceed 100 percent of the project cost
- Are appropriate to the disaster damage
- Will prevent future similar damage
- Are directly related to the eligible damaged elements
- Do not increase risks or cause adverse effects to the property or elsewhere
- Meet standards of good professional judgment

19.9.2 Pre-Disaster Mitigation (PDM)

The Pre-Disaster Mitigation (PDM) program provides funds to States, Territories, federally recognized Indian Tribal governments, and communities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. In 2018 all 50 states are each eligible to receive at least $575,000 as a set aside Eligible activities under a competitive grant program would include: risk assessments; State and local mitigation planning; the reinforcement of structures against seismic, wind, and other hazards; elevation, acquisition, or relocation of flood-prone structures; minor flood control or drainage management projects; and other activities listed in Table 2-1.

Pre-Disaster Mitigation Planning and Policy Development

- Mapping hazards and incorporating them into planning documents, potential loss estimates, and zone considerations
- Assessing inventories of public facilities
- Refining and updating building codes and zoning requirements
- Training & Education
- Developing loss mitigation incentives to the public

Pre-Disaster Mitigation Projects

- Relocating Critical Facilities in high hazard zones, developing new facilities, or arranging use of alternative staging sites
- Retrofitting or upgrading critical buildings and infrastructure to resist natural hazards
- Improving reliability or redundancy of infrastructure to mitigate essential service outages and lifeline interruptions from natural hazards like rockfalls, debris flows, earthquakes and hurricanes
- Projects involving mitigating losses and ensuring functionality of Critical Public Facilities and infrastructure will be favored by FEMA

Benefit-Cost Analysis is required for all projects submitted for FEMA 75% cost share, and FEMA will eliminate from funding consideration those proposals with lower Benefit-Cost ratios. Submitted projects must be consistent with the findings of the county and State Pre-Disaster Mitigation Plans.

19.9.3 The Flood Insurance Program

The National Flood Insurance Program provides Flood Mitigation Assistance (FMA) grant funds to state and local governments for studies, research, and mitigation for structures covered by flood insurance. The funds come from flood insurance premiums with the intent that flood insurance losses with be reduced.

For properties subject to repetitive losses, the Repetitive Flood Claims (RFC) grant program provides funding to reduce or eliminate the long-term risk of flood damage to structures insured under the NFIP that have had one or more claim payments for flood damages. The long-term goal of the RFC program is to reduce or eliminate claims under the NFIP through mitigation activities that are in the best interest of the NFIP. RFC funds may only mitigate structures that are located within a State or community that cannot meet the cost share or management capacity requirements of the FMA program. RFC awards will prioritize projects that create the greatest savings to the NFIP based on a benefit-cost analysis. The Severe Repetitive Loss (SRL) Pilot Program provides funding to reduce or eliminate the long-term risk of flood damage to severe repetitive loss residential structures insured under the NFIP. SRL program applicants shall give priority to eligible project sub-applications that demonstrate the greatest savings to the NFIP based on a BCR. The BCA must be completed using a FEMA-approved methodology.



20. Plan Monitoring, Evaluation, Maintenance, and Update Procedures

20. PLAN MONITORING, EVALUATION, MAINTENANCE AND UPDATE PROCEDURES

2012 Plan	Reasons for Updates / Revisions in this 2018 Plan
The 2012 planning plan maintenance and implementation process was described.	• In general, the plan should be updated as mitigation projects and actions are implemented, new benefit/cost analysis becomes available, legislative mandates or recommendations change, public interests are expressed, or new technical hazard information becomes available. • This chapter has been revised with specific monitoring, evaluation and update procedures. A check list of hazard mitigation projects to monitor for future inclusion in this plan is given, so that any ongoing or anticipated activities are specifically identified for the next plan update. • Examples of recent activities to promote hazard mitigation in other plans are detailed. • Public awareness workshops continue to be organized. • The start-up of new proposed projects is monitored. Projects will continue to be nominated for funding with involvement of the Hawaii Emergency Management Agency. • The next plan will be the updated on the five-year cycle. The planning committee will update the risk assessments and prioritize the new mitigation projects. The next new plan will discuss the planning process for the past cycle and document the public's involvement. • Estimated planning update milestones and timelines are included • Guidelines for grant eligible types of projects are given. • The activities that are eligible for FEMA funding and those not eligible for FEMA funding are described

20.1 General

The City & County of Honolulu Hazard Mitigation Program is the collective effort of many different agencies, organizations, communities, and individuals working together to identify opportunities and make investments to reduce long term risk from natural disasters. The ongoing efforts of this program are documented in this City & County of Honolulu *Multi-Hazard Pre-Disaster Mitigation Plan*.



Figure 20-1: Hazard Mitigation is a shared mission

The Multi-Hazard Mitigation Plan was developed as a "living" document and will be updated and revised as new information becomes available. FEMA requirements for the Pre-Disaster Mitigation Plan after adoption by the local governing body include monitoring, evaluating, and updating the plan at least every 5 years. In recognition of the need for establishing a formal process for hazard mitigation planning within the Honolulu's operational structure, the City will initiate an approach to ensure that this plan is kept updated and pertinent actions are incorporated in other plans as applicable. In addition to Table 19-2 that summarizes the recommended mitigation actions, this chapter now includes Table 20-1 that establish strategic priorities, outcomes, methods, and objectives for plan implementation and Table 20-2 that includes presently ongoing or future hazard mitigation projects which should be explicitly monitored for future implementation into the plan updates. The updates may be necessary following the actions or events listed below:

- Progress of ongoing mitigation actions within the City and County of Honolulu.
- Development of new mitigation recommendations.
- Changes necessary because of Federal, State, or County legislative acts, appropriations, mandates and recommendations, such as the FEMA Building Resilient Infrastructure and Communities (BRIC), a new pre-disaster hazard mitigation grant program created by Section 1234 of the Disaster Recovery Reform Act of 2018. BRIC will focus on reducing the nation's risk by funding public infrastructure projects that increase a community's resilience before a disaster. Examples of interest areas include infrastructure mitigation projects; hazard mitigation planning; building codes and enforcement; and risk informed funding.
- Public input in mitigation and other existing planning activities.

- Technical updates based on new data, analysis, or scientific modeling capabilities.
- New information on environmental conditions that indicate new mitigation needs.
- Identification and analysis of county structures with emphasis on critical facilities.
- Incorporate hazard analysis in the county's general plan process to evaluate the impact on land use, zoning, etc., issues.

Program Implementation

The Program Coordinator is responsible for effectively communicating about the hazard mitigation plan and program. During the hazard mitigation planning process, a few common themes emerged. Based on these common themes, all of the goals, objectives and mitigation actions were synthesized into four strategic priorities. These strategic priorities reduce complexity when communicating about the plan and simplify the process of adjusting the implementation strategy.

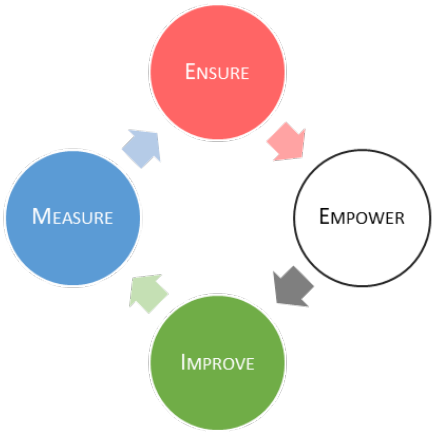


Figure 20-2: Interconnected Strategic Priorities

Four Strategic Priorities

1. **Ensure Disaster Resilience**
2. **Empower Disaster Resilience**
3. **Improve Disaster Resilience**
4. **Measure Disaster Resilience**

Each strategic priority is built upon a desired outcome with methods to achieve the outcome and underlying objectives. All of the specific actions in this plan fall within one of these four strategic priorities.

Strategic Priority I: Ensure Disaster Resilience

Outcome: Effective laws, policies, rules, and implementation for disaster risk reduction and resilience

Methods

- Support the legislative process with recommendations, best-practices, and subject-matter expertise
- Operate in accordance with best-practices and subject-matter expertise

Objectives

1. Support update, amendment, and addition to the City and County of Honolulu General Plan, Community Plans, and City Departmental policies and rules
2. Support update, amendment, and addition to the Revised Ordinances of Honolulu Chapters 16, 27, 20,21A, and 25 and State of Hawai'i Revised Statutes 205A and 484.
3. Support development of products and processes for implementation of the disaster resilience regulatory framework

Strategic Priority II: Empower Disaster Resilience

Outcome: Institutionalized disaster resilience across all City departments and non-governmental stakeholders

Methods

- Support coordinated efforts in both public and private sector
- Develop and implement specific programs

Objectives

1. Develop and improve mechanisms to coordinate disaster resilience efforts across all City departments and non-governmental stakeholders via multi-agency groups, regular meetings, and regular communications
2. Provide effective public information, technical information, and technical assistance to support individual, family, and business resilience
3. Develop and improve incentive and rebate programs, including participating in CRS, to support individual, family, and business resilience

Strategic Priority III: Improve Disaster Resilience

Outcome: Strengthened neighborhoods, infrastructure, services, environment, and economic assets

Method

- Develop and execute specific hazard mitigation projects

Objectives

1. Plan and execute projects to protect critical facilities and infrastructure, including shelters, to ensure life-safety and effective emergency response capability
2. Plan and execute projects to protect essential facilities and infrastructure to ensure continuity of community lifelines and safe conditions
3. Plan and execute projects to protect neighborhood and economic assets

Strategic Priority IV: Measure Disaster Resilience

Outcome: Information to validate, adjust, and advance disaster resilience efforts

Method

- Continually collect and analyze risk, vulnerability, investment, loss-avoidance, and other relevant information by the best methods available

Objectives

1. Evaluate infrastructure and facilities risk, including current and potential shelters
2. Study and map hazards to inform planning, regulation, and budgeting
3. Track and evaluate effectiveness of disaster resilience investment to inform planning, regulation, and budgeting

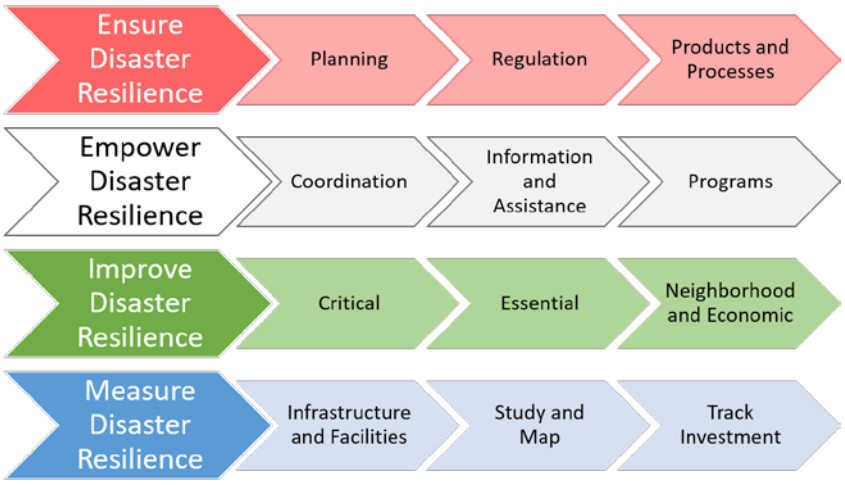


Figure 20-3: Strategic Priorities and Supporting Objectives

Table 20-1 Strategic Priorities, Outcome, Methods and Objectives

Priority	Outcome	Method	1st Objective	2nd Objective	3rd Objective
Ensure Disaster Resilience (*regulatory*)	*Effective laws, policies, rules, and implementation for disaster risk reduction and resilience*	A.) Support the **legislative process** with recommendations, best-practices, and subject-matter expertise B.) **Operate** in accordance with best-practices and subject-matter expertise	Support update, amendment, and addition to the City and County of Honolulu General Plan, Community **Plans**, and City Departmental **policies and rules**	Support update, amendment, and addition to the **Revised Ordinances of Honolulu** Chapters 16, 27, 20, 21A, and 25 and State of **Hawai'i Revised Statutes** 205A and 484.	Support development of **products and processes** for implementation of the disaster resilience regulatory framework
Empower Disaster Resilience (*programs*)	*Institutionalized disaster resilience across all City departments and non-governmental stakeholders*	A.) Support **coordinated efforts** in both public and private sector B.) Develop and implement **specific programs**	Develop and improve **mechanisms to coordinate** disaster resilience efforts across all City departments and non-governmental stakeholders via multi-agency groups, regular meetings, and regular communications	Provide effective public information, technical information, and **technical assistance** to support individual, family, and business resilience	Develop and improve incentive and rebate **programs**, including participating in CRS, to support individual, family, and business resilience
Improve Disaster Resilience (*projects*)	*Strengthened neighborhoods, infrastructure, services, environment, and economic assets.*	Develop and implement specific physical **projects**	Plan and execute projects to protect **critical facilities** and infrastructure, including shelters, to ensure life-safety and effective emergency response capability	Plan and execute projects to protect **essential facilities** and infrastructure to ensure continuity of community lifelines and safe conditions	Plan and execute projects to protect **neighborhood and economic assets**
Measure Disaster Resilience (*data*)	*Information to validate, adjust, and advance disaster resilience efforts*	Continually collect and analyze risk, vulnerability, investment, loss-avoidance, and other relevant **information** by the best methods available	Evaluate **infrastructure and facilities** risk, including current and potential shelters	**Study and map** hazards to inform planning, regulation, and budgeting	Track and evaluate effectiveness of disaster **resilience investment** to inform planning, regulation, and budgeting

Table 20-2 Hazard Mitigation Projects Monitored for Future Inclusion in this Plan

Type	Project Description	Status	Lead Agencies
Policy	Natural hazard policies for the General Plan & Community Development Plans	Coordination / Integration.	DPP
	Consider adopting coastal erosion setbacks per historical rates or disclosure of erosion rate during real estate transactions. Disclose Hazard Risks as Mandatory Seller Disclosures in Real Estate Transactions Act	Policies need to be developed per the *Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability To Coastal Hazards and Climate Impacts In the City and County of Honolulu*	DPP
	The Office of Climate Change Sustainability and Resilience has issued an Oahu Resilience Strategy that amongst its four topic areas will include Fostering Resilient Infrastructure in the Face of Natural Disasters	Announced May 30-2019 www.resilientoahu.org/resilience-strategy.	CCSR
	The Office of Climate Change Sustainability and Resilience will be developing a Long-term Recovery and Adaptation Plan	Staff Specialist being sought	CCSR
Infrastructure Facilities	Hardening of Port of Honolulu Pier	Requires funding for study of inventory of non-building infrastructure facilities to prioritize the most vulnerability facilities.	DEM
	Improve resiliency of fuel supplies during disasters; Include specific structural evaluation of the containment walls at the fuel tank farms at Honolulu Harbor and vicinity, for tsunami inundation, per the USGS study, Honolulu Port Analyses for the Hawaii Tsunami.	Disaster Preparedness through the Hawaii State Energy Council and the Hawaii Emergency Preparedness Executive Consortium.	DEM
	Kapalama Basin redevelopment to be the future site of the Pasha Group's Horizon Lines shipping operations and a new container yard, for the purpose of expanding the container handling capacity of Honolulu Harbor	Re-development of this area is to include elevating the grade to accommodate sea level rise.	PUC
	Relocate or locally defend/reinforce vital infrastructure such as roads in coastal eroding regions. Improve the materials and construction practices of roadways for greater resiliency	Public Works projects need to proceed	DDC
Buildings	Adopt 2012 and then the 2018 IBC and related codes	DPP to adopt IBC 2012 by 2019. IBC 2018 now under amendment process by the State Building Code Council per HRS 107 Part II	DPP
	Emergency shelter evaluation: All-Hazard Assessment of Hurricane Shelters and Retrofit public shelter buildings	Funding of about $500,000 annually required to do engineering studies, design retrofits and prepare construction documentation for retrofits of most vulnerable facilities.	DEM
	Incentives for homeowners and businesses to retrofit their structures	Proposed funding for program based on tax incentives required from the state legislature.	ARC
Others	UHM SOEST is producing high-resolution tsunami hazard maps (runup and depth) for building code design provisions	NOAA funded project under DBEDT Office of Planning 2018-2019.	DBEDT / DPP
	Adopt tsunami design provisions for buildings for new design and construction and for evaluating existing buildings.	Adopted in the State Building Code amendment to the 2012 IBC, SECTION 1615 TSUNAMI LOADS. However, this section needs to be adopted in the Honolulu Building Code.	DPP
	USGS update of the Hawaii seismic design maps for ASCE 7 and the IBC	Adopt in the Honolulu Building Code	USGS/DPP
	Participate in the Community Rating System	Participation may require expanded staff.	DNLR / DEM
	Assist Oahu communities to become Firewise Communities.	Ongoing	HFD / DOFAW

20.2 Plan Monitoring, Evaluation, and Update Procedures

20.2.1 *Hazard Mitigation Program Coordinator*

The Program Coordinator for the City Hazard Mitigation Program is the Office of Climate Change, Sustainability and Resiliency (CCSR). CCSR initiates and facilitates appropriate and regular hazard mitigation stakeholder engagement. CCSR also supports all City Departments and

Offices with hazard mitigation projects to ensure that investment in resilience is maximized. CCSR works closely with the Department of Emergency Management in fulfilling this role, as Hazard Mitigation is one of the five mission areas defined in the National Preparedness Goal. At the next update, the City Office of Climate Change Sustainability and Resilience will be the lead agency.

20.2.2 Ongoing Monitoring and Program Coordination

Ongoing monitoring and coordination of the Hazard Mitigation Program will occur through a Core Planning Team designated by CCSR that would meet annually in the second quarter. The Program Coordinator will facilitate an annual review to evaluate effectiveness of the program and update the program and plan, as needed. The annual review will invite all stakeholders and be conducted at a publically accessible venue, rather than the emergency operations center. Significant public participation is not generally anticipated, but is possible and would be valued. Annual reviews will primarily focus on the actions, projects and implementation strategies in the plan.

The Core Planning Team is anticipated to be comprised of representatives such as the Department of Emergency Management, Hawaii Emergency Management Agency, Department of Planning & Permitting, Hawaiian Electric Company, the Board of Water Supply, Flood Control and Dam Safety Section of the State Department of Land and Natural Resources Engineering Division, Coastal Zone Management Program of the State Office of Planning – Department of Business, Economic Development, and Tourism, State Building Code Council of the Department of Accounting and General Services, Civil and Environmental Engineering Department of the University of Hawaii at Manoa, and Harbors Division of the State Department of Transportation as principal stakeholders in disaster mitigation. Former participants in the CCSR Oahu Resilience Strategy working groups may also be enlisted. This team would be augmented by other stakeholders that participated in this plan update, and conducting quarterly update briefings with agency representative Department Emergency Coordinators (DEC) and Alternate Emergency Coordinators (AEC).

DEC/AEC are the specially trained staff from each department assigned to support the Emergency Operations Center during activation. Each city department and private stakeholder in the City's Emergency Operations Plan has multiple staff assigned as DEC/AEC. DEC/AEC staff meet monthly at the Emergency Operations Center to receive training and coordinate activities. The CCSR Program Coordinator will provide program updates to the group during at least one meeting per quarter. The primary purpose of these updates is to identify opportunities to collaborate on hazard mitigation efforts. The DEC/AEC group does not represent the entire hazard mitigation program, however it is a good opportunity to frequently engage an organized group of city stakeholders knowledgeable of natural disasters in a meaningful way.

20.2.3 Plan Evaluation and Updating

Ensuring effective monitoring, coordination, evaluation and update of the Hazard Mitigation Program is the responsibility of the Program Coordinator. The Program Coordinator will use the best means available to engage stakeholders and implement hazard mitigation. Since the plan

reflects the program, updates to the program will be captured in the plan. The online version of the plan will be considered the official version of the plan, so plan updates will ultimately be reflected there.

A.) Minor Changes

Minor, non-substantive plan content changes that do not alter the intent of approved plan may be made by the Program Coordinator after coordinating with impacted stakeholders. An example of a non-substantive change would be adding a specific hazard mitigation project to the action list that is consistent with the other actions, goals and strategies of the plan. The Program Coordinator would work with the project sponsor (usually a city department) to refine the appropriate language, inform HI-EMA, FEMA and any other impacted stakeholders of the change, and update the online version of the plan.

Any plan changes will be coordinated with the larger stakeholder group during the ongoing program coordination meetings. If changes are determined to be substantive, the Program Coordinator will initiate one of the processes for substantive plan content changes detailed below.

B.) Major Changes

Major, substantive plan content changes which may alter the intent of the approved plan will be forwarded in a notification to HI-EMA for the purposes of coordinating the City and State hazard mitigation plans. Any of the processes for substantive plan content changes will involve engaging all stakeholders for input. Substantive plan content updates will only occur through three specific processes:

- Regular Annual Review Meeting
- 5-year Complete Update Planning Process
- As-Needed Update Meeting (such as post-disaster review of the plan)

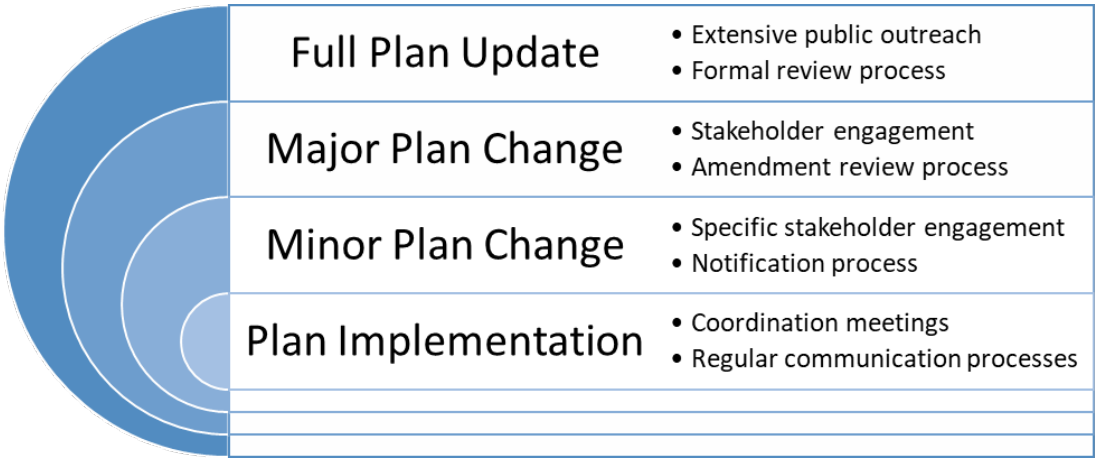


Figure 20-4: Planning and Implementation Processes

C.) Annual Review

The Program Coordinator will facilitate an annual review to evaluate effectiveness of the program and update the program and plan, as needed. The annual review will invite all stakeholders and be conducted at a publically accessible venue, rather than the emergency operations center. Significant public participation is not generally anticipated, but is possible and would be valued.

Annual reviews will primarily focus on the actions, projects and implementation strategies in the plan.

D.) 5-year Full Update Planning Process

The program will host a full planning process to completely update the plan at least every 5th year. The full update will include an in-depth evaluation of all portions of the plan and program, including the hazard identification and risk assessment. The complete update process will seek out the broadest possible input and include significant public involvement. The next revision should revisit the risk assessment to incorporate updated estimates of cost of living and replacement costs, new data on hazard areas, the effect of hazards on the community, changes in growth patterns and reductions in vulnerability due to completion of projects. The lead agency, along with community involvement, will also revisit the goals, objectives and actions to determine what, if any, should be changed. The results will determine what actions should be undertaken, reconsidered, or eliminated to further the plan's goals. Implementation of mitigation actions (whether or not FEMA funded) through planning integrated within existing city programs is considered a key to long-term success.

Specialized Planning Expertise and Capacity Support for Full Update

Due to the technical nature and intensive stakeholder engagement involved in executing an effective hazard mitigation planning process, the City and County of Honolulu will seek specialized planning expertise and surge staffing capacity via contract support. As a general rule, two years after plan approval, the Program Coordinator will assemble and submit an appropriate planning grant application for the next plan update, usually for FEMA pre-disaster hazard mitigation funds. This timeline will be sufficient to receive funds, execute an appropriate procurement process for services, and complete the planning and review process. The planning process itself is anticipated to take about 12 months. The completed draft plan should be submitted for state review and concurrence at least six months prior to plan expiration.

Future fifth –year updates of the plan will include an up to date description of the planning process to include the steps taken to revise the plan document and how the community was involved. The implementation strategy will also be up-dated to identify who will be responsible for the new or revised actions, the time frame, and the funding sources.

Table 20-3- Plan Update Milestone and Timeline Estimates

Year	Implementation Milestone	Process
2019	• In 3rd quarter of 2019, complete FEMA-approval and local adoption process for the 2019 LHMP Update	
2020 (Year 1)	• Continue stakeholder update meetings • In 2nd quarter 2020, conduct annual review to solicit Core Planning Team and stakeholder assistance to document progress to date • Evaluate the 2019 LHMP Update utilizing the framework above and update the online LHMP with the new information • In 3rd quarter of 2020, apply for FEMA PDM planning grant to develop the 2024 LHMP Update	12 month process for receiving funding
2021 (Year 2)	• Continue stakeholder update meetings • In 2nd quarter 2021, conduct annual review • Evaluate and update the 2019 LHMP • In 3rd quarter of 2021, begin procurement process for consultant support to develop the 2024 LHMP Update	12 month process for procurement
2022 (Year 3)	• Continue stakeholder update meetings • In 2nd quarter 2021, conduct annual review • Evaluate and update the 2019 LHMP • In 3rd quarter of 2022, begin planning process to develop the 2024 LHMP Update	
2023 (Year 4)	• Continue Core Planning Team, stakeholder, and general public engagement as part of the planning process to develop the 2024 LHMP	18 month process for planning and contingency
2024 (Year 5)	• Submit updated LHMP to HI-EMA to begin review process by February 2024 • Continue stakeholder update meetings • In 3rd quarter of 2024, complete FEMA-approval and local adoption process for the 2024 LHMP Update	6 month review

20.2.4 Long-Term Plan Sustainability Recommendations

By far, the most significant mitigation action has been implemented as a result of the 2007 State law HRS 107 Part II, State Building Code and Design Standards. This law requires the State and counties to adopt life-safety codes such as the International Building Code, to result in disaster resistive design standards for the Honolulu Building Code. All State, county and private construction projects must comply.

The State Building Code shall include:

1) The latest edition of the state fire code as adopted by the state fire council;
2) The latest edition of the Uniform Plumbing Code, as copyrighted and published by the International Association of Plumbing and Mechanical Officials including its appendices;
3) The latest edition of the International Building Code, the International Residential Code, and the International Energy Conservation Code, as published by the International Code Council;
4) The National Electrical Code, as published by the National Fire Protection Association;
5) Hawaii design standards implementing the criteria pursuant to Act 5, Special Session Laws of Hawaii, 2005, as applicable to:
   A. Emergency shelters built to comply with hurricane resistant criteria, including enhanced hurricane protection areas capable of withstanding a five hundred-year hurricane event as well as other storms and natural hazards; and
   B. Essential government facilities requiring continuity of operations; and
6) Code provisions based on nationally published codes or standards that include, but are not limited to, residential and hurricane resistant standards related to loss mitigation standards in accordance with section 431P-12, elevator, mechanical, food and tsunami, existing buildings, and onsite sewage disposal.

Section 1206 of the Disaster Recovery Reform Act of 2018 authorizes FEMA to provide assistance to state and local governments for building code and floodplain management ordinance administration and enforcement. Since the State Building Code Council is unfunded, such federal assistance should be sought.

City departments with public facility responsibilities are the initiators of capital improvement and repair and maintenance projects at the City level. The lead agency can therefore function as a communication link and discussion forum for responsive planning and to recognize opportunities for mitigation projects that may acquire FEMA support, and thereby include hazard mitigation as an integral part of capital improvement planning.

Natural hazard disaster mitigation should become integrated into pre-existing planning efforts, such as the Oahu Development and Sustainable Community Plans. Currently, these plans tend to recognize changes due to development trends, but not necessarily the need to mitigate against natural hazard effects that may have great impact on community sustainability. Therefore, City action should be sought to require integration of the Pre-Disaster Mitigation Plan into existing County plan updates currently mandated under City Charter.

20.3 Update Outreach Activities

HI-EMA plans to team to conduct regular annual briefings with DEM, in order to stay updated on funding opportunities and requirements of NOAA and FEMA. As an aid to the Planning Committee, notes relating to FEMA conditions and rules for funding of hazard mitigation projects are included in the following section.

Other anticipated updates in the next 1 to 4 years would include:

- Public awareness community-based workshops and symposia.
- Start-up of any proposed mitigation and planning projects.
- Continuing project nomination opportunities for funding.

Public Outreach. The City & County of Honolulu will continue to hold interagency meetings and public workshops. For more grassroots involvement, the County has mentored a community outreach network, the Cross-Island Community Resilience Network, that serves two functions: 1) to prepare communities to respond to emergencies and 2) to serve as a two- way communication conduit between the community and County officials. This communication network functions during non-emergency periods as well as emergency periods. The mitigation plan will also be shared on the city's website along with appropriate contact information to ensure that stakeholders are able to engage and stay engaged in the program.

20.4 FEMA Funding Eligibility

The following list provides examples of activities that are NOT eligible for HMA funding:

- Projects that do not reduce the risk to people, homes, neighborhoods, structures, or infrastructure
- Projects that are dependent on another phase of a project(s) in order to be effective and/or feasible
- Projects for which actual physical work such as groundbreaking, demolition, or construction of a raised foundation has occurred prior to award
- Projects constructing new buildings or facilities with the exception of safe room construction and SRL mitigation reconstruction
- Projects that create revolving loan funds
- Activities required as a result of negligence or intentional actions, or the reimbursement of legal obligations such as those imposed by a legal settlement, court order, or State law
- Activities on Federal lands or associated with facilities owned by another Federal entity
- Major flood control projects related to the construction, demolition, or repair of dams, dikes, levees, floodwalls, seawalls, groins, jetties, breakwaters, and erosion projects related to beach nourishment or re-nourishment
- Projects for hazardous fuels reduction in excess of 2 miles from structures
- Projects that address unmet needs from a disaster that are not related to mitigation
- Retrofitting facilities primarily used for religious purposes, such as places of worship (or other projects that solely benefit religious organizations)
- Projects that only address man-made hazards

- Projects that address operation, deferred or future maintenance, repairs, or replacement (without a change in the level of protection provided) of existing structures, facilities, or infrastructure (e.g., dredging, debris removal, replacement of obsolete utility systems, bridges, and facility repair/rehabilitation
- Projects to do the following:
  - Landscaping for ornamentation (trees, shrubs, etc.)
  - Site remediation of hazardous materials (with the exception eligible activities such as, the abatement of asbestos and/or lead-based paint and the removal of household hazardous wastes to an approved landfill)
  - Water quality infrastructure
  - Address ecological or agricultural issues
  - Protection of the environment and/or watersheds
  - Forest management
  - Prescribed burning or clear-cutting
  - Creation and maintenance of fire breaks, access roads, or staging areas
  - Irrigation systems
- Mapping, flood studies, and planning activities, such as plan revisions/amendments or risk assessments, when they do not result in a FEMA-approved hazard mitigation plan
- Studies not directly related to the design and implementation of a proposed mitigation project
- Preparedness measures and response equipment (e.g., response training, electronic evacuation road signs, interoperable communications equipment)

The following activities are not eligible as stand-alone activities but are eligible only when included as a functional component of eligible mitigation activities:

- Real property or easements purchases required for the completion of an eligible mitigation project. For safe room projects, no real property or easement purchase is eligible
- Studies that are integral to the development and implementation of a mitigation project, including hydrologic and hydraulic, engineering, or drainage studies

Mitigation Projects Eligible for FEMA Grant Funding under one or more of the five HMA programs:

- Property Acquisition and Structure Demolition – The acquisition of an existing at-risk structure and, typically, the underlying land, and conversion of the land to open space through the demolition of the structure
- Property Acquisition and Structure Relocation – The physical relocation of an existing structure to an area outside of a hazard-prone area, such as the Special Flood Hazard Area (SFHA) or a regulatory erosion zone and, typically, the acquisition of the underlying land. The property must be deed-restricted in perpetuity to open space uses to restore and/or conserve the natural floodplain functions
- Structure Elevation – Physically raising an existing structure to an elevation at or above the Base Flood Elevation (BFE) or higher if required by FEMA or local ordinance
- Mitigation Reconstruction – The construction of an improved, elevated building on the same site where an existing building and/or foundation has been partially or completely demolished or destroyed. Mitigation reconstruction is only permitted if traditional structure

elevation cannot be implemented and for structures outside of the regulatory floodway or coastal high hazard area

- Dry Flood-proofing – Techniques applied to keep structures dry by sealing the structure to keep floodwaters out:
  - Dry Flood-proofing of Historic Residential Structures is permissible only when other techniques that would mitigate to the BFE would cause the structure to lose its status
  - Dry Flood-proofing of Non-residential Structures must be performed in accordance with NFIP Technical Bulletin 3-93, Non-Residential Flood-proofing—Requirements and Certification, and the requirements pertaining to dry flood-proofing of nonresidential structures found in 44 CFR Parts 60.3(b)(5) and (c)(4)
- Minor Localized Flood Reduction Projects – These projects may include the installation or modification of culverts and floodgates, minor floodwall systems that generally protect an individual structure or facility, storm-water management activities such as creating retention and detention basins, and the upgrade of culverts to bridges
- Structural Retrofitting of Existing Buildings – Modifications to the structural elements of a building to reduce or eliminate the risk of future damage and to protect inhabitants
- Emergency power generators:
  - PDM Program: Generators and/or related equipment purchases (e.g., generator hook-ups) are eligible when the generator directly relates to the hazards being mitigated and is part of a larger project.'
  - HMGP: A permanently installed generator that is a stand-alone project can be considered under regular HMGP funding if the generator protects a critical facility. Critical facilities may include police and fire stations, hospitals, and water and sewer treatment facilities. A generator that is a component of a larger project (e.g., elevation of a lift station) can also be funded under regular HMGP funding.
- Non-structural Retrofitting of Existing Buildings and Facilities – Modifications to the non-structural elements of a building or facility to reduce or eliminate the risk of future damage and to protect inhabitants
- Safe Room Construction – Safe room construction projects are designed to provide immediate live safety protection for people in public and private structures from severe wind events, including hurricanes. This type of project includes retrofits of existing facilities or new safe room
- Infrastructure Retrofit – Measures to reduce risk to existing utility systems, roads, and bridges
- Soil Stabilization – Projects to reduce risk to structures or infrastructure from erosion and landslides, including installing geo-textiles, sod stabilization, installing vegetative buffer strips, preserving mature vegetation, decreasing slope angles, and stabilizing with rip rap and other means of slope anchoring
- Wildfire Mitigation – Projects to mitigate the risk to at-risk structures and associated loss of life from the threat of future wildfire through:
  - Defensible Space for Wildfire – Projects creating perimeters around homes, structures, and critical facilities through the removal or reduction of flammable vegetation
  - Application of Ignition-resistant Construction – Projects that apply ignition-resistant techniques and/or non-combustible materials on new and existing homes, structures, and critical facilities

  - Hazardous Fuels Reduction – Projects that remove vegetative fuels proximate to the at-risk structure that, if ignited, pose significant threat to human life and property, especially critical facilities
- Post-Disaster Code Enforcement – Projects designed to support the post-disaster rebuilding effort by ensuring that sufficient expertise is on hand to ensure appropriate codes and standards, including NFIP local ordinance requirements, are utilized and enforced
- 5% Initiative Projects – These HMGP projects provide an opportunity to fund mitigation actions that are consistent with the goals and objectives of the State and local Hazard Mitigation Plans. Activities that might be funded under the 5% Initiative include:
  - The use, evaluation, and application of new, unproven mitigation techniques, technologies, methods, procedures, or products
  - Equipment and systems for the purpose of warning citizens of impending hazard
  - Purchase of generators or related equipment, such as generator hook-ups
  - Hazard identification or mapping and related equipment for the implementation of mitigation activities
  - Geographic Information System (GIS) software, hardware, and data acquisition whose primary aim is mitigation
  - Public awareness or education campaigns about mitigation
  - Evaluation of model building codes in support of future adoption and/or implementation



21. Glossary

21. GLOSSARY

Assets - Lives, buildings, utilities and transportation systems, cultural, social. . .

Benefit - Any increase in utility or well-being to an individual, group or society associated with an action or choice. Bounded from below by price. It is synonymous with value in economic theory. Benefits and costs are complementary - a cost is a negative benefit, since costs decrease well-being and benefits increase well-being.

Benefit/Cost Analysis - A systematic quantitative method of assessing the desirability of government projects or policies when it is important to take a long view of future effects and abroad view of possible side-effects. Benefit/cost analysis is recommended as the technique to use in a formal economic analysis of government programs or projects. (From OMB A-94)

Consequences - Damages (full or partial), injuries, and losses of life, property, environment, and business that can be quantified by some unit of measure, often in economic or financial terms.

Cost - Any reduction in utility or well-being to an individual, group or society associated with an action or choice.

Damage - Damage refers to physical destruction measured by physical indicators such as the number of deaths and injuries or the number of buildings destroyed.

Disaster - The impact of a natural event upon a vulnerable community resulting in disruption, damage, and casualties that cannot be relieved by the unaided capacity of locally-mobilized resources.

Disaster Management - The efficient use of resources to coordinate the processes of relief, recovery, and reconstruction.

Disaster Response - Activities occurring in the aftermath of a disaster which assist disaster victims and which rehabilitate or reconstruct damaged infrastructure.

Discount Rate - Discount rate is the interest rate used in calculating the present value of expected yearly benefits and costs. Net present value represents the discounted value of future benefits and costs. Discounting reflects the time value of money and the view that benefits and costs are worth more when they are experienced sooner. OMB determines the discount rate for analysis of federally funded projects.

Empirical - Relying on experience or observation, capable of being verified or disproved by observation or experiment.

Exposure - The number, types, qualities, and monetary values of various types of property or infrastructure and life that may be subject to an undesirable or injurious hazard event.

GIS - Geographic Information System. A computerized mapping system and tool that enables the visual display of geography to various scales linked with information, often from databases. For the purposes of hazard mitigation, the system allows planners to take information about a specific area, to overlay a hazard to see areas that might be impacted, and to develop actions to minimize the impacts.

Hazard - An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of harm or loss.

Hazard Mapping - The process of geographically establishing where natural hazards have a likelihood of occurrence.

Impacts - The impacts of a disaster include market-based and non market-based effects. Market-based impacts include destruction of property and a reduction in income and sales. Non-market effects include environmental consequences and psychological effects suffered by persons involved in a disaster.

Loss - Any reduction in value, or well-being to individuals, groups or society. A loss is a cost. Losses avoided are benefits.

> **Direct Losses** - Losses linked directly to a hazard event including all damages and employment losses due directly to the closure of damaged facilities.
>
> **Indirect Losses** - All losses other than direct losses. Indirect losses include economic losses due to dislocations in undamaged factories or commercial ventures, banking, and insurance as well as non financial losses such as loss of historical resources, pain, and suffering.

Mitigation - Actions taken to reduce or eliminate long-term risk to people and property from hazards and their effects. Mitigation activities contrast with short-term risk-reducing actions such as preparedness, response and recovery measures and risk spreading measures such as insurance.

Natural Hazard - The occurrence of a potentially damaging natural phenomenon.

Probable - Likely to occur; reasonably expected; realistic.

Probability and Frequency - A measure of how often an event is likely to occur. Frequency can be expressed as the average time between occurrences or exceedances (non-exceedances) of an event or the percent chance or probability of the event occurring or being exceeded (not exceeded) in a given year or a longer time period.

Relief - Attention to immediate and basic needs of disaster survivors. These needs include food, clothing, shelter, and medical or emotional care. In the case of fast-impact disasters such as floods, earthquakes or cyclones, this process is directed at saving lives and alleviating further suffering.

Risk - Potential losses associated with a hazard, defined in terms of expected probability and frequency, exposure, and consequences. Risk is therefore the product of specific risk and elements at risk; the convolution of the probability hazard, vulnerability (or fragility), and asset exposure.

Risk Assessment - A process or method for evaluating risk associated with a specific hazard and defined in terms of probability and frequency of occurrence, magnitude and severity, exposure, and consequences.

Vulnerability - The susceptibility to physical injury, harm, damage, or economic loss.

List of Acronyms

AAL	Average Annualized Loss
ADCIRC	ADvanced CIRCulation model for coastal ocean hydrodynamics
ADT	Average Daily Traffic
AELR	Annualized Earthquake Loss Ratio
ALR	Average Annualized Loss Ratio
AMBER	Areal Mean Basin Estimated Rainfall
ASCE	American Society of Civil Engineers
ASTM	American Society of Testing and Materials
ATWC	Alaska Tsunami Warning Center
BCA	Benefit Cost Analysis
BFE	Base Flood Elevations
BID	Building Inventory Database
BNLR	Board of Natural and Land and Resources
BWS	Board of Water Supply
CAP-SSSE	Community Assistance Program – State Support Service Element
CAV	Community Assistance Visit
CDD	Civil Defense Division (Department of Defense)
CDUP	Conservation District Use Permit
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFM	Certified Floodplain Manager
CIP	Campbell Industrial Park
CLEAN	Campbell Local Emergency Action Network
CLOMR	Conditional Letters of Map Revisions
COAMPS	Ocean/Atmosphere Mesoscale Prediction System
CRS	Community Rating System
CWRM	State Commission on Water Resource Management
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act (National)
CZMP	Coastal Zone Management Program (Hawaii)
DAGS	Department of Accounting and General Services
DAGS DPW	Department of Accounting and General Services, Division of Public Works
DBEDT	Department of Business Economic Development and Tourism
DCCA	Department of Commerce and Consumer Affairs
DCS	Distributed Control Systems
DEM	Department of Emergency Management (formerly Oahu Civil Defense Agency)
DFIRM	Digital Flood Insurance Rate Maps
DHHL	Department of Hawaiian Home Lands
DHR	Department of Human Resources
DLNR	Department of Land and Natural Resources

DOA	Department of Agriculture
DOE	Department of Education
DOFAW	Division of Forestry and Wildlife, Department of Land and Natural Resources
DOH	Department of Health
DOT	Department of Transportation
DP	Development Plan (or Sustainable Community Plan)
DPP	Department of Permitting and Planning, City & County of Honolulu
DSP	Dam Safety Program (Hawaii or National)
EA	Environmental Assessment
EAP	Emergency Action Plan
EC	Elevation Certificates
EERI	Earthquake Engineering Research Institute
EIS	Environmental Impact Statement
EOP	Emergency Operations Plan
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPGA	Effective Peak Ground Acceleration
ESRI	Environmental Systems Research Institute
EST	Empirical Simulation Technique
EWC	East-West Center
FEMA	Federal Emergency Management Agency
FFG	Flash Flood Guidance
FHAT	Flood Hazard Assessment Tool
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Studies
FMAP	Flood Mitigation Assistance Program
FNMOC	Fleet Numerical Meteorology and Oceanography Center
GDAS	Global Data Assimilation System
GFDL	Geophysical Fluid Dynamics Laboratory
GFS	Global Forecast System
GIS	Geographic Information Systems
GPS	Global Positioning Systems
GSF	Gross Square Feet
HAR	Hawaii Administrative Rules
HARNG	Hawaii Air National Guard
HAZMAT	Hazardous Materials
HAZUS	Hazards U.S.
HAZUS MH	Hazards United States Multi-Hazards
HDC	Hawaii Drought Council
HDOT	Hawaii Department of Transportation

HDP	Hawaii Drought Plan
HECO	Hawaiian Electric Company
HEER	Hazard Evaluation and Emergency Response
HEPCRA	Hawai‘i Emergency Planning and Community Right to Know Act
HFD	Honolulu Fire Department
HFO	Honolulu Forecast Office
HGMP	Hazard Mitigation Grant Program
HHRF	Hawaii Hurricane Relief Fund.
HIGICC	Hawaii Geographic Information Coordinating Council
HLEM	Hurricane Loss Estimation Model
HMA	Hazard Mitigation Assistance
HMPG	Hazard Mitigation Grant Program
HMS	Multi-Hazard Mitigation Strategy
HPD	Honolulu Police Department
HRS	Hawaii Revised Statutes
HSEAC	Hawaii State Earthquake Advisory Committee
HSERC	Hawaii State Emergency Response Commission
HSHAC	Hawaii State Hurricane Advisory Committee
HTA	Hawaii Tourism Authority
HUD	Housing and Urban Development
HVO	Hawaii Volcano Observatory (USGS)
IBC	International Building Code
ICC	Increased Cost of Compliance
ICG	Intergovernmental Coordination Group
IIS	Interagency and International Services
IOC	Intergovernmental Oceanographic Commission
JTWC	Joint Typhoon Warning Center
LEPC	Local Emergency Planning Committee
LHMC	Local Hazard Mitigation Committee
LIDAR	Light Detection and Ranging
LOMR	Letters of Map Revisions
LUO	Land Use Ordinance (Honolulu’s zoning code)
MCE	Maximum Considered (Credible) Earthquake
MDE	Maximum Design Earthquake
MHPCC	Maui High Performance Computer Center
MMI	Modified Mercalli Intensities
MSAC	Multi-Hazard Science Advisory Committee
MWFRS	Main Wind Force Resisting System
NASA	National Aeronautics and Space Administration
NAVOCEANO	Naval Oceanographic Office
NCDC	National Climatic Data Center

NCEP	National Centers for Environmental Prediction
NCH	Nature Conservancy of Hawaii
NCSS	National Cooperative Soil Survey
NCTAMS	Naval Computer and Telecommunication Area Master Station
NDMC	National Drought Mitigation Center
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NFDRS	National Fire Danger Rating System
NFIP	National Flood Insurance Program
NMOC	Naval Meteorology and Oceanography Command
NOAA	National Oceanic and Atmospheric Administration
NOGAPS	Navy Operational Global Atmospheric Prediction System
NPL	National Priority List
NPS	National Park Service
NWCC	National Weather and Climate Center
NWR	NOAA Weather Radio
NWS	National Weather Service
NWW3	Wavewatch III (NOAA)
OHMPC	Oahu Hazard Mitigation Planning Committee
OMPO	Oahu Metropolitan Planning Organization
OP	Office of Planning (DBEDT)
ORTP	Oahu Regional Transportation Plan
PA/SI	Preliminary Assessment / Site Inspection
PAO	Pacific Area Office (FEMA)
PDC	Pacific Disaster Center
PDM	Pre-Disaster Mitigation
PDSI	Palmer Drought Severity Index
PGA	Peak Ground Acceleration
PIM	Public Infrastructure Map
PMEL	Pacific Marine Environmental Laboratory
PSC	Pacific Service Center
PSDI	Palmer Drought Severity Index
PTWC	Pacific Tsunami Warning Center
PUC	Primary Urban Center
PUC	Public Utilities Commission
PWS	Public Water System
RACES	Radio Amateur Civil Emergency Services
RCFP	Rural Community Fire Protection
RCUH	Research Corporation of the University of Hawaii
RFPC	Rural Fire Protection and Control
RPM	Remedial Project Manager(s)

RVA	Risk and Vulnerability Assessment
SARA	Superfund Amendments and Reauthorization Act
SCD	State Civil Defense
SCP	Sustainable Community Plan (or Development Plan)
SDAR	Site Discovery, Assessment and Remediation
SDC	Seismic Design Category
SDF	Special Direct Facility
SEAOH	Structural Engineers Association of Hawaii
SFHA	Special Flood Hazard Area
SHOALS	Scanning Hydrographic Operational Airborne Lidar System
SHPD	State Historic Preservation Division
SMA	Special Management Area
SOEST	School of Ocean and Earth Sciences and Technology (University of Hawaii)
SOSC	State On Scene Coordinator(s)
SPI	Standardized Precipitation Index
SPM	Shore Protection Manual (prediction technique)
SRL	Severe Repetitive Loss
SRP	Site Rehabilitation Prioritization
SSURGO	Soil Survey Geography
SSRI	Social Science Research Institute (University of Hawaii)
STAPLEE	Social, Technical, Administrative, Political, Legal, Economical, Environmental
STIP	Statewide Transportation Improvement Program
TIP	Transportation Improvement Program
TSDN	Technical Support Data Notebook
UBC	Uniform Building Code
UH	University of Hawaii
UHM	University of Hawaii - Manoa
USACE	United States Army Corps of Engineers
USARPAC	United States Army Pacific
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
VOAD	Voluntary Organizations Active in Disasters
VOG	Volcano Gas
VRP	Voluntary Response Program
WAM	Wave Model
WERC	Wind Engineering Research Council
WMD	Weapons of Mass Destruction
WMD NBC	Weapons of Mass Destruction - Nuclear, Biological, or Chemical



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