STATE OF HAWAII
DEPARTMENT OF DEFENSE
CIVIL DEFENSE DIVISION
OFFICE OF THE DIRECTOR OF CIVIL DEFENSE
3949 DIAMOND HEAD ROAD
HONOLULU, Hawaii 9616-4495

State of Hawai‘i Multi-Hazard Mitigation Plan 2013 Update

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Prepared By

Martin & Chock, Inc.
1132 Bishop Street, Suite 1550
Honolulu, Hawaii 96813

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Hawaiʻi State Civil Defense
Disaster Assistance Branch
Homeland Security Branch
Plans and Operations Branch
Recovery Branch
Special Planning Staff
Telecommunications Branch
Training, Education and Information Branch

Hawaiʻi County Civil Defense

Kauaʻi County Civil Defense

Maui County Civil Defense

City & County of Honolulu Department of Emergency Management

Hawaiʻi State Hazard Mitigation Forum

Hawaiʻi State Earthquake Advisory Committee (HSEAC)

State of Hawaiʻi Drought Council

State of Hawaiʻi Building Code Council

Hawai‘i State Department of Business, Economic Development & Tourism, Office of Planning
Managers
Coastal Zone Management Staff Planners
Land Use Planners

Hawai‘i State Land Use Commission

Hawai‘i State Department of Land & Natural Resources
Office of Conservation & Coastal Lands Program
Division of Forestry & Wildlife
Commission on Water Resource Management

Hawai‘i State Department of Education

Hawai‘i State Department of Transportation

Hawai‘i State Department of Accounting & General Services

Hawai‘i State Department of Health

Honolulu Board of Water Supply

University of Hawai‘i
School of Engineering
School of Ocean, Earth Sciences & Technology
Hawai‘i Coastal Geology Group
University of Hawai‘i Sea Grant
Center for the Study of Active Volcanoes

City & County of Honolulu

County of Hawai‘i

County of Kaua‘i

County of Maui

US Army Corps of Engineers

US Geological Survey (USGS)
Hawaiian Volcano Observatory

NOAA National Weather Service
Pacific ENSO Applications Center

International Tsunami Information Centre, UNESCO (hosted by NOAA NWS)
NOAA Pacific Services Center

FEMA Region IX Pacific Area Office

Pacific Regional Integrated Sciences and Assessment (Pacific RISA)

Pacific Disaster Center

Hawai‘i Wildfire Management Organization

State THIRA Working Group Participants
Points of Contact:

Hawai‘i THIRA POC: Vern Miyagi
Hawai‘i SPR POC: Delores Cook
THIRA Technical Consultant: Gary Chock

Name	State/Fed Agency
Mayne, Doug	State Civil Defense (SCD)
Miyagi, Vern T.	SCD
Gustafson, Vic	SCD
Burnett, George	SCD
Greenly, Gary	SCD
Tengan, Danny	SCD
Richards, Kevin	SCD
Yoshimura, Steve	SCD
Kunishige, Shelly	SCD
Okamura, Havinne	SCD
Cook Delores	State Department of Defense (DOD)
Anthony, Charles	DOD
Kishi, Arnold	Department of Accounting and General Services (DAGS -ICSD)
Thirugnanam, Jeyan	DAGS
Low, Todd	Agriculture
Lutz, Maria	American Red Cross (ARC)
Clairmont, Toby	Health Care Association of Hawai‘i (HAH)
Vincent, Mike	Attorney General (AG)
Scott, Mitchem	Department of Homeland Security (DHS) Risk Management Division
Want, Mark	Department of Business, Economic Development, and Tourism (DBEDT)
Toy, Ed COL	Hawai‘i National Guard (HING)
Hioki, Reynold LTC (T)	HING Chief Information Officer (CIO)
Okamura, Lance LTC	HING Civil Support Team (CST)
Flynn, William MAJ	HING CBRNE Enhanced Response Force Package (CERFP)
Park, Sarah Dr	Department of Health (DOH)
Kawaoka, Keith	DOH
Redulla, Jason	Department of Land and Natural Resources (DLNR)
Butay, Jade	Department of Transportation (DOT)
Antoque, Dane	HING Joint Director of Military Support
Lau, Robin (LTC)	HING
Ishimura, Darren	Hawaiian Electric Company (HECO)
Toussant, Clarence	U. S. Army Pacific Defense Coordinating Element Hawai‘i (USARPAC DCE-HI)
Marhoffer, William	U. S. Coast Guard (USCG)

County THIRA Working Group Participants

Name	County Agency
City & County of Honolulu	
Kaku, Melvin N	Department of Emergency Services
Hirai, Peter J.S.	Department of Emergency Services
Van Beelen, Crystal	Department of Emergency Services
Epstein, Paul	Honolulu Police Department
Kaneshiro, Gerald	Honolulu Police Department
Yoshioka, Wayne	Department of Transportation Services
Chambers, Courtney	Emergency Services Department
Ogawa, Garrett	Department of Facility Maintenance
Kam, Clarice	Department of Facility Maintenance
Abelaye, Sandra	Department of Transportation Services
Alameda, Nate	Honolulu Fire Department
Farris, Jeff	Honolulu Fire Department
County of Kaua‘i	
Marshall, Mark	Kaua‘i County Civil Defense Agency (KCDA)
Ushio, Elton	KCDA
Tawc, Chelsie	KCDA
Daligdig, Ted	KCDA
Blanc, Sarah	Mayor’s Office
Nuland-Ames, Linda	Mayor’s Office
Motta, Sally	Department of Finance
Asher, Roy	Kaua‘i Police Department (KPD)
Contrades, Michael	KPD
Takamura, Jon	KPD
Tabata, Lyle	Department of Public Works
Fujimoto, Donald	Department of Public Works -Environmental Services
Dill, Larry	Department of Public Works
Carvalho, Kaleo	Transportation Agency
Mahikou, Celia	Transportation Agency
Eddy, William	Department of Water
Cobb-Adams	Housing Agency
Takahashi, Kealoha	Office of Elderly Affairs
Westerman, Robert	Kaua‘i Fire Department
Carddock, David	State Department of Education
County of Hawai‘i	
Fuata, Ben	Hawai‘i County Civil Defense Agency
Drummond, John	Hawai‘i County Civil Defense Agency
Arbles, Aaron	Hawai‘i County Fire Department
Okamoto, Keith	Department of Water Supply
Ikeda, Daryl	Department of Water Supply
Gonsalves, Robert	Department of Environmental Management – Solid Waste Division
Parker, Alan	Office of Aging
Ishii, Ben	Department of Public Works - Engineering
Tsuchiya, Bert	Department of Information Technology
Weber, Larry	Hawai‘i County Police Department
Hanson, Bill	
Hosaka, Duane	

County of Maui

Foust, Anna	Maui Civil Defense Agency
Geers, Michael J.	Maui Civil Defense Agency
Collum, Robert	Maui Civil Defense Agency
Buika, Jim	Maui Planning Department
Nishimoto, Marc	Maui District Health Office
Pyland, Shannan	American Red Cross
Martin, Val	Maui Fire Department
Miyahira, Gail	Maui Memorial Medical Center

State Hazard Mitigation Forum Members

Name	Affiliation
Buika, James	Maui - Planning
Chock, Gary*	Martin & Chock, Inc.
Fujii, Neal	DLNR – Drought/Water Cons Coordinator
Haigh, Doug	Kaua‘i - DPW
Hamnett, Mike Dr.	RCUH
Hiu, Timothy	DPP – Honolulu
Kawata, Erwin	Board of Water Supply – Program Administrator
Keolanui, Stan	U. S. Army Corps of Engineers – Emergency Management
Kong, Laura Dr.*	NWS/International Tsunami Info Center
Matsuda, Edwin	DLNR – Flood Control/Dam Safety
Ogata-Deal, Ann*	State Office of Planning – Coastal Zone Management
Cantin, Michael	NWS/Honolulu Forecast Office
Thomas, Don Dr.*	Center for Study – Active Volcanoes – UH
Kaanoi Clemente	HECO
Thomas Payne	Chaminade University
Jody Galinato	Kaua‘i County

* - also members of Hawai‘i State Earthquake Committee (HSEAC)

Ex Officio Participants (non-voting):

Mayne, Doug	State Civil Defense (SCD) – Vice Director
Miyagi, Vern	SCD – Executive Officer
Kanda, Larry	SCD-HAZMAT Advisor (Prior HAZMAT Officer)
Duncan, Ian	SCD-HAZMAT Officer
Okamura, Havinne	SCD-Mitigation Planner
Kaku, Mel	CC of Honolulu Dept of Emergency Management – Director

Technical Author of the Plan

Gary Chock, S.E.
Martin & Chock, Inc.
1132 Bishop Street Suite 1550
Honolulu, HI 96813

State Disaster Resiliency Strategy Workshop Participants

Group Description	Last Name	First	Agency / Company
Hurricanes and Floods	Agawa	Darron	DLNR
THIRA Implementation	Andie	John	Hawai‘i National Guard
Recovery and Macro-Economic Effects	Antoque	Dane	HING Joint Director of Military Support
Land Use and Building Requirements	Atta	George	Honolulu Dept. of Planning and Permitting
Recovery and Macro-Economic Effects	Black	Tom	VeriClaim Inc.
Health Vulnerability and Risk	Brennan	Barry	CTAHR UH Extension Agrosecurity Coordinator
Recovery and Macro-Economic Effects	Brewbaker	Paul	Council of Economic Advisors, TZ Economics
Land Use and Building Requirements	Buika	Jim	County of Maui Planning Department
Infrastructure Resilience	Bullock	Darren	USCG Port Security Specialist
Climate Change Adaptation	Burke	James	NDPTC
Infrastructure Resilience	Butay	Jade	Dept. of Transportation (DOT)
THIRA Implementation	Chatman	Andrea	Pacific Disaster Center
Drought and Wildfires	Ching	Wayne	DOFAW
Tsunami and Earthquake	Chock	Gary	Martin & Chock, Inc.
Health Vulnerability and Risk	Clairmont	Toby	Health Care Association of Hawai‘i (HAH)
Infrastructure Resilience	Clemente	Kaanoi	HECO Transmission and Distribution Initiatives
Recovery and Macro-Economic Effects	Colllum	Robert	Maui Civil Defense Agency
Infrastructure Resilience	Contreras	Michael	Hawaiian Telecom
Recovery and Macro-Economic Effects	Costa	George	County of Kaua‘i Office of Economic Development
Health Vulnerability and Risk	Crabtree	Chris	Health Care Association of Hawai‘i (HAH)
Hurricanes and Floods	DeJesus	Vic	Central Pacific Hurricane Center
THIRA Implementation	Duncan	Ian	State Civil Defense State Hazard Mitigation Officer
Climate Change Adaptation	Eversole	Dolan	UH Sea Grant College
Land Use and Building Requirements	Fernandez	Orasa	DOE Safety Branch
Infrastructure Resilience	Fisher	Elizabeth	USDOT FHWA Hawai'i
Hurricanes and Floods	Foster	Matt	Central Pacific Hurricane Center
Tsunami and Earthquake	Fryer	Gerard	Pacific Tsunami Warning Center
Health Vulnerability and Risk	Frye	John	Pacific Command
Drought and Wildfires	Fujii	Neal	DLNR Drought Coordinator
Infrastructure Resilience	Fukumoto	Gary	HECO Director of Planning and Design

Group Description	Last Name	First	Agency / Company
Recovery and Macro-Economic Effects	Golojuch	Michael	Honolulu Budget and Fiscal Services
Recovery and Macro-Economic Effects	Greenley	Julie	Pacific Disaster Center
THIRA Implementation	Gustafson	Vic	Hawai‘i State Civil Defense
Climate Change Adaptation	Hamnett	Mike	RCUH
THIRA Implementation	Hirai	Peter	Honolulu Dept. of Emergency Services
Land Use and Building Requirements	Hiu	Tim	Honolulu Dept. of Planning and Permitting - Acting Chief
Land Use and Building Requirements	Hwang	Dennis	Reinwald O'Connor & Playdon LLP
THIRA Implementation	Jones	Tyler	Pacific Command
Infrastructure Resilience	Kawata	Erwin	Honolulu Board of Water Supply
Health Vulnerability and Risk	Kern	Judy	Dept.of Health (DOH) Disease Outbreak Control Division
Land Use and Building Requirements	Kobayashi	Jason	DOE Safety Branch
Tsunami and Earthquake	Kong	Laura	International Tsunami Information Center
Infrastructure Resilience	Luke	Carter	Hawai‘i Dept. of Transportation Harbors Division Engineering Program Branch
Recovery and Macro-Economic Effects	Lutz	Maria	American Red Cross
THIRA Implementation	Lyman	Robert	Colonel, USARPAC DCO
Hurricanes and Floods	Matsuda	Edwin	DLNR Flood Control and Dam Safety Section
THIRA Implementation	Mayne	Doug	Hawai‘i State Civil Defense Vice Director
THIRA Implementation	Miyagi	Vern	Hawai‘i State Civil Defense Executive Officer
Climate Change Adaptation	Morrison	Nathalie	Office of State Planning
Recovery and Macro-Economic Effects	Nagata	Pamela	Honolulu Department of Emergency Management
Land Use and Building Requirements	Ogata-Deal	Ann	Dept. of Business, Economic Development & Tourism
THIRA Implementation	Okamura	Havinne	State Civil Defense
Recovery and Macro-Economic Effects	Pacheco	Zac	American Savings Bank Business Continuity Coordinator
Health Vulnerability and Risk	Park	Sarah	Dept. of Health (DOH)
Recovery and Macro-Economic Effects	Peralta	Ryan	City and County of Honolulu
Infrastructure Resilience	Ratte	Marc	MECO
Tsunami and Earthquake	Richards	Kevin	Hawai‘i State Civil Defense

Group Description	Last Name	First	Agency / Company
Tsunami and Earthquake	Robertson	Ian	Dept. of Civil and Environmental Engineering, UHM
Land Use and Building Requirements	Sakai	Susan	Belt Collins Hawai‘i Ltd.
Infrastructure Resilience	Sakakida	Gareth	Hawai‘i Transportation Association Managing Director
Infrastructure Resilience	Santo	Paul	Dept. of Transportation (DOT) Highways Division Design Branch
THIRA Implementation	Sato	Alvin	Hawai‘i National Guard
Recovery and Macro-Economic Effects	Shibata	Mike	Central Pacific Bank
Hurricanes and Floods	Shieh	Owen	Joint Typhoon Warning Center
Recovery and Macro-Economic Effects	Tamura	Marsha	State Civil Defense Citizen Corps Coordinator
Tsunami and Earthquake	Thomas	Don	Center for Study – Active Volcanoes – UHH
Recovery and Macro-Economic Effects	Toy	Ed	Colonel, Hawai‘i National Guard
Recovery and Macro-Economic Effects	Trombley	Ray	Bank of Hawai‘i Hawai‘i First for Continuity
Recovery and Macro-Economic Effects	Turcan	Jaroslav	American Savings Bank Business Continuity Coordinator
Recovery and Macro-Economic Effects	Uchima	Brian	First Insurance Company of Hawai‘i Senior Risk Control Consultant
THIRA Implementation	Uson	Joe	Homeland Defense Program Manager, PACOM
Tsunami and Earthquake	Van Beelen	Crystal	Honolulu Dept. of Emergency Services
Land Use and Building Requirements	Vincent	Mike	Dept. of the Attorney General
Infrastructure Resilience	Want	Mark	Dept. of Business, Economic Development, and Tourism

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

Executive Summary

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Executive Summary

Introduction to the State Hazard Mitigation Plan

Authorized by §322 of the Robert T. Stafford Act as amended by §104 of the Disaster Mitigation Act of 2000 (DMA 2000), 44 CFR Part 201, Hazard Mitigation Planning, establishes criteria for developing state and local hazard mitigation plans. This act required states and counties to have approved hazard mitigation plans to receive Pre-Disaster Mitigation funding. The Standard State Hazard Mitigation Plan is also required for non-emergency assistance provided under the Stafford Act, including Public Assistance restoration of damaged facilities and the Hazard Mitigation Grant Program. The development of state and local hazard mitigation plans is critical for maintaining eligibility for future Federal Emergency Management Agency (FEMA) mitigation and disaster recovery funding.

The State of Hawai‘i’s Multi-Hazard Mitigation Plan was originally approved on October 27, 2004, and the update in 2010 was approved on October 4, 2010. DMA 2000 requires that the state plan is updated every five years to maintain eligibility for disaster assistance. Local county mitigation plans must be updated every five years. The 2013 State plan utilized the prior efforts of the counties in preparing local mitigation plans as well as state, federal, nongovernmental organizations in the State of Hawai‘i Threat Identification and Risk Assessment of 2012. The State assembled a broad base of stakeholders in a State Disaster Resiliency Strategy Workshop to identify and prioritize disaster mitigation actions and recommended policies. In addition, the State plan references several specific state agency mitigation plans, such as the flood mitigation plan and the drought mitigation plan.

State of Hawai‘i Commitment to Multi-Hazard Mitigation Planning

The State of Hawai‘i is committed to a long-term strategy for reducing the risks of natural hazards. Hawai‘i State has experienced a range of climate and hydrological hazards, seismic and geological hazards, and technological hazards that have resulted in great costs to lives, property, and the economy of the state. In response to disaster experiences, the state developed a framework and an ongoing process for hazard mitigation throughout the state. Hazard mitigation refers to *actions and measures taken before an emergency occurs and includes any activity to reduce the impacts from a disaster*. The purpose of a hazard mitigation plan is to protect lives and property from loss and destruction during a natural hazard. Hazard mitigation helps to maintain the quality of life by reducing the immediate costs of response and recovery to hazards and long-term costs to the economy.

By conceptualizing hazard mitigation in a disaster risk reduction framework towards achieving community disaster resilience, the state can reduce the cost and extent of disasters by addressing the underlying risks. The better we can understand the hazard threat in relation to the sensitivity of people and key sectors to the hazard, the greater likelihood of preventing disaster. To reduce disaster risks in the State requires an integrated, multi-level, multi-sector, collaborative approach to risk reduction with additional emphasis on building community resilience.

Development of the State's Mitigation Planning Process

The Disaster Mitigation Act of 2000 required local mitigation plans to be developed prior to the development of the standard state plan. Because the State recognizes the importance of the roles that the county governments play in enacting programs at the local level, the State Civil Defense supported the development of county plans as well as drafted the state's hazard mitigation plan. SCD mitigation staff, forum members, and associates travelled to the neighboring islands providing information, research, and technical assistance. In each county, the executive branch and the civil defense agency convened steering and technical advisory committees, or "disaster mitigation committees," and invited partners to participate in planning and mitigation activities. Through a series of committee meetings, the planning teams conducted briefings on hazard mitigation and on the development of a risk and vulnerability assessment and a hazard mitigation plan. Relationships established with the private sector have been critical to sustaining efforts in hazard reduction. As the information flow increased among the committees and planning teams, the process improved and the assessment and strategy became better informed.

The Civil Defense Administrators presented discussions about hazard mitigation and the goals of hazard mitigation planning programs to community groups and local organizations. The counties invited the general public to participate in the hazard mitigation planning processes through standardized surveys.

As awareness increased throughout the counties, it became easier to develop the hazard mitigation plans. The state-level planning process benefited from the county planning processes. Since the State retains the responsibility to ensure the viability and recovery of the entire state in any disaster, the best strategy has been to build the state planning process through partnerships, networks, and local mitigation enhancements. Besides the interaction of the state and counties in the SHMF, the State of Hawai‘i Multi-Hazard Mitigation Plan reflects the developments at the county level.

Public awareness and education programs have continued through members of the Forum and of the advisory committees, who have used their influence and assignments in their agencies and organizations to extend the hazard mitigation information. For example, the Hawai‘i Coastal Zone Management Program produced hazard mitigation guides and other materials to distribute at community fairs and public events, and the UH SeaGrant College has published updated editions of the Homeowner's Handbook to Prepare for Natural Hazards. In addition to producing materials to educate the general public, the UH Center for the Study of Active Volcanoes developed educational materials and curriculum for summer science courses to train teachers, which further extended the reach of mitigation work to youth in Hawai‘i. NOAA National Weather Service and other federal agencies participated in an array of activities annually to

educate the general public and engaged in training exercises to improve capacity for disaster response and mitigation. NOAA also developed an assessment tool for tsunami risks available on the web for use by the general public. Many SHMF members extend their reach through agency activities and further collaborated in public opportunities for hazard mitigation through public awareness and education.

The THIRA 2012 process was very instrumental in engaging stakeholders in a holistic process towards encouraging a convergence towards disaster resilience. The State determined that it would be more appropriate for the Hawai‘i THIRA to be based on county THIRA workshops of local stakeholders that preceded the workshops of the state stakeholder groups. THIRA was also performance-based to the extent that achieving Core Capability Targets in fact represents attaining multi-hazard resilience for disaster and threat prevention, protection, mitigation, response, and recovery, and required holistic awareness of the total impacts of disasters to the 31 Core Capabilities that communities depend on during all types of disasters. Per DHS, the THIRA process was also to be used in follow-on vulnerability analysis, and be incorporated into the jurisdiction's Hazard Mitigation Plan. The 2012 Threat Identification and Risk Assessment and State Preparedness Report identified gaps in Core Capabilities that largely influence disaster outcomes in the Planning, Mitigation, Response, and Recovery Missions. Thus, in 2012, THIRA became the major effort of the State in re-invigorating strategic thinking of what is necessary to achieve disaster resilience and preparedness. A comprehensive evaluation of state preparedness was also conducted. It is also significant from many earlier efforts in that the principal participants were the agencies and organizations responsible for performing these essential Missions themselves, rather than just planners and advisory groups of experts.

2013 Mitigation Plan Update Process

The 2013 update relies on extensive input from experts representing County, State, and Federal government agencies. Research and updates have been included from university researchers, private engineers and planners, hazard advisory committees, professional associations, public information officers, and regional organizations. This update further assesses gaps that have been realized and lessons learned in disaster risk management as a result of the disasters in Hawai‘i and in other places, such as the 2009 tsunami in Samoa and the Great East Japan Earthquake and Tsunami of 2011, Hurricane Katrina, and Pacific Islands coastal communities' sea level rise and climate impacts. By learning lessons and applying them to risk management in Hawai‘i, the State will strengthen its risk reduction practices.

Although State Civil Defense assistance with the local mitigation planning processes were ongoing during the three years preceding this 2013 plan, the state mitigation plan update process officially began in August 2012, with initial discussions on the strategy to update the plan taking place at State Civil Defense on reconvening the State Hazard Mitigation Forum (SHMF) towards being more actively involved in the development of the state hazard mitigation plan.

The SCD and its SHMF members coordinated the strategy for developing the update process. In previous plan updates, the State worked in concert with the four Counties and the county local mitigation plans became the foundation for the state plan. In addition, an evaluation of the 2010 mitigation plan was conducted. The evaluation provided documentation about the value of the

plan and changes needed in the plan for the 2013 update. In the course of the evaluation, SCD engaged SHMF and advisory committee members for plan review and to make recommendations for the update. In addition, SCD mitigation staff, and SHMF and advisory committee members were able to recommend experts in areas of the plan within their organizations be consulted on the plan update. As a result, experts in beach erosion and shoreline management, climate variability and change, structural analyses, land use, and state infrastructure were consulted as knowledgeable experts. The evaluation respondents found that the mitigation plan was most useful for identifying and prioritizing mitigation actions, but that the plan should be re-organized for greater clarity and better coordination with the county hazard mitigation plans.

Numerous individuals from these advisory committees, agencies, and organizations spent their time reviewing the plan and they provided detailed information for revisions based on their expertise. The Office of Planning conducted a coordinated review through its programs and associations, with the Director verifying the updated information before authorizing release of the updated information. The State Drought Coordinator in the Department of Land and Natural Resources Commission on Water Resource Management worked with experts in another DLNR division (Forestry & Wildlife), at the Honolulu Board of Water Supply, and the Hawai‘i Wildlife Management Organization to provide a detailed and coordinated document recommending revisions. Because the leadership and structure of agencies and organizations vary, the formality with which information was provided varied; yet, there was significant input in the plan based on extensive knowledge.

The following State agencies provided significant input into the revision of the plan by reviewing sections pertaining to their mandates and their knowledge. These include: Hawai‘i State Civil Defense; Hawai‘i County Civil Defense; Kaua‘i County Civil Defense; Maui County Civil Defense; City & County of Honolulu Department of Emergency Management; the Hawai‘i State Hazard Mitigation Forum; the Hawai‘i State Earthquake Advisory Committee (HSEAC); the Hawai‘i State Hurricane Advisory Committee (HSHAC); the State of Hawai‘i Drought Council; the State of Hawai‘i Building Code Council; Hawai‘i State Land Use Commission; the Hawai‘i State Department of Business, Economic Development & Tourism, Office of Planning; Hawai‘i State Land Use Commission; Hawai‘i State Department of Land & Natural Resources; Hawai‘i State Department of Education; Hawai‘i State Department of Transportation; Hawai‘i State Department of Accounting & General Services; Hawai‘i State Department of Defense; Hawai‘i State Department of Health; Hawai‘i State Department of Agriculture; University of Hawai‘i (School of Ocean, Earth Sciences & Technology, Hawai‘i Coastal Geology Group, UH Sea Grant, UH Social Science Research Institute); Martin & Chock, Inc.; US Army Corps of Engineers; US Geological Survey (USGS); NOAA Integrated Data for Environmental Applications (IDEA) Center; NOAA National Weather Service; the Pacific ENSO Applications Center; the International Tsunami Information Centre; NOAA Pacific Services Center; FEMA Region IX Pacific Area Office; the Pacific Risk Management ‘Ohana (PRiMO); the Pacific Disaster Center; the East-West Center; and, the Pacific Regional Integrated Sciences and Assessment (Pacific RISA). (See full listing in the acknowledgements section.)

On August 22, 2012, the State Hazard Mitigation Forum convened to discuss the plan update. The intent of the meeting was to discuss the elements of the updated plan and to make recommendations consistent with plan requirements as specified by FEMA. In addition and at the direction of SCD, the SHMF members reviewed the goals and objectives for hazard

mitigation in the State and recommended to SCD that the goals and objectives currently meet the mitigation strategy of the State. The SHMF members also reviewed the results of the State Disaster Resilience Strategy Workshop that recommended priorities for mitigation actions and policies in the State of Hawai‘i and to the reduction of risks identified in the mitigation actions.

Several members from the hazard mitigation community at large presented brief descriptions of proposed projects and the contribution that these projects will make to mitigation. Several projects have been submitted because they make significant contributions to hazard reduction, but they may not be specifically targeted for FEMA Hazard Mitigation Assistance grant programs. Even so, some of the projects need collaborative agency support or approval from SCD to ensure coordination. Other projects may be eligible for State funding under agency mandates or from other federal funds. The SHMF approved the inclusion of the mitigation projects and proposed plans.

In addition, SCD received updates on ongoing mitigation projects and have taken into further consideration a five-year strategic planning process to improve coordination and implementation. SHMF members stressed the need for strong coordination as the Forum and its member participation are voluntary. During the previous three years, volunteer subcommittees for public awareness and education and hazard mitigation planning helped to coordinate efforts to assist the county plan update process and advice in the state plan update process.

In August, the draft State of Hawai‘i Multi-Hazard Mitigation Plan was uploaded to the secure server to seek additional review on revised sections of the plan. Notification was sent to the broader disaster management community in the state, which included federal, state, county, and private, non-governmental partners. The final draft for submission to FEMA for review is then uploaded to the public awareness website for additional review and comment by the public.

The final element of the plan update process is to ensure that the plan is adopted by the Governor of the State of Hawai‘i. The process of updating the plan has been coordinated with the Director and Vice Director of Civil Defense to follow up previous briefings with the Governor about the mitigation planning process and to secure his signature on the adoption letter for the approval of the State of Hawai'i Multi-Hazard Mitigation Plan, 2013 Update.

Risk and Vulnerability Assessment

The State of Hawai‘i assessed hazard risks and vulnerability based on information compiled in a geographic information system (GIS), primarily at the County level where more critical spatial information is located. Hazard layers were developed using a variety of data sources, but were most important in assessing county risks and vulnerabilities. Because the state worked with the four counties in developing their risk and vulnerability assessments, the counties included the State’s critical facilities and lifeline infrastructure in their risk and vulnerability assessments. The County assessments formed the initial basis of the State’s risk and vulnerability assessment.

Other studies have improved knowledge of changing shorelines and erosion rates, as well as methods for beach replenishment. New technologies in LIDAR and remote sensing imagery offer the ability to improve building inventories and footprints to improve modeling. Ultimately

the data has been refined for inclusion in models, such as HAZUS-MH, which can provide good loss estimates and can direct attention to projects that would likely have the greatest impacts in reducing hazard risks. The results of the State critical facility HAZUS-MH analysis for hurricanes and earthquakes provides detailed information on risks associated with average annualized loss, high costs from structural damage in events, and high loss of functionality from a disaster event. The lists of facilities in the top ten indicate areas of critical need for focusing structural retrofit recommendations to reduce hazards and strengthen critical facilities, such as the Honolulu International Airport.

The State Legislature convened a working group to evaluate the feasibility of statewide uniform building code requirements based on amending national standards for Hawaiʻi conditions, especially for State supported facilities. The task force recommended the formation of a State Building Code. The State Legislature approved the state building code requirements in the 2007 session under Act 82. . "The legislature finds that . . . The adoption of a uniform set of statewide building codes applicable to one and two family dwellings, all other residential uses, and commercial and industrial buildings, and state buildings would make it possible for building owners, designers, contactors, and code enforcers within the State to apply consistent standards. The International Building Codes is currently being considered for adoption by all counties. The health and safety considerations related to the codes are of statewide interest, especially relating to emergency disaster preparedness." Enacted as Hawaiʻi Revised Statutes Chapter 107 Part II, State Building Code and Design Standards, the organization of the State of Hawaiʻi Building Code Council develops and adopts improved codes. The council focused on adopting code amendments that reduce risks from hurricanes and to provide improved integrity for sheltering to be incorporated in the design of state and county buildings with large assembly occupancies.

Another proposed effort by several organizations in the State is the development of a disaster recovery plan in accordance with the National Disaster Recovery Framework. Having witnessed the devastation of Hurricane Katrina and the Great Sumatra and Great East Japan tsunami, and the difficulties of recovery efforts in many areas, several agencies proposed the development of a recovery plan that would organize the permitting, building, and development during recovery efforts. Proposed efforts in developing a recovery plan would take these potential impacts into account to ensure that people, communities, the environment, and the economy could rebound following a significant disaster. In December of 2012, the Honolulu Department of Emergency Management and State Civil Defense jointly organized a disaster recovery conference that assembled over 100 participants from the public and private sectors to focus on disaster recovery planning.

For the mitigation plan update process requirement for 2013, the state applied the criteria of including the best available data in the plan. The results of recent substantive studies within each hazard have impacts on risk reduction. For example, the results of studies on wind risk have been incorporated into that hazard chapter, and have been used to develop the stricter building codes of 2012. In this assessment of 2013, the State Multi-Hazard Mitigation Plan contains the results of implemented actions recommended by earlier versions of this plan.

SUMMARY OF HAZARDS – State of Hawai‘i Hazard Mitigation Plan Update 2013

Hawai‘i has experienced several major disasters that provide historical knowledge of impacts to support hazard mitigation planning. On September 11, 1992, Hurricane Iniki swept across the island of Kaua‘i (County of Kaua‘i), and a decade later the County had still not fully recovered from the impact of the storm on the economy and tourism industry. The total cost of the disaster exceeded $1.8 billion, not including the impact on employment and the quality of life for Kaua‘i citizens. In November 2000, flooding in Hilo (County of Hawai‘i) caused damage of more than $50 million. These disasters were severe, but estimates during post-disaster assessments demonstrate that a Hurricane Iniki-strength storm (Category 3) on the island of O‘ahu (City and County of Honolulu) would result in more than $23 billion dollars in damage to the City & County of Honolulu, and would result in loss of services to the neighbor islands, nearly collapsing the economy of the State of Hawai‘i. Severe tsunami in 1946 and 1960 resulted in the greatest loss of life in the State of Hawai‘i.

The State of Hawai‘i has experienced two major disaster declarations in the last three years (tsunami waves in March of 2011 and severe storms, flooding, and landslides in March of 2012). Several tsunami warnings were issued in March 2011 and October of 2012, with mandatory coastal evacuations that were costly for the State. There have been 30 declared wildfires across the State from 2010 to 2012 with approximately 17,000 acres burned. During the dry season of 2012 the State of Hawai‘i suffered from severe drought. Not only did all these disasters prove costly, but have had serious implications for livelihoods and the economy, which is already under stress from the “national economic disaster.”

Continued eruptions on the island of Hawai‘i since 2007 resulted in the development of potential lava flow scenarios. The Hawai‘i Volcanoes Observatory, County of Hawai‘i Civil Defense, the University of Hawai‘i Center for the Study of Active Volcanoes (CSAV), and State Civil Defense have maintained watches and issue warnings. CSAV has conducted studies into the problems created by extensive volcanic ash, which has resulted in harmful chemicals in the water catchment systems and in graze lands, affecting cattle that are already being impacted by drought.

In addition to the major disasters, the state continues to experience incidents that are not declared as disasters. Heavy rainfall and stream flooding, primarily from debris blocking culverts, caused several localized floods in communities, such as Māpunapuna near the Honolulu International Airport where a number of small businesses operate. The Spring Tide typically results in sea water flooding of low-lying areas in that community, which may also be significantly impacted by climate change. Several rockslides occurred along shoreline highways, cutting off major traffic routes, which required government funding to clear debris and implement response actions. Additional costs included business losses as employees could not get to work and costs to drivers who had to take longer travel routes during a time of rising fuel prices.

High Wind Storms and Tropical Cyclones

Winter storms have historically caused high winds gusting up to 85 mph (and higher on mountain peaks). The State of Hawai‘i is in a region of moderate hurricane hazard as summarized in the following table:

Hurricane Wind Speed Annual Odds of Occurrence in Hawai‘i by Saffir-Simpson Category

Hurricane Category	Sustained Wind Speed (averaged over 1 minute)	3-sec. Peak Gust	Annual Odds of Occurring anywhere in Hawai‘i
1	74 to 94 mph	90 to 116 mph	1 in 25
2	94 to 110 mph	117 to 134 mph	1 in 50
3 or 4	111 to 156 mph	135 to 189 mph	1 in 75
Any Hurricane	Greater than 74 mph	Greater than 189 mph	1 in 15

State and County building codes prescribe design requirements for new buildings and other structures. Topographic effects leads to amplified wind speeds that have been identified in engineering design maps for Hawai‘i and adopted in local county and state building codes. Buildings designed in Hawai‘i since Hurricane Iniki (1992) generally are designed with ultimate strength for Category 2 hurricanes. However, single family homes built to conventional minimum requirements prior to Hurricane Iniki would not have high wind resistant designs at all, leading to very high losses during Hurricanes Iwa (1982) and Iniki (1992). Presently, a Hawai‘i State Mass Care Council is evaluating the needs for post-disaster mass care and temporary housing and food services, given high expected damage to single family residential construction.

There is an apparent shortage of hurricane shelters in Hawai‘i, with existing capacity for approximately 1 out of 10 residents. However, almost all existing hurricane shelters were not designed for any greater resistance to high wind forces. Public high occupancy buildings have additional wind resistive requirements since April 2012 per the building code.

Power distribution lines are historically vulnerable to high wind outages and deterioration. The Public Utilities Commission governs rules and regulations for the design of new power transmission and distribution infrastructure. It presently uses a 2002 National Electric Safety Code. Topographic effects are not considered, unlike the building code.

Tsunamis

The Hawaiian Islands have a long history of destruction due to tsunamis and are particularly vulnerable to tsunamis originating from Alaska and Chile. As a tsunami leaves the deep water of the open sea and propagates into the more shallow waters near the coast, it undergoes a transformation. 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 of nominal in deep water may grow to be several times greater in height. Tsunami hazard is normally expressed along a shoreline in the form of maps of inundation limit and runup, terms that are illustrated below:

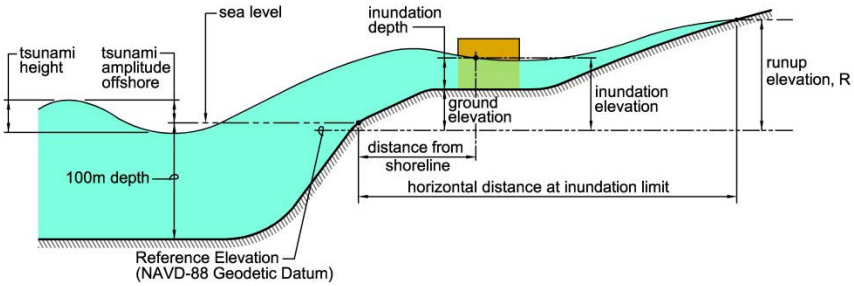

Illustration of Tsunami Terminology

With completion of the *Variations in Community Exposure and Sensitivity to Tsunami Hazards in the State of Hawai`i* by the US Geological Survey (2008) in cooperation with the Civil Defense Division of the State of Hawai‘i Department of Defense, the Office of Planning of the State of Hawai‘i Department of Business, Economic Development, and Tourism, and the Pacific Disaster Center there has been a significant contribution in understanding tsunami risks related to the social vulnerability of the population in the tsunami evacuation zone. The project provides an informational resource to build public awareness about risks in communities.

Current tsunami evacuation maps are based on the inundation of historical events over the past 100 years. The City and County of Honolulu is currently working on a reassessment of tsunami evacuation zones in the island of O‘ahu. The City has launched a 2012-2013 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. This study is also considering potential tsunamis originating in the Aleutian islands of greater than historical occurrences. It has become increasingly recognized that past assumptions for evacuation planning did not consider all possible sources of “worst case” tsunamis. The geometry of the Aleutian arc between the 1946 and 1957 earthquakes enhances tsunami risk to Hawai‘i from potentially large earthquakes in this region.

However, the siting and design of buildings in Hawai‘i and the west coast, in almost all cases, does not consider tsunami hazard. The Tsunami Loads and Effects Subcommittee of the American Society of Civil Engineers (ASCE) and Structural Engineering Institute (SEI) ASCE/SEI 7 Standards Committee are developing a proposed new Chapter 6 - Tsunami Loads and Effects for the 2016 edition of the ASCE 7 Standard. Chapter 6 will provide loads for tsunami and its effects, and the design approach would be incorporated in the International Building Code 2018 edition. While evacuation policies should be based on providing safety in “worst case” but extremely rare tsunami possibilities, they are not appropriate for building codes. The ASCE provisions will utilize a probabilistic tsunami map that is based on achieving

community resilience of critical facilities and major structures to a level consistent with other hazards such as earthquakes and hurricanes. These engineering design maps will not be as broad in extent as the "worst case" evacuation maps.

Earthquakes

Naturally occurring earthquakes in Hawaiʻi can be either of tectonic or by fault rupture. Tectonic, or lithospheric, earthquakes in Hawaiʻi occur at or near the shield volcanoes that form the islands. In these cases, the colossal weights of the volcanoes that form the islands bend the lithosphere beneath for a bathymetric map of the Main Hawaiian Islands identifying all Hawaiian volcanoes. The most recent major earthquakes in the State of Hawaiʻi of this type were the Magnitude 6.7 Kīholo Bay and Magnitude 6.0 Māhukona earthquakes that occurred on October 15, 2006. Historically, the largest earthquakes in Hawaiʻi have occurred at shallower depths due to the fault rupture mechanisms beneath the flanks of Kīlauea, Mauna Loa and Hualālai Volcanoes. 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 detachment separating the ancient oceanic crust from the emplaced volcanic pile, lying approximately 10 km beneath the Earth's surface.

The most current tools to determine the probability of earthquakes occurring in the Hawaiian Islands are the Seismic Hazard maps produced by the United States Geological Survey (USGS). The seismic hazard maps included current seismic, geologic, and geodetic information on earthquake rates associated with ground motion. The maps essentially show the distribution of earthquake ground motion levels (measured as peak ground acceleration or spectral acceleration) that have a certain probability of occurring in or near the Hawaiian Archipelago. These maps are the basis for seismic design provisions of modern building codes since 2000, insurance rates, earthquake loss studies, retrofit priorities, and land-use planning.

Past building codes that did not use these maps underestimated the seismic hazard in Hawaiʻi, and requirements for design were significantly less than present practice. In addition, Hawaiʻi has its unique "single-wall" construction and "post & pier – tofu block" foundations that were prevalent conventional home construction up through the 1970's. This type of conventional customary practice did not have any seismic or hurricane resistive requirements, and remains the most vulnerable type of housing. Approximately 25% to 30% of existing single family housing unit inventory is of this type of construction. In the Kiholo Bay earthquake of 2006, post & pier foundations led to failure rates about 3 times more frequently than modern construction.

Bridge damage due to structural damage or earthen abutment slope failures have occurred on the Big Island and Maui, causing disruption of arterial transportation networks.

Critical care hospitals and assisted living facilities have also experienced loss of function due to nonstructural and equipment damage. School buildings and other public buildings have been susceptible to ceiling collapses due to lack of bracing (not required by the building code of the time).

It is generally observed that slowness in adopting modern building codes over decades has resulted in many buildings in Hawai‘i not having seismic resistance commensurate with the state of the practice in other seismically active regions of the country.

Landslides and Rock Falls

The State of Hawai‘i combines several of the essential components for landslide and rockfall hazards: steep hillsides, heavy rainfall, and strong pressure for residential development in upland areas. Landslides and debris flows generally occur during or after severe rainfall or during strong ground shaking.

Several natural mechanisms contribute to the alteration and breakdown of rock along Hawai‘i 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. Clinker zones typically making up the margins of flows are more fragmented than the massive cores, causing void spaces and zones of weakness prone to physical weathering. Thermal contraction of rock during cooling of lava flows typically causes fracturing of rock. Dike margins also represent potential zones of weakness. Rockfall may be initiated through a combination of weathering, fracture, and steep slope. In addition to destabilization of rockfall and landslide locations due to rain, the destabilization can be caused by seismic activity. Earthquake induced landslides and rockfalls occurred in a number of locations on the islands of Hawai‘i and Maui during the 2006 Kīholo Bay and Māhukona Earthquakes.

On March 21, 2013, City and County of Honolulu Mayor Kirk Caldwell released a report that identified sites that pose rockfall hazards to city property, and announced that the city has warned about 1,000 private property owners whose land is at high risk of rockfall. The survey was prepared for the city, which already began taking protective measures at several sites owned by the government that the report flagged as hazardous. Caldwell emphasized that the report focused on city roads and city property endangered by rockfalls, not private lands. Nonetheless, it revealed some hazards involving private property.

To prevent inappropriate development, hillside lands should be placed in (preservation or) low-density residential zoning districts and provided some protection or mitigation of environmental risk factors, such as clearing of loose boulders and control of rainfall runoff, or rockfall protection. Such lands should also be subject to stricter development rules than those that apply to level land, to require that landslide and rockfall hazards be mitigated.

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. Mitigation by creation of buffer zones is an alternative or augmentative to fencing and mesh construction to retain rockfalls, where development is not already built out.

Floods

The major flooding events in Hawai‘i are caused by storms, storm surge, tsunamis, dam breaks, and high surf. 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. Under the NFIP, each county has mapped flood hazard areas and established a permit system to regulate development within these flood hazard areas. The FIRM maps identify a flood hazard area as the area that would be inundated by a 100-year flood, or a flood with a 1% chance (1:100 odds) of occurring every year. The Flood Insurance Rate Maps (FIRMs) include areas prone to rainfall or coastal still water flooding (A zones) and high waves (V zones). As a federalized insurance program, FEMA prepares a Flood Insurance Rate Map (FIRM) that depicts the Special Flood Hazard Areas (SFHAs) subject to inundation by a flood having a one percent chance or greater occurring in any given year. The FIRMS show base flood elevations (BFEs) and flood insurance risk zones. Since 1994, federal loan agencies and federally regulated or insured lending institutions require flood insurance when making, increasing, extending, or renewing loans and to maintain the coverage for the life of the loan" for all homes in special flood hazard areas. There are about 65,000 NFIP policies in place for properties in Hawai‘i.

The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community preparedness, regulatory, enforcement and public outreach actions meeting the three goals of the CRS to 1) Reduce flood losses, 2) Facilitate accurate insurance rating, and 3) Promote the awareness of flood insurance.

The following information pertains to the percentage of developed (urbanized) areas located in the 100 year floodplain by county. Source of information is the county NFIP coordinators:

County of Hawai‘i:	5%
County of Kaua‘i:	10%
County of Maui:	10%
City and County of Honolulu:	15%

The State of Hawai‘i has 172 properties on the repetitive loss list with over half located in the City and County of Honolulu (87 properties). The criteria for repetitive loss are two or more NFIP claims of more $1,000 within any ten-year period since 1978. The County of Hawai‘i has 51 repetitive loss properties, the County of Kaua‘i has 16 properties, and the County of Maui has 18 properties.

Dam Failures

Hawai‘i’s experience with dam failure resulted in the development of a program to assess the risks of dams throughout the state. Dam failures for earthen dams can 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. While there have been no additional failures since 2006, the state has inspected and characterized the hazard risk of all the dams. In 2008 and 2009, the DLNR Dam Safety Office completed a hazard assessment of all the dams and issued fact sheets on each 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. Dams assigned the high hazard potential are those where failure or miss-operation will probably cause loss of human life. By GIS spatial analysis of dam inundation areas with the property database, it is estimated that $2.25 Billion dollars of building inventory are within the potential dam break inundation areas.

Private plantation owners built a majority of existing dams in the early 1900's for irrigation and not flood control; there were no standards at that time. The State of Hawaiʻi Dam Safety Act was started in 1987 where the rules, statues, and Hawaiʻi Administrative Rules were set up by the Department of Land and Natural Resources (HAR, Title 13, Subtitle 7, Chapter 190, Dams and Reservoirs). In Hawaiʻi, a "Dam" is defined in Chapter 179D, Hawaiʻi Revised Statutes (as amended by Act 262, SLH 2007) as any artificial barrier, including appurtenant works that impounds or diverts water and that:

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 shall not apply to any artificial barrier that is less than six feet in height regardless of storage capacity or that has a storage capacity at maximum water storage elevation less than fifteen acre-feet regardless of height; or,

3. Meets additional criteria or is specifically exempt as determined pursuant to rules adopted by the board.

The County of Kauaʻi has a total of fifty-five dams and reservoirs. In the case of the County of Maui, there are a total of fifty-four dams and reservoirs. Of the fifty-four total, fifty-three are located on the island of Maui and one is located on the island of Molokaʻi. There are no dams or reservoirs on the island of Lānaʻi. The County of Hawaiʻi has thirteen dams, all of which are earth dams. Most dams in this county are old earthen berm reservoirs built during the plantation era originally for irrigation purposes. Lastly, in County of Honolulu, there are twenty-one dams and reservoirs located throughout the island of Oʻahu. Hawaiʻi Revised Statutes Chapter 179D-30 requires the Owners of State-regulated high and significant hazard potential dams and reservoirs to establish an Emergency Action Plan (EAP) to assist the local community in effectively responding to a dam safety emergency.

Coastal Erosion

It is important to understand the difference between coastal erosion and beach erosion (the later one is also known as shoreline retreat). Coastal lands may experience long-term erosion under

certain conditions. Regardless of the source, however, as the coastline erodes, the beach must eventually migrate landward or drown. If there is a sufficient source of sand, the beach, remains wide and healthy as it moves with the eroding coastline. If sand is not available to a beach on an eroding shoreline, then beach erosion will ensue, leading to narrowing and eventually beach loss.

The impact of rising sea level in the Hawaiian Islands will eventually 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-sloped coasts will be the most vulnerable to coastal erosion due to sea-level rise. A recent study conducted in 2012 by Romine and Fletcher estimated both long- and short-term erosion rates for the three of the main Hawaiian Islands (Kaua‘i, O‘ahu, and Maui). Erosion is the dominant trend of shoreline change on the islands, with 70% of the beaches indicating and erosional trend and an overall average shoreline change rate of approximately 11 centimeters per year (4.5 inches of erosion per year).

The setbacks for the islands are the following:

> County of Kaua‘i – 40 feet plus 70 years times the annual average erosion rate. There is also a lot depth formula, and whichever is greater will apply.
>
> County of Hawai‘i County – 40 feet except for small lots, where it can be 20 feet
>
> City and County of Honolulu – 40/20 – they do have 60 feet for new subdivisions
>
> County of Maui – 25 feet plus 50 years times the annual average erosion rate. However there is also a lot depth formula; whichever is greater, the setback is set.
>
> County of Hawai‘i County – 40 feet except for small lots, where it can be 20 feet

The Hawai‘i Coastal Zone Management Program (CZMP) was enacted in 1977 (Chapter 205A, HRS). Hawai‘i’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 Hawai‘i. 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. The boundary of the SMA is from the ocean generally to the nearest highway or minimum of 300 feet. 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. 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.

Droughts

In the County of Hawai‘i, extreme drought conditions have persisted for five seasons, and on Maui it has extended for seven years. Drought hazard considered three sectors impacted by drought: the water supply sector, agriculture and commerce sector, and the environment, public health and safety sector. Because Hawai‘i is at risk from multiple hazards that could impact infrastructure, such as water distribution and irrigation, and because drought persists for periods of years, long-term strategies that increase food security and water availability are critical, especially in the face of potential impacts from climate change. Over the last 100 years, Hawai‘i has experienced a downward trend in rainfall. Therefore, combined with greater water demand, future incidences and the intensity of drought may be expected to increase. The Hawai‘i Drought Plan (HDP) was prepared for use by the Hawai‘i Drought Council to improve and better coordinate drought management strategies for the State of Hawai‘i. In the modern era, a new Hawai‘i Drought Monitor map website has been developed. Drought mitigation goals are as follows:

- Expand current network of rain gages to improve rainfall monitoring.
- Develop a framework to coordinate drought response between agencies.
- Enhance current monitoring of ground- and surface-water levels.
- Establish alert procedures for declining water level conditions.
- Establish conservation programs to reduce water consumption.
- Establish contingency water-hauling programs for livestock.
- Seek authorization and funding for development of new water supply sources.
- Identify areas at risk to drought and plan for regional response actions and strategies.
- Develop additional storage and/or alternative sources of water supply.
- Develop and implement drought-related public awareness programs.
- Develop incentive programs for drought resistant practices.

Wildfires

In Hawai‘i, the fire season typically runs from the dry months of April through October. Although drought increases the potential for catastrophic wildfire, drought cannot be singled out as the sole cause or key determinant in wildfires. Initiation causes are tracked as lightning, campfires, smoking, debris burning, arson, equipment, or miscellaneous. Therefore, a more appropriate way of characterizing the relationship between wildfires and droughts is that wildland fires tend to be exacerbated by drought rather than being caused by them. About 80,000 acres have been burnt statewide during the past ten years in 666 wildfires. The mission of DNLR, Division of Forestry and Wildlife (DOFAW) is to provide protection to forest reserves, natural area reserves, wildlife and plant sanctuaries, and public hunting areas. DOFAW also cooperates with established fire control agencies for the protection of other wild land not within department protection areas to the extent needed to provide for public safety. General mitigation actions are based on increasing accessibility of firefighting assets and staging areas for them, enhancing water sources, thinning the available fire fuel loading to reduce ignitability, modernizing firefighting resources, operational coordination, and public awareness education and encouraging community planning and development standards incorporating wildfire risks. Maps of Communities at Risk have been developed for each county.

Volcanic Hazards

Volcanoes emit carbon dioxide, sulfur dioxide, sulfuric acid, hydrogen chloride, hydrogen fluoride, and hydrogen sulfide along with an array of trace gases and much larger quantities of steam derived from local groundwater. VOG (volcanic gases) is used to describe hazy conditions caused by gaseous emissions from three primary sources from Kīlauea volcano. VOG is created when Volcanic Gases (primarily oxides of sulfur, SO2) react with sunlight, oxygen and moisture. The result includes sulfuric acid and other sulfates. The concentrations sulfur dioxide gas in VOG are typically greater near the sources at the of the Kīlauea volcano in the island of Hawai‘i. VOG mostly affects the Kona coast on the west side of the Island of Hawai‘i, where the prevailing trade winds blow the VOG to the southwest and southern winds then blow it north up the island's west coast.

Sulfur dioxide is irritating to the eyes, nose, throat and respiratory tract. Short-term exposure to elevated levels of Sulfur Dioxide may cause inflammation and irritation, resulting in burning of the eyes, coughing, difficulty in breathing and a feeling of chest tightness. When it comes to VOG, "Sensitive groups" include children and individuals with pre-existing respiratory conditions such as asthma, emphysema, bronchitis, and chronic lung or heart disease. Individuals who belong to "Sensitive Groups" may respond to very low levels of Sulfur Dioxide in the air. Prolonged or repeated exposure to higher levels may increase the danger. Sulfur Dioxide levels are lessened further away or upwind from the vents. Plants and agriculture are affected: sulfur dioxide enters leaf mesophyll tissue, and once SO2 enters the moist mesophyll tissue, it combines with water and is converted to sulfuric acid which burns plant tissue. From 2007-2013, the lava flows have produced increased amounts of volcanic ash and VOG, which is now resulting in significant impacts for farmers and ranchers in Hawai‘i County.

However, for outside of Hawai‘i island, VOG impacts of sulfur dioxide levels are greatly reduced over time as the gas goes through several chemical reactions to form ammonium sulfate which eventually settles or gets washed out of the atmosphere. The direct volcanic hazard from gaseous emission of sulfur dioxide is actually minimal on islands away from the Big Island of Hawai‘i.

The chief threat of lava flows to property owners is that the flows may burn structures and bury land in areas where the lava inundation threat was ignored in development by the private sector and government. As a result, residents who are either explicitly gambling or unknowing are faced with financial losses as land values drop and insurance companies logically decide to refuse to issue new homeowners policies. There are other effects that may be almost as disruptive, as the Kalapana community discovered during the repeated inundations of the area by lava. In addition to destroying homes, the flows covered almost 2 miles of the coastal highway, leading to near isolation or much longer detour routing. The U.S. Geological Survey has prepared maps showing volcanic hazard zones in the County of Hawai‘i in the "Volcanic and Seismic Hazards on the Island of Hawai‘i," 1990. Current eruptions are tracked by HVO scientists and the information provided on projected lava flow movements help public safety officials determine the need for evacuation or other precautions.

Hazardous Materials

The combination of hazardous materials with a natural hazard could result in more severe impacts during a disaster. Such threats can result in decreased resilience and delays in long-term recovery. The Hawai‘i Emergency Planning and Community Right-to-Know Act became law in 1993 (HRS 128E). 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.

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. The DOH Hawai‘i Site Rehabilitation Prioritization (SRP) List of Priority Sites shows 464 sites with potential or known hazardous substance or petroleum contamination.

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. Local Emergency Planning Committees (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.

Health Risk and Vulnerability Assessment

The Honolulu International Airport on the island of O‘ahu (City and County of Honolulu) is ranked 25th in the nation in terms of number of passengers. Nonetheless, this airport ranks third highest in the nation for the risk of spreading the next pandemic because of three factors; its preponderance or long-distance flights that can allow germs to incubate and spread en route; its central location between Asia and the United States mainland; and regular connections to “other massive hubs, which are themselves powerful spreaders.” State of Hawai‘i health officials rely on airline flight crews and federal Transportation Security Administration (TSA), customs and border protection agents to spot passengers at Honolulu Airport who may be sick while arriving or departing.

Health impacts of disasters include:

- Limited facilities actually capable of receiving, storing, and distribution systems and procedures for pharmaceutical and emergency medical supplies.
- Limitations in health care due to demand surge or capacity degradation by damage or illness
- Post-disaster deficiencies in food preparation, sanitation, water, and hygiene
- Limitations in emergency services

Health-related hazards may also include mental health and post-traumatic stress disorders associated with disasters. There will be increased vulnerability from populations already at risk--

--those with special needs, those with mental illnesses, those with severe illnesses, and those who might be homeless. First responders to disasters will also require monitoring for post-traumatic stress, depending on the characteristics of the disaster.

Climate Change Effects

Overall climate change has uncertainty in the long-term, with coastal communities more at risk. For islands, climate change is expected to result in increases in temperature, extremes in precipitation (resulting in drought or flooding), potential changes in storm systems (possibly more frequent or increased magnitude), and rise in sea levels. Climate Change can exacerbate and facilitate impacts from other hazards. Coastal shorelines and ecosystems are at risk from climate change, which may have significant the impacts of hazards such as erosion, sea level rise, and hurricane surge, for example. Sea level changes may be due to a variety of factors. Impacts may be seen in changes to shorelines and in coastal erosion. Whereas sea level changes occurring as a result of global climate change will impact all (US) coastal areas, Hawai‘i’s shorelines will be unique uniquely affected as a result of island subsidence processes. Because of loading of the Pacific tectonic plate by the growth of Hawai‘i’s volcanoes, lithostatic flexure (down-bowing) of the plate, as well as compaction of the volcanic products, causes the islands to sink at a measurable rate. The southern half of the island of Hawai‘i is subsiding at a rate of 2.5 mm/year (25 cm/100 years); the older islands are subsiding at a somewhat slower rate. These rates are all additive to the rise in sea level resulting from those associated with global climate change. Low-lying areas of the coast can expect serious flooding as rising seas push up the water table, creating an effect called “groundwater inundation.”

Through regional assessments, Hawai‘i is trying to ultimately understand its long-term risk and vulnerability to climate change as better data that is localized for island risk assessments and new methods of addressing risks become available. Options for Implementing the Hawai‘i State Planning Act Climate Change Adaptation Priority Guidelines are measures in phases depending on assumptions of severity over time of climate change as follows:

- Phase I: Sea-Level Rise
- Phase II: Increase exposure to storm surge and flooding, intrusion
- Phase III: Major protection and or relocations / retreat

Risk Ranking

Throughout the 2013 update, the average annualized loss methodology is still in use by the state and counties to conduct cost-benefit analyses and evaluate risk by taking vulnerability and hazard probability into account (Table 1). These methods are consistent with analyses using HAZUS MH and utilize the results of that model, continue to provide reasonable risk estimations which can be used to evaluate the priority of implementing proposed mitigation actions.

Table 1 Ranking of Risks based on Average Annual Loss[1]

Kaua‘i	Honolulu	Maui	Hawai‘i
Tropical Cyclone	Tropical Cyclone	Tropical Cyclone	Tropical Cyclone
Tsunami	Tsunami	Tsunami	Earthquake
Coastal Erosion	Earthquake	Earthquake	Tsunami
Flood	Flood	Coastal Erosion	Lava Flow
Landslide and Rockfall	Landslide and Rockfall	Flood	Flood

Mitigation Priorities

The state recognizes that hazard mitigation depends on appropriate land use policies and practices, including zoning and coastal zone management, flood control, building codes and standards, infrastructure development and standards, regulatory measures, incentive programs, and participatory planning methods.

In order to set priorities, the state developed goals and objectives. These goals and objectives provide a foundation for the mitigation actions and policies that will be developed in this plan. The State Hazard Mitigation Forum conducted a review of the goals and objectives and determined the goals and objectives are achievable and complement both state and local mitigation strategies. There was consensus that these goals and objectives outline the direction for risk reduction that Hawai‘i wishes to pursue. Several of the goals listed originally emerged from the 2004 mitigation planning process where the planning subcommittee of the State Hazard Mitigation Forum suggested the goals and objectives. In 2007, the Forum reviewed the goals and objectives, and added several additional objectives. There were no changes made in the 2010 update of the Plan. In 2013, the goals and objectives were further refined to emphasize whole community disaster resilience and building Core Capabilities to address the hazards of greatest risk. In addition to comments collected with initial input from the broader hazard community who reviewed the recommendations, the State Hazard Mitigation Forum meeting on August 22, 2013 provided the final review and approved for inclusion of the goals and objectives to mitigate hazards.

[1] Risk is the expected losses from an evaluation of the probabilities of hazards with their potential to cause adverse effects on our life; health; economic well-being; social, environmental, and cultural assets; infrastructure; and the services expected from institutions and the environment. Average Annual Losses (AAL) in this table are based on the Mitigation Plan for each County and analysis performed in August, 2013 by Martin & Chock, Inc. See Tables 19.7 through 19.10 in Chapter 19 of this Mitigation Plan.

The appropriate goal of hazard mitigation in Hawai‘i should embody the target of achieving greater community resilience.

> **“Resilience is *the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events.* Enhanced resilience allows better anticipation of disasters and better planning to reduce disaster losses—rather than waiting for an event to occur and paying for it afterward.”**
>
> [Disaster Resilience: A National Imperative, 2012. Committee on Increasing National Resilience to Hazards and Disasters; Committee on Science, Engineering, and Public Policy; The National Academies]

The order of the goals and objectives do not necessarily follow in order of priority; the goals and objectives address current conditions and anticipated future needs, and represent a long-term vision for hazard reduction and enhancement of mitigation capabilities for the State of Hawai‘i.

Goal 1: Protect life and property of the people in Hawai‘i

1.1: Improve the resilience of lifelines, critical infrastructure, ports and airports, critical facilities, and supply chain and transportation networks, and reduce their vulnerability to disruption of function from hazards
1.2: Work with the Counties to assist in improvements of building codes and building inventories and risk assessments.
1.3: Ensure knowledge and accessibility of response plans, evacuation routes, and shelters and refuge areas.
1.4: Ensure adequate public sheltering space or alternative refuge structures for residents
1.5: Ensure adequate public sheltering space or alternative refuge structures for visitors
1.6: Ensure emergency services and medical facilities can provide acute care for victims of disasters.
1.7: Ensure that all lifeline and critical utility infrastructures are able to withstand hazard events or have contingency plans to quickly recover after a disaster
1.8: Ensure that all emergency response critical facilities and communication systems remain operational during hazard events
1.9: Encourage appropriate coastal development that reduces risks from coastal hazards at all stages of development.
1.10 Reduce risk by addressing the target capability gaps identified in the state Threat and Hazard Identification and Risk Assessment (THIRA) and the strategic planning process. Emphasis shall be placed on building and sustaining Core Capabilities that address high-consequence events that pose the greatest risk, and Core Capabilities that can be used to address multiple threats and hazards.

Goal 2: Continually strive to improve the state of the art for the identification of hazard areas, prediction capabilities, and warning systems.

2.1: Prepare GIS maps for all hazards with the best available information and formulate a strategy to maintain/upgrade the data.
2.2: Improve applicability of modeling systems to Hawai‘i conditions for hazard mapping, mitigation planning, and scenario training purposes.
2.3: Improve flood prediction and field-monitoring systems.

2.4: 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.
2.5: 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.

Goal 3 Produce comprehensive, multi-hazard risk and vulnerability assessments

3.1: Identify and map assets, including sensitive environmental features and natural habitats, buildings and urban developments, historical buildings and properties, and cultural sites and use areas.
3.2: Maintain and update databases on new and improved data and technology with attention to securing data that should not be shared publicly
3.3 Develop a statewide risk and vulnerability assessment (RVA)
3.4: Maintain and update RVA based on new and improved data and technology
3.5: Develop appropriate protocols for data sharing and management at federal, state, and local levels
3.6 Use HAZUS and RVA models and scenarios to identify risks and develop improvements
3.7: Continue to monitor, evaluate, and update the assessments.

Goal 4: Protect the State's natural, built, historical, and cultural assets

4.1: Incorporate indigenous cultural and natural environmental protection themes into hazard mitigation planning
4.2: Update state building codes, regulations, and design standards and specifications to cost-effectively reduce susceptibility to high wind storms, tropical cyclone, earthquakes, floods, and tsunamis.
4.3: Ensure adequacy of land use regulations and zoning standards to mitigate risks to natural hazards. Periodically review their effectiveness and update them as necessary.
4.4: Encourage and support the adoption, enforcement, training in, and updating of building codes and standards that minimize the threat to life, health, and property damage caused by natural hazards
4.5: Encourage and support the adoption, implementation, and updating of plans (including land use, resource management, and other state and county plans) that incorporate natural hazard elements (including risk and vulnerability, hazard maps, hazard mitigation best practices and standards)
4.6 Minimize environmental degradation and ensure habitat recovery

Goal 5: Minimize post-disaster recovery disruption and rebuild businesses and restore economic activity to ensure the long-term sustainability of the State's economic base

5.1: Assess economic risk and vulnerability for multiple hazards
5.2: Develop strategies to ensure that financial institutions and other critical businesses can operate during crises
5.3: Develop small business strategies and contingency plans to help businesses reopen quickly following crises

5.4: Develop reconstruction and rehabilitation plans to ensure rapid recovery from disasters that achieves a greater level of disaster resilience.
5.5: Make plans with the Hawai‘i Visitors and Convention Bureau to ensure the rapid restoration of the visitor industry to prevent long-term repercussions to the tourism industry, which is critical to the economy of the State of Hawai‘i.

Goal 6: Ensure public awareness of risks, vulnerability, and multi-hazard mitigation actions through public education, that results in efficient evacuations, self-reliant disaster preparation, 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: Provide updated risk and vulnerability assessments and plans for information distribution.
6.4: Run training exercises to make enable organizations, community-based groups, and emergency services to know how to respond during crises.
6.5: Ensure that non-structural mitigation measures are incorporated into mitigation public awareness programs.
6.6: Ensure adequate understanding of characteristics and dangers associated with natural hazards.

The State Disaster Resilience Strategy Workshop 2013 included over 60 principal stakeholder invited from groups with broad perspectives, including:

- Climate Change Adaptation
- Tsunami and Earthquakes
- Hurricanes and Floods
- Droughts and Wildfires
- Infrastructure Resilience
- Health Vulnerability and Risk
- Recovery and Macro-Economic Effects
- Threat Identification and Risk Analysis (THIRA) Implementation
- Land Use and Building Requirements

These group discussed disaster resilience objectives and strategy, and prioritized the necessary key actions and near to intermediate-term policy recommendations for disaster resilience. Results of this multi-agency, public and private sector workshop are presented in Chapter 20

Strategic Priorities For Mitigation Actions Include:

1. Update and adopt codes and design standards for tsunami, hurricane, and severe storms
2. Produce needed probabilistic design maps for tsunami for application towards mitigation for critical facilities, major buildings, bridges, and key infrastructure such as power plants and ports.
3. Develop coordinated evacuation and public information products to account for Great Aleutian Tsunami scenarios when no more than 3-1/2 hours of warning time is possible.
4. Provide greater public education on their role in disaster preparedness in the context of the limitations of what can be provided in the aftermath of a major disaster (such as a hurricane or tsunami), given Hawai‘i’s geographic isolation and dependence on an oversea supply chain.
5. Invest in additional and improved capabilities for more reliable monitoring / warning of hazards and improve the modeling of hazard impacts by taking into account Hawai‘i-specific data (particularly for incorporating Hawai‘i-specific conditions and building and bridge types into hurricane and earthquake models).
6. Adopt more preventive community impact-based mitigation policies using more advanced hazard maps developed for use earlier in the land use and development process. Incorporate longer-term environmental trends, particularly in the coastal zone.
7. Conduct multi-hazard assessments and vulnerability evaluations of critical infrastructure to include fuel storage facilities, power plants, water systems, communications sites, sewage treatment plants, water storage tanks and other facilities providing critical services and supply chain critical facilities, then implement protection and mitigation to provide greater resiliency against disasters.
8. Conduct multi-hazard assessments and vulnerability evaluations needed to ensure post-disaster adequacy of critical transportation components and systems, such as highways, bridges, ports and harbors, and airports, then implement policies and mitigation to provide greater resiliency against disasters.
9. Develop policies for using alternative types of buildings (in addition to public sector school buildings) for greater capacity for sheltering and evacuation from coastal communities.
10. Increase emergency operational plan and logistical coordination amongst agencies and responders, NGO’s, and private sector service providers and key economic sectors.
11. Improve response and recovery capabilities and arrange the availability of key resources as necessary to accommodate demand surge in critical services after a disaster.
12. Develop a post-disaster recovery and reconstruction plan integrating green technology and building code compliance to Build Back Better disaster resilience. Develop Hawai‘i-specific mitigation and retrofit techniques.

Chapter 20, Mitigation Strategy, provides further prioritization and specific mitigation actions, policies, and projects in this disaster resilient strategy.

Mitigation Plan Implementation and Maintenance

The State of Hawai‘i developed a framework for disaster risk management that ensures implementation of the Hazard Mitigation Plan. The experiences of the past three years in dealing with disasters and the recent experience in updated the hazard mitigation plan has highlighted the importance of the evaluation process and in the coordination of efforts to support the hazard mitigation process.

The county local mitigation plans provided the basis for setting priorities at the local level and the State recognizes these. SCD established goals, objectives, and priorities for mitigation plans and actions. The State will continue to involve the Hawai‘i hazard mitigation community in developing effective mitigation measures.

SCD provides guidance to the counties in further developing strategies and in updating the risk and vulnerability assessment and hazard mitigation plans. The State Hazard Mitigation Officer ensures compliance with reporting on progress of mitigation actions funded under FEMA mitigation grants. The SHMF meets quarterly to review progress and implementation of the Hazard Mitigation Plan and mitigation actions.

The State recognizes that the current effort is based on the best available data and information, but that there are significant gaps in information that will be addressed over the next three years. As projects and programs are completed and as new policies are implemented, it will be important to update the document and reprioritize management strategies. There are additional gaps related to the coordination efforts among State agencies that need to be contributing to the risk reduction process. Coordination and collaboration issues will need to be addressed in the strategic planning process to assess issues such as agency involvement, and methods for continuing an active level of coordination among the broader risk reduction community. The Hawai‘i State Hazard Mitigation Forum and State Civil Defense will help to develop appropriate protocols for information sharing and enhancements to the current data sets for the geographic information system. The SHMF will assist State Civil Defense in developing an ongoing digital update process that will become an essential part of mitigation responsibilities. As developments for this update process occur, State Civil Defense will be able to rely on improved technological advances to evaluate the effectiveness of mitigation measures. This will be critical since the disasters have made mitigation funds available in the next few years.

Support by the Governor and government leaders in the State of Hawai‘i ensures that hazard mitigation will remain a priority in the future. The increased awareness and participation by the general public will make it easier to implement projects and provide input into future needs in minimizing risks and vulnerability to hazards.

The plan requires implementation of proposed measures to improve. It further requires collaboration among government agencies, the private sector, non-governmental organizations, and communities to reduce disasters. As the State begins to address gaps in mitigation, the plans will become more robust and disaster resilience will improve.

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

1. Introduction

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CHAPTER 1

Introduction

1.1 General

This document responds to the required Standard State Plan update, as required by amendment to the Robert T. Stafford Act in the Disaster Mitigation Act of 2000, § 201.4, every three years. The State of Hawai'i had its first mitigation plan approved on October 27, 2004. The State of Hawai'i Multi-Hazard Mitigation Plan, 2007 Update, was approved on October 27, 2007, and the 2010 Updated was approved on October 4, 2010.

The mitigation plan provides the State's strategy to reduce the risks from natural hazards, and serves as a guide for mitigation practice at all levels of state government. The plan details how the state will address planning for natural hazards and identifies resources to accomplish implementation. The purpose of this introduction is primarily to inform the Federal Emergency Management Agency (FEMA) of the changes and improvements made in how the plan was developed. An overview of the content of the plan itself was given in the Executive Summary.

The State of Hawai'i will continue to comply with all applicable Federal statutes and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c), and will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d)

1.1.1 2013 Plan Organization

The plan is written in 21 chapters that cover the FEMA Crosswalk requirements and is roughly organized along the flow of the crosswalk, as follows:

1) **Chapter 1** provides this introduction and the list of changes made to the plan on the basis of the evaluation survey and follow-up discussions with the planning committee.

2) **Chapter 2** documents the hazard mitigation planning of the State of Hawai'i, describes coordination among agencies, and explains program implementation, as required under the hazard mitigation planning amendment of the Stafford Act, 44 CFR Part 201, §201.4(b) and §201.4(c)(1).

3) **Chapter 3** reviews the State assets, including buildings, facilities, lifelines, land use, environment, and populations at risk from natural hazards (§201.4(c)(2)(ii)). This

chapter considers culture and places unique to Hawai'i, and the assets and resources that support livelihoods and the economy of people in the State of Hawai'i.

4) **Chapter 4** identifies the high wind hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

5) **Chapter 5** identifies the tropical cyclone hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

6) **Chapter 6** identifies the tsunami hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

7) **Chapter 7** identifies the earthquake hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

8) **Chapter 8** identifies the landslide and rockfall hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

9) **Chapter 9** identifies the flood hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

10) **Chapter 10** identifies the dam failure hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

11) **Chapter 11** identifies the high surf hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

12) **Chapter 12** identifies the coastal erosion hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

13) **Chapter 13** identifies the drought hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

14) **Chapter 14** identifies the wildfire hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

15) **Chapter 15** identifies the volcanic hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the degree of estimated severity and frequency (§201.4(c)(2)(i)).

16) **Chapter 16** identifies the hazardous material hazards in Hawai'i State, and the regulatory accounting of these materials.

17) **Chapter 17** identifies the health vulnerability hazards in Hawai'i State, reviews the historical occurrence of the hazard, and describes the circumstances that make Hawai'i a possible hub for the introduction of pandemic influenza.

18) **Chapter 18** identifies the possible long-term climate change and sea level rise impacts to Hawai'i State, and how that may exacerbate other coastal hazards.

19) **Chapter 19** reviews the risk assessment by hazard, and these are ranked by the expected loss impacts to Hawai'i (§201.4(c)(2)(ii) and §201.4(d)).

20) **Chapter 20** provides the list of current and ongoing mitigation actions and reviews the capability of the state for mitigating hazards. This chapter considers the status of previously recommended actions that have been implemented. It then describes the updated mitigation goals and objectives for the state and then identifies mitigation actions by hazard, (§201.4(c)(3)(ii) and §201.4(c)(3)(ii)); (§201.4(c)(3)(i) and §201.4(c)(3)(iii)).

21) **Chapter 21** describes the process for implementing, monitoring, and updating the plan in order to ensure the process identified in Chapter 2 continues and the actions identified in Chapter 20 become part of implemented in the future. As part of the implementation, Chapter 21 identifies funding sources (§201.4(c)(3)(iv), §201.4(c)(3)(iv), §201.4(c)(4)(ii), 201.4(c)(4)(iii), §201.4(c)(5)(i) and §201.4(c)(5)(ii)).

1.2 Evaluation of the 2010 Plan

Every three years, the State of Hawai'i is required by the Federal Emergency Management Agency (FEMA) under the Stafford Act[1] to update the state's hazard mitigation plan. The earlier plan needed a formal review and evaluation. The purpose of the evaluation was to understand the level of access and use of the 2007 Plan, to gather perceptions of its usefulness in relation to their activities, and to get suggestions about what to improve in the current plan and what to consider for the update. It was determined in 2010 that a survey should be undertaken that should be supplemented with discussions of members of the hazards community. For informational purposes, the 2010 report on the 2007 hazard mitigation plan has been included in Appendix 1A at the end of this chapter. A summary of the evaluation is provided in this section of this chapter.

[1] §322 of the Robert T. Stafford Act, as amended by §104 of the Disaster Mitigation Act of 2000 (DMA 2000), 44 CFR Part 201, Hazard Mitigation Planning.

1.2.1 Recommendations for the 2013 Plan Update

In terms of suggestions for improving the plan and future updates, there were several areas for consideration. The State Hazard Mitigation Forum reviewed the results of the 2007 evaluation and discussed the suggested changes, which cover a wide range of items. The 2013 Hazard Mitigation Forum also provided recommendations in moving forward with the plan update process. In order to identify changes for the updated plan in 2013, a rapid evaluation of the Hawai'i Multi-Hazard Mitigation Plan was conducted in January 2013 with the State Hazard Mitigation Forum. It was found that many of the evaluation recommendations of the 2007 plan were largely unattained in the 2010 plan update. Therefore, we provide Table 1-1 to indicate how the 2013 plan has taken these earlier evaluation recommendations into account. In January 2013, it was also recommended that the 2013 plan:

- Consider prioritizing the hazard chapters by severity of risks
- Include Hazard mitigation successes of the state
- Emphasize the economic impacts of disasters, such as business interruption losses
- Consider protection of island supply chain and critical infrastructure
- Consider food security as a part of the Hawai'i Mass Care Council
- The overall state perspective should be that a disaster resilience strategy should be more than a compilation of county project proposals
- Add sea level rise considerations particularly as it relates to coastal erosion and subsidence
- Add a pandemic health vulnerability chapter based on THIRA

Also, based on earlier discussions in the fall of 2012, specific areas suggested by FEMA in the update included:

- Incorporation of THIRA information on primary hazards
- Unification of risk assessment to enable its use as a module in other planning efforts
- Risk ranking to be data driven such as HAZUS MH modeling where appropriate
- Stakeholder active input and documentation of the update process with Input from other agencies (beyond SCD) and ongoing efforts
- Mitigation action project tracking of success and effectiveness
- Comprehensive hazard mitigation program with strategy for broader effectiveness
- Implementation of Hazard Mitigation into other planning efforts
- Documentation of building code updates
- Using other funding mechanisms beyond just FEMA programs
- Recovery policies to be established pre-disaster to incorporate hazard mitigation

Table 1.1 identifies the recommendations and the determination about how the 2013 plan addresses those issues.

Table 1.1 Recommended Changes to the 2013 Update from the Evaluation

Suggestion	Discussion and Treatment in the 2013 Update
Incorporate climate change predictions, such as sea-level rise, to the hazard assessments.	Information from assessments was included in the 2007 update and subsequently in the risk and vulnerability assessment and mitigation actions in the 2010 plan update. Additional advances and studies have been incorporated into Chapter 18 of the 2013 plan update and incorporated into the mitigation strategy of Chapter 20.
Ensure that future impacts are included in the risk and vulnerability analysis.	Risk and Vulnerability Assessments in Hazards Chapters 4 through 18, and Chapter 19, provide the best available data and analyses on modeled risks and vulnerability. The HAZUS-MH models look at projected risks from hurricanes and earthquakes, and floods to some extent (but with less skill). GIS layers of hazards and key population and employment areas have been used to consider tsunami risks and flood risks. There are drought and wildfire risk and vulnerability studies, but these have less spatial detail and primarily impact conservation and agricultural areas. Extensive risk maps are included in the drought mitigation plans for the State and counties. The State has updated shoreline erosion studies that can also be used to consider sea level rise impacts. For many of the hazards, climate change will add a dimension of risk.
Develop a trigger for state agencies to review and incorporate plan's policies into long-range and emergency planning.	Interpretation of this suggestion varied in discussions. Discussion focused on getting the timeline of the development planning and required mitigation planning, so that information on updates can be shared on the Secured Server and the State Hazard Mitigation Forum. Agencies and communities need to have access to the information that affects long-range general plans, land use, and emergency planning. The Chapter 20 summary of ongoing mitigation planning activities are of near-term completion, and the prioritized mitigation actions of Chapter 20 highlight the next potential updates of highest priority.
Develop a recovery plan.	The recovery plan is important for consideration and coordination of hazard mitigation options. This started in the THIRA 2012 Target Capabilities of the Recovery Mission, and the key measures for recovery incorporated in the Chapter 20 Prioritized Components of the Strategy for Infrastructure Resilience, Recovery and Macro-Economic Effects, and Threat Identification and Risk Analysis (THIRA) Implementation of Core Capability Building

Suggestion	Discussion and Treatment in the 2013 Update
Focus more on implementation (i.e. identifying funding sources and partners to bring the plan to life).	While the plan has to meet specific requirements, the plan does focus efforts on implementation. The mitigation measures and their priority were developed by the agency stakeholders themselves rather than being assigned by the State Hazard Mitigation Forum. Therefore, the expressed objectives of the numerous participants reflect their opinions, which should influence agency prioritization. Also, not all mitigation measures are dependent on FEMA funding.
Emphasize stronger integration with County general plans and community development plans.	The County multi-hazard mitigation plans integrate considerable input from their general plans and community development plans. The 2013 plan incorporated information from the updated County multi-hazard mitigation plans and from reviews of community organizations and ways that these organizations contribute to community resilience.
Encourage mitigation efforts as a result of state-county cooperation.	The intent of mitigation actions are to work in concert with the counties for implementation of mitigation. This continues to be highlighted in the State plan update.
Include more detailed GIS analysis and maps showing high risk to multiple hazards.	The maps used in the previous mitigation plans are the result of integration in GIS maps. The GIS hazard maps are used to develop the risk and vulnerability assessment. Although numerous maps have been included in the State plan update, they require considerable space. The planning team recognizes the importance of GIS maps, and these are included in updated risk and vulnerability assessments for State structures and facilities in Hazards Chapters 4 through 18, and Chapter 19 of the 2013 updated plan. In addition, the counties have recently updated their GIS hazard layers as part of each county's multi-hazard mitigation plan update process.
Prioritizing the hazard chapters by severity of risks	This has been done with the Chapters on Tropical Cyclones, Tsunami, Earthquakes, appearing first.
Include Hazard mitigation successes of the state	Chapter 20 discusses numerous recent hazard mitigation and planning achievements.
Emphasize the economic impacts of disasters, such as business interruption losses	Economic impacts from disasters and recovery was one of the themes of focus in the State Disaster Resilience Strategy Workshop. The State Disaster Resilience Strategy has several actions intended to enable faster recovery after a disaster.
Consider protection of island supply chain and critical infrastructure	The effects of major types of disasters on Critical Infrastructure and Key Resources (CIKR) were developed in the THIRA 2012 process and carried over and refined during the development of the state hazard mitigation strategy (Disaster Resilience Strategy). Hawai'i is particularly dependent on supply chain infrastructure for post-disaster response and recovery.

Suggestion	Discussion and Treatment in the 2013 Update
Consider food security	Food security can take two parts for a population of the size of Hawai'i: local food production and ensuring the supply chain to Hawai'i. A disaster may affect local food availability; for example, a hurricane would devastate local farms and forests. Therefore, the concept of food self-sustained locally does not ensure food security during disasters. This consideration is a part of the Hawai'i Mass Care Council current investigations.
The overall state perspective should be that a disaster resilience strategy should be more than a compilation of county project proposals	The hazard mitigation strategy was developed from an overarching perspective of effectively building disaster resilience, rather than the perspective of assembling individual projects to fund.
Add sea level rise considerations particularly as it relates to coastal erosion and subsidence	We now have a Climate Change Effects Chapter 18. We use the distinction of effects to recognize that climate change acts to exacerbate the effects of other hazards, rather than being an independent hazard of its own. Therefore, we consider it an optional enhancement of the Hawai'i Plan, rather than a FEMA requirement.
Add a pandemic health vulnerability chapter	This has been included in Chapter 17, Health and Vulnerability Assessment, regardless of whether it is required by FEMA rules for Standard State Mitigation Plans. Therefore, we consider it an optional enhancement of the Hawai'i Plan.
Incorporation of THIRA information on primary hazards	The THIRA analysis of the impacts of the most significant hazards on Core Capabilities has been helpful in the development of the State Disaster Resilience Strategy of this plan. THIRA has also helped place more emphasis on the performance of critical infrastructure and systems that are essential to the community, rather than just the vulnerability of individual buildings.
Unification of risk assessment to enable its use as a module in other planning efforts	Risk assessment is now Chapter 19, which can be exported to other planning efforts. Actually, the entire State Hazard Mitigation Plan is now modularized so the pertinent information on any hazard or aspect of risk assessment can be more effectively imported by other plans.
Risk ranking to be data driven such as HAZUS MH modeling where appropriate	The risk ranking utilized the severity of risk as measured by equivalent average annual economic losses, i.e., the expected losses from an evaluation of the probabilities of hazards with their potential to cause adverse effects on our life; health; economic activities, infrastructure; and the services expected from institutions. For earthquake, hurricane, and flooding, HAZUS MH was appropriate to the extent that local building inventory was modeled.

Suggestion	Discussion and Treatment in the 2013 Update
Stakeholder active input and documentation of the update process with Input from other agencies (beyond SCD) and ongoing efforts	The THIRA 2012 and State Disaster Resilience Strategy Workshop 2013 purposefully engaged a much broader group of stakeholders than in prior hazard mitigation plans.
Mitigation action project tracking of success and effectiveness	In Chapter 20 we summarize most of the significant recent mitigation actions in the State.
Comprehensive hazard mitigation program with strategy for broader effectiveness	In 2013, the goals and objectives of hazard mitigation were further refined to emphasize whole community disaster resilience and building Core Capabilities to address the hazards of greatest risk.
Implementation of Hazard Mitigation into other planning efforts	Chapter 2 has a discussion of hazard mitigation planning in the State of Hawai'i indicating the multi-agency approach utilized.
Documentation of building code updates	The effectiveness of the State Building Code adopted by the State in 2010 is now documented in further accomplishment by its adoption by all four counties in 2012.
Using other funding mechanisms beyond just FEMA programs	The State Disaster Resilience Strategy towards hazard mitigation includes policies and standards and other measures that are based on the criteria of feasibility, timeliness, and effectiveness, rather than being limited to the narrow eligibility criteria of FEMA programs.
Recovery policies to be established pre-disaster to incorporate hazard mitigation	In Chapter 20, we provide details on such policy measures. It is often too late if a community waits until after a disaster, because when delayed the appropriate measures to Build Back Better resilience would not be in place, and then the local jurisdiction also loses the opportunity to be eligible for federal aid to accomplish that goal if it has only has enacted outdated standards.

1.3 Documentation of Changes in the 2010 Plan Update

The above changes in approach and additions undertaken for the 2013 update of the State of Hawai'i Multi-Hazard Mitigation Plan are examined in the context of the FEMA required crosswalk elements of a Standard State Hazard Mitigation Plan. Table 1.2 explains the gap or lesson learned from the 2010 update and subsequent evaluation recommendation, the way that the issue is addressed in 2013 plan, and the basis to make the change in the plan or decisions related to hazard mitigation.

Table 1.2 FEMA Required Elements and Changes for the 2013 Plan based on Evaluation

Plan Requirement	Description
ADOPTION OF THE PLAN BY THE STATE	
Adoption of the Plan **Location**: Front matter of the plan	**Evaluation and Lessons Learned from the 2010 Plan Update** The Governor was briefed about hazard mitigation planning by the Director and Vice Director of Civil Defense, and the plan will be adopted prior to FEMA approval.
	Methods for Analysis and Decisions for Changes in 2013 update State Civil Defense advises the Governor's Office about the details of the plan to ensure plan adoption.
PLANNING PROCESS	
Documentation of the Planning Process **Location**: Chapters 1, 2 and 21	**Evaluation and Lessons Learned from the 2010 Plan Update** The process for mitigation planning has been officially implemented since the formation of the State Hazard Mitigation Forum. Even though mitigation actions have been implemented every year since then, it is important to document the process and explain it in the plan. The State Hazard Mitigation Forum conducted an evaluation to support changes made in document format and content.
	Gap Addressed and Change incorporated into the 2013 plan update This document begins with evaluations of the 2007 and 2010 plans (Chapter 1) that supports changes made throughout the plan. Chapter 2 explains the multi-agency hazard mitigation in the State of Hawai'i. Chapter 21 documents the specific planning process utilized in this update..
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Forum helped to advise and drive the process by making recommendations to the format and content for inclusion in the plan, as well as participating as moderators in the State Disaster Resiliency Strategy Workshop 2013. Changes are approved by SCD, and approved by the State through adoption of the plan by the Governor.
Coordination Among Agencies **Location**: Chapter 2	**Evaluation and Lessons Learned from the 2010 Plan** The State Hazard Mitigation Forum and other hazard advisory groups and emergency management organizations provide interagency coordination at state, county, and federal levels.
	Gap Addressed and Change incorporated into the 2013 plan update The level of participation was increased to include more state and federal agencies, NGO's and private sector responsible or affected in the Missions of Planning, Mitigation, Response, and Recovery.
	Methods for Analysis and Decisions for Changes in 2013 update State Civil Defense drove the process in the THIRA 2012 "from the ground up through the counties to the state" process and State Disaster Resilience Strategy Workshop to engage multi-agency participants at many local , state, and federal levels to come to consensus recommendations to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD and approved by the State through adoption of the plan by the Governor.

Program Integration **Location**: Chapter 2; Chapter 20 – current mitigation actions	**Evaluation and Lessons Learned from the 2010 Plan Update** The State Hazard Mitigation Forum provided opportunities for agencies to share programs. Chapter 2 in the plan provides an overview of state and county programs and policies that contribute to hazard mitigation, and there continues to be attention toward integrating these programs in hazard mitigation plans, and integrating hazard mitigation in other programs.
	Gap Addressed and Change incorporated into the 2013 plan update Continued effort to ensure greater integration of hazard mitigation in agencies through communication to a broader group of stakeholders and explicit consideration of disaster resilience goals and objectives, so that common interests were discovered and appreciated.
	Methods for Analysis and Decisions for Changes in 2013 update State Civil Defense drove the process in the THIRA 2012 "from the ground up through the counties to the state" process and State Disaster Resilience Strategy Workshop to engage multi-agency participants at many local , state, and federal levels to come to consensus recommendations to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and approved by the State through adoption of the plan by the Governor.
RISK ASSESSMENT	
Identifying Hazards **Location**: Chapters 4-18	**Evaluation and Lessons Learned from the 2010 Plan Update** In the development of the 2007 plan, the planning team was encouraged to add consideration and treatment of climate change, with emphasis on sea level rise and extreme events, public health risks, dam failures, and human-induced hazards because of increased experience in managing risks from these hazards and because these can become disasters for island systems and can also further exacerbate impacts of disasters in situations of cumulative and secondary impacts. Also, the plan had become cumbersome and difficult to export to other planning efforts.
	Gap Addressed and Change incorporated into the 2013 plan update The plan was substantially changed both in organization and updated content based on the results of studies and experience with hazard occurrences, so that is now has separate chapters on each hazard or effect: Chapter 4. High Wind Storms 5. Tropical Cyclones 6. Tsunamis 7. Earthquakes 8. Landslides and Rock Falls 9. Floods 10. Dam Failures 11. High Surf 12. Coastal Erosion 13. Droughts 14. Wildfires 15. Volcanic Hazards 16. Hazardous Materials 17. Health Risk and Vulnerability Assessment 18. Climate Change Effects.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Forum was briefed on the proposed re-organization and that direction was approved for development of the 2013 plan. Changes are approved by SCD, and approved by the State through adoption of the plan by the Governor.
Profiling Hazards **Location**: Chapters 4-18	**Evaluation and Lessons Learned from the 2010 Plan Update** The plan involved information from agencies and experts in each of the hazard areas. Historical records were included. Information that can be distributed spatially has been incorporated into the State's GIS database and distributed as spatial information. The 2010 plan did not completely integrate the finding of the local hazard mitigation plans that were most recently approved in 2009, 2010 and 2012

	Gap Addressed and Change incorporated into the 2013 plan update The hazard profiling has benefited from completion of several hazard analyses since 2010. Profiling of hazards is based on use of **best available data.** Additional information has been provided by State Civil Defense and hazard experts. The information includes: 1) Local county hazard mitigation plans 2) Hawai'i Mass Care Council (2013 SCD): A large working group convened to plan for mass care delivery of food and shelter essential living needs for residents displaced over several months due to damage to their homes. 3) RCGP - Regional Catastrophic Preparedness Grant – County Hurricane Catastrophic Planning Project – Operations and Logistics (2012-2013, DEM): This RCGP project is managed by the Honolulu Department of Emergency Management, but involves planning of the emergency supply chain for delivery of goods and services to all counties after a major (Cat 4) hurricane disaster. 4) Aleutian Tsunami Inundation Modeling (2013 SCD): The inundation resulting from a large magnitude earthquake (Mw 9 or greater) on a previously disregarded section of the Aleutian subduction zone is now being modeled for utilization in an update of tsunami evacuation plans and maps. 5) O'ahu Coastal Communities Evacuation Planning Project (2012-2013 Honolulu DEM): This project is paired with the Aleutian Tsunami Inundation Modeling to develop appropriate plans for "second line of fallback" evacuation zones for Great Aleutian Tsunami scenarios, develop more optimized routing and evacuation signage, and locate tsunami refuge areas that have close enough proximity to each region of the inundated coastline. 6) SDOT Hurricane and Tsunami Vulnerability of Coastal Bridges and Commercial Ports throughout Hawai'i (2012-2013 HDOT): State Department of Transportation (Highway and Harbor Divisions) is evaluating the vulnerability of coastal bridges and ports to storm surge and tsunami inundation, considering the structural characteristics and the criticality of the structure in the transportation network and harbor functionality. 7) State Bridge Seismic Retrofits (HDOT): For several years, the Hawai'i Department of Transportation has been performing seismic retrofitting of older vintage bridges that were vulnerable due to lack of modern seismic design detailing or insufficient accommodation of movement and lack of anchorage and ties at joints. 8) THIRA (2012-2013 , SCD) : The THIRA is an all-hazards Core Capability-based assessment that establishes a foundation to justify and guide preparedness activities and investments toward achieving capability targets in the Prevention, Protection, Mitigation, Response, and Recovery Missions. 9) State of Hawai'i Building Code (2007-2012): 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. Hawai'i-specific wind microzonation maps, taking the effect of topography into account, were adopted as local Hawai'i amendments; these Hawai'i wind design maps were awarded the 2010 Outstanding Civil Engineering Achievement Award by the American Society of Civil Engineers Hawai'i Chapter.
	10) As of 2012, the Mass Management System tool now Include topographic wind effects in the output of the model, to allow identification of the topographically-amplified wind speeds for any individually defined storm scenario. 11) Hurricane Shelter Assessments and Retrofits ongoing at various sites (ongoing, SCD and DAGS): The state legislature previously appropriated funding of $3.8 million to enable dozens of deficient public hurricane shelter buildings at public schools to be retrofitted to address structural issues and enclosure protection. 12) State General Flood Control Plan Update (2013, DLNR): The plan is undergoing a re-organization and integration of information for all counties into an online format.

	13) New Digital Flood Insurance Rate Maps (2009-2012): The DFIRM's have been adopted based on FEMA's 2008 Flood Insurance Study of hurricane inundation boundaries for the west and south coasts of all islands. The hazard analysis considered the combination of storm surge and hurricane-induced wave hazards. 14) Dam evacuation zones and Emergency Action Plans (DLNR): through the actions of the State Department of Land and Natural Resources (DLNR), almost all regulated dams in the state now have Emergency Actions Plans submitted by the owners of the dams, and nearly all dams have contingency evacuation maps prepared by the counties based on modeling developed under DLNR. 15) Rockfall Mitigation along State Roadways and Highways (SDOT): Rockfall and landslide mitigation is being addressed through rock clearing, anchoring of fall mitigation meshes, and slope stabilization. 16) Flood Control projects and infrastructure improvements (DLNR): these have been implemented in the Maili Basin, Hāmākua Ditch, Ala Wai Canal watershed. 17) Waikiki Beach restoration: this project periodically pumps offshore natural sand deposits and emplaces areas with the more significant erosion of beach frontage. 18) Hardening of American Red Cross Headquarters EOC and the Department of Education EOC in Honolulu: These projects addressed some vulnerability to windborne debris. 19) Modernization of the warning sirens (2012-2014): Hawai'i is performing a $25 million upgrade of its emergency warning sirens and using satellite machine-to-machine (M2M) devices. 20) Post & Pier Retrofit Expert Tool (2010-2012),: In response to the damage experience by post and pier homes during the Kiholo Bay and Māhukona Earthquakes of September 15, 2006, three retrofit options were developed, with the applicability of each retrofit based on the location of the house and its structural properties. 21) HAZUS MH MR4 with Hawai'i Enhanced Data (2008-2010); New building inventory data for the County of Maui and County of Hawai'i makes HAZUS MH capable of producing earthquake damage maps and reports at a much higher spatial resolution, based on the best available building inventory and soil data. . 22) Updated Hawai'i HAZUS Atlas (2013): Working in close collaboration with the Hawai'i State Civil Defense (SCD) and Hawai'i State Earthquake Advisory Committee (HSEAC), PDC updated the Hawai'i HAZUS Atlas (HHA) to incorporate the HAZUS MH MR4 with Hawai'i Enhanced Data.
	Methods for Analysis and Decisions for Changes in 2013update The State Hazard Mitigation Planning Consultant made recommendations to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and approved by the State through adoption of the plan by the Governor.
***Assessing Vulnerability:* Assessing Vulnerability by Jurisdiction** **Location**: Chapter 4-18; Chapter 19	**Evaluation and Lessons Learned from the 2010 Plan Update** Detailed risk and vulnerability assessments have been conducted as part of the County planning processes and the Counties maintain detailed, parcel-level risk assessment information. Inclusion of local community assessments strengthens information.
	Gap Addressed and Change incorporated into the 2013 plan update Updated asset layers and hazard layers were used in the plan to reassess the risk and vulnerability assessment. The new studies and hazard profile information with GIS maps reveal that there are facilities that demand consideration for flood and tsunami risk. Research on wind hazard risks using topographic analysis of wind speed-up values has been applied to an assessment of building codes, and the wind hazard layers and "speed-up" maps have been integrated into the GIS database, and used in assessing vulnerability. . The integration of these assets with the hazards mapping using GIS occurs in each hazard chapter under consideration of risk and vulnerability and then is compiled in Chapter 19. Detailed GIS maps occur in the County plans. The State plan focuses primarily on State assets at risk. Chapter 19 reveals structural risk and vulnerability for the State's critical facilities, which strengthens recommendations for mitigation actions in Chapter 20.

	Methods for Analysis and Decisions for Changes in 2010 update The State Hazard Mitigation Planning Consultant performed the analysis and gave briefings to the SHMF and other stakeholders that were approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
***Assessing Vulnerability:* Assessing Vulnerability of State Facilities** **Location**: Chapter 4 – 18; and Chapter 19	**Evaluation and Lessons Learned from the 2010 Plan Update** In the 2010 plan update process, it was revealed that the State critical facilities had not been linked to GIS hazard maps for understanding risk, and there was a gap in assessing vulnerability of state facilities based on topographic, island-specific risks. The need to use improve HAZUS-MH in assessing risk to state facilities was identified as a gap and undertaken as analysis for the 2010 plan update.
	Gap Addressed and Change incorporated into the 2013 plan update Assessment of structural risk and vulnerability of state critical facilities has been conducted using HAZUS-MH or similar methodology to reveal average annualized loss and damage scenarios of facilities with highest damages and greatest loss of function for flood, tsunami, hurricane/strong wind, and earthquake risks. These results are used to inform mitigation actions proposed in Chapter 20.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed the analysis which formed the basis of recommendations to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
Estimating Potential Losses by Jurisdiction §201.4(c)(2)(iii) **Location**: Chapter 19	**Evaluation and Lessons Learned from the 2010 Plan Update** Estimates of potential losses by hazard by jurisdiction are included in the County local mitigation plans, and referenced in Chapter 19.
	Gap Addressed and Change incorporated into the 2013 plan update Changes in the potential loss estimates have been included in Chapter 19 risk and vulnerability assessment based on the integration of new studies into loss analyses, as referenced previously.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed the analysis which formed the basis for recommendations to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
Estimating Potential Losses of State Facilities §201.4(c)(2)(iii) **Location**: Chapter 19	**Evaluation and Lessons Learned from the 2010 Plan Update** Estimates of potential losses by hazard (primarily hurricane, flood, and earthquake in HAZUS-MH analyses, but also some coastal inundation and tsunami risks) for state facilities are included in the County local mitigation plans, and referenced in the hazard chapters.
	Gap Addressed and Change incorporated into the 2013 plan update Martin & Chock, Inc, worked with URS to update Hawai'i's building inventory in HAZUS-MH. In addition, the structural risk and vulnerability assessment conducted by Martin & Chock, Inc. with the UH in 2010 provided key information on potential losses from disaster damage and from loss of functionality in different disaster scenarios, and contributes to the loss information reflected in Chapter 19. Tsunami risk has been substantially re-analyzed.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed the analysis which formed the basis for recommendations to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.

MITIGATION STRATEGY	
Hazard Mitigation Goals §201.4(c)(3)(i) **Location**: Chapter 20	**Evaluation and Lessons Learned from the 2010 Plan Update** The SHMF reviewed and updated the hazard mitigation goals and objectives. In 2010, additions were made to reflect the need to protect communities and vulnerable populations. Additions were made to include consideration of climate change. Importance was placed not only on structures and the built environment, but on natural resources and the environment, which also support the economy and livelihoods.
	Gap Addressed and Change incorporated into the 2013 plan update The SHMF reviewed the previous goals and objectives and made some additions and modifications to reflect a more comprehensive disaster resilience strategic outlook.
	Methods for Analysis and Decisions for Changes in 2010 update The State Hazard Mitigation Planning Consultant performed an analysis of stakeholder input provided at the State Disaster Resiliency Strategy Workshop 2013, which formed the basis for recommendations to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
State Capability Assessment §201.4(c)(3)(ii) **Location**: Chapters 2 and 20	**Evaluation and Lessons Learned from the 2010 Plan Update** The 2010 plan included discussions of organizations, institutions, policies, laws, programs, and projects that support hazard mitigation in the State of Hawai'i.
	Gap Addressed and Change incorporated into the 2013 plan update There is a more comprehensive discussion of current capabilities in Chapter 2.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed the draft plan recommendations that were approved for inclusion in the plan by the SHMF. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
Local Capability Assessment: §201.4(c)(3)(ii) **Location**: Chapters 2 and 20	**Evaluation and Lessons Learned from the 2010 Plan Update** The 2010 plan included assessments of local capabilities for hazard mitigation in each of the county local mitigation plans, including discussions of organizations, institutions, policies, laws, programs, and projects that support hazard mitigation. However, the goals and objectives, and priorities of each county were not described.
	Gap Addressed and Change incorporated into the 2013 plan update The 2013 plan includes an assessment of local capabilities based on updates of the county local mitigation plans and the development of the new local mitigation plans including their goals and objectives and implementation priorities.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed the draft plan integration with the local plan recommendations, which were approved for inclusion in the plan by the SHMF. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
Mitigation Actions: §201.4(c)(3)(iii) **Location**: Chapter 20	**Evaluation and Lessons Learned from the 2010 Plan Update** Based on the risk and vulnerability assessment and impacts from disasters, the SHMF and Hawai'i State Earthquake advisory committee recommended mitigation actions.
	Gap Addressed and Change incorporated into the 2013 plan update There was a significant change in the process of engagement. State and County agencies and organizations have directly formulated input and recommendations and priorities for the plan based on the results of the updated risk and vulnerability assessments. In this regard, the State Hazard Mitigation Forum did not place itself in decision-making authority above the stakeholders, but rather acted as moderator of the stakeholder deliberations.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Forum helped to advise and drive the process by making recommendations to the stakeholders to which they modified, revised, added, and then prioritized approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.

Funding Sources: §201.4(c)(3)(iv) **Location**: Chapter 21	**Evaluation and Lessons Learned from the 2007 Plan Update** A table of potential funding sources was included in the hazard mitigation plan update.
	Gap Addressed and Change incorporated into the 2013 plan update An updated table of potential funding sources has been included in Chapter 21.
	Methods for Analysis and Decisions for Changes in 2010 update The State Hazard Mitigation Planning Consultant performed the draft plan integration with the local plan recommendations, which were approved for inclusion in the plan by the SHMF. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
COORDINATION OF LOCAL MITIGATION PLANNING	
Local Funding and Technical Assistance: §201.4(c)(4)(i) **Location**: Chapters 20 and 21	**Evaluation and Lessons Learned from the 20010 Plan Update** As discussed in Chapter 7 of the 2010 plan, State Civil Defense provides the primary source of funding and technical assistance for local mitigation planning.
	Gap Addressed and Change incorporated into the 2013 plan update There is no significant change. State Civil Defense provides the primary role of funding source (i.e., primary applicant) and technical assistance for local mitigation planning. .
	Methods for Analysis and Decisions for Changes in 2010 update The State Hazard Mitigation Planning Consultant performed the draft plan integration with the local plan recommendations, which were approved for inclusion in the plan by the SHMF. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
Local Plan Integration: §201.4(c)(4)(ii) **Location**: Chapters 20 and 21	**Evaluation and Lessons Learned from the 2010 Plan Update** The State plan is based on local assessments of risk and vulnerability to jurisdictions, critical facilities, lifelines, and other assets. These aspects were integrated directly into the State plan. State Civil Defense reviews the local mitigation plans prior to sending to FEMA for formal review and ensures that local plans are integrated into the State plan.
	Gap Addressed and Change incorporated into the 2013 plan update There was a major update to import hazard analysis information and mitigation goals and objectives of the counties specifically in the State plan, so that the local plans have more influence on the State plan, and the State plan is better coordinated and more consistent with the latest local jurisdiction updated plans.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed the draft plan integration with the local plan recommendations, which were approved for inclusion in the plan by the SHMF. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
Prioritizing Local Assistance: §201.4(c)(4)(iii) **Location**: Chapter 21	**Evaluation and Lessons Learned from the 2010 Plan Update** Discussions in Chapter 7 review the prioritization process, where local assistance is prioritized based on demonstration of critical need from risk and vulnerability assessments. In addition, the counties risks from particular hazards are considered in funding allocation. The SHMF reviewed the prioritizations related to availability of funding and eligibility for particular funding resources.
	Gap Addressed and Change incorporated into the 2013 plan update There are no significant changes in the process for prioritizing supporting assistance for local plans approved in 2009-2012, but the State uses criteria based on disaster resilience target capabilities developed in 2012-2013 established by the SHMF and reviewed by SCD. Therefore, it is anticipated that the next updates of the local hazard mitigation plans will be adjusted for consistency with the state consensus-based framework of disaster resilience, as opposed to just designing projects to accommodate FEMA funding constraints.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed the draft plan integration with the local plan recommendations, which were approved for inclusion in the plan by the SHMF. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.

NFIP AND REPETITIVE LOSS FLOOD MITIGATION STRATEGY	
Repetitive Loss Mitigation Strategy **Location**: Chapter 6 on NFIP; County Plans	**Evaluation and Lessons Learned from the 2010 Plan Update** Each of the County plans addresses repetitive loss properties in local flood ordinances. The State's National Flood Insurance Program Coordinator resides in the Department of Land and Natural Resources Engineering Division. Repetitive losses are considered under the scope of the flood mitigation strategy. The description of losses is included in Chapter 9 as part of the risk and vulnerability assessment and reviews the policies and actions in place to address flood risks.
	Gap Addressed and Change incorporated into the 2013 plan update As part of the County local mitigation plan updates, there has been increased attention to addressing flood risks, including strategies to address repetitive loss. Also, updated information on NFIP policies in effect and repetitive flood losses were obtained and analyzed.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed an analysis of stakeholder data which formed the basis for the draft chapter presented to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.
Identification and Analysis of Mitigation Actions: **NFIP Compliance** **Location**: Chapter 9	**Evaluation and Lessons Learned from the 2010 Plan Update** The State's National Flood Insurance Program Coordinator resides in the Department of Land and Natural Resources Engineering Division and ensures compliance of the State and Counties with the National Flood Insurance Rate Program.
	Gap Addressed and Change incorporated into the 2013 plan update There are several issues related to NFIP that been updated based on working with the county floodplain coordinators. The information is documented in the updated plan in Chapter 9. In addition, flood insurance rate maps (FIRMs) have been updated in digital format, reviewed, and approved for each of the counties. Recommendations for improving flood mitigation are included in the Chapter 20 mitigation actions.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed an analysis of stakeholder data which formed the basis for the draft chapter presented to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan..
PLAN MAINTENANCE PROCESS	
Monitoring, Evaluation, and Updating the Plan §201.4(c)(5)(i) **Location**: Chapter 8	**Evaluation and Lessons Learned from the 2010 Plan Update** For the 2010 plan, a schedule was outlined to monitor progress, evaluate, and update the plan. This resulted in the development of the Planning Subcommittee to monitor implementation of the plan. A schedule was developed for the SHMF to review the process for updating the plan.
	Gap Addressed and Change incorporated into the 2013 plan update The State Hazard Mitigation Forum will continue to meet quarterly to review actions and ensure implementation of the plan. Prior to the next plan update, there will be an evaluation of the effectiveness and implementation of the 2013 update plan, and this will be used to guide the update currently scheduled for 2018. The plan evaluation was embedded in the document previously, but plan approval requires a more formalized evaluation process that should be conducted several months before the plan update. The current evaluation summarizing evaluations from 2007 through 2013 appears in Chapter 1 as a model for how to organize recommendations and account for them in future evaluations of the mitigation planning process.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed the analysis which formed the basis for recommendations to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.

Monitoring Progress of Mitigation Activities: §201.4(c)(5)(ii) and (iii) **Location**: Chapter 8	**Evaluation and Lessons Learned from the 2007 Plan Update** SCD monitors the progress of mitigation activities through required reporting and program accountability. The SHMF provides integration of multiple agencies and monitors progress during the quarterly meetings, and ensures that opportunities for funding from multiple sources are pursued and coordinated.
	Gap Addressed and Change incorporated into the 2010 plan update There is formal change to the role of the State Hazard Mitigation Forum as having an oversight of the process that has been established in the State of Hawai'i to monitor the progress and ensure implementation of hazard mitigation activities. However, the Forum is not representative of all stakeholders in hazard mitigation and it is still an advisory committee to State Civil Defense rather than its agent, and so State Civil Defense will need to offer opportunities for direct input of a broader group of participants, as exemplified in 2012-2013, that can also involve the Forum in an effective assisting role of fostering disaster resilient policies and actions.
	Methods for Analysis and Decisions for Changes in 2013 update The State Hazard Mitigation Planning Consultant performed the analysis which formed the basis for recommendations to the SHMF that were approved for inclusion in the plan. Changes are approved by SCD, and final approval by the State comes through the Governor's adoption of the plan.

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STATE OF HAWAII

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Appendix 1A

Evaluation Results
2007 State of Hawai‘i Multi-Hazard Mitigation Plan

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Evaluation Results
State of Hawai‘i Multi-Hazard Mitigation Plan, 2007 Update

prepared by:
Hazards, Climate, and Environment Program, University of Hawai‘i Social Science Research Institute

in support of:
State of Hawai'i Civil Defense

submitted:
July 7, 2010

Introduction

Every three years, the State of Hawai‘i is required by the Federal Emergency Management Agency (FEMA) under the Stafford Act[1] to update the state's hazard mitigation plan. In order to identify changes that would be required in the updated plan, the plan needed a review and formal evaluation. Unfortunately, there was not sufficient time to conduct a long-term evaluation of all the processes, and given time constraints for attaining and addressing information to meet state deadlines, it was determined that a survey should be undertaken.

The rapid evaluation of the Hawai‘i Multi-Hazard Mitigation Plan, 2007 Update was conducted in early June 2010 with a small group of people involved in mitigation of multiple hazards. The purpose of the evaluation is to understand the level of access and use of the Plan, to gather perceptions of its usefulness in relation to their activities, and to get suggestions about what to improve in the current plan and what to consider for the 2010 update. This report summarizes the evaluation results. The detailed answers of the respondents to each of the survey question can be found in the Appendices.

Methodology

HCE-UH SSRI consulted the State of Hawai‘i Hazard Mitigation Officer and State Civil Defense staff to develop the objectives of the evaluation, which were targeted at improving the quality and distribution of the plan, updating content, and ensuring usefulness of the plan in support of the State of Hawai‘i's hazard mitigation efforts. A draft survey was developed by HCE-UH SSRI in May 2009. The draft survey was reviewed by Dr. Judith Inazu (Director, Office of Evaluation Services and Associate Director, Social Science Research Institute, University of Hawai‘i) and Dr. Don Thomas (Director Center for the Studies of Active Volcanoes). Their comments informed revisions in the draft related to length of the instrument, phrasing of questions to improve clarity, and increasing the level of detail by respondents of their involvement in disaster management.

[1] §322 of the Robert T. Stafford Act, as amended by §104 of the Disaster Mitigation Act of 2000 (DMA 2000), 44 CFR Part 201, Hazard Mitigation Planning.

Suggestions on Improvement and Future Update

The respondents who selected "not every useful", were asked to suggest ways in which the plan could be improved. Four responses were given, including: 1) keep it simple; 2) shortening the executive summary; 3) new outlook and approach by the State Civil Defense; and, 4) more GIS analysis and mapping of risk areas (Appendix 9). Three out of eight people who mentioned a need for focus on additional hazards that have emerged as threats in their work, specified sea level rise (Appendix 10).

In relation to the respondents' suggestions regarding how the 2010 State of Hawai'i Multi-Hazard Mitigation Plan Update can be made more useful to the respondents or their organizations, nearly half of the respondents gave their input (Appendix 11), a summary of which is provided as follows:

- Incorporate climate change predictions, such as sea-level rise, to the hazard assessments.
- Ensure that future impacts are included in the risk and vulnerability analysis.
- Develop a trigger for state agencies to review and incorporate plan's policies into long-range and emergency planning.
- Develop a recovery plan.
- Consider the role of pedestrian and bicycle facilities and training in evacuation. (See Appendix 11 for an example from the State of New York).
- Provide an index of federal, state, and county funding programs and sources for each hazard.
- Improve the visual design.
- Develop a new outlook and approach by State Civil Defense.
- Focus more on implementation (i.e. identifying funding sources and partners to bring the plan to life).
- Emphasize stronger integration with County general plans and community development plans.
- Encourage mitigation efforts as a result of state-county cooperation.
- Include more detailed GIS analysis and maps showing high risk to multiple hazards.

Conclusion

The results of the survey highlight the relevance of the multi-hazard mitigation plan for the hazards community throughout the State of Hawai'i. The survey respondents reinforced several key aspects of the plan, and highlighted ways to make the document more relevant and useful to the hazards community.

Access to and Use of Multiple Hazard Mitigation 2007 Plan Update

The result of the evaluation showed that a significant proportion of the respondents may not have a hard copy of the Hawai‘i Multi-Hazard Mitigation Plan, 2007 Update, but know where to access the plan. However, it further demonstrates that the plan should be distributed more widely. Most participants want digital copies, and the plan can be further distributed by sending the website link out to the broader community when published. The discussions within the planning subcommittee were that the subsections could be separated further and better navigation could be built into the digital files to enable participants to find information more readily.

In terms of the use of the plan, the survey respondents represented a wide range of people working in multiple hazard mitigation; however, slightly more than half of them never used the plan mainly due to the lack of time and priority in their agencies and organizations. Those who use the plan feel that it is useful for most of their activities, in particular for them to identify, evaluate, and prioritize mitigation activities. The planning subcommittee discussed this issue and identified the need to encourage incentives for collaboration and leveraging resources to increase the use of the plan. The plan update process should highlight some opportunities for collaboration.

Suggestions on Improvement and Future Update

In terms of suggestions for improving the plan and future update, there were several areas for consideration. Sea level rise is considered as a new threat that should be addressed. In the list of identified hazard areas, sea level rise was not listed. In the 2007 plan, sea level rise was treated as a significant impact of climate change and the projections that are being suggested were included in the plan update. There have been more localized efforts in understanding risk and vulnerability from sea level rise since the 2007 update, and the new information from Hawai‘i will be included in the 2010 plan update.

The State Hazard Mitigation Forum planning subcommittee discussed the other suggestions, which cover a wide range of items without focus one specific area. The following table identifies the recommendation and determination about ways to address the issue:

Suggestion	**Discussion and Treatment in the 2010 Update Process**
Incorporate climate change predictions, such as sea-level rise, to the hazard assessments.	Information from assessments was included in the 2007 update in Chapter 3, section 3.5 and subsequently in the risk and vulnerability assessment in Chapter 5 and mitigation actions in Chapter 7. Since the 2007 Plan Update, there have been additional advances and studies. These will be incorporated into the 2010 plan update process.
Ensure that future impacts are included in the risk and vulnerability analysis.	Studies on damages and modeled impacts from hazards have been included in Chapter 5: Risk and Vulnerability Assessment. However, not all of the hazards have been modeled to the same extent and detail that would consider all future impacts, especially since there is a great deal of uncertainty as to frequency, magnitude, and impact of the hazards.

Suggestion	**Discussion and Treatment in the 2010 Update Process**
Develop a trigger for state agencies to review and incorporate plan's policies into long-range and emergency planning.	Interpretation of this suggestion varied in discussions. Discussion focused on getting the timeline of the development planning and required mitigation planning, so that information on updates can be shared on the Secured Server and the State Hazard Mitigation Forum website (www.mothernature-Hawai'i.com). Competing priorities and deadlines make it difficult to focus on all types of planning however; agencies and communities may need to know information from long range general plans, land use, and emergency planning.
Develop a recovery plan.	The recovery plan is important for consideration and coordination of hazard mitigation options. This has been suggested several times, although it has been challenging to find funds that will support this effort.
Consider the role of pedestrian and bicycle facilities and training in evacuation. (See Appendix 11 for an example from the State of New York).	This item has not been considered for contribution to the mitigation plans previously. This would be an important piece of information for collaborating with other universities or planners that have developed similar models.
Provide an index of federal, state, and county funding programs and sources for each hazard.	Chapter 8 Appendix lists funding and programs for addressing each hazard.
Improve the visual design.	The first plan and update were developed to address content, and the project is not working with a graphics designer to improve visual designs.
Develop a new outlook and approach by State Civil Defense.	The current mitigation planning process is based on meeting federal requirements, so finding a new approach may be not be as flexible as this recommendation requests. It is not clear what "a new outlook and approach" means.
Focus more on implementation (i.e. identifying funding sources and partners to bring the plan to life).	While the plan has to meet specific requirements, the planning team appreciates the recommendation, and would prefer to focus efforts on implementation. Constraints expressed by numerous participants on time and agency prioritization might be considered here in order to determine ways to overcome barriers to implementation of the plan. Even though the planning team had considerable discussion about this, they determined that this topic will need more discussion in the future.
Emphasize stronger integration with County general plans and community development plans.	The County multi-hazard mitigation plans integrate considerable input from their general plans and community development plans. In the 2007 update, "community organizations" were identified as assets to the state because of the localized work that contributes to hazard mitigation. The 2010 plan will incorporate information from the updated County multi-hazard mitigation plans and from reviews of community organizations and ways that these organizations contribute to community resilience.
Encourage mitigation efforts as a result of state-county cooperation.	The intent of mitigation actions are to work in concert with the counties for implementation of mitigation. This continues to be highlighted in the State plan update.

Suggestion	**Discussion and Treatment in the 2010 Update Process**
Include more detailed GIS analysis and maps showing high risk to multiple hazards.	The maps used in the previous mitigation plans are the result of integration in GIS maps. The GIS hazard maps are used to develop the risk and vulnerability assessment. Although numerous maps have been included in the State plan update, they require considerable space and the formatting for the document does not allow detailed resolution. The planning team recognizes the importance of GIS maps, and these will be included in updated Risk and Vulnerability assessments for State structures and facilities in Chapter 5 of the updated plan. In addition, the counties have recently updated their GIS hazard layers as part of each county's multi-hazard mitigation plan update process. These maps will be referenced rather than duplicated in the 2010 plan update

The recommendations from the survey provide data and information for discussion and reflection by the planning subcommittee and the State Hazard Mitigation Forum in moving forward with the plan update process. During the 2010 plan update process, the planning subcommittee will determine ways to integrate recommendations and make the plan more useful for the hazards community.

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2. Mitigation Planning

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CHAPTER 2

Mitigation Planning

2010 Plan	Reasons for Updates / Revisions in this 2013 Plan
The 2010 plan discussed the planning effort for this document and various organizations involved.	• The 2013 plan includes a broader discussion of the mitigation planning process at the Federal, State and local levels. • National goals and programs are explained. • Hazard mitigation is defined and the range of hazard mitigation activities and examples are presented.

2.1 Hazard Mitigation Planning Background Information

As the direct and indirect costs of disasters continue to rise, it becomes particularly critical that preparing for the onslaught of damage from these events must be done in order to reduce the amount of damage and destruction. This strategy is commonly known as mitigation. 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.

Aside from the direct costs, or those damages and losses directly attributable to the disaster, Americans also suffer from indirect costs, most of which may take much longer to recover from. Direct costs are short-term and may include such costs as debris removal, setting up an emergency shelter, repairs to transportation, critical utilities, and supply chain, and the cost of repairs to public, private and commercial sectors. Indirect costs are those incurred sometime after the event, perhaps six months or more. These long-term costs include the permanent loss of employment, loss of tax revenues from business relocation health expenses incurred from a permanent injury or counseling to deal with the loss of a loved one.

Recovery from disasters requires resources to be diverted from other public and private programs, adversely affecting the productivity of the economy. Business interruption insurance only covers a small part of actual losses. Loss of economic productivity and downtime in tourism are critical issues. One need only look at the impact that Hurricane Iniki had on the people of County of Kaua‘i in 1992. Unemployment six months after the storm was running at over 16

percent.[1] Six years after the storm, several hotels had not reopened and, until the mid 2000's upturn in tourism, the County of Kaua'i's economy was lagging significantly behind the rest of the State.[2]

This plan focuses on mitigation, i.e., strategies to reduce risks. Mitigation actions help safeguard personal and public safety. Retrofitting bridges, for example, can help keep them from being washed out, which means they will be available to fire trucks and ambulances in the event of a storm. Installing hurricane clips and fasteners can reduce personal and real property losses for individuals and reduce the need for public assistance in the event of a hurricane. Increasing coastal setbacks reduces the risk of deaths and property losses from tsunamis and storm surge. Increased setbacks also reduce the risk of property losses from coastal erosion.

Another important benefit of hazard mitigation is that money spent today on preventative measures can significantly reduce the impact of disasters in the future, including the cost of post-disaster cleanup. Reducing overall economic losses and social disruption will enable the community to recover to pre-disaster conditions as quickly and efficiently as possible, not to mention the costs saved. The goal is to become a "disaster-resilient" county where our lifeline systems of roads, utilities, infrastructure, and other support facilities are designed to continue operating in the midst of high winds, rising water, or shaking ground. Critical facilities such as hospitals, schools, and fire stations would be located in safe areas, rather than areas prone to high hazards. Resilient structures would be built or retrofitted to meet the safest building code standards available. Natural areas that provide buffers to flooding or other hazards would be conserved.

Pre-disaster planning will also help post-disaster operations become more efficient. Priorities for mitigation during reconstruction can also be identified, helping to reduce the high costs of recovery after a disaster. The state emergency response effort will run more smoothly because of the guidance provided in this strategy. State Civil Defense continues to identify shelters that meet special needs requirements, and to work on reducing the deficit of shelters needed for strong wind events. In 2012-2013, a SCD-fostered Hawai'i Mass Care Council is developing the needs and resources available to address mass care after a major hurricane landfall, considering the special supply chain issues of Hawai'i.

2.1.1 Scope of This Multi-Hazard Plan

This plan focuses on natural hazards, with a priority on disaster-potential hazards. Other plans focus on human-caused hazards such as terrorism. 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:

- Certain hazards cause cascading hazard effects (e.g., earthquakes may cause landslides, rockfalls, local tsunamis, or dam break flooding; hurricanes cause wind damage and flooding; etc.)

[1] Pers. Comm. Mike Hamnett, October 9, 2000

[2] Ibid

- Priorities can be established to allocate limited resources to areas susceptible to the most severe or frequent hazards
- Areas identified as susceptible to multiple types of risks may require special attention;
- Common responses often apply to different hazards;
- 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-loading (hurricane) and ground-shaking (earthquake).

2.2 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 update 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 Part 201.6 which relates local hazard mitigation planning are provided below (recent amendments effective October 16, 2009 are shown in underlined italics):

2.2.1 State Coordination of Hazard Mitigation

Hazard mitigation is any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards and their effects. The purpose of mitigation planning is for State, local, and Indian tribal governments to identify the natural hazards that impact them, to identify actions and activities to reduce any losses from those hazards, and to establish a coordinated process to implement the plan, taking advantage of a wide range of resources. The key responsibilities of the State per the Robert T. Stafford Disaster Relief and Emergency Assistance Act are to coordinate all State and local activities relating to hazard evaluation and mitigation and to "Prepare and submit to FEMA a Standard State Mitigation Plan following the criteria established in § 201.4 as a condition of receiving non-emergency Stafford Act assistance and FEMA mitigation grants."

2.2.2 Requirements of CFR Title 44: Emergency Management and Assistance §201.4 Standard State Mitigation Plans

(a) *Plan requirement.* States must have an approved Standard State Mitigation Plans meeting the requirements of this section as a condition of receiving non-emergency Stafford Act assistance and FEMA mitigation grants. Emergency assistance provided under 42 U.S.C. 5170a, 5170b, 5173, 5174, 5177, 5179, 5180, 5182, 5183, 5184, 5192 will not be affected. Mitigation planning grants provided through the Pre-disaster Mitigation (PDM) program, authorized under section 203 of the Stafford Act, 42 U.S.C. 5133, will also continue to be available. The mitigation plan is the demonstration of the State's commitment to reduce risks from natural hazards and serves as a guide for State decision makers as they commit resources to reducing the effects of natural hazards.

(b) *Planning process.* An effective planning process is essential in developing and maintaining a good plan. The mitigation planning process should include coordination with other State agencies, appropriate Federal agencies, interested groups, and be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.

(c) *Plan content.* To be effective the plan must include the following elements:

(1) Description of the *planning process* used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.

(2) *Risk assessments* that provide the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments. The risk assessment shall include the following:

(i) An overview of the type and location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate;

(ii) An overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned or operated critical facilities located in the identified hazard areas shall also be addressed;

(iii) An overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment.

The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

(3) A *Mitigation Strategy* that provides the State's blueprint for reducing the losses identified in the risk assessment. This section shall include:

(i) A description of State goals to guide the selection of activities to mitigate and reduce potential losses.

(ii) A discussion of the State's pre- and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas; a discussion of State funding capabilities for hazard mitigation projects; and a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.

(iii) An identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section should be linked to local plans, where specific local actions and projects are identified.

(iv) Identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities.

(v) A State may request the reduced cost share authorized under § 79.4(c)(2) of this chapter for the FMA and SRL programs, if it has an approved State Mitigation Plan meeting the requirements of this section that also identifies specific actions the State has taken to reduce the number of repetitive loss properties (which must include severe repetitive loss properties), and specifies how the State intends to reduce the number of such repetitive loss properties. In addition, the plan must describe the strategy the State has to ensure that local jurisdictions with severe repetitive loss properties take actions to reduce the number of these properties, including the development of local mitigation plans.

(4) A section on the *Coordination of Local Mitigation Planning* that includes the following:

(i) A description of the State process to support, through funding and technical assistance, the development of local mitigation plans.

(ii) A description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the State Mitigation Plan.

(iii) Criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which should include consideration for communities with the highest risks, repetitive loss properties, and most

intense development pressures. Further, that for non-planning grants, a principal criterion for prioritizing grants shall be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.

(5) A *Plan Maintenance Process* that includes:

(i) An established method and schedule for monitoring, evaluating, and updating the plan.

(ii) A system for monitoring implementation of mitigation measures and project closeouts.

(iii) A system for reviewing progress on achieving goals as well as activities and projects identified in the Mitigation Strategy.

(6) A *Plan Adoption Process.* The plan must be formally adopted by the State prior to submittal to us for final review and approval.

(7) *Assurances.* The plan must include assurances that the State will comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c) of this chapter. The State will amend its plan whenever necessary to reflect changes in State or Federal statutes and regulations as required in 44 CFR 13.11(d) of this chapter.

(d) *Review and updates.* Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities and resubmitted for approval to the appropriate Regional Administrator every three years. The Regional review will be completed within 45 days after receipt from the State, whenever possible. We also encourage a State to review its plan in the post-disaster timeframe to reflect changing priorities, but it is not required.

[67 FR 8848, Feb. 26, 2002, as amended at 67 FR 61515, Oct. 1, 2002; 69 FR 55096, Sept. 13, 2004; 72 FR 61565, 61738, Oct. 31, 2007]

2.2.3 The Disaster Mitigation Act of 2000

The Disaster Mitigation Act of 2000 authorized 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 critical services 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."

2.2.4 Hazard Mitigation Assistance Programs

There are three programs funded by FEMA that provide funds for Hazard Mitigation Assistance (HMA). Eligible types of mitigation activities for these programs are summarized in Table 2.1.

1. Hazard Mitigation Grant Program (HMGP)
2. Pre-Disaster Mitigation (PDM)
3. Flood Mitigation Assistance (FMA)

Table 2.1 Eligible Types of Mitigation Activities for Assistance Programs

	HMGP	PDM	FMA
1. Mitigation Projects	√	√	√
Property Acquisition and Structure Demolition	√	√	√
Property Acquisition and Structure Relocation	√	√	√
Structure Elevation	√	√	√
Mitigation Reconstruction			√
Dry Floodproofing of Historic Residential	√	√	√
Dry Floodproofing of Non-residential Structures	√	√	√
Minor Localized Flood Reduction Projects	√	√	√
Structural Retrofitting of Existing Buildings	√	√	
Non-structural Retrofitting of Existing Buildings	√	√	√
Safe Room Construction	√	√	
Wind Retrofit for One- and Two-Family	√	√	
Infrastructure Retrofit	√	√	√
Soil Stabilization	√	√	√
Wildfire Mitigation	√	√	
Post-Disaster Code Enforcement	√		
Generators	√	√	
5 Percent Initiative Projects	√		
Advance Assistance	√		
2. Hazard Mitigation Planning	√	√	√
3. Management Costs	√	√	√

All applicants with projects funded by the Hazard Mitigation Grant Program, Pre-Disaster Program, and State programs are required to submit quarterly reports to State Civil Defense. Also, quarterly reports for projects funded by the Flood Mitigation Assistance Program will be submitted to the Department of Land and Natural Resources. DLNR manages the National Flood Insurance Program.

2.2.4.1 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, 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 for Enhanced Mitigation Plan management, 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.

Section 406 applies to post-disaster mitigation of buildings and infrastructure damaged by a Presidentially-declared disaster, being the work required to return the damaged facility to its pre-disaster <u>and</u> in conformity with current applicable codes, specification. Section 406 mitigation is addressed by 44CFR 206.226 Restoration of Damaged Facilities.

Some mitigation activities are difficult to evaluate using FEMA-approved cost-effectiveness methodologies. Up to 5 percent of the total HMGP funds may be set aside by the Grantee to pay for such activities. Activities that might be funded under the 5 Percent 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 hazards; Purchase of generators or related equipment, such as generator hook-ups;
- Hazard identification or mapping and related equipment for the implementation of mitigation activities;
- GIS software, hardware, and data acquisition whose primary aim is mitigation;
- Public awareness or education campaigns about mitigation; and
- Evaluation of model building codes in support of future adoption and/or implementation.

HMGP will also fund extraordinary post-disaster code enforcement and building inspection costs if the jurisdiction uses a State-mandated building code and is participating in the NFIP.

HAZARD MITIGATION GRANT PROGRAM SUCCESS STORY: HARDENING OF HONOLULU HARBOR OPERATIONS

NEED: The insular nature of the State of Hawai‘i makes Hawai‘i highly dependent on maritime cargo to maintain and sustain its economic viability. Approximately, 90% of all shipments to Hawai‘i come via surface ships and Port of Honolulu which is absolutely the key shipping node because all cargo enters the port first and distributed from that location to locations on the island of O‘ahu and the neighbor islands. The most vulnerable portion is the transmission of electrical power which is currently furnished via overhead power lines by Hawai‘i Electric Company. During hurricane force winds, those lines will become inoperable either by the separation of the lines from the supporting poles or by the destruction of the poles. Restoration of power could take up to two weeks which will severely hinder rapid disaster recovery and devastate the economy of the State. The Matson Navigation Company handles about 75% of the maritime cargo; therefore, it is the single most important shipping entity for Hawai‘i.

PROJECT DESCRIPTION: Hazard Mitigation Grant Program (HMGP) funds were used to supplement Matson funds to purchase and to install three (3) 1000KW mobile generators. The project was completed in November 1998 and allows Matson to power four of its five giant gantry cranes to off-load and load cargo; 75 refrigerated shipping containers; the control center; and the maintenance shop. The generators are housed in hardened containers and located out of the floodplain. Total project cost was $720,000 of which Matson funded $540,000 and the remaining amount of $172,000 came from HMGP.

BENEFITS: Immediate benefit is that the project insures that the Honolulu Harbor will be operational after a major disaster through Matson’s operations which is critical for disaster recovery and the economy of Hawai‘i. The State Department of Business, Economic Development, and Tourism stated the following: “Matson carries 3,000 containers per week from the Mainland United States to Hawai‘i. The merchandise carried by Matson is valued at $140 million per week or $7.3 billion a year. The value is 65% of all Hawai‘i merchandise imports. Matson transports most of Hawai‘i’s construction materials, motor vehicles, and groceries for the major outlets. Matson is also the major transportation company for military movement between Hawai‘i and the Mainland”. Also, Matson has agreed in a Memorandum of Agreement to allow the State to prioritize cargo shipments to Hawai‘i after a disaster.

2.2.4.2 Pre-Disaster Mitigation (PDM)

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. The PDM Program is authorized by Section 203 of the Stafford Act, 42 U.S.C. 5133. The PDM Program is designed to assist States, Territories, Indian Tribal governments, and local communities to implement a sustained pre-disaster natural hazard mitigation program to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding in

future disasters. 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.

Goals and Objectives:

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.

Eligible Activities for the PDM Grant Program include:

- Property Acquisition and Structure Demolition or Relocation
- Structure Elevation
- Dry Flood-Proofing
- Minor Localized Flood Reduction Projects
- Structural Retrofitting of Existing Buildings
- Non-structural Retrofitting of Existing Buildings

- Safe Room Construction
- Infrastructure Retrofit
- Soil Stabilization
- Wildfire Mitigation
- Hazard Mitigation Planning
- Management Costs

Submitted projects must be consistent with the findings of the county and State Pre-Disaster Mitigation Plans.

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.

Priorities for awards and the total amount available for this nationwide competitive program have been subject to annual revisions. 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.

2.2.4.3 The Flood Insurance Program

The FMA program is authorized by Section 1366 of the National Flood Insurance Act of 1968, as amended (NFIA), 42 U.S.C. 4104c, with the goal of reducing or eliminating claims under the National Flood Insurance Program (NFIP). The National Flood Insurance Fund (NFIF) provides the funding for the FMA program. The funds come from flood insurance premiums with the intent that flood insurance losses with be reduced. 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. For properties subject to repetitive losses, the 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 Biggert-Waters Flood Insurance Reform Act of 2012 eliminated the former Repetitive Flood Claims and Severe Repetitive Loss programs.

Consistent with the legislative changes made in the Biggert-Waters Flood Insurance Reform Act of 2012, cost-share availability under the FMA program depends on the type of properties included in the grant. For example, severe repetitive loss properties may receive up to 100 percent Federal funding and repetitive loss properties may receive up to 90 percent.

- In the case of mitigation activities to severe repetitive loss structures:
    - FEMA may contribute up to 100 percent Federal funding of all eligible costs, if the activities are technically feasible and cost-effective; or
    - The expected savings to the NFIF from expected avoided damages through acquisition or relocation activities, if the activities will eliminate future payments from the NFIF for severe repetitive loss structures through an acquisition or relocation activity.

- In the case of mitigation activities to repetitive loss structures, FEMA may contribute up to 90 percent Federal funding of all eligible costs.

- In the case of all other mitigation activities, FEMA may contribute up to 75 percent Federal funding of all eligible costs.

2.3 Mitigation Planning by the State of Hawai‘i

The State of Hawai‘i has been proactive in implementing hazard mitigation measures throughout the state. This includes mitigation measures implemented through state laws and regulations, administrative rules in agencies, and within county rules and ordinances. Furthermore, hazard mitigation has not been limited to regulatory action, but has been incorporated into statewide planning frameworks, programmatic measures, and public education in pursuit of disaster risk reduction. In this 2013 plan update, there has been an overall reassessment of recommended actions with an emphasis on developing disaster resilience.

Most significantly from an overall hazard mitigation perspective of comprehensive effectiveness, in 2007, the State had enacted a statute (Hawai‘i Revised Statues Chapter 107 Part II, State Building Code and Design Standards) requiring the periodic adoption of model building codes with amendments to take into account Hawai‘i-specific requirements. The State created a State Building Code Council to develop the codes and state amendments. In April of 2010, the State adopted the International Building Codes (IBC), 2006 with Hawai‘i amendments that have wind microzonation maps accounting for topographic wind amplification (see Appendix 5A at the end of Chapter 5 – Tropical Cyclones). Hawai‘i maps of flood, earthquake, hurricane wind effects incorporating Hawai‘i topography, and local rainfall intensity, are all incorporated in the Hawai‘i State Building Code suite of design and standards. This is probably the greatest single step taken in modern times to establish a major implementation of hazard mitigation in mandatory plans to reduce the vulnerability of infrastructure to natural hazards.

The existing law permits the counties to make modifications to design and construction requirements in the local county building code. However, by requiring the Hawai‘i State Building Code to be the basis for the local code, and given that all four county building officials must unanimously agree to any provisions in the Hawai‘i State Building Code, unnecessary divergences between the building code adopted by the counties are avoided. The statute applies a deadline for each county to adopt the state code within two years, and by the end of 2012 all four counties had adopted the IBC 2006 with state and local county amendments, achieving the first time in state history (since 1959) that the state and all four counties utilized the same building code. Continuation of this process would also ensure that in a disaster, state facilities would be

repaired or reconstructed to incorporate modern building codes in force, resulting in upgraded facilities that would be Built Back Better.

The State has also put significant effort into upgrading shelters. The State Legislature provided more than $10 million in funding to retrofit schools and develop some public needs shelters. Lessons learned from Hurricane Katrina have increased efforts for developing special needs shelters and shelters for pets. The State has engaged the visitor industry to ensure that protocols are developed to protect tourists during hazard events, with the primary focus being on sheltering in hotels. To enable risk reduction activities, the State passed a law that provides immunity from liability for assisting in civil defense activities. It has provisions for immunity to encourage the provision of private shelters (see Appendix 2A at the end of this chapter).

Recent experience with multiple types of hazard events has reinvigorated the disaster management community to focus on developing strategies of resilience that will improve risk mitigation throughout the state. The intent of this chapter is to demonstrate the extensive amount of focus on hazard mitigation in the State. The historical and current attention to mitigation policies and projects provide the background for the strategy that the state pursues. Mitigation policies and actions that have been undertaken are described in detail in each hazard-specific chapter. Additional policies related to general planning are highlighted.

2.3.1 Organizations for Mitigation Planning

2.3.1.1 State Civil Defense

Responsibility of all disasters or major crises in the State of Hawai‘i begins at the county level. As the disaster or crisis develops, the State Civil Defense System provides the operational infrastructure and procedures to apply additional resources to meet the demands of the emergency from all appropriate levels of government. Each county has a civil defense agency to develop mitigation plans at the county level, and these are coordinated with State Civil Defense. State Civil Defense has an active outreach program that goes to schools, public meetings and other venues to provide presentations, open forum discussions, and to support community disaster planning efforts for all hazards.

2.3.1.2 State Hazard Mitigation Forum

The State Hazard Mitigation Forum oversees recommendations for hazard mitigation planning and public awareness. It was formed by State Civil Defense and includes participants from State and County agencies with mitigation responsibilities and public and private interests. The State of Hawai‘i recognizes that reducing the impact of hazards occurs at many different levels in many different categories, and therefore, needs to involve multiple sectors, organizations, government agencies, and communities in mitigation. The State Hazard Mitigation Forum was formed based on this concept that we need to involve many perspectives and knowledge to better develop sustainable hazard mitigation strategies.

In order to ensure that the counties are represented and stay informed about mitigation policies and measures, the county mayors or their designated, official representatives are also members. Other members serve two-year terms and are nominated based on their experience and expertise,

rather than according to the organizations that they represent. There are 16 voting members of the Forum. Several ex-officio members regularly attend and participate in SHMF meetings because of their interest and responsibilities related to hazard mitigation planning. Meetings occur at least three times each year, but more frequently when reviewing mitigation grant proposals, new research and funding opportunities or mitigation plans. On an annual basis and at the direction of State Civil Defense, the State Hazard Mitigation Forum in conjunction with State agencies and the county governments reviews the mitigation projects listed in the State and County Plans. Also, new projects will be solicited from potential applicants. Evaluation should determine if the mitigation projects are achieving the goals of the State's mitigation strategy.

2.3.1.3 Hawai'i State Earthquake Advisory Committee

The Hawai'i State Earthquake Advisory Committee (HSEAC), founded in 1990 by State Civil Defense and working continuously for 23 years, has guided research and completed seismic related hazard mitigation planning projects for the State of Hawai'i. It continues to work with partners in the private sector, local government agencies, and federal agencies in an ongoing commitment and focus on earthquake and tsunami science, response issues, concerns, risks, and planning needs as they relate to the State's recognized risks, while supporting State and County Multi-Hazard Mitigation Plans.

The Hawai'i State Earthquake Advisory Committee (HSEAC) has contributed significantly to developing mitigation projects in the state. Several projects to improve decision-making were initiated through the committee. To help Hawai'i's disaster managers better prepare for and respond to potentially devastating earthquakes, the HSEAC and the Pacific Disaster Center jointly created the Hawai'i HAZUS Atlas (HHA). The HHA is a web-based catalog of 20 earthquakes selected by HSEAC based on "plausible" hypothetical and historical events located in and around the Counties of Maui and Hawai'i. The HHA contains loss estimation data and analyses based on HAZUS MH scenarios. With HHA, communities can use HAZUS MH results to assist in disaster planning before, during, and after a destructive earthquake. In the event of a disaster, several members of the committee are available to be mobilized so that they can assist in conducting post-disaster rapid assessments. Several projects have received funding based on needs identified during assessments conducted in response to FEMA-1664-DR-HI. The committee actively pursues projects that improve mitigation in accordance with their 5-year plan. The meetings occur quarterly, with communication by email in the interim. In June 2007, State Civil Defense, the Hawai'i State Earthquake Advisory Committee, and the Hawai'i Coastal Zone Management Program were named as joint recipients of the Western States Seismic Policy Council's "2007 Overall Award for Excellence in Mitigation" for the *Earthquake Hazards and Estimated Losses in the County of Hawai'i* publication.

2.3.1.4 Pacific Disaster Center

The Pacific Disaster Center provides resources, data, and tools to improve disaster management. In support of SCD, PDC has developed tools that can be used for natural hazards assessments, fire management, tsunami response, and an earthquake hazard atlas. The tools provide essential information required for developing sound mitigation actions.

2.3.1.5 Office of Planning, Hawai‘i State Department of Business, Economic Development and Tourism

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. The Hawai‘i Coastal Zone Management (CZM) law, Hawai‘i Revised Statutes Chapter 205A, was enacted in 1977. Hawai‘i’s coastal zone management area includes all lands of the State and the area extending seaward from the shoreline to the limit of the State’s police power and management authority, including the United States territorial sea. The Office of Planning (OP), in the State Department of Business and Economic Development and Tourism (DBEDT), is the lead agency for administering Chapter 205A. One of the statutory objectives of Chapter 205A is to reduce the hazards to life and property from coastal hazards. OP consists of the Land Use Division and the Planning Division, which includes the Hawai‘i Coastal Zone Management (CZM) Program, State Geographic Information System Program, and Special Plans Branch.

2.3.1.6 Strategic Industries Division Hawai‘i State Department of Business, Economic Development and Tourism

The Energy Branch of the Strategic Industries Division of the Department of Business, Economic Development and Tourism is responsible for designing a plan to promote conservation of energy and promotion of commercialization of Hawai‘i’s sustainable energy resources and technology to reduce the State’s high dependency on imported oil.

2.3.1.7 University of Hawai‘i Center for the Study of Active Volcanoes

Public Outreach Program to Schools and Community: During the academic year, the staff of the Center for the Study of Active Volcanoes (CSAV) makes weekly to bi-weekly visits to public, private, and charter schools on the island of Hawai‘i to make presentations to 4th, 6th, and 8th grade classes on earthquake and lava flow awareness and safety. This is an ongoing program that reaches in excess of 1000 students per year. As resources allow, CSAV also operates earthquake awareness booths at builder’s expositions, community festivals, and Hawai‘i County Fairs that provide earthquake preparedness information and homeowner’s guides to installing earthquake retrofit mitigation measures.

2.3.1.8 University of Hawai‘i Sea Grant College Program

Founded in 1968, the University of Hawai‘i Sea Grant College Program (UH Sea Grant) is part of a national network of 32 programs that promote better understanding, conservation, and use of coastal resources. UH Sea Grant has five focus areas:

- Healthy Coastal Ecosystems
- Sustainable Coastal Development
- Safe and Sustainable Seafood Supply
- Hazard Resilience in Coastal Communities
- Sustainable Coastal Tourism

UH Sea Grant extension agents play a vital role in providing local communities, individuals, businesses and agencies throughout Hawai‘i with the resources necessary in making informed plans and decisions regarding coastal natural hazards. Notable public education accomplishments include the UH Sea Grant publication *Coastal Hazard Mitigation Guidebook, Natural Hazard Considerations for Purchasing Coastal Real Estate in Hawai‘i: A Practical Guide of Common Questions and Answers, A Landowner's Guide to Coastal Protection,* and the *Homeowner's Handbook to Prepare for Natural Hazards*.

UH Sea Grant has also established the Center of Excellence in Island Climate Adaptation and Policy (ICAP) in 2009.ICAP coordinates research, education, and policy recommendations through a team of academic specialists in UH Mānoa's Planning, Ocean Science, Hawaiian Studies departments and the Law School. The 2012 publication of *Climate Change Law and Policy in Hawai‘i* is a product of this center.

2.3.1.9 Hawai‘i State Climate Office

The Hawai‘i State Climate Office (HSCO) was established in 2002, and provides information on Hawai‘i's Climate, such as rainfall, temperature, etc. It is located in the Department of Meteorology at the University of Hawai‘i in Mānoa. Dr. Pao-Shin Chu is the state Climatologist and he is also a professor in the Department of Meteorology. During the past few years, the HSCO updated the annual average rainfall maps and station information for all the four counties of the Hawai‘i State. The *Climatic Atlas of Tropical Cyclones over the Central North Pacific* was published by the HSCO.

2.3.1.10 Department of Land and Natural Resources, Flood Control Program:

Chapter 179, Flood Control and Flood Water Conservation, Hawai‘i Revised Statutes (HRS), established a flood control program for the State of Hawai‘i within the Department of Land and Natural Resources. The program provides for DLNR as the State Coordinating Agency to coordinate all federal and state flood control projects undertaken in Hawai‘i and for such technical or financial assistance to its political subdivisions as may be desirable or necessary to assure maximum benefits to the people of the State from the expenditure of state funds for flood control purposes. The State of Hawai‘i NFIP Coordinator has ensured that all of the counties remain compliant with NFIP requirements. Mitigation activities include the development of the Hawai‘i Flood Mitigation Plan in two phases, 1) interdepartmental coordination and 2) public education and awareness programs. The plan focuses on the following premises: 1) Tasks and responsibilities are in existence and have been assigned to the counties' Department of Public Works or the Department of Land Utilization relative to the enforcement of the Building Code and Flood Hazard Rules and Regulations; 2) DLNR coordinates and integrates intergovernmental Flood Hazard Mitigation Program and activities; and 3) DLNR establishes a continuing public awareness program and ensures public input in plan development. Certified Floodplain Managers are trained under DLNR.

FEMA has developed the Community Assistance Program - State Support Services Element (CAP-SSSE). The purpose of the program is leverage the States support in providing technical assistance to NFIP communities, and monitoring and evaluating local floodplain management

programs. DLNR participates in the CAP-SSSE program and conducts an array of activities to fulfill the mission of the program. Some activities include, but not limited to:

- Conduct Community Compliance Audits (a.k.a. CAVs)
- Conduct Training Workshops and Public Outreach
- Attend National and Regional NFIP related conferences
- Publish a quarterly newsletter (Wai Halana)
- Provide Technical Assistance to community officials and the public
- Conduct V zone properties audits
- Maintain an Internet Website dedicated to NFIP awareness

Monitoring compliance with NFIP is accomplished, in part, by requiring FEMA Elevation Certificates (pre and post construction submittals), which help assures buildings within SFHA are constructed in compliance with laws; reviewing applications for subdivisions and related construction plans, building permits and grading/gru6bing permits for compliance; responding to complaints, and taking appropriate actions to correct noncompliance. This includes reviewing, approving, preparing, and submitting to FEMA and maintaining a Letter of Map Changes, which are used to update FEMA's FIRMs.

2.3.1.11 Department of Land and Natural Resources, State Dam Safety Program

During and following the heavy rain events of March 2006, which included several dam incidents, the Hawai‘i Dam Safety Program embarked on a process approach to mitigate against dam failures within the State.

Process 1 – Inspections
The first process was to conduct statewide emergency inspections of all regulated dams to verify that there was no imminent danger for failure.
Process 2 – Update Statewide Dam Inventory
The second process step is to verify and update the Statewide Dam Inventory.

Process 3 – Hazard Risk Assessment
For the third process step, the Department retained the Pacific Disaster Center, (PDC), to undertake a hazard potential risk assessment of the dams, by modeling and analyzing the anticipated area at risk from a dam failure.

Process 4 – Emergency Preparedness
The fourth process step is to assess and improve the owners' and operators' emergency preparedness for their dam facilities. The Department is also working with local county civil defense agencies to improve the EAPs for dams, and also planning on contracting with a private consultant to assist in developing pilot sample EAPs for each county.

Process 5 – Dam Owner / Operator Training
The Department partnered with the United States (US) Bureau of Reclamation (BOR) and the American Society of Civil Engineers (ASCE) to provide dam owner and operator training in inspection and emergency preparedness, thereby enabling them to enhance their own internal assessment and inspection programs.

2.3.1.12 Hawai‘i Drought Council

The Hawai‘i State Water Commission and the Hawai‘i Department of Agriculture convened the Hawai‘i Drought Council (HDC) for statewide drought mitigation planning and response. The Hawai‘i Drought Council is the steering group that oversees the implementation of drought related activities in the State of Hawai‘i. The Council consists of department heads of the key state drought response agencies consisting of the Department of Agriculture (co-chair), the Department of Land and Natural Resources (co-chair), the State Civil Defense, a representative from the Governor's Office and four (4) County Officials designated by the Mayors. In addition, ex-officio members participate in the Council activities as advisors. They include the Hawai‘i Association of Conservation Districts, Hawai‘i Farm Bureau, Hawai‘i Cattlemen's Council, and the East Maui Irrigation Company, Ltd.

The Hawai‘i Drought Council has prepared the Hawai‘i Drought Plan to improve and better coordinate drought management strategies for the State of Hawai‘i. The plan outlines mitigation measures and appropriate response actions during periods of drought to reduce and minimize the effects upon the people and natural resources. The statewide drought mitigation plan provides public and state and local agencies a clear description of the procedures and mechanisms used to monitor drought-related resources (before, during, and after a drought event), assess drought needs, define triggers that engage actions and mitigate drought impacts. The Hawai‘i Drought Plan was originally completed in 2000 and updated in 2005, with additional research on economic costs associated with drought in 2008 and 2010.

Each county has a department designated with the responsibility of managing water resources. Kaua‘i County, Hawai‘i County and Maui County each have a Department of Water that manages, controls, and operates waterworks in their respective jurisdictions. The Board of Water Supply oversees these responsibilities for the City & County of Honolulu.

2.3.1.13 Hawai‘i Wildfire Management Organization

The Hawai‘i Wildfire Management Organization (HWMO) is a 501(c)(3), tax-exempt organization headquartered in Waimea on the island of Hawai‘i and was founded in 2002 by a diversity of stakeholders including scientists, land managers, representatives of local, State, and Federal agencies, ranchers, environmentalists, and fire fighters who came together to characterize wildfire threats and develop strategies to mitigate those threats. HWMO conducts collaborative wildfire preparedness planning, implements fuels management projects, offers educational activities related to wildfire, coordinates projects to re-establish native plants that are more fire tolerant, conducts cooperative research, and offers technical support, including GIS analysis and mapping.

2.3.1.14 Department of Land and Natural Resources Division of Forestry and Wildlife (DOFAW)

DLNR has the authority under Chapter 185, Hawai‘i Revised Statures, Land Fire Protection Law, for the prevention, pre-suppression, and suppression of wildfires for 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.

2.3.1.15 Coastal Lands Program, Department of Land and Natural Resources

The Board of Land and Natural Resources established the Coastal Lands Program within DLNR's Land Management Division in November 1997. The purpose of the program is to establish a comprehensive framework to protect and conserve the state's beaches. The framework is recorded in the Coastal Erosion Management Plan– COEMAP, which provides an overview of beach loss problems in the state of Hawai‘i and lays out a management framework to control erosion. Recommendations include projects for beach renourishment and mitigation measures to reduce erosion.

2.3.1.16 Hawai‘i Coastal Geology Group

The Coastal Geology Group, organized by Dr. Chip Fletcher, is an affiliation of researchers, technicians, and graduate students within the Department of Geology and Geophysics that conduct investigations of shoreline change, carbonate geology, reef geology, sedimentology and coastal morphodynamics. The organization's research has been used to influence policies and plans in the state for reducing shoreline erosion and for understanding the relationship of coastal changes to sea level and other impacts

2.3.1.17 Structural Engineers Association of Hawai‘i

The Structural Engineers Association of Hawai‘i has taken a leading role for decades in promoting the development and adoption of building codes appropriate for Hawai‘i. It is a member of the State Building Code Council. It also has published investigative reports after hurricane and earthquake disasters in Hawai‘i. After the October 15, 2006 Kiholo Bay earthquake, it performed ATC-20 Post-Earthquake Building Safety Evaluations. From this experience, it developed protocols for State Civil Defense for deployment of building safety inspection teams in future disasters.

2.3.1.18 United States Army Corps of Engineers Honolulu District

An Army Corps permit must be obtained for any dredge, fill, and/or discharge activities regardless of land ownership. 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 Corps of Engineers permit. Section 103, Marine Protection, Research, and Sanctuaries Act of 1972, as amended (33 USC 1413) authorized the Corps of Engineers to issue permits for the transportation of dredged material for the purpose of dumping it into ocean waters. 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. The National Environmental Policy Act of 1969 (NEPA) requires the preparation of a federal Environmental Impact Statement (EIS) or Environmental Assessment (EA).

2.3.1.19 Pacific Regional Science & Assessment (Pacific RISA)

The Pacific Regional Integrated Science and Assessment (Pacific RISA) program is a collaboration among agencies and organization in the US Pacific Islands to develop assessment tools and research to understand short and long-term climate impacts. The tools and information are developed to help governments prepare for changes in climate and develop adaptation strategies. The work builds on results from the Pacific Regional Assessment on the Consequences of Climate Variability and Change.

2.3.1.20 State of Hawai'i Department of Health Office of Hazard Evaluation and Emergency Response (HEER)

HEER is responsible for implementing the Hawai'i Environmental Response Law (HRS 128D) and the State Contingency Plan (HAR 11-451), as well as the Hawai'i Emergency Planning and Community Right-to-Know Act (HRS 128E), to protect human health, public welfare, and the environment and provide state leadership, support and partnership in preventing, planning for, responding to, and enforcing environmental laws relating to releases or threats of releases of hazardous substances, pollutants or contaminants.

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 Hawai'i Emergency Planning and Community Right-to-Know Act became law in 1993 (HRS 128E), and promulgated SARA Title III in the State of Hawai'i.

A Hawai'i State Emergency Response Commission (HSERC) was formed and each of the four counties in Hawai'i 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.

2.3.1.21 DOT Hazardous Materials Risk Management Program

State Department of Transportation management encompasses different modes of transportation, a wide assortment of hazardous materials (for example, chemicals, radioactive materials, and infectious substances), manufacturers (hazardous materials and packaging products), shippers, and carriers of all sizes. Information on unintentional releases of hazardous materials and the consequences are collected and analyzed. Identifying low probability, high consequence events (which may not be apparent from incident data) and providing appropriate levels of protection are among the more demanding aspects of this risk management program. A further challenge is to strike a proper balance between levels of safety and costs that result from regulations, special permits, and approvals.

2.4 Multi-Hazard Mitigation Policies

There are a number of mitigation actions in place. There have been improvements in energy management and in building codes upgrades. Development and nearshore construction will be altered by new shoreline setback rules, discussed in the previous section on coastal erosion. Integrated resource management and community management efforts have helped to build resilience from impacts of hazards.

2.4.1 Land Use

Land use policies are one of the primary ways to mitigate the impacts of natural hazards. Proper use and maintenance of the land helps to minimize disasters. As an island state surrounded by a vast ocean, Hawai‘i recognizes the value and importance of its limited lands. The land provides natural resources, value, and assets to the lives of the people and wildlife and to the economy.

The State of Hawai‘i Legislature established the Land Use Commission to administer the state-wide zoning law developed to ensure proper and appropriate development and long-term protection of the state’s land assets and natural resources. The Commission is responsible for preserving and protecting Hawai‘i’s lands and encouraging those uses to which lands are best suited. To best protect these lands, the State of Hawai‘i has classified lands into four categories for types of use: Urban, Rural, Agricultural, and Conservation.

The Department of Land and Natural Resources Land Division is responsible for managing State-owned lands in ways that will promote the social, environmental and economic well-being of the people of Hawai‘i and for insuring that these lands are used in accordance with the goals, policies and plans of the State. Lands that are not set aside for use by other government agencies come within the direct purview of the division. The Land Use Law requires the Commission to specifically consider the following criteria in review of any petition for a boundary amendment:

A. Conformity to the goals, objectives and policies of the Hawai‘i State Plan (Chapter 226, Hawai‘i Revised Statutes) and the Functional Plans adopted pursuant to the State Plan.

B. Extent to which the proposed reclassification conforms to the applicable district standards

C. Impacts on the following State concerns:
    1. preservation or maintenance of important natural systems or habitats;
    2. maintenance of valued cultural, historical or natural resources;
    3. maintenance of other natural resources relevant to Hawai‘i’s economy, including but not limited to agricultural resources;
    4. commitment of state funds and resources;
    5. provision for employment opportunities and economic development; and
    6. provision for housing opportunities for all income groups, particularly the low, low-moderate, and gap groups

D. The representations and commitments made by the petitioner in securing a boundary change.

Furthermore, the Commission must take into account the General Plan of the respective County; and, where applicable, the objectives, policies and guidelines of the State Coastal Zone Management Law (Chapter 205A, Hawai‘i Revised Statutes).

Each of the counties maintains responsibility over land classified as urban land and the counties determine the zoning within the urban districts. These policies are defined separately in each county. In order to develop land, land use permits must be obtained from the planning and permitting departments.

2.4.1.1 Office of Planning

The Office of Planning (OP) is located in the Department of Business, Economic Development and Tourism, and houses the Land Use Division and Planning Division, including the Hawai‘i Coastal Zone Management (CZM) Program, State Geographic Information System Program, and Special Plans Branch. OP is the only state agency mandated to look at a variety of public policy issues in the State from a long-term, statewide, and cross-functional perspective. The integration of its four functional groups uniquely positions OP to develop long-term strategies for complex, crosscutting problems that extend across the boundaries of a wide range of agencies. OP integrates hazard mitigation to the extent practicable into state and regional planning processes and initiatives. OP has made a commitment to improve the integration of hazard mitigation into the development approval process. These actions improve public decision making and the wise use of resources.

The following mitigation policies and activities demonstrate how OP influences and coordinates with other state and county agencies to incorporate hazard mitigation into their activities. It also demonstrates how the planning initiatives of OP promote mitigation as part of its authorities and responsibilities. Hazard mitigation policies are incorporated in several key laws governing the activities of OP. These key laws include the Hawai‘i Coastal Zone Management Act (Hawai‘i Revised Statutes Chapter 205A) and the State Planning Act (Hawai‘i Revised Statutes Chapter 225M).

2.4.1.2 Federal Consistency

The national Coastal Zone Management Act (CZMA) requires federal agencies to conduct their planning, management, development, and regulatory activities in a manner consistent to the maximum extent practicable with the enforceable policies of state CZM programs. State CZM lead agencies have the authority to review federal actions for consistency with their federally approved CZM programs. In Hawai‘i, OP is the state CZM lead agency and thus is empowered to conduct federal consistency reviews. The informational and procedural requirements for CZM federal consistency reviews are prescribed by federal regulations (15 CFR 930).

Because there is a significant federal presence in Hawai‘i, CZM federal consistency is a valuable State management tool. Federal planning, regulatory, and construction activities have direct and significant effects on land and water uses throughout the State. Federal agencies issue permits for a number of coastal activities and developments, and they control vast tracts of land. The range of federal activities and permits reviewed is extensive and includes harbor projects, beach nourishment projects, military facilities and training exercises, fisheries management plans and

regulations, open ocean aquaculture, and dredge and fill operations. In addition, projects funded by certain federal grant programs are reviewed for potential impacts to CZM resources.

In conducting federal consistency reviews, OP assesses whether federal agency activities are consistent with the coastal hazard objective and policies of Chapter 205A.[3] Specifically, federal agency actions are assessed for consistency with National Flood Insurance Program flood hazard requirements and maps. OP assessments also consider potential tsunami inundation areas and subsidence hazards. Notices of CZM federal consistency reviews are published regularly in the Office of Environmental Quality Control's, *The Environmental Notice,* in the Coastal Zone News Section. This provides the public an opportunity to review and comment on various federal actions.

[3] The coastal hazard objective is to reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, subsidence, and pollution. Policies include development and communication of adequate information about hazards, control of development in hazard prone areas, compliance with the federal flood insurance program, and prevention of coastal flooding from inland projects.

2.4.1.3 Advocating State Issues at Boundary Change Petitions and Proceedings before the State Land Use Commission

Pursuant to State law (Hawai‘i Revised Statutes Chapter 205 and 225M), OP develops and presents the position of the State of Hawai‘i in all boundary change petitions and proceedings before the State Land Use Commission (LUC). (See Chapter 4 for detailed description of the Land Use Commission law and boundary review process). The LUC provides a forum for educating land use decision-makers on natural hazards and hazard mitigation, and advocating for incorporation of hazard mitigation strategies in land use development in general, as well as for individual petitions.

In developing the State's position, OP solicits input from federal, state, and county agencies regarding anticipated effects of the boundary change on areas of concern to the agency as well as programs planned by the agency in the region or the subject area. OP solicits input from the State Civil Defense Division of the State Department of Defense in every petition for boundary change. Where applicable and when OP has knowledge of natural hazards occurring in the subject area, it will specifically request comments relative to those hazards.

When an agency raises concerns about natural hazards, OP follows up on the concerns. The multi-agency comments, petition filings, and additional information gathered are analyzed and become an important basis of the State's position on a land use boundary change or other proceeding. OP files written testimony with the LUC clarifying the State's policy and proposing mitigation measures. If there is a risk to public safety due to the probabilities of natural hazards occurring in the area, OP will provide analysis and recommendations based on further state agency reviews and collaboration with the federal and county governments. At the hearings on the petitions and other proceedings, OP may call witnesses to testify on behalf of the State of Hawai‘i. OP may also seek public input.

Recommendations range from approval with conditions to mitigate the hazard, to denial of all or part of the request for reclassification of the land. OP will look for ways to strengthen integration of natural hazard assessment and mitigation in the LUC process and decision making.

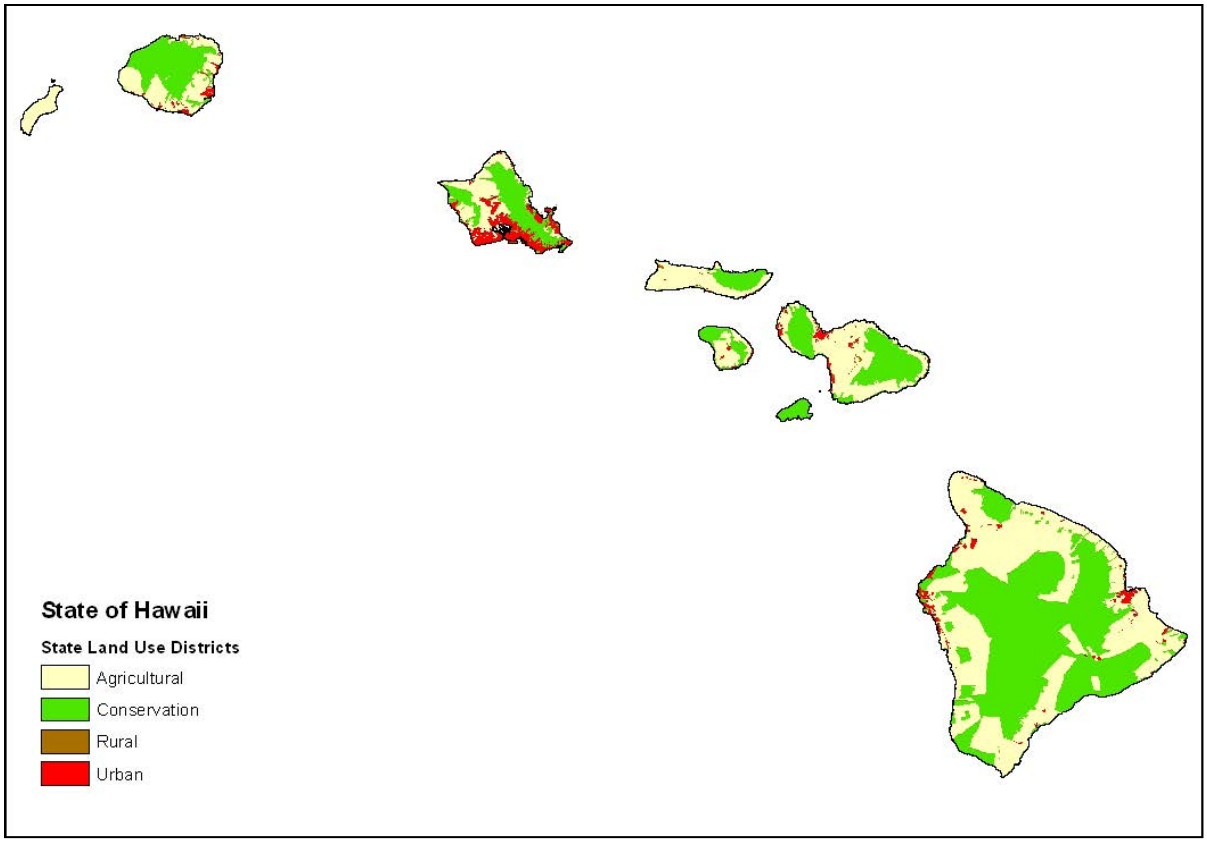

Figure 2.1 State of Hawai‘i – State Land Use Districts

2.4.1.4 Integration of Hazard Mitigation into the Permit Approval Process

OP is coordinating with state and county regulatory (permitting) agencies to ensure consistency with the hazard mitigation objectives and policies of Hawai‘i’s Coastal Zone Management Act (Hawai‘i Revised Statutes Chapter 205A). One way of accomplishing this consistency is to ensure that agencies fully consider the risks and vulnerabilities of a proposed development to hazards occurring in the development area. If that analysis takes place and a development is approved, the approval should reflect the analysis and if appropriate, contain enforceable hazard mitigation conditions. OP is working on several projects in this regard.

Permit Gap Project: OP is assessing the current effectiveness of the county planning departments and the BLNR in implementing the objectives and policies of HRS Chapter 205A through their respective permitting authorities.[4] Pursuant to Chapter 205A, each county identifies and regulates development within a geographically defined Special Management Area (SMA) extending from the shoreline inland. SMA boundaries may range from about 100 yards to several miles inland from the shoreline.

[4] The county planning departments issue SMA permits and Shoreline Setback Variances, and the BLNR issues Conservation District Use Permits

The SMA permit system is unique because it provides overarching guidance through State law for managing coastal development. The SMA permit is a management tool used to assure that permitted uses and activities that are defined as developments in the SMA are designed and carried out in compliance with the CZM objectives and policies and SMA guidelines. It is implemented by each of the four counties according to their ordinances and rules. OP, as lead agency for the CZM Program, monitors the effectiveness of the counties in administration of the SMA. OP is currently assessing the effectiveness of the counties in implementing the SMA and as necessary, developing a strategy for improvement. This broad-based project will analyze effectiveness in carrying out all ten of the objectives of Chapter 205A. A possible strategy for closing any gaps is the inclusion of mitigating conditions in permit approvals.

Written Policy Guidance: In 2007, OP began issuing written policy guidance to major state and county land use regulatory bodies – the county planning departments and the Board of Land and Natural Resources (BLNR) – on the need to integrate hazard mitigation into their land use planning and management processes, and suggested that they familiarize themselves with the FEMA-approved state and county multi-hazard mitigation plans as a starting point.

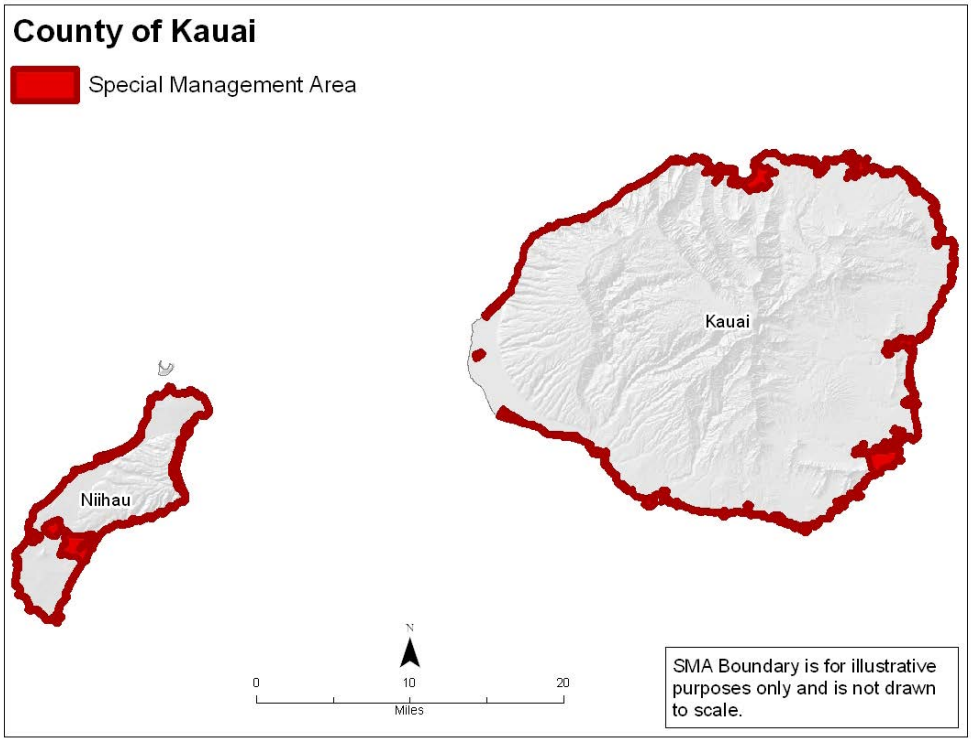

Figure 2.2 Special Management Area for the County of Kaua'i[5]

[5] State of Hawai'i GIS Program, 2010

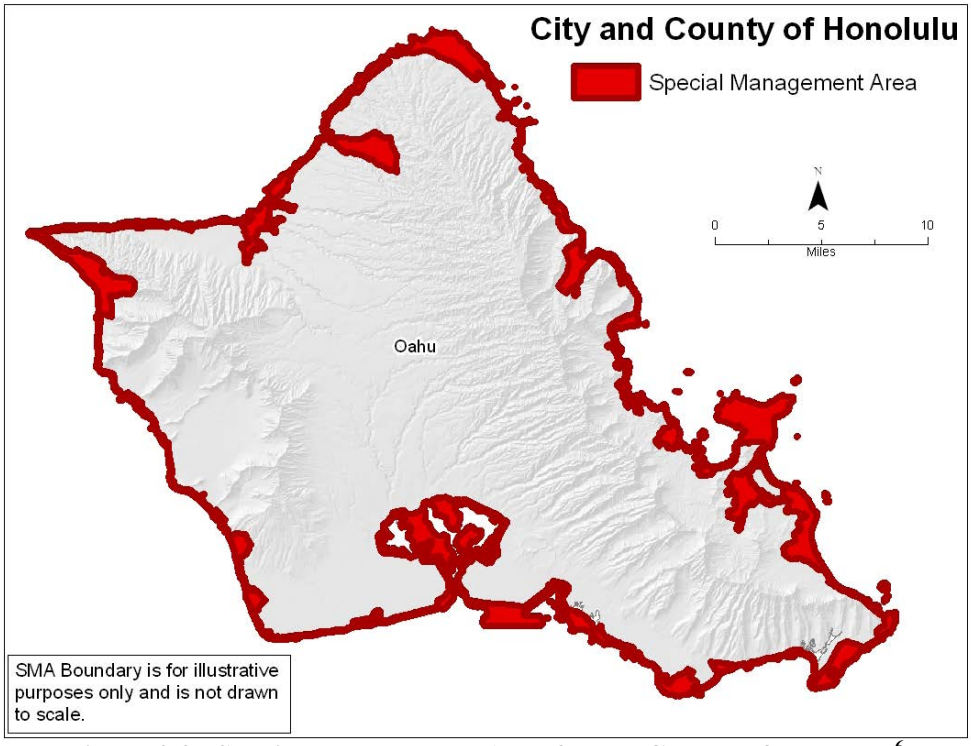

Figure 2.3 Special Management Area for the County of Honolulu[6]

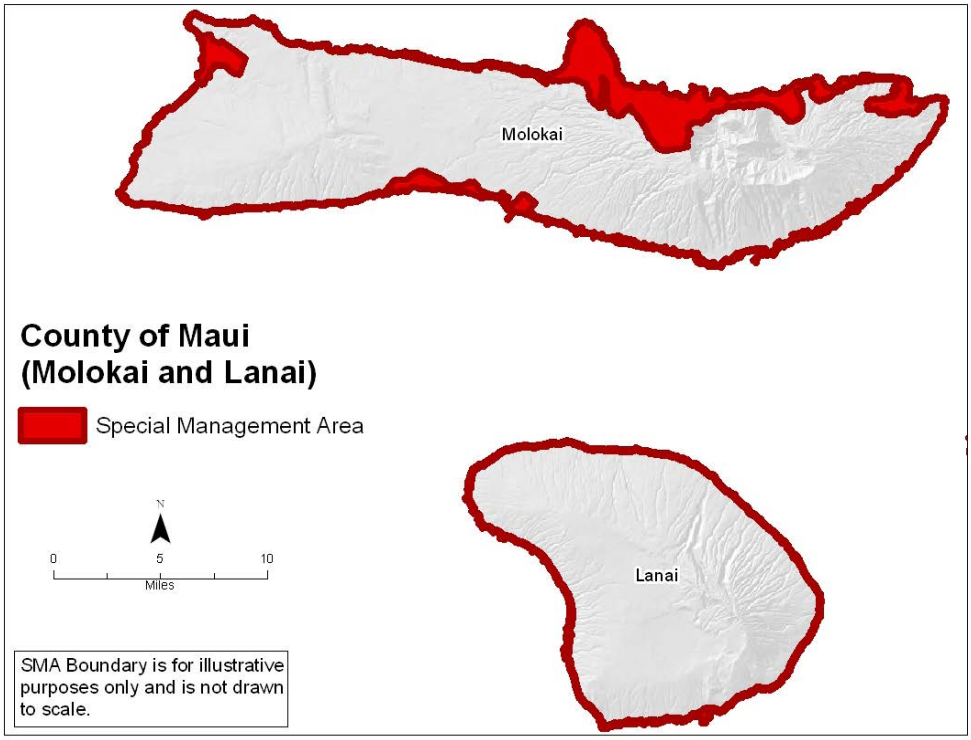

Figure 2.4 Special Management Area for the County of Maui (Islands of Moloka‘i and Lāna‘i)[7]

[6] State of Hawai‘i GIS Program, 2010
[7] Ibid

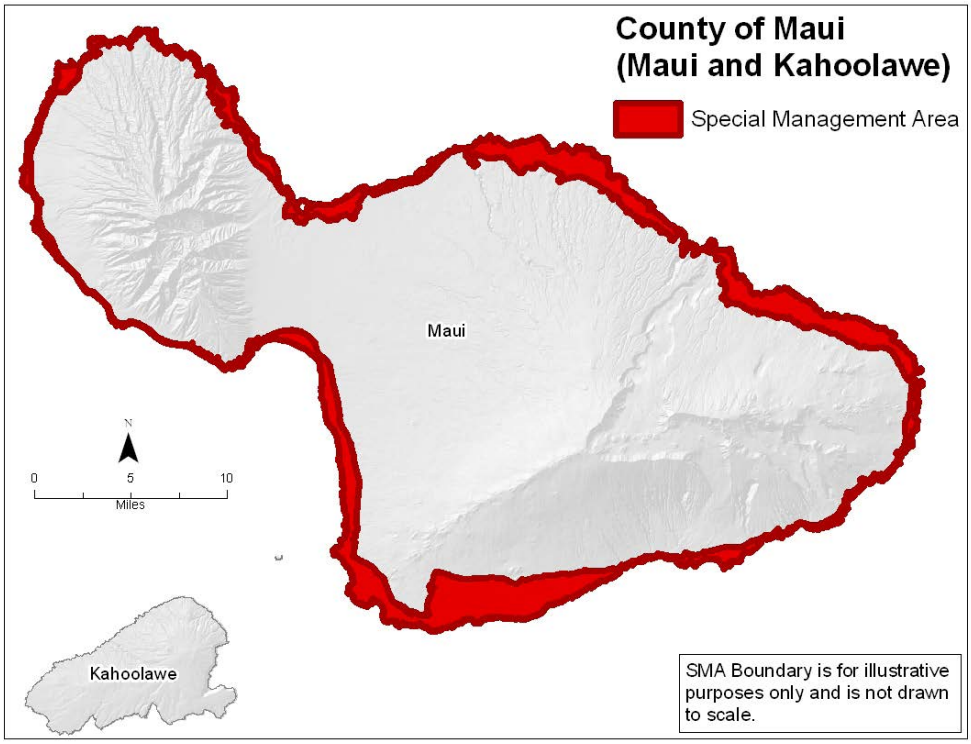

Figure 2.5 Special Management Area for the County of Maui (Islands of Maui and Kahoʻolawe)[8]

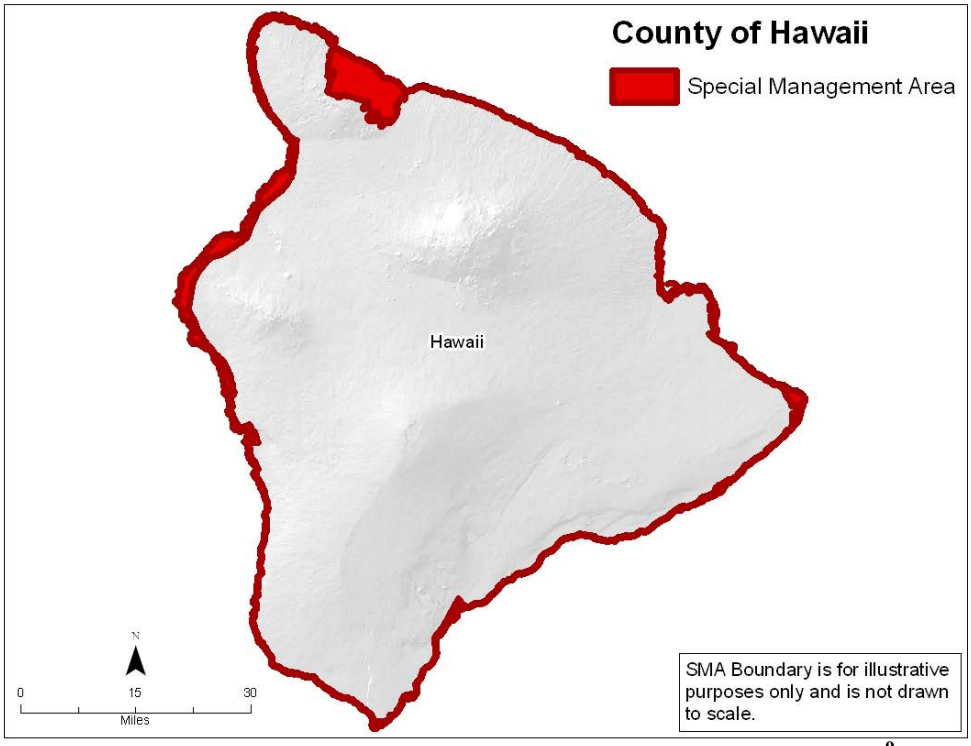

Figure 2.6 Special Management Area for the County of Hawaiʻi[9]

[8] State of Hawaiʻi GIS Program, 2010
[9] Ibid

2.4.2 Coastal Erosion Mitigation Policies and Actions

Analyses have enabled several counties (Maui and Kaua‘i) to increase their local shoreline setback rules to adjust for seasonal shoreline variation. As of 2013, shoreline studies have occurred in all of the islands, except Hawai‘i Island which does not have sandy shorelines. Studies on O‘ahu (Fletcher et al., 1997) demonstrated that nearly 24% or 27.5 km (17.1 mi) of an original 115 km (71.6 mi) of sandy shoreline (1940s) has been either significantly narrowed (17.2 km; 10.7 mi) or lost (10.3 km; 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 $700,000 to $1 million per year, in order to maintain the beach in its current state.

The new setbacks are being implemented based on the projections of the average annual erosion rates, as follows:

County of Kaua‘i - Generally, will be 70 times the average annual erosion rate, plus a 40 foot buffer (20 foot storm buffer plus 20 foot safety buffer between house and future shoreline). For shallow lots, where the minimum buildable area will not be achieved (2300 square feet), there is a table with fixed setbacks based on lot depths (from <100 feet, to 160 feet deep). None are less than 40 feet from the shoreline.

County of Maui - 50 times the average annual erosion rate, plus at 25 foot buffer, or a distance based on average lot depth (from a table), whichever is greater.

City & County of Honolulu - 40 feet for older subdivisions, 60 feet for newer subdivisions, 20 feet with a Shoreline Setback Variance. [not updated]

County of Hawai‘i - Generally 40 feet, but they are sometimes progressive with using their authority to increase the setback distance when they believe conditions warrant it for public health, welfare, and safety (such as the buffer area for tsunami run-up in Hilo). They have denied a subdivision request in Kapoho because they were confident it would be submerged within the next 100 years.

2.4.3 State Building Code and Design Standards

In 2007, the State Legislature created a State Building Code Council, comprised of subject matter experts and government agency representatives, with the authority to establish a comprehensive suite of codes applicable to all construction in the state of Hawai‘i. The statute governing this process is Hawai‘i Revised Statues Chapter 107 Part II, STATE BUILDING CODE AND DESIGN STANDARDS. The State Building Code Council is the technical body with the background expertise to evaluate model building codes and develop amendments necessary to make the codes appropriate for Hawai‘i conditions. Under the present statute, once the Council develops and approves a Hawai‘i code, it is then legally adopted into the Hawai‘i Administrative Rules (HAR) of the Department of Accounting and General Services (DAGS).

Counties have two years from the date of establishment of the HAR State Building Code to adopt the Hawai‘i State Building Code as the local county building including the addition of any locally-approved county amendments. The process has successfully enabled a unified set of nearly comprehensive building codes to be adopted by the state and the counties for the first time ever since statehood. In 2012, mitigation for hurricanes and strong winds has been improved by the incorporation of design maps that define the effects of topography on windspeed. The implementation of this body of work was given an Outstanding Engineering Achievement Award by the Hawai‘i Chapter of the American Society of Civil Engineers.

Table 2.2 Hawai‘i State Building Code Council - 2013 Status of Codes in Hawai‘i

Required Codes	Status of Major Codes Adopted by the State and the Counties*				
CODE	State of Hawai‘i	Kaua‘i	Honolulu	Maui	Hawai‘i
Fire	2006 UFC (2009 UFC)	2006 UFC	1997 UFC (2006 UFC)	1997 UFC (2006 UFC)	1988 UFC (2006 UFC)
Building	2006 IBC (2009 IBC)	2006 IBC	2006 IBC	2006 IBC	2006 IBC
Plumbing	2006 UPC (2012 UPC)	2003 UPC (2006 UPC)	1997 UPC (2006 UPC)	2006 UPC	2006 UPC
Electrical	2008 NEC (2011 NEC)	2008 NEC	2005 NEC (2011 NEC)	2008 NEC (2011 NEC)	2008 NEC
Energy	2006 IECC (2009 IECC)	2009 IECC	2006 IECC (2009 IECC)	2006 IECC (2009 IECC)	2006 IECC
Residential	None (2006 IRC & 2009 IRC)	2003 IRC (2006 IRC)	2003 IRC (2006 IRC)	(2006 IRC)	
Flood	HRS Chapter 179 Flood (DLNR Board) Chapter 179D Dams (2007)	Chapter 15 Article 1 (amended 6/2006)	2004 LUO Chapter 21.9-10 and ROH Chapter 16.11	1993 Chapter 19.62	2011 Chapter 27
Tsunami	none	Essentially none; flood ordinance simply references FEMA flood maps that do not include any tsunami. Latest FEMA FIRM maps exclude tsunami	Applicability of legacy 1980 provisions in ROH Chapter 16.11 is unclear, since it just references the FEMA flood maps that do not include any tsunami criteria)..	Essentially none; flood ordinance references FEMA flood maps that do not include any tsunami. Latest FEMA FIRM maps exclude tsunami	Essentially none; flood ordinance references FEMA flood maps for V zones, that do not include tsunami hazard Latest 2008 FIRM maps exclude tsunami

* Note: codes in parenthesis for the State are those where work will be discontinued or where State Building Code Council approved codes will not be implemented due to termination of State Building Code Council administrative support by DAGS in July 2012 due to lack of funding. Codes in parenthesis for the counties are those that are presently in development or proposed for local adoption.

2.4.4 Ocean Resources Management Plan

The *Ocean Resources Management Plan* (*ORMP*) is a comprehensive plan mandated by Hawai‘i Revised Statutes (HRS) Chapters 205A and 225M for conservation and sustainability of ocean and coastal resources. OP completed the update of the Hawai‘i Ocean Resources Management Plan (ORMP) in 2013. Work towards preparation of an updated *ORMP* began in 2011, when the Office of Planning (OP) received a grant from NOAA to begin the update process. The *ORMP* works by identifying eleven Management Priorities for the next five-year planning period, by identifying responsible agencies and resources, and by providing a method for performance measures and reporting.

The ORMP is a product of extensive collaboration with a wide spectrum of government agencies whose work pertains to ocean resources, including state and county agency participants in the ORMP Policy Group, comprised of cabinet-level directors of agencies that manage the ocean, and the ORMP Working Group, consisting of ocean and coastal resource planners from state, county and federal agencies.

In updating the Plan, OP undertook extensive public outreach and agency coordination. Public meetings were held statewide to inform the public of this initiative. Diverse stakeholders, including nonprofit groups, the business community, and private citizens provided input to the plan. A series of eight statewide Public Listening Sessions (PLS) were held from April to June 2012. These were attended by over three hundred individuals who described issues and problems on their island. A Public Review Draft 2013 ORMP was made available in October 2012. It was widely circulated and became the basis for a second round of nine statewide Public Listening Sessions held from October to November 2012. A comment period was held open until the end of January 2013.

Hawai‘i is facing pressures that will have a significant impact on our ocean and coastal environment including urbanization, tourism, recreational and commercial ocean uses, sea level rise and other natural hazards to include beach erosion, inundation of land, increased flood and storm damage, saltwater intrusion into the freshwater lens aquifer, the rising of the water table, and more frequent or more powerful weather events., marine debris, and invasive species. The ORMP was updated to address these issues.

Perspective 1: Connecting Land and Sea

Management Priority #1	Appropriate Coastal Development
Management Priority #2	Management of Coastal Hazards
Management Priority #3	Watershed Management

Perspective 2: Preserving our Ocean Heritage

Management Priority #4	Marine Resources Management
Management Priority #5	Coral Reef Management
Management Priority #6	Ocean Economy
Management Priority #7	Cultural Heritage of the Ocean

Perspective 3: Promoting Collaboration and Stewardship

Management Priority #8	Training, Education, and Awareness
Management Priority #9	Collaboration and Conflict Resolution
Management Priority #10	Community and Place-Based Ocean Management Projects
Management Priority #11	National Ocean Policy and Pacific Regional Ocean Initiatives

In 2009, the ORMP Working Group and ICAP prepared *A Framework for Climate Change Adaptation in Hawai'i.* Topics included building a climate change adaptation team, developing and adopting a long-term vision, identifying planning areas and opportunities relevant to climate change, scoping climate change impacts to major planning sectors, conducting a vulnerability assessment, and conducting a risk assessment. Such planning efforts aid in disaster preparedness and build resilient communities. A core group of ORMP partners drafted climate change policy legislation that became part of the Governor's 2012 Legislative Packet as Senate Bill 2745. This climate change adaptation bill passed the 2012 Legislature and was signed by Governor Neil Abercrombie as Act 286 (2012); it adds climate change adaptation priority guidelines to the Hawai'i State Planning Act, Hawai'i Revised Statutes Chapter 226. As a priority guideline, climate change adaptation must now be considered in state and county budgetary, land use, and other decision-making processes.

2.4.5 Coastal Nonpoint Pollution Control Program

Nonpoint source pollution is a coastal hazard under Chapter 205A. The national CZMA Reauthorization Amendments of 1990 required the coastal zone and water quality agencies of each state with a federally-approved CZM Program to develop and implement a Coastal Nonpoint Pollution Control Program (CNPCP) based on guidance provided by the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA). The CNPCP applies throughout the State.

2.4.6 Ocean and Coastal Lands

It is the mission of the Office of Conservation and Coastal Lands (OCCL) to protect and conserve Conservation District lands and beaches within the State of Hawai'i for the benefit of present and future generations, pursuant to Article XI, Section 1, of the Hawai'i State Constitution. The use of Conservation District lands is regulated by Chapter 13-5, Hawai'i Administrative Rules, (HAR), "Conservation District" and Chapter 183C, Hawai'i Revised Statutes, (HRS). These rules and regulations identify land uses that require Conservation District Use Permits (CDUP) as well as impose fines for violations within the district. The potential uses of Conservation District lands are numerous. The OCCL is an office with multiple functions, such as: permit processing, prosecution of land use violations, resolution of shoreline encroachments, enactment of beach restoration projects (i.e. Waikiki Beach Improvements), administration of contested cases involving CDUP's and shoreline certifications.

2.4.7 Use of GIS Mapping to Enhance Hazard Information and Improve Effectiveness in Government Decision Making

The State Geographic Information System (GIS) Program is established in OP under HRS Chapter 225M to develop and implement a coordinated statewide planning and geographic information system. Under this multi-agency, statewide geographic information system, planning applications including spatial data analyses can be used to enhance decision making. The vision of the State GIS Program is to establish a national model for statewide GIS programs by leading and coordinating the continued growth of the State's Enterprise GIS. The Enterprise GIS reflects advances in the evolving nature of GIS technology and provides a one-stop point of access to spatial databases for the purpose of improving overall efficiency and effectiveness in State government decision making.

The Hawai‘i State Earthquake Advisory Committee of State Civil Defense completed the process of customizing FEMA's HAZUS loss estimation model for earthquake hazards in the Counties of Maui and Hawai‘i. Customization included three major areas: (a) ground motion attenuation function was customized to produce the closest fit to the ground motion acceleration data from past earthquakes striking the County of Hawai‘i, (b) building inventory was revised to account for Hawai‘i's unique building construction types, including single-wall construction, the number and locations of specific building types, and Hawai‘i construction costs, and (c) soil types were customized to account for general locations of volcanic ash and alluvium deposits, and a comprehensive soil profile type survey of the island of Hawai‘i was accommodated in the soil type assignments for each census tract. This is the highest level of customization possible, requiring a unique combination of expertise in Hawai‘i seismicity, structural engineering, local building construction, geographical information systems, in-depth knowledge of HAZUS software file structure for data base files, and the ability to customize data files.

2.4.8 Watershed Management

The mission of the DOFAW Watershed Protection and Management Program is to ensure water yields by protecting and enhancing the condition of watersheds through various management activities:

- Prevent and suppress forest and range fires
- Conduct public hunting seasons
- Control livestock trespass in forest and natural area reserves
- Survey and control noxious plants, forest insects and diseases
- Reforest deteriorating and /or disturbed state watersheds
- Produce and distribute tree seedlings for windbreaks, soil erosion control, and watershed enhancement
- Promote, encourage, and advocate for incentives to encourage the maintenance and enhancement of key watersheds on private lands.

2.4.9 Energy Management

2.4.9.1 Hawai‘i Clean Energy Initiative

The Hawai‘i Clean Energy Initiative (“HCEI”), is “to establish a long-term partnership that will result in a fundamental and sustained transformation in the way in which renewable energy efficiency resources are planned and used in the State,” To implement HCEI, on October 20, 2008, the State of Hawai‘i Division of Consumer Advocacy, DBEDT, and the Hawaiian Electric Company, Inc. (“HECO”) entered into an Energy Agreement committed to achieving 70 percent clean energy for electricity and transportation by 2030. In 2009, pursuant to Act 155, the Hawai‘i Legislature provided “first step[s]” for meeting this goal through energy law and policy through various measures, including:

- Increasing the renewable energy portfolio standard from 20 percent by 2020 to 40 percent by 2030;
- Charging the Public Utilities Commission (“PUC”) with establishing energy efficiency portfolio standards to achieve 4,300 gigawatt hours (or 30 percent) of electricity use reductions by 2030;
- Expanding the duties of the energy resources coordinator,28 who dually serves as DBEDT director; and
- Requiring sellers to provide electricity-cost information in residential real property sales.
- Accordingly, Under Hawai‘i's Renewable Portfolio Standard (RPS), the Hawaiian Electric Companies must meet the following percentages of “renewable electrical energy” sales:
    - 10% of net electricity sales by December 31, 2010;
    - 15% of net electricity sales by December 31, 2015;
    - 25% of net electricity sales by December 31, 2020; and
    - 40% of net electricity sales by December 31, 2030.

2.4.9.2 Energy Emergency Preparedness (EEP) Program and Plan

The State of Hawai‘i Energy Council has outlined emergency operations procedures in their *Energy Emergency Preparedness (EEP) Program and Plan*. Authority for administering these procedures comes from the Hawai‘i Revised Statutes Chapters 128 and 125C and administrative directives 95-02, the Civil Defense Policy. Under this policy the Energy Council’s mission is to support emergency operations by coordinating activities necessary to facilitate the affected energy utilities’ safe, rapid restoration to the commercial energy grid and provide temporary emergency generators to safely and rapidly provide and sustain electricity for essential and emergency facilities and services until the commercial energy utility service can be restored. The Energy Council will also facilitate the availability and adequacy of fuel supplies, storage, and distribution.

Recognizing that Hawai‘i is an island state, it is dependent on imported fossil fuels for its primary energy resources. Should a disaster occur that closes the ports on each island, there will be a disaster. The State has developed several strategies in recognition of these problems, including several mitigation actions. Alternative energy sources are especially important to be able to sustain power at critical facilities and to plan for an event where Hawai‘i becomes cut off

from the world due to natural hazards or security issues. To this end, the State of Hawai‘i Department of Business, Economic Development, and Tourism (DBEDT) has implemented a number of programs to build Hawai‘i State’s resilience in the area of energy.

2.4.9.3 Strategic Industries Division

The Strategic Industries Division is one of five divisions of the Department of Business, Economic Development and Tourism, State of Hawai‘i government. Staff expertise includes planning, research, engineering, accounting, management, project development, and contract management for the development of projects and policies encouraging wise use of and technological advancement in the areas of energy and ocean resources; diversification of the economy; energy security and energy emergency preparedness; identification, development, and promotion of promising industries and technologies; development of recycling and remanufacturing businesses; and promotion of Hawai‘i’s high tech expertise to overseas markets. The Division includes the Energy Branch, including the Clean Hawai‘i Center; the Ocean Resources Branch; and the Strategic Technology Industry Development Branch. The Strategic Industries Division supports statewide economic efficiency, productivity, and diversification by promoting, attracting and facilitating Hawai‘i-based industries which engage in the sustainable development of Hawai‘i’s energy, environmental, ocean, recyclable, and technological resources. The Division’s goals and objectives support technology and resource-based economic development.

Incentives have been designed for residents to use solar power, instead of relying solely on the power system. Incentives include:

Corporate Tax Incentives

- Commercial Solar Energy System Income Tax Credit
- Commercial Wind Energy System Income Tax Credit
- A State tax credit is allowed for investment in “qualified high technology businesses.” See: www.hawaii.gov/tax/hi_tech.html. Non-fossil fuel energy is included under the “qualified research” section. The relevant sections of chapter 235 of the Hawai‘i Revised Statutes are available here: www.capitol.hawaii.gov
    - http://www.capitol.hawaii.gov/hrscurrent/Vol04_Ch0201-0257/HRS0235/HRS_0235-0110_0009.htm
    - http://www.capitol.hawaii.gov/hrscurrent/Vol04_Ch0201-0257/HRS0235/HRS_0235-0007_0003.htm
- New businesses or business expansions in State “Enterprise Zones” may be eligible for a variety of incentives, ranging from waiving of County fees to exemption from certain State taxes. Eligible types of businesses include agricultural production or processing; manufacturing; wind energy production; and nine other general areas. For more information, see: www.hawaii.gov/dbedt/ezones

Personal Tax Credit

- Residential Solar Energy System Credit
- Residential Wind Energy System Credit

Solar Water Heating Loan Programs

- Solar Roof Loans for O‘ahu Residents are provided through the City’s Rehabilitation Loan Program. The goal is to make the installation of solar water heating systems affordable to low- and moderate- income homeowners and landlords renting to low- and moderate- income tenants.
- Kaua‘i County loan program: www.dsireusa.org

Utility Rebates

- **Commercial Solar Water Heating (Kaua‘i)**
  Summary available here: www.dsireusa.org
  Company Website here: www.kauaielectric.com
- **Residential Solar Water Heating (Kaua‘i)**
  Summary available here: www.dsireusa.org
  Company Website here: www.kauaielectric.com
- **Residential Solar Water Heating Programs (O‘ahu , Maui, Moloka‘i, Lanai, Hawai‘i)**
  Summary available here: www.dsireusa.org
  Company Website here: www.heco.com

Tax Incentives for Alternative Transportation Fuels

- Corporate income tax credit for ethanol production: http://www.state.hi.us/dbedt/ert/ethanol-incentive.html
- Alternative fuels for on-highway use are subject to one-half the effective tax rate, on an energy content basis, of diesel fuel: http://www.state.hi.us/dbedt/ert/fueltax-act143.html
- Alcohol fuels are exempt from the 4% state excise tax on retail sales. The relevant section (section 237-27.1) of the Hawai‘i Revised Statutes is available here: www.capitol.hawaii.gov
- Electric vehicles are allowed special license plates, free parking at meters, and no HOV lane restrictions: http://mano.icsd.hawaii.gov/dbedt/ert/ev-act.html

Sun Power for Schools

The "Sun Power for Schools" program is a program of Hawaiian Electric Industries (HEI) which collects voluntary donations from electric utility customers and uses the funds, together with utility funds and support from the State Department of Education and the U.S. Department of Energy, for solar electric system installations at schools on the islands of O‘ahu, Maui, Moloka‘i, and Hawai‘i, curriculum development, and hands-on educational activities including the “Solar Sprint.” More information is available from HEI at www.heco.com.

Rules, Regulations & Policies

- Solar Contractor Licensing: www.dsireusa.org
- Net Metering: www.state.hi.us/dbedt/ert/netmeter.html
- Renewable Portfolio Standard Goal: www.state.hi.us/dbedt/ert/rps.html
- Solar Access Law: Covenant Restrictions: www.dsireusa.org
- Solar Water Heating Systems for State Facilities: www.dsireusa.org

In addition to the incentives, Hawai‘i has developed a long-term energy strategy. Hawai‘i State encourages recycling and reuse of materials to reduce dumping in landfill areas. One of the energy plants converts waste products into energy. These activities would help to rid the island of additional debris following a severe storm. Less worry about fossil fuels will help reduce potential oil spills and hazardous materials spills during storms.

The Hawai‘i State Energy Forum formed and worked on developing energy strategies that would reduce reliance on fossil fuels. Representatives include leaders in industry, management, and organizations. Currently, a task force is meeting to explore the potential use of liquid natural gas and what the conversion process would be for the state.

2.5 Hazard Mitigation Grant Program Projects

Currently funded HMGP projects in Hawai‘i are summarized below:

HMGP	Project Name	Approval Date	End Date	Total Cost	75%	25%	Status
1575	State Management Costs	11/20/2006	12/31/2015	$245,187	$183,890	$61,297	Ongoing.
	Woodlawn Ave. Bridge Flood Mitigation: Mitigate future flood risk along the Mānoa Stream.	6/13/2008 Phase One approval letter	12/31/2015	$2.8million	$2.1Million	$700,000	Ongoing. Second appeal to FEMA for time extension approved 12/12/2011.
	Disaster Public Awareness Campaign	5/15/2007 Project approval letter	12/31/2010	$160,000	$120,000	$40,000	In process of closeout.
1640	State Management Costs	3/24/2008	2/28/2013	$145,600	$109,200	$36,400	In process of closeout.
	Community Wildfire Protection Plans	3/25/2008	3/25/2010	$40,000	$29,768	$10,232	In process of closeout.
	Wildfire Resources Planning Project	3/26/2008	3/31/2010	$20,000	$14,769	$5,231	Project withdrawal approved by FEMA 8/24/2012.
	Envelope hardening for the Pi`ikoi Building against hurricane force winds	10/10/2008	2/28/2013	$244,000	$183,000	$61,000	Ongoing. Extension approved 8/24/2012.
	Mo`ikeha Building envelope protection against hurricane force winds.	12/10/2008	7/30/2011	$107,000	$80,250	$26,750	In process of closeout.
	Critical Fuel Break Management & Dip Tank Measures			$250,000	$187,450	$62,550	Pending FEMA review and approval.
	Remote Automated Weather Stations (RAWS)	6/24/2008	6/24/2010	$66, 667	$31,812	$12,952	Closed.
1664	State Management Costs	7/18/2008	6/1/2013	367,107	$275,330	$91,777	Ongoing.
	Hawai‘i State Gap Analysis for 2007 Plan Update and Mitigation Plan	6/18/2007	2/10/2011	$612,597	$153,149	$612,597	In process of closeout. Cost match paid to FEMA lock-box.
	Hardening of Honolulu Board of Water Supply EOC Emergency Generator Facilities	9/18/2009	7/31/2012	$300, 000	$225,000	$75,000	Ongoing.

HMGP	Project Name	Approval Date	End Date	Total Cost	75%	25%	Status
	Hardening of Emergency Generator Facilities at HBWS EOC Facilities	9/2/2009	6/1/2013	$700,000	$525,000	$175,000	Ongoing. Extension approved through June 1, 2013.
	Hardening of Hilo High School Gymnasium and Offices	5/24/2012	1/24/2014	$535,264			FEMA approval letter dated May 24, 2012
	Kaua`i Historic Building Envelope protection against high- winds	12/10/2010	12/10/2012	$461,250	$153,750	$615,000	Ongoing. Reimbursement requests processed and completed.
1743	Hardening of the ARC Headquarters Building	12/12/2011		$38,450	$15,750	$22,700	Ongoing. MOA final 3.6.12.
	Critical Facility Retrofit, Waiakea High School Gym	10/12/2011	12/11/2013	$430,523	$322,892	$107,631	Ongoing. MOA in place.
	State Management Costs	12/6/2011	2/6/2014	$22,385	$22,385		Ongoing
1814	State Management Costs	3/2/2012	3/2/2015	$60,979			Open, ongoing.
	Urban Treefall hazardous inventory and assessment of high-wind risk to residential communities			$533,334	$400,000	$133,334	
	Lanikai Rockfall Mitigation			$925,086	$690,000	$235,086	Amended: $1,005,078
	Kona Hospital Retrofit			$3,530,989	$1,187,000	$882,747	In-kind: $1,593,989
1967 - Proposed projects	State Management Costs						Applications submitted to FEMA
	5% Initiative Project - Siren Installation						
	Community Clinic of Maui Retrofit						
	Retrofit of Building 303						
4062	State Management Costs			Waiting for 6-month lock letter.			

**Updated on 1-9-2013

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

Appendix 2A

Excerpt from Hawai‘i Revised Statutes Sections 128-18 and 128-19 on Immunities

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Excerpt from Hawaii Revised Statutes,

Sections 128-18 and 128-19 on Immunities:

§128-18 Immunities; rights. (a) Neither:

(1) The State;
(2) Any political subdivision of the State;
(3) Any public utility or vital facility;
(4) Private agencies or entities; nor
(5) Except in cases of wilful misconduct, persons engaged in civil defense functions pursuant to this chapter (including volunteers whose services are accepted by any authorized person),

shall be civilly liable for the death of or injury to persons, or property damage, as a result of any act or omission in the course of the employment or duties under this chapter.

(b) No act or omission shall be imputed to the owner of any vehicle by reason of the owner's ownership thereof; provided that nothing herein shall preclude recovery by any person for injury or damage sustained from the operation of any vehicle which may be insured under section 41D-8 to the extent of the insurance, and unless specifically provided, insurance effected under section 41D-8 shall not include coverage of such risk during a civil defense emergency period. The governor may insure vehicles owned by the State or in the custody and use of the civil defense agency, but insurance effected under section 41D-8 on vehicles used for purposes other than civil defense need not necessarily include coverage of the insured vehicle against the risk incurred or which would be incurred under this chapter as a result of the use of the insured vehicle for civil defense.

(c) Members of the United States army, air force, navy, marines, or coast guard on any duty or service done under or in pursuance of an order or call of the President of the United States or any proper authority, and the national guard from any other state ordered into service by any proper authority, to assist civil authorities engaged in civil defense functions pursuant to this chapter shall not be liable, civilly or criminally, for any act done or caused by them in pursuance of duty in such service. [L 1951, c 268, pt of §2; RL 1955, §359-18; HRS §128-18; gen ch 1985; am L 1992, c 87, §3; am L 2002, c 220, §2]

§128-19 Immunity from liability of private shelter. Any individual, partnership, firm, society, unincorporated association, joint venture group, hui, joint stock company, corporation, trustee, personal representative, trust estate, decedent's estate, trust, or other legal entity whether doing business for itself or in a fiduciary capacity, owning or controlling real property, who voluntarily and without compensation grants a license or privilege for, or otherwise permits, the designation by the director of civil defense for the use of the whole or any part of the property for the purpose of sheltering persons during an actual, impending, mock or practice attack shall, together with its successors in interest, if any, not be civilly liable for negligently causing the death of or injury to any person or damage to any personal property on the property of the licensor in connection with the use of the licensed premises for the purposes designated. For purposes of this section, the consideration paid by any guest or person for transient accommodation lodging shall not be considered compensation. [L 1965, c 24, §1; Supp, §359-18.5; HRS §128-19; am L 1976, c 200, pt of §1; gen ch 1985; am L 2002, c 220, §3]

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

Appendix 2B

State of Hawai‘i Activity and Capability Assessment

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Agency Name (Mission/Function) **State of Hawai'i**	Programs, Plans, Policies, Regulations, Funding, and/or Practices	Point of Contact (Name, Address, Phone, Email)	Effect on Loss Reduction		
			Support	Facilitate	Hinder
Office of the Governor	The Governor is the chief executive of the State of Hawai`i and ensures that all laws of the state are executed. The Governor is responsible for state agencies, establishes the goals of the state and outlines ways to reach those goals. - The Governor is required to adopt the plan. - Important to brief in advance about the deadlines, especially October, for the official signed adoption. - Governor & Lt. Gov ensure participation in planning process by all departments	Governor, State of Hawai`i Executive Chambers State Capitol Honolulu, HI 96813 Phone: 808-586-0034 Fax: 808-586-0006 Web Site: http://www.hawaii.gov/gov	**Yes**	**Yes**	
Lieutenant Governor	The Lt. Governor serves as Secretary of State for intergovernmental relations of the State of Hawai`i and leads the Administration's drug control efforts. Additionally, the Lt. Governor acts in place of the Governor when the Governor is out of state.. -Important to have the Governor & Lt. Gov ensure participation in planning process by all departments	Office of the Lieutenant Governor State Capitol, Honolulu, Hawai`i 96813 Phone:(808) 586-0255; Fax: (808) 586-0231 e-mail: ltgov@hawaii.gov Web Site: http://www.hawaii.gov/ltgov"	**Yes**	**Yes**	
Accounting & General Services	DAGS is responsible for managing and supervising a wide range of State programs and activities. - DAGS is responsible for all State facilities and for risk management. DAGS oversees the insurance aspects of State facilities, and works with FEMA in disasters to determine the amount of damage over the insurance. It will be critical to seek cooperation in data sharing on the replacement values of buildings. The planning team will need consultation on results of HAZUS-MH model outputs for facilities. - DAGS is the **Chair of the State Task Force on Building Codes**. They have added disaster specific amendments - Divisions protect information and finances for the State that are vital to state functions and must be protected in disasters: Keeps state's accounting and financial records; state archives of business research, land research, legislation and laws, genealogy, forms & fees, vital	Kalanimoku Building 1151 Punchbowl Street Honolulu, Hawai`i 96813 PHONE: 586-0400 FAX: 586-0775 e-mail: dags@hawaii.gov Web Site:http://www.hawaii.gov/dags	**Yes**	**Yes**	

	records, etc.; Conducts audits to ensure accountability of accounting systems; Manages IT and telecommunications systems in the State - Cyber Security – Sets up security for the state systems to prevent loss of critical information from cyber attacks/terrorism				
	Land Survey Division - The duties of this division contribute to land management, important for disaster mitigation. Important to ensure the best maps are included in the plan. - Prepare, furnish and maintain maps and descriptions of all public lands required by other State agencies for the issuance of Governor's Executive Orders, general leases, grants of easements as well as the sale of government lands or purchase of private lands for public purposes. - Review shoreline maps prepared by private or government surveyors submitted to the State for certification. - Review and report all quiet title actions referred by the Department of the Attorney General. - Perform mathematical check on all Land Court and File Plan maps. - Maintain copies of Land Court and File Plan maps with computations and related data. - Furnish copies of all government subdivisions and boundary survey maps, copies of survey descriptions and other map products, including File Plan and Land Court maps to government agencies, private organizations or individuals. - Perform field survey work to establish the boundaries of the various government parcels. - Provide topographic and boundary surveys for schools and other public projects. - Provide survey triangulation station information to other agencies and to the public. - Serve as an official depository of all Government Survey Registered Maps and other historic maps, field books, calculations and other survey information.	State Land Surveyor **Kalanimoku Bldg.** 1151 Punchbowl St., Room 210 Honolulu HI 96813 Ph: 808 586-0380 Fax: 808 586-0383 E-Mail: landsurvey@hawaii.gov	**Yes**	**Yes**	
	Public Works Division The Public Works Division plans, coordinates, organizes, directs and controls a variety of engineering and architectural services for the State, including land	Kalanimoku Building 1151 Punchbowl St. P.O. Box 119 Honolulu, Hawaii 96813			

	acquisition, planning, designing, inspecting and managing construction projects, facilitating quality control, contracting, construction management, and equipping facilities and other improvements for State agencies. The Division, through its Leasing Branch, locates, negotiates and leases office space in non-state buildings for user agencies. Division has a critical role in structural risk and vulnerability assessment and risk reduction.	Ph: (808) 586-0526 Fax: (808) 586-0521			
Agriculture (HDOA)	The Hawai'i Department of Agriculture works to support, enhance and promote Hawaii's agriculture and aquaculture industries. - HDOA is critical for inspection of goods brought into Hawaii during disasters for response phase. Facilities that are used for food storage and distribution need to be considered for mitigation as these service as critical facilities.	1428 South King Street Honolulu, Hawai`i 96814 PHONE: 973-9560 FAX: 973-9613 e-mail: hdoa.info@hawaii.gov Web Site: http://www.hawaii.gov/hdoa/			
Attorney General (ATG)	The Attorney General is the chief legal officer and chief law enforcement officer of the State of Hawaii. - Will ensure and enforce laws that support hazard mitigation efforts.	Hale Auhau 425 Queen Street Honolulu, Hawai`i 96813 PHONE: 586-1500 FAX: 586-1239 e-mail: hawaiiag@hawaii.gov Web Site: http://www.hawaii.gov/ag MARK BENNETT Attorney General			
Budget & Finance	The Department of Budget and Finance develops near- and long-term financial plans and strategies for the State, and provides programs for the improvement of management and financial management of State agencies. Important for understanding the costs associated with disaster management, for support in allocating funds for emergency response, and for securing funds for mitigation efforts, including documentation of cost-share and in-kind matching requirements for the State. Facilities are critical to fiscal operations during the post-disaster and recovery phases.	No. 1 Capitol District Building 250 South Hotel Street Honolulu, Hawai`i 96813 PHONE: 586-1518 FAX: 586-1976 e-mail: HI.BudgetandFinance@hawaii.gov Web Site: http://www.hawaii.gov/budget			

Business, Economic Development & Tourism	The Department of Business, Economic Development & Tourism is Hawaii's resource center for economic and statistical data, business development opportunities, energy and conservation information, and foreign trade advantages. Programs support the economic viability of the State and are essential to recovery from any disaster. DBEDT will be coordinating the development of disaster contingency plans for businesses. The tourism sector is the largest economic sector and at high risk from disaster threats, which requires special consideration in disaster planning. DBEDT maintains the State's statistical data, which is essential for developing appropriate projections for impacts and useful in linking with risk and vulnerability assessments. *Office of Planning –* Oversees development and land use regulations for the state. OP oversees the Coastal Zone Management program, which has identified coastal hazards as a focus area. CZM reviews shoreline setbacks and shoreline management areas. In addition, CZM coordinates the Ocean Resource Management Plan, which has a working group on Coastal Hazards and a Climate Caucus. • Coastal Zone Management Program • GIS Program *Energy Division* *Tourism*	No. 1 Capitol District 250 South Hotel Street Honolulu, Hawai`i 96813 PHONE: 586-2355 FAX: 586-2377 e-mail: director@dbedt.hawaii.gov Web Site: http://www.hawaii.gov/dbedt			
Commerce & Consumer Affairs	DCCA's goals are to promote a strong and healthy business environment while protecting the community from unfair and deceptive business practices. DCCA has responsibility for all types of businesses in Hawaii. Along with DBEDT, DCCA could play a significant role in helping businesses deal with disasters and resume operations quickly post-disaster, which would be a significant benefit to the State's economy.	King Kalakaua Building 335 Merchant Street Honolulu, Hawai`i 96813 PHONE: 586-2850 FAX: 586-2856 e-mail: dcca@dcca.hawaii.gov Web Site: http://www.hawaii.gov/dcca			
Defense	The mission of the State of Hawaii Department of Defense, which includes the Hawaii National Guard (HING) and State	3949 Diamond Head Road Honolulu, Hawai`i 96816-4495			

	Civil Defense (SCD), is to assist authorities in providing for the safety, welfare, and defense of the people of Hawaii. Provides significant resources in disaster response. Has significant critical facilities needed for response and recovery from natural and "engineered"disasters. Ability to marshal significant human resources for aid in dealing with disasters.	PHONE: 733-4246 FAX: 733-4238 e-mail: webmaster@dod.state.hi.us Web Site: hawaii.gov/dod Hawai`i State Civil Defense Web Site: www.scd.hawaii.gov			
Education (K-12)	The commitment to a quality education for all of Hawaii's children. DOE are the primary shelter facilities for the general population. Opportunities for building capacity to understand and cope with disasters through the educational system.	Queen Lili`uokalani Building 1390 Miller Street Honolulu, Hawai`i 96813 PHONE: 586-3310 FAX: 586-3320 Web Site: http://doe.k12.hi.us/			
Hawaiian Home Lands	The Department of Hawaiian Home Lands is responsible for administering the Hawaiian home lands program as established by Prince Jonah Kuhio Kalaniana'ole. DHHL continues to strive for Prince Kuhio's vision of returning native Hawaiian people to the land and developing healthy, self-sufficient Hawaiian communities, through the many benefits and programs it offers. The Department of Hawaiian Home Lands has a few key roles in mitigation: 1) Oversight of the types of development on DHHL to ensure reduction of risks; 2) Increases resilience of "host" population, who statistically have some of the greater socioeconomic vulnerabilities that increase risks from disasters and often prevent recovery.	Hale Kalaniana'ole 91-5420 Kapolei Parkway Kapolei, HI 96707 Tel: (808) 620-9500 Web Site: http://www.hawaii.gov/dhhl			
Health	The mission of the Department of Health is to protect and improve the health and environment for all people in Hawai`i.	Kinau Hale 1250 Punchbowl Street Honolulu, Hawai`i 96813 PHONE: 586-4410 FAX: 586-4444 e-mail: webmail@doh.hawaii.gov			

		Web Site: http://www.hawaii.gov/health ***All Hazards Preparedness*** 1250 Punchbowl Street Honolulu, Hawaii 96813 Phone: (808) 587-5879 ***Bioterrorism Preparedness and Response Branch*** 1132 Bishop Street, Suite 1900 Honolulu, Hawaii 96813 Phone: (808) 587-6569 ***Environmental Health*** Environmental Management Division 919 Ala Moana Blvd.,Room 300 Honolulu, Hawaii 96814-4920 Phone: (808) 586-4304 ***Clean Air Branch*** *Clean Water Branch*, Room 301 Phone: (808) 586-4309 ***Safe Drinking Water Branch***, Room 308 Phone: (808) 586-4258 ***Solid and Hazardous Waste Branch***, Room 212 Phone: (808) 586-4226 ***Wastewater Branch***, Room 305			
Human Resources Development	The Department of Human Resources Development shall provide timely and responsive leadership, resources, and services to fully support the State in the recruitment, management, and retention of a high-performing workforce.	Leiopapa a Kamehameha Building 235 South Beretania Street Honolulu, Hawai`i 96813 PHONE: 587-1100 FAX: 587-1106			

Public Safety	Department of Public Safety oversees the state's Corrections Division, which includes state prisons and community correctional facilities, as well as the Law Enforcement Division, including the Narcotics, Protective Services and Sheriffs Divisions. - Critical facilities as first responders to ensure order during disasters. - Need to ensure protection of facilities, communications systems, etc. - Need to identify security to keep prison population safe while preventing escapes, which would add problems during disasters. – Need to ensure disaster response plans are up-to-date.	919 Ala Moana Boulevard Honolulu, Hawai`i 96814 PHONE: 587-1350 FAX: 587-1282 Web Site: http://www.hawaii.gov/psd			
Taxation	The mission of the Department of Taxation is to administer the tax laws for the State of Hawaii in a consistent, uniform, and fair manner. - Important for function of State budgets and economy. - For disasters, need to ensure protection of building as critical government and economic facility.	Princess Ruth Keelikolani Building 830 Punchbowl Street Honolulu, Hawai`i 96813 PHONE: 587-1540 FAX: 587-1560 e-mail: tax.directors.office@hawaii.gov Web Site: http://www.hawaii.gov/tax			
Transportation	Department of Transportation is responsible to plan, design, construct, operate, and maintain State facilities in all modes of transportation, including air, water, and land. Coordination with other State, County, and Federal programs is maintained in order to achieve the objective. Harbors Airports Roadways	Aliiaimoku Hale 869 Punchbowl Street Honolulu, Hawai`i 96813 PHONE: 587-2150 FAX: 587-2167 e-mail: dotpao@hawaii.gov Web Site: http://www.hawaii.gov/dot			
Hawaii State Judiciary	Critical to governance in the State. Important to ensure operability post-disaster.				
Hawaii State Public Library System	Provides archives of historical and cultural resources; maintains state information; provides the general public with access to information.				

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

3. Land Use & Development

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CHAPTER 3

Land Use and Development

3.1 Geography

3.1.1 General

Oʻahu consists of In Hawaiʻi is surrounded by the Pacific Ocean, about 2,400 miles southwest of the Continental United States. The Hawaiian Islands cover 10,932 square miles. Located at Longitude 154° 40' W to 162° W and Latitude 16° 55' N to 23°N, the Hawaiian Archipelago is comprised of 132 volcanic islands, atolls, reef, and shoals extending in an East to West direction across the North Pacific Ocean between 19 and 22 degrees north latitude[1]. There are eight main islands located at the southeastern end of the island chain: Niʻihau, Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, Kahoʻolawe, Maui, and Hawaiʻi. The remainder islands, atolls, and shoals are known as the Northwestern Hawaiian Islands and form part of the Papahānaumokuākea Marine National Monument created in June of 2006.

3.1.2 Islands of Kauaʻi and Niʻihau

Kauaʻi, the oldest of the main Hawiian islands, is locate is comprised of the remains of a massive volcano. In the center of the island is Kawaikini Peak, rising 5,170 feet and Mount Waiʻaleʻale, rising 5,080 feet. Mount Wai'ale'ale is the rainiest spot on earth, averaging 460 inches of rain a year, and contributes to this island's nickname – the Garden Island. Many streams flow from these mountains to the sea through canyons in the volcanic rock. Waimea canyon has colorful rock walls that are 2,857 feet high. Rugged cliffs along the northwestern coast make it impossible to build a road around the whole island. The island of Niʻihau, nicknamed "The Forbidden Island," is a private island owned by the Robinson family. The island is semi-arid with a dry climate, although several lakes provide fresh water.

3.1.3 Island of Oʻahu

The island of Oʻahu consists of the remains of two shield volcanoes: the Koʻolau volcano in the east side of the island and the Waiʻanae volcano in the west side of the island[2]. The valley between the mountains of these two extinct volcanoes consists of a fertile, rolling plain that supported both sugar and pineapple plantation agriculture in the past. Those industries have now

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[1] Juvik, Sonia and Juvik, James, Department of Geography, University of Hawaiʻi at Hilo, *Atlas of Hawai'i*, 1998

[2] Ibid

been largely replaced by residential development and diversified agriculture. A most notable landmark is the 760-foot extinct volcanic crater, known as Diamond Head, located on the southeastern end of the island at the end of world-famous Waikīkī beach.

3.1.4 Island of Maui

The Island of Maui, also known as the valley isle, is the second largest island in the Hawaiian Archipelago with approximately 727 square miles of land. The island was formed approximately 1.3 million to 0.7 million years ago by two volcanic cones, Haleakalā in East Maui and Pu‘u Kukui (Mauna Kahalawai) on West Maui. Haleakalā and Pu'u Kukui rise to elevations of 10,023 feet and 5,788 feet, respectively. Haleakalā, which last erupted in 1790, is a dormant volcano that could erupt in the next 100 years.[3] A relatively flat isthmus, formed of sand blown inland when the sea was somewhat younger during the late Pleistocene period joins the two cones. East Maui is geologically younger than West Maui, as apparent by the absence of deeply incised canyons and extensive areas of volcanic lava and cinders on the southwestern slopes of Haleakalā. The lands more suitable for agriculture, including the gentle slopes of central Maui and tablelands of West Maui, resulted from alluvial deposits and the decomposition of basaltic materials.

3.1.5 Island of Moloka‘i

The island of Moloka‘i, nicknamed the friendly isle, is the fifth largest of the Main Hawaiian Islands. It has land area of approximately 260 square miles. The island was formed primarily by the coalescence of two shield volcanoes approximately 1.8 million to 1.3 million years ago. The two volcanoes that conform the island are the East Moloka‘i volcano (also known as Kamakou) and the West Moloka‘i volcano (also known as Mauna Loa). A separate volcano (with different composition from the adjacent West Moloka‘i volcano) now subsided below sea level exists west of Moloka‘i and is known as the Penguin Bank[4].

3.1.6 Islands of Lāna‘i and Kaho‘olawe

The island of Lāna‘i is the sixth largest of the Main Hawaiian Islands. Also known as the Private Isle, Lāna‘i has a land area of approximately 141 square miles. The island was formed from a single shield volcano that last erupted about 1.3 million years ago.[5] A low lying basin in the center of the island is what is left of the volcano's caldera. The island is sheltered from the prevailing northeastern trade winds by the more massive West Maui Mountains in the island of Maui. Because of its protected location, Lāna‘i boasts a much dryer climate than those of the other Main Hawaiian Islands.

The smallest of the Main Hawaiian Islands, Kaho‘olawe, has a land area of approximately 45 square miles. It was formed by a single volcano that underwent the shield and post-shield stages. Kaho‘olawe has a very dry climate because of its low relief (highest point on the island is Pu‘u

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[3] Juvik, Sonia and Juvik, James, Department of Geography, University of Hawai‘i at Hilo, *Atlas of Hawai'i*, 1998

[4] Ibid

[5] Ibid

Moʻaʻulanui at 1,483 feet above sea level) and its sheltered location in the shadow of mammoth Haleakalā in the island of Maui.

3.1.7 Island of Hawaiʻi

The island Hawaiʻi, the largest of the habitable Hawaiian Islands, covers 4,038 square miles. Five volcanoes, two of which are still active, formed this island. The Kohala volcano is located on the northern side of the island and the Hualālai volcano is located on the western side of the island. Mauna Kea volcano and Mauna Loa volcano lie near the center of the island and Kīlauea volcano is located on the eastern side of of the island. Mauna Kea, at 13,796 feet above sea level, is the highest point in the state. Still classified as active volcanoes, Mauna Loa and Kīlauea erupt intermittently, sometimes spewing fiery lava streams flowing down the mountains to the sea. High cliffs, with silvery waterfalls falling over the edge and into the ocean, protect the north and southeastern coasts of Hawaiʻi.

3.2 Political Division

Politically, the State of Hawaiʻi is divided into 5 counties: County of Kauaʻi , City and County of Honolulu, County of Maui, County of Kalawao, and County of Hawaiʻi. The County of Kauaʻi encompasses the islands of Kauaʻi and Niʻihau. The City and County of Honolulu includes the island of Oʻahu and the Northwestern Hawaiian Islands. The County of Maui consists of the islands of Molokaʻi (with the exception of the Kalaupapa peninsula which constitutes the County of Kalawao), Lānaʻi, Kahoʻolawe, and Maui. Lastly, the County of Hawaiʻi has jurisdiction over the island of Hawaiʻi.

Within the County of Kauaʻi, the island of Kauaʻi is divided into five judiciary districts: Hanalei, Kawaihau, Līhue, Waimea, and Kōloa. The island of Niʻihau is administered under the Waimea District of the the island of Kauaʻi. A map indicating the judicial boundaries of the County of Kauaʻi is included in Figure 3.1.

The City and County of Honolulu is divided into seven judicial districts: Waiʻanae, Waialua, Wahiawā, Koʻolauloa, Koʻolaupoko, ʻEwa, and Honolulu. A map showing the judicial districts of the City and County of Honolulu is included in Figure 3.2. The Northwestern Hawaiian Islands (not included in Figure 3.2) are under the jurisdiction of the Honolulu district.

Within the County of Maui, the island of Maui is divided into four judicial districts: Lahaina, Wailuku, Makawao, and Hāna. The island of Kahoʻolawe is considered part of Maui island's District of Makawao. The islands of Molokaʻi and Lānaʻi only have a single district with same name as the island. Even though a separate county, the County of Kalawao is typically treated as a district of the island of Maui for statistical purposes. A political map of the County of Maui is included in Figure 3.3.

Lastly, the County of Hawaiʻi is made up of nine judicial districts North Kohala, South Kohala, Hāmākua, North Hilo, South Hilo, North Kona, South Kona, Puna and Kaʻū. Figure 3.4 depicts a map of the County of Hawaiʻi with its judicial district boundaries.

Figure 3.1 Political Division of the County of Kaua‘i

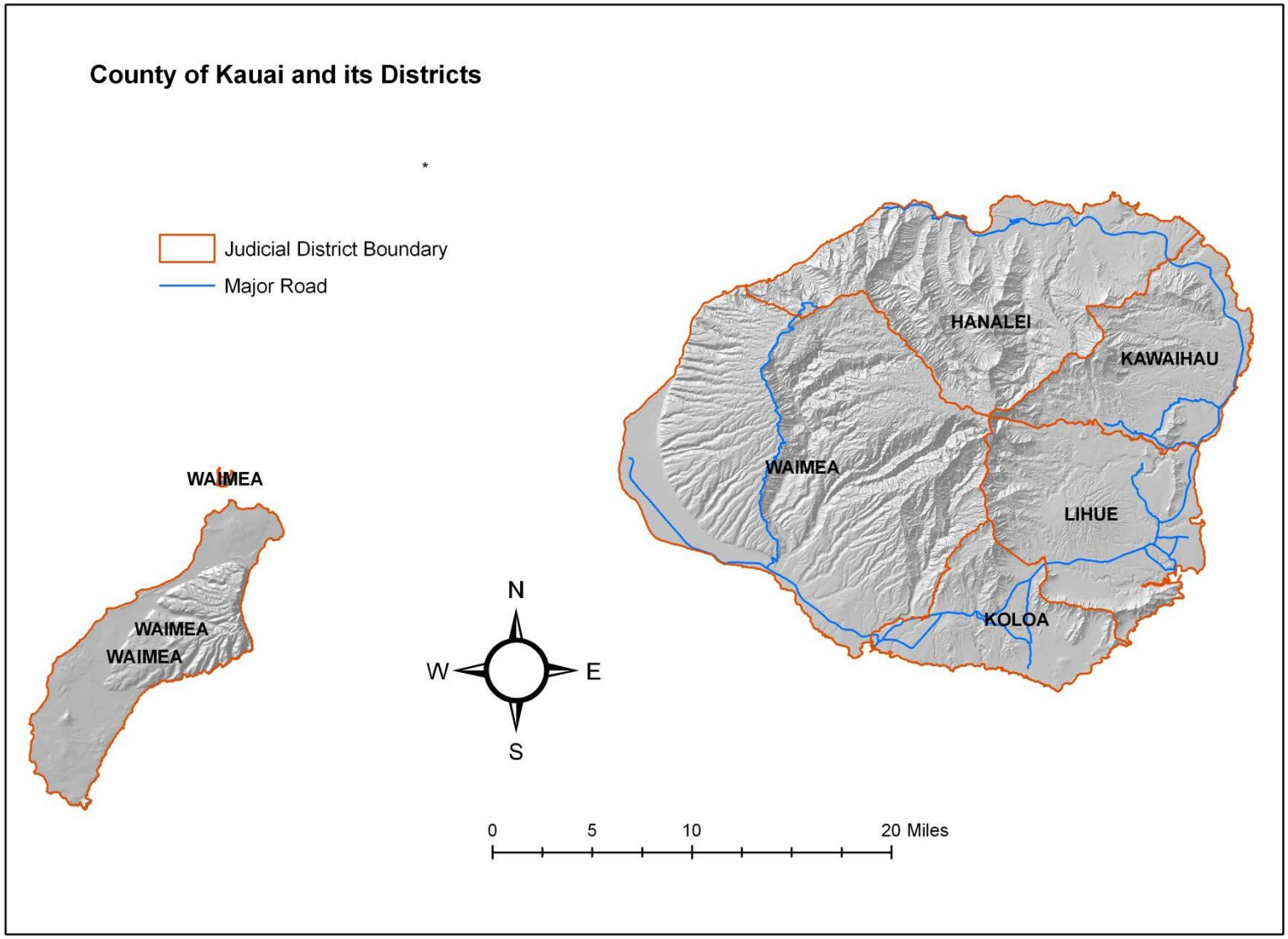


Figure 3.2 Political Division of the City and County of Honolulu

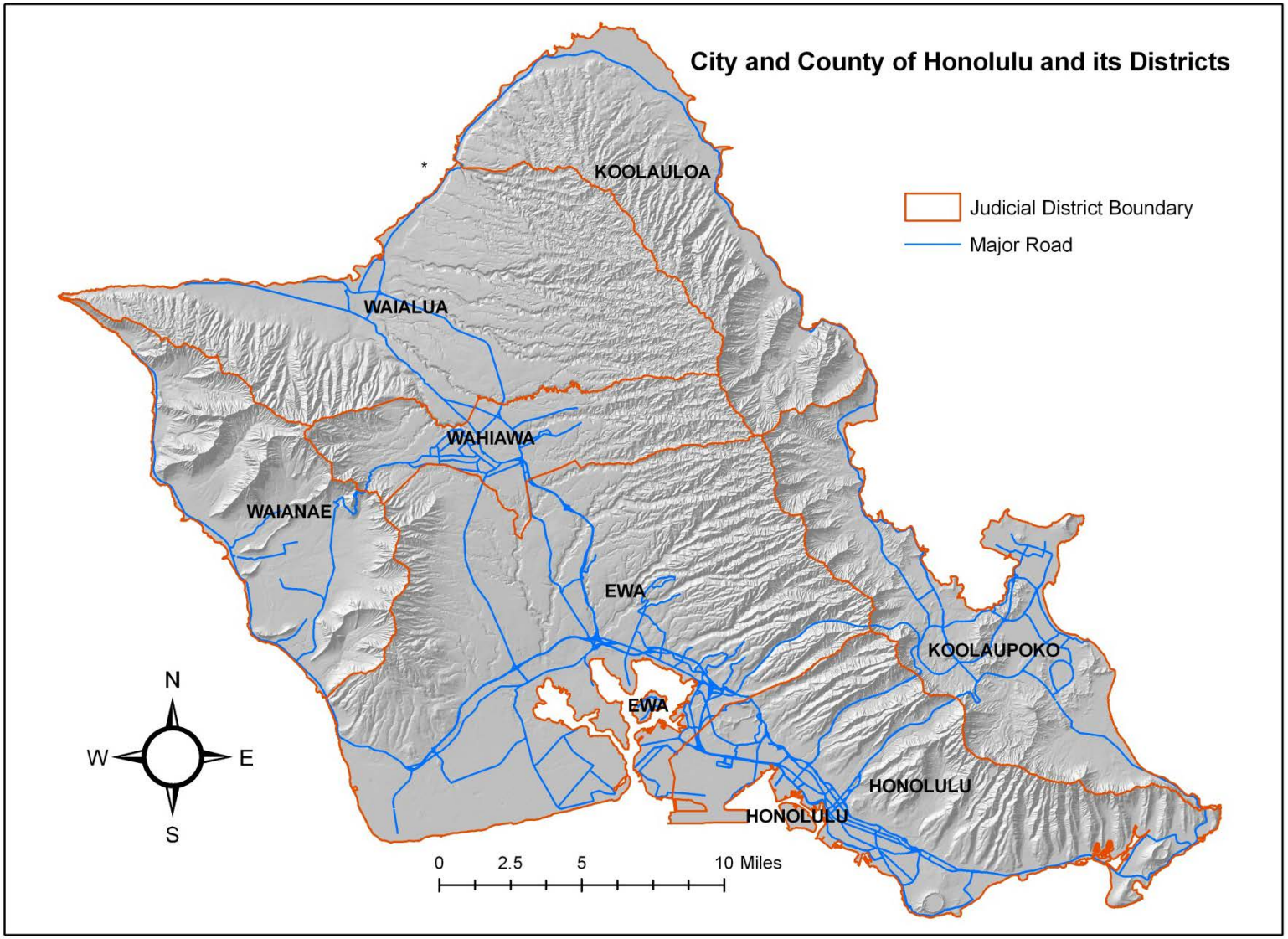


Figure 3.3 Political Division of the County of Maui

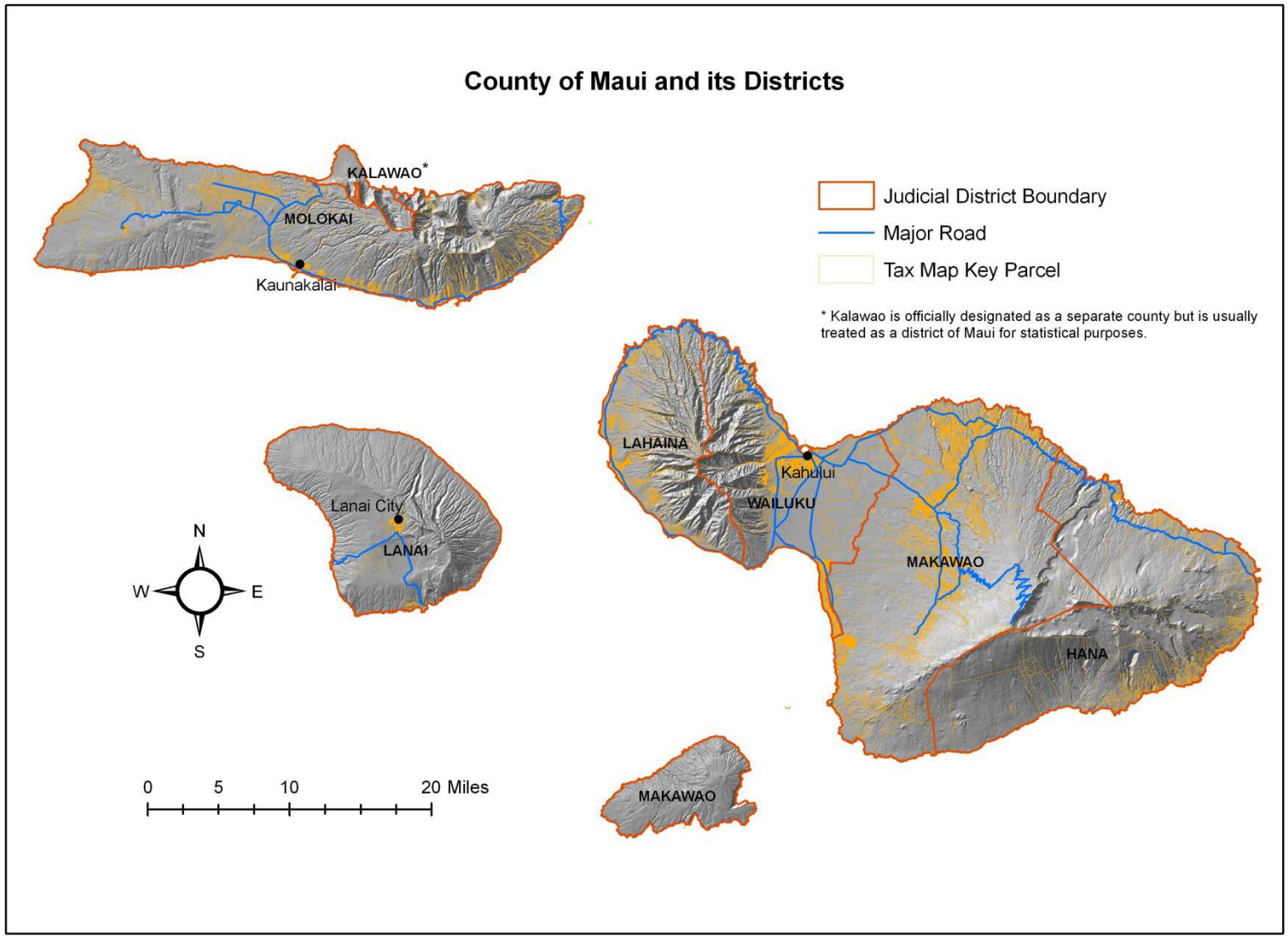
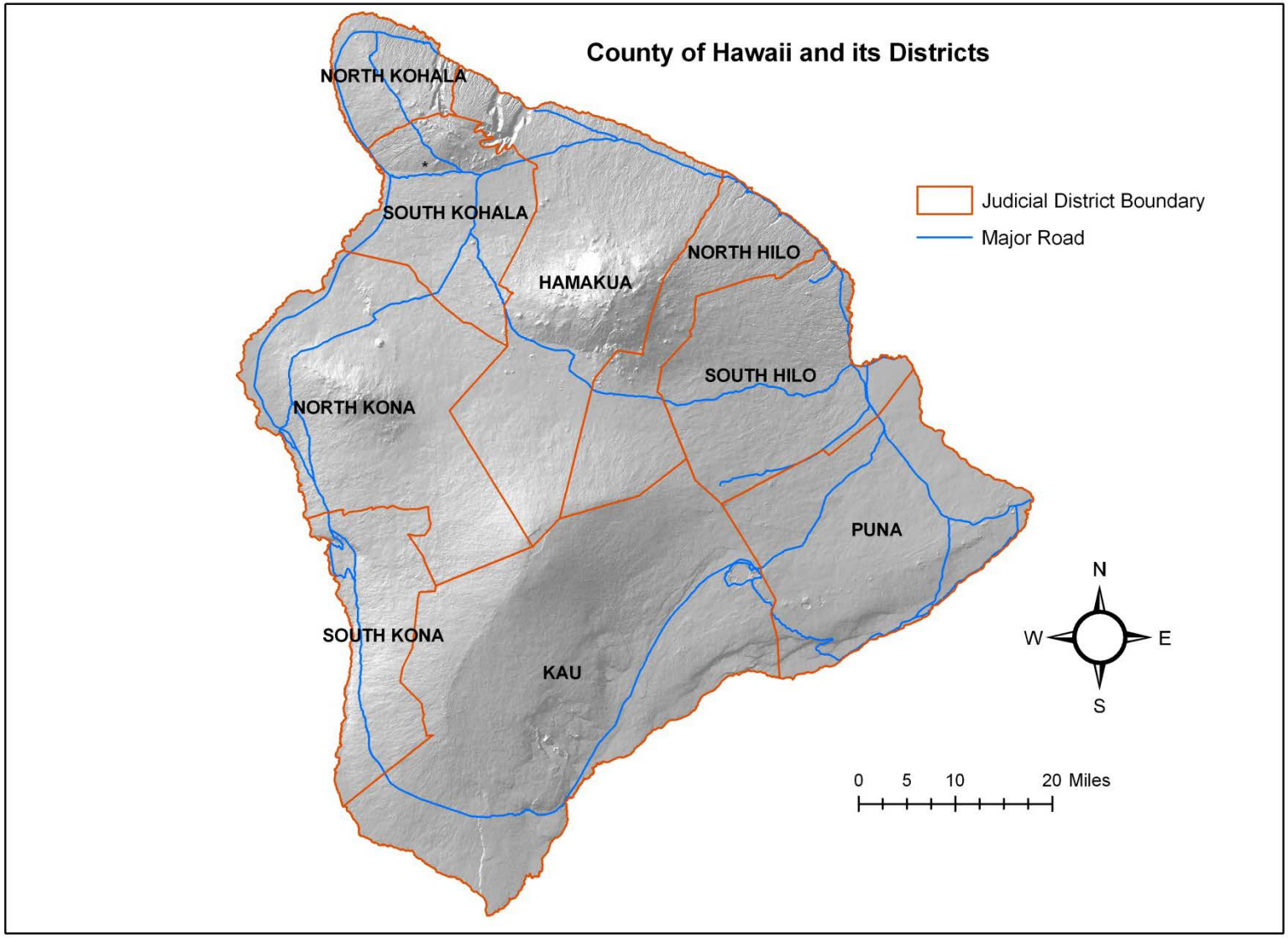


Figure 3.4 Political Division of the County of Hawai‘i



3.3 Demographics

According to 2011 estimates, the State of Hawai‘i has a resident population[6] of 1,374,810 people.[7]. The majority of the population is concentrated on the island of O‘ahu (City and County of Honolulu) with a total of 963,607 inhabitants. Based on the United States Census Bureau data for 2000, approximately ninety two percent (92%) of the population resides in urban areas.[8] Between 2000 and 2011, the State of Hawai‘i’s resident population increased by 162,140 people. Resident population figures by County are included in Table 3.1.

Table 3.1 State of Hawai‘i Population by County[9]

County	1990 Resident Population	2000 Resident Population	2010 Resident Population	2011 Resident Population	Total Change (1990 to 2011)	Percent Change (1990 to 2011)
Kaua‘i	51,676	58,560	62,217	67,701	16,025	31%
Honolulu	838,534	875,881	955,636	963,607	125,073	15%
Maui	101,709	128,968	155,125	156,764	55,055	54%
Hawai‘i	121,572	149,261	185,381	186,738	65,166	54%
TOTAL	1,113,491	1,212,670	1,363,359	1,374,810	261,319	24%

Because of the high volume of tourists that visit the State of Hawai‘i steadily throughout the year, it is the de facto population[10], and not the resident population, that determines the State’s infrastructure and service needs. The percent difference between the resident population and the de facto population for the years 1990, 2000, and 2010 is approximately 11, 10, and 8 percent, respectively. This significant difference in populations can be attributed to the steady number of visitors over the past three decades. A comparison between resident and de facto populations for the State is included in Table 3.2.

With few exceptions, the average daily visitor census for the State has increased at a fairly constant rate from 1990 to 2011. During this period, the low was 147,498 visitors in 1991 (hurricanes Iwa and Iniki) while the high was 189,445 visitors in 2005. After the 2005 all-time

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6 Resident population figures are based on place of usual residence, regardless of physical location on the estimate or census date. Figures include military personnel stationed or home-ported in Hawai‘i and residents temporarily absent. Figures exclude visitors present.

7 The State of Hawai‘i Data Book 2011, Table 1.06

8 The State of Hawai‘i Data Book 2011, Table 1.21

9 The State of Hawai‘i Data Book 2011, Table 1.06

10 De facto population figures are based on all persons present in and area, regardless of military status or usual place of residence. Figures include visitors present but exclude residents temporarily absent, both calculated as an average daily census.

high in average daily visitors statewide, the tourism industry took a dip in response to the great recession affecting the United States. Thus, average daily visitors for the state decreased to 165,082 visitors in 2009. Following the 2009 low, the number of average daily visitors has been once more steadily climbing to 185,824 visitors in 2011. Visitor statistics for the State of Hawai‘i for the period between 1990 and 2011 are included in Table 3.3.

Population projections developed by the Department of Business, Economic Development, and Tourism estimates the resident population of the State of Hawai‘i for the years 2020, 2030, and 2040 to be 1,481,236, 1,602,338, and 1,709,915, respectively.[11] These resident population estimates translate to increases in population of approximately 8, 17, and 25 percent over the 2011 resident population figure of 1,374,810.

Table 3.2 State of Hawai‘i Resident and De Facto Population[12]

Population	April 1, 1990	April 1, 2000	July 1, 2010	Percent Change		
				1990 to 2000	2000 to 2008	1990 to 2008
Resident	1,108,229	1,211,537	1,363,359	9.3%	12.5%	23.0%
De Facto	1,230,731	1,337,991	1,468,091	8.7%	9.7%	19.3%
Percent Difference	11.1%	10.4%	7.7%			

[11] The State of Hawai‘i Data Handbook 2011, Table 1.28

[12] The State of Hawai‘i Data Book 2011, compiled from Tables 1.06 and 1.09

Table 3.3 State of Hawai‘i Total Yearly Visitor Arrivals and Average Daily Visitors[13]

Year	Yearly Visitor Arrivals	Average Daily Visitors
1990	6,723,531	154,517
1991	6,518,460	147,323
1992	6,473,669	152,249
1993	6,070,995	147,498
1994	6,364,674	156,630
1995	6,546,759	157,098
1996	6,723,141	158,297
1997	6,761,135	157,187
1998	6,595,790	157,389
1999	6,741,037	164,439
2000	6,948,594	168,637
2001	6,303,789	158,247
2002	6,389,059	160,195
2003	6,380,439	161,048
2004	6,912,094	171,481
2005	7,416,574	185,445
2006	7,528,106	189,441
2007	7,496,820	189,412
2008	6,713,436	172,487
2009	6,420,448	165,082
2010	6,916,894	177,949
2011	7,174,397	185,824

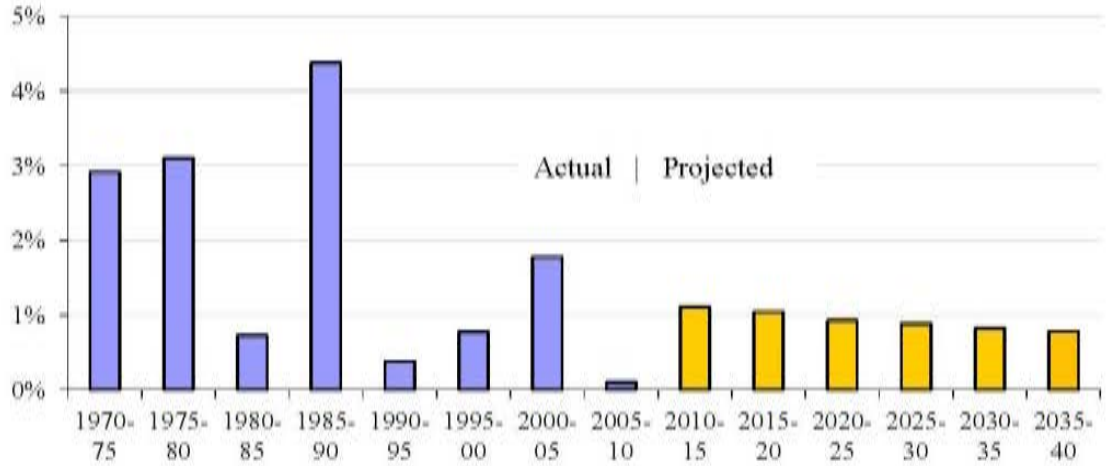
3.3.1 Employment

It is expected that Hawai‘i’s future growth will be primarily related to the rate of expansion of the economies of the United States mainland and Japan. These two economies are the sources of Hawai‘i’s tourism demand and the main export markets for Hawai‘i’s goods and services. According to the 2012 Population and Economic Projections for the State of Hawai‘i to 2040 by the Hawai‘i Department of Business, Economic Development and Tourism, the state’s total number of civilian jobs (wage and salary jobs plus self-employed jobs) is expected to show a slightly higher growth than that the number of civilian wage and salary jobs owing to increasing share of self-employed jobs to total jobs. The share of self-employed jobs to total civilian jobs has increased from 14.3 percent in 1980 to 21.3 percent in 2010 reflecting a faster growth in self-

[13] Table compiled from Tables D1 and D4 of the “County Social, Business and Economic Trends in Hawai‘i: 1990 -2011” by the Hawai‘i State Department of Business, Economic Development & Tourism, 2013. Yearly visitor arrivals figures include visitors staying overnight or longer anywhere in the state, and any overnight or non-overnight interisland trips reported by these visitors. Average daily visitor figures only include visitor arrivals by air.

employed jobs than wage and salary jobs. This trend is expected to continue in the future, but at a more moderate rate than observed in the past. For reference, the graph on Figure 3.5 shows the actual and projected average annual growth rates of civilian jobs for the State.

Figure 3.5 State of Hawai'i Average Annual Growth of Civilian Jobs[14]



In terms of the short-term projections (2020), the number of employed persons in the State will reach 633,000 by 2020, up 7.8% from 2010. The City and County of Honolulu's share of statewide jobs will likely fall relative to the Neighbor Islands. By 2020, the County of Kaua'i is expected to have 46,500 civilian jobs, 5.3% of statewide civilian jobs, and up from 5.2% in 2010. In the case of the City and County of Honolulu, civilian jobs in 2020 are projected to be 611,800. This figure would represent 69.4% of state total civilian jobs, down from 71.1% in 2010. The County of Maui is projected to have 110,900 civilian jobs in 2020. This would amount to 12.6% of statewide civilian jobs projected for this year, up from 11.9% in 2010. Lastly, the County of Hawai'i is expected to have 112,200 civilian jobs in 2020 or 12.7% of statewide civilian jobs for this year, up from 11.9% in 2010.

In the case of the long-term projections (2040), the figures indicate that jobs in the City and County of Honolulu will increase at a much slower rate than in the other counties. This trend is consistent with actual statistics from the past three decades. Even though the jobs in the Neighbor Island counties are not expected to grow as fast as their populations, a faster job growth in the Neighbor Islands than the state as a whole will increase their share of statewide total jobs to 33.9% in 2040 from 28.9% in 2010.

Summaries of actual (2010) and projected (2020 to 2040) numbers of civil jobs and civil employment by county is included in Table 3.4. To compliment this table, average annual growth rates for civil jobs and civil employment is included in Table 3.5. In the tables, total number of civil jobs includes wage and salary jobs plus self-employed jobs.

[14] *Population and Economic Projections for the State of Hawai'i to 2040*, Hawai'i Department of Business, Economic Development and Tourism, Research and Economic Analysis Division, March 2012

Table 3.4 Actual and Projected Civilian Jobs and Employment[15]

STATE	2010	2020	2030	2040
Resident Population	1,363,621	1,481,200	1,602,300	1,708,900
Civilian wage & salary jobs	623,573	673,800	716,200	753,700
Total civilian jobs	792,057	881,400	964,600	1,044,900
Total civilian employment	587,400	633,00	672,400	708,500
County of Kaua'i				
Resident Population	67,226	75,600	84,400	93,000
Civilian wage & salary jobs	29,500	31,900	34,000	35,800
Total civilian jobs	40,900	46,500	52,000	57,500
Total civilian employment	29,050	32,300	35,300	38,000
City and County of Honolulu				
Resident Population	955,775	1,003,700	1,052,100	1,086,700
Civilian wage & salary jobs	458,600	489,000	513,600	534,100
Total civilian jobs	562,800	611,800	653,400	690,400
Total civilian employment	414,500	434,200	448,500	459,900
County of Maui				
Resident Population	155,214	181,000	207,300	232,900
Civilian wage & salary Jobs	69,200	77,100	84,200	90,700
Total civilian jobs	94,400	110,900	127,700	145,300
Total civilian employment	68,700	78,500	87,700	96,600
County of Hawai'i				
Resident Population	185,406	220,900	258,500	296,300
Civilian wage & salary jobs	66,300	75,700	84,500	93,100
Total civilian jobs	93,900	112,200	131,400	151,700
Total civilian employment	75,150	88,000	100,900	113,900

Table 3.5 Actual and Projected Average Annual Growth Rate for Civilian Jobs and Employment[16]

STATE	2000-2010	2010-2020	2020-2030	2030-2040
Population	1.2%	0.9%	0.8%	0.7%
Civilian wage & salary jobs	0.6%	0.8%	0.6%	0.5%
Total civilian jobs	0.9%	1.1%	0.9%	0.8%
Total civilian employment	0.0%	0.8%	0.6%	0.5%
County of Kaua'i				
Population	1.4%	1.2%	1.1%	1.0%
Civilian wage & salary jobs	0.5%	0.8%	0.6%	0.5%
Total civilian job	1.2%	1.3%	1.1%	1.0%
Total civilian employment	0.0%	1.1%	0.9%	0.8%
City and County of Honolulu				
Population	0.9%	0.5%	0.5%	0.4%
Civilian wage & salary jobs	0.5%	0.6%	0.5%	0.4%
Total civilian jobs	0.7%	0.8%	0.7%	0.6%
Total civilian employment	-0.0%	0.5%	0.3%	0.3%
County of Maui				
Population	1.9%	1.6%	1.4%	1.2%
Civilian wage & salary jobs	0.6%	1.1%	0.9%	0.8%
Total civilian jobs	1.3%	1.6%	1.4%	1.3%
Total civilian employment	0.0%	1.3%	1.1%	1.0%
County of Hawai'i				
Population	2.2%	1.8%	1.6%	1.4%
Civilian wage & salary jobs	1.2%	1.3%	1.1%	1.0%
Total civilian jobs	1.7%	1.8%	1.6%	1.4%
Total civilian employment	0.6%	1.6%	1.4%	1.2%

[15] *Population and Economic Projections for the State of Hawai'i to 2040*, Hawai'i Department of Business, Economic Development and Tourism, Research and Economic Analysis Division, March 2012

[16] Ibid

3.4 Land Use

3.4.1 The State of Hawai‘i Land Use Law

The State Land Use Law (Chapter 205, Hawai‘i Revised Statutes) is unique in the history of Hawai‘i land use planning. Originally adopted by the State Legislature in 1961, the Land Use Law establishes an overall framework of land use management within the State. The statewide zoning established in the State Land Use law is administered by the Land Use Commission (LUC), which is composed of nine members appointed by the Governor and confirmed by the State Senate (one member appointed for each of the counties except the County of Kalaheo and five members appointed at large).The State Land Use Law classifies the lands within the State of Hawai‘i into one of four Districts: Urban, Rural, Agricultural, and Conservation.

The Urban District generally includes lands characterized by “city-like” concentrations of people, structures, and services. This District also includes vacant areas for future development. Jurisdiction of this district lies primarily with the respective counties. Generally, lot sizes and uses permitted in the Urban District area are established by the respective County through ordinances or rules.

Rural Districts are composed primarily of small farms intermixed with low-density residential lots with a minimum size of one-half acre. Jurisdiction over Rural Districts is shared by the Commission and county governments. Permitted uses include those relating or compatible to agricultural use and low-density residential lots. Variances can be obtained through the special use permitting process.

The Agricultural District includes lands for the cultivation of crops, aquaculture, raising livestock, wind energy facility, timber cultivation, agriculture-support activities (i.e., mills, employee quarters, etc.) and land with significant potential for agriculture uses. Golf courses and golf-related activities may also be included in this district, provided the land is not in the highest productivity categories (A or B) of the Land Study Bureau’s detailed classification system. Uses permitted in the highest productivity agricultural categories are governed by statute. Uses in the lower-productivity categories – C, D, E or U - are established by the Commission and include those allowed on A or B lands as well as those stated under Section 205-4.5, Hawai‘i Revised Statutes.

Conservation Districts are comprised primarily of lands in existing forest and water reserve zones and include areas necessary for protecting watersheds and water sources; scenic and historic areas; parks, wilderness, open space, and recreational areas; habitats of endemic plants, fish, and wildlife; and all submerged lands seaward of the shoreline. The conservation District also includes lands subject to flooding and soil erosion. Conservation Districts are administrated by the State of Hawai‘i Board of Land and Natural Resources and uses are governed by rules promulgated by the State of Hawai‘i Department of Land and Natural Resources (DLNR) Office of Conservation and Coastal Lands (OCCL).

As of December 31, 2011, the LUC has classified approximately 198,622 acres of land in the State of Hawai‘i as urban, 11,602 acres as rural, 1,928,318 acres as agricultural, and 1,973,846

acres as conservation.[17] Maps indicating the Land Use Districts for all the counties in the State are included in Figure 3.6 through Figure 3.9.

3.4.1.1 Conservation District Subzones

As was previously mentioned, lands categorized as conservation are managed by the DLNR OCCL. In order to proper administer such lands, DLNR has divided the Conservation District into five subzones: Protective, Limited, Resource, General, and Special. Omitting the special subzone, the four subzones are arranged in a hierarchy of environmental sensitivity, ranging from the most environmentally sensitive (protective) to the least sensitive (general). The special subzone is applied in special cases specifically to allow a unique land use on a specific site. Maps indicating the Conservation District Subzones for all counties in the State are included in Figure 3.10 through Figure 3.13.

Each subzone has a unique set of identified land uses which may be allowed by discretionary permit. The identified land uses for each subzone are outlined in Chapter 13-5 Subchapter 2 of the State of Hawai‘i Administrative Rules. The OCCL can only accept a permit application for an identified land use listed under the particular subzone covering the subject property. Most of the identified land uses require a discretionary permit or some sort of approval from the DLNR or the State of Hawai‘i Board of Land and Natural Resources (BLNR). Major permits are required for land uses, which have the greatest potential impact, and an environmental assessment and/or an environmental impact statement (EIS) is required (and may also require a Public Hearing); minor permits are required for land uses which may have fewer impacts, decision making is delegated to the Board Chairperson (and may not require a Public Hearing) or to the OCCL for other minor uses.

[17] The State of Hawai‘i Data Handbook 2011, Table 6.03

Figure 3.6 Land Use Districts for the County of Kaua‘i

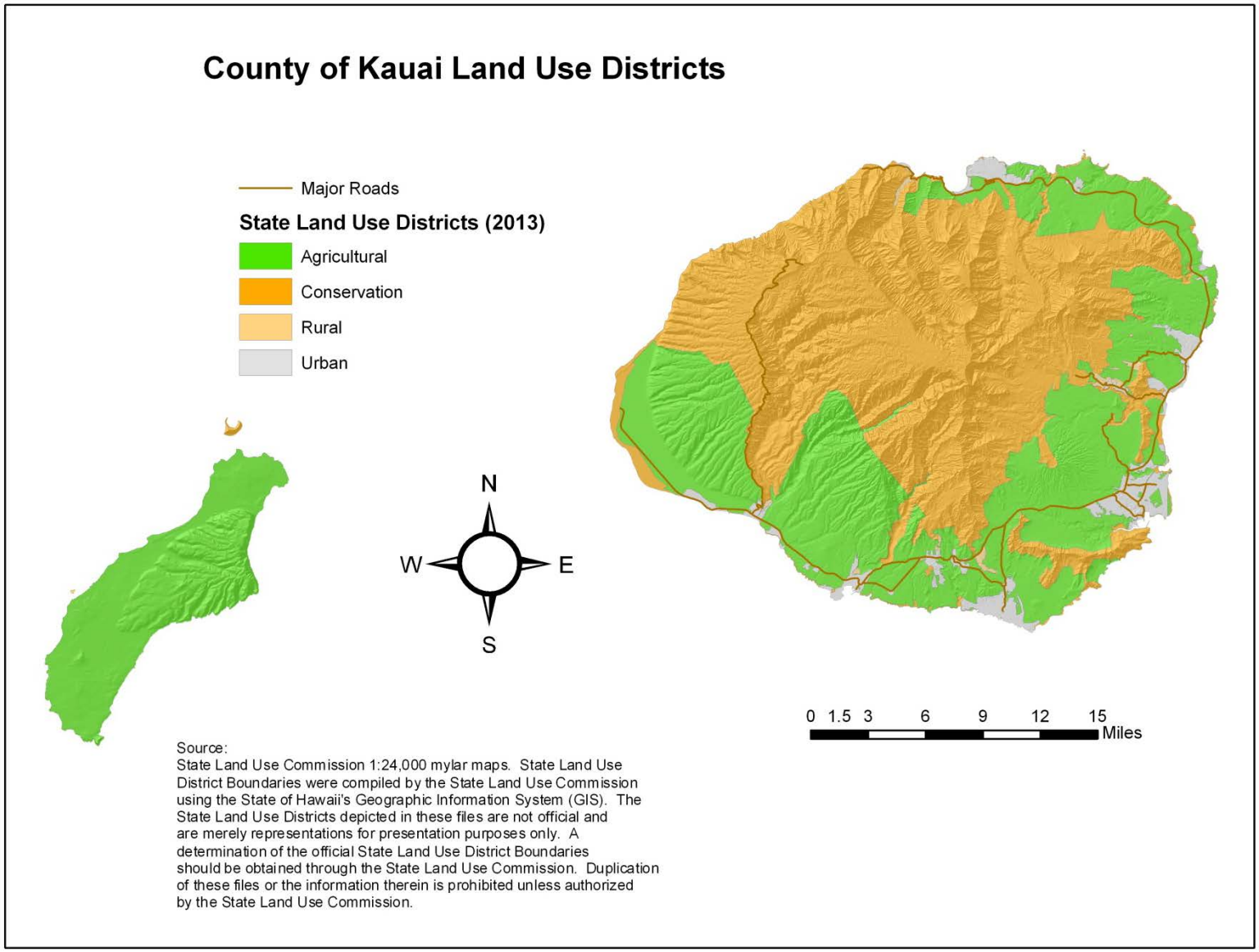


Figure 3.7 Land Use Districts for the City and County of Honolulu

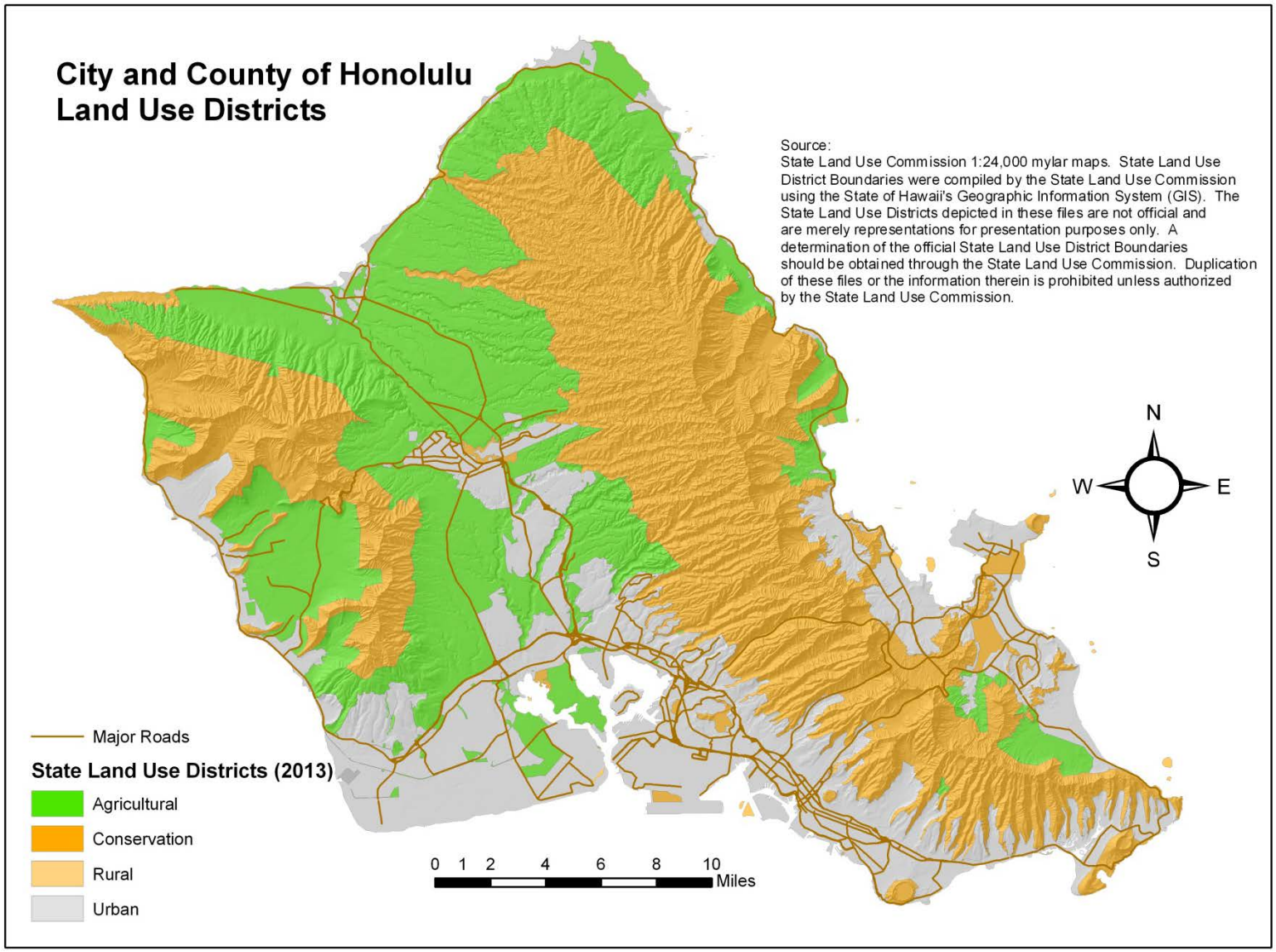


Figure 3.8 Land Use Districts for the County of Maui

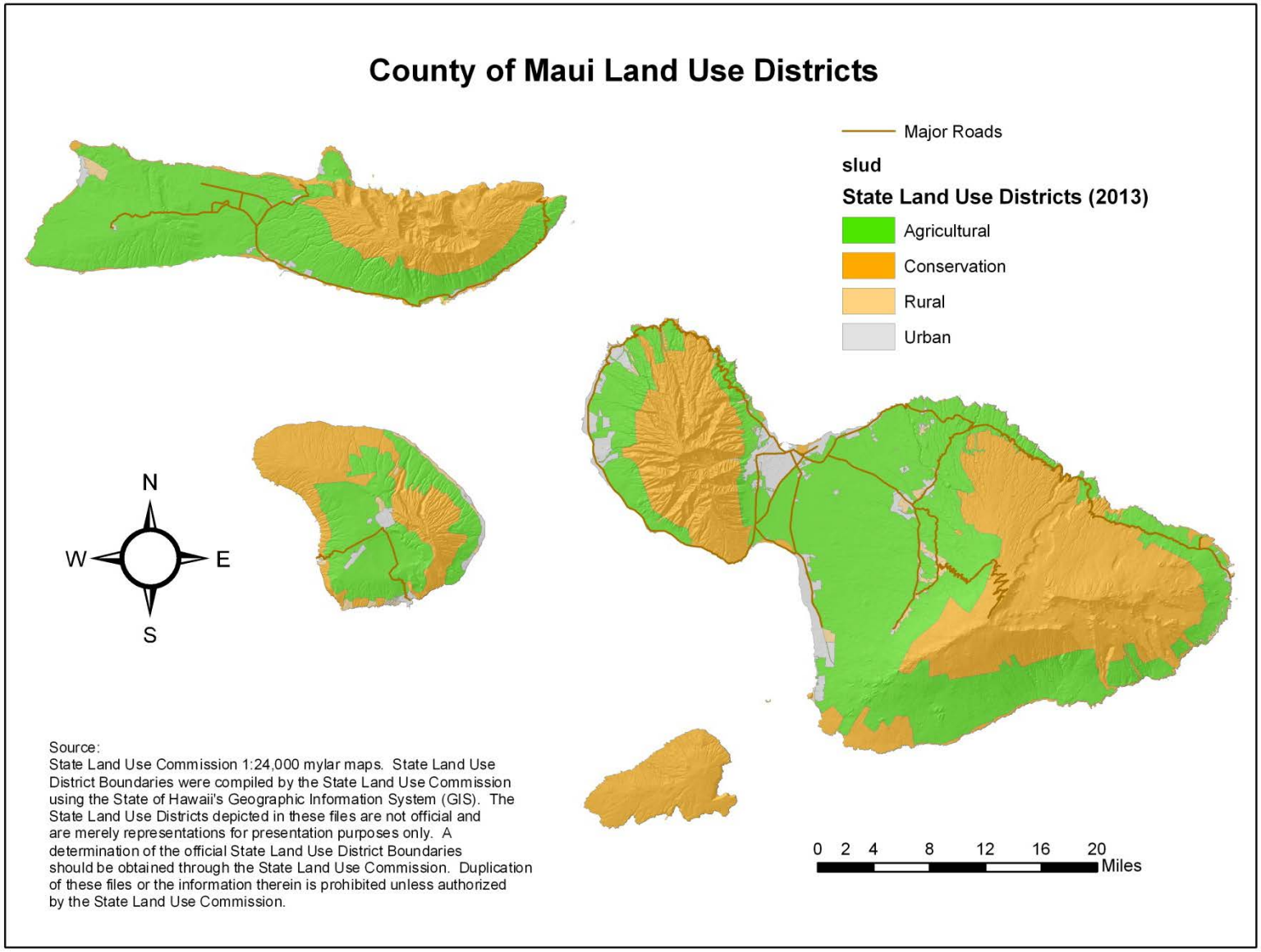


Figure 3.9 Land Use Districts for the County of Hawai‘i

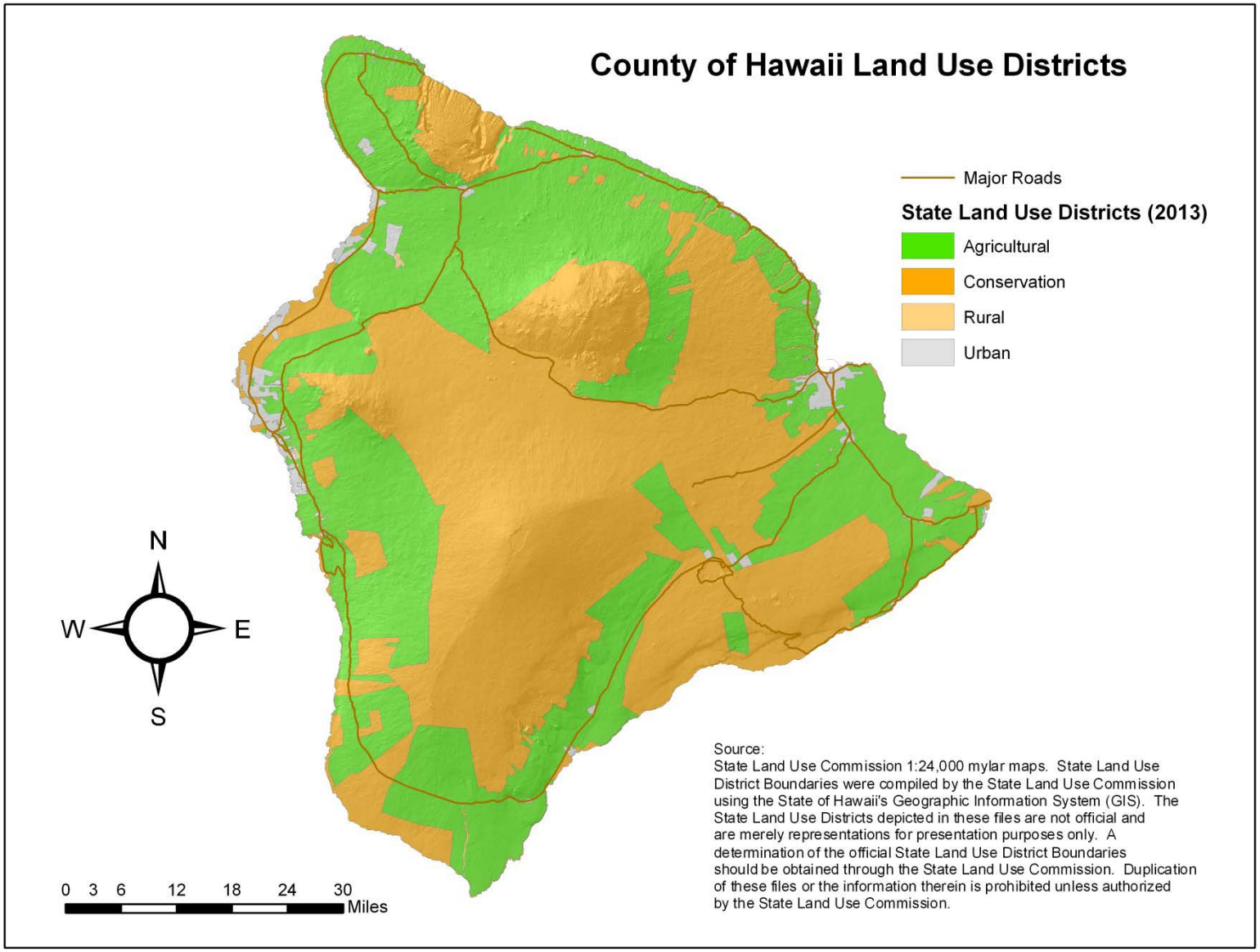


Figure 3.10 Conservation District Subzones for the County of Kaua‘i

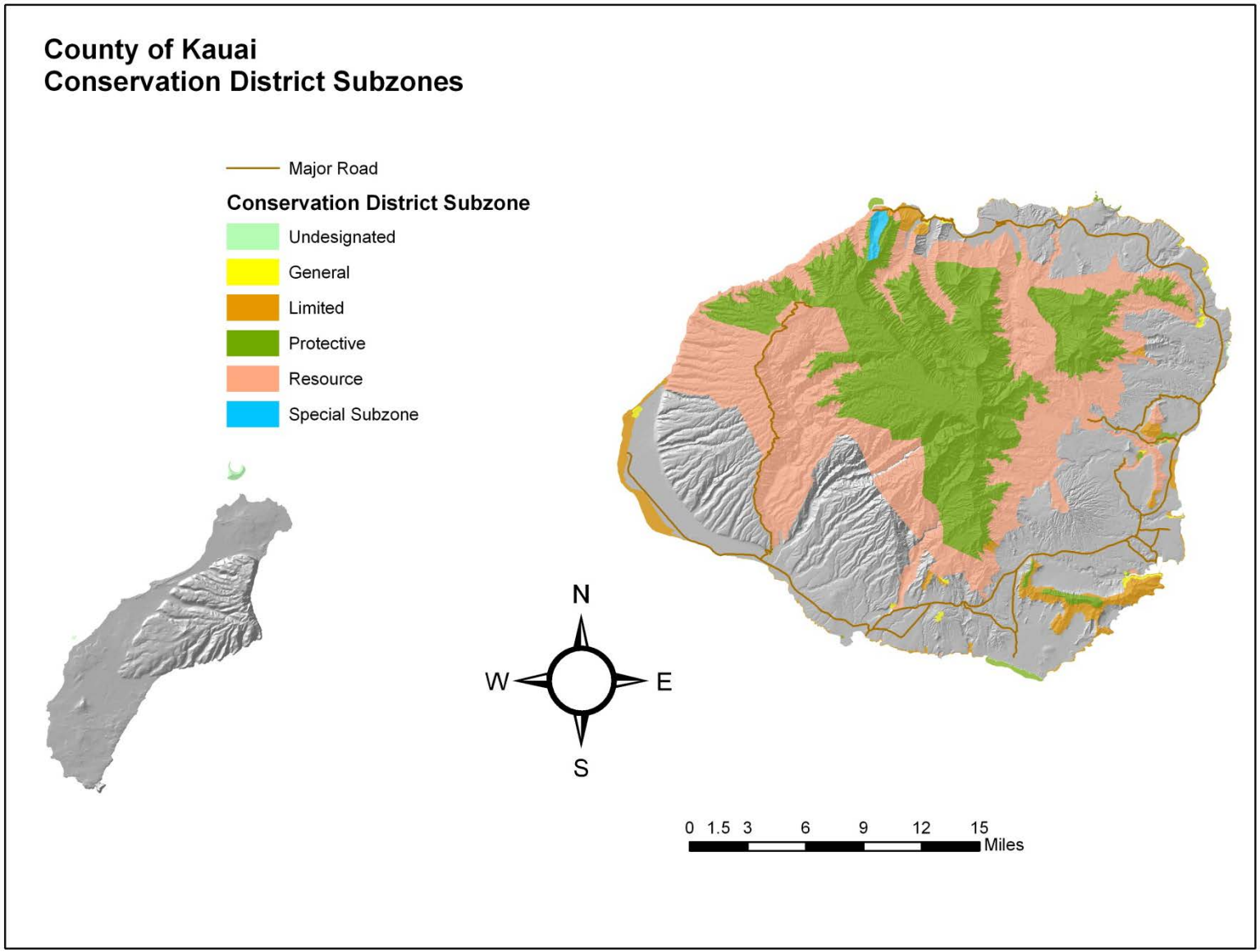


Figure 3.11 Conservation District Subzones for the City and County of Honolulu

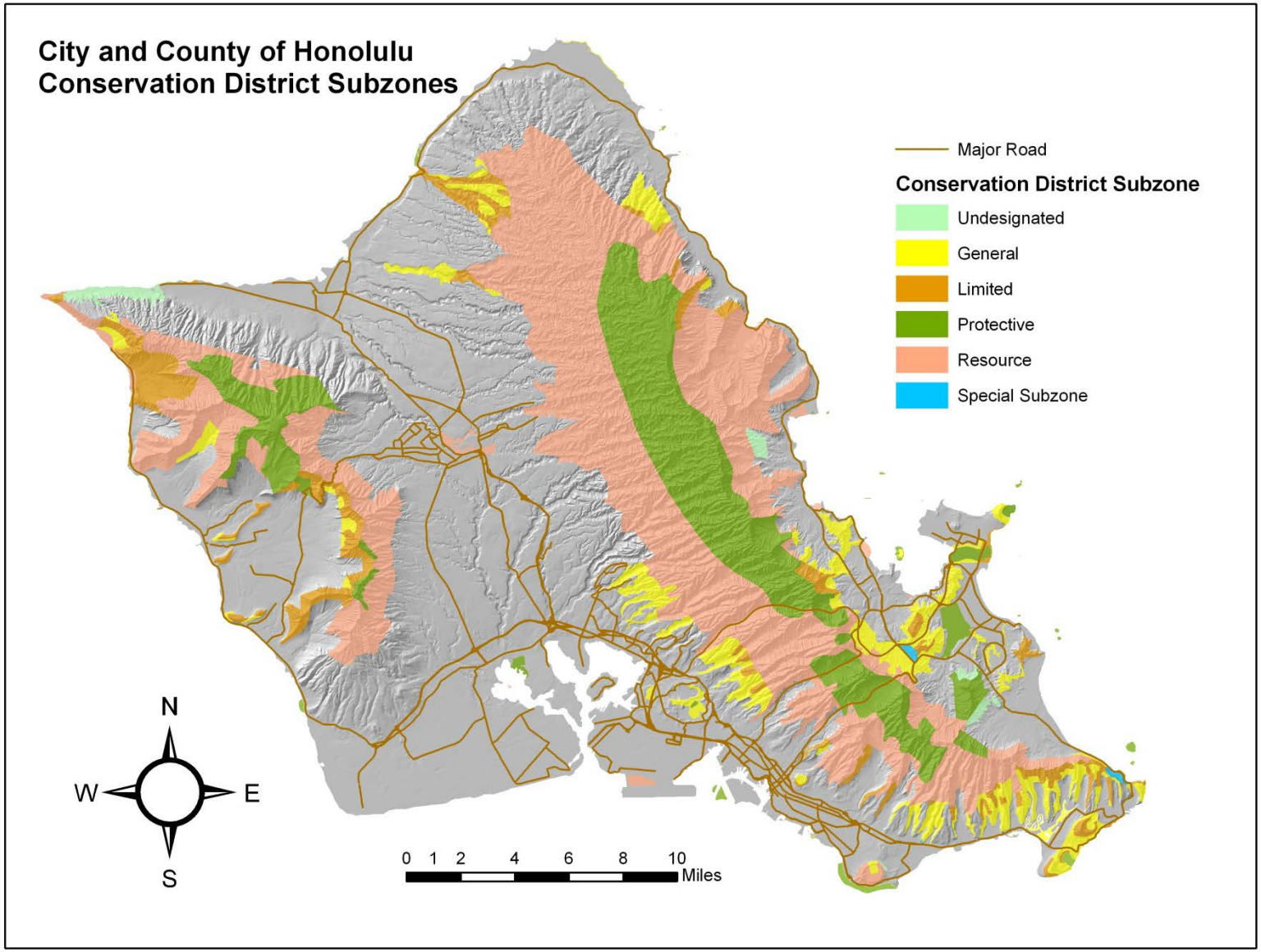


Figure 3.12 Conservation District Subzones for the County of Maui

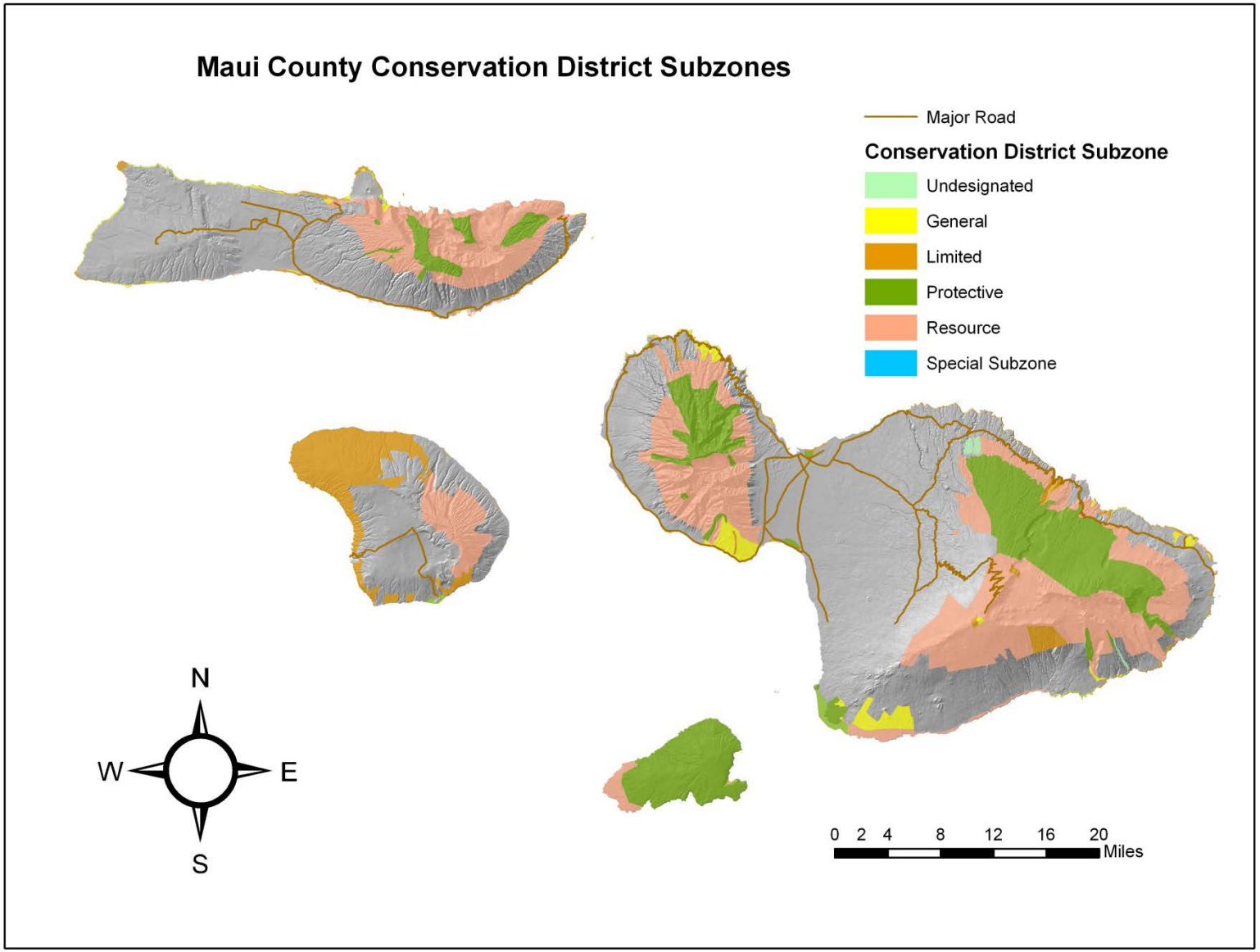
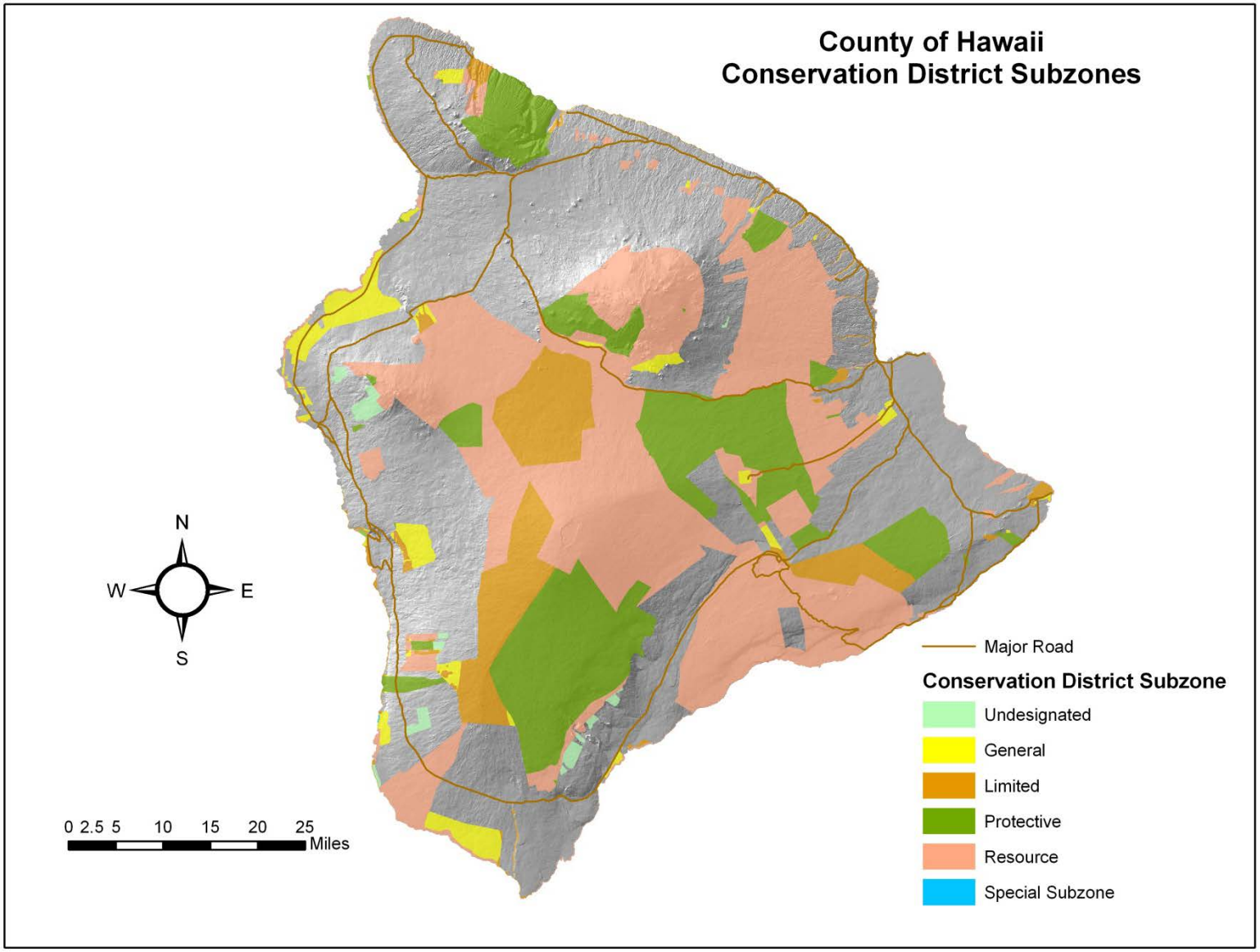


Figure 3.13 Conservation District Subzones for the County of Hawai‘i



STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

4. High Wind Storms

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CHAPTER 4
High Wind Storms

Reasons for Updates / Revisions in this 2013 Plan
• 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 discussion of wind and wind effects nomenclature has been added. Wind roses to graphically show the annual wind patterns are added. • A chronology of high wind events in Hawai‘i 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 climatology from tropical cyclone activity in the Central Pacific region. • Topographic effects due to Hawai‘i’s mountainous terrain are quantified using information now adopted in the State Building Code and awarded the Outstanding Civil Engineering Achievement of 2010 by the Hawai‘i Chapter of the American Society of Civil Engineers. • The different hazard curves of tropical cyclones and all other wind events are clearly distinguished and discussed. • The relevance of this work to power infrastructure as well as building structures is also identified. • Electrical distribution pole standard upgraded for new construction per PUC rule updates • Studies of vulnerable critical facilities; periodic adoption of current building codes • Development of certified wall assemblies for residential safe rooms

Summary of Mitigation Projects for the State of Hawai‘i
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; • assessment of wind hazards using an more accurate building inventory database, screening and certification of private sector shelters, and all hazards public shelter evaluations; • testing of single wall construction for wind loading; and • provision of incentives for homeowners to perform retrofits.

4.1 High Wind Storms Hazard Description

4.1.1 General

Wind is one of the most costly insured property perils, causing more damage than earthquakes, freezing, or other natural perils. *Wind* is defined as the horizontal component of natural air moving close to the surface of the earth[1]. Windspeeds vary with height above ground – the higher the elevation, the stronger the wind. There are several ways to measure the speed at which air is moving, or windspeed. The most commonly used methodologies for measuring windspeed are:

- *The Fastest Mile Windspeed* is the average recorded speed during a time interval in which one mile of wind passes a fixed measuring point. The measurement is taken at an elevation of 33 feet in open terrain. The Fastest Mile Windspeed measurement was historically used in many older building codes and design standards such as the Uniform Building Code (all editions) and the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures (until the 1993 edition).
- *Sustained Wind* is the windspeed averaged over 1 minute. This is the measurement standard used by the National Weather Service.
- *Peak Gusts* are the maximum wind gust speeds averaged over a period of two to five seconds. This is the measurement standard used by modern U.S. and Hawai‘i building codes.

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[2].

- *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. This negative pressure is also known as lift. 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 fells tremendous internal pressures pushing up from inside of the building together with the negative wind pressure lifting the roof from the outside.

In most 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

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[1] Ludlum, David, *The American Weather Book*, Boston, Massachusetts: Houghton Mifflin Company, 1982, 57p

[2] *Understanding the Wind Peril*, Insurance Institute for Property Loss Reduction, 1994, 15p

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 of the building.

4.1.2 **Wind Patterns**

Winds in Hawai‘i originate from three main sources: trade winds, Kona winds, and hurricanes. High winds from trade winds (which blow 70% of the time[3]) Kona winds (30% of the time), and rare winds from hurricanes and tropical storms passing through Hawaiian waters all affect Hawai‘i.[4] The hazards from tropical cyclones are discussed in Chapter 5. This chapter focuses the other two wind patterns and the relative risk between the tropical cyclonic and other wind patterns.

4.1.2.1 Trade Winds

Northeast trade winds are dominant throughout most of the year and generally range in velocity between 10 and 20 mph. However, trade winds of 40–60 mph occasionally occur for several days at a time when the sub-tropical high- pressure cell located in the central North Pacific Ocean intensifies. 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. These persistent winds became known as trade winds long ago when clipper ships carrying cargo depended on the broad belt of Easterly winds encircling the globe in the subtropics for fast passage.

To illustrate the prevalence of trade winds in the Hawaiian Islands, Figures 4.1a to 4.1c show wind roses for the Kahului International Airport in the island of Maui (County of Maui). As can be seen in the figures, the wind roses indicate that northeast and east-northeast trade winds are dominant most of the time and generally range in velocities 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.

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.[5] The east-facing coastlines, as a result, are the coasts and most impacted by trade winds. During the 1993–1994 and 1994–1995 winter seasons, for example, strong and gusty trade winds of 40 to 50 mph lasted several days and inflicted damage to roof tops, tree limbs, and telephone equipment. In February 2013, gusty trade winds over 50 mph lasted for two days, causing numerous power outages due to damaged electrical transmission and distribution networks.

In the case of the island of Maui, trade winds appear to be stronger when passing through the isthmus between the West Maui Mountains and Haleakalā, so that windspeeds at location such as Mā‘alaea and north Kīhei may be higher than locations along the island’s north shore. This increase in windspeed is the result of wind channeling which often occurs when wind passes between two mountains or into a valley.

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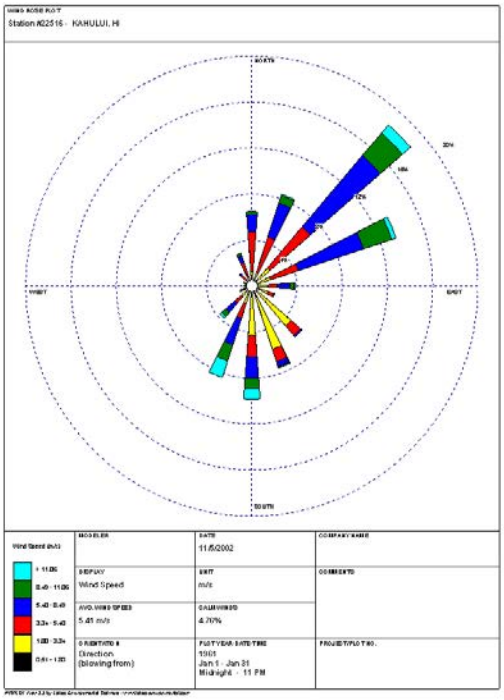
[3] Kodama, 1998

[4] Fletcher, 2000

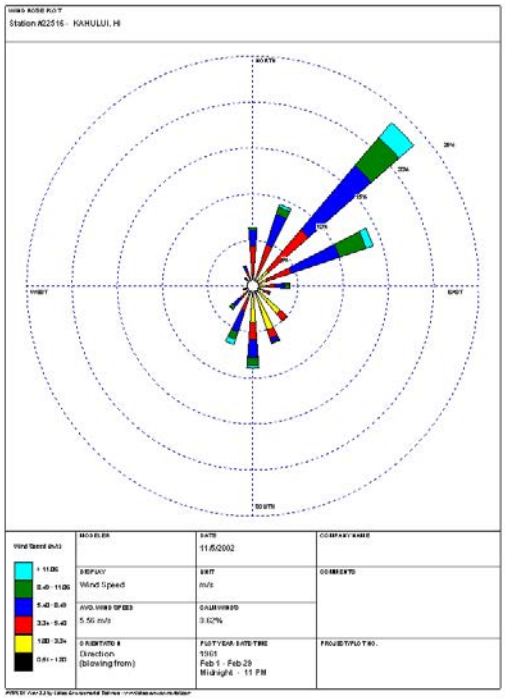
[5] Ibid

Strong, gusty trade winds can cause problems for mariners. These strong trades, blowing from the northeast, funnel through the major channels between the islands--Kaua‘i, Kaiwi, Pailolo, Kalohi, ‘Au‘au, and ‘Alenuihāhā Channels--at speeds 5-20 knots faster than the speeds over the open ocean. 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. Mariners must exercise good judgment prior to entering the waters exposed to strong trades, especially in the major channels.

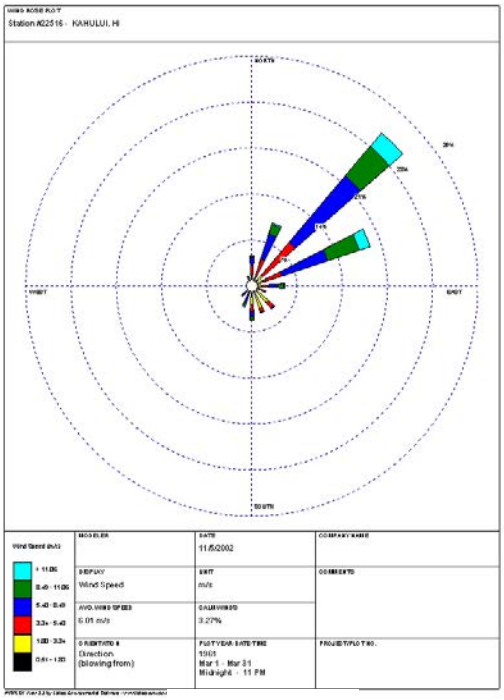
Figure 4.1a January through April Wind Roses for Kahului Airport, Island of Maui, Hawai‘i



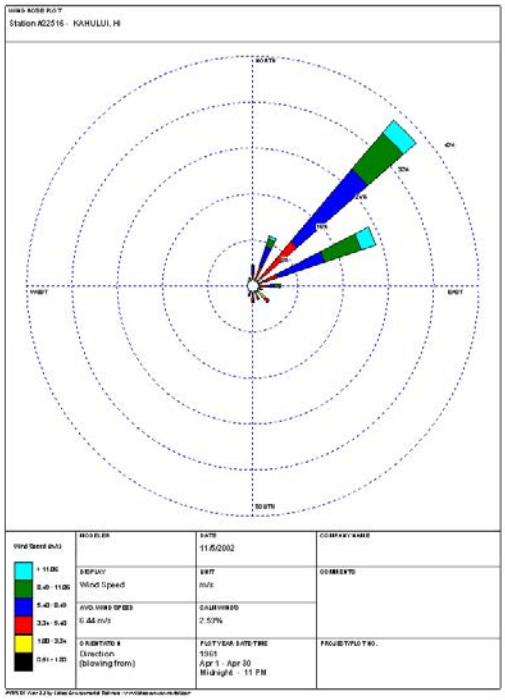
January



February

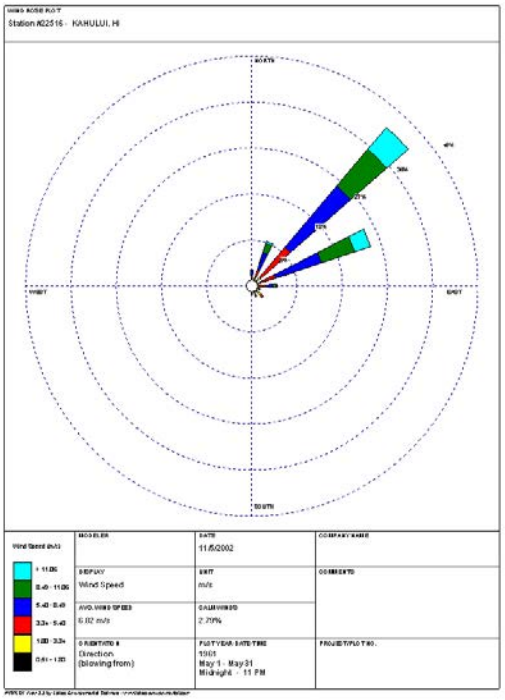


March

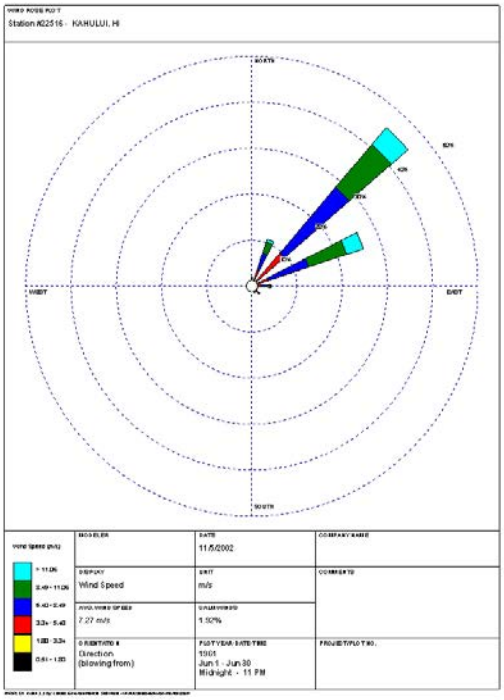


April

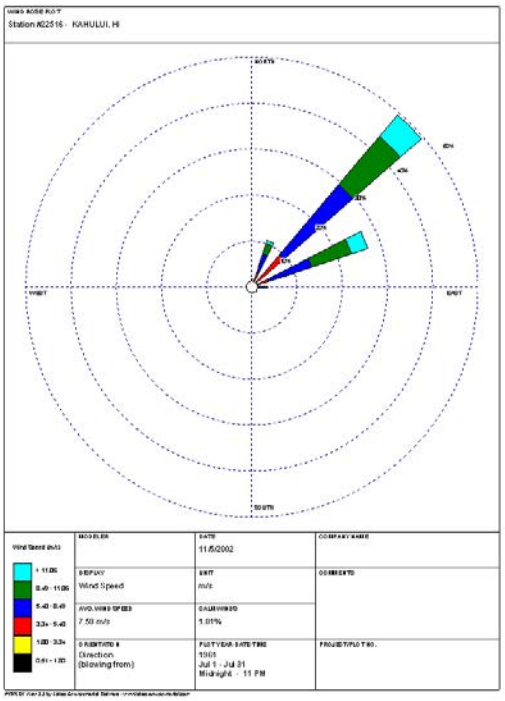
Figure 4.1b May through August Wind Roses for Kahului Airport, Island of Maui, Hawai'i



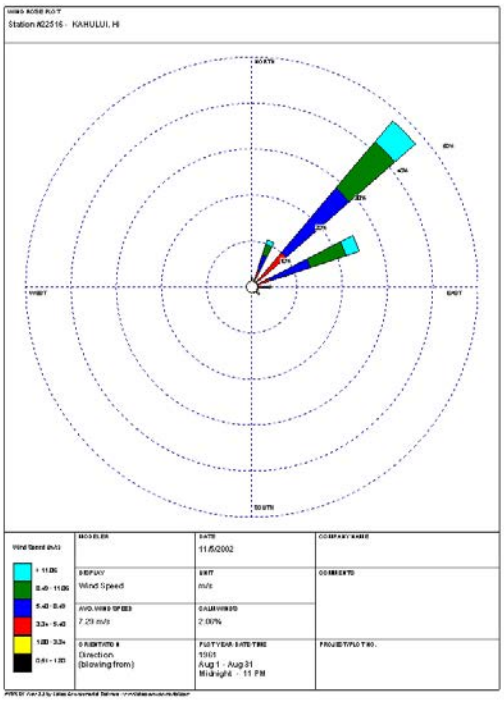
May



June

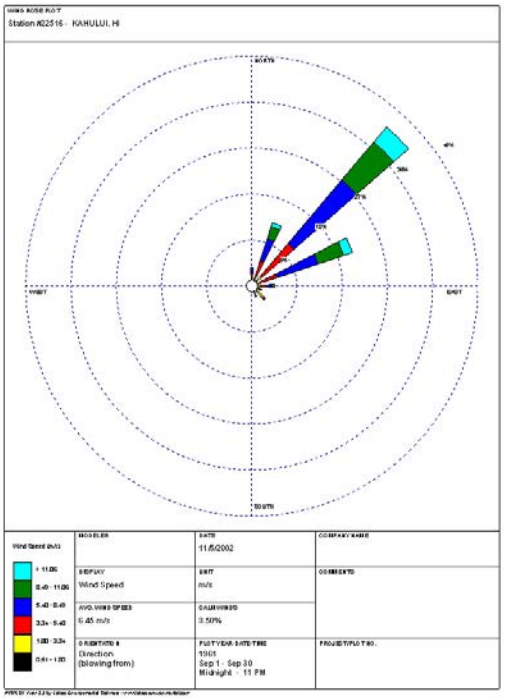


July

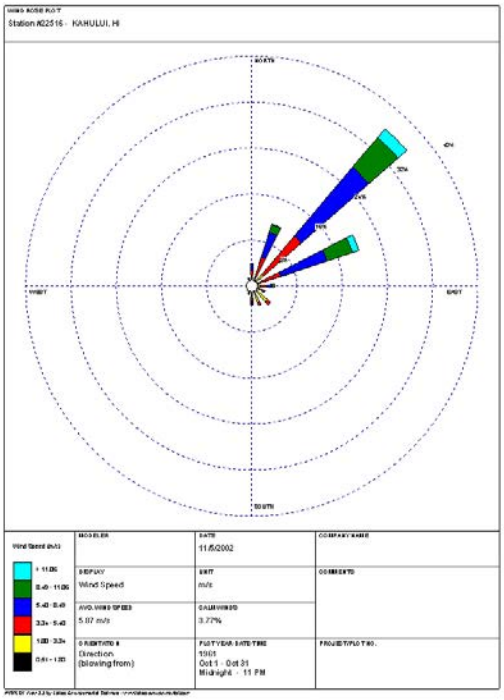


August

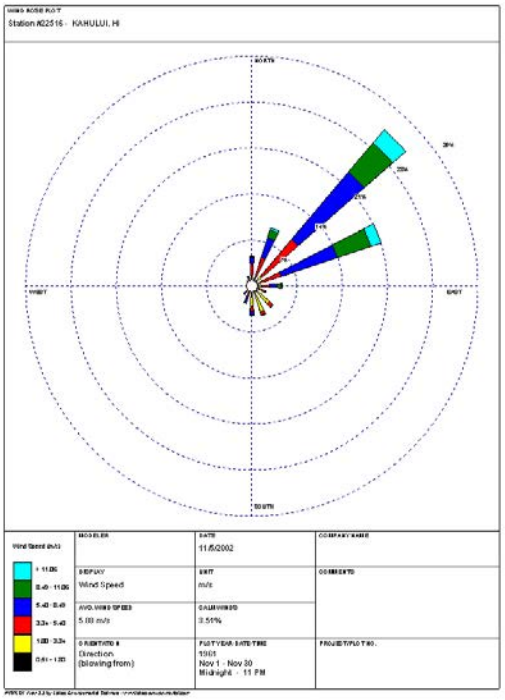
Figure 4.1c September through December Wind Roses for Kahului Airport, Island of Maui, Hawai‘i



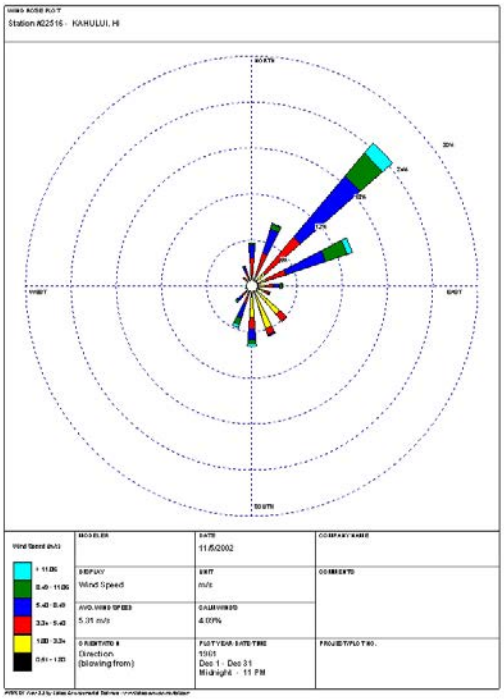
September



October



November



December

4.1.2.2 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. They occasionally occur as light and variable winds during summer months when trade wind circulation breaks down, but in winter they can be very strong when storm systems moving 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° - 35° N and 175° E – 140° W and move erratically, though with a slow tendency toward the west.[6] These storms are persistent and can last up to two weeks. During this time, considerable damage can be inflicted to boats caught in the open ocean or boats anchored in SW exposed anchorages. Coastal erosion can also result from the extended periods of heavy rain, strong surf and high winds. On land, effects of strong Kona winds can be very dramatic. Because of mountainous topography, winds can accelerate down the slopes of mountains, hills, and escarpments to over 100 miles per hour. Winds with these speeds can be very destructive when they reach heavily populated coastal or interior low lying areas. It is common during these episodes for trees to be uprooted, for signs and utility poles to be overturned, and for residential roofs to be blown off. The Kāneʻohe-Kahaluʻu area, on the windward coast of the Island of Oʻahu (City and County of Honolulu), has had extensive wind damage due to strong Kona winds.

By far the most notable documented Kona wind event to affect the island of Hawaiʻi (County of Hawaiʻi) was that of January 1980, which caused damages of $42 million. (Disaster Declaration DR-613-HI) The loss on the island of Hawaiʻi was $11.7 million. Agriculture – macadamia, coffee, foliage and flower farms – had major losses. The island of Maui (County of Maui) was also declared a disaster area during this storm[7] The January 1980 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.

One of the most common impacts of a wind storm is the loss of electrical service to some communities. 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. In December 26, 2008, the entire electrical grid on the island of Oʻahu was blacked out for around 12 hours due to a Kona storm. The blackout was triggered by lightening 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.

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[6] Kodama 1998

[7] Haraguchi, Paul, "Storm of January 8 - 10, 1980, State of Hawaiʻi", State of Hawaiʻi Department of Land and Natural Resources (DLNR), December 1980.

4.2 Significant Historical Events

High Wind events, distinct from tropical cyclones, affect the Islands on a relatively regular basis. Table 4.1 provides a comprehensive list of recorded high wind events for over a century. 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 all storms up until 1997; trade winds, Kona storms and tropical cyclones[8], are provided on Figures 4.2a through 4.2e.

Table 4.1 Historical High Wind Events[9]

Date	Description	Island
August 9, 1871	Strong winds	Oʻahu
December 7, 1896	Strong winds	Maui
January 21, 1906	High winds	Maui
March 6-7, 1906	High winds	Oʻahu
January 12-13, 1914	High NE winds	Oʻahu
December 26, 1915	High winds	Oʻahu
January 10, 1916	High winds	Oʻahu
January 14, 1916	High winds	Maui
December 3-4, 1918	High winds	Oʻahu
June 8, 1926	Possible Tornado	Oʻahu
January 17, 1948	High winds	Maui
January 23-26, 1948	High winds	Maui
January 15-17, 1949	High winds	Oʻahu
November 27-28, 1954	High winds	Oʻahu
December 21, 1955	High winds	Maui
January 17-18, 1959	Storm	Oʻahu, Maui
October 24, 1961	Strong winds	Oʻahu
January 15-17, 1963	Strong winds, gusts of up to 70 mph	Oʻahu, Maui
January 30-31, 1963	Strong winds, gusts of up to 84 mph	Oʻahu, Maui
February 28, 1963	Tornado	Oʻahu
March 31, 1963	Strong winds	Oʻahu
March 30-31, 1963	High winds	Oʻahu

[8] Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002

[9] Fletcher 2002, NOAA NWS website http://www.prh.noaa.gov/hnl/pages/stormdata/

Table 4.1 Historical High Wind Events[9]

Date	Description	Island
December 19-23, 1964	Strong winds	Maui
November 10-15, 1965	High winds	Oʻahu
December 18, 1966	Whirlwind	Oʻahu
February 16-17, 1967	Gusty winds	Oʻahu
November 2-11, 1967	High trade winds	Oʻahu, Maui, Kauaʻi
December 9, 1967	High winds	Maui
December 12, 1967	Strong winds, winter storm	Oʻahu, Maui
January 16-17, 1968	Winter storm, wind gusts > 50 mph	Oʻahu
February 15-18, 1968	SW winds, gusts to 62 mph	Oʻahu
April 9-10, 1968	30-50 mph winds	Oʻahu
November 28, 1968	Strong winds up to 69 mph	Oʻahu, Kauaʻi
December 5-6, 1968	Storm	Maui
January 30, 1969	Strong winds	Oʻahu
February 20-21, 1969	Strong winds	Oʻahu, Maui
January 13-15, 1970	High winds, 96mph, gusts to 117mph	Oʻahu
December 25-29, 1970	Winter storm, 50-60 mph	Oʻahu, Maui
January 5, 1971	Strong winds	Oʻahu, Maui, Kauaʻi
January 21, 1971	Tornado at Whitmore Village	Oʻahu
February 4, 1972	Gusts to 69 mph	Oʻahu
August 15, 1973	Dust devil	Oʻahu
November 23-27, 1975	Storm	Maui
February 5-7, 1976	Strong winds	Oʻahu, Maui
November 6-7, 1976	Strong winds	Oʻahu
October 22, 1978	70 mph winds	Oʻahu
January 11-19, 1979	High winds in excess of 50 mph	Maui
January 8-10, 1980	Storm	Oʻahu, Maui, Kauaʻi
February 11, 1981	Strong winds	Oʻahu
February 11, 1982	Winter storm, strong winds	Oʻahu, Kauaʻi
February 13, 1982	Tornado	Oʻahu
December 18-19, 1982	Gusty trade winds up to 60 mph	Oʻahu, Maui, Kauaʻi
December 23-24, 1982	High winds	Oʻahu
September 23, 1983	Tornado at Pearl City	Oʻahu
September 29, 1983	High winds	Oʻahu
December 24-25, 1983	Winter storm, gusts > 50 mph	Oʻahu, Maui, Kauaʻi
March 1-3, 1984	Gusts 30-40 mph	Oʻahu, Kauaʻi
December 24-25, 1984	Kona Storm	Oʻahu, Maui, Kauaʻi
January 29-30, 1985	High winds, Nānākuli & Waiʻanae	Oʻahu
March 1-11, 1985	Gale force trade winds	Oʻahu, Maui
November 30, 1985	Strong northerly winds	Oʻahu
April 8, 1986	Strong winds at Nānākuli	Oʻahu
May 13, 1986	Small tornado at Waipahu	Oʻahu

Table 4.1 Historical High Wind Events[9]

Date	Description	Island
March 28, 1986	Tornado at Barbers Point	Oʻahu
December 5, 1986	Gusts up to 50 mph	Oʻahu, Kauaʻi
January 19, 1987	High winds, 35 mph	Oʻahu
November 4-5, 1988	Storm with gusts of 40-50 mph.	Oʻahu, Maui
December 5-6, 1988	S winds of up to 50 mph	Oʻahu, Maui
December 17-18, 1988	Gusty winds	Maui
December 30-31, 1988	40-50 mph winds	Oʻahu, Maui
March 1-4, 1989	Storm, strong winds	Oʻahu, Maui
December 9-11, 1989	Gusty winds	Oʻahu, Maui, Kauaʻi
February 6-9, 1990	Gusts to 60 mph	Oʻahu
January 27, 1991	Strong winds	Maui
March 9, 1993	Frontal system, strong winds, minor damage	Oʻahu Maui
December 4-6, 1993	Strong trade winds, 60-80 mph	Oʻahu, Maui, Kauaʻi
March 12-16, 1994	Strong gusty trade winds, 40-50 mph	Oʻahu
April 14-19, 1995	Strong trade winds, 40-50 mph	Oʻahu
December 7-8, 1996	N winds, gusts to 60 mph	Oʻahu
December 23-25, 1996	Southwest winds of 40 mph	Maui
December 26-31, 1996	S and SW winds, gusts to 75 mph	Oʻahu, Kauaʻi
January 2-3, 1997	S winds, gusts to 60 mph	Oʻahu, Kauaʻi
January 27-29, 1997	SW winds, 60 mph	Oʻahu, Maui, Kauaʻi
February 25-27, 1997	High winds downed several trees and utility poles and blew off part of a roof from a house in the ʻĪao Valley on the island of Maui.	Maui
January 5-8, 1998	Westerly winds of 40 to 60 mph near the summit of Haleakalā on the island of Maui.	Maui
January 29, 1998	West to northwest winds of 50 to 60 mph near the summit of Haleakalā on the island of Maui.	Maui
April 3-4, 1998	West to northwest winds of 40 to 60 mph near the summit of Haleakalā on the island of Maui.	Maui
April 9-11, 1998	NE winds up to 55 mph, power outages	Oʻahu, Maui
April 13, 1998	West to northwest winds of 40 to 60 mph near the summit of Haleakalā on the island of Maui.	Maui
November 30, 1998	West to northwest winds of 50 to 60 mph near the summit of Haleakalā on the island of Maui.	Maui
January 15, 1999	A spotter from upcountry Maui reported strong winds which knocked down power lines. Average sustained winds from 8 a.m. to 6 p.m. at Haleakalā were 40 mph, while a peak wind of 74 mph was recorded at 1:00 p.m.	Maui
February 3-4, 1999	High winds toppled eucalyptus trees near Seabury Hall and along Kaupakalua Road. A large tree near Seabury Hall broke two power poles, leaving 125 customers in the Olinda area along Piʻiholo Road without electrical service. Another falling eucalyptus tree was blamed for snapping conductor wires along Kaupakalua Road that affected about 50 homes in that area and Kokomo. At 8:00pm at Haleakalā, the peak gust was 68 mph and the highest sustained wind speed was 48 mph.	Maui

Table 4.1 Historical High Wind Events[9]

Date	Description	Island
March 20-21, 1999	Wind gusts up to 55 mph, fallen trees, power outages, minor roof damage	Oʻahu, Maui
May 5, 1999	Dust devil in Kunia	Oʻahu
July 26-27, 1999	Winds up to 50 mph, fallen trees, power outages, dust storms; winds with gusts over 70 mph in the Māʻalaea on the island of Maui.	Oʻahu, Maui
August 31, 1999	Winds with gusts between 35 and 55 mph in the central valley of the island of Maui.	Maui
November 28-29, 1999	Strong winds 30-45 mph	Oʻahu, Maui
March 22-23, 2000	Winds of 30 to 35 mph with gusts up to 45 mph along the southern coastal section of the saddle area on the island of Maui, from Māʻalaea to Kīhei.	Maui
April 1-5, 2000	Trade winds of 20 to 35 mph across all islands. Gusts of up to 60 mph reported on the island of Maui. Winds partially blew off a roof at Lahaina Elementary School and overturned a delivery van along Honoapiʻilani Highway (State Highway 30) near Olowalu on the island of Maui. Also on the island of Maui, blowing dust caused the closure of Kīhei Road near the Maui Zoo.	Maui
November 17, 2000	Winds of 30 to 40 mph with gusts as high as 50 mph in the saddle, downslope sections, and in the Māʻalaea Bay area of the west side of the island of Maui.	Maui
January 14, 2001	Northeast winds of 35 to 40 mph with gusts up to 55 mph	All Islands
February 14-16, 2001	NE winds 35 to 40 mph, gusts to 55 mph, localized power outages	Oʻahu
February 26, 2001	Waterspout ashore at Ehukai beach	Oʻahu
April 12, 2001	30 mph east to northeast winds with gusts up to 43 mph in locales in the central valley and western parts of the island of Maui. Some power outages were attributed to the high winds.	Maui
August 31, 2001	Sustained winds 25 to 35 mph, gusts to 51 mph	All Islands
November 26-27, 2001	SW winds 40-45 mph, gusts to 50 mph, fallen trees, localized roof damage, power outages	Oʻahu
December 2-3, 2001	NE to E winds 30 to 40 mph, gusts to 50 mph., fallen trees, power outages, localized roof damage	All Islands
December 11-14, 2001	NE to E winds 30 to 40 mph, gusts to 55 mph., fallen trees, power outages	All Islands
January 17-20, 2002	E to E/NE winds 30 to 40 mph, gusts to 50 mph	All Islands
January 29-30, 2002	E to E/NE winds 30 to 40 mph, gusts to 45 mph	All Islands
February 26-27, 2002	East to east/northeast winds of 30 to 40 mph with gusts of up to 44 mph on the islands of Maui and Lānaʻi	Maui, Lanai
March 17-18, 2002	N to NE winds 30 to 40 mph, gusts to 50 mph	Oʻahu, Maui
April 1, 2002	West to Southwest winds estimated at 50 to 60 mph with gusts up to 65 mph near the summit of Haleakalā on the island of Maui.	Maui
January 4-5, 2003	SW to W winds, fallen trees, power outages, localized roof damage	Oʻahu, Maui
January 14-16, 2003	SW to W winds, gusts to 50 mph, fallen trees, power outages; southwest to west winds gusted to 70 mph on the high elevations of the island of Maui.	Oʻahu
January 14, 2003	Southwest to west winds gusted to 70 mph on the high elevations of the island of Maui.	Maui

Table 4.1 Historical High Wind Events[9]

Date	Description	Island
June 3, 2003	F0 tornado	O‘ahu
November 19, 2003	NE winds 30 to 40 mph, gusts to 65 mph, fallen trees, power outages, localized roof damage	O‘ahu
December 21, 2003	North to northeast winds of 35 to 45 mph with gusts of up to 50 mph swept across Haleakalā summit, island of Maui.	Maui
December 29, 2003	Southwest winds of 40 to 60 mph with one gust over 90 mph at and near Haleakalā summit, island of Maui.	Maui
January 12, 2004	Southwest to west winds with gusts up to 70 mph affected areas at and near Haleakalā summit, island of Maui.	Maui
January 14, 2004	High winds, fallen trees, power outages, considerable roof damage, school closures	O‘ahu Maui
January 22-23, 2004	Thunderstorm, gusts to 60 mph	O‘ahu
January 25, 2004	Funnel cloud, F0 tornado	O‘ahu
February 7, 2004	F0 tornado	O‘ahu
February 27-28, 2004	S thunderstorm winds, gusting to 58 mph, fallen trees, power outages, localized roof damage	O‘ahu, Maui
March 11, 2004	Strong winds with gusts over 63 mph at Haleakalā summit, island of Maui.	Maui
November 14-16, 2004	Winds gusting to 46 mph, power outages	O‘ahu
December 2, 2004	Winds with gusts up to 70 mph at Haleakalā summit, island of Maui.	Maui
December 6, 2004	East to Southeast winds gusted to 60 mph at Haleakalā summit, island of Maui.	Maui
January 8-10, 2005	Gusty thunderstorms, fallen trees and fences, power outages	O‘ahu, Maui, Kaua‘i
February 11-12, 2005	20-25 mph, 50 mph gusts, fallen trees, power outages	O‘ahu
March 14-15, 2005	Gusty winds, fallen trees, power outages, property damage	O‘ahu, Maui
December 4, 2005	F0 tornado, minor damage to one house	O‘ahu
December 18, 2005	Gusty winds, power outages, localized roof damage, 1 fatality	O‘ahu, Maui
February 2, 2007	High winds, gusts to 70 mph.	O‘ahu
February 18, 2007	Trade Winds with gusts up to 57 mph at Haleakalā summit, island of Maui	Maui
December 4, 2007	High winds, gusts to 55 mph; high winds with gusts of up to 82 mph	O‘ahu, Maui, Molokai
December 13, 2008	Gusty thunderstorms, fallen trees, damages to roadways, homes and other structures, and agriculture; schools closure	O‘ahu, Maui, Kaua‘i
February 17-18, 2013	Trade winds with gusts up to over 50 mph causes damage to electrical transmission tower and utility poles	O‘ahu

Figure 4.2a Historic Occurrences of Strong Winds from all Storms up until 1997, Island of Kaua'i

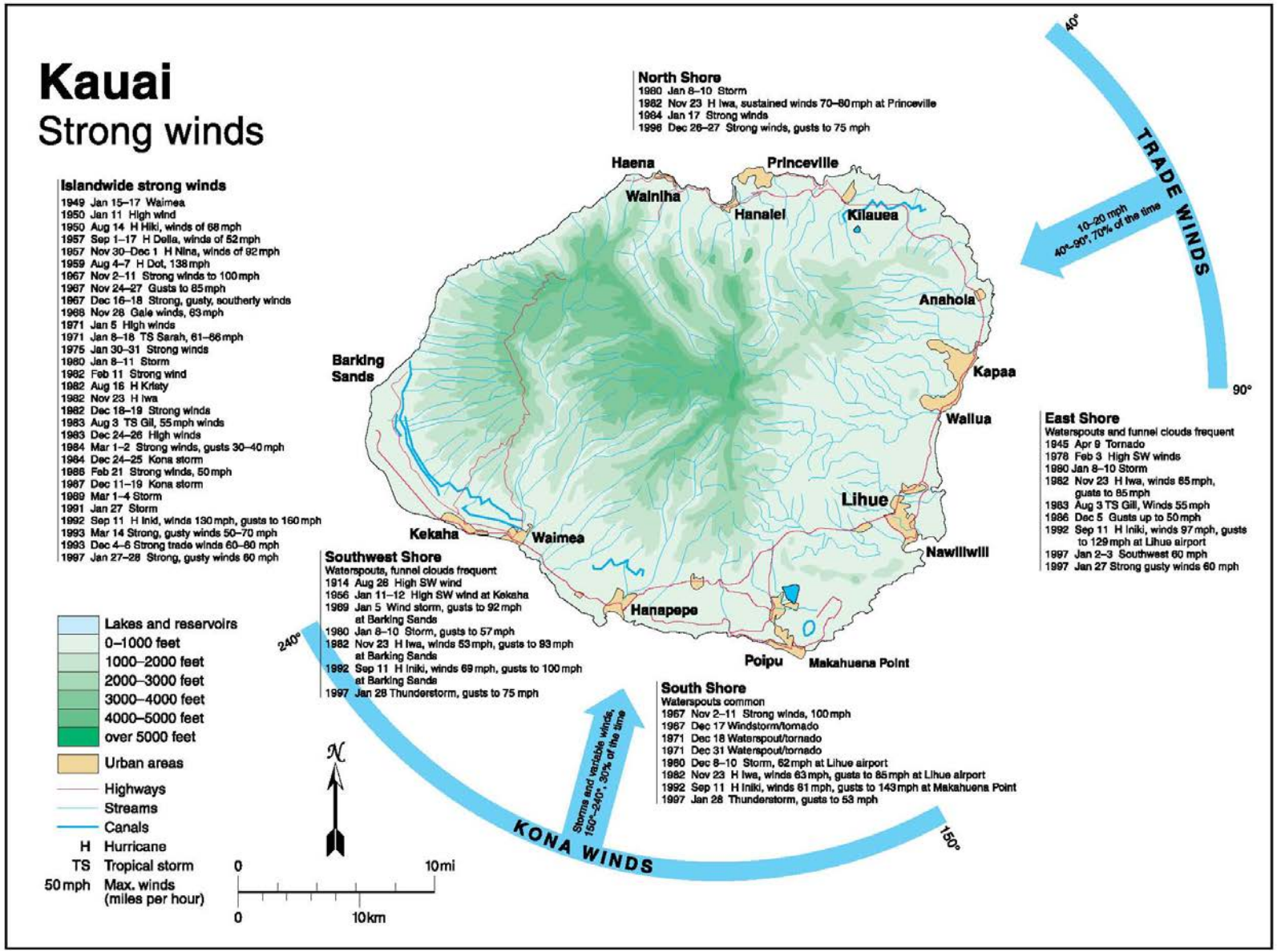


Figure 4.2b Historic Occurrences of Strong Winds from all Storms up until 1997, Island of O'ahu

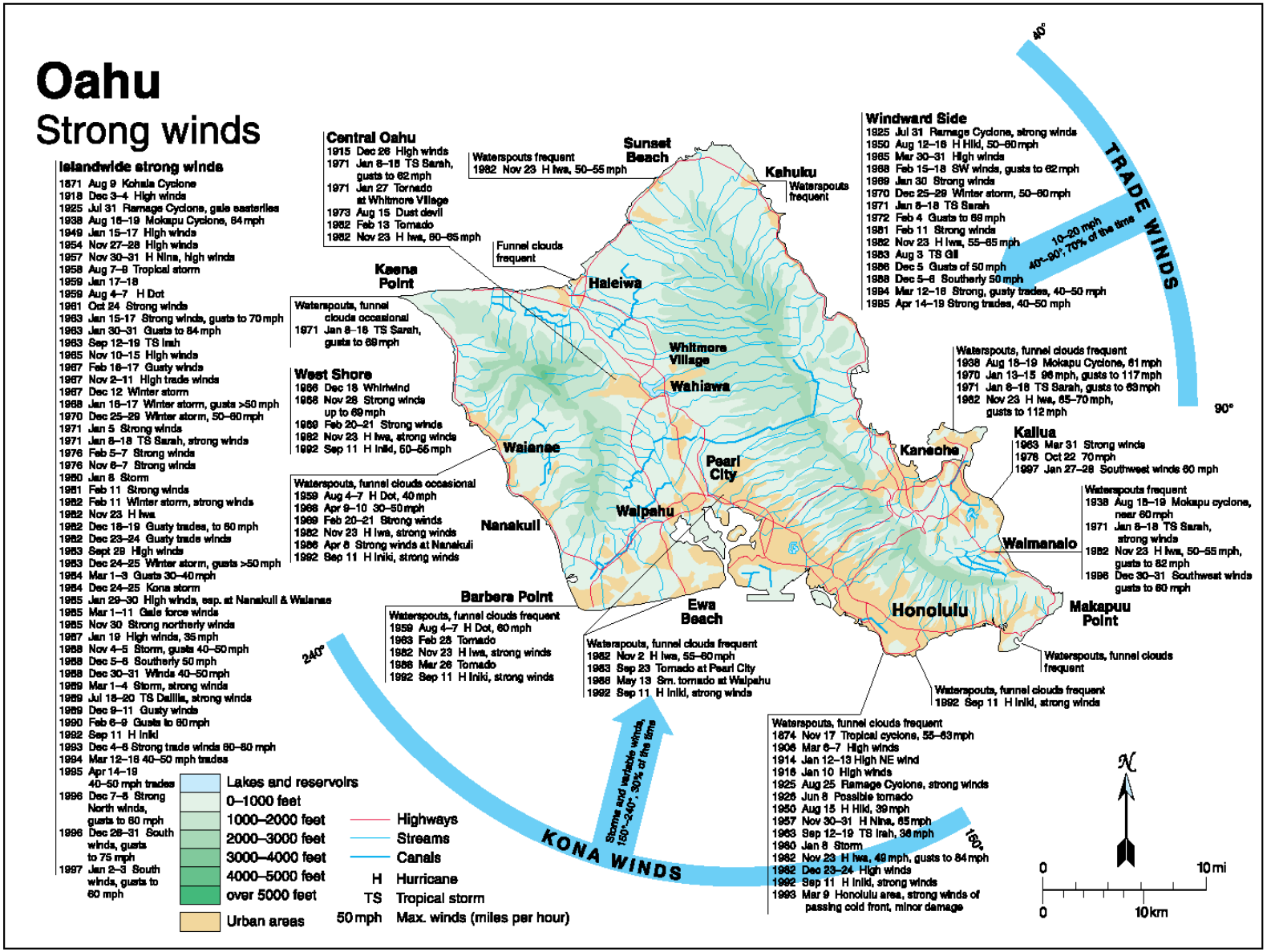


Figure 4.2c Historic Occurrences of Strong Winds from all Storms up until 1997, Maui

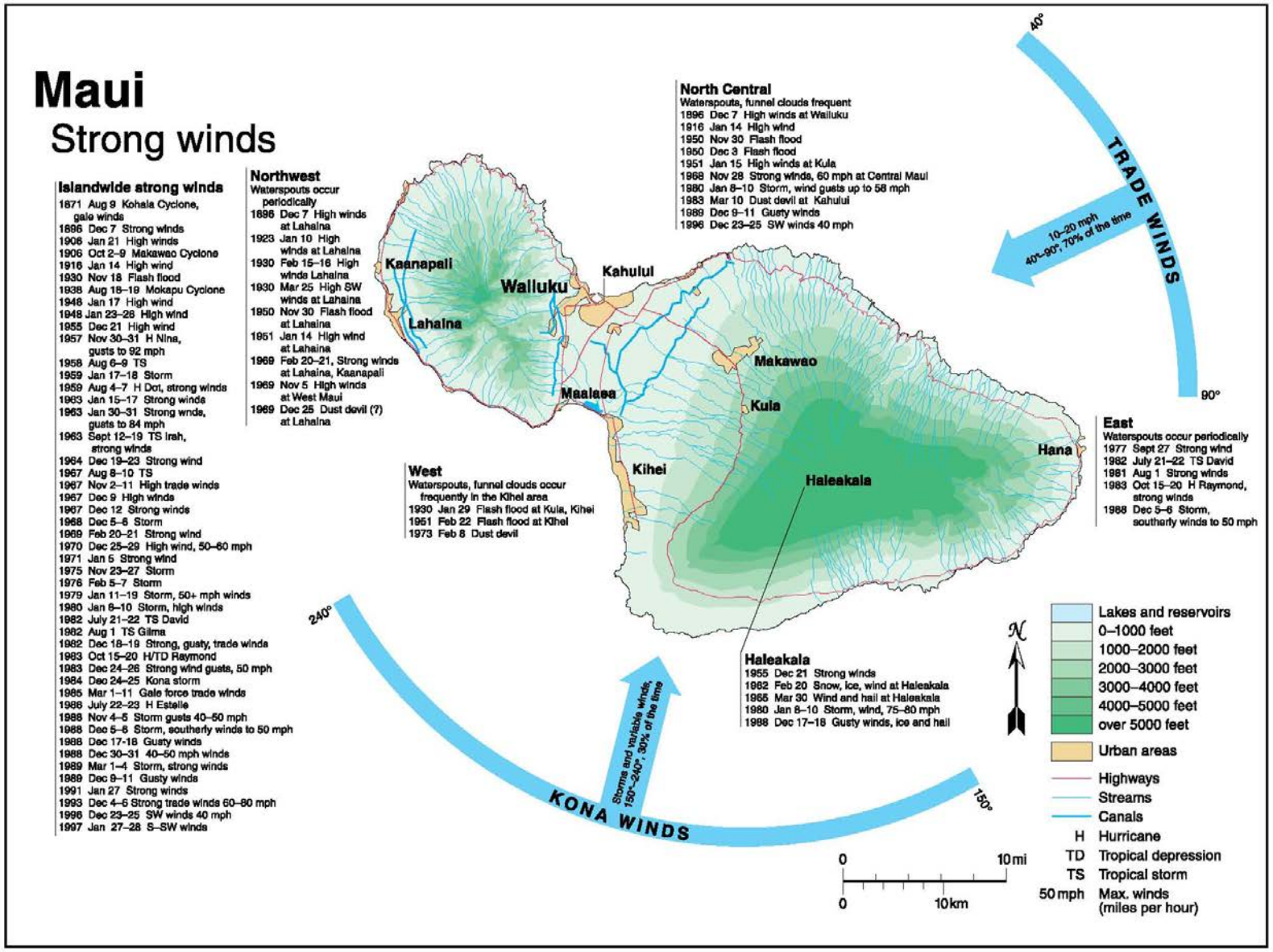


Figure 4.2d Historic Occurrences of Strong Winds from all Storms up until 1997, Islands of Moloka‘i and Lāna‘i

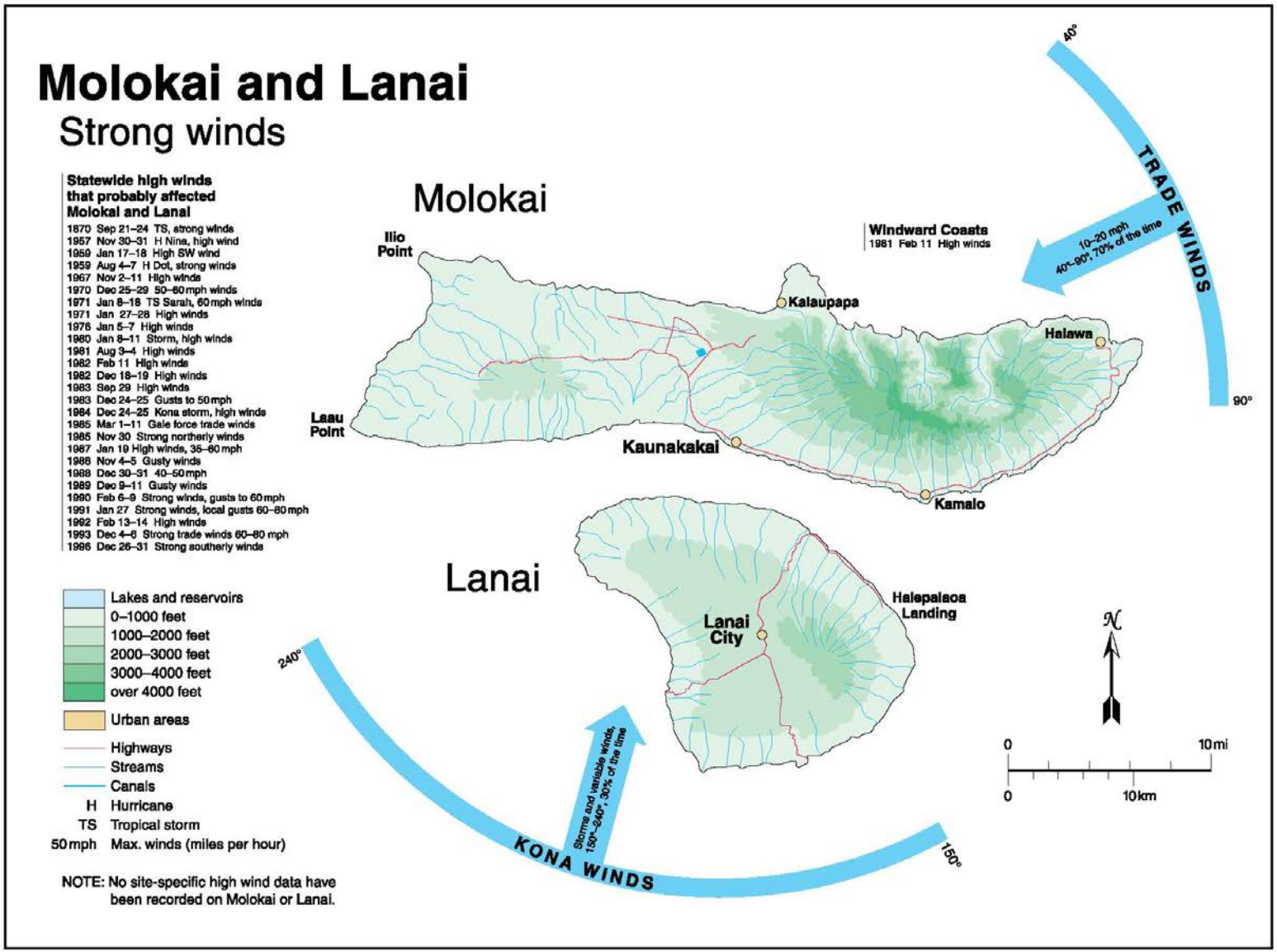
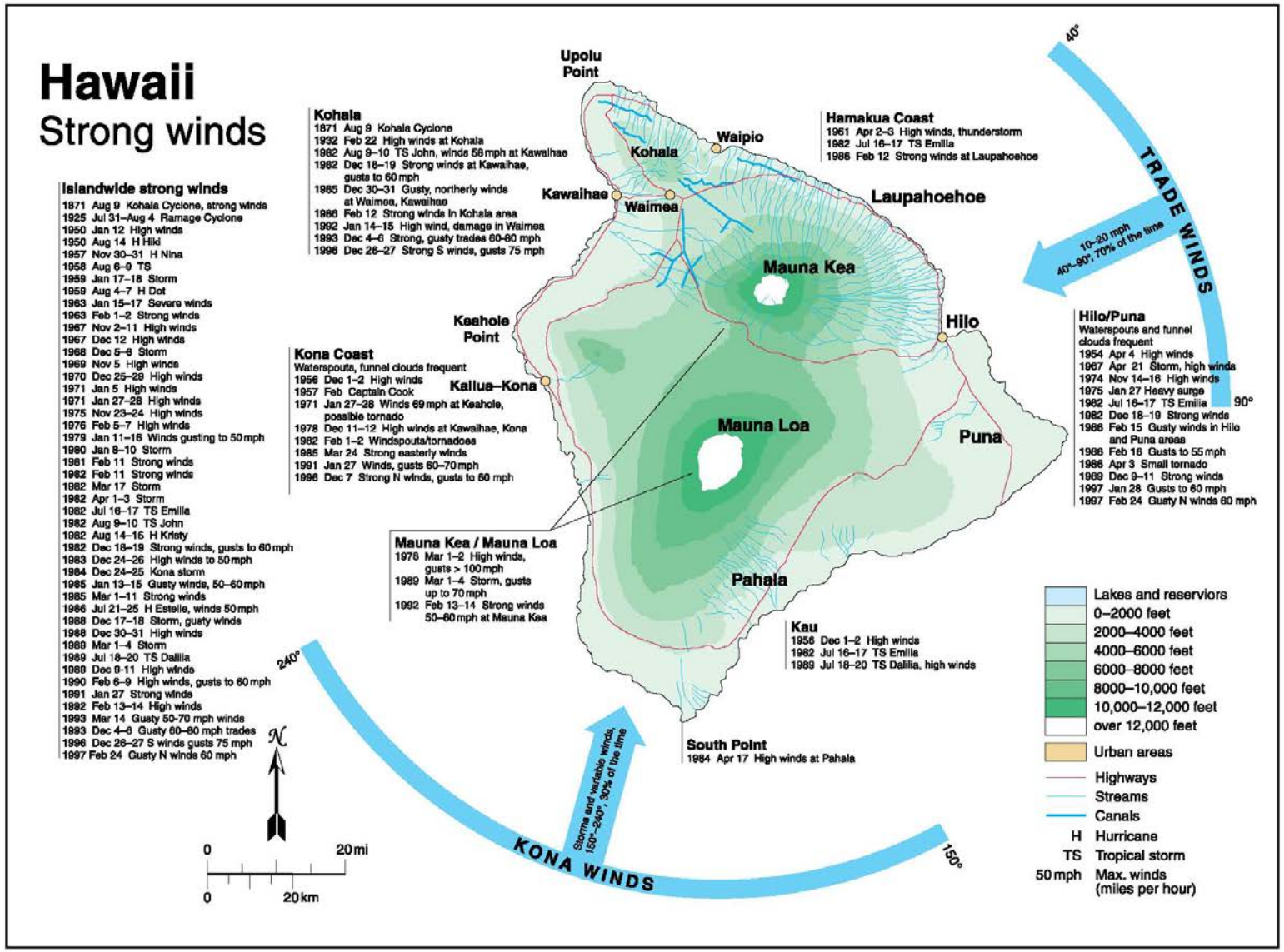


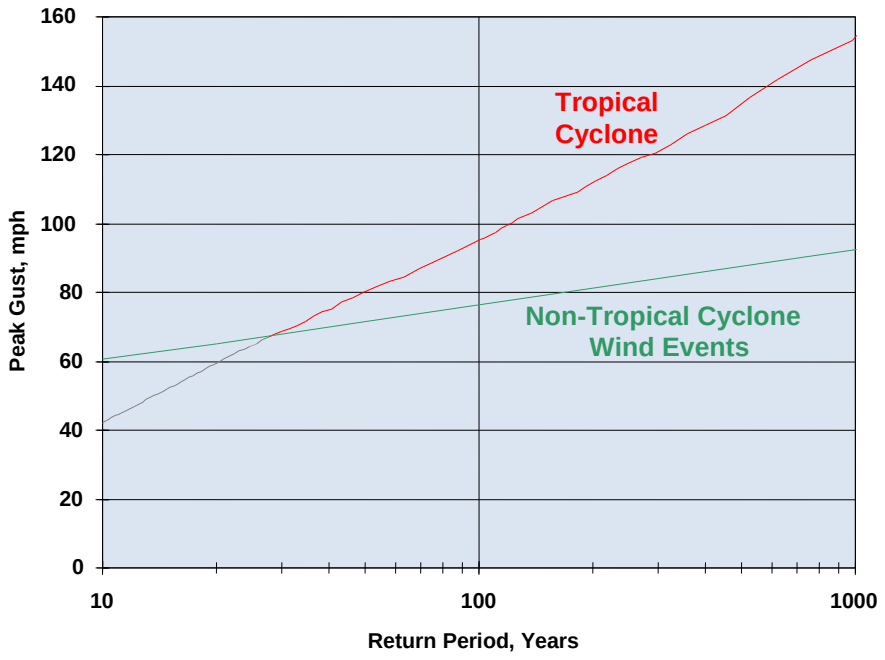
Figure 4.2e Historic Occurrences of Strong Winds from all Storms up until 1997, Island of Hawai'i



4.3 Probability of Occurrence

The distinction between the tropical cyclonic winds and Trade and Kona winds is illustrated by the hazard curves for the Hawaiian Islands shown in Figure 4.3. The figure shows that the relatively low wind speeds that occur more frequently are more likely to be from Trade and Kona winds while the relatively high but less frequent wind speeds are more likely to be caused by tropical cyclones. The figure shows that winds of 68 mph or less, which can still be very damaging, are more likely to occur due to non-cyclonic winds. Greater 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 4.3 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 is more likely to be caused by tropical cyclones in the form of hurricanes. However, damage associated with storms with lower windspeeds, such as: minor structural damage for structures deficient compared to current building standards; non-structural water damage due to windblown rain; flooding associated with wind storms, or; damage to power distribution systems deficient compared to current building standards, is more likely to be caused by Trade or Kona wind storms.

4.4 Risk Assessment

4.4.1 Topographic Effects on Windspeed

Historically, the magnitude of wind speed-up caused by topography in Hawai‘i has not been well understood, and it was not previously considered in any code currently used in Hawai‘i. The International Building Code (IBC) does have a topographic factor, but its formulation is not applicable to the complex topography that exists in Hawai‘i and would give misleading results.

Wind speed-ups have recently been empirically determined again by two investigators, but both utilizing the data from the NASA project by Chock et al in 2002. The Chock empirical speed-up functions have better fit to the data, and the contour maps of speed-up are generated over a varied-interval grid to be commensurate with the intervals of tested data points. The project developed empirical predictive models for peak gust, mean speed, and peak/mean speed ratio based on the complex interaction of site location within landforms and nonlinear transformations of terrain parameters. The methodology used multiple terrain analysis techniques performed on a 30M DEM raster grid, incorporating a large area of the surface morphology both upwind and downwind of each site. By doing so, greater predictive skill was achieved.

Maps produced by the Hawai‘i Hurricane Relief Fund (HHRF) in 2002 did not have as good a fit to the data, and uses a regular grid interval much finer than that used in data collection, which would be inconsistent. Therefore, the maps produced by Chock for Hawai‘i were preferred and are presently used in the Hawai‘i State Building Code and all county building codes. As a result, buildings of all types constructed under this code 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 topographic speed-up methodology does not include Fujita microbursts, mini-swirls. It also does not include possible “cadiabatic” effects associated with an unstable atmospheric stratification (although it does model special cases of downslope topographic wind accelerations).

Topographical factor maps are provided on Figures 4.4a through 4.4f. This work was awarded the Outstanding Civil Engineering Achievement of 2010 by the Hawai‘i Chapter of the American Society of Civil Engineers.

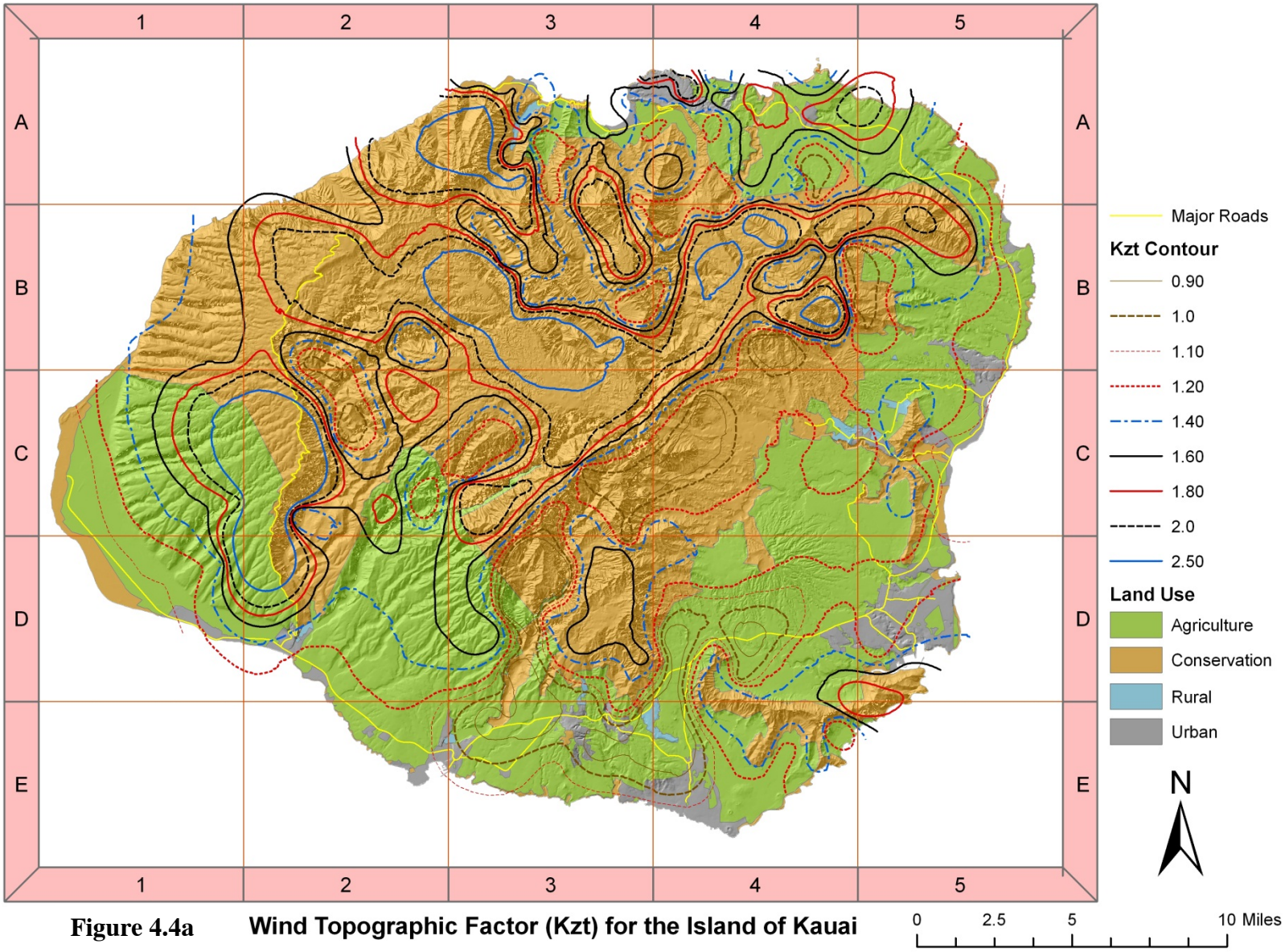


Figure 4.4a **Wind Topographic Factor (Kzt) for the Island of Kauai**

Note: Electronic map available from the State of Hawaii, Department of Accounting and General Services, under State Building Code Council.

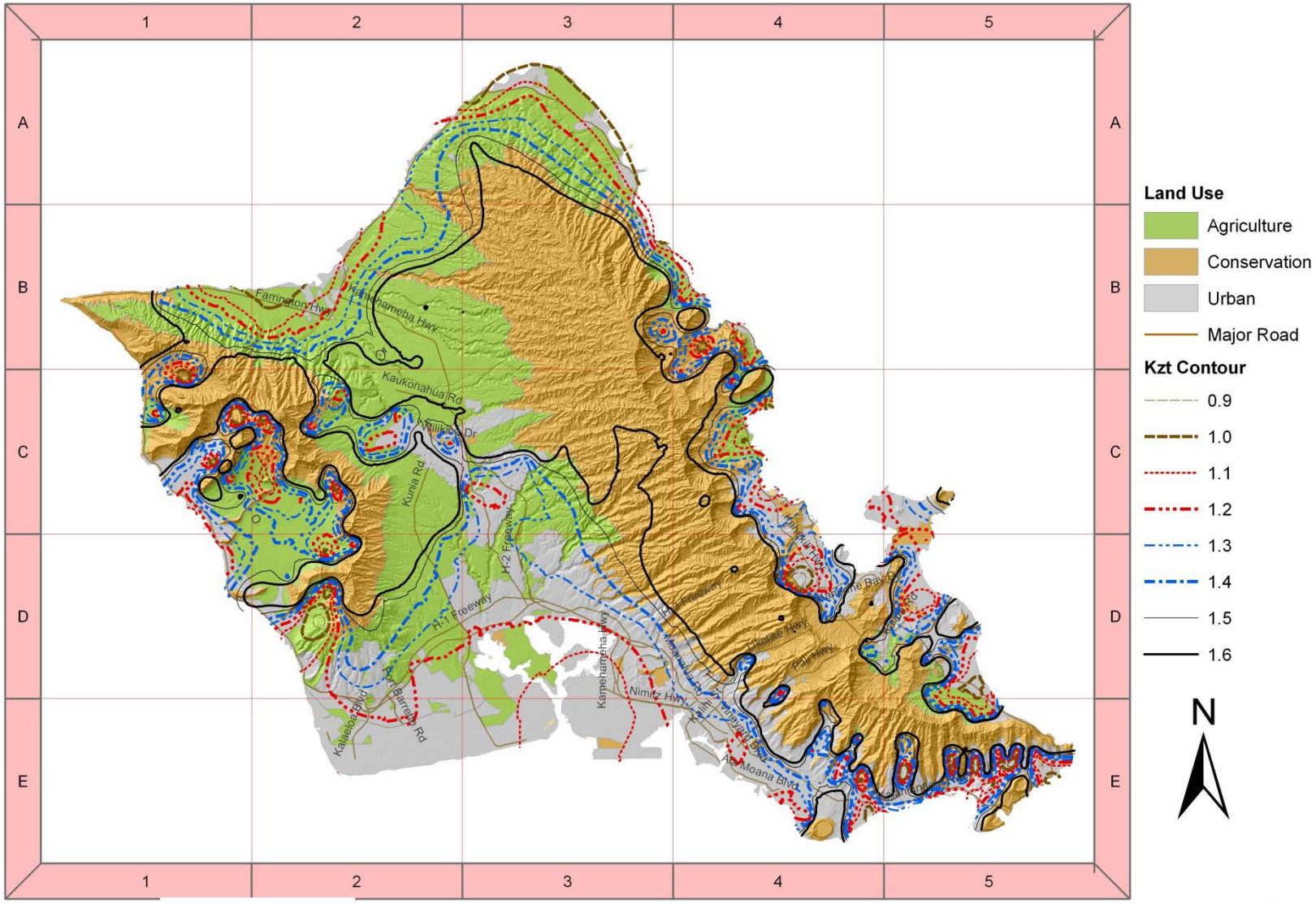


Figure 4.4b **Kzt Contour for the Island of Oahu**

Note: Electronic map available from the State of Hawaii, Department of Accounting and General Services, under State Building Code Council.

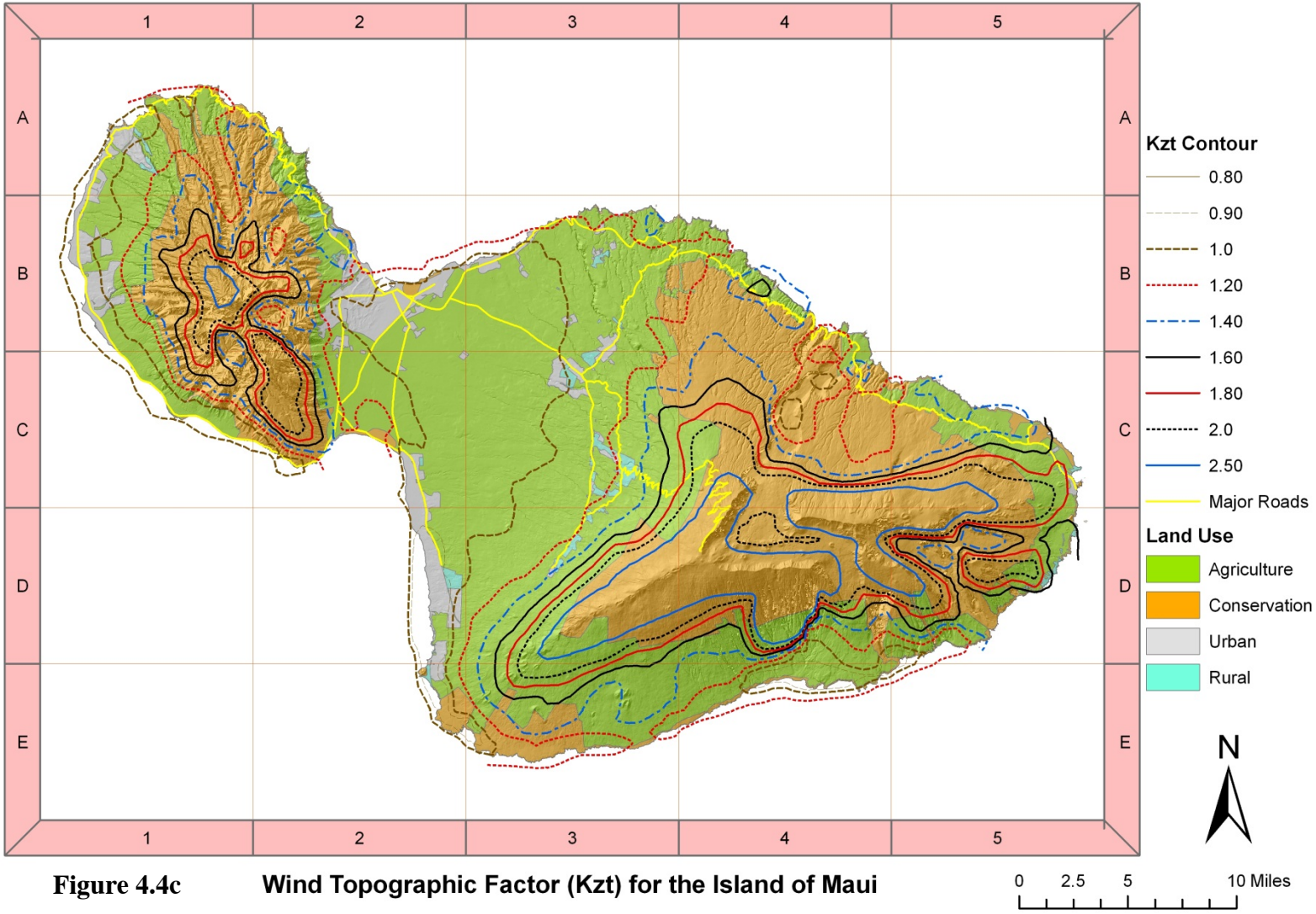
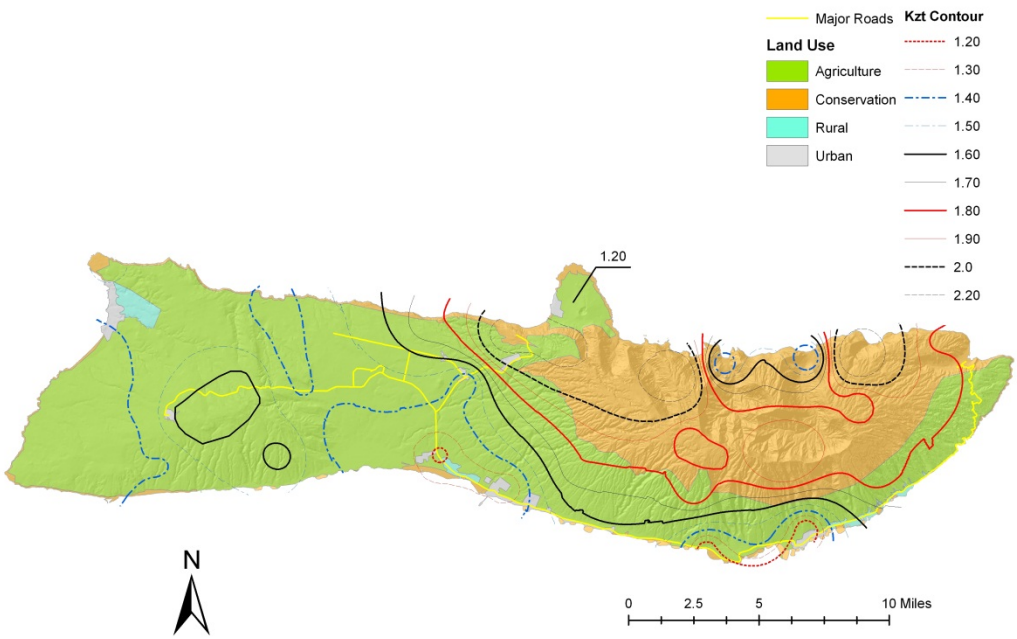


Figure 4.4c **Wind Topographic Factor (Kzt) for the Island of Maui**

Note: Electronic map available from the State of Hawaii, Department of Accounting and General Services, under State Building Code Council.

Figure 4.4d Wind Topographic Factor (Kzt) for the Island of Molokai



Note: Electronic map available from the State of Hawaii, Department of Accounting and General Services, under State Building Code Council.

Figure 4.4e Wind Topographic Factor (Kzt) for the Island of Lanai

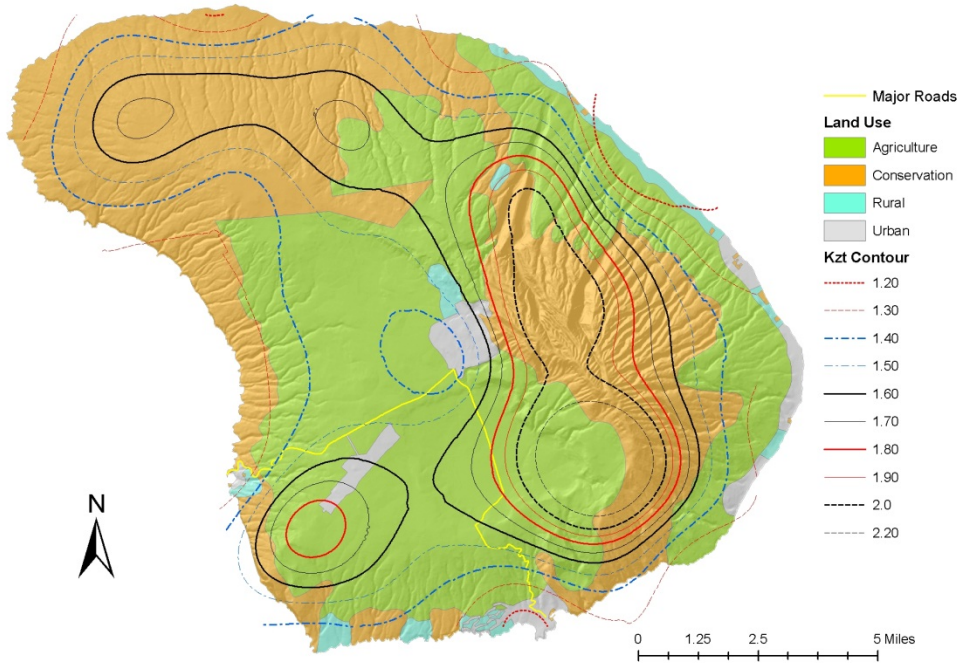
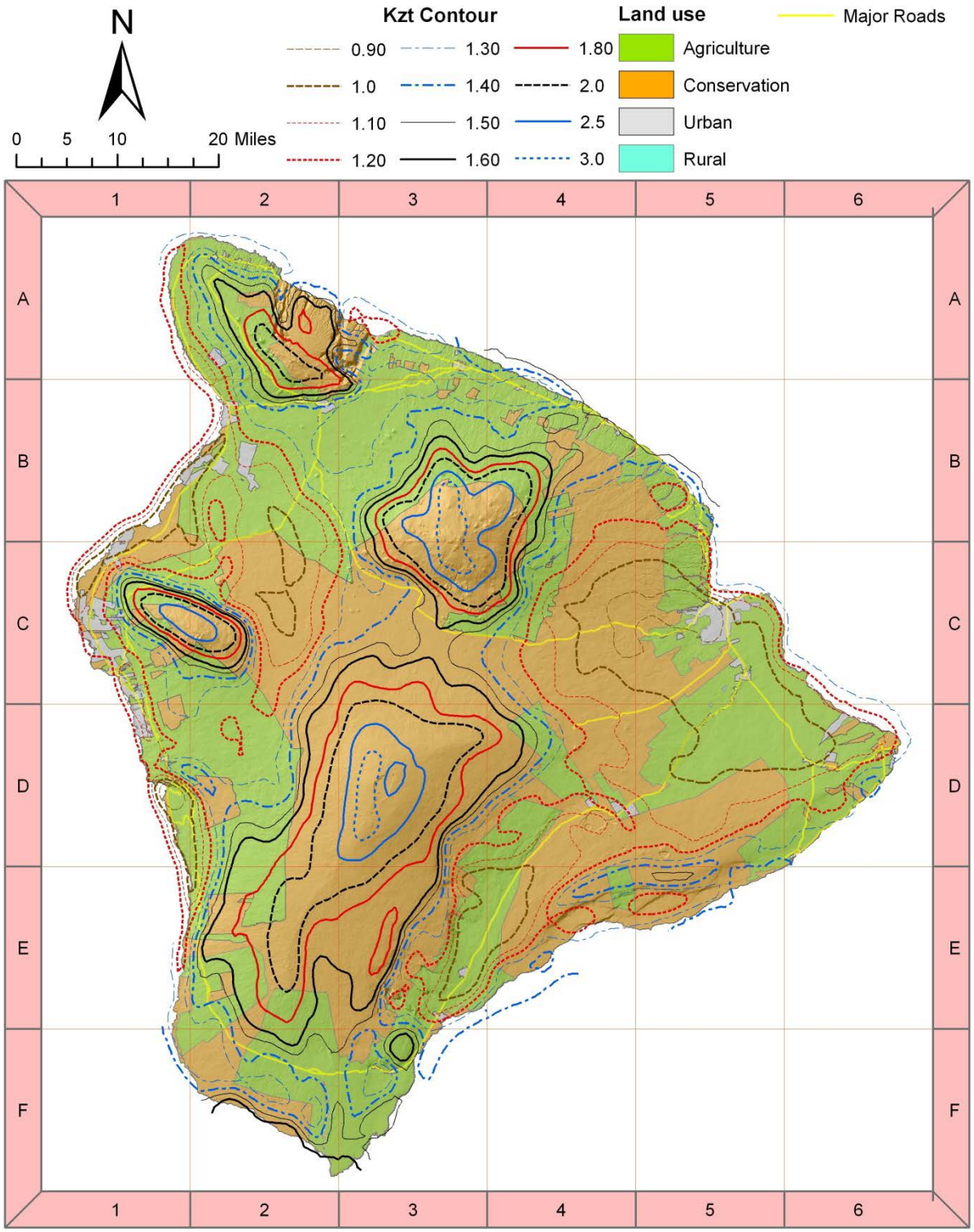


Figure 4.4f Wind Topographic Factor (Kzt) for the Island of Hawaii



Note: Electronic map available from the State of Hawaii, Department of Accounting and General Services, under State Building Code Council.

4.4.2 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 State of Hawai‘i Public Utilities Commission (PUC) has recently adopted the 2002 National Electrical Safety Code which improves the design standards for electrical transmission and distribution systems.

4.5 Mitigation Strategies

4.5.1 Previous and Current Efforts

Hawai‘i design wind pressures have changed over the years in the building code (see Table 4.2) The Uniform Building Code (UBC) design windspeed was based on an analysis of Honolulu weather station data by H.C.S. Thom in 1968 *without* consideration of hurricane history. The UBC wind loadings have historically lagged the ASCE 7 standard with respect to hurricane hazard because almost all the UBC constituent states were not in hurricane regions (except for Hawai‘i, which was only recently recognized after Hurricanes Iwa and Iniki). The critical benchmark year identifying structures previously designed to an inadequate wind pressure would be 1985, the date of Hawai‘i’s adoption of the 1982 UBC edition.

Table 4.2 Design Wind Pressures per Code Vintage Years[10]

Building Code Years	Typical Design Wind Pressure at 10 meters height
IBC 2003	26 psf
UBC 1991 to 1997	30 psf
UBC 1982 to 1988	26.5 psf
UBC 1958 to 1979	15 psf

4.5.2 Future Hazard Mitigation Projects

Refer to the Chapter 5 – Tropical Cyclones 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; development of certified assemblies for residential safe rooms; provision of incentives for homeowners to perform retrofits; assessment of wind hazards using an more accurate building inventory database; screening and certification of private sector shelters, and; all hazards public shelter evaluations.

[10] Table is based on component and cladding wall pressures for an enclosed building near the coastline but not near a corner of a window.

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

5. Tropical Cyclones

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CHAPTER 5
Tropical Cyclones

Reasons for Updates / Revisions in this 2013 Plan
• Tropical cyclone winds present a distinctly different level of wind hazard to Hawai‘i compared to weather systems. The scope of this chapter has expanded to include all tropical cyclones (tropical depressions, tropical storms and hurricanes) as these are all contributors to the wind hazard curve (based on windspeed). Cyclonic storm activity in the Central Pacific region near Hawai‘i is described. • The chapter provides more background information and images. The different effects of tropical storms winds, storm surge, environmental are identified. • 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 that could function as shelters; established a policy for strengthening of critical public facility enclosure integrity. • Developed Hawai‘i certifications for residential safe room assemblies. • The recently completed coastal Flood Insurance Study based on tropical cyclones is summarized. • HAZUS MH now includes a hurricane loss estimation module. The hazard assessment using average annualized losses has been updated using HAZUS MH. • Topographic wind effects have been included to integrate with the output of the Hurrevac model, to allow identification of the topographically-amplified wind speeds for any individually defined storm scenario for planning and emergency response purposes within Hurrevac/MMS. Estimated peak gust wind speeds are calculated at each “zone” at representative sites. • Hurricane hazard mitigation projects have been revised.

Summary of Mitigation Projects for the State of Hawai‘i	
Project	Priority
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.	High
Emergency shelter evaluation: All-Hazard Assessment of Hurricane Shelters.	High
Retrofit public shelter buildings to increase capacity and refine actual evacuation demand and update policies to decrease sheltering deficit.	High
Incentives for homeowners and businesses to retrofit their structures.	Medium
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 O‘ahu using HAZUS MH.	Medium
Assimilate the USCOE 2009 Hurricane Evacuation Behavioral Study into evacuation and sheltering policies.	Medium
Develop a 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 Hawai‘i.	Medium

5.1 Tropical Cyclones Hazard Description

5.1.1 General

Hurricanes, tropical storms, and typhoons are collectively known as tropical cyclones. Tropical cyclone winds present a distinctly different hazard to Hawai‘i than winds from other storm systems (strong Trade winds or Kona winds) and are the most devastating natural hazard in Hawai‘i. Tropical cyclones typically form in the warm tropical waters to the south of Hawai‘i 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 eye.

The tropical depressions, tropical storms, and hurricanes that affect the Hawaiian Islands typically originate in the warm waters off the western coast of Mexico and Central America and move in a westerly fashion across the Pacific. Once these atmospheric systems reach approach Hawai‘i, their trajectory is affected by the prevailing northeasterly trade winds. Hawai‘i lies at a longitude near to that of the center of the subtropical high which drives the trade winds. Therefore, most tropical storms, tropical depressions, and hurricanes that approach Hawai‘i will naturally curve to the northwest unless the subtropical high extends usually far to the west. In the trades, winds turn to the south with height contributing to a southeasterly steering wind. In the upper troposphere, the winds over the islands are southwesterly and contribute to north turns as well.[1]

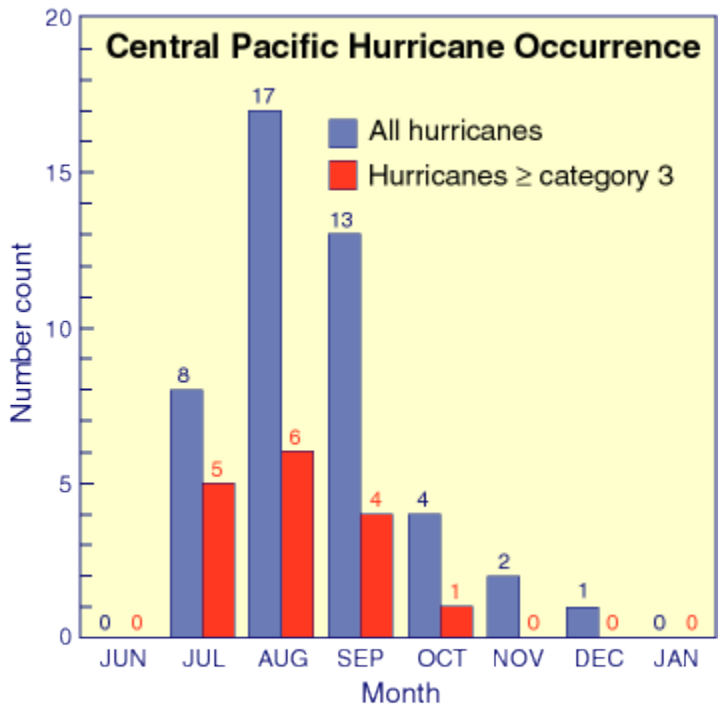
Due to the dependence of tropical storm activity on ocean water temperature, tropical storm activity in the Pacific is most prevalent over the summer months. Figure 5.1 shows the monthly frequency of hurricanes in the central pacific with most activity in July through September, reducing in frequency and strength in October through December. El Niño weather patterns also increase the frequency of hurricanes. The El Niño Southern Oscillation (ENSO) is characterized by warmer sea surface temperatures in the Central Pacific. Historically, El Niño conditions are associated with greater tropical cyclone activity. La Niña is characterized by atypically cooler sea surface temperatures in Central Pacific.

An average hurricane season in Hawai‘i has about four to five tropical cyclones. In the past five years, the Central Pacific has had below-average activity due to neutral ENSO, or the absence of El Niño conditions. Eight of the past ten years have been below average.

Presently, the Central Pacific Hurricane Center can receive weather satellite data every 6 to 15 minutes.

[1] Schroeder, Tom, *Hawai‘i Hurricanes: Their History, Causes, and the Future*, Hawai‘i Coastal Hazard Planning Project, Office of State Planning, December 1993

Figure 5.1 Central Pacific Hurricane Occurrences by Month



Because they spin counter-clockwise in the Northern Hemisphere, east-facing coastlines in Hawai‘i 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 mountain cliffs. As Hurricane Iwa passed west of the island of O‘ahu (City and County of Honolulu), the highest winds were observed at the northern slopes of the Ko‘olau range near in the locality of Kāne‘ohe. Even so, coastlines facing the passing storms are usually adversely impacted by both wind and storm surge damage, like the Wai‘anae Coast on the island of O‘ahu (City and County of Honolulu) was as Hurricane Iniki passed to the west, before making landfall on the island of Kaua‘i. (County of Kaua‘i). 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 influence storm impact to the coastal zone.

5.1.2 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). The Simpson/Saffir Hurricane Scale is presented in Table 5.1 along with damage potential to Island infrastructure. Tropical cyclones are classified as follows:

Hurricane - An intense tropical weather system with a well-defined circulation and maximum sustained winds of 74 mph (64 knots) or higher. In the western Pacific, hurricanes are called "typhoons." Similar storms in the Indian Ocean are called "cyclones."

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.

Table 5.1 Saffir/Simpson Hurricane Scale Ranges

nHurricane Category	Central Pressure		1-min. Sustained Winds	Fastest Mile Speed mph	Peak Gust (over land) mph	Approximate Storm Surge Height (ft.)	Damage Potential (with Tropical Pacific Modifications)
	Mm of mercury at 0 degrees C (32 degrees F)	Sea level pressure (inches)					
Tropical Depression	≥ 1008	≥ 29.77	≤ 38 mph (< 17 m/s)	≤ 29	≤ 41	# 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	99.3-1007	28.91-29.74	39-73 mph (17-32 m/s)	30-66	42-80	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	28.92-29.30	74-95 mph (33-43 m/s)	67-90	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 (44-49 m/s)	91-103	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	111-129 mph (30-38 m/s)	106-126	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	130-156 mph (59-69 m/s)	127-133	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	> 157 mph (> 69 m/s)	> 153	> 171	> 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.

5.1.3 Hurricane-Related Damage

Storm surge, rain, and wind cause most of the damage associated with hurricanes. Storm surge floods and erodes coastal areas, salinates land and groundwater, contaminates water supply, causes agricultural losses, damages structures and infrastructure, and results in loss of life. Rain damages structures, infrastructure, and agriculture, and results in loss of life. Hawai‘i’s topography channels rain onto mountain slopes, causing flash flooding and landslides. Strong winds can create tremendous amounts of debris (which impact utilities and transportation), cause agricultural losses, destroy lightly constructed buildings with inadequate foundational support, and result in loss of life.

5.1.4 High Wind Effects

During a tropical cyclone, high directional winds may damage or destroy homes, businesses, public buildings and infrastructure. Barometric pressure is very low during a tropical cyclone, 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 microbursts (sudden intense downdrafts) and two mini-swirls (a violent whirlwind, not tornado) had occurred on the island of Kaua‘i.[2].

Structural damage can be caused by the high pressures as well as impacts from debris carried by the high winds.

5.1.5 Hurricane Storm Surge and Scour Effects

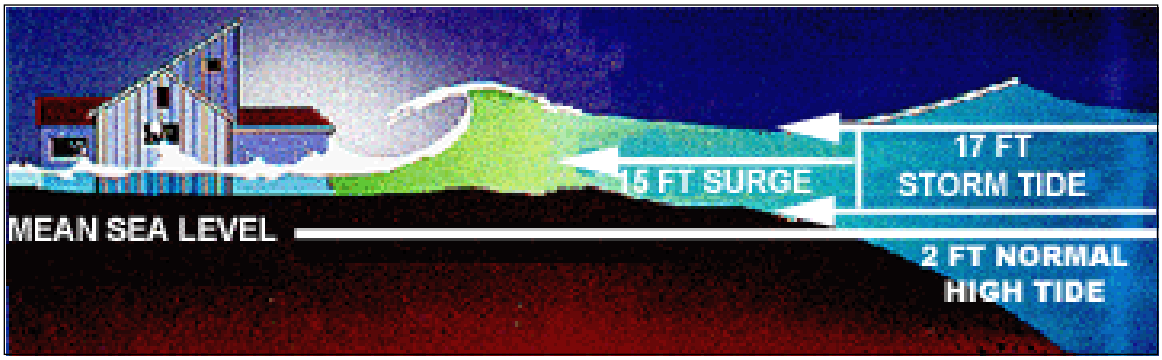
In additional to damage from high winds, more commonly, tropical storms generate large swell causing varying degrees of damage. This is the hallmark of hurricanes that pass close to but do not directly impact the islands. Impacts from these can be severe and lead to beach erosion, large waves and marine overwash despite the fact that the hurricane may have missed the island. Communities on the Wai‘anae coast on the island of O‘ahu (City and County of Honolulu) suffered severe damage from hurricanes Iwa and Iniki, yet neither of these storms actually hit the island of O‘ahu**.**

About 90% of the deaths that occur along the coastline and result from hurricanes are caused not by wind, but by storm surge. Storm surge flooding is water that is pushed up onto otherwise dry land by onshore winds. 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

[2] Fletcher, 2000

dangerous part of a hurricane as pounding waves create very hazardous flood currents. Stream flooding is much worse inland during the storm surge because of backwater effects. Worst-case scenarios occur when the storm surge occurs concurrently with high tide. For example, if a normal astronomical tide is 2 feet and a storm surge is 15 feet, then the resulting storm tide will be 17 feet in height (see Figure 5.2).

Figure 5.2 Storm Surge Illustration[3]



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, and
(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 Hawai‘i.

In studying the aftermath of Hurricane Iniki it was documented by researchers at the Army Corps of Engineers and the University of Hawai‘i[4] 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 5.3.

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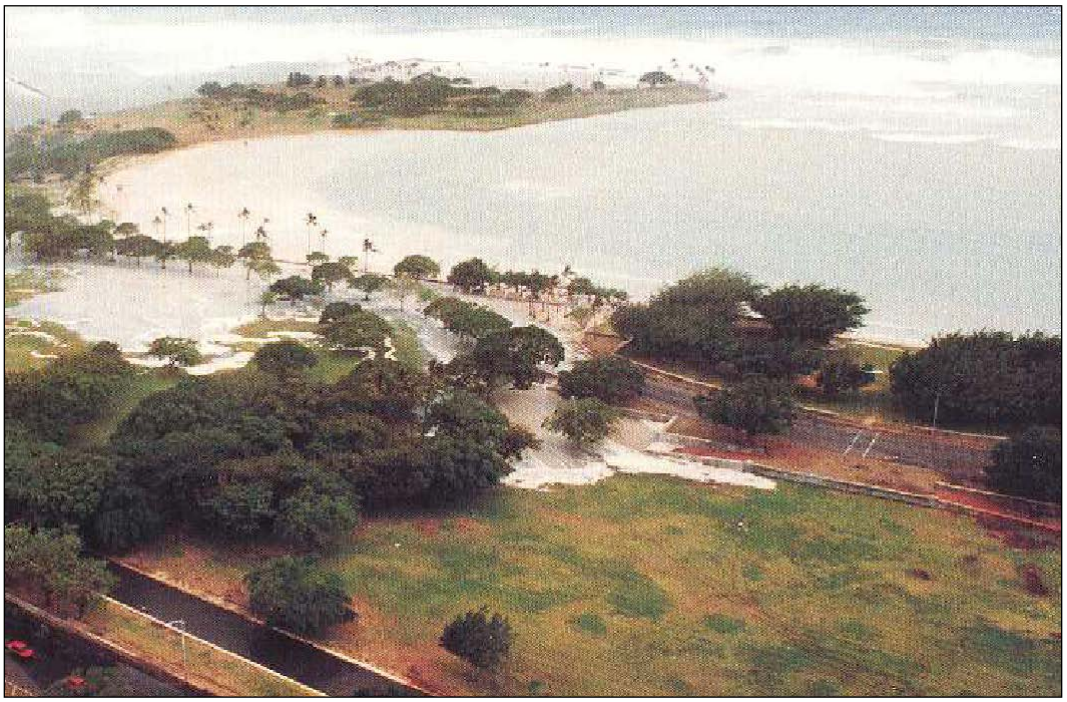
[3] National Oceanic and Atmospheric Administration (NOAA), National Hurricane Center

[4] Fletcher et al, 2004

Figure 5.3 Ala Moana Park (Island of O‘ahu) Flooding Caused by Hurricane Iniki in 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.

5.2 Significant Historical Events

5.2.1 History of Hurricanes in Hawai‘i

On the island of Kaua‘i, numerous high wind events have affected the entire island, and many were associated with passing storms. Hurricanes Dot (1959), ‘Iwa (1982), and Iniki (1992) were exceptionally damaging. Hurricane Dot packed sustained winds of 75 mph with gusts of 165 mph as it passed directly over the island of Kaua‘i. Winds and flooding led to $5.5-6 million (at the time) in agricultural losses and hundreds of houses and trees were damaged.

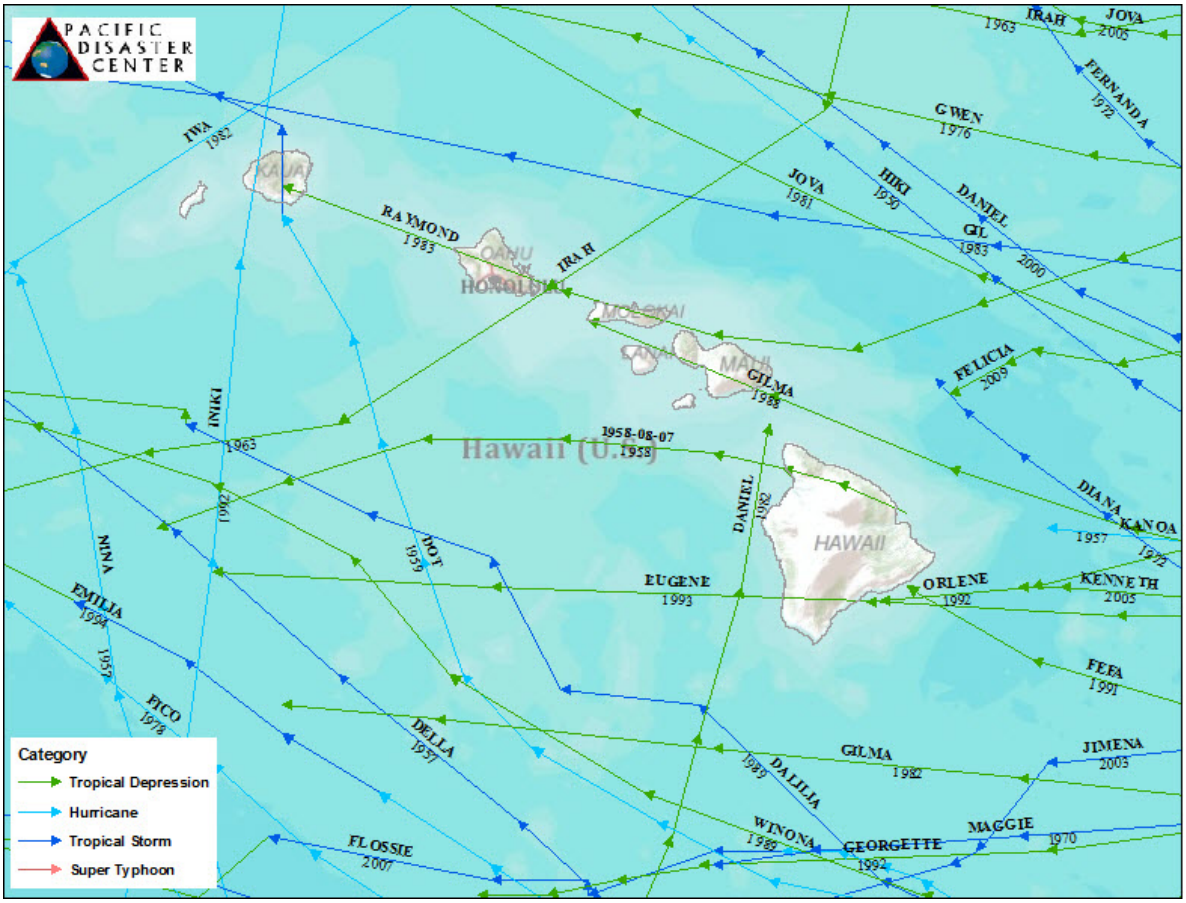
Hurricanes ‘Iwa and Iniki both produced high waves ranging 20-30 feet and winds over 125 mph. Although Hurricane ‘Iwa passed to the northwest of the island of Kaua‘i, the high surf it produced, combined with a 5-6 foot storm surge, flooded 600 feet inland in areas between Kekaha and Po‘ipu and caused $312 million in damage. Ironically, despite the massive flooding and wind damage to the Po‘ipu area, redevelopment following ‘Iwa occurred in precisely the

same location, only to be devastated 10 years later by Hurricane Iniki. Today, these same areas are once again densely developed.

On September 11, 1992, Hurricane Iniki, the strongest and most destructive hurricane to hit the Hawaiian Islands, made landfall just west of Port Allen on the island of Kaua‘i’s south shore. Iniki's winds were sustained at 130 mph and gusts topped 160 mph. Winds and waves destroyed 1,421 houses and caused minor to heavy damage to some 13,000 houses. Although Hurricanes ‘Iwa and Iniki did not strike the island of O‘ahu directly, communities on O‘ahu’s Wai‘anae Coast and Wahiawā-Mililani suffered severe damage.

Of course not all of the storms make landfall in Hawai‘i (Figure 5.4) and actual hurricane strikes in Hawai‘i are relatively rare in modern record.[5] Those hurricanes that head north to the east of the Islands cross colder water and tend to dissipate before reaching the Islands. Tropical Storm Felicia (2009) is a recent example of this degradation of intensity over cooler waters (Figure 5.5). More commonly, near misses that generate large swell and moderately high winds causing varying degrees of damage are the hallmark of hurricanes passing close to the islands.

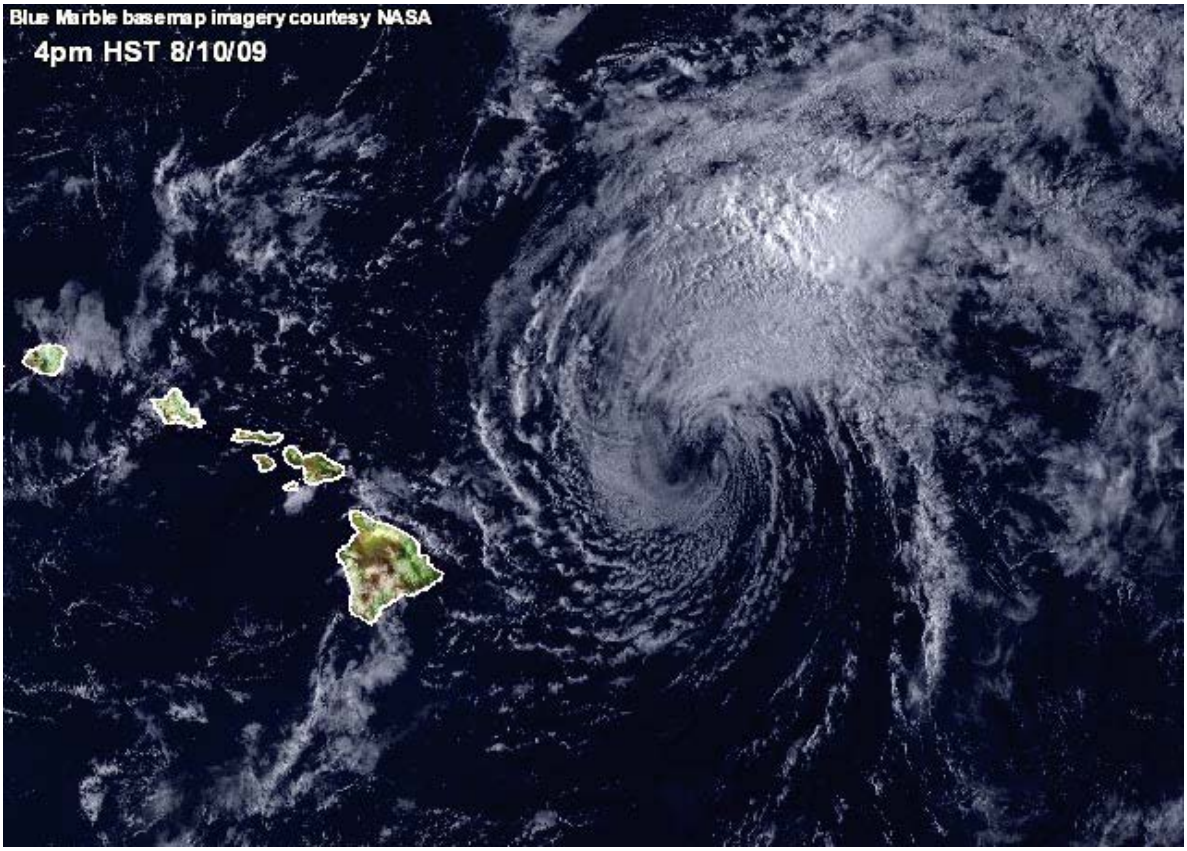
Figure 5.4 Historical Storm Tracks in the Vicinity of Hawai‘i[6]



[5] Schroeder 1993

[6] Pacific Disaster Center, www.pdc.org, 2010

Figure 5.5 Tropical Storm Felicia Approaching Hawai'i on August 10, 2009[7]



A summary of significant Hawaiian hurricanes over the last century along with the estimated damage from each hurricane is summarized in Table 5.2. Table 5.3 lists the hurricanes and tropical storms that are recorded to have had some effect on the islands since 1871.

Table 5.2 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	$2,800,000,000	4

[7] Weather Underground Website, Image Retrieved on October 5, 2009 from http://www.wunderground.com/blog/JeffMasters/comment.html?entrynum=1276&tstamp=&page=65

Table 5.3 Historical Tropical Cyclones Affecting the Hawaiian Islands[8]

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-feet 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

5.2.2 Hurricane Flood Insurance Study for the Hawaiian Islands

FEMA has incorporated hurricane inundation from model scenarios into a flood insurance study for all islands including Hawai‘i. The Hurricane Flood Insurance Study (FIS) for the Hawaiian Islands was conducted under FEMA contract number EMW-2003-CO-0046, RMTC/URS Task Order 013 (Cheung et al, 2002). 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: Kaua‘i (Kaua‘i County), O‘ahu (City and County of Honolulu), Molokai, Maui, Lanai (Maui County), and Hawai‘i (Hawai‘i County). Although the effective (i.e., past) FIRMs for each county have accounted for tsunami hazards, the hurricane flood hazard had not been previously separately evaluated in a comprehensive study throughout the islands.

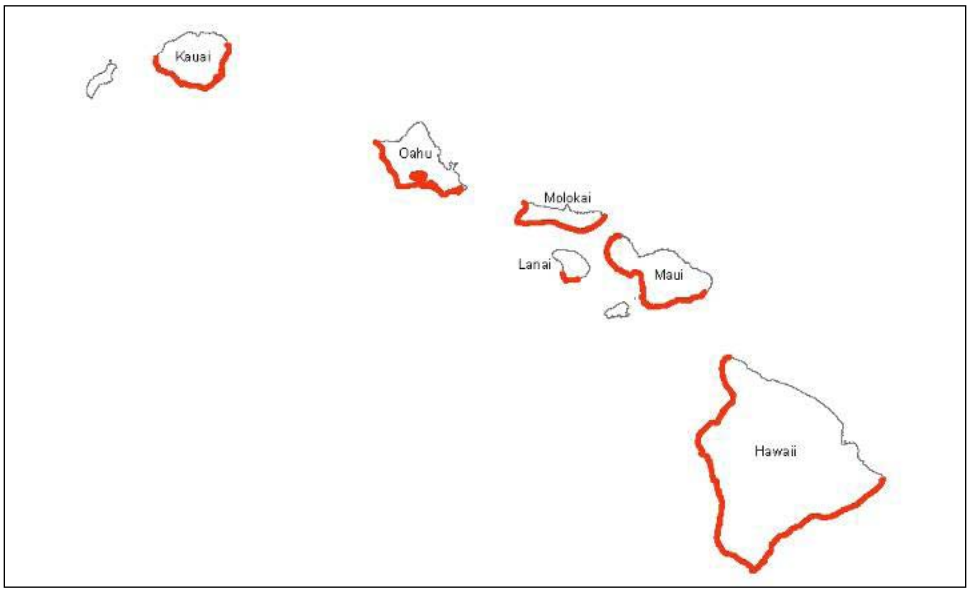
[8] Fletcher, 2002, National Oceanic and Atmospheric Administration (NOAA) National Weather Service Website, retrieved from www.prh.noaa.gov/hnl/pages/stormdata

In general, the hurricane coastal hazard analysis was limited to the southern coast of each island. This is due to several factors, including the predominance of tsunami hazards and limited low-lying areas susceptible to hurricane hazards along the north shore of the islands due to the seasonal high waves. The limits of the study are illustrated in Figure 5.6.

Transects were laid-out within the study limits and representative placement was evaluated during the field reconnaissance performed from July 24th through August 6th, 2007. The topographic base consisted of LiDAR collected under FEMA Task Orders 12 and 26. The LiDAR data were collected in the fall of 2006, post-processed to bare earth and quality controlled to meet FEMA mapping standards. These data were assimilated together with the best available bathymetric datasets, including USACE hydrographic LiDAR, into high-resolution seamless digital elevation models.

The hazard analysis considered the combination of storm surge and hurricane-induced wave hazards. This included independent analysis and/or modeling of storm surge, return frequency flood elevations, wave setup, overland wave hazards, and wave runup. The ADvanced CIRCulation model for coastal ocean hydrodynamics (ADCIRC) was selected to develop the stillwater elevations or storm surge for the study area. The Empirical Simulation Technique (EST), also developed by the USACE, was used to determine the stillwater frequency curves for the 10-, 2-, 1-, and 0.2-percent annual chance stillwater elevations. Deepwater wave conditions were determined using the Shore Protection Manual (SPM) prediction technique and limited fetch analyses were performed in harbor and sheltered areas. Wave setup was differentiated and evaluated for areas with and without fronting reefs. Areas of primary frontal dune were identified, delineated, and eroded. Overland wave propagation hazards were evaluated using the WHAFIS model. Wave obstructions were verified at representative transect locations by field reconnaissance. Wave run-up was evaluated using the RUNUP 2.0 and TAW methodologies, depending of the presence of reefs and local steepness of the bathymetry.

Figure 5.6 Extents of Hurricane Storm Surge Inundation Study



Wave hazard analyses were conducted at FIS transect locations, in addition to more tightly-spaced "mapping transects." These additional transects were facilitated by the application of an integrated GIS toolset that automates repetitive modeling tasks, and enables a more detailed analysis than typical coastal FIS studies. Wave setup values were assigned to these transects according to analysis at adjacent FIS transects. Otherwise, the mapping transects were treated with the same overland wave propagation and wave runup assessments as the FIS transects.

The coastal hazards determined from the above analyses were synthesized in the form of the standard 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 0.2% return frequency stillwater elevation was exceeded by cumulative flood elevation from the 1% stillwater elevation and wave setup, therefore, the boundary of the 0.2% annual chance event was not delineated. In steeper areas where mapping scale limits the gutter placement, the SFHAs are only identified by the position of the 100-yr flood boundary. Mapped Base Flood Elevations (BFEs) 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 BFEs.

The Flood Insurance Study 100 year (1% annual probability) boundaries were mapped. These maps show a number of locations where areas of coastal flooding exceeded the original FIRM flood zones, while other areas currently designated in flood zones where not within the 100 year boundary, keeping in mind that the 100 year boundary does not include riverine flooding.

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.

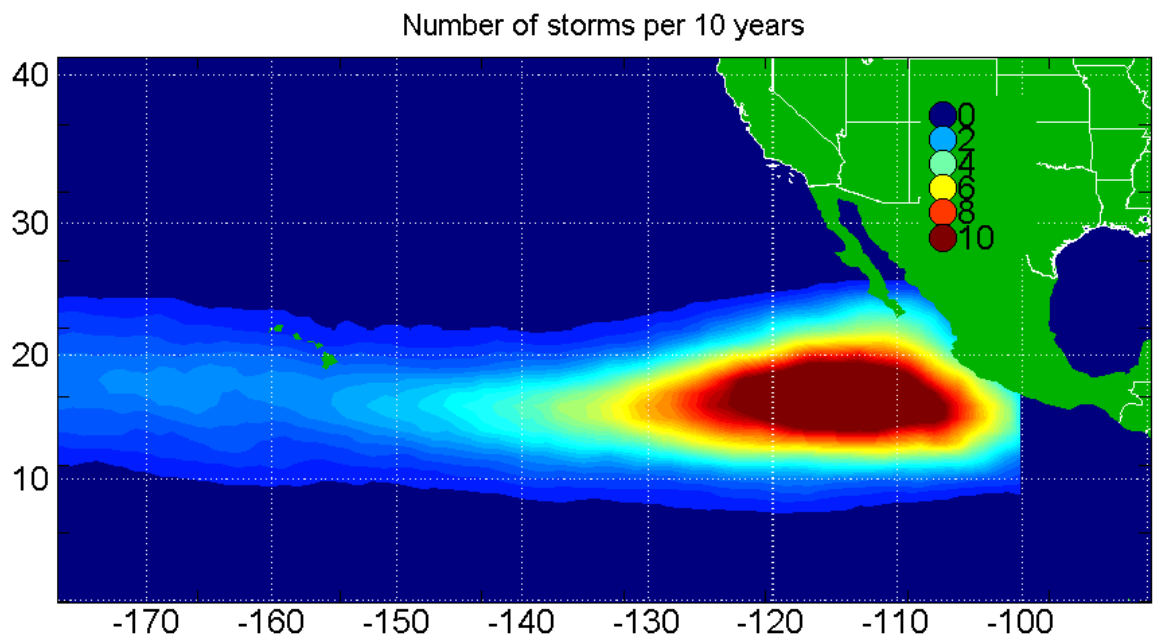
5.3 Probability of Occurrence

A myth in Hawaiʻi is that the islands that constitute the County of Maui (Molokaʻi, Lānaʻi, Kahoʻolawe, and Maui) and the City and County of Honolulu (Oʻahu) are less vulnerable to a direct hit by a hurricane than the islands of Kauaʻi and Hawaiʻi. This myth has developed as a result of the fact that, until 1950, tropical storms hitting the Hawaiian Islands were not classified as hurricanes. It was not until the advent of weather satellites that the nature of storms in this part of the world was understood to be hurricanes.

It is now known that since 1950, five hurricanes or tropical storms have caused serious damage in Hawaiʻi. Hurricane Nina in 1957 produced record winds in Honolulu on the island of Oʻahu. Hurricane Dot was responsible for extensive damage on the island of Kauaʻi in 1959. Hurricane ʻIwa resulted in widespread damage on the islands of Kauaʻi and Oʻahu in Hurricane Estelle

produced very high surf on the islands of Hawai‘i and Maui and floods on the island of O‘ahu in 1986. Hurricane Iniki produced widespread severe damage on the island of Kaua‘i and on the leeward coast of the island of O‘ahu in 1992. In addition to all these destructive hurricanes, seven other tropical storms or hurricanes could have caused serious damage to the islands since 1950. Among these hurricanes that missed the islands are Hurricane Fernanda in 1993 and Hurricane Emilia in 1994 (the strongest hurricane to pass through the Central North Pacific Ocean). Therefore, contrary to some belief, all of the Main Hawaiian Islands are at approximately the same risk of a direct hit by a hurricane. As will be discussed later, the uniform risk of all islands to tropical cyclones has been validated by simulations and frequency maps (see Figure 5.7).

Figure 5.7 Monte Carlo Stochastic Simulation Showing the number of times a hurricane passes within 75 nautical miles per 10 years in the Eastern and Central Pacific[9]



5.3.1 Development of Current Design Windspeed and Topographic Amplification Criteria for Hawai‘i

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. Earlier Monte Carlo programs have been developed, but they are not available in the public sector. A new

[9] Peterka, J. and Banks, D., Wind Speed Mapping of Hawai‘i and Pacific Insular States by Monte Carlo Simulation – Final Report, National Aeronautic and Space Agency (NASA) Center for Aerospace Information, Hanover, MD, 2002

model by Peterka incorporates an analysis of tropical cyclone track statistics in portions of the Eastern and Western Pacific basins, which has been used to generate hundreds of thousands of simulated tropical storms and cyclones in these regions. A well-evaluated wind field model is then used to predict the wind speeds at a given location for each storm. The Peterka analysis, utilizing a more robust dataset of historical storms and simulating hundreds of thousands of storms in the east and central Pacific, indicates differential hazard across the state, which appears more consistent with the physical process of storm migration from east to central Pacific. The Peterka analysis would indicate that O‘ahu, Maui, and Hawai‘i county hurricane hazard have been underestimated in past codes. The results may have a 10% uncertainty in the estimated windspeed values, so it is unlikely that a change of design windspeed for O‘ahu would be considered. The current analysis does not include any potential effects of long-term climatic change, but a simulation could be performed for postulated future conditions. The analysis implicitly includes the historical frequency of ENSO events. The directional probabilities of windspeed are approximately uniform. The hazard information deals only with long-term hazard levels; seasonal and climatic effects on hurricane hazard are typically addressed by NWS and CPHC advisories.

Peterka and Bank (2002) - *Windspeed Mapping of Hawai‘i and Pacific Insular States by Monte Carlo Simulation,* Vickery (2001) – *Hazard Mitigation Study for the Hawai‘i Hurricane Relief Fund*, and other recent studies by Chock have been used to estimate the average return period for different category hurricanes in the State of Hawai‘i and the island of O‘ahu, as given in Table 5.4.

Table 5.4 Hurricane Annual Odds of Occurrence by Saffir Simpson Category Incorporating NASA and HHRF Sponsored Research and ASCE7-10

Hurricane Category	Sustained Wind	3-sec. Peak Gust	NASA/HHRF	
			Anywhere in Hawai‘i	O‘ahu Only
1	74 to 94 mph	90 to 116 mph	1 in 25	1 in 80
2	94 to 110 mph	117 to 134 mph	1 in 50	1 in 320
3 or 4	111 to 156 mph	135 to 189 mph	1 in 75	1 in 400
Any Hurricane	Greater than 74 mph	Greater than 90 mph	1 in 15	1 in 55

The most recent windspeed hazard curve developed for Hawai‘i is given in ASCE 7-10 as shown in Figure 5.8. 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 5.4, 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 5.8 Windspeed Recurrence Intervals for Hawai‘i based on the 2010 Edition of ASCE-7

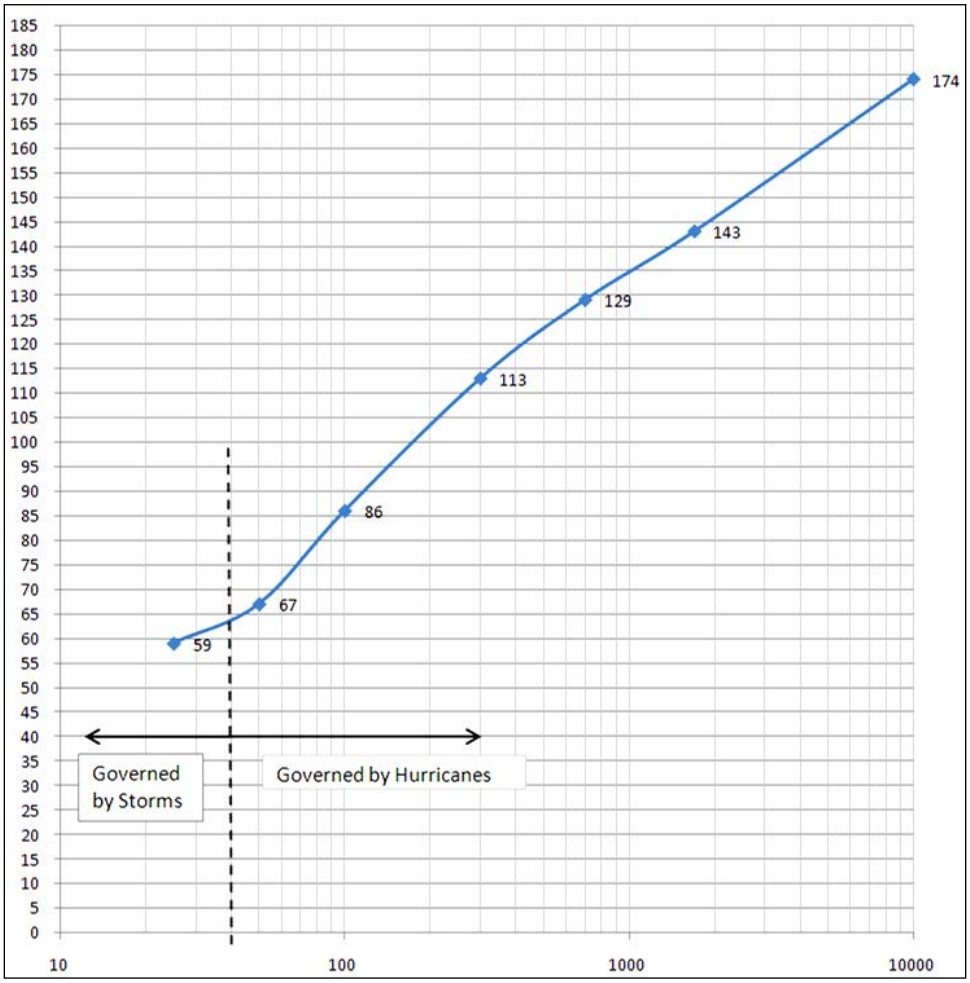


Table 5.5 Approximate Relationship between Saffir/Simpson Category and Wind Speed (adapted from ASCE7-10)

Saffir/Simpson Hurricane Category	Sustained Wind Speed Over Water[a]		Gust Wind Speed Over Water[b]		Gust Wind Speed Over Land[c]	
	mph	(m/s)	mph	(m/s)	mph	(m/s)
1	74–95	33–43	90-116	40.2-51.9	81-105	36.2-46.9
2	96–110	44–49	117-134	52.3-59.9	106-121	47.4-54.1
3	111–129	50–58	135-158	60.3-70.6	122-143	54.5-63.9
4	130–156	59–69	159-189	71.1-84.5	144-171	64.4-76.4
5	> 157	> 69	>190	>84.5	>171	>76.4

[a]1-minute average wind speed at 33 ft (10 m) above open water.
[b]3-second gust wind speed at 33 ft (10 m) above open water.
[c] 3-second gust wind speed at 33 ft (10 m) above open ground in Exposure Category C. This column has the same basis (averaging time, height, and exposure) as the basic wind speed.

5.3.2 Hurricane Hazard Analysis

5.3.2.1 Building Codes

The 2006 International Building Code was adopted by all Counties in the State of Hawai‘i through the recently developed State Building Code. 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. The complete State Building Code is included in Appendix 5A at the end of this chapter. The significant changes between the adoption of 2006 International Building Codes between the State and the counties are discussed below.

Two important improvements pertaining to resiliency to hurricane-force winds and windborne debris generated by tropical cyclones have resulted from the adoption of the State Building Code Appendix U, Hawai‘i Hurricane Sheltering Provisions for New Construction and Appendix W, Hawai‘i Wind Design Provisions for New Construction.

The wind maps of Appendix W have been developed to account for the windspeed amplification that occurs due to local topography of the Hawaiian Islands. Hawai‘i-specific maps have also been developed and adopted into building codes to account for the wind speed amplification that occurs due to local island topography. A more comprehensive description of the studies to determine the windspeed hazard curves and topographical amplification effects is provided in Chapter 4 –High Wind storms. Maps of effective windspeeds resulting from amplification of the basic wind speed for topographical and directionality effects and exposure category are shown in Figure 5.9 through Figure 5.13. Hawai‘i-specific wind design criteria resulting from this investigation were adopted by the State and all counties through amendments to the 2006 International Building Code in 2010-1012. As a result, buildings of all types constructed using current codes 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 major buildings are compliant with structural integrity for Category 3 storms. The wind maps produced in this study define a standard for a uniform level of protection for hurricane hazard throughout the County.

One significant aspect of the adoption of the 2006 IBC statewide is the consideration of windborne debris protection for any glazing lower than 60 feet above the ground level in buildings located in a windborne debris region. Hawai‘i is considered a windborne debris region and consequently the 2006 IBC requires impact protection of the glazing. 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 Hawai‘i. Therefore, the State Building Code amendments to the 2006 IBC (Appendix W) 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. Per Appendix U, Public hurricane shelters must also satisfy similar criteria in providing enhanced hurricane protection areas capable of withstanding

a 500 year hurricane. Essential government facilities must be designed for continued operation during such an event.

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 (2005) to verify the required level of protection. The University of Hawai‘i has a wind cannon capable of testing strengthened windows and other debris protective devices to the ASTM standard. This is intending to increase the local availability of products and ultimately reduce the cost of providing windborne debris protection to the glazed areas of a structure.

In the near future, the Chapter on Wind Loads in ASCE 7 will have a major update in its 2010 edition. The major impact of this update will be the reintroduction of Exposure Category D for coastal areas in hurricane prone regions. Coastal areas in hurricane prone regions were excluded from Exposure Category D starting in the 1998 edition of ASCE 7 in response to a 1998 study by P. Vickery and P. Skerlj that concluded that during hurricanes, the roughness of the ocean surface is more accurately represented by Exposure Category C. However, newer research suggests during hurricanes, the roughness of the ocean surface is actually dampened by foam, spray, and bubbles created by large waves. Thus, the Wind Committee of ASCE 7 has decided to reintroduce Exposure Category D for coastal zones in hurricane prone regions. For Hawai‘i, the return of Exposure Category D will result in an increase in the design wind pressures for buildings located at or near the coastline.

Another significant update in the upcoming 2010 edition of ASCE 7 is the recognition of the site specific wind maps for Hawai‘i produced by G. Chock and J. Peterka. Although the maps will not be included in the main body of the standard, they will be acknowledged in the commentary for the Wind Chapter. The Wind Chapter of the 2010 edition of ASCE 7 will, however, use windspeed maps at the strength level instead of at the service level. Because the windspeeds and hence the wind pressures will be at the strength level, the load factors for wind loads will also be updated. This change from service to strength level will require that the Hawai‘i site specific wind maps be also updated from the service to the strength level so that they are compatible with the provisions of the 2010 edition of ASCE 7. The Department of Business Economic Development and Tourism, Office of Planning, has sponsored a Hawai‘i Wind Design Guide to assist building officials and design professionals with this transition.

Figure 5.9 Effective Wind Speed for the Island of O‘ahu

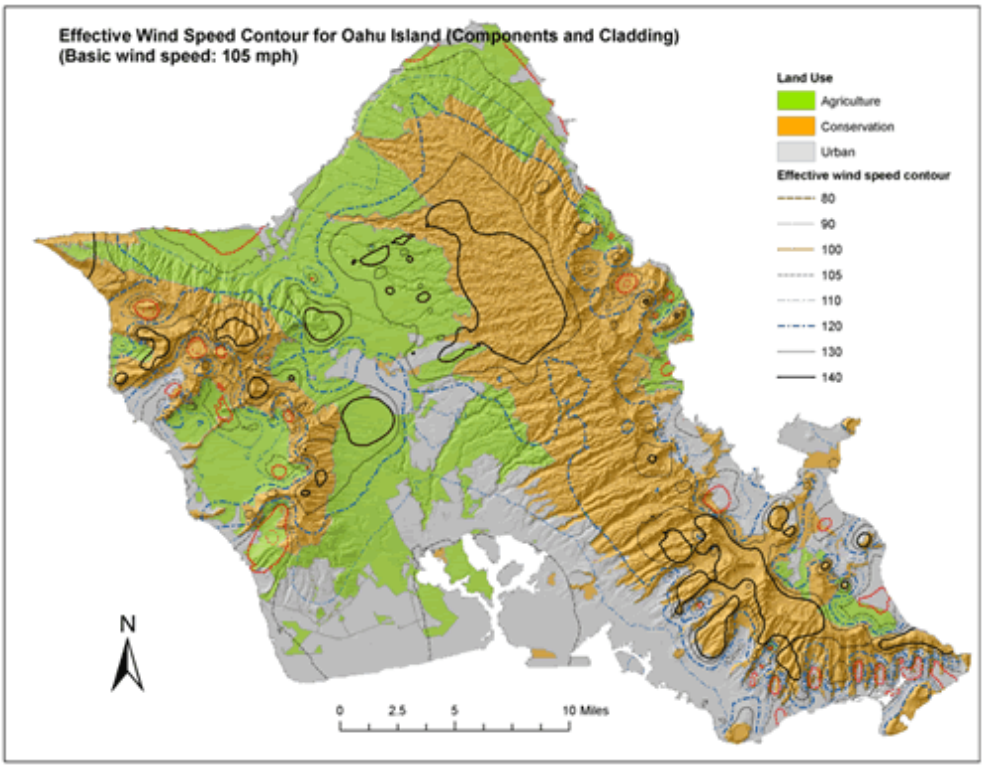


Figure 5.10 Effective Wind Speed for the Island of Maui

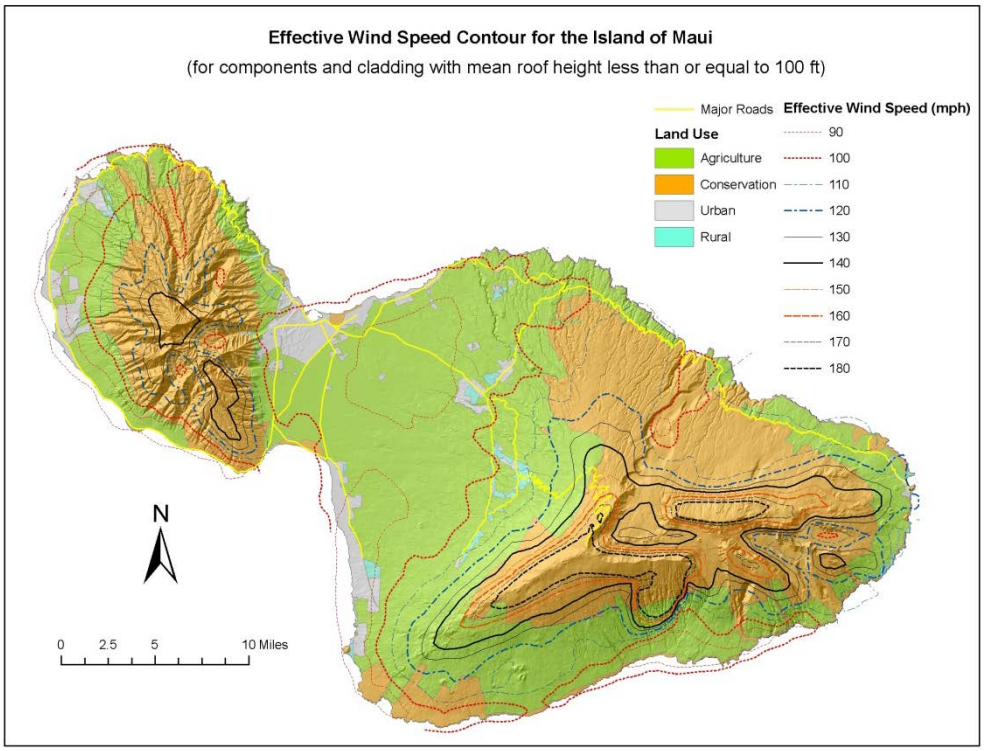


Figure 5.11 Effective Wind Speed for the Island of Moloka‘i

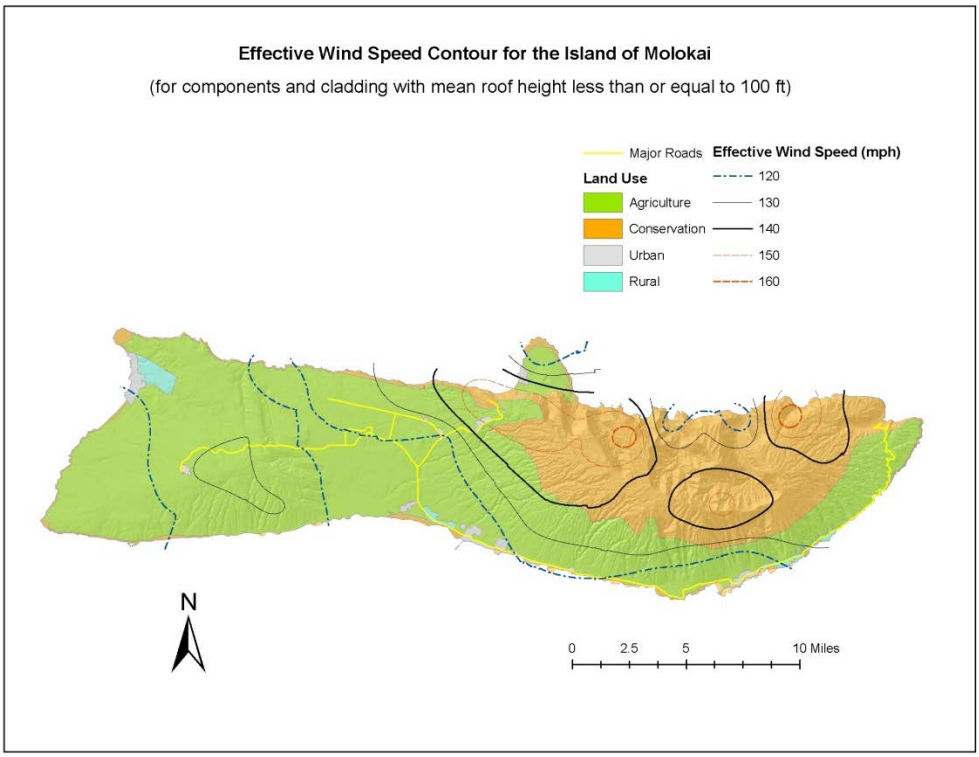


Figure 5.12 Effective Wind Speed for the Island of Lāna‘i

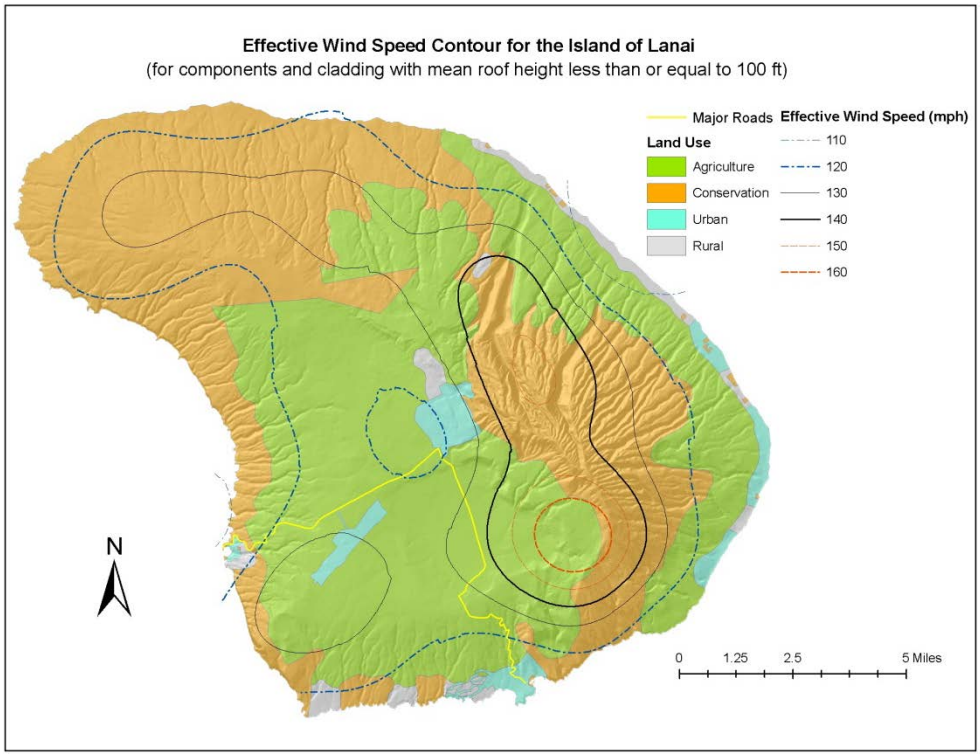
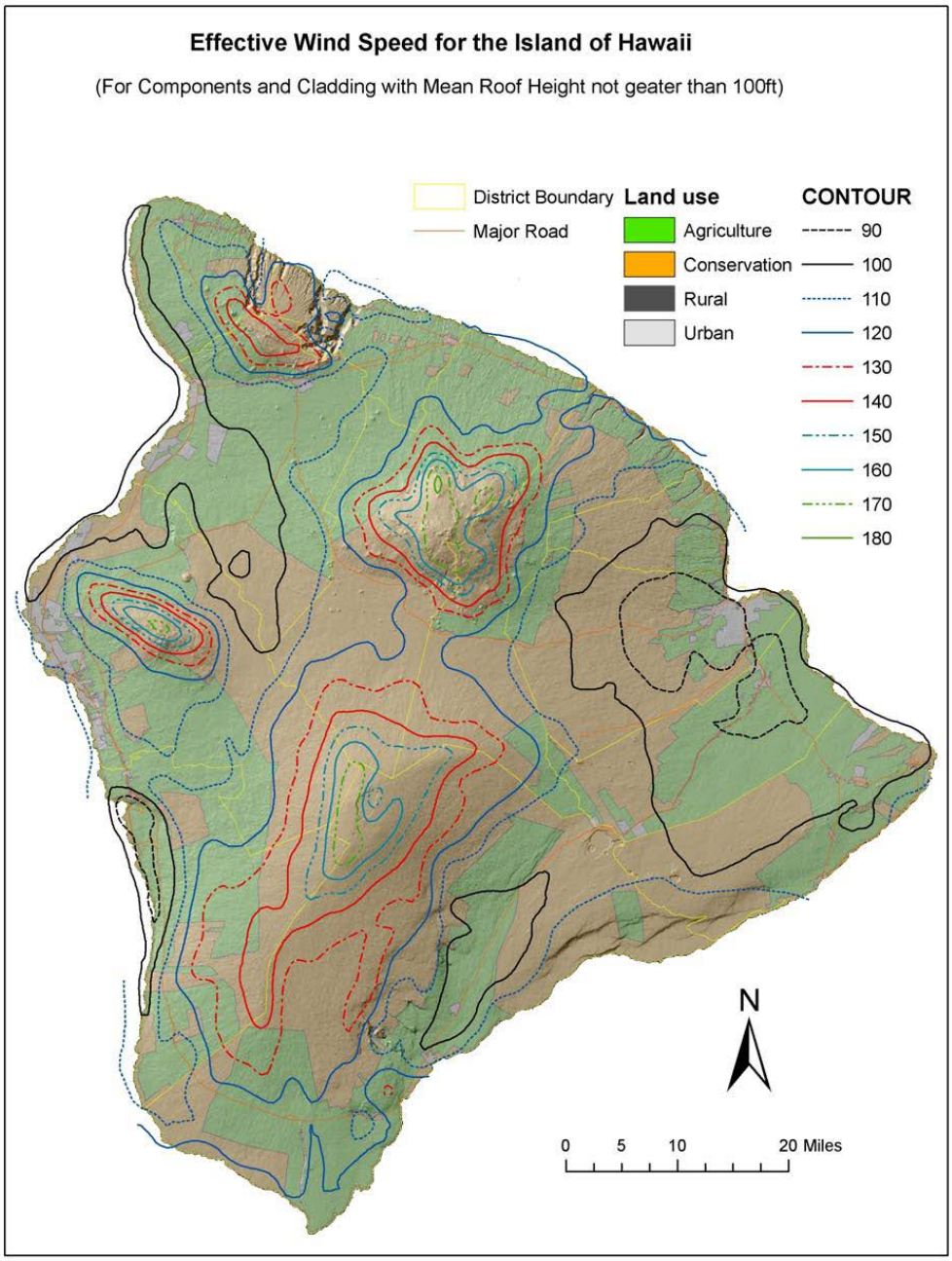


Figure 5.13 Effective Wind Speed for the Island of Hawai‘i



5.3.2.2 New Hurricane Sheltering Construction (State Building Code Appendix U)

Appendix U (Hawai‘i State Hurricane Sheltering Provisions for New Construction) of the State Building Code addresses the requirements relating to storm shelters, essential government facilities, and enhance hurricane protection areas (EHPA) within high occupancy government buildings. It also includes provisions for Hawai‘i residential safe rooms as an economical option in lieu of complete enclosure via glazing protection (see discussion pertaining to State Building Code Appendix W in previous section).

Per this appendix, public hurricane shelters must satisfy criteria for providing protection areas capable of withstanding a hurricane with a 500 year return period. In the case of EHPA for governmental high occupancy buildings, Appendix U establishes the criteria for minimum life safety design for a hurricane having a return period of 1,000 years. Design wind pressures and windborne debris requirements are among these criteria.

In terms of residential safe rooms, the appendix requires that they not be constructed within areas subject to stream or coastal flooding or dam failure inundation. Besides location, the appendix includes performance specifications (i.e. ventilation, exiting, communication, maximum occupancy, etc.), minimum structural integrity requirements, and windborne debris requirements.

5.4 Risk Assessment

5.4.1 Potential Losses from Future Hurricanes

Hurricane Iniki in September 1992 is an example of the level of destruction that a hurricane can generate. Residential property losses on Kaua‘i alone totaled an estimated $2.2 billion. Insurance losses alone exceeded $1.6 billion.

Comparatively, the exposure of the City and County of Honolulu to Hurricane losses is far greater than that of Kaua‘i. A recent assessment of Honolulu essential facilities (RMTC / URS JV 2010) also investigated losses of general building stock in the county. The estimated losses during a 500-700 year return period hurricane, corresponding to a Category 3 event, were $26.2 billion. This is higher than a previous estimate based on the Office of Planning, Hawai‘i Coastal Hazard Mitigation Planning Project in December 1993 of $13.9 to 23.3 billion for a Category 3 hurricane scenario.

5.4.2 Assessment of Hurricane Risks Relative to Other Natural Hazards

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: $AAL = \sum L_i \times P_i$

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 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 that allows users 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, which has broaden its user base in Hawai‘i and throughout the nation. The hazard component of the HAZUS Tropical Cyclone Model calculates wind speed as a function of central pressure, translation speed, and surface roughness.

Currently, the GIS databases are formulated separately in each county with varying licenses to parcel data and protocols for sharing of these layers. Recent analyses have enabled the development of improved building inventories and GIS information with HAZUS analyses. Improvements in GIS enable improved loss information and vulnerability estimations. Updated data and information from recent analyses inform the loss estimates in this plan. Based on a more recent analysis, which included an analysis of the general building stock on the island of O‘ahu, with new windspeed information, the hurricane AAL risk was estimated using HAZUS MH MR4 at $216 million/year.

Based on a HAZUS AAL analysis incorporating Hawai‘i Construction Cost Data, *tropical cyclone* AAL is about $69 million in Hawai‘i County. The predominant contributor to loss is single-family residential construction.

Based on a HAZUS AAL analysis incorporating Hawai‘i Construction Cost Data, *tropical cyclone* AAL is about $65 million in the County of Maui. The predominant contributor to loss is single-family residential construction.

It should be noted that the above discussion relates to aggregated overall damage. Risk contributions will differ according to type of construction. A Building Inventory Database with TMK-property specific resolution could be used within GIS to identify areas with specific buildings of higher vulnerability, and to establish overall risk relativity based on each community’s hurricane AAL. This would allow damage functions to be utilized that are specific to Hawai‘i type construction and calibrated to the observed damage on Kaua‘i during Hurricane Iniki.

5.4.3 Building Damage Functions

Residential Building Damage Curves have been developed that permit a wide variety of endemic Hawai‘i and Guam building types to be evaluated as a function of peak gust windspeed and construction features. Hawai‘i building damage functions and risk of damage ratios (risk relativity factors) were developed by 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 Hawai‘i loss information. The influence of the following construction attributes was analyzed:

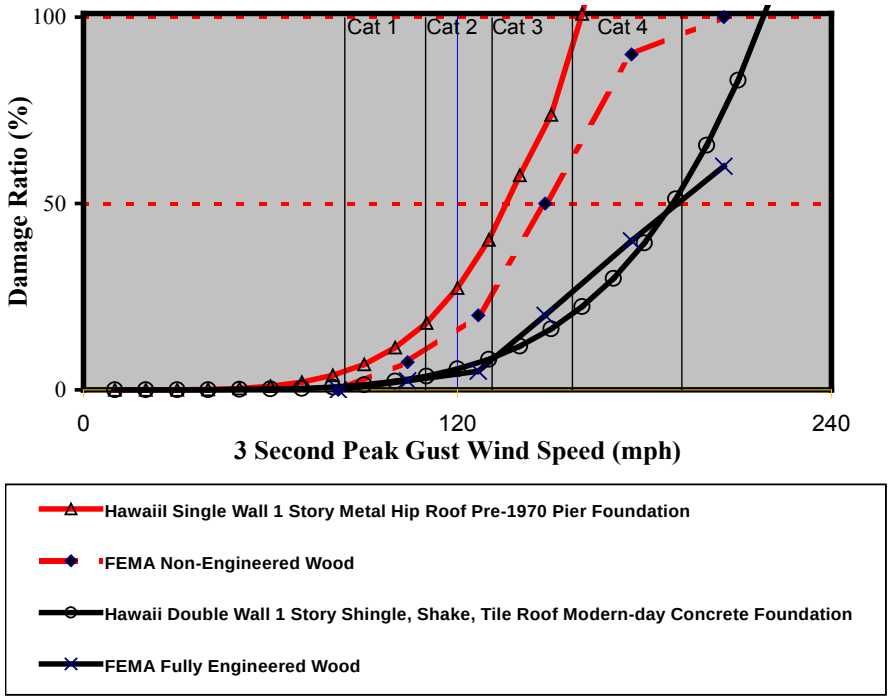
- Single or Double Wall Construction
- Height; one story or more than one story
- Roofing: Metal; Built-up Roofing or Composition; Shingles, Shakes, Tile or others
- Building Tax Valuation Categories
- Age: age split brackets, which depend on wall construction type and code benchmark years (which vary with each County)
- Foundation: Wood Piers or Concrete Slab
- Roof design: Gable or Hip

Table 5.6 Code Benchmark Years for Single Family Residences by County

Kaua‘i	Honolulu	Maui	Hawai‘i
1989	1987	1989	1993

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 5.14. Single wall construction is the most vulnerable type of residential construction for both hurricane and earthquake events.

Figure 5.14 Vulnerability of Hawai‘i Single Wall Construction Compared to Other Forms of Construction[10]



[10] Chock, 2005

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, with 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.

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. As experienced after Hurricane Iniki in Kaua‘i, post-storm debris management can be another problem. This occurs when vast amounts of vegetation debris, including potentially toxic, treated building materials from destroyed buildings, as well as other materials are burned at different sites with little management. Even with the burning, vast amounts of landfill capacity was used up with storm debris, meaning new sites would need to be developed at significant expense.

A summary of different elements of hurricane damage are listed in Table 5.7.

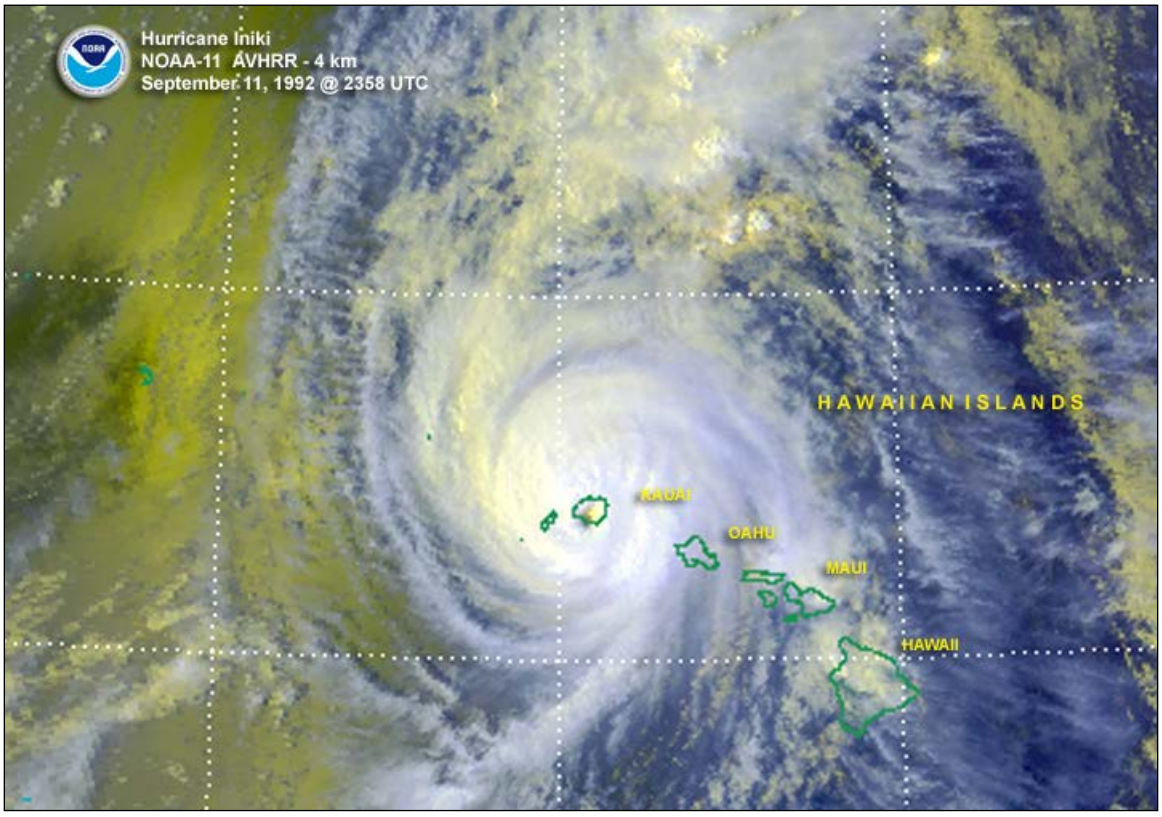
Table 5.7 Elements of Hurricane Damage

Hurricane	Storm Center
Hazard	• Wind • Rain • Waves
Exacerbation	• Local tides • Local coastal configuration
Results	• Wind damage from hurricane and spawned micro-bursts and mini-swirls • 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

5.4.4 Asset Damage

An alternate estimate of losses and vulnerability to facilities can be produced from extrapolations of hurricanes (‘Iwa and Iniki) that affected the County of Kaua‘i. This assumes that the overall damage pattern resemble those on Kaua‘i after ‘Iwa and Iniki, and that the estimates of damage from Iniki and ‘Iwa are applicable. From these and other data, primarily from the current State Data Book, estimates of asset damage and economic impact have been generated. These estimates are still useful. They give a sense of the order of magnitude (see Figure 5.15) of the potential destruction and allow for the preliminary evaluation of effectiveness of policy recommendations.

Figure 5.15 Satellite Image of Category 4 Hurricane Iniki Making Landfall in Hawai‘i on September 11, 1992[11]



[11] Wikipedia Website, Image Retrieved on October 5, 2009 from http://en.wikipedia.org/wiki/File:Hurricane_Iniki_11_sept_1992_2358Z.jpg

5.4.5 Economic Estimate of Losses Based on Analysis of Hurricane Iniki Effects

An economic study was conducted for wind hazards, and it gives some perspective on severe losses from extreme hazards in multiple sectors. If a Category 1 storm as strong as Hurricane ‘Iwa, with winds gusting at 74 mph, strikes any of the islands in the state, it can be surmised from past experience that about 12% of the houses and apartments could be destroyed or heavily damaged and about 18% would probably experience minor damages. If a Category 3 storm strikes any island with the same force as Hurricane Iniki, with winds at approximately 130 mph or greater, it can be estimated that approximately 38% of the homes will be heavily damaged or destroyed. An additional 40% will probably have minor damages. The following data (Table 5.8 through Table 5.11) were extrapolated from damage to the County of Kaua‘i during hurricanes ‘Iwa (1982) and Iniki (1992).As can be seen on the Tables, in both storm scenarios less than 10% of residential units suffering damage were destroyed. In the case of Hurricane Iniki a higher proportion suffered major damage (30%), while a smaller proportion suffered minor damage (41%).

Table 5.8 State of Hawai‘i Estimated Cost of Storms by County ($ billion in 1992)[12]

	Kaua‘i	Honolulu	Maui	Hawai‘i
‘Iwa-Strength Storm	$ 0.3-0.6	$ 4.5-7.5	$ 0.8-1.4	$ 0.8-1.4
Iniki-Strength Storm	$1.1-1.9	$13.9 -23.3	$ 2.7-4.5	$ 2.6-4.4

Table 5.9 State of Hawai‘i Estimated Cost of Storms by County ($ billion in 2013)[13]

	Kaua‘i	Honolulu	Maui	Hawai‘i
‘Iwa-Strength Storm	$ 0.5-1.0	$ 7.5-12.4	$ 1.3-2.3	$ 1.3-2.3
Iniki-Strength Storm	$1.8-3.1	$23.0 -38.6	$ 4.5-7.5	$ 4.3-7.3

Table 5.10 Damage Percentage to Residential Units by Storm and Classification

	Iniki	‘Iwa
Destroyed	8%	3%
Major damage	30%	9%
Minor damage	41%	18%
Total percentage damage	**79%**	**30%**

[12] Hawai‘i Coastal Hazard Mitigation Planning Project, Office of Planning, December, 1993 (reviewed and updated by the University of Hawai‘i, July, 2010). Study was conducted in 1992.

[13] Hawai‘i Coastal Hazard Mitigation Planning Project, Office of Planning, December, 1993 (reviewed and updated by the University of Hawai‘i, July, 2010). The inflation rate from dollars in 1992 to 2013 is 65.7%.

Table 5.11 Estimated Value of Damage per Unit ($ thousand in 2011)[14]

Condition	Value of Damage per unit
Destroyed	284.0
Major damage	55.0
Minor damage	1.6

The damage ratios and values were updated and applied to the housing stock in each county as of 2011, to construct the residential structure damage estimates in each county for both cyclones. The *Imua* Study reported the estimated damage to personal property to be approximately 45% of the estimated structural damage. Table 5.12 shows the inventory of housing units per county as of 2011. Finally, the results summarized in Table 5.13 form the best estimate of potential residential asset damage based on the most current available statistics for the State of Hawai‘i.

Table 5.12 Count of Housing Units by County (based on 2011 statistics)[15]

	Housing Units
Kaua‘i	30,269
Honolulu	337,522
Maui	71,328
Hawai‘i	83,186
TOTAL	522,305

Table 5.13 Residential Asset Damage, By County and By Hurricane ($ millions in 2011)[16]

	Hurricane Iniki		Hurricane ‘Iwa	
	Structures	**Personal Property**	**Structures**	**Personal Property**
Kaua‘i	1.2	0.5	0.4	0.2
Honolulu	13.5	6.1	4.7	2.1
Maui	2.8	1.3	1.0	0.4
Hawai‘i	3.3	1.5	1.1	0.5
TOTAL	20.8	9.4	7.2	3.2

[14] Destroyed condition refers to 2006 average estimate value based on destruction of single family homes and adjusted for inflation to 2011. Major Damage condition refers to estimated amount used on American Red Crosss street sheets and adjusted for inflation to 2011. Minor Damage condition is extrapolated from data presented in the Imua Study and adjusted for inflation to 2011.

[15] 2011 Hawai‘i State Data Book, , retrieved June 2013 from http://dbedt.hawaii.gov/economic/databook/db2011

[16] 2011 Hawai‘i State Data Book, www.hawaii.gov/dbedt/info/economic/databook/db2006, retrieved June 2013, with analysis from Hawai‘i Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study.

The estimated damage to visitor accommodations from Hurricane Iniki is based on a survey of the County of Kaua‘i’s visitor rooms conducted PKF-Hawai‘i for the Hawai‘i Hotel Association The survey found that approximately 54% of the 7,616 surveyed accommodations units to have suffered damage equivalent to an average value of $75,600 per room in 1991. After inflation adjustments, this cost is equivalent to approximately $124,856 dollars in 2011.

To estimate the cost of damage for an Iniki-type storm, the percentage of damaged units and cost of damage per unit from the PDF-Hawai‘i survey is used together with visitor statistics from the 2011 Visitor Plant Inventory by the State of Hawai‘i Department of Business, Economic Development and Tourism (DBEDT). In the case of an ‘Iwa-type storm, an estimated 18.5% of visitor accommodations are estimated to be damaged. This last percentage figure is obtained from the decline in visitor accommodations for the County of Kaua‘i (4,193 in 1983 versus 5,147 units in 1982).as reported in the State of Hawai‘i Data Book for the years before and after Hurricane ‘Iwa. The estimated cost of damaged unites by county for an Iniki and ‘Iwa-type storm is summarized in Table 5.14 Table 5.14 and Table 5.15, respectively.

Table 5.14 Visitor Accommodation Damage by County for Iniki-Type Storm ($ millions in 2011)[17]

	Total Units	Damaged Units	Cost of Damaged Units
Kaua‘i	9,872	5,331	665
Honolulu	35,001	18,901	2,360
Maui	21,745	11,743	1,467
Hawai‘i	11,113	6,002	749
TOTAL	77,731	41,975	5,241

Table 5.15 Visitor Accommodation Damage by County for ‘Iwa-Type Storm ($ millions in 2011)[18]

	Total Units	Damaged Units	Cost of Damaged Units
Kaua‘i	9,872	1,827	228
Honolulu	35,001	6,476	809
Maui	21,745	4,023	502
Hawai‘i	11,113	2,056	257
TOTAL	77,731	14,382	1,796

[17] 2011 Visitor Plant Inventory, State of Hawai‘i Department of Business, Economic Development, and Tourism, June 2010, http://dbedt.hawaii.gov/visitor/visitor-plant, retrieved June 2013, with analysis from Hawai‘i Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study.

[18] Ibid

The estimated damage to non-visitor accommodations after an Iniki-type event is based on a survey of 128 visitor related businesses on the island of Kaua‘i by Harry Spiegelberg and Associates for DBEDT. The survey found the estimated overall damage per employee to be $13,692 in 1991. After inflation adjustments, this damage figure is equivalent to approximately $22,613 dollars in 2011. DBEDT used this estimate to construct the estimated damage to non-visitor facilities. The two categories are merged into “Visitor and other facilities” and the estimated damage is the damage per employee times the number of non-agriculture, non-government employees in each county. The results for non-visitor accommodation damage for and Iniki-type storm are summarized in Table 5.16.

Table 5.16 Non-Visitor Accommodation Damage by County for Iniki-Type Storm ($ millions in 2011)[19]

	Job Count	Cost of Damage
Kaua‘i	27,900	631
Honolulu	438,400	9,914
Maui	65,600	1,483
Hawai‘i	60,300	1,364
TOTAL	592,200	13,392

The statewide damage to public utilities after hurricane ‘Iwa is estimated at $11.5 million in 1982. Assuming the same percentage of damaged businesses as other business types in the County of Kaua‘i during hurricane ‘Iwa (87%), the cost per customer was $55,000 times the inflation factor (159.6%) yields the estimated cost per customer of $88,000. After one last inflation adjustment, this cost is equivalent to approximately $90,750 in 2011. An estimated of public utility damage by county is presented in Table 5.17.

Table 5.17 Public Utility Damage after an Iniki-Type Storm ($ millions in 2011)[20]

	Customers	Cost of Damage
Kaua‘i	36,269	3,291
Honolulu	296,800	26,935
Maui	63,433	5,757
Hawai‘i	81,199	7,369
TOTAL	477,701	43,352

[19] 2011 Hawai‘i State Data Book, http://dbedt.hawaii.gov/economic/databook/db2011, retrieved June 2013, with analysis from Hawai‘i Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study. Job count only includes non-agricultural jobs.

[20] 2011 Hawai‘i State Data Book, http://dbedt.hawaii.gov/economic/databook/db2011, retrieved June 2013, with analysis from Hawai‘i Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study. Customers include electric customers as of December 31, 2011.

The damage to non-federal government property is assumed to be proportional to the number of non-federal government employees. Hurricane Iniki caused $67.0 million in damage to State and County property in 1992. The estimated damage by county based on the state population in 1992 is $21,000 per worker in 1992. After inflation adjustments, this damage figure is equivalent to approximately $33,670 dollars in 2011. Table 5.18 summarizes damage to non-federal government property by county for an Iniki-type event.

Table 5.18 Non-Federal Government Damage by County for Iniki-Type Storm ($ millions in 2011)[21]

	Workers	Cost of Damage
Kaua‘i	2,600	88
Honolulu	54,300	1,828
Maui	6,000	202
Hawai‘i	8,400	283
TOTAL	71,300	2,401

Similarly, Hurricane ‘Iwa caused $24.9 million in damage to state and county property in 1982: $6 million to the County of Kaua‘i, $0.8 million to the City and County of Honolulu; and $18.1 million to the Counties of Hawai‘i and Maui. If the state damage is proportioned in the same fashion as the county damage, the total damage on the County of Kaua‘i was $22 million (88%) and the damage per employee is $8,600 in 1982. After inflation adjustments, the cost of damage per non-federal employee is equivalent to approximately $20,050 dollars in 2011. Table 5.19 provides a summary of damage to non-federal property by county after a storm of similar magnitude to Hurricane ‘Iwa.

Table 5.19 Non-Federal Government Damage by County for ‘Iwa-Type Storm ($ millions in 2011)[22]

	Workers	Cost of Damage
Kaua‘i	2,600	52
Honolulu	54,300	1,089
Maui	6,000	120
Hawai‘i	8,400	169
TOTAL	71,300	1,430

[21] 2011 Hawai‘i State Data Book, http://dbedt.hawaii.gov/economic/databook/db2011, retrieved June 2013, with analysis from Hawai‘i Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study.

[22] Ibid

The agriculture losses from hurricane Iniki were estimated to be $78.0 million in 1991, roughly equivalent to 138% of the 1991 market value of crop and livestock sales in the County of Kaua‘i. After inflation adjustments, this loss is equivalent to approximately $129.0 million in 2011. Table 5.20 shows the estimated losses to agriculture property on a per county basis for an Iniki-type cyclone.

Table 5.20 Agriculture Losses for an Iniki-Type Storm ($ millions in 2011)[23]

	Market Sales*	Losses
Kaua‘i	41	6,652
Honolulu	164	20,130
Maui	124	17,028
Hawai‘i	165	21,521
TOTAL	494	65,331

The agricultural crop losses on the County of Kaua‘i resulting from hurricane ‘Iwa were $14.9 million in 1982. The reported statewide damage to agricultural structures was $5.2 million in 1982. If the agricultural losses are proportioned similarly to crop losses, the total agricultural losses on the County of Kaua‘i are $19.4 or 32% of the $60.5 million market value of crop and livestock sales in 1982. After inflation adjustments, this loss is equivalent to approximately $141 million in 2011. A summary of the estimated agriculture loses by county for an event similar to hurricane ‘Iwa is included in Table 5.21.

Table 5.21 Agriculture Losses for an ‘Iwa-Type Storm ($ millions in 2011)[24]

	Market Sales*	Losses
Kaua‘i	41	5,158
Honolulu	164	15,614
Maui	124	13,208
Hawai‘i	165	16,693
TOTAL	494	50,673

[23] 2011 Hawai‘i State Data Book, http://dbedt.hawaii.gov/economic/databook/db2011, retrieved June 2013, with analysis from Hawai‘i Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study. *Value of crop and livestock sales for year as follows: 2004 for Honolulu County, 2001 for Maui County, 2008 for Hawai‘i County, and 2001 for Kaua‘i County.

[24] Ibid

The final item to be discussed is this section is the clean-up cost after a tropical cyclone. The post-hurricane Iniki clean-up costs are estimated at $48.0 million in 1992, or 3.2% of the asset damage estimate for the same year. After inflation adjustments, this clean-up cost is equivalent to approximately $77.0 million in 2011. Table 5.21 and Table 5.22 provide estimates for the clean-up costs and total damages for a possible Iniki and ‘Iwa like event, respectively.

Table 5.22 Clean-Up Costs and Total Damage for an Iniki-Type Storm ($ millions in 2011)[25]

	Subtotal	Clean- Up	Total
Kaua‘i	1,564	50	3,735
Honolulu	20,368	621	52,106
Maui	3,599	113	8,617
Hawai‘i	3,521	111	8,409
TOTAL	29,052	895	72,867

Table 5.23 Clean-Up Costs and Total Damage for an ‘Iwa-Type Storm ($ millions in 2011)[26]

	Subtotal	Clean- Up	Total
Kaua‘i	492	16	1,177
Honolulu	6,034	191	14,396
Maui	1,135	36	2,687
Hawai‘i	1,121	35	2,679
TOTAL	8,782	278	20,939

It is assumed that most of the structural damage (residential, accommodation, and other business) will require mostly skilled construction labor for repairs. To determine the labor needs for the repair work, the current construction cost per worker is needed. The ratio is the 1991 general excise tax base for contracting ($4,334 million) divided by the 1991 statewide job count in the contact construction industry (33,500 workers) or $129,373 per worker. The structural damage totals are divided by the construction value per worker to calculate the number of workers needed and then multiplied by the average annual wage ($41,681 in 2010) to calculate the estimated total wages, assuming the number of workers were employed for a year, updated by inflation.

[25] 2011 Hawai‘i State Data Book, http://dbedt.hawaii.gov/economic/databook/db2011, retrieved June 2013, with analysis from Hawai‘i Coastal Hazard Mitigation Planning Project, Office of Planning, December 1993 as the original study.

[26] Ibid

It is important to remember that there is an opportunity cost to the work and income generated from the structural repairs of hurricane damage. The workers replacing structures are not building new ones. No new income is generated unless previously employed workers are now employed in the repair work, or unless workers are working "overtime" to meet the higher demand.

To calculate the impact on the visitor industry, it is assumed that tourism returns after the storm, slower after an Iniki-type storm. Table 5.24 shows the percentage of 1991 tourist expenditures by quarter after the storm.

Table 5.24 Tourist Expenditures Following Hurricane Iniki, percentage by quarter

	1st Q	2nd Q	3rd Q	4th Q
Hurricane Iniki	0%	25%	59%	75%
Hurricane 'Iwa	25%	75%	100%	100%

The estimated annual expenditures and related data can be calculated as the sum of the products of the recovery rate coefficient and the average monthly amounts for visitor expenditure, total expenditure, total sales, income, and tax revenue.

5.4.6 State Critical Facilities Structural Risk and Vulnerability Assessment

A risk assessment of the State's critical facilities was undertaken to meet the gap of information in potential damages and losses to Hawai'i. The analysis used the modified and updated HAZUS-MH study for earthquakes and hurricanes. The analysis included 274 structures that had 1) high property values, greater than $250,000 and 2) critical use to the state and its functionality or survival from disasters. Given these first two criteria, not every facility was analyzed. The analysis required site inspections to develop the database of information that the model uses to assess risk. For hurricanes, the loss estimates greater than $1 million for an event have been included in Table 5.25.

Table 5.25 State Critical Facilities ranked by Estimated Costs of Damages from Wind Loss[27]

	Hurricane Probabilistic Scenario			
Building Name	Estimated $ Loss	Est. % Loss	$ Loss Rank	% Loss Rank
Honolulu International Airport	$319,980,322	16.1%	1	214
Hawai‘i State Hospital	$46,729,356	28.4%	2	68
Kauhale Kakaako	$19,689,620	17.6%	3	211
Kula Hospital - Main Building	$16,165,578	21.4%	4	157
Foreign Trade Zone - Office	$16,135,416	23.9%	5	101
Leahi Hospital - Young Bldg - District Court	$15,677,550	29.5%	6	63
Leahi Hospital Young Building - New Wards A&C	$12,893,791	29.5%	7	63
Kauikeaouli Hale - State Court	$11,881,365	19.2%	8	203
Kahului Airport	$11,589,070	9.7%	9	232
Hilo Medical Center - Acute Care Facility	$11,248,341	11.5%	10	229
Pohulani Elderly	$11,224,213	18.7%	11	208
Kaahumanu Hale - Courthouse	$11,090,082	21.3%	12	158
Daimond Head Main Terminal	$10,478,318	23.7%	13	103
Brigham Young University - Cannon Activities Center	$8,216,914	34.2%	14	34
Court Operations - Hoapili Hale	$7,703,983	27.7%	15	69
Kona Community Hospital - Building 1 and 2	$7,642,005	24.4%	16	84
Pier 31-33 Shed - Warehouse	$7,631,536	19.0%	17	205
Hale Ho'ola Hamakua	$7,253,769	34.1%	18	36
DOH Laboratory	$7,181,330	23.7%	19	102
Maui Memorial Hospital	$7,044,162	23.5%	20	105
Lihue Airport	$6,286,140	21.0%	21	165
Diamond Head Health Center	$6,262,525	35.6%	22	31
Maui County Building - EOC	$5,641,945	28.5%	23	67
Pier 19 Shed - Warehouse	$5,478,501	22.2%	24	137
Pier 11 Shed Bldg A - Warehouse	$4,989,471	22.7%	25	126
Wailuku State Office Building	$4,439,538	27.7%	26	69
Lahaina Civic Center	$4,263,995	40.4%	27	20
Molokai General Hospital - Phase 2	$4,227,281	48.0%	28	7
Leahi Hospital Young Building - Lndy, maint, mach	$4,173,335	30.6%	29	47
Brigham Young University - Old Gym	$4,108,457	34.2%	30	34
Leahi Hospital Young Building - Dining Rm/Occy therapy	$4,038,712	30.6%	31	47
AAFES Building - Warehouse	$3,822,518	24.4%	32	83
Leahi Hosp - Trotter Bldg - Hospital	$3,763,834	30.6%	33	47
Leahi Hospital Young Building - Alexander Young Ward	$3,547,654	29.6%	34	62
Hale Ho'ola Hamakua - Old Hospital	$3,466,342	37.0%	35	27
Pier Shed 2 Nawiliwili Harbor - Warehouse	$3,455,391	36.4%	36	30
Lanai High School and Elementary School Gymnasium	$3,366,158	49.0%	37	3
DOT/Harbor Warehouse # 6 - Passenger Terminal	$3,137,507	19.0%	38	206
Aliiolani Hale	$3,121,659	22.8%	39	124
Leahi Hospital - Atherton Bldg - Hospital	$3,094,387	30.6%	40	47
Hawai‘i State Main Library	$3,061,076	22.8%	41	124
Pier 51-53 CFS Shed	$2,940,094	45.7%	42	12
Pier 10 Shed - DOT Harbors Div and Terminal	$2,892,331	19.5%	43	201
Building 300	$2,889,778	31.8%	44	38
Supreme Courtroom/Chambers/Admin	$2,820,240	22.7%	45	127
Molokai General Hospital - Phase 1	$2,778,668	48.0%	46	7
Molokai High School - Gym	$2,622,770	35.0%	47	32
Alii Aimoku Hale - Court	$2,561,382	21.3%	48	158
Leahi Hospital -Nurse Qtr #1 Wilcox	$2,555,403	30.6%	49	47
DLNR Boating and Ocean Recreation Division	$2,533,054	19.2%	50	203
Kaunakakai State Office Building	$2,499,824	48.3%	51	4
Hilo Airport - Passenger Terminal	$2,432,941	2.0%	52	268
Kau Hospital and Rural Health Clinic	$2,381,543	27.6%	53	72
Kapolei High School - Bldg G	$2,344,909	22.1%	54	138
Maui Police Department Wailuku / Hale Makai	$2,324,051	23.5%	55	104
Lanai Community Hospital	$2,292,196	36.6%	56	29
Kaua‘i Veterans' Memorial Hospital - Original	$2,279,633	14.7%	57	217

[27] Martin & Chock, Inc. with the University of Hawai‘i Social Science Research Institute, 2010.

Kahului Harbor Pier 1 Building - Cruise Terminal	$2,263,923	23.1%	58	121
Kahului Ambulance Facility	$2,240,357	23.2%	59	111
Kahuku High and Intermediate - Bldg W	$2,164,438	30.4%	60	54
Campbell High School - Bldg D	$2,151,963	19.8%	61	190
State Office Building	$2,060,613	20.0%	62	180
Kahuku High and Intermediate - Gym	$2,016,881	30.6%	63	52
Kona Community Hospital - Psychiatric Facility	$2,007,976	24.4%	64	84
Konawaena High School - Building N - Gymnasium	$1,756,125	26.6%	65	73
Kona Community Hospital - Special Services	$1,735,047	24.4%	66	84
Building 302	$1,727,260	31.8%	67	38
Waialua High and Intermediate - Gym	$1,715,757	22.6%	68	135
Honolulu Interisland Airport Terminal & Parking	$1,686,669	16.1%	69	214
Container Freight. Station # 3 - Warehouse	$1,657,272	40.1%	70	22
Building 829	$1,648,248	22.6%	71	130
Kohala Hospital	$1,644,528	19.2%	72	202
Kahuku High and Intermediate - Bldg A	$1,638,689	30.4%	73	54
Mililani High School - Bldg B	$1,621,921	23.1%	74	112
Molokai District Court	$1,616,352	48.3%	75	4
Armory	$1,609,954	27.7%	76	69
Lanakila Health Center	$1,564,580	15.7%	77	216
Kaunakakai Airport	$1,553,342	38.8%	78	25
Port Allen Pier Shed - Warehouse	$1,502,135	34.3%	79	33
Leilehua High School - Bldg R	$1,486,081	20.4%	80	172
MS/Commodities Bldg	$1,468,917	23.3%	81	108
Kahuku High and Intermediate - Bldg Y	$1,441,924	30.4%	82	54
Plant Quarantine Branch - DOH Offices	$1,416,389	23.3%	83	108
Mililani High School - Bldg E/Gym	$1,410,906	23.1%	84	112
Waipahu Elderly	$1,404,400	14.0%	85	221
Kailua High School - Gym	$1,389,252	20.2%	86	177
American Medical Ambulance	$1,370,756	23.0%	87	122
McKinley High School for Adults	$1,364,977	20.2%	88	178
Lahaina Fire Station	$1,284,643	39.7%	89	24
Campbell High School - Bldg H	$1,278,034	19.8%	90	190
Campbell High School - Bldg G	$1,250,528	19.8%	91	190
Kaunakakai Police Station	$1,229,385	48.1%	92	6
Keahole/Kohala Airport - Passenger Terminal	$1,228,436	1.0%	93	274
Campbell High School - Bldg N	$1,209,378	19.8%	94	190
Kula Hospital - Mental Facility Building	$1,207,452	24.1%	95	92
Mililani High School - Bldg L	$1,207,020	23.1%	96	112
State Office Building - Hilo	$1,193,707	5.5%	97	254
Leahi Hospital - Nurse Qtr #14	$1,171,290	31.8%	98	40
Kahului Fire Station Main Building	$1,170,379	24.6%	99	80
Campbell High School - Bldg O	$1,155,291	19.8%	100	190
Lanai Police Station	$1,103,008	46.6%	101	10
Health Center Lihue Annex	$1,098,520	20.7%	102	169
Hamakua Health Center	$1,085,611	34.1%	103	36
Wailea Fire Station	$1,081,989	26.4%	104	77
Kahuku High and Intermediate - Bldg X	$1,078,567	30.4%	105	54
Hilo Medical Center - Extended Care Facility	$1,077,813	12.1%	106	226
Kailua High School - Bldg D	$1,041,579	19.8%	107	181
Kaua‘i Veterans' Memorial Hospital - Kawaiola	$1,032,045	11.3%	108	230
Kailua High School - Bldg E	$1,021,819	19.8%	109	181
Kahului Power Plant	$1,005,365	20.9%	110	168

5.5 Mitigation Strategies

5.5.1 Recent Hazard Mitigation Activities

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 Kaua‘i failing during Hurricane Iniki. This has resulted in periodic updates to the design criteria for these poles. The most recent design criteria were adopted by the State of Hawai‘i in 2007 and are based on the 2002 National Electrical Safety Code which references the ASCE 7-98 wind load criteria. While this is an improvement on the old design standards it does not incorporate the latest Hawai‘i specific wind design criteria. It is recommended that the future mitigation project should further update the transmission and distribution line design criteria to incorporate the Hawai‘i specific wind design criteria and utilize the effective wind speed maps that account for topographical, directionality and local exposure. Procedures should be implemented to assure the adoption of the new standards so that when a power pole fails and is replaced, the replacement should meet the current standards.

- Update Debris Estimation. HAZUS MH can compute this for planning; being utilized in the Hawai‘i Mass Care Council planning of post-disaster mass care needs

- Utilized the new USCOE decision tool that includes topographic wind effects into the output of the MMS model, to allow identification of the topographically-amplified wind speeds for any individually defined storm scenario. Estimated peak gust wind speeds are calculated at each “zone” at representative sites selected for planning and emergency response purposes within Hurrevac/MMS.

- Developed Hawai‘i certifications for residential safe room assemblies.

5.5.2 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 described briefly below. Further details of the proposed projects are provided in Chapter 19.

Project	Description
Update design and construction standards for utility lifelines per the American Lifelines Association approved standards.	
Establish further upgrades to the electrical transmission and distribution design standards to incorporate Hawai‘i 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 and related codes per HRS 107 Part II.	
Test the Seismic and Wind Performance of Single Wall Construction.	
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.	
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	
Assemble a Hawai‘i-specific building inventory database by acquiring the tax assessor building stock data for classification and census block group aggregation into an Enhanced Data Hurricane Loss Estimation Model 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.	
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.	
Utilize the new USCOE-sponsored Mass Management System Tool that models clearing times for user-input hurricane and evacuation planning scenarios.	

Project	Description
Establish a policy for strengthening of critical public facility enclosure integrity.	
Adapt HAZUS-MH or other hazard modeling to the islands of Maui, Moloka‘i, and Lānai, O‘ahu, and Kaua‘i	Incorporate building inventory and critical facilities into the HAZUS MH wind risk model. Hurricanes will cause much higher losses than earthquakes to residential buildings; vulnerable structures can be identified with respect to high wind zones
Emergency shelter evaluation; Harden public schools for emergency shelters. There is a shortage of shelter buildings. Perform a comprehensive screening evaluation of public hurricane shelters and private sector buildings for possible use for refuge.	Perform a 1-year study to identify and rank Hawai‘i building types that could be deemed safer for hurricane resistance without exhaustive site investigations. Use these screening criteria to determine the number of low vulnerability buildings available for refuge in the private sector. This could result in a decrease in the number of persons that would report to a public shelter.

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

Appendix 5A

State of Hawai‘i Building Code
Chapter 3-180 Hawai‘i Administrative Rules
October 13, 2009

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DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES

Adoption of Chapter 3-180
Hawaii Administrative Rules

October 13, 2009

SUMMARY

1. Chapter 180 of Title 3, Hawaii Administrative Rules, entitled "State Building Code", is adopted.

09.15

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HAWAII ADMINISTRATIVE RULES

TITLE 3

DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES

SUBTITLE 14

STATE BUILDING CODE COUNCIL

CHAPTER 180

STATE BUILDING CODE

Subchapter 1 Rules of General Applicability

§3-180-1 Purpose
§3-180-2 Scope
§3-180-3 Definitions
§3-180-4 Adoption of the *International Building Code*
§3-180-5 Permit authorization

Subchapter 2 Amendments to the 2006 ICC, *International Building Code*

§3-180-6 Title and purpose
§3-180-7 Scope
§3-180-8 Appendices
§3-180-9 Referenced codes
§3-180-10 Existing structures
§3-180-11 Department of building safety
§3-180-12 Permits
§3-180-13 Construction documents
§3-180-14 Temporary structures and uses
§3-180-15 Fees
§3-180-16 Fire code defined
§3-180-17 Group I-1
§3-180-18 Group I-2
§3-180-19 Residential Group R
§3-180-20 Personal care service defined
§3-180-21 Assisted living facilities defined
§3-180-22 Fire command station
§3-180-23 Group I-1 assisted living facilities

§3-180-24	Group I
§3-180-25	Group R
§3-180-26	Features
§3-180-27	Gates
§3-180-28	Accessibility
§3-180-29	Unvented attic spaces
§3-180-30	Live loads posted
§3-180-31	Seismic design - short term
§3-180-32	Seismic design - 1-second period
§3-180-33	Design rain loads
§3-180-34	Structural observation defined
§3-180-35	General
§3-180-36	Statement of special inspections
§3-180-37	Report requirement
§3-180-38	Statement of special inspections
§3-180-39	Structural observations
§3-180-40	Splices
§3-180-41	Cleanouts
§3-180-42	Preservative-treated wood
§3-180-43	Fasteners in non-borate-preservative-treated and fire-retardant-treated wood
§3-180-44	Protection against decay and termites
§3-180-45	General
§3-180-46	Scope
§3-180-47	Scope
§3-180-48	Scope
§3-180-49	Public swimming pools
§3-180-50	Conformance
§3-180-51	Compliance with other codes
§3-180-52	Appendix U - Hawaii hurricane sheltering provisions for new construction
§3-180-53	Appendix W - Hawaii wind design provisions for new construction
§3-180-54	Appendix X - Hawaii provisions for indigenous Hawaiian architecture structures

SUBCHAPTER 1

RULES OF GENERAL APPLICABILITY

§3-180-1 Purpose. The purpose of this chapter is to adopt the state building code as required by section 107-25, HRS. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-2 Scope. This chapter sets forth minimum requirements for the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal, and demolition of every building or structure or any appurtenances connected or attached to buildings or structures. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-3 Definitions. In this chapter, unless the context otherwise requires:

"Chapter" means this chapter.

"IBC" means the ICC, *International Building Code*, 2006 edition, as copyrighted by the International Code Council.

"ICC" means the International Code Council.

"Section" means a section of a chapter of the *International Building Code*.

"Table" means a table in this chapter. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-4 Adoption of the *International Building Code*. The "*International Building Code, 2006 Edition*" as copyrighted and published in 2006 by International Code Council, Incorporated, 500 New Jersey Avenue, 6th Floor, Washington, DC 20001, is adopted by reference and made a part of this chapter. This incorporation by reference includes all parts of the International Building Code subject to the amendments in this chapter. The appendices of the ICC, IBC are not adopted except as provided in this chapter. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-5 Permit authorization. Each county of the State of Hawaii may, by ordinance, require that a permit be obtained from the building official for any area regulated by this chapter. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

SUBCHAPTER 2

AMENDMENTS TO THE 2006 ICC, INTERNATIONAL BUILDING CODE

§3-180-6 Title and purpose. Section 101.1 is amended to read as follows:

"**101.1 Title.** These regulations shall be known as the Building Code of the State of Hawaii, hereinafter referred to as "this code"." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-7 Scope. Section 101.2 is amended to read as follows:

"**101.2 Scope.** The provisions of this code shall apply to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal, and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures.

Exceptions:

1. Detached one- and two-family dwellings and multiple single-family dwellings (townhouses) not more than three stories above grade plane in height with a separate means of egress and their accessory structures shall be permitted to comply with the International Residential Code, if adopted by the county jurisdiction.
2. Existing State-owned buildings undergoing repair, alterations or additions and change of occupancy shall be permitted to comply with the International Existing Building Code, provided the extent of work does not exceed 50 per cent of the appraised value of the building." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-8 Appendices. Section 101.2.1 is amended to

read as follows:

"**101.2.1 Appendices.** Provisions in the appendices shall not apply unless specifically adopted.

Exceptions:

1. Appendix U, Hawaii Hurricane Sheltering Provisions for New Construction, shall be adopted.
2. Appendix W, Hawaii Wind Design Provisions for New Construction, shall be adopted.
3. Appendix X, Hawaii Provisions for Indigenous Hawaiian Architecture Structures, shall be adopted." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-9 Referenced codes. Section 101.4 is amended to read as follows:

"**101.4 Referenced codes.** The other codes referenced elsewhere in this code shall be considered guidelines of this code to the prescribed extent of each such reference.

101.4.1 Conflicts with other codes. If a referenced code conflicts with another applicable law of the jurisdiction, then said applicable law shall prevail over the guideline in the referenced code.

101.4.2 Fire prevention. Wherever the provisions of the *International Fire Code* are referenced, the *International Fire Code* shall apply to matters affecting or relating to structures, processes, and premises from the hazard of fire and explosion arising from the storage, handling, or use of structures, materials, or devices; from conditions hazardous to life, property, or public welfare in the occupancy of structures or premises; and from the construction, extension, repair, alteration, or removal of fire suppression and alarm systems or fire hazards in the structure or on the premises from occupancy or operation." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-10 Existing structures. Section 102.6 is amended to read as follows:

"**102.6 Existing structures.** Buildings in existence at the effective date of this code may have their existing use or occupancy continued if such use or occupancy was legal at the effective date of this code, provided the continued use does not constitute a hazard to the general safety and welfare of the occupants and the public." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-11 Department of building safety. Section 103 is deleted in its entirety. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-12 Permits. Section 105 is deleted in its entirety. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-13 Construction documents. Section 106 is deleted in its entirety. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-14 Temporary structures and uses. Section 107 is deleted in its entirety. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-15 Fees. Section 108 is deleted in its entirety. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-16 Fire code defined. Section 202 is amended by adding the definition of "fire code" as follows:

"**FIRE CODE.** The state fire code as adopted by the state fire council." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-17 Group I-1. Section 308.2 is amended to read as follows:

"**308.2 Group I-1.** This occupancy shall include buildings, structures or parts thereof housing more than 16 persons, on a 24-hour basis, who because of age, mental disability or other reasons, live in a supervised residential environment that provides personal care services in an assisted living facility. The residents participate in fire drills, are self starting, and may require some physical assistance from up to one staff to reach a point of safety in an emergency situation. Facilities with residents who require assistance by more than one staff, are not self starting, are bedridden beyond 14 days, or require intermittent nursing care beyond 45

days, shall reside on the first floor in all Type III, IV, and V construction, or shall be classified as Group I-2.

A facility such as the above with five or fewer persons shall be classified as a Group R-3 or shall comply with the International Residential Code in accordance with Section 101.2. A facility such as above, housing at least six and not more than 16 persons, shall be classified as Group R-4." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-18 Group I-2. Section 308.3 is amended to read as follows:

"308.3 Group I-2. This occupancy shall include buildings and structures used for personal, medical, surgical, psychiatric, nursing, or custodial care on a 24-hour basis of more than five persons who are not capable of self-preservation. This group shall include, but not be limited to, the following:

Hospitals
Nursing homes (both intermediate-care facilities and skilled nursing facilities)
Mental hospitals
Detoxification facilities
Specialized alzheimer's facilities or areas
Assisted living facilities (with residents beyond group I-1 limitations for capability)

A facility such as the above with five or fewer persons shall be classified as Group R-3 or shall comply with the International Residential Code in accordance with Section 101.2." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-19 Residential Group R. Section 310.1 is amended to read as follows:

"310.1 Residential Group R. Residential Group R includes, among others, the use of a building or structure, or a portion thereof, for sleeping purposes when not classified as an Institutional Group I. Residential occupancies shall include the following:

R-1 Residential occupancies where the occupants are primarily transient in nature, including:
Boarding houses (transient)
Hotels (transient)

Motels (transient)

R-2 Residential occupancies containing sleeping units or more than two dwelling units where the occupants are primarily permanent in nature, and facilities providing personal care services that have residents that are capable of self evacuation in an emergency situation, including:

Apartment houses
Boarding houses (not transient)
Convents
Dormitories
Facilities providing personal care services (with residents that are capable of self evacuation)
Fraternities and sororities
Hotels (nontransient)
Monasteries
Motels (nontransient)
Vacation timeshare properties

Facilities providing personal care services with 16 or fewer occupants are permitted to comply with the construction requirements for Group R-3.

R-3 Residential occupancies where the occupants are primarily permanent in nature and not classified as R-1, R-2, R-4 or I including:

Buildings that do not contain more than two dwelling units
Adult facilities that provide accommodations for five or fewer persons of any age for less than 24 hours
Child care facilities that provide accommodations for five or fewer persons of any age for less than 24 hours
Congregate living facilities with 16 or fewer persons

Adult and child care facilities that are within a single-family home are permitted to comply with the International Residential Code in accordance with Section 101.2.

R-4 Residential occupancies shall include buildings, arranged for occupancy as assisted living facilities including more than five but not more than 16 occupants, excluding staff. Residents shall meet the ability to evacuate requirements and other limitations as required in Group I-1.

Group R-4 occupancies shall meet the requirements for construction as defined for Group R-3 except as otherwise provided for in this code, or shall comply with the International Residential Code." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-20 Personal care service defined. The definition of "personal care service" in Section 310.2 is amended to read as follows:

"**PERSONAL CARE SERVICE.** The care of residents who do not require chronic or convalescent, health, medical or nursing care. Personal care involves responsibility for the safety of the resident while inside the building. The types of facilities providing personal care services shall include, but not be limited to, the following: assisted living facilities, residential care facilities, halfway houses, group homes, congregate care facilities, social rehabilitation facilities, alcohol and drug abuse centers and convalescent facilities." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-21 Assisted living facilities defined. The definition of "assisted living facilities" in Section 310.2 is amended to read as follows:

"**ASSISTED LIVING FACILITIES.** A building or part thereof housing persons, on a 24-hour basis, who because of age, mental disability or other reasons, live in a supervised residential environment which provides personal care services and are licensed by the State." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-22 Fire command station. Section 403.8 is amended to read as follows:

"**403.8 Fire command station.** Fire command stations shall comply with the fire code and be approved by the fire chief." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-23 Group I-1 assisted living facilities. Section 419.4 is added to read as follows:

"**419.4 Group I-1 assisted living facilities.** Group I-1

assisted living facilities shall comply with the provisions of Sections 419.4.1 and 419.4.2.

419.4.1 Building story limitations. Buildings shall not exceed one story in Type VB construction, two stories in Types IIB, III, IV, and VA construction, and three stories in Type IIA construction, including any allowable automatic sprinkler increases. Other construction type limitations on stories shall be limited by the provisions of Chapter 5.

419.4.2 Group I-1 smoke barriers. Group I-1 occupancies shall be provided with at least one smoke barrier in accordance with Section 709. Smoke barriers shall subdivide every story used by residents for sleeping or treatment into at least two smoke compartments. Each compartment shall have not more than 16 sleeping rooms, and the travel distance from any point in a smoke compartment to a smoke barrier door shall not exceed 150 feet (45 720 mm). At least 10 square feet (0.93 m^2) of refuge area per resident shall be provided within the aggregate area of corridors, treatment rooms, or other low hazard common space rooms on each side of each smoke barrier." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-24 Group I. Section 903.2.5 is amended to read as follows:

"903.2.5 Group I. An automatic sprinkler system shall be provided throughout buildings with Group I fire area." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-25 Group R. Section 903.2.7 is amended to read as follows:

"903.2.7 Group R. An automatic sprinkler system installed in accordance with Section 903.3 shall be provided throughout all buildings with a Group R fire area.

Exception: R-3 residential occupancies."

[Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-26 Features. Section 911.1 is amended to read as follows:

"911.1 Features. Where required by other sections of this code, a fire command center for fire department operations shall be provided and shall comply with the

fire code and be approved by the fire chief."
[Eff APR 16 2010] (Auth: HRS §107-29)
(Imp: HRS §§107-24, 107-25)

§3-180-27 Gates. Section 1008.2 is amended to read as follows:

"**1008.2 Gates.** Gates serving the means of egress system shall comply with the requirements of this section. Gates used as a component in a means of egress shall conform to the applicable requirements for doors.

Exceptions:

1. Horizontal sliding or swinging gates exceeding the 4-foot (1219 mm) maximum leaf width limitation are permitted in fences and walls surrounding a stadium.
2. Security gates may be permitted across corridors or passageways in school buildings if there is a readily visible durable sign on or adjacent to the gate, stating 'THIS GATE IS TO REMAIN SECURED IN THE OPEN POSITION WHENEVER THIS BUILDING IS IN USE'. The sign shall be in letters not less than one inch high on a contrasting background. The use of this exception may be revoked by the building official for due cause." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-28 Accessibility. Chapter 11 is deleted in its entirety and replaced to read as follows:

"**Chapter 11 - Accessibility**

1101 Scope. Buildings or portions of buildings shall be accessible to persons with disabilities in accordance with the following regulations:

1. For construction of buildings or facilities of the state and county governments, compliance with Section 103-50, HRS, administered by the Disability and Communication Access Board, State of Hawaii.
2. Americans with Disabilities Act, administered and enforced by the U.S. Department of Justice.
3. Fair Housing Act, administered and enforced by the U.S. Department of Housing and Urban Development.
4. Other pertinent laws relating with disabilities shall be administered and enforced by agencies responsible for their enforcement.

Prior to the issuance of a building permit, the owner (or

the owner's representative, professional architect, or engineer), shall submit a statement that all requirements, relating to accessibility for persons with disabilities, shall be complied with." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-29 Unvented attic spaces. Section 1203.2.2 is added to read as follows:

"1203.2.2 Unvented attic spaces. The attic space shall be permitted to be unvented when the design professional determines it would be beneficial to eliminate ventilation openings to reduce salt-laden air and maintain relative humidity 60 per cent or lower to:

1. Avoid corrosion to steel components,
2. Avoid moisture condensation in the attic space, or
3. Minimize energy consumption for air conditioning or ventilation by maintaining satisfactory space conditions in both the attic and occupied space below." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-30 Live loads posted. Section 1603.3 is amended to read as follows:

"1603.3 Live loads posted. Where the live loads for which each floor or portion thereof of a commercial or industrial building is or has been designed to exceed 100 psf (4.80 kN/m^2), such design live loads shall be conspicuously posted by the owner in that part of each story in which they apply, using durable signs. It shall be unlawful to remove or deface such notices." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-31 Seismic design - short term. Table 1613.5.6(1) is amended to read as follows:

"Table 1613.5.6(1)
Seismic Design Category Based On Short-Period Response Acceleration

Value of S_{DS}	Occupancy Category		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50 \le S_{DS} < 0.60g$	C	D	D
$0.60g \le S_{DS}$	D	D	D

"

[Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-32 Seismic design - 1-second period. Table 1613.5.6(2) is amended to read as follows:

"Table 1613.5.6(2)
Seismic Design Category Based On 1-Second Period Response Acceleration

Value of S_{DI}	Occupancy Category		
	I or II	III	IV
$S_{DI} < 0.067g$	A	A	A
$0.067g \le S_{DI} < 0.133g$	B	B	C
$0.133g \le S_{DI} < 0.20g$	C	C	D
$0.20g \le S_{DI} < 0.25g$	C	D	D
$0.25g \le S_{DI}$	D	D	D

"

[Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-33 Design rain loads. Section 1611.1 is amended to read as follows:

"1611.1 Design rain loads. Each portion of a roof shall be designed to sustain the load of rainwater that will accumulate on it if the primary drainage system for that portion is blocked plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow. The design rainfall rate shall be based on the 100-year 1-hour rainfall rate indicated in Figure 1611.1 as published by the National Weather Service

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or on other rainfall rates determined from approved local weather data.

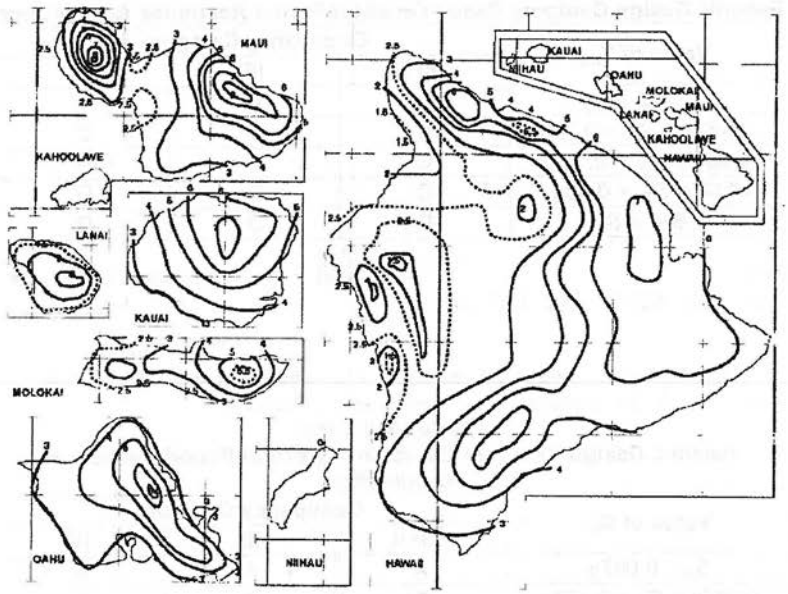

Figure 1611.1
100-Year, 1-Hour Rainfall (inches) Hawaii
For SI: 1 inch = 25.4 mm.
Source: National Weather Service, national Oceanic and Atmospheric Administration, Washington D.C."

[Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-34 Structural observation defined. The definition of "structural observation" in Section 1702 is amended to read as follows:

"STRUCTURAL OBSERVATION. Structural observation is as defined in chapter 16-115, Hawaii Administrative Rules, implementing chapter 464, Hawaii Revised Statutes. Structural observation does not include or waive the responsibility for the inspection required by Section 109, 1704 or other sections of this code." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-35 General. Section 1704.1 is amended to read as follows:

"**1704.1 General.** Where application is made for construction as described in this section, the owner or the registered design professional in responsible charge acting as the owner's agent shall employ one or more special inspectors to provide inspections during construction on the types of work listed under Sections 1704 and 1707. The special inspector shall be a qualified person who shall demonstrate competence, to the satisfaction of the building official, for inspection of the particular type of construction or operation requiring special inspection. These inspections are in addition to the inspections specified in Section 109.

Exceptions:

1. Special inspections are not required for work of a minor nature or as warranted by conditions in the jurisdiction as approved by the building official.
2. Special inspections are not required for building components unless the design involves the practice of professional engineering or architecture as defined by applicable state statutes and regulations governing the professional registration and certification of engineers or architects.
3. Unless otherwise required by the building official, special inspections are not required for occupancies in Group R-3 as applicable in Section 101.2 and occupancies in Group U that are accessory to a residential occupancy including, but not limited to, those listed in Section 312.1." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-36 Statement of special inspections. Section 1704.1.1 is amended to read as follows:

"**1704.1.1 Statement of special inspections.** The construction drawings shall include a complete list of special inspections required in Sections 1704, 1707 and 1708." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-37 Report requirement. Section 1704.1.2 is amended to read as follows:

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"1704.1.2 **Report requirement.** Special inspectors shall keep records of inspections. The special inspector shall furnish inspection reports to the owner and licensed engineer or architect of record. Reports shall indicate that work inspected was done in conformance to approved construction documents. Discrepancies shall be brought to the immediate attention of the contractor for correction, then, if uncorrected, to the licensed engineer or architect of record and to the building official. The special inspector shall submit a final signed report to the owner and licensed engineer or architect of record, stating whether the work requiring special inspection was, to the best of the inspector's knowledge, in conformance to the approved plans and specifications and the applicable workmanship provisions of this code. Prior to the final inspection required under Section 109.3.10, the licensed engineer or architect of record shall submit a written statement verifying receipt of the final special inspection reports and documenting that there are no known unresolved code requirements that create significant public safety deficiencies." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-38 Statement of special inspections. Section 1705 is deleted in its entirety. [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-39 Structural observations. Section 1709 is amended to read as follows:

"1709 **Structural observations.** Structural observations shall be performed in accordance with Section 464-5, Hawaii Revised Statutes, administered and enforced by the Department of Commerce and Consumer Affairs." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-40 Splices. Section 1808.2.7 is amended to read as follows:

"1808.2.7 **Splices.** Splices shall be constructed so as to provide and maintain true alignment and position of the component parts of the pier or pile during installation and subsequent thereto and shall be of adequate strength to transmit the vertical and lateral loads and moments

occurring at the location of the splice during driving and under service loading. Splices occurring in the upper 10 feet (3048 mm) of the embedded portion of the pier or pile shall be capable of resisting at allowable working stresses the moment and shear that would result from an assumed eccentricity of the pier or pile load of 3 inches (76 mm), or the pier or pile shall be braced in accordance with Section 1808.2.5 to other piers or piles that do not have splices in the upper 10 feet (3048 mm) of embedment." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-41 Cleanouts. Section 2104.1.9 is added to read as follows:

"**2104.1.9 Cleanouts.** Cleanouts shall be provided for all grout pours over 5 feet 4 inches in height. Special provisions shall be made to keep the bottom and sides of the grout spaces, as well as the minimum total clear area required by ACI 530.1-05/ASCE 6-05/TMS 602-05 clean and clear prior to grouting.

Exception: Cleanouts are not required for grout pours 8 feet or less in height providing all of the following conditions are met:

1. The hollow masonry unit is 8-inch nominal width or greater with specified compressive strength f_m less than or equal to 1,500 psi;
2. Fine grout is used complying with ASTM C-476 minimum compressive strength of 2,500 psi; and
3. Special Inspection is provided." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-42 Preservative-treated wood. Section 2303.1.8 is amended to read as follows:

"**2303.1.8 Preservative-treated wood.** Structural lumber, including plywood, posts, beams, rafters, joists, trusses, studs, plates, sills, sleepers, roof and floor sheathing, flooring and headers of new wood-frame buildings and additions shall be:

1. Treated in accordance with AWPA Standard U1 (UC1 thru UC4B) for AWPA Standardized Preservatives, all marked or branded and monitored by an approving agency. Incising is not required, providing that the retention and penetration requirements of these standards are met.

2. For SBX disodium octaborate tetrahydrate (DOT), retention shall be not less than 0.28 pcf B_2O_3 (0.42 pcf DOT) for exposure to Formosan termites. All such lumber shall be protected from direct weather exposure as directed in AWPA UC1 and UC2.
3. For structural glue-laminated members made up of dimensional lumber, engineered wood products, or structural composite lumber, pressure treated in accordance with AWPA U1 (UC1 thru UC4B) or by Light Oil Solvent Preservative (LOSP) treatment standard as approved by the building official. Water based treatment processes as listed in paragraphs 1 and 2 are not allowed to be used on these products unless specified by a structural engineer for use with reduced load values and permitted by the product manufacturer.
4. For structural composite wood products, treated by non-pressure processes in accordance with AWPA Standard U1 (UC1, UC2 and UC3A) or approved by the building official.

2303.1.8.1 Treatment. Wood treatment shall include the following:

1. A quality control and inspection program which meets or exceeds the current requirements of AWPA Standards M2-01 and M3-03;
2. Inspection and testing for the treatment standards as adopted by this code shall be by an independent agency approved by the building official, accredited by the American Lumber Standards Committee (ALSC) and contracted by the treating company;
3. Field protection of all cut surfaces with a preservative, which shall be applied in accordance with AWPA Standard M-4-02 or in accordance with the approved preservative manufacturer's ICC-Evaluation Services report requirements.

2303.1.8.2 Labeling. Labeling shall be applied to all structural lumber 2 inches or greater nominal thickness, with the following information provided on each piece as a permanent ink stamp on one face or on a durable tag permanently fastened to ends with the following information:

1. Name of treating facility;
2. Type of preservative;
3. AWPA use category;
4. Quality mark of third party inspection agency;

6. Year of treatment.

All lumber less than 2 inches in nominal thickness, shall be identified per bundle by means of a label consisting of the above requirements. Labels measuring no less than 6 inches by 8 inches shall be placed on the lower left corner of the strapped bundle.

2303.1.8.3 Moisture content of treated wood. When wood pressure treated with a water-borne preservative is used in enclosed locations where drying in service cannot readily occur, such wood shall be at a moisture content of 19 percent or less before being covered with insulation, interior wall finish, floor covering or other material." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-43 Fasteners in non-borate-preservative-treated and fire-retardant-treated wood. Section 2304.9.5 is amended to read as follows:

"2304.9.5 Fasteners in non-borate-preservative-treated and fire-retardant-treated wood. Fasteners for preservative-treated and fire-retardant-treated wood, other than Borate (SBX, ZB) or LOSP treatments as approved in Section 2303.1.8 Preservative-treated wood, shall be of hot dipped zinc-coated galvanized steel, stainless steel, silicone bronze or copper. The coating weights for zinc-coated fasteners shall be in accordance with ASTM A 153.

Exception: Fasteners other than nails, timber rivets, wood screws and lag screws shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B 695, Class 55 minimum.

Fastenings for wood foundations shall be as required in AF&PA Technical Report No. 7." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-44 Protection against decay and termites. Section 2304.11 is amended to read as follows:

"2304.11 Protection against decay and termites.

2304.11.1 General. Where required by this section, protection from decay and termites shall be provided by the use of naturally durable or preservative-treated wood.

2304.11.2 Wood used above ground. Structural lumber installed above ground shall be preservative-treated wood in accordance with Section 2303.1.8.

2304.11.2.1 Soil treatment and termite barriers. Where structural lumber of wood frame buildings or structures are supported directly on the ground by a concrete slab, or concrete and/or masonry foundation, Formosan subterranean termite protection shall be provided by either chemically treating the soil beneath and adjacent to the building or structure by a Hawaii-licensed pest control operator, or stainless steel termite barrier, or other termite protection measures approved by the building official.

All soil treatment, stainless steel termite barrier, and termite protection measures shall be installed according to manufacturer's recommendations for control of Formosan subterranean termites.

2303.11.3 Wood in ground contact. Wood supporting permanent buildings and structures, which is in direct soil contact or is embedded in concrete or masonry in direct contact with earth shall be treated to the appropriate commodity specification of AWPA Standard U1.

Wood in direct soil contact but not supporting any permanent buildings or structures shall be treated to the appropriate commodity specification of AWPA Standard U1 for ground contact.

2304.11.4 Retaining walls. Wood in retaining or crib wall shall be treated to AWPA Standard U1.

2304.11.5 Wood and earth separation. Where wood is used with less than 6-inch vertical separation from earth (finish grade), the wood shall be treated for ground-contact use.

Where planter boxes are installed adjacent to wood frame walls, a 2-inch-wide (51 mm) air space shall be provided between the planter and the wall. Flashings shall be installed when the air space is less than 6 inches (152 mm) in width. Where flashing is used, provisions shall be made to permit circulation of air in the air space. The wood-frame wall shall be provided with an exterior wall covering conforming to the provisions of section 2304.6.

2304.11.6 Under-floor clearance for access and inspection. Minimum clearance between the bottom of floor joists or bottom of floors without joists and the ground beneath shall be 24 inches; the minimum clearance between the bottom of girders and the ground beneath shall be 18 inches.

Exception: Open slat wood decks shall have ground clearance of at least 6 inches for any wood member.

Accessible under-floor areas shall be provided with a minimum 18 inch-by 24 inch access opening, effectively screened or covered. Pipes, ducts and other construction shall not interfere with the accessibility to or within under-floor areas.

2304.11.7 Wood used in retaining walls and cribs. Wood installed in retaining or crib walls shall be preservative treated in accordance with AWPA U1 (Commodity Specifications A or F) for soil and fresh water use.

2304.11.8 Weather exposure. All portions of timbers (over 5-inch nominal width) and glued-laminated timbers that form structural supports of a building or other structure shall be protected by a roof, eave, overhangs, flashings, or similar coverings.

All wood or wood composite panels, in weather-exposed applications, shall be of exterior type.

2304.11.9 Water splash. Where wood-frame walls and partitions are covered on the interior with plaster, tile or similar materials and are subject to water splash, the framing shall be protected with approved waterproof paper conforming to Section 1404.2.

2304.11.10 Pipe and other penetrations. Insulations around plumbing pipes shall not pass through ground floor slabs. Openings around pipes or similar penetrations in a concrete or masonry slab, which is in direct contact with earth, shall be filled with non-shrink grout, BTB, or other approved physical barrier." [Eff APR 16 2010]
(Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-45 General. Section 2308.1 is amended to read as follows:

"**2308.1 General.** The requirements of this section are intended for conventional light-frame construction. Other methods are permitted to be used, provided a satisfactory design is submitted showing compliance with other provisions of this code. Interior nonload-bearing partitions, ceilings and curtain walls of conventional light-frame construction are not subject to the limitations of this section. Alternatively, compliance with AF&PA WFCM shall be permitted subject to the limitations therein and the limitations of this code." [Eff APR 16 2010]
(Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-46 Scope. Section 2701.1 is amended to read as follows:

"**2701.1 Scope.** This chapter governs the electrical components, equipment and systems used in buildings and structures covered by this code. Electrical components, equipment and systems shall be designed and constructed in accordance with the provisions of the National Electrical Code, NFPA 70." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-47 Scope. Section 2901.1 is amended to read as follows:

"**2901.1 Scope.** The provisions of this chapter and the Uniform Plumbing Code shall govern the erection, installation, alteration, repairs, relocation, replacement, addition to, use, or maintenance of plumbing equipment and systems. Plumbing systems and equipment shall be constructed, installed, and maintained in accordance with the Uniform Plumbing Code and adopted amendments. Private sewage disposal systems shall conform to the International Private Sewage Disposal Code." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-48 Scope. Section 3001.1 is amended to read as follows:

"**3001.1 Scope.** This chapter shall be a guideline and governs the design, construction, installation, alteration, and repair of elevators and conveying systems and their components. If this chapter conflicts with another applicable law of the jurisdiction, then said applicable law shall prevail over this chapter." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-49 Public swimming pools. Section 3109.3 is amended to read as follows:

"**3109.3 Public swimming pools.** Public swimming pools shall be completely enclosed by a fence at least 4 feet (1290 mm) in height or a screen enclosure. Openings in the fence shall not permit the passage of a 4-inch-diameter (102 mm) sphere. The fence or screen enclosure shall be equipped with self-closing and self-latching gates.

Exception: Swimming, dipping, or wading pools located

on the premises of a hotel are not required to be enclosed." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-50 Conformance. Section 3405.1 is amended to read as follows:

"3405.1 Conformance. The installation or replacement of glass shall be as required by Chapter 24 for new installations." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-51 Compliance with other codes. Section 3410.3.2 is amended to read as follows:

"3410.3.2 Compliance with other codes. Buildings that are evaluated in accordance with this section shall comply with the state fire code." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-52 Appendix U - Hawaii hurricane sheltering provisions for new construction. Appendix U is added to read as follows:

"APPENDIX U

Hawaii Hurricane Sheltering Provisions for New Construction

Section U101 Community storm shelters. Chapter 4 is amended by adding Section 421 to read as follows:

SECTION 421 Community storm shelters

421.1 General. In addition to other applicable requirements in this code, community storm shelters and the following specific Occupancy Category IV buildings shall be constructed in accordance with ICC/NSSA-500:

1. Designated earthquake, hurricane or other emergency shelters.
2. Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response.

421.1.1 Scope. This appendix applies to the construction of storm shelters constructed as separate detached buildings or constructed as safe rooms within buildings for the purpose of providing safe refuge from storms that produce high winds, such as hurricanes. Such

structures shall be designated to be hurricane shelters.

421.2 Definitions. The following words and terms shall, for the purposes of this chapter and as used elsewhere in this code, have the meanings shown herein.

COMMUNITY STORM SHELTER. A building, structure, or portion thereof, constructed in accordance with ICC 500-08 ICC/NSSA Standard on the Design and Construction of Storm Shelters and designated for use during a severe wind storm event such as a hurricane.

Section U102 Hawaii residential safe room. Chapter 4 is amended by adding Section 422 to read as follows:

SECTION 422 Hawaii residential safe room

422.1 Performance-based design criteria. The residential safe room shall meet the minimum performance specifications of Sections 422.1.1 through 422.9.

422.1.1 Intent and scope. The intent of the residential safe room is to temporarily provide an enhanced protection area, fully enclosed within a dwelling or within an accessory structure to a residence, which is designed and constructed to withstand the wind pressures, windborne debris impacts, and other requirements of this section.

422.1.2 Alternative standards.

1. **Manufactured safe room designs subject to approval.** A manufactured safe room or safe room kit may be substituted if documentation is submitted and approved by the building official. The safe room shall be engineered, tested, and manufactured to meet or exceed the criteria of this section.
2. **FEMA in-residence shelter designs permitted.** It shall be permissible to build FEMA In-Residence Shelters of up to 64 square feet of floor area with walls up to 8 feet long that are built in accordance with construction details of FEMA 320.

422.2 Site criteria. Residential safe rooms shall not be constructed within areas subject to stream flooding, coastal flooding or dam failure inundation within any of the following areas:

1. FEMA Special Flood Hazard Areas (SFHA) subject to rainfall runoff flooding or stream or flash flooding;
2. Coastal zones "V" or "A" identified in the Flood Insurance Rate Map (FIRM) issued by FEMA for floodplain management purposes, in which the flood hazard are tides, storm surge, waves, tsunamis, or a combination of these hazards;
3. Areas subject to dam failure inundation as determined

by the Department of Land and Natural Resources.

422.3 Maximum occupancy. The safe room is permitted to be used for a maximum occupancy based on at least 15 square feet per person with a maximum of 8 persons in a room of up to 128 square feet of floor area.

422.4 Provisions for exiting. The room shall be equipped with an inward-swinging door and an impact-protected operable window suitable for a means of alternative exiting in an emergency.

422.5 Design for dead, live, wind, rain, and impact loads.

422.5.1 Structural integrity criteria.

1. The residential safe room shall be built with a complete structural system and a complete load path for vertical and lateral loads caused by gravity and wind.
2. The building that the residential safe room is in shall be assumed to be destroyed by the storm and shall not be taken as offering any protective shielding to the safe room enclosure.
3. The ceiling structure and wall shall be capable of supporting a superimposed debris load of the full weight of any building floors and roof above, but not less than 125 psf.
4. The residential safe room enclosure shall be capable of simultaneously resisting lateral and uplift wind pressures corresponding to a 160 mph 3-second peak gust, determined in accordance with ASCE 7, Minimum Design Loads for Buildings and Other Structures, calculated using load and importance Factors of 1.0. The site exposure factor shall be based on exposure C. The gust factor and the directionality factor shall be taken as 0.85. Topographic wind amplification caused by mountainous terrain shall be considered in accordance with the building code. Internal pressure shall be determined in accordance with ASCE 7.
5. The residential safe room shall be anchored to a foundation system capable of resisting the above loading conditions.

422.5.2 Windborne debris impact protection of building enclosure elements. The entire enclosure of the safe room, including all walls, ceilings, and openings, fixed or operable windows, and all entry doors into the safe room, shall meet or exceed Level D requirements of ASTM E 1996 (Table 422.5-1). Any wall or ceiling penetration greater

than 4 square inches shall be considered an opening.

Exception: Electrical outlet boxes and interior lighting switches not penetrating more than 2.5-inches into the interior wall surface and a plumbing piping or conduit not greater than 1.5-inch in diameter shall be exempted from this requirement.

422.5.3 Cyclic pressure loading of glazing and protective systems. Impact protective systems shall meet the ASTM E 1996 cyclic pressure requirement for the loading given in Table 422.5-1.

Table 422.5-1
Windborne Debris Protection and Cyclic Pressure Criteria for Residential Safe Rooms

ASTM E 1996 Missile Level Rating	Debris Missile Size	Debris Impact Speed	Enclosure Wall Ceiling, and Floor Cyclic Air Pressure Testing - maximum inward and maximum outward pressures
D	2 x 4 weighing 9.0 lb. +/- 0.25 lb., and with min. length 8 ft. +/- 4-inch	50 ft./sec. or at least 34 mph	35 psf inward 45 psf outward

422.6 Ventilation. The residential safe room shall be naturally ventilated to allow the enclosure to have approximately one air change every two hours. This requirement may be satisfied by 12 square inches of venting per occupant. There shall be at least two operable vents. The vents shall be protected by a cowling or other device that shall be impact tested to comply with ASTM E 1996 Level D. Alternatively, the room shall be evaluated to determine if the openings are of sufficient area to constitute an open or partially enclosed condition as defined in ASCE 7.

422.7 Communications. The residential safe room shall be equipped with a phone line and telephone that does not rely on a separate electrical power outlet. Alternatively, a wireless telephone shall be permitted to rely on an Uninterruptible Power Supply (UPS) battery device.

422.8 Construction documents. Construction documents for the residential safe room shall be directly prepared by a Hawaii-licensed professional structural engineer.

422.9 Special inspection. The construction or installation of the residential safe room shall be verified for conformance to the drawings in accordance with Chapter

17.

422.10 Notification. The owner of the residential safe room shall notify the state department of defense and county civil defense agency of the property's Tax map key or global positioning system coordinates.

Section U103 State- and County-owned public high occupancy buildings - design criteria for enhanced hurricane protection areas. Chapter 4 is amended by adding Section 423 to read as follows:

SECTION 423 State- and County-owned public high occupancy buildings - design criteria for enhanced hurricane protection areas

423.1 Intent. The purpose of this section is to establish minimum life safety design criteria for enhanced hurricane protection areas in high occupancy state- and county-owned buildings occupied during hurricanes of up to Saffir Simpson Category 3.

423.2 Scope. This section shall apply to state- and county-owned buildings which are of Occupancy Category III and IV defined by Table 1604.5 and of the following specific occupancies:

1. Enclosed and partially enclosed structures whose primary occupancy is public assembly with an occupant load greater than 300.
2. Health care facilities with an occupant load of 50 or more resident patients, but not having surgery or emergency treatment facilities.
3. Any other state- and county-owned enclosed or partially enclosed building with an occupant load greater than 5,000.
4. Hospitals and other health care facilities having surgery or emergency treatment facilities.

Exception: Facilities located within flood zone V and flood zone A that are designated by the owner to be evacuated during hurricane warnings declared by the National Weather Service, shall not be subject to these requirements.

423.3 Site criteria.

423.3.1 Flood and tsunami zones. Comply with ASCE 24-05, Flood Resistant Design and Construction, based on provisions for Occupancy Category III.

1. Floor slab on grade shall be 1.5 foot above the base flood elevation of the county's flood hazard map, or at higher elevation as determined by a

modeling methodology that predicts the maximum envelope and depth of inundation including the combined effects of storm surge and wave actions with respect to a Category 3 hurricane.

2. Locate outside of V and Coastal A flood zones unless justified by site-specific analysis or designed for vertical evacuation in accordance with a method approved by the building official. When a building within a V or Coastal A flood zone is approved, the bottom of the lowest structural framing member of any elevated first floor space shall be 2 feet above the base flood elevation of the county's flood hazard map, or at higher elevation as determined by a modeling methodology that predicts the maximum envelope and depth of inundation including the combined effects of storm surge and wave actions with respect to a Category 3 hurricane.
3. Locate outside of tsunami evacuation zones unless justified by site-specific analysis or designed for vertical evacuation in accordance with a method approved by the building official.

423.3.2 Emergency vehicle access. Provide at least one route for emergency vehicle access. The portion of the emergency route within the site shall be above the 100-year flood elevation.

423.3.3 Landscaping and utility laydown impact hazards. Landscaping around the building shall be designed to provide standoff separation sufficient to maintain emergency vehicle access in the event of mature tree blowdown. Trees shall not interfere with the functioning of overhead or underground utility lines, nor cause laydown or falling impact hazard to the building envelope or utility lines.

423.3.4 Adjacent buildings. The building shall not be located within 1,000 feet of any hazardous material facilities defined by Table 1604.5. Unanchored light-framed portable structures shall be not permitted within 300 feet of the building.

423.4 Enhanced hurricane protection area program requirements.

423.4.1 Applicable net area. At least 50 per cent of the net square feet of a facility shall be constructed to qualify as an enhanced hurricane protection area. The net floor area shall be determined by subtracting from the gross square feet the floor area of excluded spaces,

exterior walls, columns, fixed or movable objects, equipment or other features that under probable conditions cannot be removed or stored during use as a storm shelter.

423.4.2 Excluded spaces. Spaces such as mechanical rooms, electrical rooms, storage rooms, attic and crawl spaces, shall not be considered as net floor area permitted to be occupied during a hurricane.

423.4.3 Occupancy capacity. The occupancy capacity shall be determined by dividing the net area of the enhanced hurricane protection area by 15 square feet net floor area per person.

423.4.4 Toilets and hand washing facilities. Provide a minimum of 1 toilet per 50 enhanced hurricane protection area occupants and a minimum of 1 sink per 100 enhanced hurricane protection area occupants, as determined in accordance with Section 423.4.3, located within the perimeter of the enhanced hurricane protection area. These required toilet and hand-washing facilities are not in addition to those required for normal occupancy and shall be included in the overall facility fixture count.

423.4.5 Accessibility. Where the refuge occupancy accommodates more than 50 persons, provide an ADA-accessible route to a shelter area at each facility with a minimum of 1 wheelchair space for every 200 enhanced hurricane protection area occupants determined in accordance with Section 423.4.3.

423.5 Design wind, rain, and impact loads.

423.5.1 Structural design criteria. The building main wind force resisting system and structural components shall be designed per ASCE 7 for a 115 mph minimum peak 3-second gust design speed with a load factor of 1.6, and an importance factor for Occupancy Category III. Topographic and directionality factors shall be the site-specific values determined in accordance with Appendix W. Design for interior pressure shall be based on the largest opening in any exterior facade or roof surface.

423.5.2 Windborne debris missile impact for building enclosure elements. Exterior glazing and glazed openings, louvers, roof openings and doors shall be provided with windborne debris impact resistance or protection systems conforming to ASTM E1996-05 Level D, i.e., 9 lb., 2 X 4, @ 50 fps (34 mph).

423.5.3 Cyclic pressure loading of impact resistive glazing or windborne impact protective systems. Resistance to the calculated maximum inward and outward pressure shall be designed to conform to ASTM E1996-05.

423.5.4 Windows. All unprotected window assemblies and their anchoring systems shall be designed and installed to meet the wind load and missile impact criteria of this section.

423.5.5 Window protective systems. Windows may be provided with permanent or deployable protective systems, provided the protective system is designed and installed to meet the wind load and missile impact criteria and completely covers the window assembly and anchoring system.

423.5.6 Doors. All exterior and interior doors subject to possible wind exposure or missile impact shall have doors, frames, anchoring devices, and vision panels designed and installed to resist the wind load and missile impact criteria or such doors, frames, anchoring devices, and vision panels shall be provided with impact protective systems designed and installed to resist the wind load and missile impact criteria of this section.

423.5.7 Exterior envelope. The building enclosure, including walls, roofs, glazed openings, louvers and doors, shall not be perforated or penetrated by windborne debris, as determined by compliance with ASTM E1996-05 Level C.

423.5.8 Parapets. Parapets shall satisfy the wind load and missile impact criteria of the exterior envelope.

423.5.9 Roofs

423.5.9.1 Roof openings. Roof openings (e.g., HVAC fans, ducts, skylights) shall be provided with protection for the wind load and missile impact criteria of Sections 423.5.2 and 423.5.3.

423.5.9.2 High wind roof coverings. Roof coverings shall be specified and designed according to the latest ASTM Standards for high wind uplift forces.

423.5.9.3 Roof drainage. Roofs shall have adequate slope, drains and overflow drains or scuppers sized to accommodate 100-year hourly rainfall rates in accordance with Section 1611.1, but not less than 2-inches per hour for 6 continuous hours.

423.6 Ventilation

423.6.1 Mechanical ventilation. Mechanical ventilation as required in accordance with the International Mechanical Code. Air intakes and exhausts shall be designed and installed to meet the wind load and missile impact criteria of Sections 423.5.2 and 423.5.3.

423.6.2 HVAC equipment anchorage. HVAC equipment mounted on roofs and anchoring systems shall be designed and installed to meet the wind load criteria. Roof openings for roof-mounted HVAC equipment shall have a 12-

inch-high curb designed to prevent the entry of rain water.

423.7 Standby electrical system capability. Provide a standby emergency electrical power system per Chapter 27 and NFPA 70 Article 700 Emergency Systems and Article 701 Legally Required Standby Systems, which shall have the capability of being connected to an emergency generator or other temporary power source. The emergency system capabilities shall include:

1. An emergency lighting system;
2. Illuminated exit signs;
3. Fire protection systems, fire alarm systems and fire sprinkler systems; and
4. Minimum mechanical ventilation for health/safety purposes.

423.7.1 Emergency generator. When emergency generators are pre-installed, the facility housing the generator, permanent or portable, shall be an enclosed area designed to protect the generators from wind and missile impact. Generators hardened by the manufacturer to withstand the area's design wind and missile impact criteria shall be exempt from the enclosed area criteria requirement.

423.8 Quality assurance

423.8.1 Information on construction documents. Construction documents shall include design criteria, the occupancy capacity of the enhanced hurricane protective area, and Project Specifications shall include opening protection devices. Floor plans shall indicate all enhanced hurricane protection area portions of the facility and exiting routes there from. The latitude and longitude coordinates of the building shall be recorded on the construction documents.

423.8.2. Special inspection. In addition to the requirements of Chapter 17, special inspections shall include at least the following systems and components:

1. Roof cladding and roof framing connections;
2. Wall connections to roof and floor diaphragms and framing;
3. Roof and floor diaphragm systems, including collectors, drag struts and boundary elements;
4. Vertical windforce-resisting systems, including braced frames, moment frames and shear walls;
5. Windforce-resisting system connections to the foundation; and
6. Fabrication and installation of systems or components required to meet the impact-resistance requirements of Section 1609.1.2.

Exception: Fabrication of manufactured systems or

components that have a label indicating compliance with the wind-load and impact-resistance requirements of this code.

423.8.3 Quality assurance plan. A construction quality assurance program shall be included in the construction documents and shall include:

1. The materials, systems, components, and work required to have special inspection or testing by the building official or by the registered design professional responsible for each portion of the work;
2. The type and extent of each special inspection;
3. The type and extent of each test;
4. Additional requirements for special inspection or testing for seismic or wind resistance; and
5. For each type of special inspection, identification as to whether it will be continuous special inspection or periodic special inspection.

423.8.4 Peer review. Construction documents shall be independently reviewed by a Hawaii-licensed structural engineer. A written opinion report of compliance shall be submitted to State Civil Defense, the building official, and the owner.

423.9 Maintenance. The building shall be periodically inspected every three years and maintained by the owner to ensure structural integrity and compliance with this section. A report of inspection shall be furnished to the State Civil Defense.

423.10 Compliance re-certification when altered, deteriorated, or damaged. Alterations shall be reviewed by a Hawaii-licensed structural engineer to determine whether any alterations would cause a violation of this section. Deterioration or damage to any component of the building shall require an evaluation by a Hawaii-licensed structural engineer to determine repairs necessary to maintain compliance with this section." [Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-53 Appendix W - Hawaii wind design provisions for new construction. Appendix W is added to read as follows:

"APPENDIX W

Hawaii Wind Design Provisions for New Construction

W101 Revisions to chapter 16. When Appendix W is adopted,

wind design shall be in accordance with Chapter 16 as amended by Sections W101.1 through W101.10.

W101.1 Revisions to section 1603.1. Section 1603.1 is amended to read as follows:

1603.1 General. Construction documents shall show the size, section, and relative locations of structural members with floor levels, column centers and offsets dimensioned. The design loads and other information pertinent to the structural design required by Sections 1603.1.1 through 1603.1.8 shall be indicated on the construction documents.

Exception: Construction documents for buildings constructed in accordance with the conventional light-frame construction provisions of Section 2308 shall indicate the following structural design information:

1. Floor and roof live loads.
2. Ground snow load, P_g.
3. Basic wind speed (3-second gust), and effective wind speed V_{eff} (3-second gust), miles per hour (mph) (km/hr) and wind exposure.
4. Seismic design category and site class.
5. Flood design data, if located in flood hazard areas established in Section 1612.3.

W101.2 Revisions to section 1603.1.4. Section 1603.1.4 is amended to read as follows:

1603.1.4 Wind design data. The following information related to wind loads shall be shown, regardless of whether wind loads govern the design of the lateral-force-resisting system of the building:

1. Basic wind speed (3-second gust), miles per hour (km/hr), V, and effective windspeed V_{eff}.
2. Wind importance factor I, and building category.
3. Wind exposure, if more than one wind exposure is utilized, the wind exposure for each applicable wind direction shall be indicated.
4. The applicable internal pressure coefficient.
5. Components and cladding. The design wind pressures in terms of psf (kN/m^2) used for the design of exterior components, and cladding not specifically designed by the registered design professional.

W101.3 Revisions to section 1609.1.1. Section 1609.1.1 is amended to read as follows:

1609.1.1 Determination of wind loads. Wind loads on every building or structure shall be determined in accordance with Chapter 6 of ASCE 7. Minimum values for Directionality Factor, K_d, Velocity Pressure Exposure Coefficient, K_z, and Topographic Factor, K_{zt}, shall be

determined in accordance with Section 1609. The type of opening protection required, the basic wind speed and the exposure category for a site is permitted to be determined in accordance with Section 1609 or ASCE 7. Wind shall be assumed to come from any horizontal direction and wind pressures shall be assumed to act normal to the surface considered.

Exceptions:

1. Subject to the limitations of Section 1609.1.1.1, the provisions of SBCCI SSTD 10 shall be permitted for applicable Group R-2 and R-3 buildings.
2. Subject to the limitations of Section 1609.1.1.1, residential structures using the provisions of the AF&PA WFCM.
3. Designs using NAAMM FP 1001.
4. Designs using TIA/EIA-222 for antenna-supporting structures and antennas.

W101.4 Revisions to section 1609.1.2. Section 1609.1.2 is amended to read as follows:

1609.1.2 Protection of openings. In wind-borne debris regions, glazing in building shall be impact-resistant or protected with an impact-resistant covering meeting the requirements of an approved impact-resisting standard or ASTM E 1996 and ASTM E 1886 referenced therein as follows:

1. Glazed openings located within 30 feet (9144 mm) of grade shall meet the requirements of the Large Missile Test of ASTM E 1996.
2. Glazed openings located more than 30 feet (9144 mm) above grade shall meet the provisions of the Small Missile Test of ASTM E 1996.

   Exceptions:

   1. Wood structural panels with a minimum thickness of 7/16 inch (11.1 mm) and a maximum panel span of 8 feet (2438 mm) shall be permitted for opening protection in one- and two-story buildings. Panels shall be precut so that they shall be attached to the framing surrounding the opening containing the product with the glazed opening. Panels shall be secured with the attachment hardware provided. Attachments shall be designed to resist the components and cladding loads determined in accordance with the provisions of ASCE 7. Attachment in accordance with Table 1609.1.2 is permitted for buildings with a mean roof height of 33 feet (10 058 mm) or less where wind speeds do not exceed 130 mph

(57.2 m/s).

2. Glazing in Occupancy Category I buildings as defined in Section 1604.5, including greenhouses that are occupied for growing plants on a production or research basis, without public access shall be permitted to be unprotected.

3. Glazing in Occupancy Category II, III or IV buildings located over 60 feet (18 288) mm) above the ground and over 30 feet (9144 mm) above aggregate surface roofs located within 1,500 feet (458 m) of the building shall be permitted to be unprotected.

4. Glazing in Occupancy Category II and III buildings that can receive positive external pressure in the lower 60 feet (18 288 mm) shall be assumed to be openings unless such glazing is impact-resistant or protected with an impact-resistant system.

Exception: Glazing in Occupancy Category III buildings defined by Table 1604.5 of the following occupancies shall be provided with windborne debris protection:

1. Covered structures whose primary occupancy is public assembly with an occupant load greater than 300.
2. Health care facilities with an occupant load of 50 or more resident patients, but not having surgery or emergency treatment facilities.
3. Any other public building with an occupant load greater than 5,000.

Table 1609.1.2
Wind-Borne Debris Protection Fastening Schedule
For Wood Structural Panels [a,b,c,d]

Fastener Type	Fastener Spacing		
	Panel span ≤ 4 feet	Panel span > 4 feet and ≤ 6 feet	Panel span > 6 feet and ≤ 8 feet
No. 6 screws	16"	12"	9"
No. 8 screws	16"	16"	12"

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 0.454 kg, 1 mile per hour = 1.609 km/h.

a. This table is based on a maximum wind speed (3-second gust) of 130 mph and mean roof height of 33 feet or less.

b. Fasteners shall be installed at opposing ends of the wood structural panel. Fasteners shall be located a minimum of 1 inch from the edge of the panel.

c. Fasteners shall be long enough to penetrate through the exterior wall covering a minimum of 1.75 inches into wood wall framing; a minimum of 1.25 inches into concrete block or concrete; or into steel framing by at least three threads. Fasteners shall be located a minimum of 2.5 inches from the edge of concrete block or concrete.

d. Where screws are attached to masonry or masonry/stucco, they shall be attached utilizing vibration-resistant anchors having a minimum withdrawal capacity of 490 pounds.

1609.1.2.1 Building with openings. Where glazing is assumed to be an opening in accordance with Section 1609.1.2 #4, the building shall be evaluated to determine if the openings are of sufficient area to constitute an open or partially enclosed building as defined in ASCE 7. Open and partially enclosed buildings shall be designed in accordance with the applicable provisions of ASCE 7. Partially enclosed Group R-3 buildings shall also include a residential safe room in accordance with Section 422.

1609.1.2.2 Louvers. Louvers protecting intake and exhaust ventilation ducts not assumed to be open that are located within 30 ft (9144 mm) of grade shall meet requirements of an approved impact-resisting standard or the Large Missile Test of ASTM E 1996.

W101.5 Revisions to Section 1609.3. Section 1609.3 is amended to read as follows:

1609.3 Basic wind speed and topographic and directionality factors. The basic wind speed, in mph, for the determination of the wind loads shall be determined by Figure 1609.

Special wind regions near mountainous terrain and valleys are accounted within the Topographic Factor defined in Section 1609.3.3. Wind speeds derived from simulation techniques shall only be used in lieu of the basic wind speeds given in Figure 1609 when, (1) approved simulation or extreme-value statistical-analysis procedures are used (the use of regional wind speed data obtained from anemometers is not permitted to define the hurricane wind speed risk in Hawaii) and (2) the design wind speeds resulting from the study shall not be less than the resulting 700-year return period wind speed divided by $\sqrt{1.6}$.

W101.6 Addition of Section 1609.3.2. Section 1609.3.2 is added to read as follows:

1609.3.2 Effective basic wind speed conversion. For Section 2308.10.1, the provisions of ASCE 7 Section 6.4, and the exceptions permitted under Section 16099.1.1, the basic wind speed value used for determination of the wind loads, shall be the Effective Basic Wind Speed, V_{eff}, determined by Figure 1609.1.1.1, which adjusts the basic wind speed for special topographic wind regions.

W101.7 Addition of effective wind speed contour maps. Figures 1609.1.1.1(a) through 1609.1.1.1(f) are added

as follows:

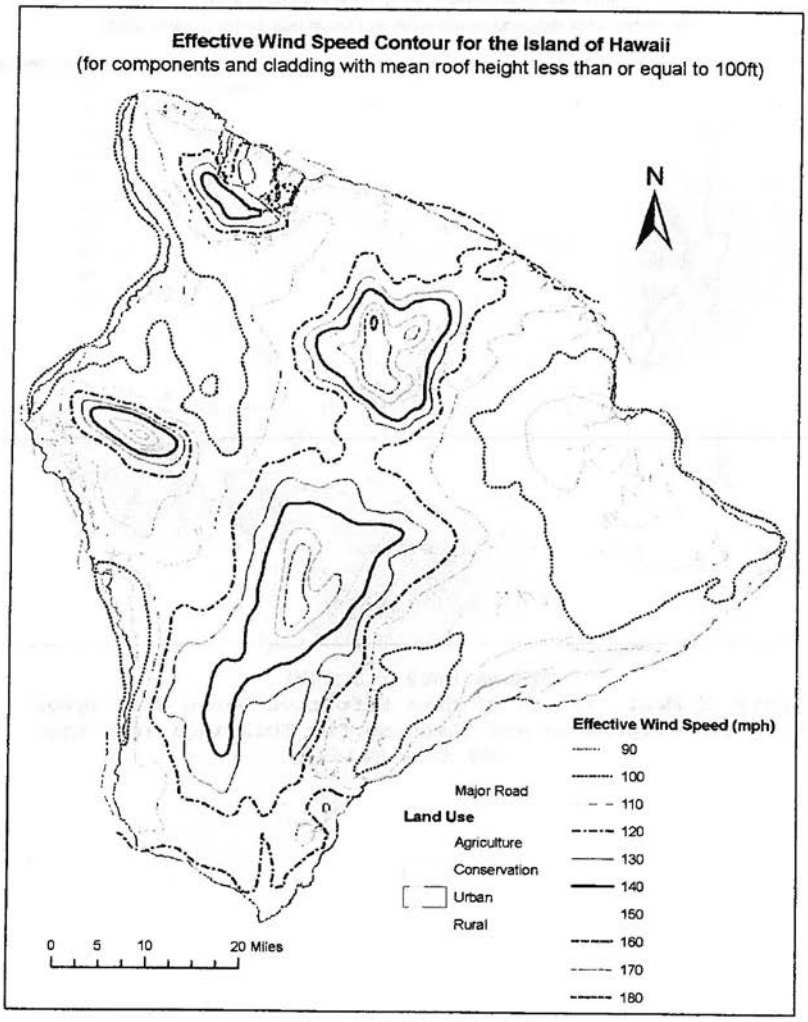


Figure 1609.1.1.1(a)
County of Hawaii Effective Basic Wind Speed, V_{eff}, for Components and Cladding for Buildings less than 100 feet Tall

2915

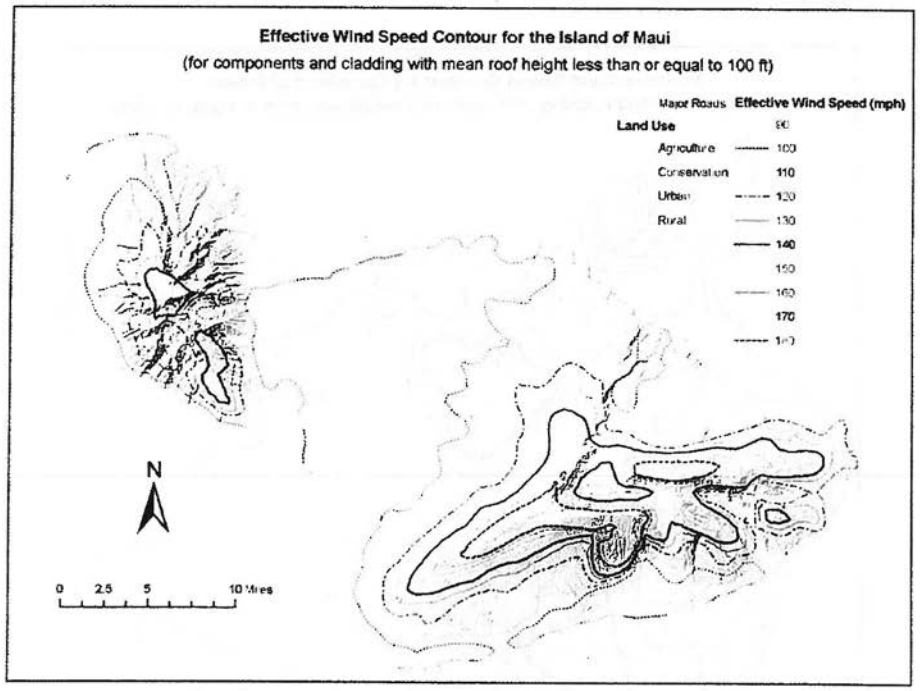


Figure 1609.1.1.1(b)
County of Maui, Island of Maui Effective Basic Wind Speed, V_{eff}, for Components and Cladding for Buildings less than 100 feet Tall

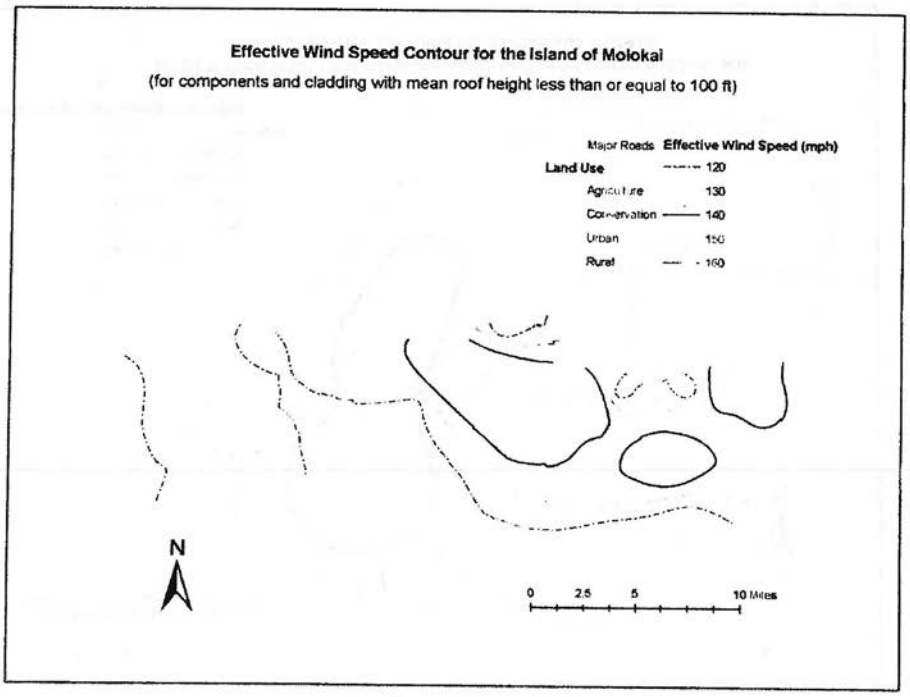


Figure 1609.1.1.1(c)
County of Maui, Island of Molokai Effective Basic Wind Speed, V_{eff}, for Components and Cladding for Buildings less than 100 feet Tall

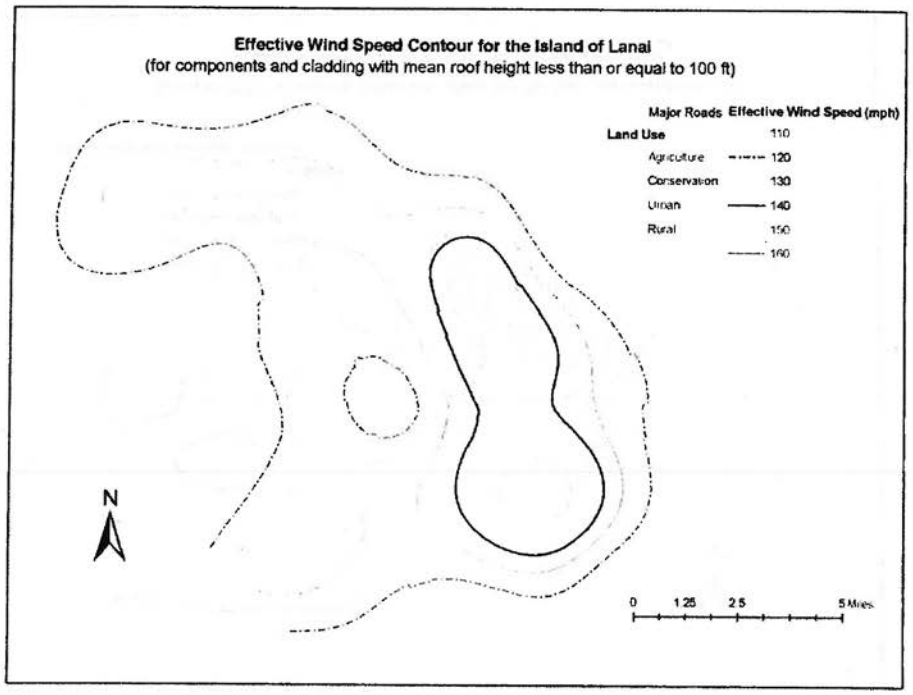


Figure 1609.1.1.1(d)
County of Maui, Island of Lanai Effective Basic Wind Speed, V_{eff}, for Components and Cladding for Buildings less than 100 feet Tall

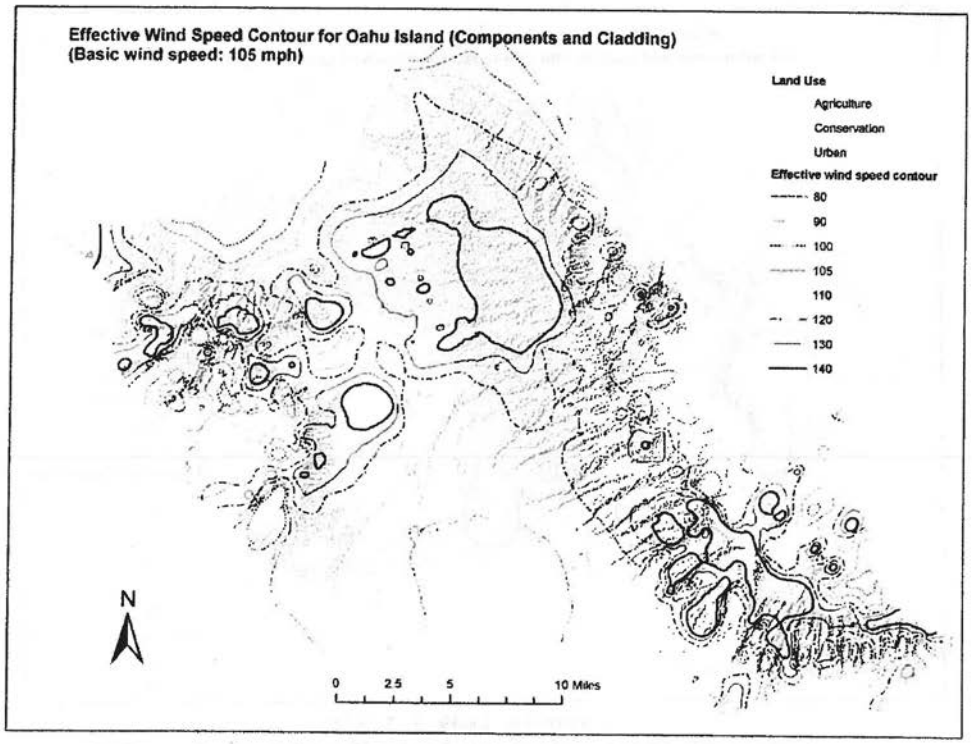


Figure 1609.1.1.1(e)
City and County of Honolulu Effective Basic Wind Speed, V_{eff}, for Components and Cladding for Buildings less than 60 feet Tall

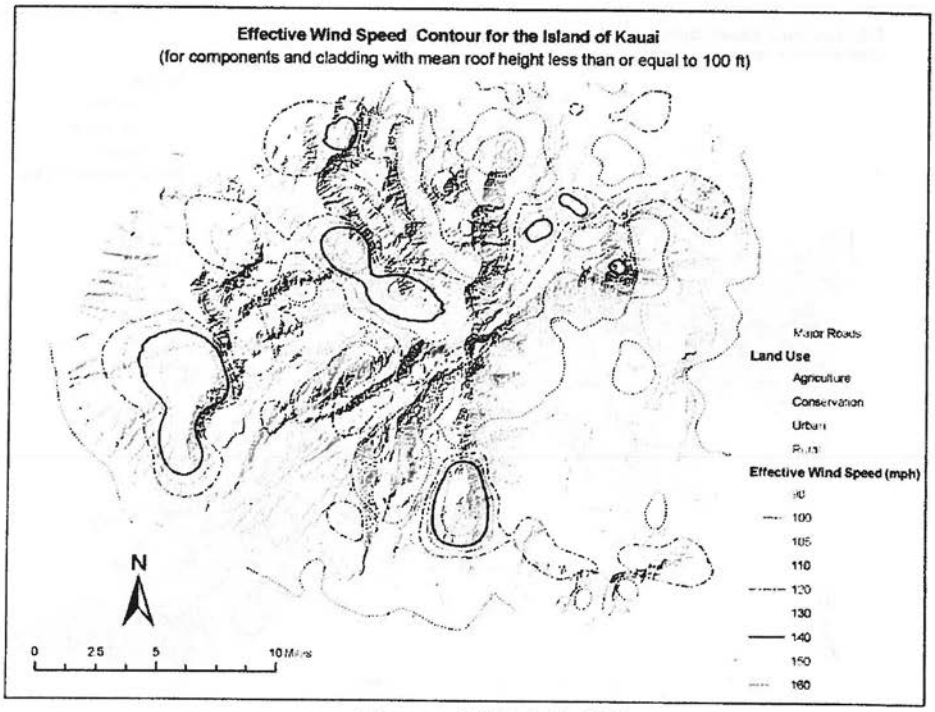


Figure 1609.1.1.1(f)
County of Kauai Effective Basic Wind Speed, V_{eff}, for Components and Cladding for Buildings less than 100 feet Tall

W101.8 Addition of section 1609.3.3. Section 1609.3.3 is added to read as follows:

1609.3.3 Topographic effects. Wind speed-up effects caused by topography shall be included in the calculation of wind loads by using the factor K_{zt}, where K_{zt} is given in Figures 1609.3.3(a) through 1609.3.3(f).

Exception: Site-specific probabilistic analysis of directional K_{zt} based on wind-tunnel testing of topographic speed-up shall be permitted to be submitted for approval by the building official.

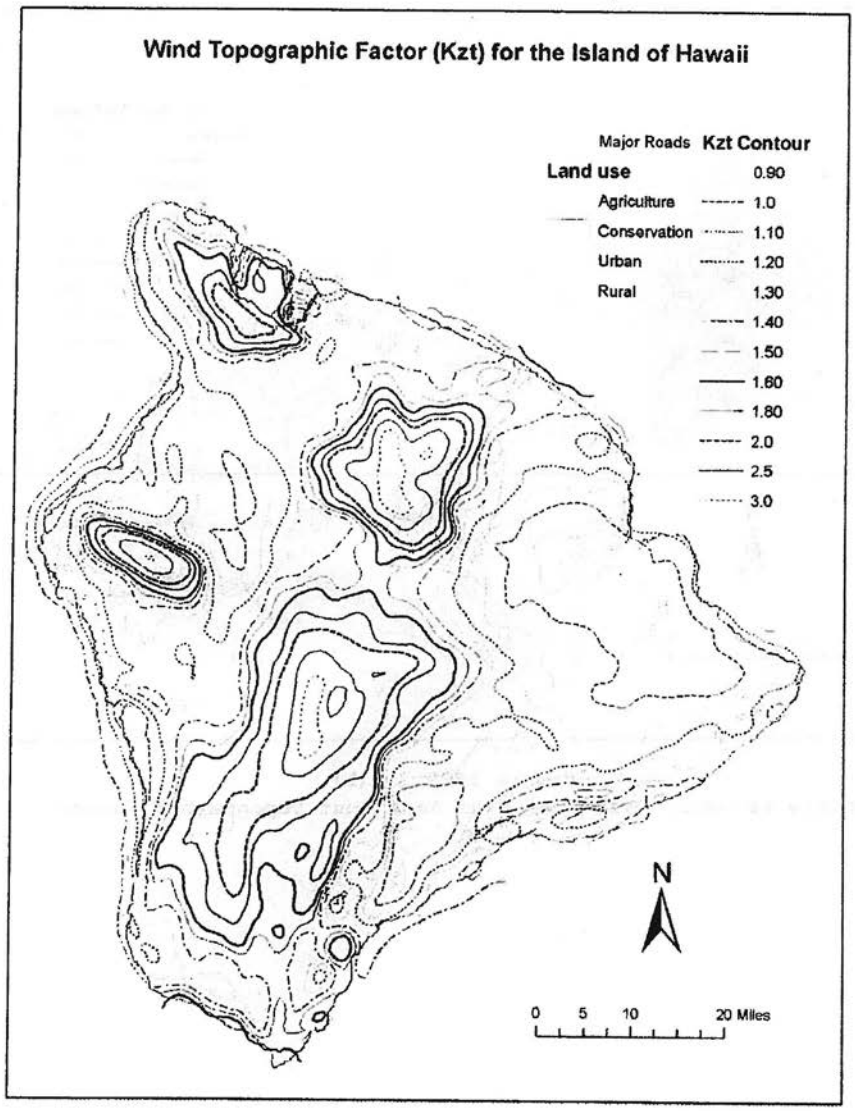


Figure 1609.3.3(a)
County of Hawaii Peak Gust Topographic Factor K_{zt}

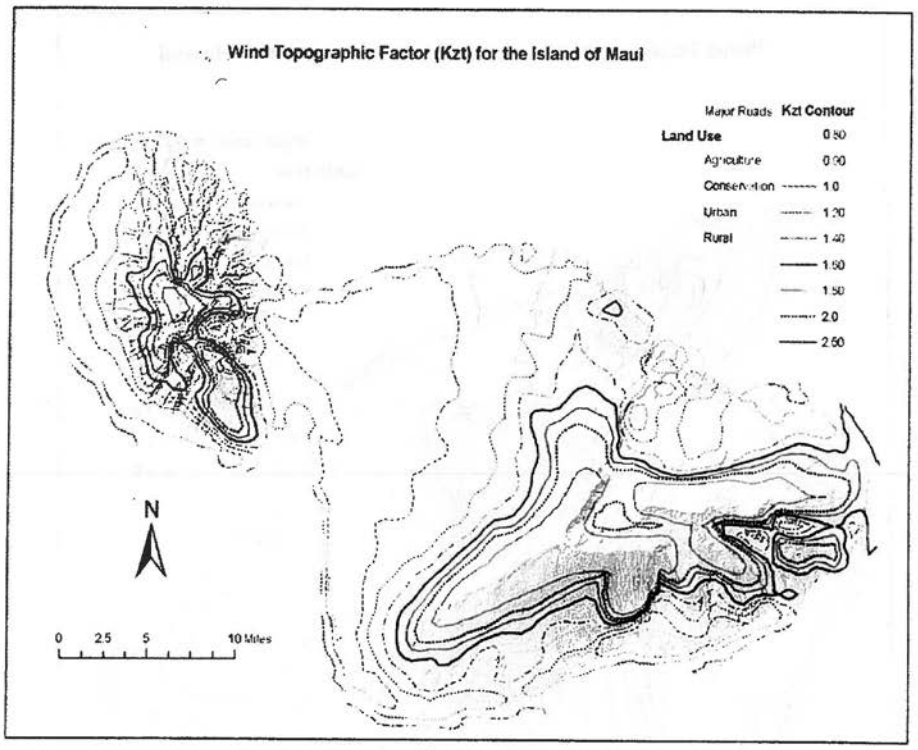


Figure 1609.3.3(b)
County of Maui, Island of Maui Peak Gust Topographic Factor
K_{zt}

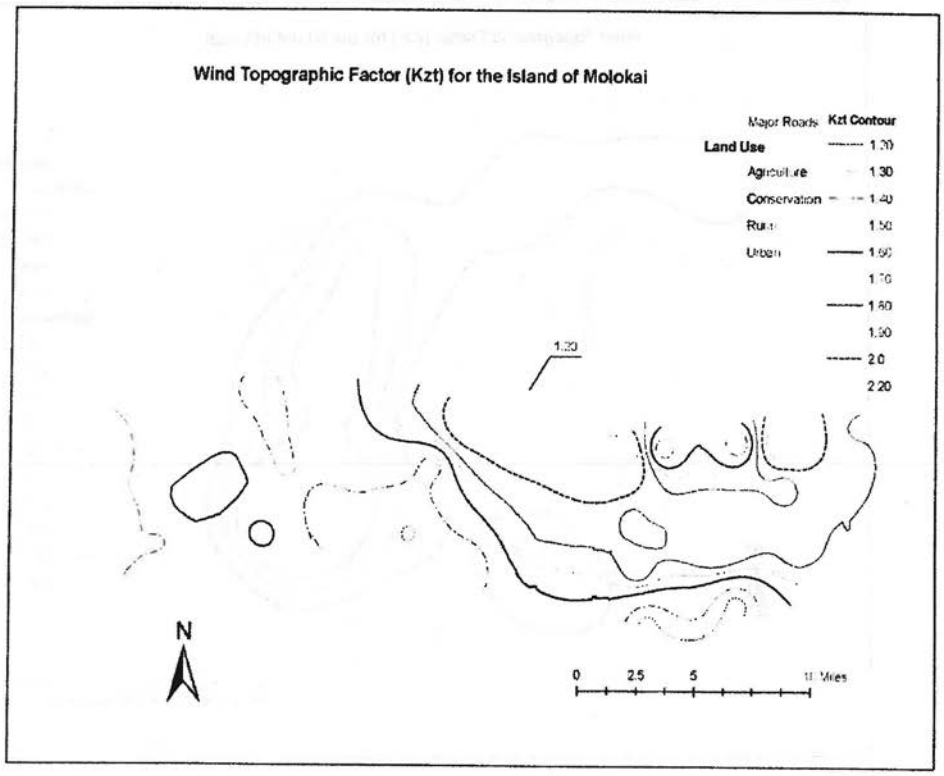


Figure 1609.3.3(c)
County of Maui, Island of Molokai Peak Gust Topographic Factor K_{zt}

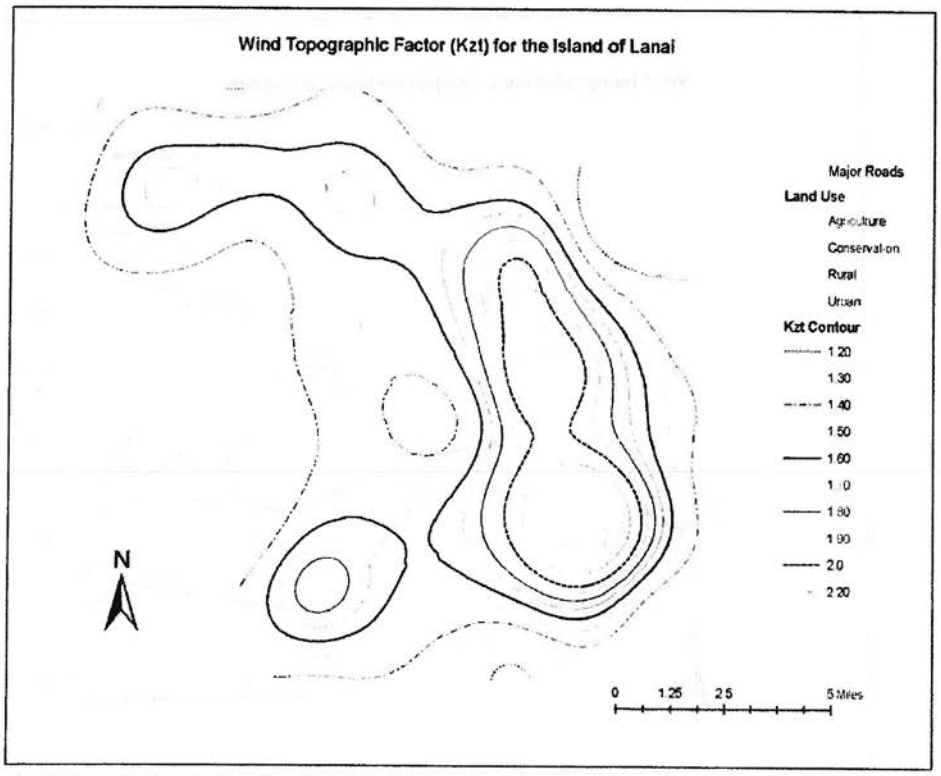


Figure 1609.3.3(d)
County of Maui, Island of Lanai Peak Gust Topographic Factor K_{zt}

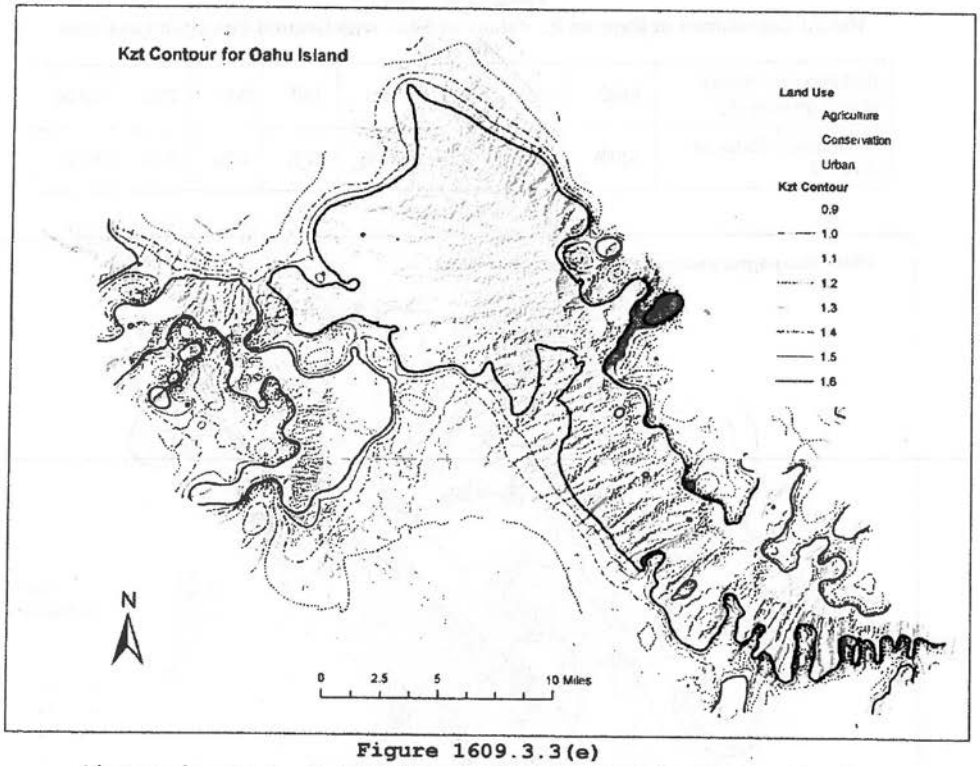


Figure 1609.3.3(e)
City and County of Honolulu Peak Topographic Factor K_{zt} for Building Heights up to 100 feet[a,b]

a. Site-specific probabilistic analysis of directional K_{zt} based on wind-tunnel testing of topographic speed-up shall be permitted to be submitted for approval by the building official. For buildings taller than 160 feet, this submittal shall include peak gust velocity profiles for all wind direction sectors.

b. At Exposure B sites with ground elevations less than 500 feet, K_{zt} values ≥1.2 shall be permitted to be reduced for building heights greater than 100 feet by multiplying K_{zt} mapped in Figure 1609.3.3(e) by the height adjustments given in the Table 1609.3.3(e)2. Interpolation is permitted.

Table 1609.3.3(e)2
Height Adjustment of Mapped K_{zt} Values at Sites with Ground Elevation Less than 500 feet

Building roof height above ground (ft)	≤100	120	140	160	180	200	220	≥240
Adjustment factor to K_{zt} ≥1.2	100%	98%	96%	94%	92%	90%	92%	94%

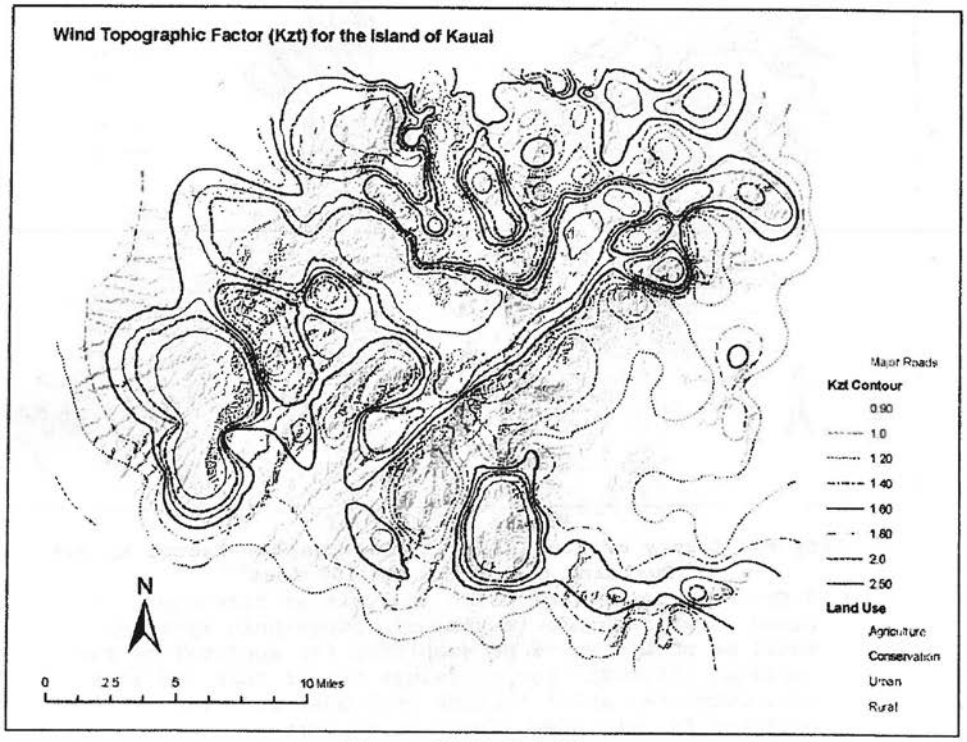


Figure 1609.3.3(f)
County of Kauai Peak Gust Topographic Factor K_{zt}

W101.9 Directionality factor. Section 1609.3.4 is added to read as follows:

1609.3.4 Directionality factor. The wind directionality factor, K_d, shall be determined from Tables

1609.3.4(a)(1) through 1609.3.4(a)(3) and 1609.3.4(b)(1) through 1609.3.4(b)(3), and Figures 1609.3.4(a)(4) and 1609.3.4(b)(4).

Table 1609.3.4(a)(1)
K_d Values for Main Wind Force Resisting Systems Sited in Hawaii County [a,b]

Topographic Location on the Island of Hawaii	Main Wind Force Resisting Systems		Main Wind Force Resisting Systems with totally independent systems in each orthogonal direction		Biaxially Symmetric and Axisymmetric Structures of any Height and Arched Roof Structures
	Mean Roof Height less than or equal to 100 ft.	Mean Roof Height greater than 100 ft.	Mean Roof Height less than or equal to 100 ft.	Mean Roof Height greater than 100 ft.	
Sites in North Kohala, South Kohala, South Kona, South Hilo, and Puna Districts at an elevation not greater than 3000 ft.	0.65	0.70	0.70	0.75	0.85
All other sites	0.70	0.80	0.75	0.80	0.95

a. The values of K_d for other non-building structures indicated in ASCE 7 Table 6-4 shall be permitted.

b. Site-specific probabilistic analysis of K_d based on wind-tunnel testing of topography and peak gust velocity profile shall be permitted to be submitted for approval by the building official, but K_d shall have a value not less than 0.65.

Table 1609.3.4(a)(2)
K_d Values for Main Wind Force Resisting Systems Sited in Maui County [a,b]

Topographic Location in the County of Maui	Main Wind Force Resisting Systems		Main Wind Force Resisting Systems with totally independent systems in each orthogonal direction		Biaxially Symmetric and Axisymmetric Structures of any Height and Arched Roof Structures
	Mean Roof Height less than or equal to 100 ft.	Mean Roof Height greater than 100 ft.	Mean Roof Height less than or equal to 100 ft.	Mean Roof Height greater than 100 ft.	
Sites on the Island of Maui at an elevation not greater than 1000 ft.	0.60	0.65	0.70	0.75	0.85
Sites on the Island of Maui at an elevation greater than 1000 ft.	0.65	.70	0.75	0.80	0.90
All other sites on the Islands of Molokai and Lanai	0.80	0.85	0.80	0.85	0.95

a. The values of K_d for other non-building structures indicated in ASCE 7 Table 6-4 shall be permitted.

b. Site-specific probabilistic analysis of K_d based on wind-tunnel testing of topography and peak gust velocity profile shall be permitted to be submitted for approval by the building official, but K_d shall have a value not less than 0.60.

Table 1609.3.4(a)(3)
K_d Values for Main Wind Force Resisting Systems Sited on Oahu, Hawaii[a,b]

Topographic Location on Oahu, Hawaii	Main Wind Force Resisting Systems		Main Wind Force Resisting Systems with totally independent systems in each orthogonal direction		Biaxially Symmetric and Axisymmetric Structures of any Height and Arched Roof Structures
	Mean Roof Height less than or equal to 100 ft.	Mean Roof Height greater than 100 ft.	Mean Roof Height less than or equal to 100 ft.	Mean Roof Height greater than 100 ft.	
Sites within valleys at an elevation of at least 50 ft. but not greater than 500 ft.	0.65	0.70	0.70	0.75	0.85
Central Oahu above an elevation of 500 ft, the Ewa and Kapolei plains, and coastal areas with K_{zt} (10m) not greater than 1.2	0.75	0.80	0.75	0.80	0.95
All other areas, including Hills, Hillsides, Ridges, Bluffs, and Escarpments at any elevation or height; coastal and inland areas with K_{zt} (10m) greater than 1.2	0.70	0.75	0.75	0.80	0.90

a. The values of K_d for other non-building structures indicated in ASCE 7 Table 6-4 shall be permitted.

b. Site-specific probabilistic analysis of K_d based on wind-tunnel testing of topography and peak gust velocity profile shall be permitted to be submitted for approval by the building official, but K_d shall have a value not less than 0.65.

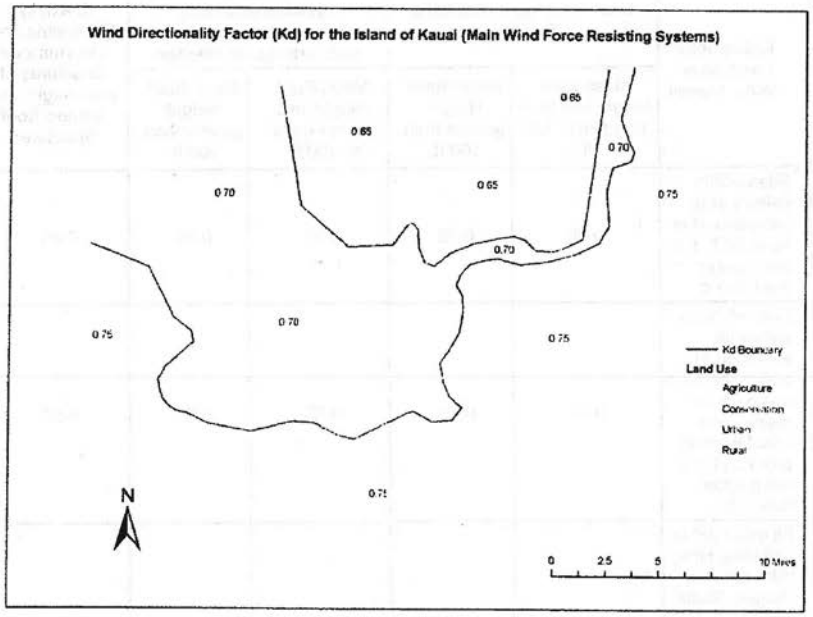


Figure 1609.3.4(a)(4)
K_d Values for Main Wind Force Resisting Systems Sited on Kauai County, Hawaii [a,b]

a. The values of K_d for other non-building structures indicated in ASCE 7 Table 6-4 shall be permitted.
b. Site-specific probabilistic analysis of K_d based on wind-tunnel testing of topography and peak gust velocity profile shall be permitted to be submitted for approval by the building official, but K_d shall have a value not less than 0.65.

Table 1609.3.4(b)(1)
K_d Values for Components and Cladding of Buildings Sited in Hawaii County [a,b]

Topographic Location on the Island of Hawaii	Components and Cladding		
	Mean Roof Height less than or equal to 100 ft.	Mean Roof Height greater than 100 ft.	Occupancy Category IV Buildings and Structures
Sites in North Kohala, South Kohala, South Kona, South Hilo, and Puna Districts at an elevation not greater than 3000 ft.	0.65	0.70	0.75
All other sites	0.75	0.80	0.85

a. The values of K_d for other non-building structures indicated in ASCE 7 Table 6-4 shall be permitted.
b. Site-specific probabilistic analysis of K_d based on wind-tunnel testing of topography and peak gust velocity profile shall be permitted to be submitted for approval by the building official, but in any case subject to a minimum value of 0.65.

Table 1609.3.4(b)(2)
K_d Values for Components and Cladding of Buildings Sited in Maui County [a,b]

Topographic Location on the County of Maui	Components and Cladding		
	Mean Roof Height less than or equal to 100 ft.	Mean Roof Height greater than 100 ft.	Occupancy Category IV Buildings and Structures
Sites on the Island of Maui at an elevation not greater than 1000 ft	0.65	0.70	0.75
Sites on the Island of Maui at an elevation greater than 1000 ft.	0.70	0.75	0.85
All other sites on the Islands of Molokai and Lanai	0.80	0.85	0.85

a. The values of K_d for other non-building structures indicated in ASCE 7 Table 6-4 shall be permitted.
b. Site-specific probabilistic analysis of K_d based on wind-tunnel testing of topography and peak gust velocity profile shall be permitted to be submitted for approval by the building official, but in any case subject to a minimum value of 0.65.

Table 1609.3.4(b)(3)
K_d Values for Components and Cladding of Buildings Sited on Oahu, Hawaii [a,b]

Topographic Location on Oahu	Components and Cladding		
	Mean Roof Height less than or equal to 100 ft.	Mean Roof Height greater than 100 ft.	Occupancy Category IV Buildings and Structures
Sites within valleys at an elevation of at least 50 ft. but not greater than 500 ft.	0.65	0.70	0.75
Central Oahu above an elevation of 500 ft, the Ewa and Kapolei plains, and coastal areas with K_{zt} (10m) not greater than 1.2	0.75	0.80	0.85
All other areas, including Hills, Hillsides, Ridges, Bluffs, and Escarpments at any elevation or height; coastal and inland areas with K_{zt} (10m) greater than 1.2	0.70	0.75	0.80

a. The values of K_d for other non-building structures indicated in ASCE 7 Table 6-4 shall be permitted.

b. Site-specific probabilistic analysis of K_d based on wind-tunnel testing of topography and peak gust velocity profile shall be permitted to be submitted for approval by the building official, but in any case subject to a minimum value of 0.65.

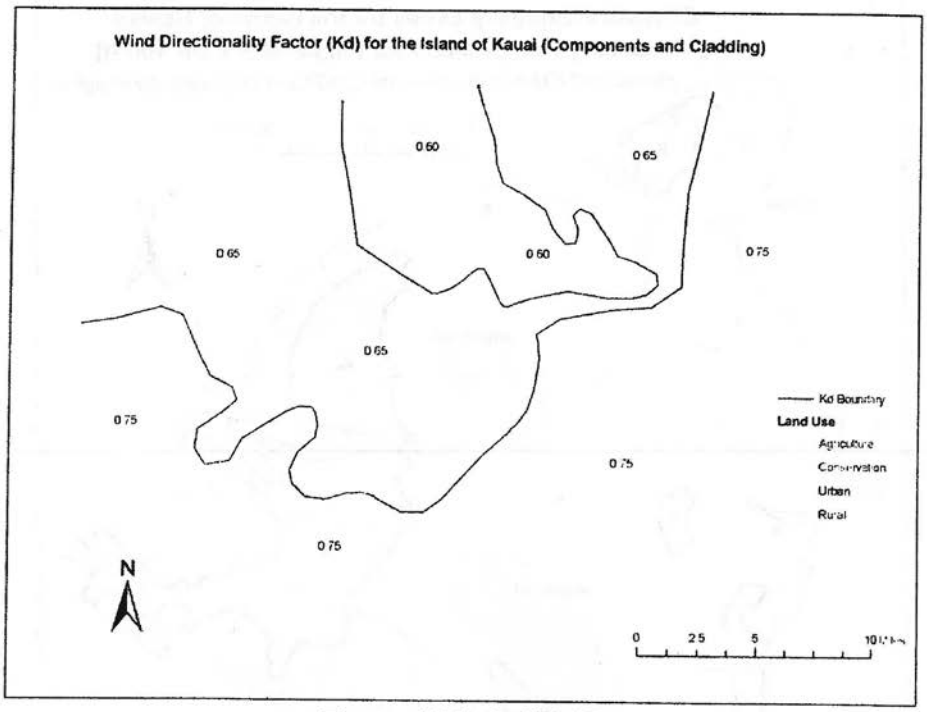


Figure 1609.3.4(b)(4)
K_d Values for Components and Cladding of Buildings Sited on Kauai County, Hawaii [a,b]

a. The values of K_d for other non-building structures indicated in ASCE 7 Table 6-4 shall be permitted.
b. Site-specific probabilistic analysis of K_d based on wind-tunnel testing of topography and peak gust velocity profile shall be permitted to be submitted for approval by the building official, but K_d shall have a value not less than 0.65.

W101.10 Addition of exposure category maps. Section 1609.4.4 is added to read as follows:

1609.4.4 Exposure category maps. Exposure categories are permitted to be determined using Figures 1609.4.4(a) through 1609.4.4(e).

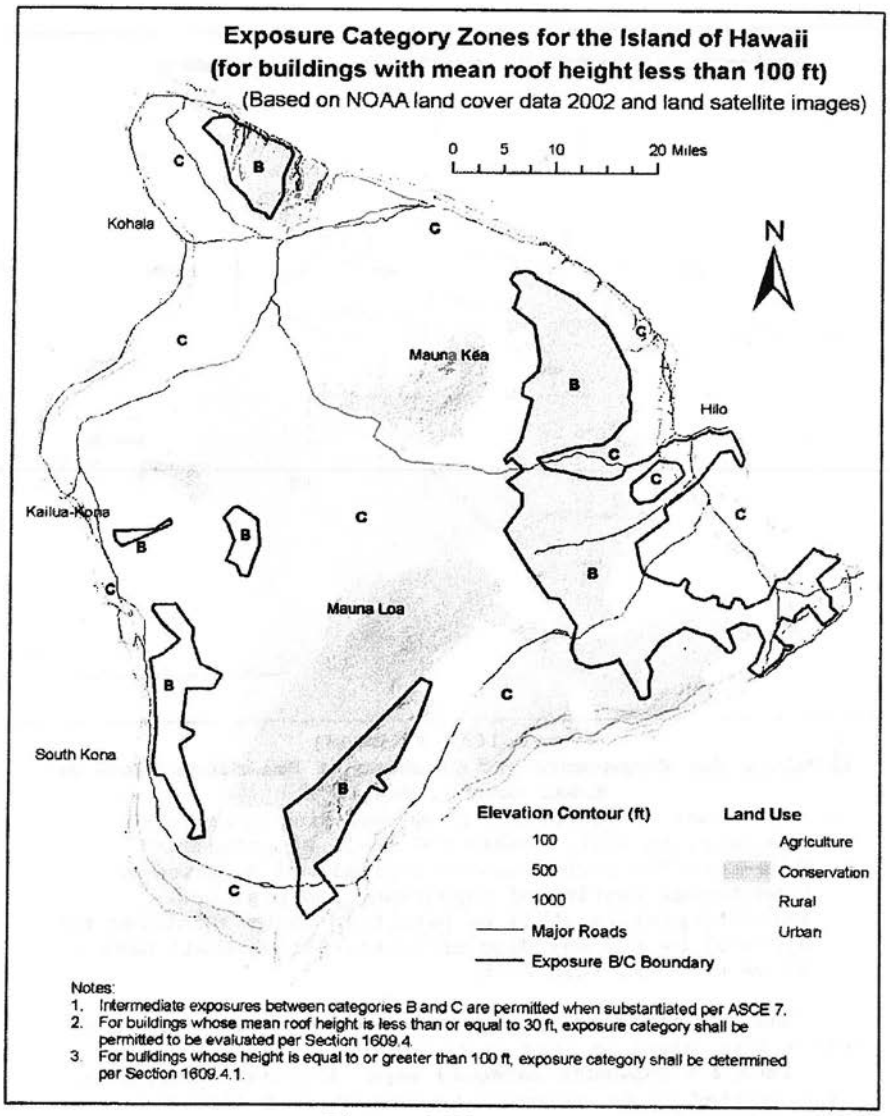


Figure 1609.4.4(a)
Exposure Category Zones for Hawaii County

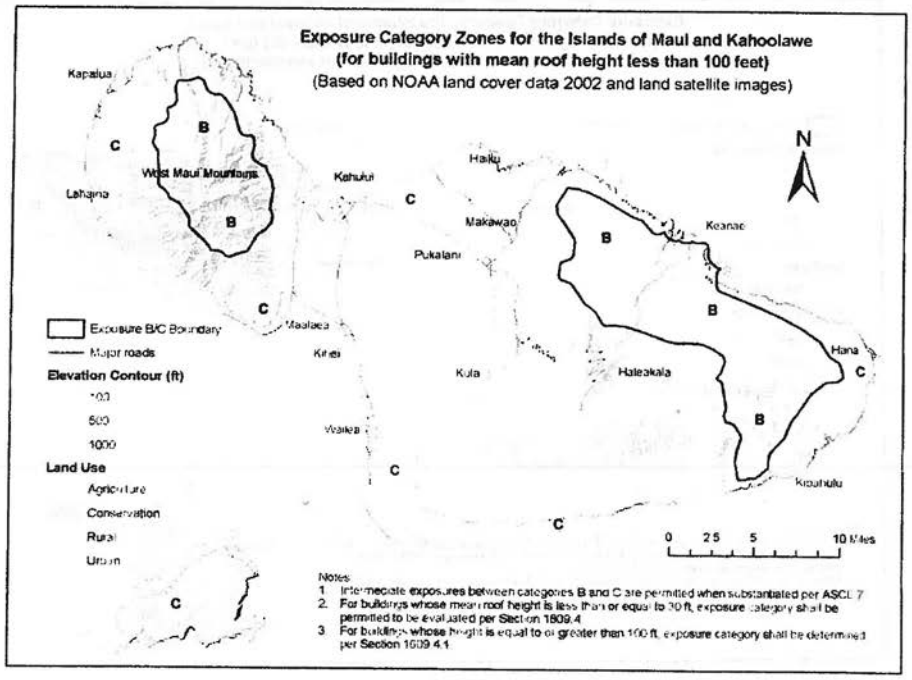


Figure 1609.4.4(b)
Exposure Category Zones for Island of Maui, Maui County

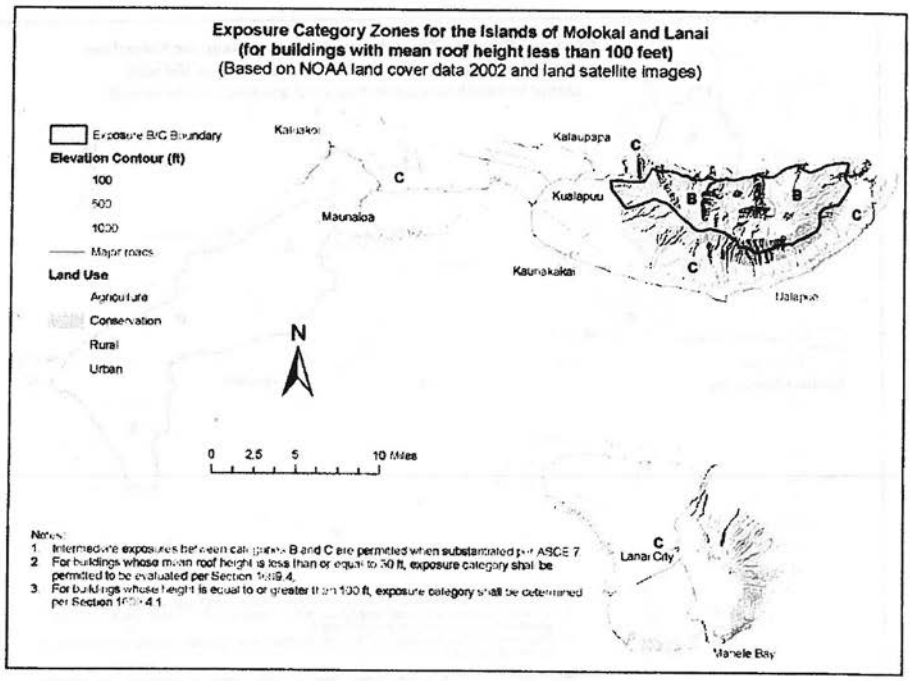


Figure 1609.4.4(c)
Exposure Category Zones for Islands of Molokai and Lanai, Maui County

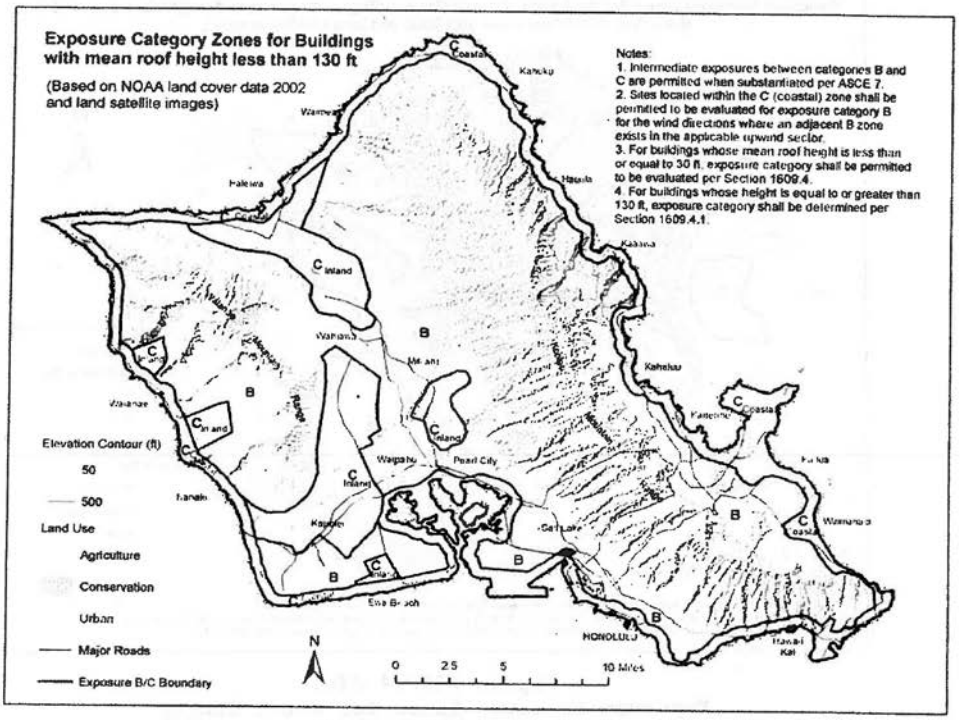


Figure 1609.4.4(d)
Exposure Category Zones for the City and County of Honolulu

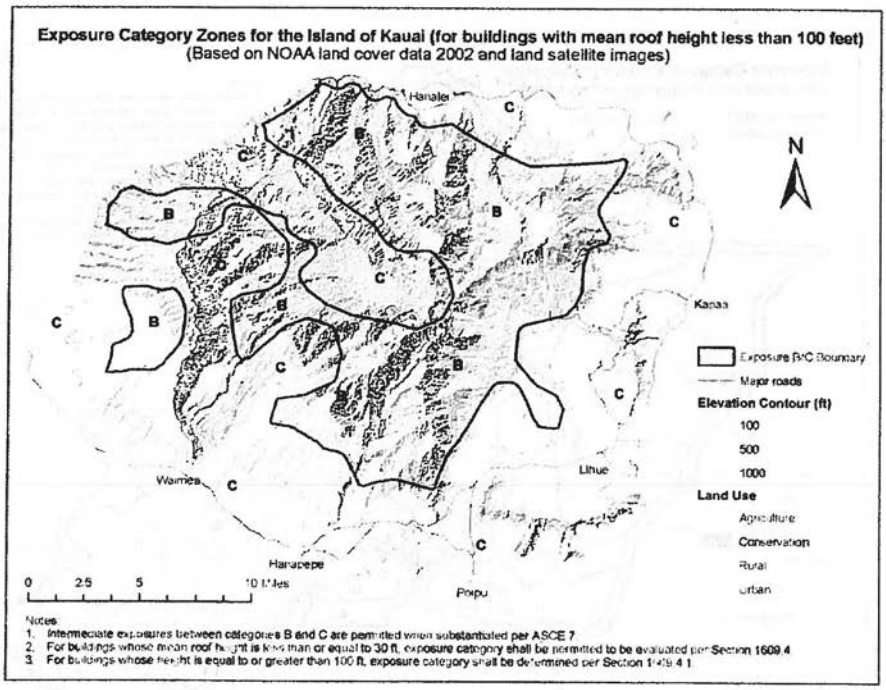


Figure 1609.4.4(e)
Exposure Category Zones for Kauai County

W102 Revisions to Chapter 23. When Appendix W is adopted, wood construction shall be in accordance with Chapter 23 as amended by Sections W102.1 and W102.2.

W102.1 Revisions to Section 2308.2.1. Section 2308.2.1 is amended to read as follows:

2308.2.1 Basic wind speed greater than 100 mph. Where the Effective Basic Wind Speed exceeds 100 mph, the provisions of the AF&PA WFCM, or the SBCCI SSTD 10 are permitted to be used.

W102.2 Revisions to Table 2308.10.1. Table 2308.10.1 is amended to read as follows:

Table 2308.10.1
Required Rating of Approved Uplift Connectors (pounds)[a,b,c,d,e,f,g,h,i]

Effective Basic Wind Speed	Roof Span (feet)							Overhangs (pounds/ft)[d]
V_{eff}, 3-sec gust	12	20	24	28	32	36	40	
85	-72	-120	-144	-168	-192	-216	-240	-38.55
90	-91	-152	-182	-213	-243	-274	-304	-43.22
100	-131	-218	-262	-305	-349	-392	-436	-53.36
110	-175	-292	-350	-409	-467	-526	-584	-64.56
120	-240	-400	-480	-560	-640	-720	-800	-76.83
130	-304	-506	-607	-708	-810	-911	-1012	-90.17

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 1.61 km/hr, 1 pound = 0.454 Kg, 1 pound/foot = 14.5939 N/m.

a. The uplift connection requirements are based on a 30-foot mean roof height located in Exposure B. For Exposure C and for other mean roof heights, multiply the above loads by the adjustment coefficients below.

Exposure	Mean Roof Height (feet)									
	15	20	25	30	35	40	45	50	55	60
B	1.00	1.00	1.00	1.00	1.05	1.09	1.12	1.16	1.19	1.22
C	1.21	1.29	1.35	1.40	1.45	1.49	1.53	1.56	1.59	1.62

For SI: 1 inch – 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 1.61 km/hr, 1 pound = 0.454 Kg, 1 pound/foot = 14.5939 N/m.

b. The uplift connection requirements are based on the framing being spaced 24 inches on center. Multiply by 0.67 for framing spaced 16 inches on center and multiply by 0.5 for framing spaced 12 inches on center.

c. The uplift connection requirements include an allowance for 10 pounds of dead load.

d. The uplift connection requirements do not account for the effects of overhangs. The magnitude of the above loads shall be increased by adding the overhang loads found in the table. The overhang loads are also based on framing spaced 24 inches on center. The overhang loads given shall be multiplied by the overhang projection and added to the roof uplift value in the table.

e. The uplift connection requirements are based upon wind loading on end zones as defined in Figure 6-2 of ASCE 7. Connection loads for connections located a distance of 20 percent of the least horizontal dimensions of the building from the corner of the building are permitted to be reduced by multiplying the table connection value by 0.7 and multiplying the overhang load by 0.8.

f. For wall-to-wall and wall-to-foundation connections, the capacity of the uplift connector is permitted to be reduced by 100 pounds for each full wall above. (For example, if a 500-pound rated connector is used on the roof framing, a 400-pound rated connector is permitted at the next floor level down.)

g. Interpolation is permitted for intermediate values of basic wind speeds and roof spans.

h. The rated capacity of approved tie-down devices is permitted to include up to a 60-percent increase for wind effects where allowed by material specifications.

i. V_{eff} is given by Figure 1609.1.1.1." [Eff APR 16 2010]
(Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-180-54 Appendix X - Hawaii provisions for indigenous Hawaiian architecture structures. Appendix X is added to read as follows:

"APPENDIX X

Hawaii Provisions For Indigenous Hawaiian Architecture Structures

Section X101 General.

X101.1 Scope. The provisions of this appendix shall apply exclusively to Indigenous Hawaiian Architecture Structures. The purpose of these provisions is to acknowledge and establish procedures for designing and constructing indigenous Hawaiian architecture structures.

X101.2 Publications incorporated by reference. The following publications are incorporated by reference and made a part of these provisions. Where there is a conflict between Appendix X and the referenced documents, Appendix X shall prevail.

1. "Hawaiian Thatched House" (1971), by Russell A. Apple, published by the United States Department of the Interior,
2. "Hale Construction Standards" (2000), by Francis Sinenci and Bill Sides,
3. "The Hawaiian Grass House in Bishop Museum" (1988), by Catherine C. Summers, and
4. "Arts and Crafts of Hawaii", Section II, Houses (1957) by Te Rangi Hiroa (Peter H. Buck)

X101.3 Definitions. For purposes of this appendix, the following words and terms shall have the meanings shown herein. Refer to Chapter 2 for general definitions.

CERTIFIED HALE BUILDER. means a person who has obtained a certificate of completion for satisfactorily completing a course in Hawaiian hale construction from the University of Hawaii, or any of its community colleges, or as approved by the Building Official.

GROUP OF STRUCTURES. A group of indigenous Hawaiian architecture structures that are in close proximity to each other and have an aggregate floor area of 1,800 square feet or less.

INDIGENOUS HAWAIIAN ARCHITECTURE STRUCTURE or HALE. A structure that is consistent with the design, construction

methods and uses of structures built by Hawaiians in the 1800's, which uses natural materials found in the Hawaiian islands, and complies with this appendix and references.

SEPARATION. The clear distance between two structures.

SETBACK. The clear distance between a structure and a property line.

Section X201 Material requirements.

X201.1 Hale materials. Hale shall be constructed using only materials grown and harvested in the State of Hawaii.

X201.2 Wood framing material. The wood members for the hale, such as posts and rafters, shall be, but not limited to hardwoods of unmilled, straight sections of trunks or branches of the following species:

1. Casaurina equisitafolia (ironwood).
2. Prosopis-allid (kiawe).
3. Eucalyptus robusta (eucalyptus).
4. Psidium cattleianum (strawberry guava).
5. Metrosideros polymorpha (ohia).
6. Rizophora mangle (mangrove).

Exception: Ardisia elliptica (inkberry) may be used only for roof purlins as an alternative to specified woods listed in Items 1 through 6.

X201.3 Roofing and siding. Thatched roofing and siding materials for the hale may be any grass or leaf material grown and harvested in the State of Hawaii, to include but not be limited to pili, kualohia, pueo, kawelu, sugarcane leaves, and ti leaves.

X201.4 Cord. Natural or synthetic cord used for lashing structural members of the hale shall be 400 pound test. Cord used for tying floating purlins and thatched materials shall be 100 pound test. All cord used on the hale shall be shades of green, tan, brown or black.

X201.5 Metal prohibited. Metal shall not be used for the construction of the hale.

Section X202 Size and location.

X202.1 Height and size limitation. Hale shall be one-story, detached structure not exceeding 1,800 square feet. Hale shall not exceed the size indicated in Table X202.1.

Table X202.1
Maximum Size of Hale (feet)

Hale Halawai	Hale Ku'ai	Hale Noa	Hale Wa`a
30 X 60	14 X 20	14 X 24	30 X 60

X202.2 Zoning requirements. Hale shall comply with minimum yard requirements in the zoning codes.

X202.3 Minimum separation. The minimum separation between a hale and another structure shall be at least 10 feet for a one-story structure; 15 feet for a two-story structure; or a distance equal to the height of the hale, whichever is more. The minimum separation between two hale shall be at least 10 feet or a distance equal to the height of the taller hale.

X202.4 Hale Noa. Hale noa structures may only be constructed on property where a separate residence exists on the property.

Section X203 Allowable and prohibited uses.

X203.1 Allowable uses. To the extent permitted by other applicable law, allowable uses for hale structures shall be in accordance with Table X203.1.

Table X203.1
Allowable Use for Each Hale Type

Use	Hale Halawai	Hale Ku'ai	Hale Noa	Hale Wa`a
Eating (ai)	Allowed	Allowed	Not permitted	Allowed
Assembling (halawai)	Allowed	Allowed	Not permitted	Allowed
Sleeping (moe)	Not permitted	Not permitted	Allowed	Not permitted
Retailing (e.g., fruits) (ku'ai)	Allowed	Allowed	Not permitted	Allowed
Storage (papa'a)	Not permitted	Allowed	Not permitted	Allowed

X203.2 Prohibited uses and activities. The following uses and activities shall be prohibited from occurring within or near the hale:

1. Cooking.
2. Open flames.
3. Generators.
4. Extension cords.
5. Electrical switches, fixtures, or outlets.
6. Plumbing faucets, fixtures, or drains.
7. Power tools.
8. No screen, mesh, plastic or any other similar material shall be attached to the hale.
9. Hale shall not be used as a food establishment as defined in the administrative rules adopted by the state department of health.

X203.3 Maintenance. The hale shall be maintained by the owner to ensure structural integrity. Repairs for

maintenance of the hale shall not require additional building permits.

Section X301 Fire protection.

X301.1 Fire protection classifications. Fire protection for Indigenous Hawaiian architecture structures shall be as required in Table X301.1.

Table X301.1
Fire Protection Requirements Based on Setback

Class	Setback Requirements	Fire Protection Requirements
A	The structure (or a group of structures) is: 1. Located at least 100 feet from any existing structure on the same or neighboring properties; and 2. Located at least 100 feet from any property line, except as follows: a. If the property line abuts a public way, the 100 feet minimum setback for that property line shall be reduced by the width of the public way, b. If the property line abuts the shoreline, the minimum setback for that property line shall be the shoreline setback, or c. For any hale ku'ai in the agricultural district that is less than 200 square feet, that is completely open on three sides, and that is used as an agricultural products' stand and if the property line abuts a public way, the minimum setback for that property line shall be 15 feet.	No fire protection is required for the structure.
B	The structure (or a group of structures) that conforms to applicable zoning setback requirements but does not satisfy Class A setback requirements.	Automatic fire sprinkler system shall be installed in accordance with design standards in Section X301.2. An electrical permit is required for fire sprinklers systems.

X301.2 Automatic fire sprinklers. The design standards for automatic fire sprinklers for Class B indigenous Hawaiian architecture structures shall be in accordance with NFPA 13.

Exception: The design standards for automatic fire sprinklers for Class B indigenous Hawaiian architecture

structures shall be permitted as follows:

1. 18 gallons per minute for a single head at 140 square feet maximum coverage of roof area.
2. 13 gallons per minute for each subsequent head at 140 square feet maximum coverage of roof area per head.
3. The minimum supply pressure at the base of the riser riser shall not be less than 40 pounds per square inch.
4. The minimum residual pressure at the highest sprinkler shall be not less than 12 pounds per square inch.
5. Sprinkler head spacing shall not exceed 14 feet.
6. Sprinkler heads shall be open type upright, pendent, or sidewall with 1/2-inch or 17/32-inch orifice and have a wax corrosion resistant coating.
7. The total number of sprinklers on a branch shall not exceed 6 heads.
8. The total number of sprinklers shall not exceed the quantity shown in Table X301.2(a).

Table X301.2(a)
Total Number of Fire Sprinklers Based on Pipe Size

Piping Size	Number of Sprinklers
1 inch diameter	2 sprinklers
1¼ inch diameter	3 sprinklers
1½ inch diameter	5 sprinklers
2 inch diameter	10 sprinklers
2½ inch diameter	30 sprinklers
3 inch diameter	60 sprinklers

9. The pipe schedule table in Item 8 shall not apply to hydraulically designed systems.
10. The water density shall not be less than 0.10 gpm per square foot.
11. The source of water may be by domestic water meters, detector check meter, underground well, storage tank, swimming pool, ponds, etc., but must meet the design requirements for adequate pressure and duration.
12. Water supply shall be sufficient to provide 30 minutes duration.
13. If domestic water meters are used as the source of water for the fire sprinklers, without a storage

tank and booster pump, the maximum number of sprinklers shall not exceed the number shown in Table X301.2(b).

Table X301.2(b)
Total Number of Fire Sprinklers Based on Water Meter Size

Size of Water Meter	Number of Sprinklers
5/8 inch water meter	1 sprinkler
¾ inch water meter	2 sprinklers
1 inch water meter	3 sprinklers
1½ inch water meter	7 sprinklers
2 inch water meter	11 sprinklers
3 inch water meter	27 sprinklers

14. The piping material shall be hard drawn copper with silver solder or brazed fittings, or carbon steel with corrosion-resistant coatings. Plastic pipes shall not be allowed, except for below grade supply pipes.
15. Fire sprinkler system shall be actuated by smoke detectors located at the highest points of the roof and spaced as recommended by the manufacturer.
16. Flow control valves shall be either hydraulically or electrically operated with a manual override switch.
17. Where the width of a roof exceeds the width allowed for one row of sprinklers, two or more rows of sprinklers shall be placed such that the entire roof area is protected.
18. Prevailing wind direction shall be considered in the placement of sprinklers.
19. Deflectors for sprinklers shall be parallel with the roof surface or tilted slightly towards the peak of the roof.
20. Fire sprinklers system shall have a local alarm activated by a smoke detector.

X301.3 Certification of water supply. For any hale that requires fire protection pursuant to X301.1, the applicant shall provide a certification from a licensed engineer or a licensed C-20 contractor that the water supply for the fire sprinkler system has been tested and is capable of delivering the required fire flow for 30 minutes duration.

X302 Smoke alarm. Any hale used for sleeping shall have an approved battery operated smoke alarm installed in

the hale.

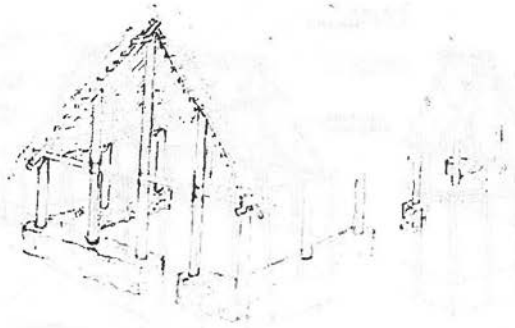
Section X401 Design standards.

X401.1 General design standards. All types of hale shall be designed and constructed in accordance with the standards set out in this section.

1. The minimum diameter size of all structural members shall be measured at the member's midpoint, except that the minimum diameter size of posts shall be measured at the smaller end. For structure sizes not specifically shown in the tables, the requirements in the next larger width size shall be applicable.
2. The specifications for structural members were estimated based on no wind loads. Hale shall be constructed to allow all thatching materials to separate from the structure prior to adding significant loads.
3. The mix formula for mortar specified in these rules shall be one part portland cement, four parts clean sand, and sufficient fresh water to make the mixture workable.
4. Every hale, except hale noa, shall have at least two sides completely open.
5. Lashing and thatching methods shall comply with illustrations found in "Arts and Crafts of Hawaii" or "The Hawaiian Grass House in Bishop Museum" referenced in Section X101.2.

X402 Allowable designs. Hale shall be designed and constructed in accordance with the requirements in Sections 402.1 through 402.4.

X402.1 Hale Halawai. Each end of the hale halawai may be open or thatched. The ends may also be constructed with a thatched roof hip as an alternate design. Hale Halawai shall be designed in accordance with the following schematics and illustrations. Structural components for Hale Halawai shall meet the size and spacing requirements in Table X402.1(a). Foundations for Hale Halawai shall be designed in accordance with Table X402.1(b).



HALE HALAWAI
Open End Style

HALE HALAWAI
Thatched End Style

FRAMING SCHEMATIC

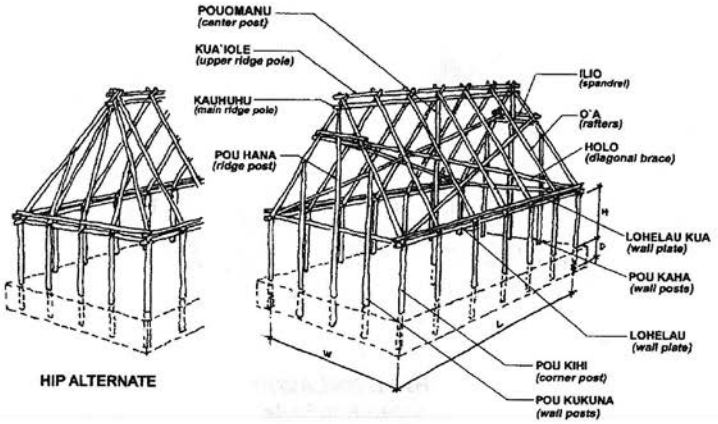
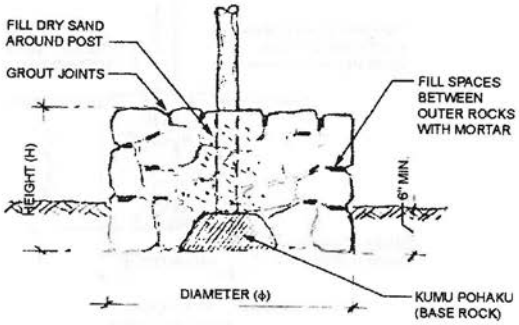
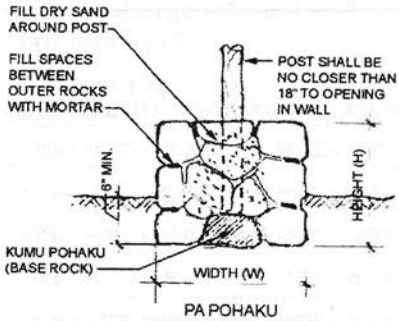


Table X402.1(a)
Size and Spacing Requirements for Structural Components used in Hale Halawai

Size W x L x H	*pou kihi*	*pou kukuna & pou kaha*	*pou hana & pouomanu*	*o'a*	*kua'iole & holo*	*kauhuhu*	*lohelau*	Maximum post spacing (feet)	Maximum rafter spacing (feet)
	Minimum Diameter (inches)								
12' x 20' x 7'	4	3½	4	3½	2½	3	3	5	3
14' x 24' x 7'	4	4	4½	3½	2½	3	3½	5	3
24' x 30' x 7'	5	4½	4½	4	2½	3	3½	5	3
25' x 50' x 7'	5½	5	5½	4	2½	3	3½	5	3
30' x 60' x 7'	6	5½	6	4½	2½	3	4	5	3



KAHUA
(PEDESTAL)



PA POHAKU
(FOUNDATION WALL)

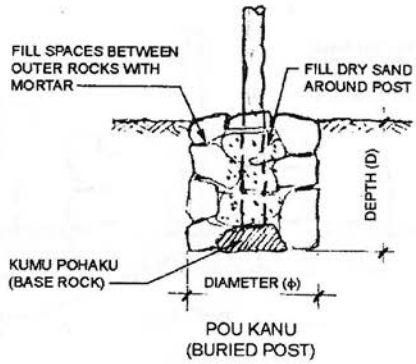
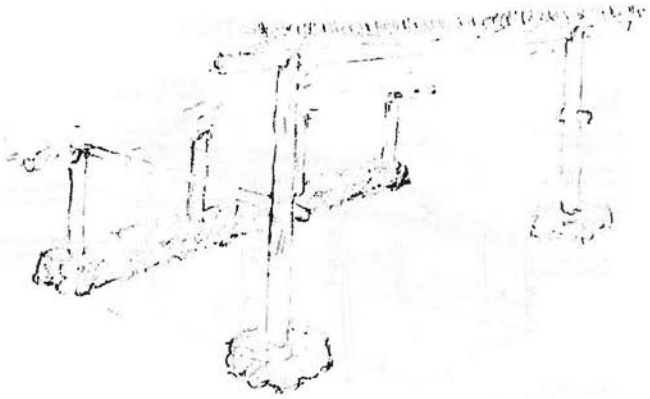


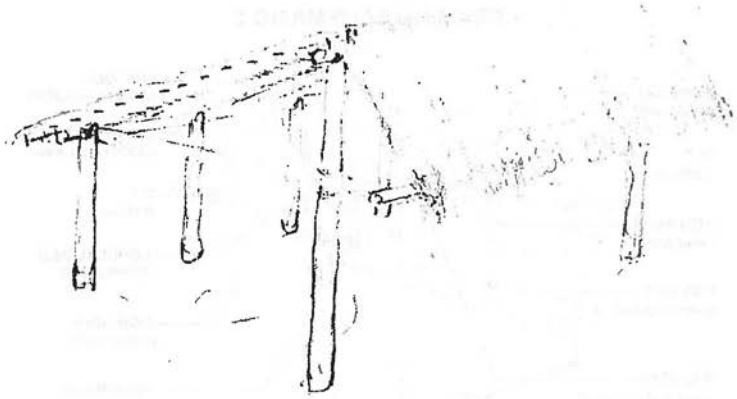
Table X402.1(b)
Foundation Design for Hale Halawai

Size (W x L x H)	**Foundation Type**		
	kahua Diameter x Height	**pa pohaku** Width x Height x Length	**pou kanu** Diameter x Depth
12' x 20' x 7'	3'6"φ x 24"H	2'6"W x 2'8"H x 4'0"L	30"φ x 2'8"D
14' x 24' x 7'	3'8"φ x 24"H	2'6"W x 2'8"H x 4'0"L	30"φ x 2'9"D
24' x 30' x 7'	4'0"φ x 30"H	3'0"W x 3'0"H x 4'0"L	36"φ x 3'0"D
25' x 50' x 7'	4'0"φ x 30"H	3'0"W x 3'0"H x 4'0"L	36"φ x 3'0"D
30' x 60' x 7'	4'0"φ x 30"H	3'0"W x 3'3"H x 4'0"L	36"φ x 3'3"D

X402.2 Hale Ku'ai. Hale Ku'ai shall be designed in accordance with the following schematics and illustrations. Structural components for Hale Ku'ai shall meet the size and spacing requirements in Table X402.2(a). Foundations for Hale Ku'ai shall be designed in accordance with Table X402.2(b).

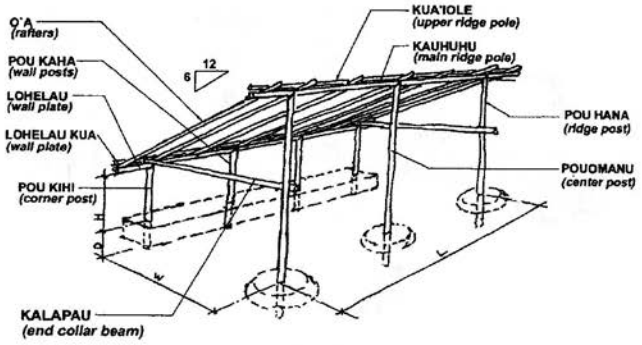


HALE KU`AI
SHED STYLE



HALE KU`AI
GABLE STYLE

FRAMING SCHEMATIC 1



FRAMING SCHEMATIC 2

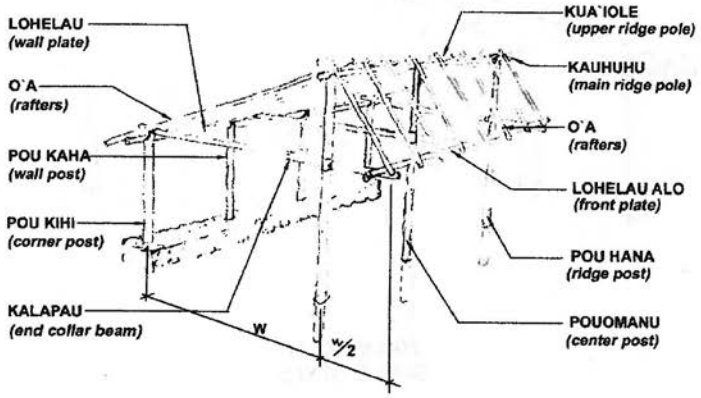
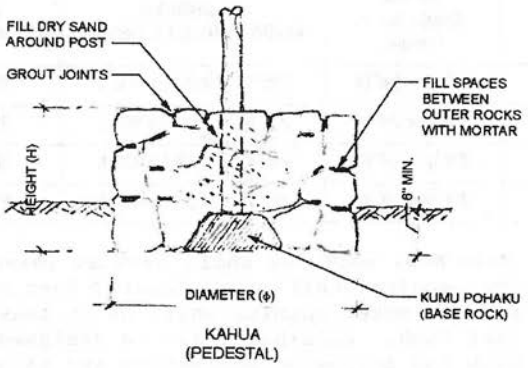


Table X402.2(a)
Size and Spacing Requirements for Structural Components used in Hale Ku'ai

Size (W x L x H)	*pou kihi*[a]	*pou kaha*[a]	*pou hana*[b]	*pouo manu*[b]	*o'a*	*kua'iole & holo*	*kauhuhu*	*lohelau*	Maximum rafter spacing (feet)
	Minimum Diameter (inches)								
5' x 10' x 5'	4	3	3	4	3	2	3	2	4
9' x 12' x 5'	4	3	3	4	3	2	3½	2	4
12' x 16' x 5'	4½	3½	4	4	3½	2	4	2½	4
14' x 20' x 5'	4½	3½	4	4	3½	2½	4½	2½	4

[a] The maximum post spacing for pou kihi and pou kaha is five feet.
[b] The maximum post spacing for pou hana and pouomanu is twelve feet.



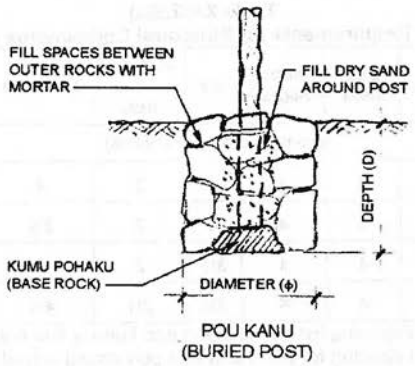
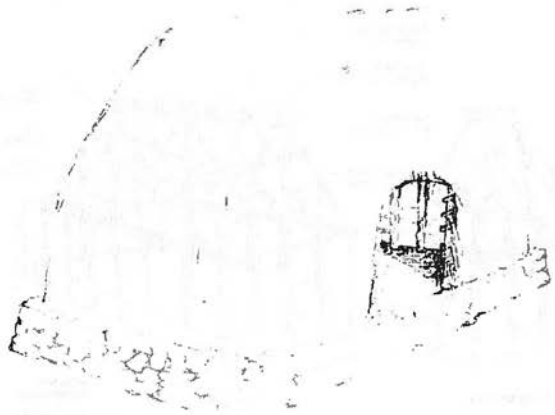


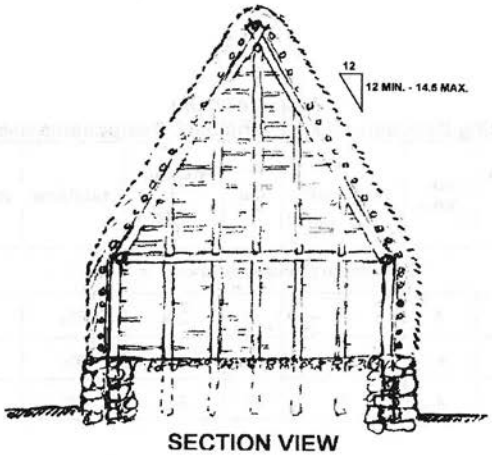
Table X402.2(b)
Foundation Design for Hale Ku'ai

Size (W x L x H)	Foundation Type		
	kahua Diameter x Height	**pa pohaku** Width x Height x Length	**pou kanu** Diameter x Depth
5' x 10' x 5'	3'0"φ x 24"H	2'6"W x 2'0"H x 4'0"L	30"φ x 2'6"D
9' x 12' x 5'	3'4"φ x 24"H	2'6"W x 2'0"H x 4'0"L	30"φ x 2'6"D
12' x 16' x 5'	3'6"φ x 24"H	2'6"W x 2'8"H x 4'0"L	30"φ x 2'8"D
14' x 20' x 5'	3'8"φ x 24"H	2'6"W x 2'8"H x 4'0"L	30"φ x 2'9"D

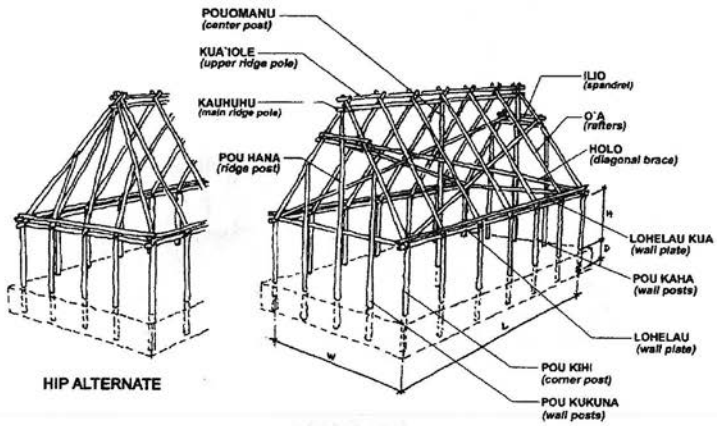
402.3 Hale Noa. Hale Noa shall have at least two openings. One opening shall be at least 3 feet wide and 5 feet high, and the other opening shall be at least 2 feet wide and 3 feet high. Hale Noa shall be designed in accordance with the following schematics and illustrations. Structural components for Hale Noa shall meet the size and spacing requirements in Table X402.3(a). Foundations for Hale Noa shall be designed in accordance with Table X402.3(b).



HALE NOA



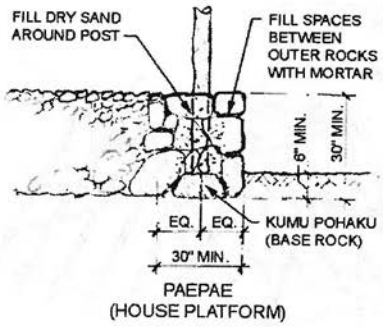
SECTION VIEW



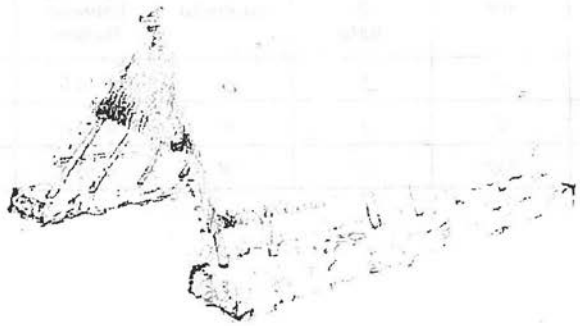
FRAMING SCHEMATIC

Table X402.3(a)
Size and Spacing Requirements for Structural Components used in Hale Noa

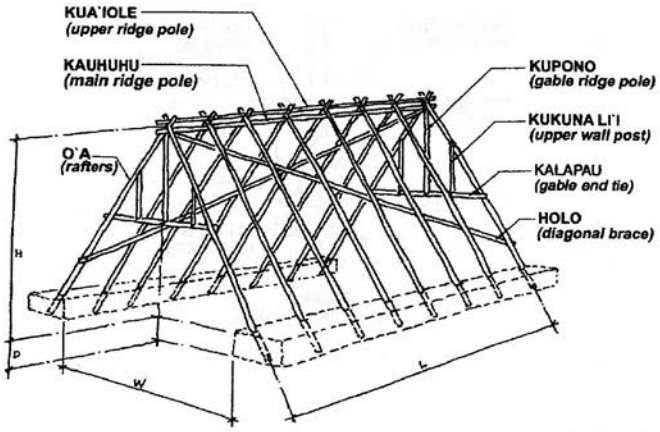
Size W x L x H	*pou kihi*	*pou kukuna & pou kaha*	*pou hana*	*pouomanu*	*o'a*	*kua'iole & holo*	*kauhuhu*	*lohelau*	Maximum post spacing (feet)	Maximum rafter spacing (feet)
	Minimum Diameter (inches)									
9' x 12' x 7'	3½	3	4	3	3	2½	3½	2½	6	4
12' x 20' x 7'	4	4½	4	3	3½	2½	3½	2½	6	4
4' x 24' x 7'	5½	4½	4	3	3½	2½	3½	3	6	4



**402.4 Hale Wa`a.** Hale Wa`a shall be designed in accordance with the following schematics and illustrations. Structural components for Hale Wa`a shall meet the size and spacing requirements in Table X402.4.



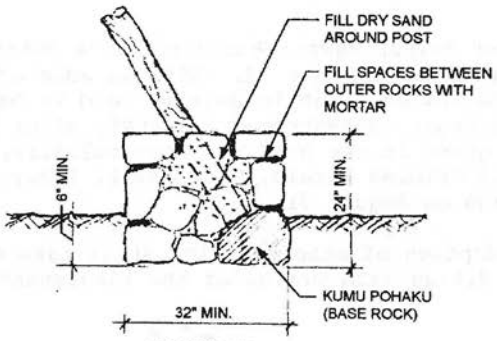
HALE WA`A



FRAMING SCHEMATIC

Table X402.4
Size and Spacing Requirements for Structural Components used in Hale *Wa`a*

Size (W x L)	***o'a***	***kua'iole*** & ***holo***	***kauhuhu***	**Spacing between Rafters**	**Minimum Ridge Height** (H)
20' x 60'	4"	3"	4"	4' to 5'	22½'
25' x 60'	5"	3"	4"	4' to 5'	27½'
30' x 60'	5½"	3"	4"	4' to 5'	27½'



PA POHAKU
(FOUNDATION WALL) "

[Eff APR 16 2010] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES

Chapter 3-180, Hawaii Administrative Rules, on the Summary Page dated October 13, 2009 was adopted on October 13, 2009, following a public hearing held on Oahu, Maui, Hawaii, and Kauai on September 30, 2009, after public notice was given in the Honolulu Star Bulletin, The Maui News, Hawaii Tribune Herald, West Hawaii Today, and The Garden Island on August 31, 2009.

The adoption of chapter 3-180 shall take effect ten days after filing with Office of the Lieutenant Governor.

RUSS K. SAITO, State Comptroller
Department of Accounting and General Services and Chairperson, State Building Code Council

APPROVED:

LINDA LINGLE, Governor
State of Hawaii

Dated: 4/4/10

APPROVED AS TO FORM:

Deputy Attorney General

Filed

180-82

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

6. Tsunamis

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CHAPTER 6
Tsunamis

Reasons for Updates / Revisions in this 2013 Plan
• The Hawaiian Islands have a long history of destruction due to tsunamis and are particularly vulnerable to tsunamis originating from Alaska and Chile. Twenty-eight tsunamis with flood elevations greater than 3.3 ft (1 m) have made landfall in the Hawaiian Islands during recorded history. This translates into a recurrence interval of one large tsunami reaching Hawaiian shores every 7 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 as examples for tsunami effects to Pacific Islands like those in Hawai‘i. • Further historical data on tsunamis affecting Hawai‘i during the past 100 years is presented. • Additional information on tsunami detection and warning is provided. • A major overhaul of the state’s warning siren system began in 2012 • A discussion of a recent community vulnerability study is provided. • New tsunami inundation and new evacuation maps are discussed. • (An estimate of tsunami average annualized losses is calculated based on these maps and property values in a GIS-geocoded database.) Tsunami annual losses are estimated. • New proposed project to implement the new ASCE tsunami design standard is discussed.

Summary of Mitigation Projects for the State of Hawai‘i	
Project	**Priority**
Update tsunami evacuation maps for Great Aleutian tsunami	High
UHM SOEST should produce probabilistic tsunami hazard maps (runup and inundation depth) for the ASCE-2016 and IBC-2018 building code design provisions.	High
Adopt tsunami design provisions for buildings for new design and construction and for evaluating existing buildings.	High
Preliminary engineering of tsunami and coastal flood mitigation retrofit of critical infrastructure.	High
Identify and retrofit critical BWS pumping stations in the tsunami inundation zone.	High

6.1 Tsunamis Hazard Description

6.1.1 General

A tsunami is a series of long-period sea waves of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major submarine slides, or catastrophic volcanic eruptions. Although landslides and volcanoes cause some local tsunamis, probably more than 95 percent of tsunamis result from subduction earthquakes.

The earthquakes associated with tsunamis are referred to as "tsunamigenic" earthquakes."[1] The association between earthquakes and tsunamis results from the fact that both are generated by the tectonic displacement of the earth's crust.[2] 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 resulting from subduction zone earthquakes. The earthquake's magnitude, depth, fault characteristics, and coincident slumping of sediments or secondary faulting control the size of the tsunami.

Tsunamis are characterized as shallow-water waves, that is their wavelength, is much greater (about 20x) the depth of the ocean. Shallow-water waves are different from wind-generated surf waves. Wind-generated waves usually have a period (time between two successional waves) of five to twenty seconds and a wavelength (distance between two successional waves) of about 100 to 200 meters (300 to 600 ft). A tsunami wave can have a period in the range of five minutes to two hours and an open ocean wavelength in excess of 100 miles. It is because of their long wavelengths that tsunamis behave as shallow-water waves. A wave is characterized as a shallow-water wave when the ratio between the water depth and its wavelength gets very small. The speed of a shallow-water wave form is equal to the square root of the product of the acceleration of gravity (32ft/sec/sec or 980cm/sec/sec) and the depth of the water. Hence in very deep water, a tsunami will travel at high speeds and propagate across transoceanic distances with limited energy loss. For example, where the ocean is 20,000 feet (6100 m) deep, tsunami travel about 550 miles per hour (890 km/hr), the speed of a jet airplane.

6.1.2 Tsunamis in Hawai'i and Travel Time

6.1.2.1 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 States of

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[1] Cox, Doak and Morgan, Joseph, "*Local Tsunamis and Possible Local Tsunamis in Hawai'i*", National Science Foundation, 1977, 118p

[2] Ibid

Washington, Oregon, and California, 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.

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 6.1 shows the travel times of tsunamis originated from earthquakes in the Pacific Rim.

There were several recent tsunamis in the Pacific; some of which required mandatory shoreline evacuations in March 2010 and December 2012. Studies have been conducted that improve the understanding of tsunami from various directions. Based on the tsunami inundation mapping effort, new evacuation maps are being developed. Updated evacuation maps were originally expected with completion of the evacuation mapping updates by 2012. However, based on the inundation modeling and mapping efforts, it became apparent that tsunamis could affect coastal areas to a greater extent than previously understood; therefore, a new effort began in 2012 to consider a Great Aleutian Tsunami.

6.1.2.2 Near-Source Tsunamis

Hawai'i is also vulnerable to tsunamis that can be induced "locally" by such events as volcanic eruptions, earthquakes, or sub-aerial and submarine landslides. These local events are most likely to be generated on the island of Hawai'i and could reach the coastlines of most major Hawaiian Islands within less than one hour. Figure 6.2 shows the travel times of tsunamis originated from earthquakes within the Hawaiian Islands.

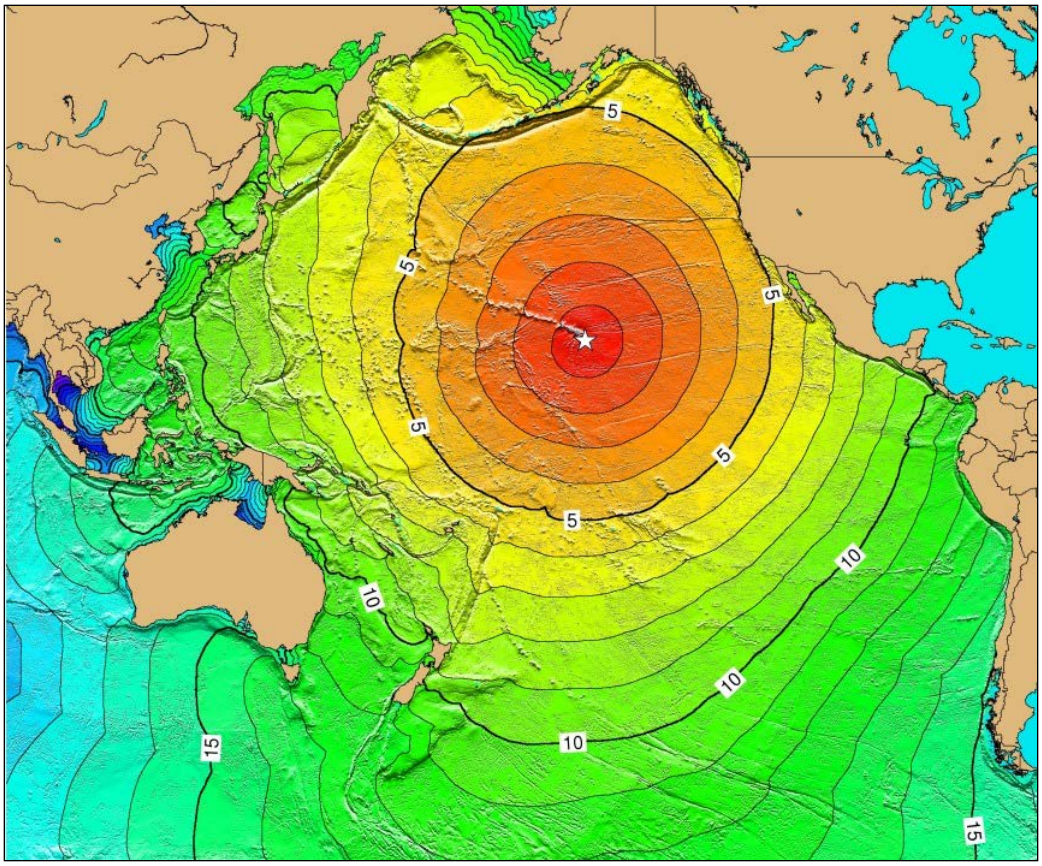


Figure 6.1 Approximate Travel Time in Hours of Tsunamis Generated by Earthquakes in the Pacific Rim[3]

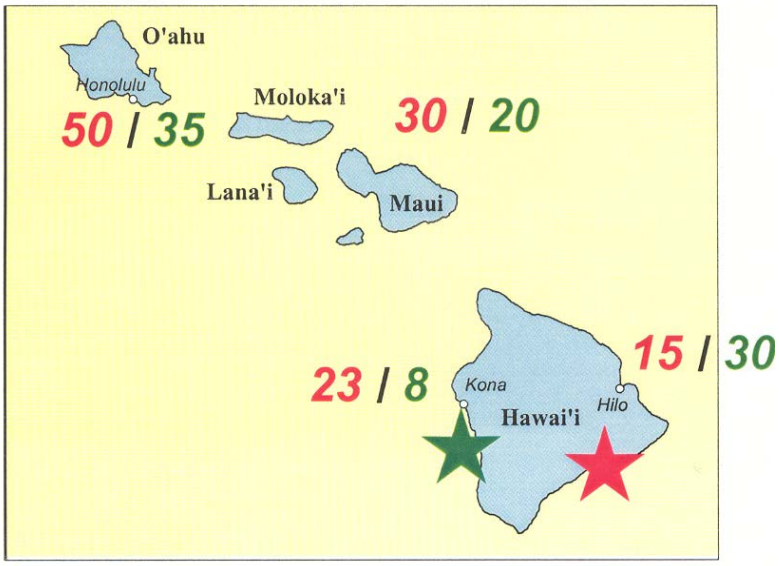


Figure 6.2 Approximate Travel Time in Minutes of Tsunamis Generated by Local Earthquakes (Red & Green Stars)[4]

[3] Image from National Oceanic and Atmospheric Administration (NOAA) Website, Retrieved October 14, 2009 from http://www.ngdc.noaa.gov/hazard/icons/1975_1129.jpg

As a tsunami leaves the deep water of the open sea and propagates into the more shallow 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 (see Figure 6.3).

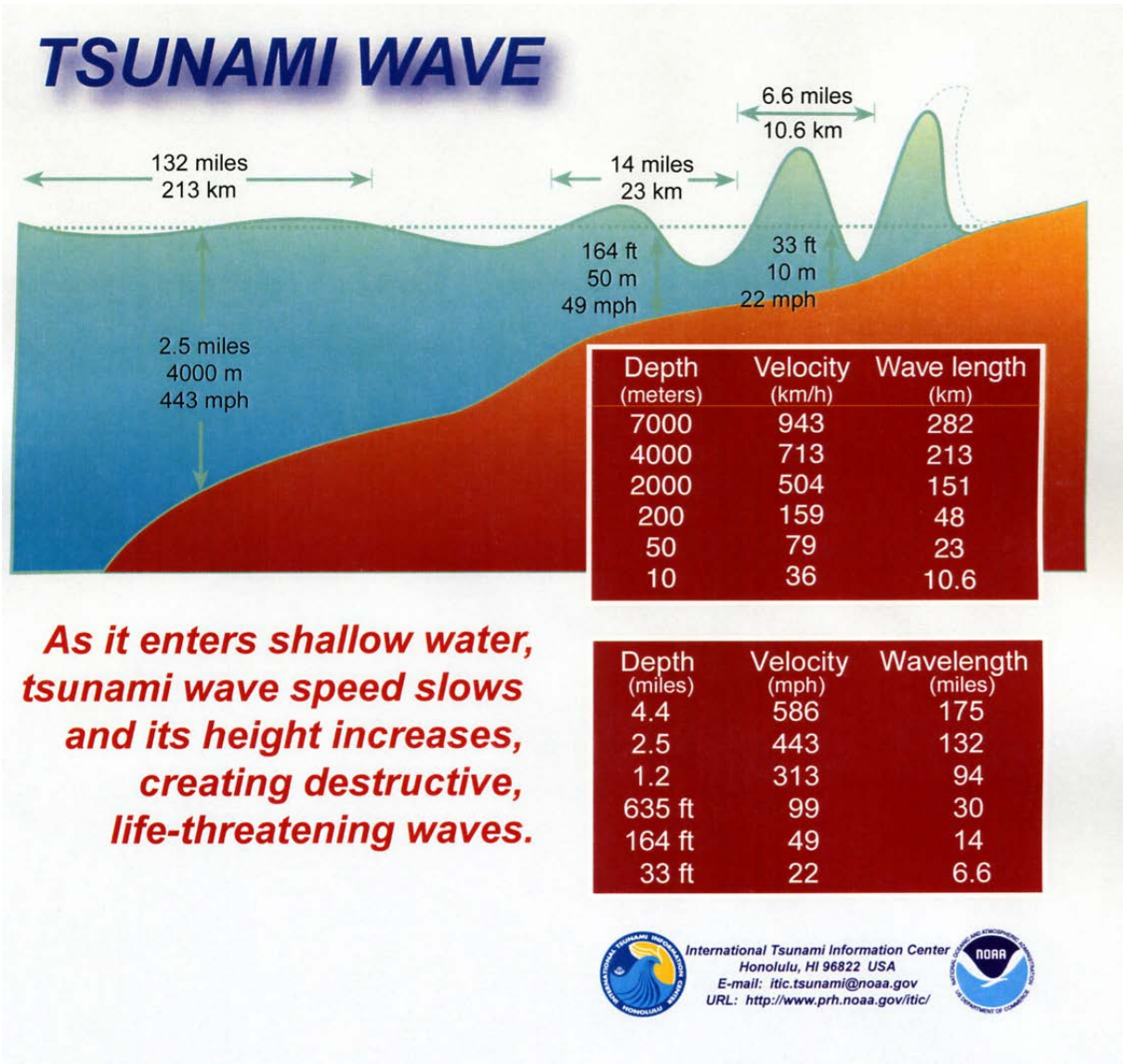


Figure 6.3 Example of a Tsunami Wave Characteristics

[4] Image courtesy of the International Tsunami Information Centre

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. Figure 6.4 illustrates the difference between wind- and tsunami-induced waves.

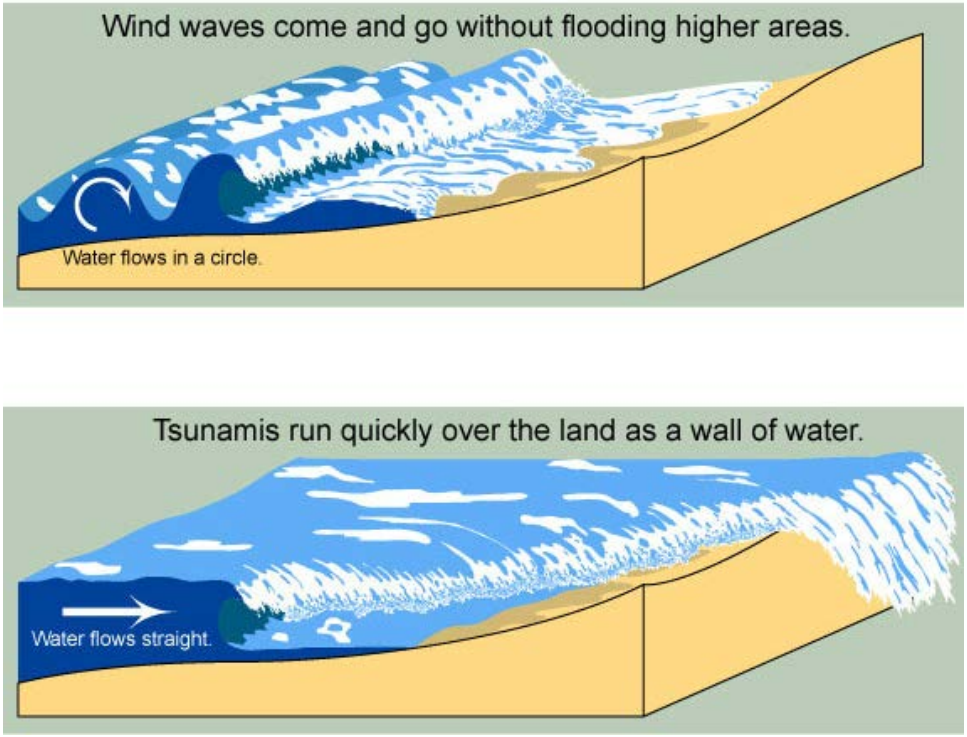


Figure 6.4 Wind-Generated Waves versus Tsunami-Generated Waves[5]

When a tsunami finally reaches the shore, it may appear as a rapidly rising or falling tide, a series of breaking waves, or even a bore. Although most people imagine a tsunami as a large, steep wave breaking on the shore, tsunamis generally appear as an advancing tide without a developed wave face and produce rapid flooding of low-lying coastal areas. Reefs, bays, entrances to rivers, undersea features and the slope of the beach all help to modify the tsunami as it approaches the shore. Because the long-period wave can bend around obstacles, the tsunami can enter bays and gulfs having the most intricate shapes. Experience has shown that wave heights increase in bays that narrow from the entrance to the head, but decrease in bays that have narrow entrances. Unlike storm waves, tsunami waves may be very large in embayment, actually experiencing amplification in long funnel- shaped bays. Shores of islands protected by coral reefs commonly receive less energy than unprotected coastlines lying in the direct path of an approaching tsunami. Islands in a group may "shadow" one another reducing the tsunami effect. Small islands may experience reduced run-up as the tsunami waves may refract around them. Fringing and barrier reefs appear to have a mitigating influence on tsunamis by dispersing the wave energy.

[5] Image from University of Washington Earth & Space Sciences Website, Retrieved October 13, 2009 from http://www.ess.washington.edu/tsunami/index.html

Tsunamis rarely become great, towering breaking waves. Sometimes the tsunami may break far offshore. In other cases, it may form into a bore: a step-like wave with a steep breaking front. A bore can occur if the tsunami moves from deep water across a gently sloping near-shore bathymetry, or over a sharp discontinuously like a shallow fringing reef.

The water level on shore can rise many feet. In extreme cases, water level can rise to more than 50 feet (15 m) for tsunamis of distant origin, and over 100 feet (30 m) for tsunamis generated near the earthquake's epicenter. The first wave may not be the largest in the series of waves. One coastal area may see no damaging wave activity while in another area destructive waves can be large and violent. Flooding tsunami waves tend to carry debris and people out to sea when they retreat. Currently, many people are not aware of the severity of run-up that can occur during tsunamis. See Figure 6.5.

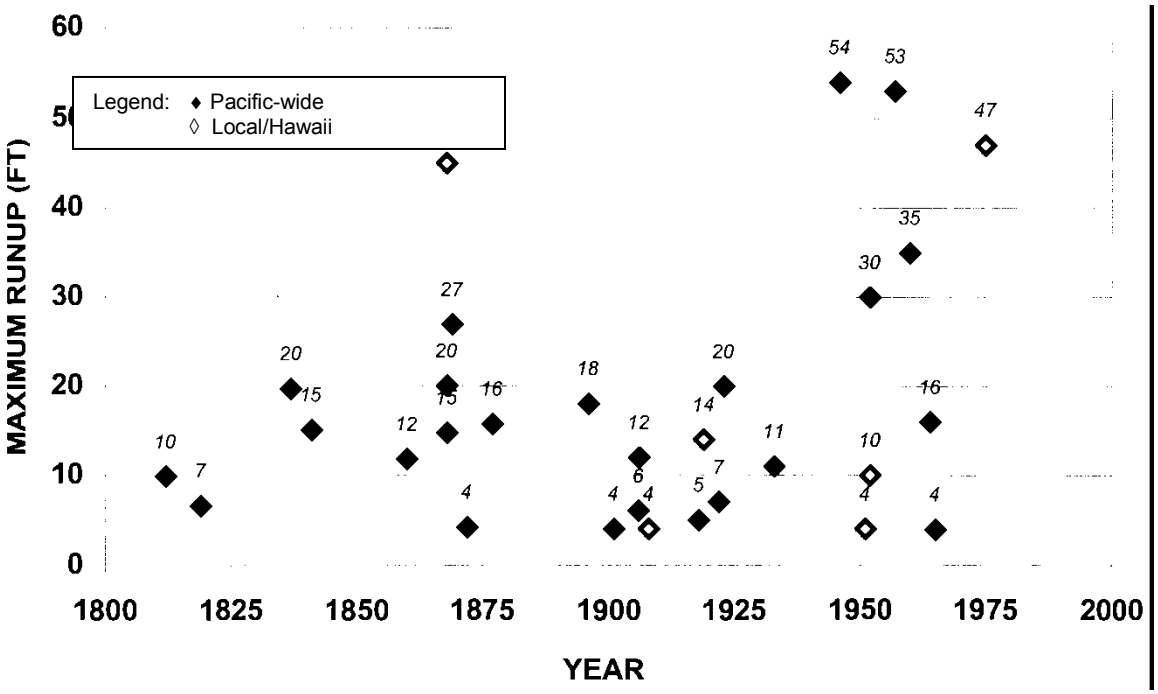


Figure 6.5 Tsunamis Impacting Hawai'i from 1800 to 2003

A tsunami's effect at the shoreline is measured in terms of run-up height and inundation limit. Figure 6.6 shows and 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[6] is steeper. Even so, inundation can be significant and is usually greatest along low-lying coastal plains.

[6] Bathymetry is the measurement of the depths of oceans, seas, or other large bodies of water.

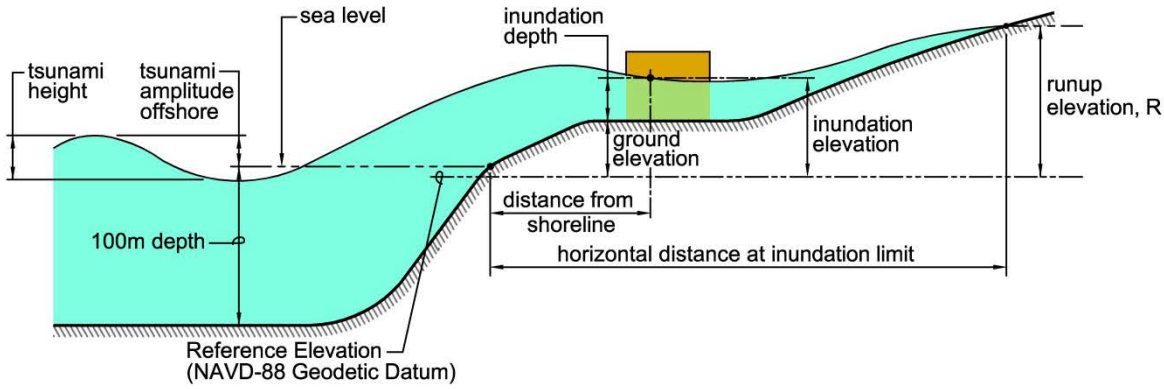


Figure 6.6 Illustration of Tsunami Terminology

At sea level on the coast there is no safe place during a tsunami. On low-lying shorelines such as in the river and stream valleys that characterize so much of Hawai‘i, a tsunami may occur as a rapidly growing high tide that rises over several minutes, and inundates low coastal regions. The return of these flood waters to the sea causes much damage. At headlands the refractive focusing of the wave crest leads to energy concentration and high magnitude run-up.

6.2 Significant Historical Events

The recorded history of tsunamis in Hawai‘i encompasses several phases according to the availability of recorded data. During the 19th century, numerous tsunamis were reported in newspapers, weeklies, and books written by residents at the time. The cause of tsunamis was not generally known, nor was the origin in terms of whether the tsunami was the result of a seismic event in a distant source such as the Aleutian Islands of Alaska or a local submarine landslide in the Hawaiian Islands. Toward the end of the 19th century, seismological stations became available to record and locate earthquakes. Through the instruments in these stations, it became easier to associate distant earthquakes with tsunamis in Hawai‘i. The establishment of the Hawai‘i Volcano Observatory in 1912 brought the expertise needed to accurately determine the origin and causes of local earthquakes and tsunamis in the islands. After the 1946 tsunami, the Tsunami Warning System was established and a group of experts was constituted to track and document origin, wave heights, and other data pertinent to tsunamis.

Up to May of 2013, twenty-eight tsunamis with run-up heights greater than 3.3 feet (1 meter) have made landfall in the Hawaiian Islands during recorded history and 4 have had significant damaging effects. In fact, tsunamis in the Hawaiian Archipelago have cumulatively killed the largest number of people of all natural hazards affecting the islands. Tsunamis reaching the Hawaiian Islands have exhibited tremendous variability in terms of their run-up heights, inundation distances, and the damage they have inflicted. Table 6.1 lists tsunamis affecting the State of Hawai‘i with run-up heights greater than 3.3 feet (1 meter). To complement the aforementioned table, Table 6.2 lists tsunami destruction in the State of Hawai‘i.

The tsunamis of 1868 and 1975 were locally generated by earthquakes beneath the southern coast of the island of Hawai‘i. The waves produced by the 1868 tsunami destroyed several coastal villages in the Ka‘ū and Puna districts of the Island of Hawai‘i (most of which were never rebuilt). The 1975 tsunami claimed two lives and caused widespread damage along the Kalapana coast on the East side of the island of Hawai‘i.

The most devastating tsunamis to hit the State of Hawai‘i in the last century occurred in 1946 and 1960. The tsunami of 1946 originated in the Aleutian Islands, and struck the Hawaiian Islands without warning. Over 170 people were killed in the Island of Hawai‘i, mainly at Laupāhoehoe and Hilo where the wave heights averaged 30 feet. The maximum wave height reported on the island of Hawai‘i was 55 feet at Pololū Valley on the northern tip of the island.

The May 1960 tsunami (generated by the magnitude 9.5 Great Valdivia Earthquake in Chile) was one of the most destructive to hit the Hawaiian Islands. In the town of Kahului in the island of Maui, damage estimate was about $763,000 in the low coastal areas of the town. The waves washed inland for a distance of about 3,000 feet to ground elevations of about 6 feet. The Kahului Shopping Center and immediate vicinity received most of the damage. This tsunami also had significant effect on the town of Hilo, on the east shore of the Island of Hawai‘i. Although the arrival time of this tsunami was correctly predicted, many people failed to heed the warnings and evacuations mandated by the authorities were insufficient. As a result, 61 lives were lost as waves up to 35 feet high crashed through homes in Hilo. Whole city blocks were swept clean of all buildings, and 580 acres were flooded. $23 Million in damages were reported in Hilo.

A much less destructive tsunami hit the island of Maui in March 1964 (generated by the magnitude 9.2 Great Alaskan Earthquake) with a recorded maximum run-up at Kahului of 12 feet and doing estimated $53,000 (1964 dollars) damage.[7]

In 2010, a tsunami generated by a magnitude 8.8 earthquake offshore of the Region of Maule in Chile, arrived to the Hawaiian Islands approximately at noon on February 27. Although very similar in nature to the May 22 tsunami generated by the Valdivia Earthquake also in Chile, the 2010 tsunami did not cause any damage to property, injury, or loss of life because its run-ups were much lower than those of the 1960 tsunami. The tsunami generally generated run-ups between 3 and 4 feet across all shores of all Hawaiian Islands with the higher run-ups occurring on the south and east facing shores.

Although not destructive, the latest tsunami to hit the Hawaiian Islands occurred in 2011. This tsunami was generated by a magnitude 9.0 earthquake off the coast of Tōhoku, Japan. Likewise the 2010 tsunami created by the Chile earthquake, this tsunami did not cause any damage to property, injury, or loss of life in any of the Hawaiian Islands.

[7] The Tsunami Page of Dr. George P.C. Website, Retrieved on October 14, 2009 from http://www.drgeorgepc.com/Tsunami1964Hawai‘i.html

Table 6.1 Tsunamis Affecting Hawai‘i, 1812-2002 (*Source: International Tsunami Information Centre, 2004)*

TSUNAMIS AFFECTING HAWAI'I, 1812-2002 (> 1 M RUNUP)										
Yr		**Mo**	**Day**	**Ms**	**MM**	**Runup (m)**	**Runup (ft)**	**Runup Station Location**	**Source**	**Notes (H=Hawai'i, M=Maui, Mo=Molokai, O=O'ahu, K=Kauai'i)**
1812	12/21/1812	12	21			3	10	Ho'okena, Hawai'i	S.California?	1 (H)
1819	4/12/1819	4	12			2	7	W. Hawai'I, Hawai'i	North Coast Chile	1 (H)
1837	11/7/1837	11	7			6	20	Hilo, Hawai'i	South Coast Chile	3 (H,M,O)
1841	5/17/1841	5	17			4.6	15	Hilo, Hawai'i	Kamchatka	3 (H,M,O)
1860	12/1/1860	12	1			3.6	12	Maliko, Maui	N. Pacific?	2 (M)
1868	8/13/1868	8	13			4.5	15	Hilo, Hawai'i	North Chile	6 (H.M.O,K)
1868	10/2/1868	10	2			6.1	20	Kahaualea, Hawai'i	S. Pacific?	1 (H)
1869	7/24/1869	7	24			8.2	27	Puna Coast, Hawai'i	S. Pacific?	2 (H,M)
1871	2/20/1871	2	20	7					Off Lanai?	
1872	8/23/1872	8	23			1.3	4	Hilo, Hawai'i	Aleutians	1 (H)
1877	5/10/1877	5	10			4.8	16	Wai'akea, Hawai'i	N. Chile	8 (H,M,O)
1896	6/15/1896	6	15			5.5	18	Keauhou Landing, Hawai'i	Japan	15 (H,M,K)
1868	4/2/1868	4	2	7.9	XII	13.7	45	Keauhou Landing	Ka'u	many observations
1908	9/21/1908	9	21	6.8	VI	1.2	4	Hilo, Hawai'i	Mauna Loa NE Rift	1 (H)
1919	10/2/1919	10	2	6.1		4.3	14	Ho'opuloa, Hawai'i	South Kona (landslide possibly)	3 (H), Hoopuloa submarine landslide
1926	3/20/1926	3	20			1.5			Off Wailupe, Oahu	
1951	8/21/1951	8	21	6.9	VIII	1.2	4	Ho'okena, Hawai'i	South Kona	
1952	3/17/1952	3	17	4.5	V	3	10	Kalapana, Hawai'i	Kilauea South Flank	1 (H)
1975	11/29/1975	11	29	7.2	VIII	14.3	47	Keauhou Landing, Hawai'i	Kilauea South Flank	many observations (H), 2 deaths/19 injured, **$4.1 million**;
										32 campers at foot of Pu'u Kapukapu - rocks fell pushing
										them to beach where waves started 1) 1.5 m wave,
										2) 7.9 m (26-ft)wave carried campers into crevice/ditch saving
										them from being carried to sea; subsidence 3-3.5 m (11.5ft)Halape
1901	8/9/1901	8	9	7.8		1.2	4	Ho'opuloa, Kailua-Kona, Hawai'i	Vanuatu	
1906	1/31/1906	1	31	8.1		1.8	6	Hilo, Hawai'i	Ecuador	
1906	8/17/1906	8	17	8		3.6	12	Ma'alea, Maui	Chile	
1918	9/7/1918	9	7	8		1.5	5	Hilo, Hawai'i	Kurils	
1922	11/11/1922	11	11	8.1		2.1	7	Hilo, Hawai'i	Chile	
1923	2/3/1923	2	3	8.1		6.1	20	Hilo, Hawai'i	Kamchatka	
1933	3/2/1933	3	2	8.3		3.3	11	Ka'alualu, Hawai'i	Japan	
1946	4/1/1946	4	1	7.1		16.4	54	Waikolu Valley, Moloka'i	Aleutians	159 deaths, **$26 million**, in Hilo (3800 km), 8-m waves,
										every house facing bay washed across st/smashed
1952	11/4/1952	11	4	8.2		9.1	30	Ka'ena Point, O'ahu	Kamchatka	**$0.8-1.0 million**
1957	3/9/1957	3	9	8.1		16.1	53	Kaua'i, Kaua'i	Aleutians	**$5 million**, arr Laie, Oahu (3600 km away) 12ft wave
1960	5/22/1960	5	22	8.5		10.7	35	Hilo, Hawai'i	Chile	61 deaths, **$26.5 million**
1964	3/28/1964	3	28	8.4		4.9	16	Waimea Bay, O'ahu	Alaska	
1965	2/4/1965	2	4	8.2		1.1	4	North Kaua'i, Kaua'i	Aleutians	2 observations on Kaua'I
EQ - NO TSUNAMI										
1983	11/16/1983	11	16	6.6					Kao'iki	Ext damage SE Hawai'i, **>$6 million**
1989	6/25/1989	6	25	6.1					Kalapana	SE Hawai'i, **Almost $1 million**
2011	3/11/2011	3	11	9.0					Honshu, Japan	
						covert m-ft	3.286713			

Table 6.2 Tsunami Destruction in Hawai'i *(Source: International Tsunami Information Centre)*

DATE	SOURCE	DEATHS*	WHERE	Run-up**	REMARKS
1837	Earthquake in Chile	16	Hawaiian islands	6 m / 19.6 ft	14 deaths on the Big Island and 2 on Maui.
1868	Earthquake off the Big Island	47	Big Island	13.7 m / 45 ft	The earthquake also caused a landslide in Pahala that killed 37 bringing total deaths to 79.
1877	Earthquake in Chile	5	Hilo	4.8 m / 16 ft	Also 17 injured in Hilo.
1923	Kamchatka earthquake	1	Hilo	6.1 m / 20 ft	Others may have been killed (up to 12 others) and extensive damage occurred in Hilo and Kahului.
1933	Earthquake in Japan	1,600	Japan	3.3 m / 10.8 ft	No deaths in Hawaii but 17 feet waves were reported at Napoopoo.
1946	Earthquake in Aleutian islands	159	Mostly in Hilo (96) but also Kauai (15), Maui (14), & Oahu (9)	16.4 m / 53.8 ft	The largest natural disaster recorded to have occurred in Hawaii.
1952	Kamchatka earthquake	0	Hawaiian islands	9.1 m / 29.9 ft	Damage occurred on Kauai, Maui, Oahu, and in Hilo.
1957	Earthquake in the Aleutian islands	0	Hawaiian islands	16.12 m / 52.8 ft	Caused extensive damage on Kauai.
1960	Earthquake in Chile	61	Hawaiian islands	10.7 m / 35.1 ft	Over 1,000 people died in Chile, Japan, The Philippines, and Hawaii.
1964	Earthquake in Alaska	0	Hawaiian islands	4.9 m / 16.1 ft	106 people died in Alaska and 16 died on the North American coast. Damage occurred in Hilo and Kahului.
1975	Earthquake off the Big Island	2	Halape	14.3 m / 47 ft	19 others were injured.

* For more details see Doak C. Cox, "Tsunami Casualties and Mortality in Hawaii", University of Hawaii, Environmental Center, June 1987.

**Maximum run-up is the greatest height the tsunami was found to reach above the normal shore. The measurements listed are for the highest run-up recorded anywhere in Hawaii for that event (listed in meters and feet).

6.3 Probability of Occurrence

Currently, there are no tsunami probabilistic hazard maps for inundation or evacuation of the islands for distant and near source tsunamis. However, the historical frequency of tsunamis with 1 meter of runup is about 1 in 15 years. Considering that tsunamis are the hazard most likely to occur on the Hawaiian Islands, emphasis should be put to develop probabilistic inundation maps for construction standards for all islands such that critical facilities around the state have a uniform level of protection against tsunamis.

The University of Hawai‘i (UH) School of Ocean and Earth Science Technology (SOEST) tsunami inundation contours were compared to the more recent 2008 south and west shore Flood Insurance Study (FIS) 100-year coast flood boundary, which is proposed to form the basis for the updated Digital Flood Insurance Rate Maps (DFIRM) flood hazard maps. The comparisons show that the tsunami inundation areas are generally larger than the coastal flood inundation based on hurricane wave setup, highlighting the importance of considering tsunami inundation now omitted in the DFIRM maps. The tsunami inundation analysis is based on deterministic scenarios not on statistical probabilistic methods. The deterministic scenarios simulate all historic damaging tsunamis within the last 100 years as well as other simulated tsunamis. An improved analysis would develop maps based on probabilistic data.

6.3.1 Tsunami Evacuation Mapping

The State of Hawai‘i’s previous tsunami evacuation maps were developed in 1991 using estimates of historical event runups and one-dimensional transect inundation models. 2010-vintage tsunami evacuation maps, which were developed for the State of Hawai‘i Civil Defense and can be found in the phone books, are based on two-dimensional inundation model for just the historical events within the last 100 years. The two-dimensional model approach provided an effective tool to numerically reconstruct five major Trans-Pacific tsunamis that have affected Hawai‘i within the last 100 years. This approach produced greater inundation areas in flat land locations adjacent to steep slopes, where a one-dimensional model did not adequately describe the complex flow patterns.

The 2010 evacuation zones were 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. (This enables the public to quickly recognize whether they are or are not in an evacuation zone.) Populated areas within the tsunami evacuation zones have been designated as such throughout the islands of Hawai‘i, Maui and Moloka‘i, and a project to do so for the island of O‘ahu is underway.

More accurate maps are considered priorities of the state-wide mitigation plan, based on the results of two dimensional models for, a) evacuation zones for worst-case Aleutian earthquakes, and b) probabilistic hazard criteria for a tsunami design zone (see Section 6.5.3).

6.3.2 Signage

Populated areas within the tsunami evacuation zones have been signed as such throughout the islands of all counties. Figure 6.6 shows the standard signs used to define tsunami evacuation areas in the State of Hawaiʻi. Existing signs are routinely maintained, repaired, and replaced as needed.

Figure 6.7 Tsunami Evacuation Area Signage in the State of Hawaiʻi

The City and County of Honolulu is currently planning a reassessment of tsunami evacuation zones in the island of Oʻahu. The City has launched a yearlong 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 Oʻahu Emergency Evacuation Plan Project is funded by a $500,000 grant from the Oʻahu Metropolitan Planning Organization with matching funds from the city. The project aims to analyze communities across the island to determine challenges they face in evacuation residents and tourists during a tsunami warning. Analyses would help planners determine where to place signs for tsunami evacuation areas and develop strategies to minimize traffic congestion. The one-year project will identify high-rise coastal evacuation areas on Oʻahu and develop a strategy to designate evacuation routes, route signage, and refuge area locations. Project objectives are the following:

- Develop specific emergency evacuation route plans and identify 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.

- Geographical Information System (GIS) –based evacuation route plan and tsunami evacuation signage plan for Oʻahu.

The project is leveraging active community involvement, particularly in the towns of Kailua, Kāneʻohe, and Hauʻula and also along the communities of the north shore of the island.

6.3.3 Planning Considerations for a Great Aleutian Tsunami

It has become increasingly recognized that past modeling did not consider all possible sources of tsunamis. The geometry of the Aleutian arc between the 1946 and 1957 earthquakes enhances tsunami risk to Hawai‘i from potentially large earthquakes in this region.[8]

6.3.3.1 Re-examination of the Potential for Great Earthquakes along the Aleutian Island Arc with Implications for Tsunamis in Hawai‘i (Butler):

- Several segments of the Aleutian arc have the potential for magnitude Mw 9 events.
- The geometry of the Aleutian arc between the 1946 and 1957 earthquakes enhances tsunami risk to Hawai‘i from potentially large earthquakes in this region.
- In the region between the ruptures of the 1946 and 1957 great tsunami generating earthquakes in the Aleutians, there is an approximately 700 kilometer extent in the east Aleutian Islands without significant fault displacement in more than a century, which has the potential for a magnitude 9.0–9.4 earthquake with a concomitant large tsunami.
- The National Ocean and Atmospheric Administration (NOAA) Method of Splitting Tsunami (MOST) and Short-term Inundation Forecasting (SIFT) tsunami forecast model for an Mw 9.25 earthquake in this region shows inundations in Hawai‘i significantly exceeding historic run-ups and current evacuation zones.
- THIRA 2012 used approximate tsunami inundation maps based on analysis by the NOAA PMEL MOST model for an Aleutian Mw = 9.25 event.
- Since then, extensive study has been performed of the range of Aleutian events of Mw of 9 or greater than would significantly exceed current evacuation limits in Hawai‘i. Therefore, a second “fallback” evacuation zone is being considered for just this particular source of great earthquakes.
- Detailed independent analysis by the higher resolution UH Mānoa NEOWAVE model has produced similar results to the MOST Model. Sufficient information has been produced for starting initial planning for O‘ahu.
- USGS has stated that they regard the Alaskan earthquake scenarios as plausible worst case scenarios for Hawai‘i based on the examination of other gigantic earthquakes around the world, including the 1960 Chile, 2004 Indonesia, and 2011 Japan earthquakes.

6.3.4 Local Tsunami Real-Time Warning System

In the early 2000’s, a new tidal gage system was put in place to alert police of a local tsunami generated from earthquakes or landslides off the southern coast of the island of Hawai‘i. This

[8] Re-examination of the Potential for Great Earthquakes along the Aleutian Island Arc with Implications for Tsunamis in Hawaii (Butler), Seismological Research Letters (Jan./Feb. 2012)

system senses sea level rise at six locations on this southern shoreline.[9] It alerts the Pacific Tsunami Warning Center (PTWC), which immediately confirms the event by correlating it to an earthquake signal, and advises the County Civil Defense (or the police after working hours). This system supplements the slower and less definitive earthquake-only awareness local advisement policy.

6.3.5 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. Descriptions of the types of warnings issued by the PTWC and how they trigger the warning sirens according to NOAA's National Weather Service Forecast Office in Honolulu, Hawai'i are as follows:

- *Tsunami Warning:* A tsunami warning is issued when a potential tsunami with significant widespread inundation is imminent or expected. Warnings alert the public that widespread, dangerous coastal flooding accompanied by powerful currents is possible and may continue for several hours after arrival of the initial wave. Warning's also alert emergency management officials to take action for the entire tsunami hazard zone. Appropriate actions to be taken by local officials may include the evacuation of low-lying coastal areas, and the repositioning of ships to deep waters when there is time to safely do so. Warnings may be updated, adjusted geographically, downgraded, or canceled. To provide the earliest possible alert, initial warnings are normally based only on seismic information.

- *Tsunami Watch:* A tsunami watch is issued to alert emergency management officials and the public of an event which may later impact the watch area. The watch area may be upgraded to a warning or advisory - or canceled - based on updated information and analysis. Therefore, emergency management officials and the public should prepare to take action. Watches are normally issued based on seismic information without confirmation that a destructive tsunami is underway.

- *Tsunami Advisory:* A tsunami advisory is issued due to the threat of a potential tsunami which may produce strong currents or waves dangerous to those in or near the water. Coastal regions historically prone to damage due to strong currents induced by tsunamis are at the greatest risk. The threat may continue for several hours after the arrival of the initial wave, but significant widespread inundation is not expected for areas under an advisory. Appropriate actions to be taken by local officials may include closing beaches, evacuating harbors and marinas, and the repositioning of ships to deep waters when there is time to safely do so. Advisories are normally updated to continue the advisory, expand/contract affected areas, upgrade to a warning, or cancel the advisory.

- *Tsunami Information Statement:* A Tsunami Information Statement is issued to inform

[9] Walker, Daniel, *Local Tsunami Real-time Warning System*, Science of Tsunami Hazards, 20, 1, 2002

emergency management officials and the public that an earthquake has occurred. In most cases, information statements are issued to indicate there is no threat of a destructive tsunami and to prevent unnecessary evacuations as the earthquake may have been felt in coastal areas. An information statement may, in appropriate situations, caution about the possibility of destructive local tsunamis. Information statements may be re-issued with additional information, though normally these messages are not updated. However, a watch, advisory or warning may be issued for the area, if necessary, after analysis and/or updated information becomes available.

- *Tsunami Evacuation:* Sirens will sound. Turn on radio. Those who are in tsunami evacuation zones must begin evacuation when the evacuation advisory is issued by civil defense.

- *Urgent Tsunami Warning*: Possible tsunami generated by a significant earthquake in local waters. Sirens will sound. Turn on radio. If an urgent tsunami warning is announced, leave the evacuation zones immediately.

Hawai‘i Civil Air Patrol (CAP) aircraft capable of night flights with instrument-rated pilots equipped with speakers and sirens on the islands of Kaua‘i, O‘ahu, Maui, and Hawai‘i are deployed to alert areas where any land-based sirens have malfunctioned. CAP has eleven aircrafts. On March 10, 2011, when the PTWC issued the tsunami warning resulting from the Great East Japan Earthquake, CAP planes were airborne within 20 minutes. Similarly, on February 27, 2010, CAP responded with eight aircrafts in the early morning to provide warnings after the magnitude 8.8 Maule, Chile earthquake and tsunami. During the October 27, 2012 Queen Charlotte Fault M7.7 earthquake and tsunami warning and evacuations, CAP flights were again conducted in night operations over a 3-hour period. During a tsunami warning, CAP aircrafts may fly as low as 500 feet covering beach, residents, campers, and near-shore boaters.

In December 2012, several weeks after the October 27, 2012 Queen Charlotte Fault earthquake and tsunami evacuation, State Civil Defense began an overhaul of the State’s warning siren system. Control and communication components on all sirens have been completed, allowing officials to verify that a siren has sounded through redundant satellite and cellular modern systems.

Total number of sirens statewide	371
Number of outdated and malfunctioning sirens to be replaced	125
New sirens to be installed	146
Total number of sirens after overhaul	517

6.4 Risk Assessment

6.4.1 Vulnerability and Potential Losses from Tsunami

Tsunami risk in coastal communities of the United States is a function of the extent of tsunami hazards, land use types, population, and economic patterns in threatened areas. To improve our Nation's ability to understand and manage risks associated with tsunamis, we must augment the traditional National Tsunami Hazard Mitigation Plan (NTHMP) research focus on hazard assessments with research dedicated to understanding societal vulnerability to these threats, defined as the exposure, sensitivity and resilience of communities.

6.4.2 Tsunami Mapping

Two types of tsunami maps need to be distinguished: tsunami inundation and tsunami evacuation maps. Tsunami inundation maps show the historical or calculated limits of inundation in terms of the limits of inland inundation and the run-up height.

The tsunami evacuation zones are derived from tsunami inundation maps, but are more conservative than the inundation maps in that they encompass broader areas that are potentially at risk that should be evacuated and refer to readily identifiable physical landmarks such as roads where possible. On one hand, these evacuation zones should not be so broad as to jam evacuation capabilities; on the other hand, they should not be too narrow to risk injury or death.

The National Tsunami Hazard Mitigation Program requires two-dimensional numerical and credible worse-case scenarios when mapping tsunamis affecting the States of Alaska, California, Washington, Oregon, and Hawai'i. The methodology to meet this standard essentially uses the same 5 historical events (4 from Aleutian Island-generated tsunamis and one from a Chile-generated tsunami) used by the original tsunami map, but uses a two-dimensional methodology to take into consideration bathymetry, topography, geography. Dr. Kwok Fai Cheung at the University of Hawai'i developed tsunami inundation models that take into account the bathymetry of the nearshore runup areas, wave height, and wave direction in calculating the potential impacts. The model results have been reviewed and approved by the state. The mapping results are currently informing the tsunami evacuation mapping. The public requires information that will best inform on actions to take during the tsunami and where they should go.

Kwok Fai Cheung from the University of Hawai'i (UH) School of Ocean and Earth Science Technology (SOEST), is capable of developing probabilistic tsunami inundation maps. According to Cheung, *"development of probabilistic tsunami inundation maps is the first step in assessing vulnerability of infrastructure and buildings in the process of strategically formulating future land-use policy. Integration of probabilistic tsunami inundation maps with economics and infrastructure data via GIS will help better understand the potential level and risk of destruction and greatly assist the Hawai'i plan and mitigate the impacts of future tsunamis."*[10]

[10] Cheung, Kwok and Craw, Megan, *Vulnerability of Coastal Infrastructure and Buildings to Tsunamis, 2009*

6.4.3 Tsunami Risk Assessment

The Tsunami Risk Assessment Project was a study looking at the variations in land use, demographics, and economic assets in land prone to tsunami hazards for the State of Hawai‘i. To address these impacts, the United States Geological Survey (USGS) initiated the project with the State of Hawai‘i Civil Defense, the State of Hawai‘i Office of Planning GIS Program, the Pacific Tsunami Museum, the Pacific Disaster Center (PDC), and the University of Hawai‘i (UH).

Similar to the coastal flooding hazard an assessment of exposure to risk is estimated based on the exposure and the tsunami inundation zone.

To describe tsunami-prone landscapes and community vulnerability to tsunamis on the Hawaiian coast, (USGS Scientific Investigations Report 2007-5208) used geographic-information-system (GIS) tools and publicly available geospatial data to create spatial overlays of hazard and socioeconomic data. Details on each of the socioeconomic datasets used in this analysis follow an overview of our analytical approach and the study area.

Vulnerability calculations and comparisons are limited to the exposure and sensitivity of the urban footprint and certain assets, including developed land, populations (residential, employee, and tourists), economic assets and critical facilities. Exposure is defined as the amount of an asset (for example, the number of residents of a town) within a tsunami evacuation zone.

The USGS study considered population using block-level census data (note that the 2010 census data was not available in time for this plan update process). For the preliminary analysis, the population statistics include data disaggregated by gender, age, race, households, employees, single mothers, dependent populations, public venues, and hotels. The rationale was that the locations of populations during a tsunami affect their vulnerability. This information helps to target programs to reduce risks to tsunami. This study needs to be updated to the developing evacuation maps based on great Aleutian tsunamis; the prior study was based on an underestimated inundation extent.

The study found a number of critical and essential facilities in the 1991-era evacuation zone, summarized in Table 6.3. Table 6.4 lists the property value at risk in the tsunami evacuation zones. Table 6.5 through Table 6.8 show a large percentage of the State’s business activity, employees and economic activity are also located in the tsunami evacuation zone.

Table 6.3 Critical and Essential Facilities in the Tsunami Evacuation Zones[11]

Facility	Maui	Kaua'i	Hawai'i	Honolulu	State
Critical Facility					
Civil Defense	0	0	0	0	0
National Security	3	2	3	0	8
Fire Stations	1	1	1	3	6
Police Stations	1	1	1	2	5
Ambulance Services	1	1	1	1	4
Hospitals	0	0	0	0	0
Outpatient Care Centers	2	0	0	5	7
Office of Physicians	123	8	51	49	231
Electrical Facilities	1	0	1	0	2
Gas Facilities	1	0	0	0	1
Public Works	0	1	1	0	2
Radio & TV Stations	1	0	3	0	4
Wastewater Facilities	0	0	0	1	1
Water & Sewer Facilities	1	0	1	1	3
Essential Facilities					
Banks & Credit Unions	18	9	12	11	50
Courts & Legal Offices	1	0	4	1	6
Gas Stations	8	0	4	11	23
Government Offices	9	5	70	15	99
International Affairs Offices	0	0	0	0	0
Grocery Stores	12	7	2	14	35

[11] Wood, N., Church, A., Frazier, T., and Yarnal, B., (2008), Variations in community exposure and sensitivity to tsunami hazards in the State of Hawaii, U.S. Geological Survey, Scientific Investigative Report 2007-5208, Reston, Virginia, p 38

Table 6.4 County and State Tsunami Risk in Evacuation Zones by Tax Parcel Information[12]

		Land value	Building value	Total value
County Totals	Maui County Total	$8,411,785,737	$7,274,805,597	$15,686,591,334
	Kaua‘i County Total	$2,632,006,212	$1,251,307,411	$3,883,313,623
	Hawai‘i County Total	$3,865,625,506	$3,952,402,720	$7,818,028,226
	Honolulu County Total	$15,722,529,595	$3,100,187,724	$18,822,717,319
Descriptive Statistics	**Total for State**	**$30,631,947,050**	**$15,578,703,452**	**$46,210,650,502**
	Minimum	$12,247	$0	$12,294
	1st Quartile (25% Percentile)	$10,862,856	$820,209	$17,602,779
	2nd Quartile (Median)	$101,558,968	$37,207,221	$152,199,721
	3rd Quartile (75% Percentile)	$408,899,505	$130,551,795	$525,042,931
	Maximum	$4,321,903,737	$3,931,192,052	$6,702,439,949

Table 6.5 County and State Tsunami Risk in Evacuation Zones by Business[13]

		Businesses	Employees	Sales Volume (U.S. dollars)
County Totals	Maui County Total	2,166	25,339	$4,232,252,000
	Kaua‘i County Total	508	4,769	$741,201,000
	Hawai‘i County Total	1,751	16,382	$2,476,263,000
	Honolulu County Total	1,354	20,623	$2,656,514,000
Descriptive Statistics	**Total for State**	**5,779**	**67,113**	**$10,106,230,000**
	Minimum	0	0	$0
	1st Quartile (25% Percentile)	0	0	$0
	2nd Quartile (Median)	5	46	$3,522,000
	3rd Quartile (75% Percentile)	38	710	$81,720,000
	Maximum	994	9,066	$2,358,727,000

[12] Wood, N., Church, A., Frazier, T., and Yarnal, B., (2008), Variations in community exposure and sensitivity to tsunami hazards in the State of Hawaii, U.S. Geological Survey, Scientific Investigative Report 2007-5208, Reston, Virginia, p 38

[13] Ibid

Table 6.6 Businesses in the State of Hawai'i[14]

Sector	In Tsunami	Total	Percent (%)
Agriculture, Forestry, Fishing and Hunting	19	277	7%
Mining	2	26	8%
Utilities	7	38	18%
Construction	264	3518	8%
Manufacturing	169	1993	8%
Wholesale Trade	233	2638	9%
Retail Trade	1245	7637	16%
Transportation and Warehousing	137	1166	12%
Information	97	872	11%
Finance and Insurance	229	2045	11%
Real Estate and Rental and Leasing	531	3129	17%
Professional, Scientific, and Technical Services	341	5294	6%
Management of Companies and Enterprises	0	7	0%
Administrative and Support and Waste Management and Remediation Services	225	1991	11%
Educational Services	110	1224	9%
Health Care and Social Assistance	580	7101	8%
Arts, Entertainment, and Recreation	157	899	17%
Accommodation and Food Services	590	3479	17%
Other Services (except Public Administration)	552	5041	11%
Public Administration	186	1351	14%
Non-classified	105	950	11%
TOTAL IN STATE	**5,779**	**50,676**	**11%**

[14] Wood, N., Church, A., Frazier, T., and Yarnal, B., (2008), Variations in community exposure and sensitivity to tsunami hazards in the State of Hawaii, U.S. Geological Survey, Scientific Investigative Report 2007-5208, Reston, Virginia, p 38

Table 6.7 Employees in the State of Hawai'i[15]

Sector	In Tsunami	Total	Percent (%)
Agriculture, Forestry, Fishing and Hunting	279	4317	6%
Mining	34	822	4%
Utilities	485	1822	27%
Construction	3174	33727	9%
Manufacturing	1417	23100	6%
Wholesale Trade	6015	35711	17%
Retail Trade	9452	70591	13%
Transportation and Warehousing	2098	20255	10%
Information	536	11489	5%
Finance and Insurance	1413	22441	6%
Real Estate and Rental and Leasing	5407	26131	21%
Professional, Scientific, and Technical Services	1350	27086	5%
Management of Companies and Enterprises	0	223	0%
Administrative and Support and Waste Management and Remediation Services	2458	20086	12%
Educational Services	3374	36437	9%
Health Care and Social Assistance	4284	70311	6%
Arts, Entertainment, and Recreation	1270	8897	14%
Accommodation and Food Services	17962	82553	22%
Other Services (except Public Administration)	2395	22952	10%
Public Administration	3254	37068	9%
Non-classified	456	4024	11%
TOTAL IN STATE	**67,113**	**560,043**	**12%**

[15] Wood, N., Church, A., Frazier, T., and Yarnal, B., (2008), Variations in community exposure and sensitivity to tsunami hazards in the State of Hawaii, U.S. Geological Survey, Scientific Investigative Report 2007-5208, Reston, Virginia, p 38

Table 6.8 Sales Volume in the State of Hawai'i[16]

Sector	In Tsunami	Total	Percent (%)
Agriculture, Forestry, Fishing and Hunting	$36,364,000	$1,280,692,000	3%
Mining	$8,314,000	$328,406,000	3%
Utilities	$403,167,000	$732,201,000	55%
Construction	$932,913,000	$9,230,622,000	10%
Manufacturing	$692,543,000	$9,699,895,000	7%
Wholesale Trade	$1,842,813,000	$16,232,057,000	11%
Retail Trade	$2,282,942,000	$16,513,172,000	14%
Transportation and Warehousing	$329,096,000	$2,659,957,000	12%
Information	$144,302,000	$2,583,500,000	6%
Finance and Insurance	$258,125,000	$3,614,498,000	7%
Real Estate and Rental and Leasing	$782,304,000	$4,129,790,000	19%
Professional, Scientific, and Technical Services	$186,962,000	$4,386,287,000	4%
Management of Companies and Enterprises	$0	$16,926,000	0%
Administrative and Support and Waste Management and Remediation Services	$285,858,000	$2,194,764,000	13%
Educational Services	$37,705,000	$242,233,000	16%
Health Care and Social Assistance	$707,125,000	$8,986,372,000	8%
Arts, Entertainment, and Recreation	$101,712,000	$850,479,000	12%
Accommodation and Food Services	$976,397,000	$4,485,941,000	22%
Other Services (except Public Administration)	$95,712,000	$1,197,812,000	8%
Public Administration	$1,876,000	$13,802,000	14%
Non-classified	$0	$0	0%
TOTAL IN STATE	**$10,106,230,000**	**$89,379,406,000**	**11%**

An estimate of tsunami losses was made for the island of O'ahu based on a UH SOEST inundation analysis for the island (Kwok-Fai Cheung, et al.) primarily using on a compilation of historical tsunamis over the last 100 years, and a single family residential database. Similar inundation studies have recently been performed of the other counties but the data is not currently available in the preparation of this plan, therefore interim loss estimates have been made for the other counties. A loss estimate for the County of Maui was previously made using notional predetermined run-ups as described in the County of Maui Hazard Mitigation Plan (2010). No previous estimated have been made for the other countries therefore the inundation

[16] Wood, N., Church, A., Frazier, T., and Yarnal, B., (2007), Variations in community exposure and sensitivity to tsunami hazards in the State of Hawaii, U.S. Geological Survey, Scientific Investigative Report 2007-5208, Reston, Virginia, p 38

analysis for O‘ahu is extrapolated for Kaua‘i and Hawai‘i based on available databases and a comparable portion of their evacuation zones. It is assumed that the analysis approximately represents all tsunami inundation over a 100 year period, despite the analysis not being truly probabilistic. Based on the flood loss curves in HAZUS MH, for single family houses with respect to flood height it was assumed that all houses inundated by 2 to 6 feet suffered 30% damage to the total structure and contents value. For houses inundated by 6 to 15 feet, it was assumed that the losses were 45% of the total building and contents value. For inundation greater than 15 feet, 75% losses were assumed. For inundation less than 2 feet minimal structural losses are expected.

The exposure and loss calculations are summarized in Table 6.9. The building values in the table are based on a structure value of $225 per square foot plus an additional cost for contents within and around the building of 18% based on previous Hawai‘i hurricane loss estimates for single family homes. This resulted in estimated losses for the compilation of maximum recorded historic events in each of the counties of Kaua‘i, Honolulu, Maui, and Hawai‘i equal to $418, $1,520, $1,152 and $924 million respectively.

Table 6.9 Loss Estimate for Historic Tsunamis ($ Millions)

		Kaua‘i	Honolulu	Maui	Hawai‘i
Maximum Inundation Level (m)		-	11.3	-	-
Single Family Building and Contents Value within Inundation Zone ($ mil)[1,2,3,4]		$839	$3,053	$1,955	$1,236
All Type Building and Contents Value within Inundation Zone ($ mil)[5]		$2,558	$9,304	$5,960	$6,899
Single Family Residential Property Damage	Average Damage Ratio[6]	0.35	0.35	0.35	0.35
	Total Loss ($ mil)	$294	$903	$684	$433
All Property Damage	Average Damage Ratio[7]	0.19	0.19	0.19	0.16
	Total Loss ($ mil)	$494	$1,798	$1,152	$1,093

Notes:

1. To determine exposure on Kaua‘i and Hawai‘i, evacuation maps are used in lieu of inundation model. Comparisons with evacuation maps of similar vintage for Honolulu and Maui show that this is a good estimate. Current, recently updated evacuation maps for Honolulu and Maui are necessarily more conservative.
2. Based on structural value of $225 / sf plus contents value of additional 18%.
3. Single family building area not available for Kaua‘i, therefore based on all buildings and ratio of single family to all building from Maui County
4. This includes building structure and interior contents but not land value.
5. Not available for Honolulu therefore based on single family and ratio of single family to all buildings from Maui.
6. Average damage ratio calculated for Honolulu and Maui. Honolulu ratio applied to Kaua‘i and Hawai‘i. Based on HAZUS single family damage functions for flood at different depths.
7. Based on damage ratio for non-single family residential properties of 1/3rd that for single family residential properties.

Property losses in Hawai‘i were also estimated for an extreme worst case tsunami scenario based on a Magnitude 9.0 earthquake rupture in the Aleutian chain near Alaska. The losses are summarized in Table 6.10. The inundation area for the Aleutian event is significantly larger and results in damage in each of the counties that two to five times that for the historic tsunamis.

Table 6.10 Loss Estimate for M9.0 Aleutian Tsunami ($ Millions)

		Kaua‘i	Honolulu	Maui	Hawai‘i
Maximum Inundation Level (m)		35	35	20	28
Single Family Building and Contents Value within Inundation Zone ($ mil)[1]		$3,917	$3,917	$4,410	$2,639
All Type Building and Contents Value within Inundation Zone ($ mil)[2]		$5,127	$5,127	$5,772	$4,584
Single Family Residential Property Damage	Average Damage Ratio[3]	0.47	0.42	0.52	0.47
	Total Loss ($ mil)	$1,845	$5,058	$2,312	$1,246
All Property Damage	Average Damage Ratio[4,5]	0.41	0.41	0.44	0.37
	Total Loss ($ mil)	$2,088	$6,472	$2,538	$1,719

Notes:

1. Single family building area not available for Kaua‘i. Based on all buildings and ratio of single family to all building from Maui.
2. Not available for O‘ahu therefore based on single family and ratio of single family to all buildings from Maui.
3. Based on HAZUS single family damage functions for flood at different depths. Damage ratio for Kaua‘i based on average for other counties.
4. Based on damage ratio for non-single family residential properties of 1/3rd that for single family residential properties.
5. Damage ratio for O‘ahu and Kaua‘i based on average for Maui and Hawai‘i other counties.

The estimate of losses for the maximum historic tsunami events along each stretch of shoreline was multiplied by an average weighted frequency factor, F_f, for repeated events based on the series of historical events at two locations in the island of O‘ahu, Hale‘iwa and Waikīkī, where the most complete record of events are located. A factor at each location was calculated based on the sum of the squares of ratios of the recorded inundation depth to maximum inundation depth. This is based on the premise that a tsunami with an inundation depth of half the maximum tsunami will result in approximately one quarter of the damage due to reduced depth and horizontal inundation distance. The weighted frequency ratios for the two sites are as follows:

At Hale‘iwa:

$$F_f = (9/17)^2 + (12/17)^2 + (11/17)^2 + (17/17)^2 + (17/17)^2 + (15/17)^2 + (2/17)^2 = 3.99$$

At Waikīkī:

$$F_f = (8/9)^2 + (3/9)^2 + (5/9)^2 + (5/9)^2 + (9/9)^2 + (4/9)^2 + (5/9)^2 + (3/9)^2 + (2/9)^2 = 3.18$$

The average frequency factor was therefore equal to 3.58, which is assumed to apply statewide. The annual probability of occurrence for the historic tsunamis is therefore calculated as 0.0358. The Aleutian chain event is estimated to have an average return period of 2500 years. This corresponds to an average probability of occurrence of 0.0004. Combining the probabilities of these events, multiplied by the losses from each event, results in calculated average annualized losses given Table 6.11.

Table 6.11 Average Annualized Tsunami Losses ($ Millions)

	Kaua‘i	Honolulu	Maui	Hawai‘i
Average Annualized Tsunami Losses	$19	$67	$42	$40

The annualized loss estimate is generally greater than losses from earthquakes, while being less than the anticipated hurricane losses. The loss estimate could be improved with a truly probabilistic tsunami inundation study, a more complete and updated property database and calibrated damage curves.

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.

6.5 Mitigation Strategies

6.5.1 Tsunami Forecasting

Operational forecast responsibilities for tsunamis are divided among two warning centers: the Pacific Tsunami Warning Center (PTWC) with headquarters in ‘Ewa Beach, 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.

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 auspice s 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 is also the interim warning center for the following:

- Countries in the Indian Ocean
- United States interests (Puerto Rico and the United States Virgin Islands) and Countries in the Caribbean Sea
- Countries bordering the South China Sea (China, Macao, Hong Kong, Taiwan, Philippines, Malaysia, Brunei, Indonesia, Singapore, Thailand, Cambodia, and Vietnam).

6.5.2 Detection and Forecast Systems

6.5.2.1 Deep Ocean Assessment and Reporting of Tsunamis (DART) System

When an earthquake-induced tsunami occurs, the first available information about the tsunami's source is based only on the available seismic information for the earthquake event. As the tsunami waves propagate across the ocean, they successively reach buoys with instrumentation to measure sea level information and report data back to the tsunami warning centers. The warning centers, finally, process the data to produce tsunami forecasts that can be used to issue watches, warnings, or evacuations.

Over the past 20 years, The National Oceanic and Atmospheric Administration's (NOAA) Pacific Marine Environmental Laboratory (PMEL) identified the need for of real-time measurement and modeling techniques that integrate new technologies and knowledge about deep ocean tsunami dynamics. With this initiative, PMEL developed the DART system. In 2006, the DART system was deployed operationally by NOAA's National Data Buoy Center (NDBC).

The difference between regular buoys that measure changes in sea levels and a DART system is that in addition to a moored surface buoy that communicate in real time, a DART system also consists of a seafloor bottom pressure recording (BPR) system capable of detecting tsunamis as small as 1 cm through changes in water pressure. The components of a DART system can be seen in Figure 6.8. When the BPR is triggered, it transmits data to the surface buoy through an acoustic modem. The buoy, in turn, relays the data via a geostationary operational environmental satellite (GOES) link to ground stations. The ground stations finally demodulate the signals for immediate dissemination to NOAA's Tsunami Warning Centers and PMEL.

The conceptual plan for the DART system envisioned a total of 39 stations throughout the Pacific and Atlantic Oceans and the Caribbean Sea. By April 17, 2006, 15 of the 39 stations owned by NOAA had been completed. Since that date, the Governments of Australia, Chile, Indonesia, and Thailand have joint efforts with NOAA in expanding the DART system. As can be seen in Figure 6.9, as of October of 2009, 48 stations owned by NOAA and these Governments have been completed in the Pacific, Atlantic, and Indian Oceans and in the Caribbean Sea.

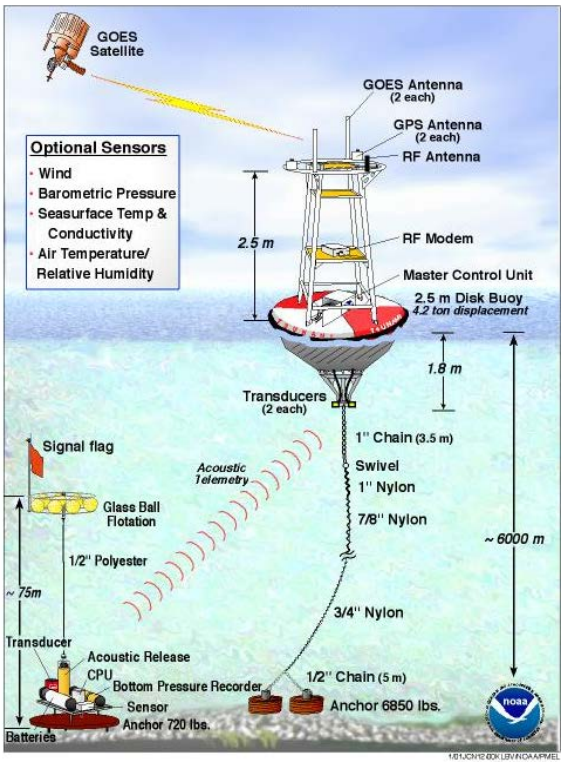


Figure 6.8 Components and Specifications of the DART Mooring System[17]

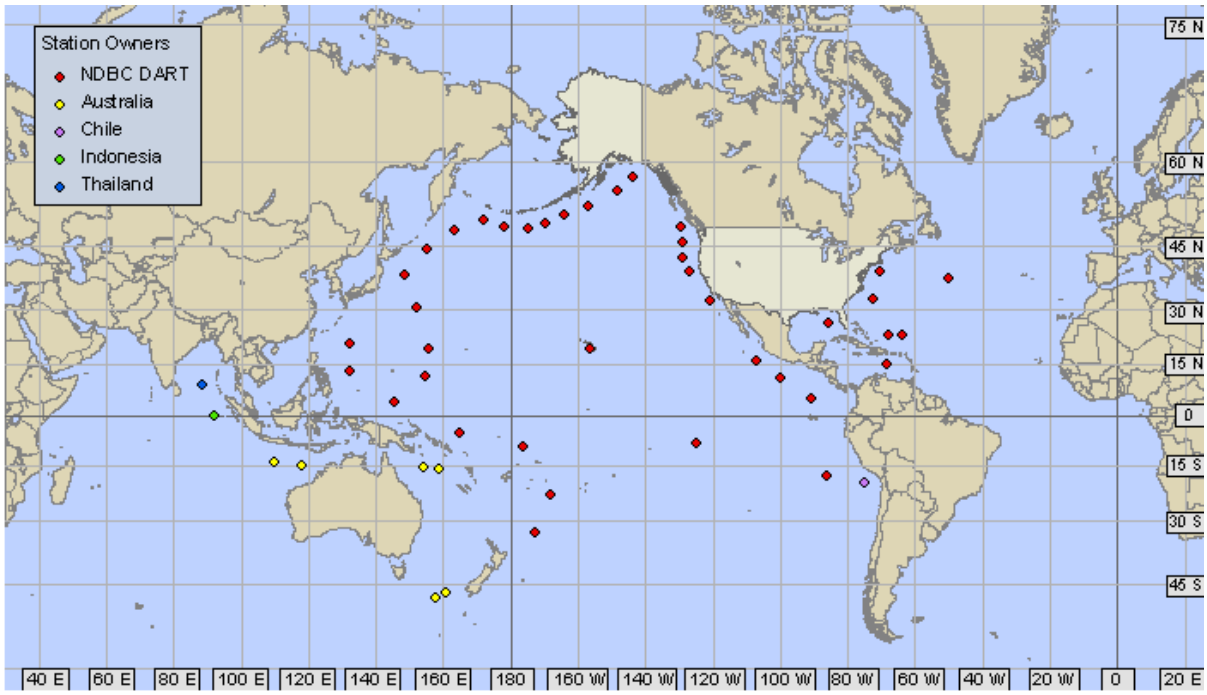


Figure 6.9 Completed DART Stations around the Globe[18]

[17] Image from National Oceanic and Atmospheric Administration (NOAA) Website, Retrieved on October 15, 2009 from http://nctr.pmel.noaa.gov/Dart/dart_ms1.html

6.5.2.2 Short-Term Inundation Forecasting for Tsunamis (SIFT) System

The SIFT system is in operational use in NOAA Tsunami Warning Centers. A SIFT forecast is the numerical estimate of amplitude, travel time, and additional tsunami properties using an inundation model constrained by real-time tsunami observations for specific coastal locations. Forecast products include estimates of tsunami amplitudes, flow velocities and arrival times for offshore, coastal and inundation areas. Stand-by Inundation Models (SIMs) are being developed to provide real-time tsunami predictions for selected coastal locations while the tsunami is propagating through the open ocean, before the waves have reached many coastlines. SIMs will be incorporated into the SIFT United States tsunami warning system for use at the Pacific and West Coast / Atlantic Tsunami Warning Centers.

The PTWC will issue a Tsunami Warning, Watch, Advisory or Information 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.

6.5.2.3 Vessel Evacuation-Staging Areas Offshore

The Coast Guard wants to establish a vessel-staging area about a half-mile off O‘ahu’s south shore, where ships could ride out tsunami warning safely in deep water. A tsunami warning would activate the Coast Guard to ensure commercial and recreational vessels move to and stay in separate staging areas. Commercial ships would assemble off Keehi Lagoon, while recreational boats would stage to the east. The zones would be separated by a mile-wide buffer zone. The entire area would run from the east end of Honolulu airport’s reef runway to the Diamond Head lighthouse, in waters about 300 feet deep. Following a public comment period, the staging plan could go into effect in July or August 2013.

6.5.3 Future Mitigation Projects

Future tsunami mitigation plans are listed and briefly discussed.

6.5.3.1 The Development of ASCE 7 Tsunami Loads and Effects Design Provisions

The Tsunami Loads and Effects Subcommittee of the American Society of Civil Engineers (ASCE) and Structural Engineering Institute (SEI) ASCE/SEI 7 Standards Committee is developing a proposed new Chapter 6 - Tsunami Loads and Effects for the 2016 edition of the

[18] Image from National Oceanic and Atmospheric Administration (NOAA) Website, Retrieved on October 15, 2009 from http://www.ndbc.noaa.gov/dart.shtml

ASCE 7 Standard. Chapter 6 will provide loads for tsunami and its effects, and the design approach will also incorporate aspects of Performance Based Tsunami Engineering. These new provisions would apply to a limited class of Risk Category III and IV buildings and structures and taller Risk Category II buildings, and the provisions will not apply to low-rise Risk Category II and Risk Category I buildings.

It is presently anticipated that the ASCE 7 Tsunami Loads and Effects chapter will be applicable only to the states of Alaska, Washington, Oregon, California, Hawai‘i, and in later updates to include the territories of Guam, American Samoa, and Puerto Rico. Ground shaking effects and subsidence from a preceding local offshore Maximum Considered Earthquake will also be considered prior to tsunami arrival for Alaska and states in the Pacific Northwest regions governed by nearby offshore subduction earthquakes.

Table 6.12 Direct Exposure of the Five Western States to Tsunami Hazard

State	Population at Direct Risk (Lower-bound estimates based on present evacuation zones[19,20])	Profile of Economic Assets and Critical Infrastructure
California	275,000 residents plus another 400,000 to 2,000,000 tourists; 840 miles of coastline	>$200 Billion plus 3 major airports (SFO, OAK, SAN) and 1 military port, 5 very large ports, 1 large port, 5 medium ports
	Total resident population of area at immediate risk to post-tsunami impacts:[21] 1,950,000	
Oregon	25,000 residents plus another 55,000 tourists; 300 miles of coastline	$8.5 Billion plus essential facilities, 2 medium ports,1 fuel depot hub
	Total resident population of area at immediate risk to post-tsunami impacts[21]: 100,000	
Washington	45,000 residents plus another 20,000 tourists; 160 miles of coastline	$4.5 Billion plus essential facilities, 1 military port, 2 very large ports, 1 large port, 3 medium ports
	Total resident population of area at immediate risk to post-tsunami impacts[21]: 900,000	
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	
Alaska	105,000 residents[20], plus highly seasonal visitor count; 6,600 miles of coastline	>$10 Billion plus International Airport’s fuel depot, 3 medium ports plus 9 other container ports; 55 ports total
	Total resident population of area at immediate risk to post-tsunami impacts[2]: 125,000	

[19] United States Geological Survey (USGS) Scientific Investigations Reports 2007-5208 (HI) updated, 2007-5283 (OR), 2008-5004 (WA), 2012-5222 (CA)

[20] Primarily Ketchikan, Sitka, Juneau, Yakutat, Skagway, Valdez, Seward, Homer, Anchorage, Kodiak, Sand Point, Unalaska, and Adak.

[21] National Research Council, 2011, Tsunami Warning and Preparedness, An Assessment of the U.S. Tsunami Program and the Nation's Preparedness Efforts

A method of Probabilistic Tsunami Hazard Analysis has been established in the recognized literature that is generally consistent with Probabilistic Seismic Hazard Analysis in the treatment of uncertainty. Accordingly, a probabilistic hazard map of offshore tsunami wave heights is being developed. Structural member acceptability criteria will be based on performance objectives for a 2,500-year Maximum Considered Tsunami.

Maps of 2,500-year probabilistic tsunami inundation for Alaska, Washington, Oregon, California, and Hawai‘i now need to be developed for use with the ASCE design provisions. Technically, these maps establish the basis of design and would most likely be emulated internationally once the U.S. tsunami design provisions and maps are published under ASCE.

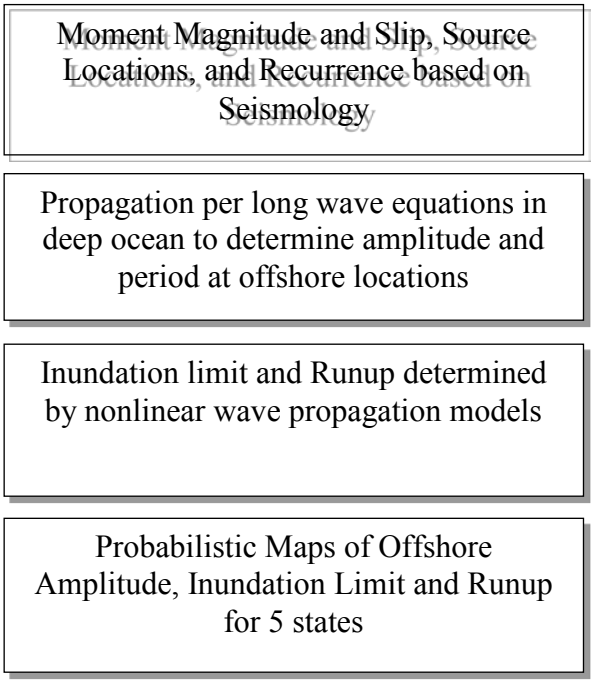
6.5.3.2 Background Information on Tsunami Hazard Identification

The United States do not design any buildings and structures to resist tsunami effects, and a significant risk is presently ignored in engineering design**.** Heretofore, there has been approximately $2 million invested by NOAA-USGS-FEMA-NSF, Caltrans and the California Geological Survey towards research into tsunamigenic seismic source investigations, inundation model validation, and the development of the Probabilistic Tsunami Hazard Analysis Methodology. However, the primary focus of these investments have been for evacuation planning for deterministically chosen scenarios and evacuation warning and awareness programs, and not towards consistent probabilistic tsunami hazard maps applicable to design of structures for resiliency. Indeed, a 2011 National Research Council report, *Tsunami Warning and Preparedness: An Assessment of the U.S. Tsunami Program and the Nation's Preparedness Efforts* has identified a significant issue in the varying approaches used by each state for deterministic hazard maps that has not resulted in consistent standardized probabilistic mapping criteria

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 trend for tsunami science going forward.

For national tsunami design provisions to achieve a consistent reliability standard of structural performance for community resilience, a new generation of tsunami inundation hazard maps for design is required. In the last eight years, there has been significant research and development of tsunami hazard and inundation analytical tools that have recently become effective for producing probabilistic tsunami design maps. The States of California, Oregon, and Hawai‘i have state statutes requiring that probabilistic tsunami hazard inundation maps as developed and available be incorporated into zones of required investigations, restricted land use zoning, and building codes. The implementation of design standards for critical facilities is also included in state hazard mitigation plans and state disaster resilience plans. Presently the State of California is proceeding in coordination with ASCE in resolving seismic source slip parameters for the Cascadia Subduction Zone that is critical to the Pacific Northwest, and California intends to

Probabilistic Tsunami Hazard Analysis



eventually develop additional inundation maps that will provide additional detail within the tsunami design zone established with the ASCE criteria.

These new tsunami design zone maps will define the coastal zones where structures of greater importance would be designed for tsunami resistance and community resilience. The approach developed by the ASCE Tsunami Loads and Effects Subcommittee of the ASCE 7 Standard would result in the first unification of tsunami hazard definition for design and would reflect the modern approach of Performance-Based Engineering.

The total national effort necessary for accomplishing the tsunami hazard mapping of the five western states for community risk mitigation through structural design amounts to approximately $400,000, to be completed within a one-year period of performance to which the collaborators have committed. Tasks 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 for the major populated/developable regions of the five western states based on 90-meter grid of topography.

3. Development of higher resolution 10-meter probabilistic design maps for PMEL reference sites constituting key communities of highest importance in the five western states. This effort establishes reference benchmarking for the later development of

consistent local probabilistic inundation maps covering greater geographical extent by the five western states under the National Tsunami Hazard Mitigation Program.

a. California 11 reference sites
b. Oregon 5 reference sites
c. Washington 5 reference sites
d. Hawai‘i 12 reference sites
e. Alaska 17 reference sites
f. Workshop for coordination of the above reference site maps with independent modelers associated with the above states

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.

Subsequent to this project, the individual states would proceed further to develop additional high resolution inundation maps for other coastal areas as needed in accordance with the procedure of the ASCE 7 Standard, for local adoption during the 2018-2019 timeframe when the IBC 2018 is adopted by the states and local county jurisdictions. That subsequent effort would be performed by tsunami modelers selected by the states and coordinated under the National Tsunami Hazard Mitigation Program (presently being re-authorized).

Project	Description - Status
Tsunami structural design provisions for buildings based on probabilistic criteria.	Design provisions for tsunami impact and inundation / scouring. Under development by ASCE for future adoption into the State Building Code.
Update tsunami evacuation maps: Tsunami Inundation and Runup Mapping	The 2-D model based on good topographic data along the coastline (e.g., LIDAR) used to develop evacuation maps needs to be expanded to include the critical Aleutian subduction zone seismic gap between the ruptures of the 1946 and 1957 earthquakes. Ongoing project: Any necessary evacuation zone changes would be done based on updated information from UH SOEST.
UHM SOEST should produce probabilistic tsunami hazard maps (runup and inundation depth) for the ASCE-2016 and IBC-2018 building code design provisions.	
Tsunami Protection of: Wailuku-Kahului Waste Water Reclamation (WWR) Facility; MECO Kahului Power Plant	These facilities are within the tsunami inundation and evacuation zones. Proposed projects.
Identify and retrofit critical water system pumping stations in the tsunami inundation zone.	
Preliminary engineering of tsunami and coastal flood mitigation retrofit of critical infrastructure.	

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

7. Earthquakes

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CHAPTER 7
Earthquakes

Reasons for Updates / Revisions in this 2013 Plan
• More information is provided on the fundamental seismological mechanisms for earthquakes in Hawai‘i, which is unlike continental seismology. All islands are subject to deep earthquakes resulting from the plate flexural stresses in the lithosphere generated by the 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 Kīholo Bay earthquake; it is described and its effects on O‘ahu in particular regards to unexpected island-side electricity failures. The HECO implementation of mitigation measures taken to prevent this in the future is detailed. • The most current seismic design code available is the International Building Code (IBC). These provisions incorporate state of the art seismic hazard mapping of Hawai‘i developed by the U.S. Geological Survey (USGS) and the Hawai‘i State Earthquake Advisory Committee. Seismic hazard based on the International Building Code is explained. • The average annualized risk analysis is updated per HAZUS MH along with related mitigation activities. Based on an analysis of Hawai‘i construction cost data, projected earthquake average annual loss is estimated. • The continuation of seismic retrofits of bridges is described. • Seismic hazard mitigation project recommendations are updated.

Summary of Mitigation Projects for the State of Hawai‘i	
Project	Priority
Adopt 2012 IBC and related codes per HRS 107 Part II	Medium
Testing of the Seismic and Wind Performance of Single Wall Construction	Medium
Incentives for homeowners and businesses to retrofit their structures	Medium
Update the HAZUS MH model to incorporate detailed data on State and County Bridges and determine seismic risk of collapse/outage.	Medium

7.1 Seismic Hazard Description

7.1.1 General

An earthquake is the sudden release of strain energy in the Earth's crust, resulting in waves of shaking that radiate outward from the earthquake source.[1] The Earth's crust, which can be oceanic or continental, is the uppermost layer of the lithosphere[2]. The oceanic crust is approximately 3 to 6 miles thick while the continental crust is approximately 20 to 30 miles thick.[3] When stresses in the crust exceed the strength of the rock, it breaks along lines of weakness (either a pre-existing or new fault plane) and results in earthquakes.

The point where an earthquake starts is termed the focus or hypocenter and may be many kilometers deep within the earth. The point at the surface of the crust directly above the focus is called the earthquake epicenter. The distance between the hypocenter and the epicenter is termed the focal depth. In the case of underwater earthquakes, the focal depth is measured from the hypocenter to the surface of the oceanic crust. The severity of earthquakes is dependent on the energy released from the fault or epicenter. Other factors influencing the severity of an earthquake include: magnitude, proximity to the epicenter, depth of the epicenter, duration, soil characteristics, and type of ground motion. The effects of an earthquake can be felt far from the epicenter.

7.1.2 Earthquake Magnitude and Intensity

Scientists portray earthquake shaking using several parameters, including magnitude, intensity, and peak ground acceleration (PGA) to understand damage and to develop building codes and mechanisms to reduce earthquake risk. The Richter scale measures magnitude. An earthquake of 5.0 is a moderate event, 6.0 is a strong event, 7.0 is a major earthquake, and a "great quake" exceeds 8.0. For each whole number increase, there is a 10-fold jump in seismic wave amplitude (or, a 30-fold gain in energy released). For example, a 6.0 earthquake generates 30 times more energy than a 5.0 quake and 900 times (30 times 30) greater than a 4.0 earthquake.

Intensity, on the other hand, is measured by the Modified Mercalli Intensity Scale (MMI). The MMI scale has twelve levels and ranges from Level I (events faintly registered by scientific instruments) to Level XII (catastrophic destruction). Table 7.1 shows abbreviated descriptions of the twelve levels of the MMI and Table 7.2 correlates peak ground acceleration and peak ground velocity to the MMI.

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1 Pacific Disaster Center Website, Retrieved October 6, 2009 from http://www.pdc.org/iweb/earthquakes.jsp?subg=1

2 The lithosphere constitutes the rigid outer layer of the planet. It includes the crust and the upper mantle.

3 Wikipedia Online Encyclopedia Website, Retrieved October 7, 2009 from http://en.wikipedia.org/wiki/Crust_%28geology%29#cite_note-amonline-0

Table 7.1 The Modified Mercalli Intensity Scale

LEVEL	DESCRIPTION
I	Not felt except by a very few people under special conditions. Motion detected mostly by instruments.
II	Felt by a few people especially those on upper floors of buildings. Suspended objects may swing.
III	Felt noticeably indoors. Standing automobiles may rock slightly.
IV	Felt by many people indoors, by a few outdoors. At night, some people are awakened. Dishes, windows, and doors rattle.
V	Felt by everyone. Many people are awakened. Some dishes and windows are broken. Unstable objects are overturned.
VI	Felt by everyone. Many People become frightened and run outdoors. Some heavy furniture is moved. Some plaster falls.
VII	Most people are alarmed and run outside. Damage is negligible in buildings of good construction, considerable in buildings of poor construction.
VIII	Damage is slight in specially damaged structures, considerable in ordinary buildings, great in poorly built structures. Heavy furniture is overturned.
IX	Damage is considerable is specially designed buildings. Buildings shift from their foundations and partly collapse. Underground pipes are broken.
X	Some well-built wooden structures are destroyed. Most masonry structures are destroyed. The ground is badly cracked. Considerable landslides occur on steep slopes.
XI	Few, if any masonry structures remain standing. Rails are bent. Broad fissures appear in the ground.
XII	Catastrophic destruction. Waves are seen on the ground surface. Objects are thrown in the air.

Table 7.2 Specific to Hawai‘i Correlation between MMI Levels and Peak Ground Acceleration and Velocity

Modified Mercalli Intensity (MMI)	**I**	**II-III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**
Perceived Shaking	Not Felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Potential Damage	None	None	None	Very Light	Light	Moderate	Moder-ate/Heavy	Heavy	Very Heavy
Peak Acceleration (%g)	<3.2	3.2-8.1	8.1-13	13-20	20-32	32-51	51-80	80-128	>128
Peak Velocity (%g)	1.9	1.9-6.4	6.4-11	11-18	18-28	28-47	47-74	74-120	<120

7.1.3 Earthquakes in Hawai‘i

Naturally occurring earthquakes in Hawai‘i can be either of tectonic or volcanic nature. Tectonic, or lithospheric, earthquakes in Hawai‘i occur at or near the shield volcanoes that form the islands. In these cases, the colossal weights of the volcanoes that form the islands bend the lithosphere beneath for a bathymetric map of the Main Hawaiian Islands identifying all Hawaiian volcanoes (see Figure 7.1). *As the volcanoes grow, they add more and more weight on the lithosphere, causing it to bend and flex downward. Away from the islands, the lithosphere flexes upwards in response to the volcanic load. Such bending results in earthquakes that are most frequent beneath the actively growing volcanoes and less frequent beneath the older volcanoes.*

After a period of time, probably several millions of years, the flexing of the lithosphere stops, and the accumulated strain is released in the form of earthquakes.[4] The mechanism under which the weight of the Hawaiian Islands bend the lithosphere until energy is released in the form of earthquakes is depicted in Figure 7.2

Historically, the largest earthquakes in Hawai‘i have occurred at shallower depths, beneath the flanks of Kīlauea, Mauna Loa and Hualālai Volcanoes. 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 Kīlauea’s south flank, and in 1868, the largest earthquake in recorded Hawaiian history beneath the Ka‘ū district on Mauna Loa’s southeast flank, estimated as a M7.9 earthquake. (Figure 7.3 by Klein, et al, 2001).

Strong earthquakes, while infrequent, may endanger people and property by shaking structures, causing ground cracks, ground settling and landslides. Strong earthquakes in Hawai‘i’s past have destroyed buildings, water tanks and bridges and damaged roadways, water, sewer and utility lines. Soil and topographic conditions may exacerbate potential earthquake hazards where steep slopes and water saturated soils may be susceptible to mudflows or landslides. Large earthquakes may also generate localized tsunamis which provide little or no time for advanced warning.[5]

Damage caused by earthquakes can be classified as structural or nonstructural. The structural components of buildings are those that carry stress loads, including columns, beams, braces, floor, roof, load-bearing walls, and foundations. Nonstructural components include every other part of the building and its contents. Common non-structural components include ceilings, windows, office equipment, file cabinets, HVAC equipment, electrical equipment, furnishings, and lights. Nonstructural damage may cause personal injury, property damage, or loss of function often resulting in more significant damage than structural damage. Examples of hazardous nonstructural damage that have occurred in past earthquakes include broken glass, overturned tall and heavy cabinets, falling ceilings or overhead light fixtures, and ruptured piping. Earthquake ground shaking has three effects on nonstructural components: inertial or shaking effects on the nonstructural elements themselves, distortions imposed on nonstructural components when the building structure sways back and forth, and separation or pounding across separation joints between adjacent structures. Building codes primarily address structural components.[6]

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[4] United Sates Geological Survey (USGS) Hawaiian Volcano Observatory Website, Retrieved October 7, 2009 from http://hvo.wr.usgs.gov/earthquakes/

[5] Heliker, 1990.

[6] Wiss, Janney, Elstner Associates, Inc., September 1994. Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide. FEMA 74 (3rd ed.).

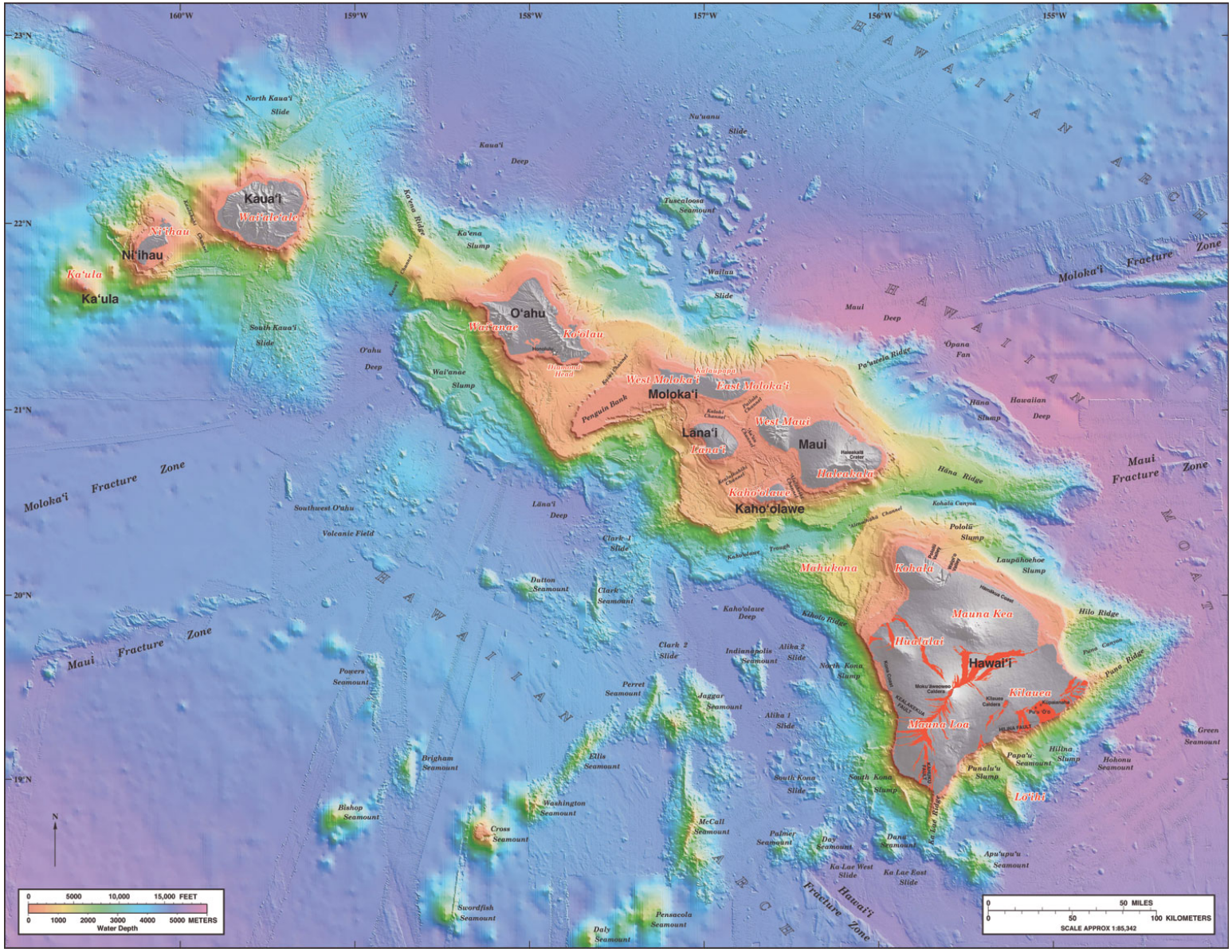

Figure 7.1 Bathymetric Map of the Main Hawaiian Islands

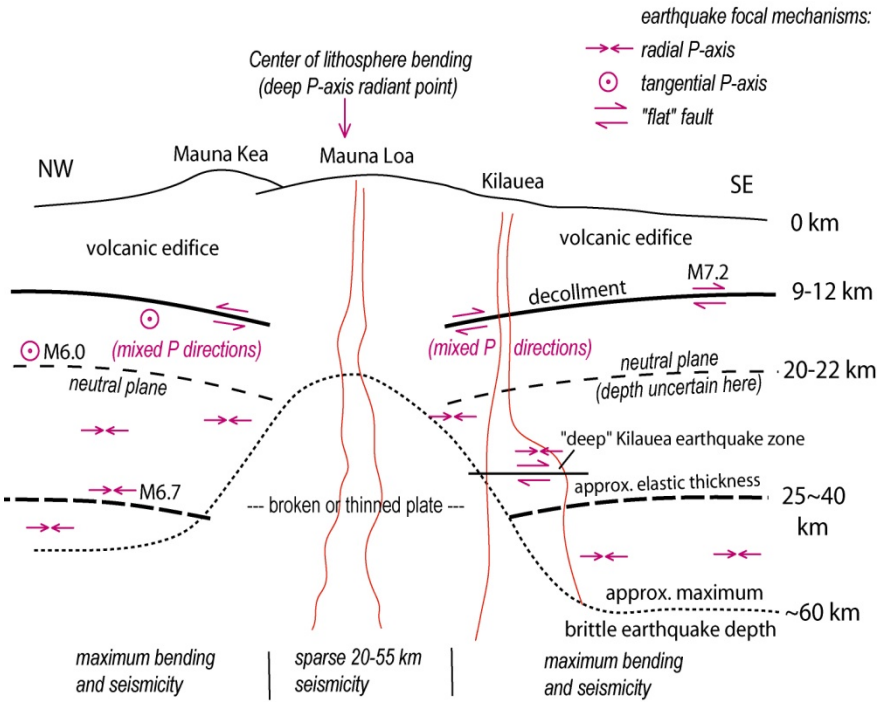

Figure 7.2 Earthquake Focal Mechanisms in Hawai'i

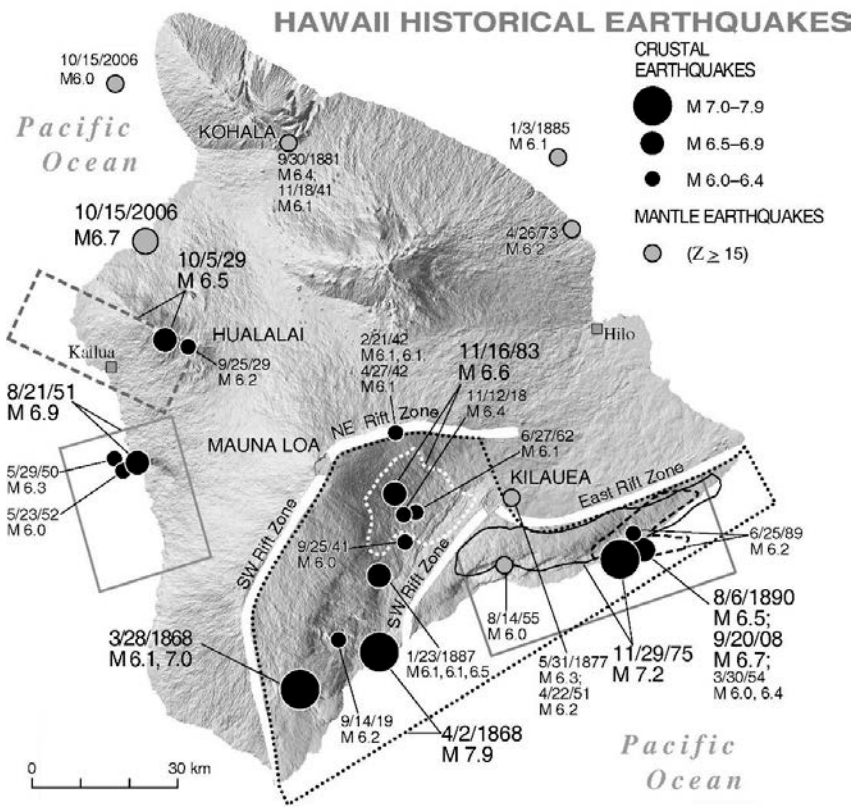

Figure 7.3 Hawai'i Historical Earthquake Locations[7]

[7] Fred Klein, USGS, 2001

7.1.4 Soil Conditions

7.1.4.1 General

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. Weaker soil indicates areas of greater potential hazard therefore Site Class should also be considered in individual building assessments.

To be able to utilize the strong motion data recorded by the USGS Hawaiian strong motion network, knowledge of the subsurface site conditions beneath the USGS stations was required. The subsurface geology and, more important, the shear-wave velocity (V_S) structure beneath the USGS stations has been unknown to date. The information is invaluable to verify the appropriateness of the empirical ground motion attenuation models being used in the state hazard maps produced by USGS and in site-specific hazard analyses for engineering design.

To obtain V_S information beneath the USGS strong motion sites, Spectral Analysis of Surface Waves (SASW) surveys were performed by the University of Texas, Austin, and URS Corporation in January 2008 (Wong *et al*. 2008).

The SASW methodology is a non-destructive and non-intrusive seismic method. It utilizes the dispersive nature of Rayleigh-type surface waves propagating through a layered material to estimate the shear-wave velocity profile of the material (Stokoe et al. 1994; Joh 1996). In this context, dispersion arises when surface-wave velocity varies with wavelength or frequency. Dispersion in surface-wave velocity arises from the changing stiffness properties of the soil and rock layers with depth. Spectral analysis is used to separate the waves by frequency and wavelength to determine the experimental ("field") dispersion curve for the site. An analytical procedure is then used to theoretically match the field dispersion curve with a one-dimensional layered system of varying layer stiffness's and thicknesses. The one-dimensional V_S profile that generates a dispersion curve that matches the field dispersion curve is presented as the profile at the site.

The surveys took place from January 7 to 17, 2008 at 22 USGS strong motion sites. Several surveys were also performed at Kawaihae Harbor. The high PGA's recorded at the Waimea Station and the North Kohala Police Station are probably due to thin soil site amplification where a strong velocity contrast exists between the soil and underlying basalt. Based on the survey results, all of the 22 USGS strong motion sites are "soil" sites with V_S30 values ranging from 442 ft/sec at the USDA Laboratory in Hilo (National Earthquake Hazards Reduction Program [NEHRP] site class E) to 1,812 ft/sec at the South Kohala Fire Station (NEHRP C). Surprisingly, none of the strong motion sites had rock-like V_S30 values, even sites where basalt outcropped at the surface, such as at the University of Hawai'i at Hilo.

As demonstrated in the 2006 Kīholo Bay and Māhukona earthquakes, where some strong motion stations recorded peak horizontal accelerations close to 1g, site response effects can be significant on the Island of Hawai'i . As part of FEMA-supported studies following the earthquakes, a new 1:100,000-scale map of site conditions on the Island of Hawai'i was produced. The mapping makes use of about 25 new SASW measurements (Wong *et al.,*

2008) and 1:100,000-scale geologic mapping by Sherrod *et al.* (2007). An earlier 2006 site class map portrayed nearly all of the island as NEHRP site class B; however, based on about 20 SASW measurements in areas mapped as basalt, it is believed that most of the island should be mapped as NEHRP C or D. V_S30 estimates for these basalt sites ranged from 844 to 1,812 ft/sec, spanning NEHRP classes C and D. The median value for these V_S30 estimates is 1,304 ft/sec, with a log mean of 1,274 ft/sec and a standard deviation of 274 ft/sec. The sites cover a range of basaltic rock conditions as depicted on the geologic map, including lava flows, scoria cones, littoral deposits, spatter or tuff cones, cinder cones, and lava domes. Other geologic map unit groups for which only a few V_S30 estimates were made from SASW data include alluvium, ash/tephra, and artificial fill. These were assigned to map units NEHRP site class D, C to E, and C to E, respectively. Geologic deposits for which there is no quantitative velocity data and preliminary site class assignments have been made are sand dunes (D), landslide deposits (D), and glacial deposits (D).

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 EPGA of greater than 0.10g are generally necessary to begin to induce liquefaction.

7.1.4.2 Soil Type and Site Class

The Natural Resources Conservation Service (NRCS) and the National cartography and Geospatial Center (NCGC) created and currently maintain and update the Soil Survey Geographic (SSURGO) database. The SSURGO database consists of digital geo-referenced spatial data, attribute data, and metadata. Geo-referenced spatial data are spatial objects: polygons, lines, points, and nodes whose coordinates represent reallocations on the Earth's surface in one of several coordinate systems. The data consist of the following features: soil survey area boundaries, water boundaries, soil boundaries, and conventional and special soil features.

The SSURGO database provides the most detailed level of information. Using National Cooperative Soil Survey (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. Soil maps for the City and County of Honolulu and the Counties of Maui and Hawai‘i are included in Figure 7.4 through Figure 7.6.

Data for each major layer of soil include: particle size distribution, bulk density, available water capacity, soil reaction, salinity, and organic matter content. Similarly, data on each soil include: flooding, water table depth, depth to bedrock, soil subsidence. Lastly, Use and management data include: sanitary facilities, construction materials, building site development, recreational development, water management, rangeland potential, crops, woodland suitability, and wildlife habitat suitability.

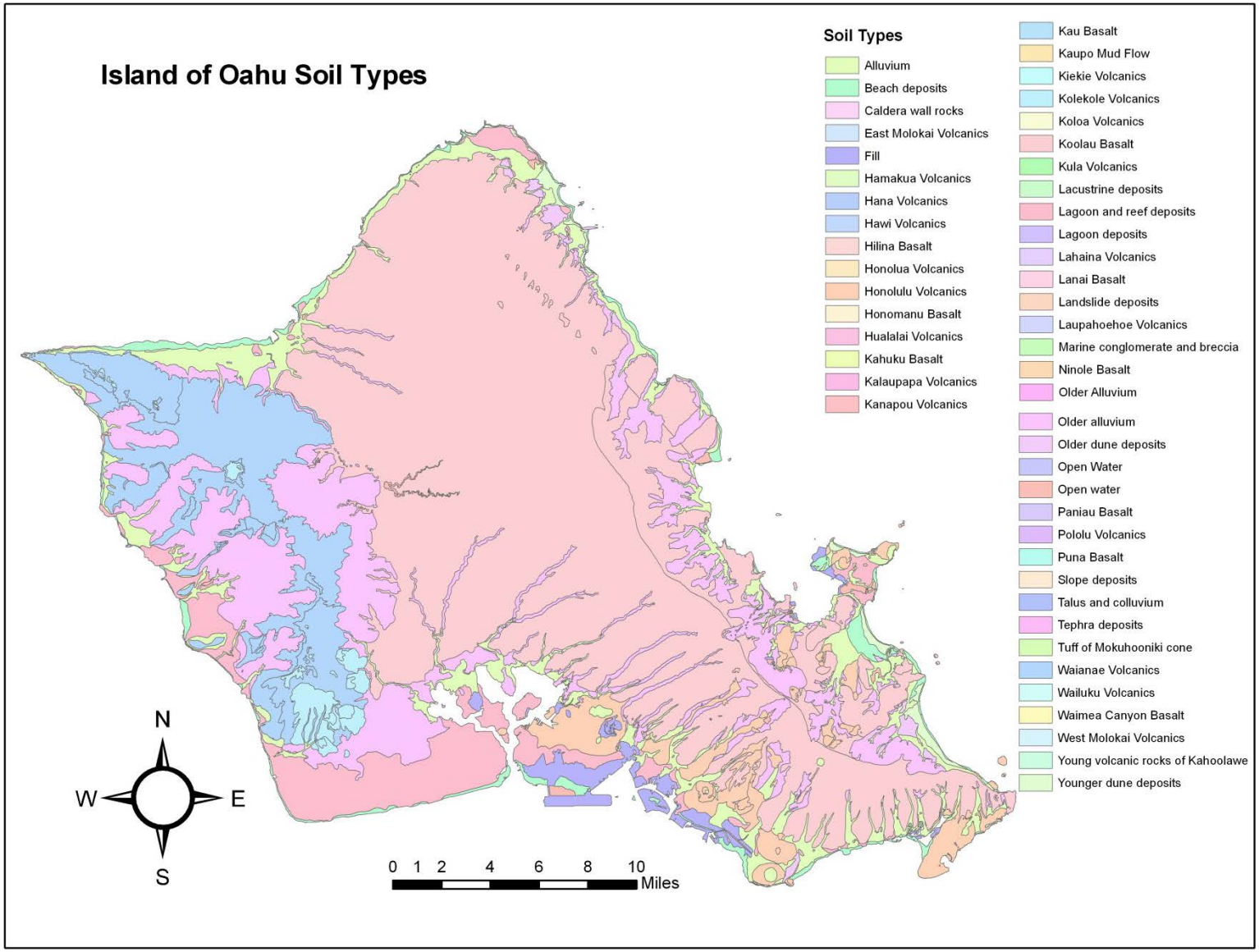

Figure 7.4 City and County of Honolulu Soil Types

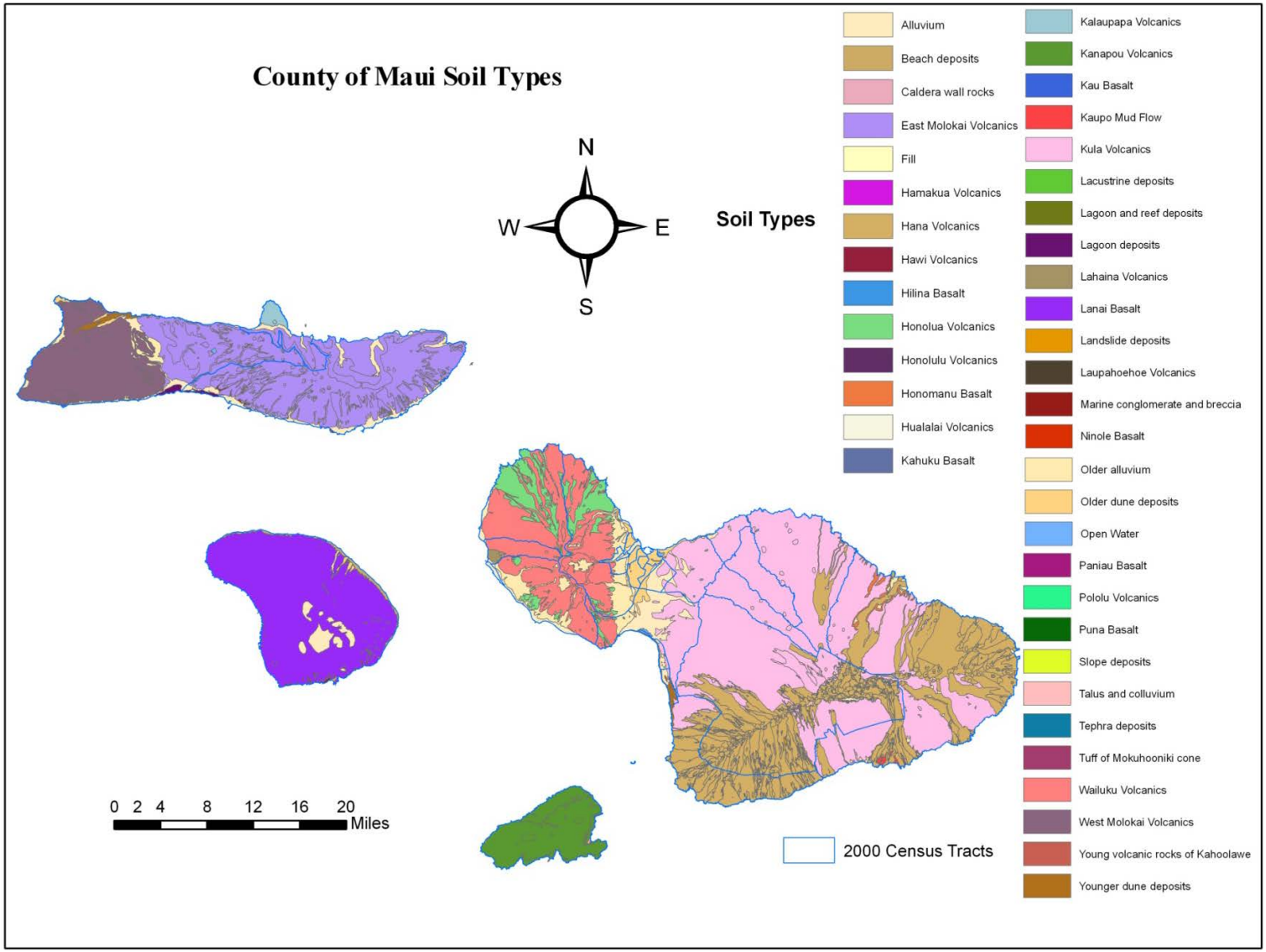

Figure 7.5 County of Maui Soil Types

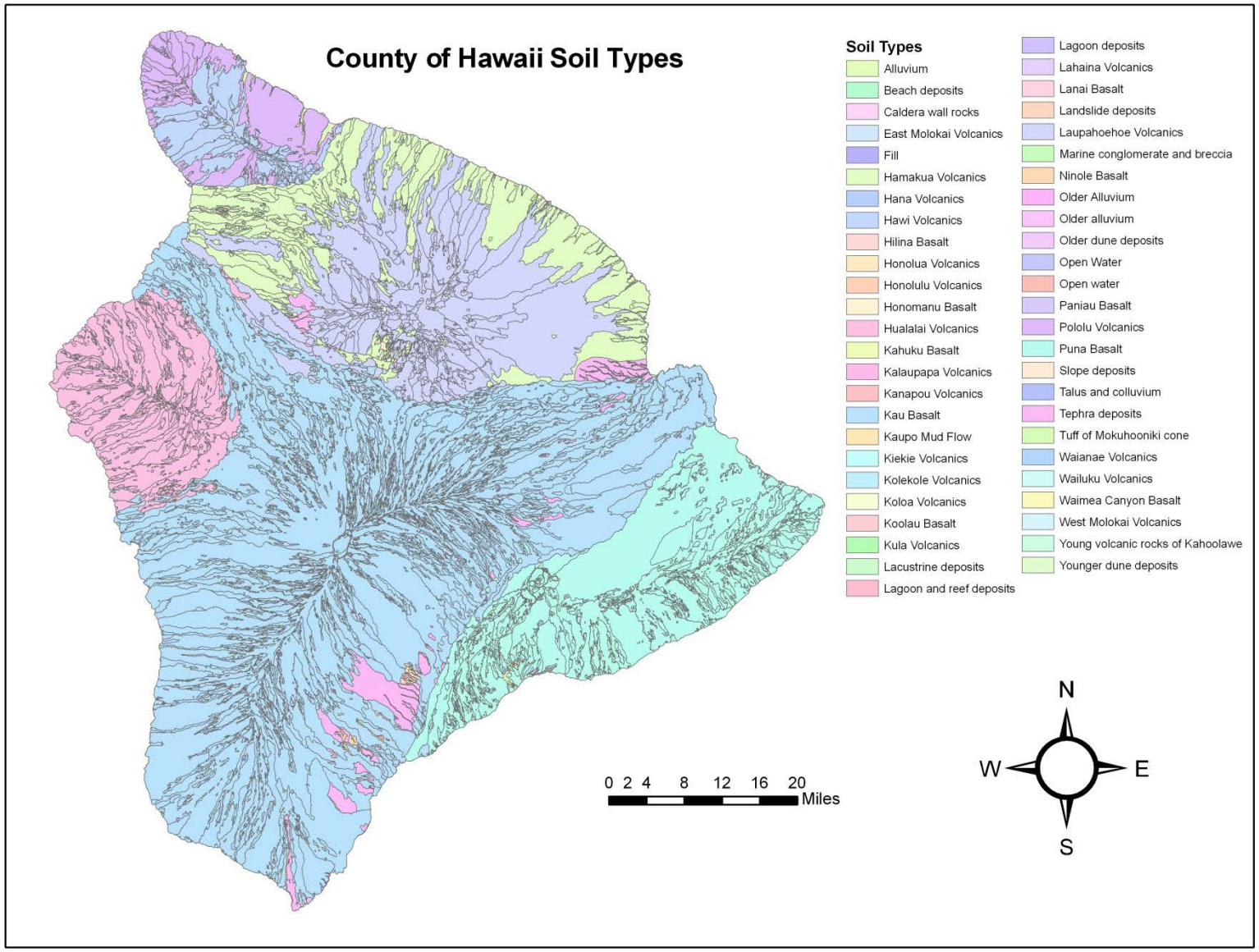

Figure 7.6 County of Hawai‘i Soil Types

Based on the soil classification from the SSURGO database, it is possible to determine Probable Site Classes for the design of buildings and other structures. A Site Class is a classification assigned to a site based on the types of soils present and their engineering properties as defined by a particular building code or standard.

The International Building Code (IBC), for example, classifies sites according to soil shear wave velocity, standard penetration resistance, and soil undrained shear strength as either A, B, C, D, E, or F (Site Class A and F corresponding to the best and poorest soil conditions, respectively). A complete description of the Site Class classification per the IBC is included in Table 7.3. The IBC also requires that when the soil properties of a site are not known in sufficient detail to determine the Site Class, Site Class D shall be used unless the building official determines that Site Class E or F soil is likely to be present at the site. Figure 7.7 through Figure 7.9 show the Site Classes for the City and County of Honolulu and the Counties of Maui and Hawai‘i as referenced by the IBC. .Site specific geotechnical exploration that includes soil borings are necessary to validate the Site Class presented in the aforementioned Figures.

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 6.0 or greater with estimated peak ground accelerations of greater than 0.10g are generally necessary to begin to induce liquefaction. Soil liquefaction studies particular to the County of Maui are presented and discussed in detail in the following section.

Table 7.3 International Building Code Site Class Definitions

Site Class	Soil Profile Name	AVERAGE PROPERTIES IN TOP 100 FEET		
		Soil Shear Wave Velocity, V_s [ft/s]	Standard Penetration Resistance , N	Soil Undrained Shear Strength, S_u [psf]
A	Hard rock	$V_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < V_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < V_s \leq 2{,}500$	$N > 50$	$S_u > 2{,}000$
D	Stiff soil profile	$600 \leq V_s \leq 1{,}200$	$15 \leq N \leq 50$	$1{,}000 \leq S_u \leq 2{,}000$
E	Soft soil profile	$V_s < 600$	$N < 15$	$S_u < 1{,}000$
E	-	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity Index, PI > 20 2. Moisture Content, $w \geq 40\%$, and 3. Soil undrained shear strength, $S_u < 500$ psf		
F	-	Any profile containing soils having one or more of the following characteristics: 1. Soils Vulnerable to potential failure or collapse under seismic loading such as liquefiable sols, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or hgihly organic clays (H > 10 feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays (H > 25 feet with plasticity index PI > 75) 4. Very thick soft/medium stiff clays (H > 120 feet)		

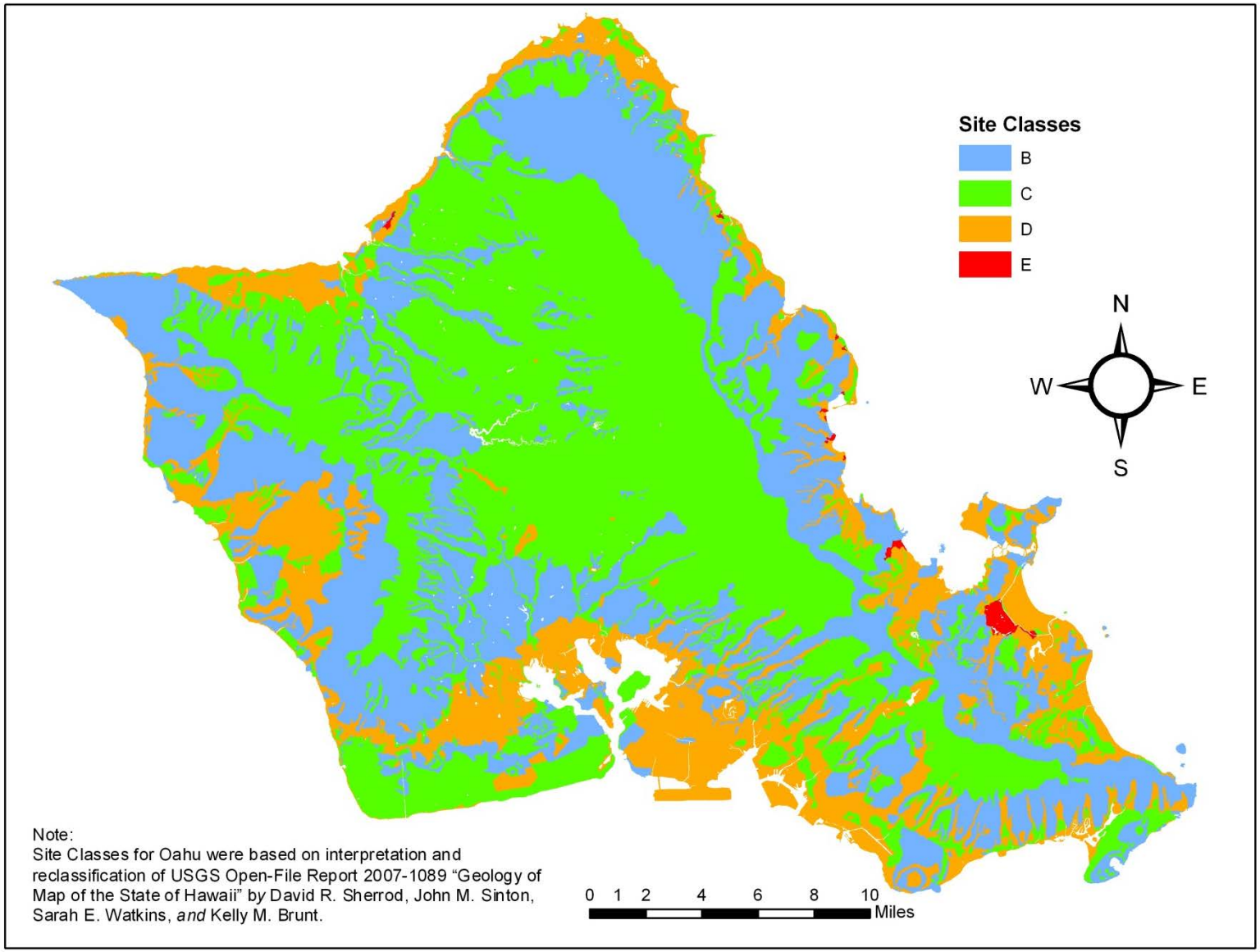

Figure 7.7 City and County of Honolulu Probable Site Classes

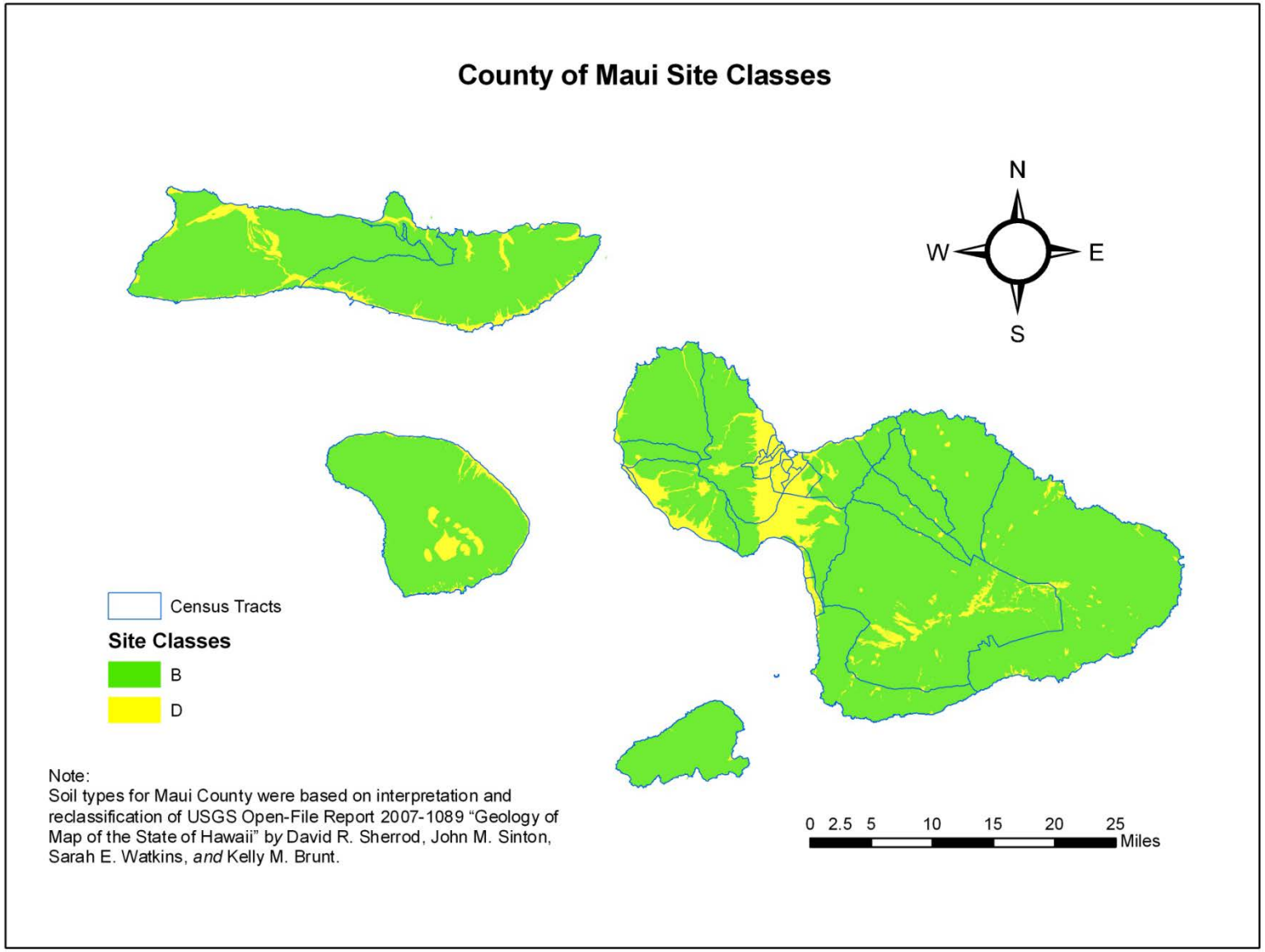

Figure 7.8 County of Maui Probable Site Classes

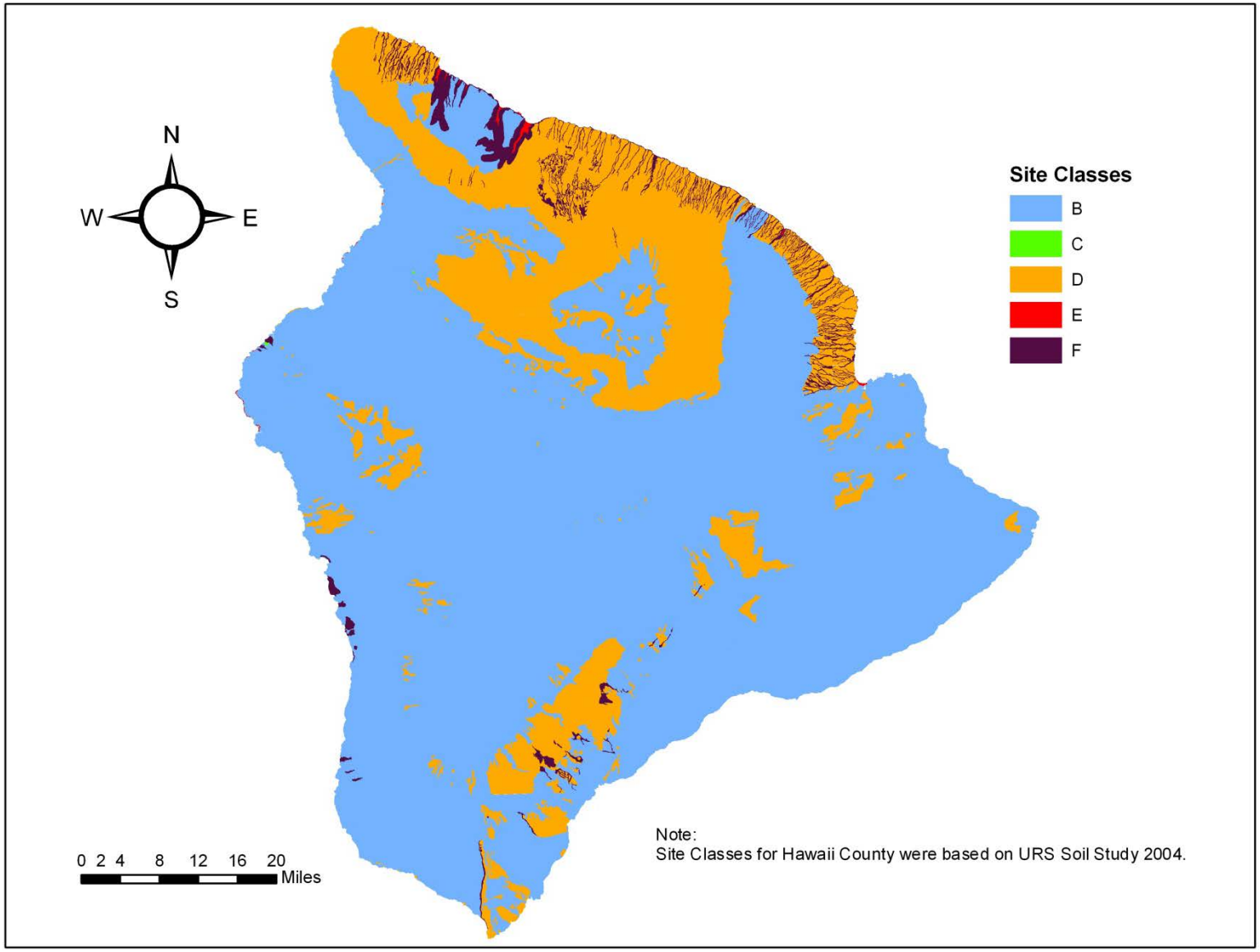

Figure 7.9 County of Hawai‘i Probable Site Classes

7.1.4.3 Soil Liquefaction

Liquefaction can be defined as a process by which sediments below the water table temporarily lose strength and behave as a viscous liquid rather than a solid.[8]. Seismic waves from earthquakes can cause pore water pressure[9] in the soil to rise to levels exceeding the weight of the overlaying soil, causing the layer to liquefy. Liquefied soil in turn exerts higher pressures on the foundations and retaining walls of buildings and other structures, which can cause them to tilt of slide. Increased water pressure in liquefied soils can also trigger landslides and cause the collapse of dams as was witnessed in the nearly collapse of the Lower San Fernando dam during the San Fernando Earthquake in California in 1971.[10]

In an attempt to reduce liquefaction hazards when designing and constructing new buildings or other structures in the State of Hawaiʻi, the National Oceanic Atmospheric Administration (NOAA) Coastal Service Center sponsored a project[11] in 2005 to identify areas with the potential for soil liquefaction in the islands of Hawaiʻi and Maui.

The project consisted of the collection and organization of soil data and site conditions (geology, topography, groundwater level, etc.), the development of a Geographic Information System (GIS) based data base, the development and demonstration of a technique to assess liquefaction susceptibility, and the preparation of liquefaction potential zoned maps.

In the case of the island of Maui, three main areas of interest were included in the study: the west Maui region (from Lahaina to Nāpili), the south Maui area (from Kīhei to Mākena), and the central Maui region (Kahului and Wailuku). Two other smaller zones, Ukumehame and Māʻalaea were also subjects of the study since there were some small collections of date from these locations.

The results of the study are presented as a map that identifies liquefaction susceptibility for the areas of concern included in the study. Such map is included in Figure 7.10. In the map, areas in green indicate low susceptibility to liquefaction while areas in red specify areas with high susceptibility to liquefaction.

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8 Nicholson, Peter, Thomas, Amy, and Wallace, Carolyn, Development and Application of a GIS Model for Mapping Liquefaction Susceptibility in Maui, National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center, 2009

9 Pore water pressure refers to the pressure of groundwater held within a soil or rock, in gaps between particles or pores.

10 University of Washington Soil Liquefaction Website, Retrieved December 15, 2009 from http://www.ce.washington.edu.liquefaction/html/what/what1.html

11 Nicholson, Peter, Mapping Potential Liquefaction Hazard Zones for Coastal Hawaiʻi and Maui, National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center, 2003-2006

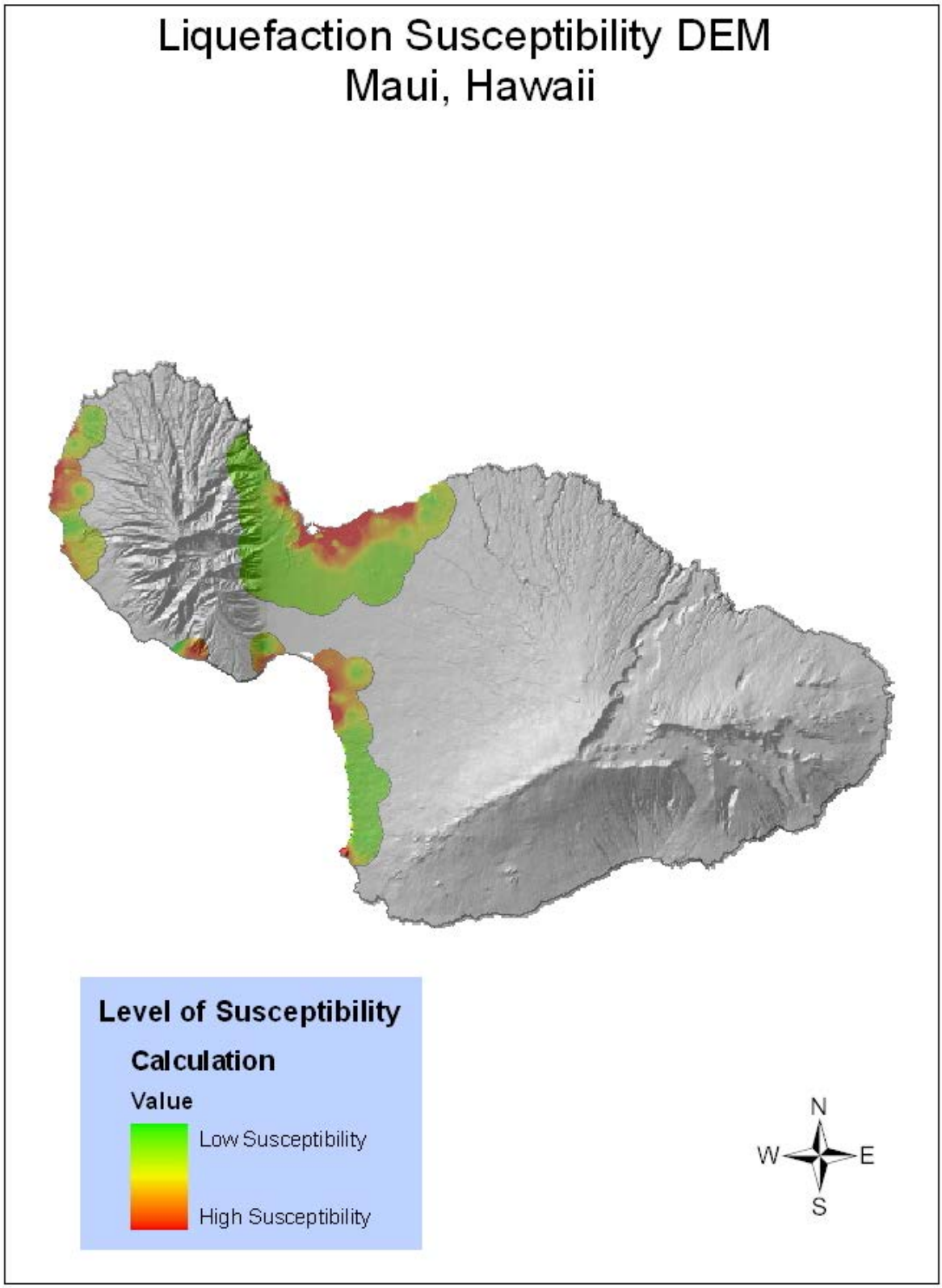

Figure 7.10 Liquefaction Susceptibility Map for the Island of Maui

7.1.4.4 Susceptible Earthquake-Induced Ground Failure Areas

More detailed maps based on soils are needed to identify earthquake-induced ground failure hazards such as liquefaction, landslide, and surface rupture. 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 EPGA of more than 0.10g are generally necessary to induce liquefaction. There is further work needed to better define areas susceptible to liquefaction and landslides. Localized ground surface rupture may be found in closer proximity to the seismic source zone, but should not be viewed as extensions of subsurface seismic faults.

7.2 Significant Historic Events

The Island of Hawaiʻi has experienced 13 damaging earthquakes of magnitude 6 or greater since 1868. The largest of these occurred in 1868 in the Kaʻū district on the southeast flank of Mauna Loa with an estimated magnitude of 7.5 to 8.0. Although the 1868 earthquake caused damage island-wide, the devastation was greatest in Kaʻū where the earthquake triggered a mudflow killing 31 people and coastal subsidence generated a tsunami that destroyed several villages. Approximately 79 people were killed as a result of the earthquake of 1868 with most of the casualties resulting from the mudslide and the tsunami.[12]

In February 19, 1871, the Lānaʻi Earthquake had a magnitude of 7 or greater. Massive rock falls and cliff collapse occurred on Lānaʻi as well as damages to homes. A house and several churches were flattened on the islands of Maui and Molokaʻi. Two houses were reported to have split open on the island of Oʻahu. Also, ground fractures and land slippages were reported in Waiʻanae (island of Oʻahu) and Lahaina (island of Maui).

The 1938 magnitude 6.9 earthquake with epicenter north of the island of Maui has been another of the most significant seismic events to affect the County of Maui. This earthquake was of tectonic nature, resulting from loading and bending of the earth's crust by the immense weight of the islands. The earthquake occurred on January 22 and had submarine hypocenter located about 12 miles northeast of Keʻanae Point in East Maui.[13] Of all the Hawaiian Islands, the island of Maui suffered the greatest damage. Damage on Molokaʻi and Lānaʻi was small and resulted from a few ground cracks. The Hawaiʻi Volcano Observatory describes the damage in the island of Maui as follows:

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[12] Heliker, C. "Volcanic and Seismic Hazards on the Island of Hawaiʻi", U.S. Geological Survey, 1990.

[13] United States Geological Survey Hawaiʻi Volcano Observatory Website, Retrieved October 8, 2009 from http://hvo.wr.usgs.gov/volcanowatch/1999/99_04_08.html

"Landslides blocked the roads to Hāna [Pi'ilani Highway] and completely severed communications for several days. Two large oil tanks near Hāna shattered, and 30,000 gallons of oil flowed into the ocean. Ranches in southeastern Maui suffered heavy damage as water tanks and stone walls were razed. Fortunately, no lives were lost, and injuries were few. No tsunami accompanied the shock. Central and west Maui were not spared from damage. Concrete buildings cracked from Kahului to Lahaina. The fire station tower in Kahului shifted half an inch."[14]

The O'ahu Earthquake of 1948 was measured between 4.8 and 5.0 and resulted in broken store windows, plaster cracks, ruptures in building walls, and a broken underground water main.

A large earthquake, unrelated to volcanic activity, was located 25 miles beneath Honomū in the South Hilo district in 1973. This earthquake had a magnitude of 6.2 and caused $5.6 million worth of damage and injured 11 people.[15]

The largest earthquake on the island during the 20th century occurred on the south flank of Kīlauea in 1975. This earthquake had a magnitude of 7.2 and caused coastal subsidence at Kalapana, generated a tsunami that killed 2 people in the Hawai'i Volcanoes National Park, destroyed houses in the Ka'ū district, sank fishing boats in Keauhou Bay within the North Kona district, and damaged boats and piers in Hilo, within the South Hilo district.[16]

The most recent large magnitude earthquakes to affect the Hawaiian Islands were the Kīholo Bay and Māhukona earthquakes of October, 2006. Both earthquakes, with epicenters in the Island of Hawai'i, were felt throughout the State. These two earthquakes, and the damage caused by them, will be discussed in further detail later in this chapter.

Two other moderate magnitude earthquakes have been recorded since the 2006 Kīholo Bay and Māhukona earthquakes, both having epicenter in Island of Hawai'i. The M5.4 earthquake with the epicenter at 19.346°N, 155.066°W on August 14, 2007 and the M5.2 earthquake with the epicenter at 19.328°N, 155.210°W on April 14, 2009, however, did not cause any damage[17]. Table 7.4 presents a list of earthquakes with magnitude 6.0 or greater that have occurred in the Hawaiian Islands since the mid 1800's.

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[14] United States Geological Survey Hawai'i Volcano Observatory Website, Retrieved October 8, 2009 from http://hvo.wr.usgs.gov/volcanowatch/1999/99_04_08.html

[15] Ibid.

[16] Heliker, C., "Volcanic and Seismic Hazards on the Island of Hawai'i", U.S. Geological Survey, 1990.

[17] United States Geological Survey Website, Retreived 2009 from http://earthquake.usgs.gov/earthquakes/states/historical_state.php

Table 7.4 History of Earthquakes in Hawai‘i, Magnitude 6.0 and Greater, 1868 - Present[18]

Year	Date	Richter Magnitude	Source / Epicenter
1868	March 28	6.5 – 7.0	Mauna Loa south flank
1868	April 2	7.5 – 8.1	Mauna Loa south flank
1871	February 19	7.0	South of Lāna‘i Island
1908	September 20	6.7	Kīlauea South Flank
1918	November 2	6.2	Ka‘ōiki, between Mauna Loa & Kīlauea
1919	September 14	6.1	District, Mauna Loa south flank
1926	March 19	>6.0	NW of Hawai‘i Island
1927	March 20	6.0	NE of Hawai‘i Island
1929	September 25	6.1	Hualālai
1938	January 22	6.9	North of Maui Island
1940	June 16	6.0	North of Hawai‘i Island
1941	September 25	6.0	Ka‘ōiki
1948	June 28	4.6	South of O‘ahu Island
1950	May 29	6.4	Kona
1951	April 22	6.3	Lithospheric
1951	August 21	6.9	Lithospheric
1952	May 23	6.0	Kona
1954	March 30	6.5	Kīlauea south flank
1955	August 14	6.0	Lithospheric
1962	June 27	6.1	Ka‘ōiki
1973	April 26	6.3	Lithospheric
1975	November 29	7.2	Kīlauea south flank
1983	November 16	6.6	Ka‘ōiki
1989	June 25	6.1	Kīlauea south flank
2006	October 15	6.7	Kiholo Bay, Hawai‘i Island
2006	October 15	6.0	Māhukona, Hawai‘i Island

7.2.1 Kīholo Bay and Māhukona Earthquakes

The most recent major earthquakes in the State of Hawai‘i were the Magnitude 6.7 Kīholo Bay and Magnitude 6.0 Māhukona earthquakes that occurred on October 15, 2006 at 7:07am and 7:14 am respectively.[19] Within a 48-hour period of these earthquakes, several aftershocks of varying magnitude occurred. Figure 7.11 and Figure 7.12 depict the location, magnitude, and depth of the two initial earthquakes and their aftershock. As can be seen on the figures, both the Kīholo Bay and Māhukona earthquakes were centered near the Kona coastline of the island of Hawai‘i. The largest ground shaking for these earthquakes was at the northern end of the island, but did not directly coincide with the epicenters of the earthquakes. The largest ground motions were recorded at the towns of Waimea and Hāwī. These areas had amplified ground motion due to softer soil conditions at these locations. The most heavily damaged buildings were concentrated in the Waimea and Hāwī areas with some damage also in the Honoka‘a and Kona areas. There was very little damage at the south end of the island. For reference, an intensity map of the Hawaiian Islands for the Kīholo Bay Earthquake is included in Figure 7.13.

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[18] Atlas of Hawai‘i, Third Edition, 1998. Updated from US Geological Survey (USGS) data, retrieved July 2010 from http://earthquake.usgs.gov/regional/states/historical_state.php#hawaii, as best available data.

[19] Robertson et al, 2006; EERI, 2006; EERI et al, 2006

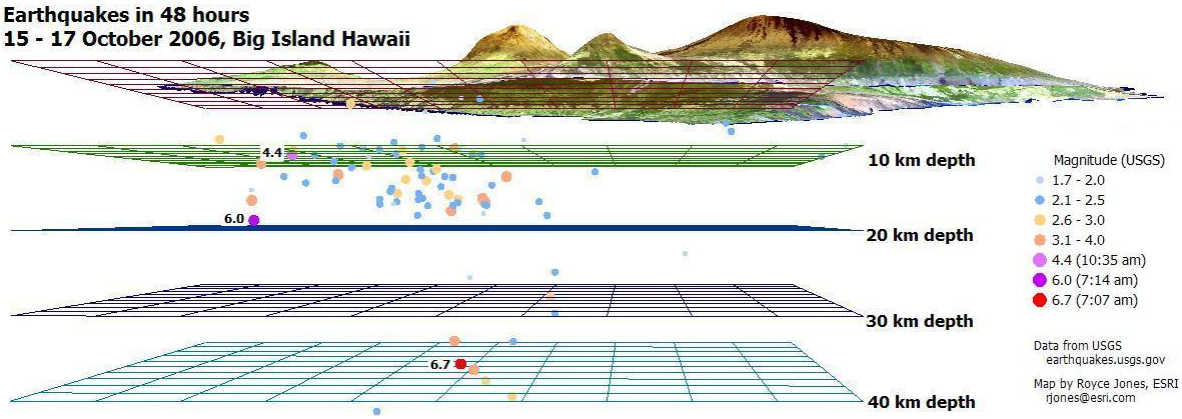

Figure 7.11 Earthquakes within 48 hours of the Kīholo Bay and Māhukona Earthquakes[20]

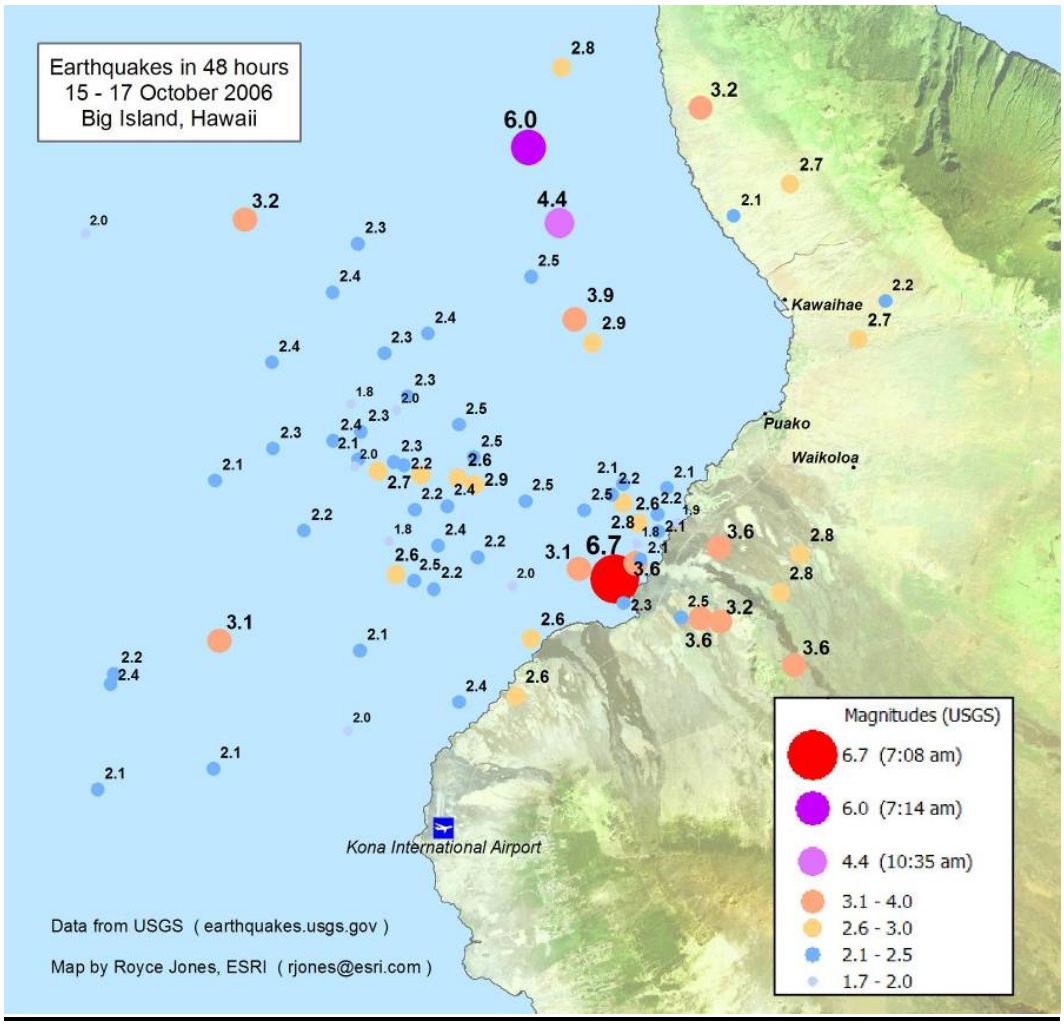

Figure 7.12 Earthquakes within 48 hours of the Kīholo Bay and Māhukona Earthquakes[21]

[20] Data from USGS 2006; Maps from Royce Jones, ESRI, 2006

[21] Ibid

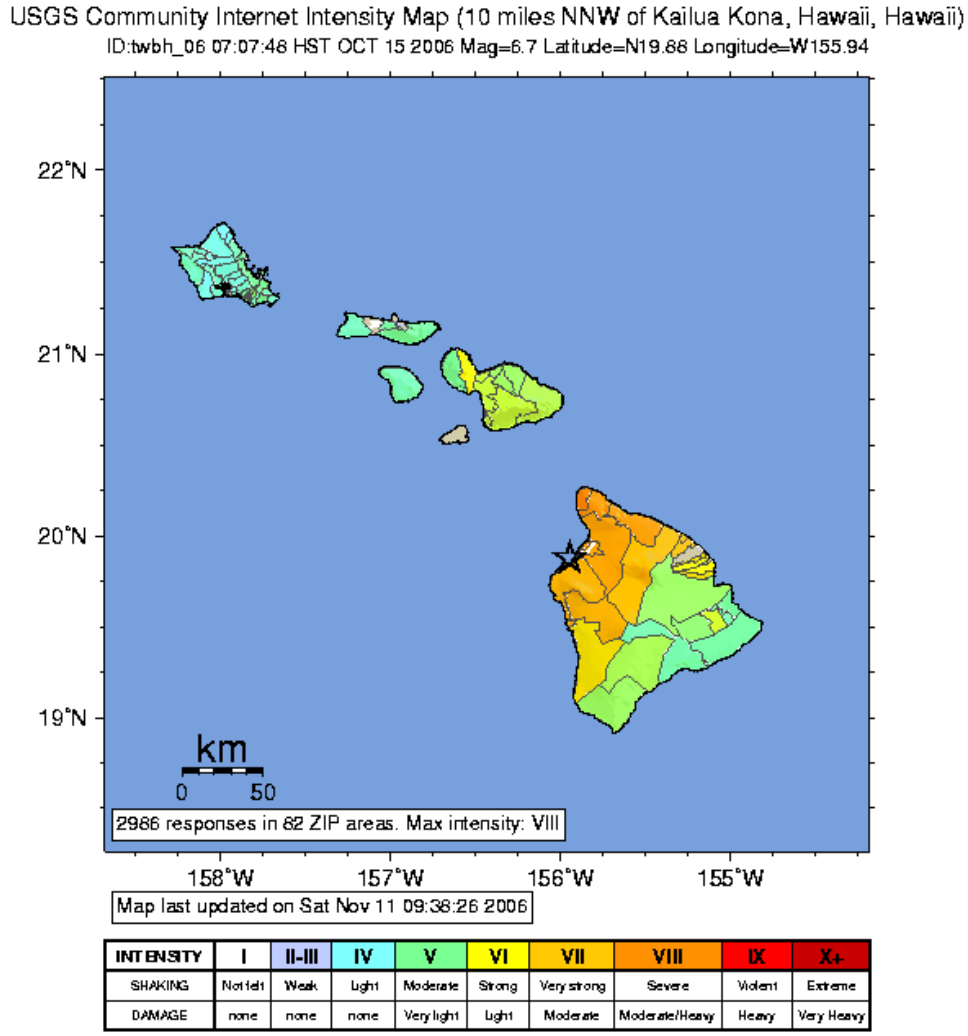

Figure 7.13 USGS Community Internet Intensity Map for the Kīholo Bay Earthquake

The main October 15 Kīholo Bay earthquake probably reflected the long-term accumulation and release of lithospheric flexural stresses. The long-term stresses consist in part of stresses generated in the crust and mantle by the weight of the volcanic rock that composes the islands. Such deeper mantle earthquakes at approximately 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 Honomū (on the northeast coast of the island of Hawai'i), the 1938 M7 Maui, and the 1871 M7 Lāna'i earthquakes.

The Kīholo earthquake was the first earthquake greater than 6.0-magnitude in almost twenty years. It was not actually a single earthquake, and several aftershocks of lower magnitude followed for more than a month after the major tremors on October 15, 2007.

7.2.1.1 Performance of the Kawaihae Harbor in the Island of Hawai'i

One of the two major commercial ports on the island of Hawai'i, the commercial port facility at Kawaihae Harbor consists of two pile-supported concrete piers, a 500-foot long Pier 1 and the 1500-foot long Pier 2, which is operationally divided into Piers 2, 2A, and 2B and a few warehouse and administrative buildings, and an asphalt paved shipping container yard. An aerial picture of Kawaihae Harbor is included in Figure 7.14. This facility was located less than 24 km (15 miles) from the epicenter of the Kīholo Bay Earthquake.

Figure 7.14 Aerial Image of Kawaihae Harbor

Kawaihae Harbor sustained major damage from liquefaction and lateral spreading. Sand boils were observed throughout the harbor area. Much of the fill material under the shipping container handling yard consists of dredged fill. As this material liquefied, the resulting lateral spreading caused significant vertical settlement of the asphalt pavement, and lateral displacement of the pile supported concrete piers. Large areas of the asphalt yard, had settled up to approximately 6 inches. A series of cracks with widths ranging from approximately 1/4 inch to several inches were observed roughly aligned parallel with the shoreline. Cumulatively, these cracks displayed lateral spreading of 6 inches or more. Pier 1 displaced as much as 6 to 12 inches laterally towards the harbor. This movement indicates that the piles were moved and/or distressed by the lateral spreading of the liquefied soil beneath and landward of the pier.

Port Damages

The most pronounced damage at Kawaihae was the failure of 1950's era Pier 1. This portion of the pier, which includes a concrete bulkhead wall, tie rods, anchor block and surrounding structures (Figure 7.15 shows and interpreted subsurface profile of the pier.), experienced a significant amount of damage. Primary damage and displacements greater than 15 inches occurred to Pier 1. Visible damage to the pier structure included:

- Longitudinal cracks in the bulkhead cap, concrete sheetpile and rock revetments.
- Yielding and necking of the tie rods, but no breakage with 4-6 inches lateral translation and 12-15 inches movement in the rip rap at the north end of the pier.
- Significant settlement behind the anchor block and in pavements.

Other areas experience small deformations (less than 2 inches) and more minor damage. Piers 2, 2A and mooring dolphins which are 1960's and 1990's era structures experienced only minor cracking or spalling and remain in service. Terminal yard pavements experienced settlement and cracking damage. Terminal shipping warehouses, the harbor masters office and grain silage building also experienced racking, masonry cracking and minor cladding damage. The fuel tank farm and cement silo experienced only minor cracking. Several electrical and water utilities were broken. The cement and grouted rip rap storm drainage channel also experienced minor cracking displacements, but remained serviceable.

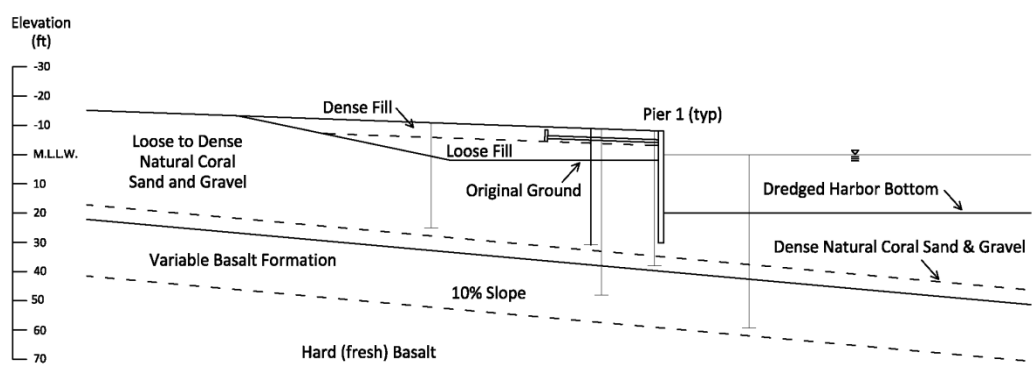

Figure 7.15 Interpreted Subsurface Profile of Pier 1

Site Response Study

The subsurface geology of Kawaihae Harbor, i.e., loose coral deposits, (Figure 7.12) is significantly different than geologies of the strong motion sites that recorded the Kīholo Bay earthquake, which are located on volcanic soil, ash, or rock. Estimates of surface ground motions at Kawaihae were between 0.3 and 0.6g. A site response analysis was performed based on an average shear wave velocity (V_S) profile. A total of nine Spectral-Analysis-of-Surface Waves (SASW) surveys lines were surveyed at Kawaihae Harbor. The results of the SASW surveys indicate fill and soil thickness of 40 to 90 feet over basalt. Low blow count SPT data in the coralline soils and observed liquefaction confirm that the upper 30 to 50 feet is code site class F.

Liquefaction Studies

Liquefaction is a soil behavior phenomenon where shear strength loss occurs due to the rapid build-up of excess pore-water pressure, which reduces effective stresses in the soil to zero. It is most commonly generated by strong earthquake ground shaking. In general, soils most susceptible to liquefaction are loose, saturated, uniformly graded sands containing little or no fines, such as dredged fills used to construct reclaimed landside areas of the harbor.

Evidence of liquefaction was observed extensively at Kawaihae Harbor in the vicinity of Pier 1 and 2, in pavement areas at the pier structures, in the terminal yard area and within the waterfront storage warehouses. Sand boil emissions occurred through cracks in pavements, with associated settlements up to 7 inches, including shallow footings. Lateral displacements up to 18 inches were observed at Pier 1, at the seawall revetment area between Pier 1 and 2, as localized displacement within the sloping fills abutting the piers.

7.2.1.2 Performance of Other Building and Non-Building Structures in the County of Hawai'i

Several building and non-building structures in the island of Hawai'i suffered minor to significant structural and non-structural damage during the Kīholo Bay and Māhukona Earthquakes.

Prior to the earthquake, trainings on post-disaster structural inspections were conducted for structural engineers and others with structural expertise. The Applied Technology Council (ATC) Training enabled available trained volunteers to assist the County of Hawai'i with post disaster inspection. The ATC inspections[22] reported the following:

- The County reports that 1682 homes were inspected:
  - 67 Red (4%)
  - 227 Yellow (13%)
  - 1388 Green (83%)
- 231 of these homes were evaluated by Structural Engineering Association of Hawai'i (SEAOH) in one week, including several detailed re-evaluations:
  - 36 Red (16%)
  - 48 Yellow (21%)
  - 147 Green (63%)
- Other buildings and structures, such as churches, were also inspected by SEAOH Members (not included in the above)
- American Red Cross did a windshield survey and reported 40 homes destroyed and 280 with major damage, and about 2009 with minor damage
- FEMA reports 10 destroyed and 1627 damaged.

Other examples of structures observed to have structural or non-structural damage are illustrated in Figure 7.16 and Figure 7.17.

[22] Gary Chock, Martin & Chock, Inc. 2007

Figure 7.16 Structural Damage to Highway 19 near Paauilo[23]

Figure 7.17 Non-Structural Ceiling Damage to Kona Hospital[24]

[23] Source: Gary Chock, Martin & Chock, Inc. 2007
[24] Ibid

7.2.1.3 Performance of Building and Non-Building Structures in the County of Maui

The island of Maui was also impacted by the Kīholo Bay and Mākuhona Earthquakes. The seismic movement induced several landslides) and rockfalls along Pi‘ilani Highway (Highway 31) along the southeastern coast the island. The roadway was closed near Manawainui due to an incipient rockfall. About 500 residents were cut-off in the Manawainui area due to the incipient rockfall hazard and due to a bridge closure damaged to abutment erosion at Pa‘ihi. For more information about the landslides and rockfalls that occurred during and after the Kīholo Bay and Mākuhona Earthquakes, please refer to Chapter 6 –Landslides, Debris Flows, and Rockfalls.

7.2.1.4 Performance of Building and Non-Building Structures in the City and County of Honolulu

Little physical damage was observed on the island of O‘ahu after the Kīholo Bay earthquake with the major impact due to the loss of electricity service in the entire county. O‘ahu was unexpectedly placed in an island-wide power blackout when the earthquake triggered false low hydraulic fluid levels in level switches for the two largest generators representing 23% of the grids capacity at the main generating plant at Kahe point on the west coast of the island. Nearly at the same time, operators manually shut down two other units representing 12% of the grid’s capacity because the earthquake shaking was interpreted instead as turbine malfunction. With four main generators shutdown (two automatically and two manually) that had produced 35% of the grid’s power, there was insufficient capacity of the remaining system to meet demand. This initiated a progressive sequence of manual load shedding which was not able to prevent automatic shutdowns of the remaining generators triggered by load imbalances. Within 20 minutes of the earthquake, all 19 generators on O‘ahu with a combined capacity of 1225 megawatts had shutdown.

Power outages impaired public information and media communication efforts on the day of the earthquake. Eighty percent of radio and television stations in the State did not broadcast due to a lack of emergency generators at either the stations or their transmitter sites. Cable Television and internet service were not available due to lack of emergency power. As expected, cellular telephone systems were overloaded. As a result, many residents were cut off from important information sources, including State government, during the day of the earthquake. Honolulu International Airport was not operational on October 15th because it lacked sufficient emergency power. It took nearly 19 hours for the Hawaiian Electric Company (HECO) to restore power to 99.2% of its 291,000 customers. Concerned about balancing power generation with the electrical demand by customers, the utility had to restore power gradually. HECO officials indicated that if supply and demand had become unbalanced, it could have resulted in much longer outages from damaged equipment or having to restart the restoration. The basic process of simply powering up the grid can take four to eight hours with HECO’s large steam-generator units.

7.2.14 Summary of Damage to Building and Non-Building Structures in the State of Hawai'i

A summary of damage and estimated cost of damage for the State of Hawai'i following the Kīholo Bay Earthquake is included in Table 7.5.

Table 7.5 Summary of Damage to the Island of Hawai'i following the October 2006 Earthquakes[25]

Damage as of 12/31/2006	Number of Facilities with Major Damage	Number of Facilities with Minor Damage	Estimated Cost ($ millions)
Hawai'i County Buildings	15	7	$16
Hawai'i State Buildings	1	21	$0.5
University / Community Colleges	3	17	$2.5
Public Schools	1	25	$5
Libraries	0	3	$0.2
Hospitals	2	3	$3.5
Private Businesses	36	264	$46+
Private Residences	304	1705	$10+
Hawai'i County Bridges			$0.2
State Bridges			$7
Hawai'i County Roads			$3
State Highways			$31
Harbors	1	1	$7 up to $30
Electric Utilities			$4
Agricultural Damage	2	1	$12
Reservoirs		2	$1
State and National Parks	5	16	$7
Total of Estimates	370	2063	$155 - $180

[25] Gary Chock, Martin & Chock, Inc. April 2007, slide 49

7.3 Probability of Occurrence

The most current tools to determine the probability of earthquakes occurring in the Hawaiian Islands are the Seismic Hazard maps produced by the United States Geological Survey (USGS) in 1998. The seismic hazard maps included current seismic, geologic, and geodetic information on earthquake rates associated with ground motion. The maps essentially show the distribution of earthquake ground motion levels (measured as peak ground acceleration or spectral acceleration[26]) that have a certain probability of occurring in or near the Hawaiian Archipelago. These maps are the basis for seismic design provisions of building codes, insurance rates, earthquake loss studies, retrofit priorities, and land-use planning.

Documentation for 1998 hazard maps (Seismic Hazard in Hawai‘i: High Rate of Large Earthquakes and Probabilistic Ground-Motion Maps, by Fred W. Klein, Arthur D. Frankel, Charles S. Mueller, Robert L. Wesson, and Paul G. Okubo, Bulletin of the Seismological Society of America, Vol. 91, No. 3, pp. 479-498. June, 2001); USGS report 2724 is available at the USGS Website at http://pubs.usgs.gov/imap/2000/i-2724.

The latest family of building codes, the International Building Code (IBC) series, define seismic hazard, and thus design earthquake forces, using probabilistic maps based on the seismic hazard mapping developed by the USGS. In essence, the IBC uses two maps that indicate spectral acceleration having a probability of exceedance of 2% in 50 years for periods of 0.2 seconds (short periods) and 1.0 seconds (long periods). The maps include an implicit adjustment for a deterministic Maximum Considered Earthquake (MCE) for different seismic sources. The spectral accelerations shown on the maps correspond to sites with Site Class B (rock) and to structures with 5% damping. The IBC includes the two maps for all States, Territories, and Puerto Rico. The applicable maps for the State of Hawai‘i are shown in Figure 7.18. The design spectral accelerations shown in these maps for a given site are equal to two thirds of the MCE expected at such site. If required, the accelerations are modified, usually amplified, according to the soil conditions present at the site if conditions other than rock exist (Site Class other than B).

While the USGS seismic hazard maps are available for a variety of probability levels and ground motion parameters, the 2% exceedance in 50-year Peak Ground Acceleration maps may be the most appropriate single map for planning at the current time, being consistent with building design criteria in the IBC. USGS seismic hazard maps for different probability levels and ground motion parameters are available at the USGS website at http://pubs.usgs.gov/imap/i-2724/.

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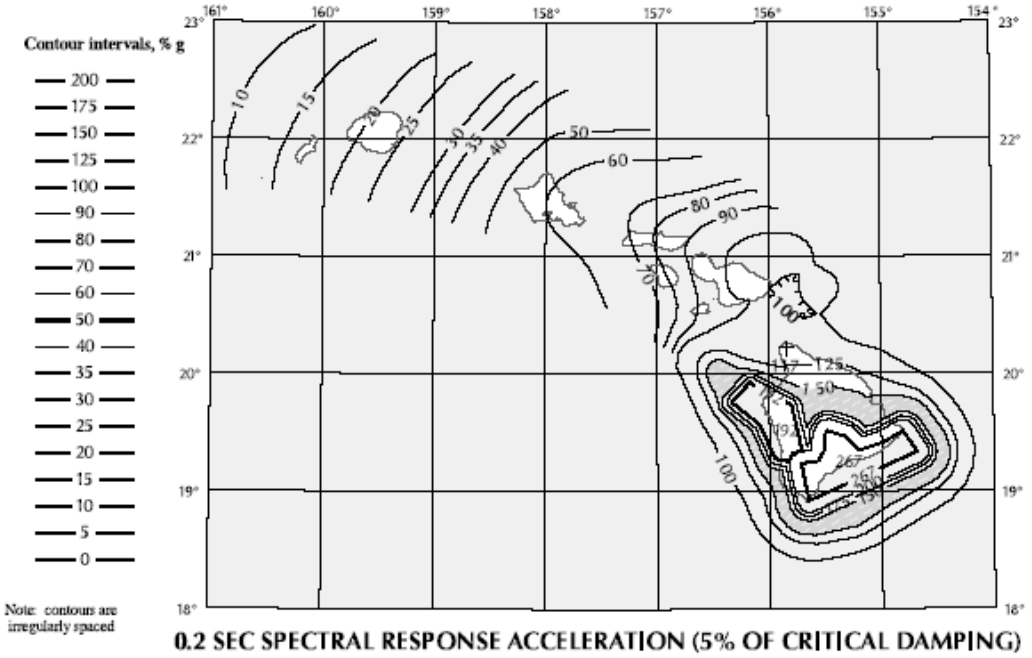
[26] The States Geological Survey (USGS) defines peak ground acceleration is the motion experienced by a particle on the ground at the time of an earthquake. Therefore, peak ground acceleration is a good measure for buildings up to seven stories (or buildings with small periods) since it is a natural simple design parameter that can be related to a horizontal force that can be easily used in the design of a building. Spectral acceleration, on the other hand, is approximately the motion experienced by a building or structure, modeled by a particle mass on a massless vertical road having the same natural period of vibration as the building or structure. Spectral acceleration is also a good index hazard to buildings because it more closely related to the behavior of buildings than peak ground acceleration. Nonetheless, the relation of spectral acceleration to a horizontal design force is more complicated than that of peak ground acceleration because the former takes in consideration the period of the building.



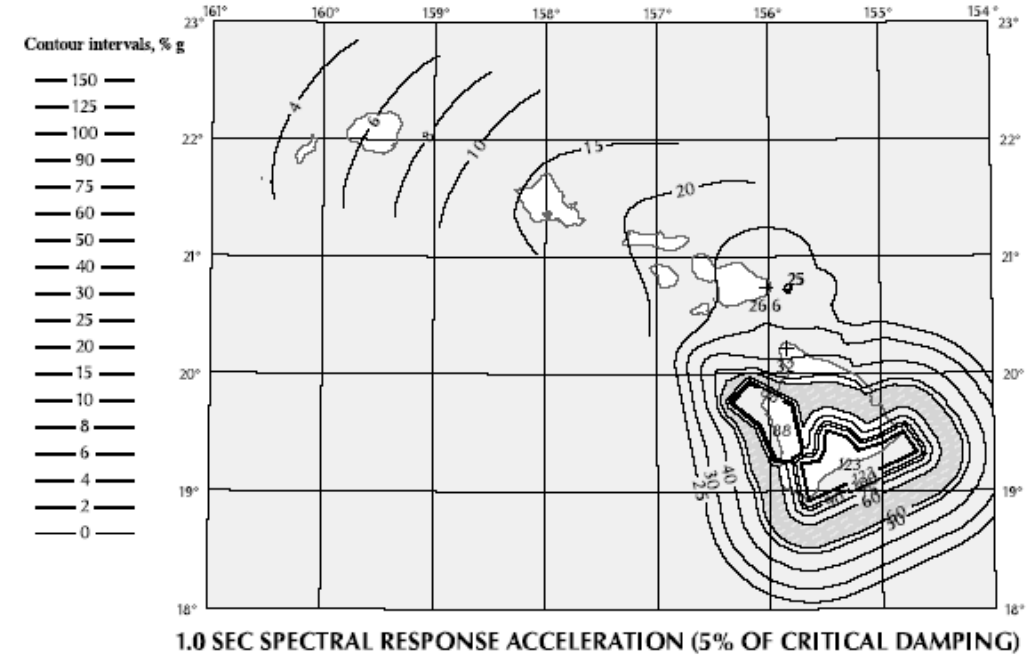


Figure 7.18 Maximum considered earthquake ground motion for the State of Hawai‘i of 0.2 and 1.0 second spectral accelerations (5% damping, Site Class B) (ASCE, 2005)

7.4 Risk Assessment

7.4.1 Vulnerability and Potential Losses from Earthquakes

In order to measure earthquake losses, researchers employ a computer program known as Hazards U.S. (HAZUS). The Federal Emergency Agency (FEMA) developed the software in partnership with the National Institute of Building Sciences (NIBS). Characteristics of a hypothetical or actual earthquake are entered into HAZUS, and HAZUS then estimates the intensity of ground shaking and calculates losses based on the ground shaking results. Losses include the number and types of buildings damaged, number of casualties, damage to transportation systems, disruption to utilities and critical services, and estimated economic losses. Two sample scenarios using HAZUS, prepared by Martin & Chock, Inc. for the State of Hawai‘i Civil Defense and the Hawai‘i Coastal Zone Management Program are included in Appendix 7A at the end of this chapter.

7.4.2 Losses Estimated from Lessons Learned about Earthquakes Impacts

Assessments made following the Kīholo Earthquake on October 15, 2006 improved models and assessments for calculation of losses due to earthquakes in Hawai‘i. Initial runs of the HAZUS software estimated potential damage at $155 million for structures. In reality, costs associated with the Kīholo Earthquake exceed $580 million Post-disaster evaluations continued to inform risk assessment models. Lessons learned were applied to risk reduction applications and hazard mitigation projects. Information was used from study of the total costs to improve the building inventories and, in doing so, have improved the quality of the HAZUS models used in Hawai‘i.

Assessments made following the Kīholo Earthquake on October 15, 2006 improved models and assessments for Hawai‘i. Initial runs of the HAZUS software estimated potential damage at $155 million for structures. In reality, costs associated with the Kīholo Earthquake exceed $580 million Post-disaster evaluations continued to inform risk assessment models. Lessons learned were applied to risk reduction applications and hazard mitigation projects. Information was used from study of the total costs to improve the building inventories and, in doing so, have improved the quality of the HAZUS models used in Hawai‘i.

Average Annualized Loss (AAL) of earthquake events is also computed using the HAZUS model. HAZUS computes losses for eight earthquake scenario events with different return periods: 100-year, 250-year, 500-year, 750-year, 1000-year, 1500-year, 2000-year, and 2500-year.

Based on a HAZUS AAL analysis incorporating soil site factor mapping and Hawai‘i Construction Cost Data, *earthquake* AAL is estimated at about $65.1 million in the County of Hawai‘i. The predominant contributor to loss is the single-family residential construction.

Under similar assumptions, *earthquake* AAL is expected at about $20 million in the County of Maui. The main contributor to loss in this case is again the single-family residential sector.

In the case of the City and County of Honolulu, *earthquake* AAL is estimated at approximately $21 million. Annual income losses are estimated at another $2 million. The predominant contributor to loss in this County is single-family residential construction.

Lastly, the County of Kaua‘i lies in an area of reduced seismic risk and was not considered in this study. However, if a severe earthquake affects the island of O‘ahu (City and County of Honolulu), the County of Kaua‘i would be impacted severely in the receipt of goods, services, and finances since many systems rely on the ports and harbors or institutions on the island of O‘ahu. Therefore, *earthquake* AAL for the County of Kaua‘i is estimated at approximately $0.2 million.

7.4.3 Structural Risk and Vulnerability for State Critical Facilities

As part of addressing gaps recognized in the 2007 plan, funds were applied to a structural risk and vulnerability assessment of state critical facilities. The State Building Inventory accounts for several thousand buildings. Of these, 274 buildings were identified as critical facilities for the first order of detailed analysis using the rapid visual engineering field surveys to ground truth building data used in the HAZUS model.

Buildings were ranked according to the damage costs from a probabilistic earthquake scenario. The following Table 7.6 includes loss estimates greater than $1 million from a single event, which are 114 buildings of the 274 State critical facilities.

While it would be easy to recommend structural hazard mitigation actions for all of the buildings on the list, there may not be sufficient funds for all of the retrofits needed; therefore, this list provides a rationale for prioritization of earthquake risk reduction.

The first three areas that would experience the highest damages would be the Honolulu International Airport on the island of O‘ahu and Keāhole-Kona and Hilo International Airports on the island of Hawai‘i (the island with the greatest seismic threat). The Honolulu International Airport is a critical gateway to the main island in state, although the airport would experience less than 10% damage to the facility. Therefore, portions of the facility would likely still be able to function in a post-earthquake scenario. Should both airports on the island of Hawai‘i be damaged, the economic burden on the county of Hawai‘i would increase and cause additional difficulty in disaster recovery.

The next several buildings on the list are a mix of hospitals and medical facilities, elderly care homes, and office buildings. Ka‘ū Hospital ranks 15th in terms of costs of damage from the earthquake, but first in terms of the percentage of facility lost.

A review of the buildings on the list indicates that the percentage loss of the building, and therefore, loss of functionality of the facility should be strongly considered in making determinations for mitigation. The purpose and service of the facility must be weighed in decisions to mitigate the hazards. Some of the facilities will have the greatest economic impact, but other mitigation actions for hospitals and elderly care homes will have the most impact on human dimensions of disaster.

Table 7.6 Earthquake Losses for State of Hawai‘i Buildings, in Order of $ Loss Rank[27]

Hawai‘i State Buildings	Earthquake Probabilistic Scenario			
Building Name	Estimated $ Loss	% Loss	$ Loss Rank	% Loss Rank
Honolulu International Airport	$183,917,250	9.3%	1	215
Keāhole-kona Airport - Passenger Terminal	$87,477,445	73.5%	2	18
Hilo Airport - Passenger Terminal	$83,163,578	69.9%	3	19
Hilo Medical Center - Acute Care Facility	$48,646,770	49.8%	4	44
Kula Hospital - Main Building	$27,511,598	36.4%	5	63
Kauhale Kaka‘ako	$21,095,150	18.9%	6	180
Foreign Trade Zone - Office	$19,945,574	29.5%	7	86
Kona Community Hospital - Building 1 and 2	$17,628,084	56.2%	8	32
State Office Building - Hilo	$17,050,131	78.5%	9	15
Diamond Head Main Terminal	$13,064,352	29.5%	10	85
Kauikeaouli Hale - State Court	$11,839,387	19.1%	11	166
Pohulani Elderly	$11,307,708	18.9%	12	179
Pier 31-33 Shed - Warehouse	$9,306,849	23.2%	13	109
Kahului Airport	$8,644,388	7.3%	14	232
Ka‘ū Hospital and Rural Health Clinic	$8,603,021	99.6%	15	1
Hawai‘i State Hospital	$8,071,422	4.9%	16	236
Pier 11 Shed Bldg A - Warehouse	$7,878,854	35.9%	17	66
Wailuku State Office Building	$7,855,109	49.0%	18	46
Hilo Medical Center - Extended Care Facility	$7,723,634	86.6%	19	9
Pier 19 Shed - Warehouse	$7,386,921	29.9%	20	84
Hilo Harbor Pier 1 - Warehouse facility	$7,328,769	96.1%	21	3
Hilo Harbor Pier 2 - Interisland warehouse facility	$7,328,769	96.1%	21	3
Hilo Public Library	$7,254,572	97.2%	23	2
Brigham Young University - Cannon Activities Center	$6,891,120	28.7%	24	98
Hale Ho‘ola Hamakua	$6,280,154	29.5%	25	87
Maui County Building - EOC	$5,769,433	29.2%	26	95
Hale Ho‘ola Hamakua - Old Hospital	$5,676,556	60.6%	27	29
Kohala Hospital	$5,484,563	64.1%	28	25
Ka‘ahumanu Hale - Courthouse	$5,427,760	10.4%	29	213
DOT/Harbor Warehouse # 6 - Passenger Terminal	$4,782,447	29.0%	30	96
Ali‘iōlani Hale	$4,727,199	34.5%	31	71
Court Operations - Hoapili Hale	$4,491,081	16.1%	32	199
Supreme Courtroom/Chambers/Admin	$4,290,556	34.5%	33	70
AAFES Building - Warehouse	$4,264,845	27.2%	34	102
Kona Community Hospital - Psychiatric Facility	$4,117,034	50.0%	35	42
Konawaena High School - Building N - Gymnasium	$4,063,488	61.6%	36	27
Maui Memorial Hospital	$4,007,700	13.4%	37	204
Kahului Harbor Pier 1 Building - Cruise Terminal	$3,683,232	37.6%	38	60
Lanakila Health Center	$3,575,681	35.9%	39	65
Kona Community Hospital - Special Services	$3,557,437	50.0%	40	43
Kahului Ambulance Facility	$3,502,581	36.2%	41	64
Building 300	$3,452,324	38.0%	42	57
Brigham Young University - Old Gym	$3,445,560	28.7%	43	97
Lāna‘i High School and Elementary School Gymnasium	$3,437,294	50.0%	44	41
Keakeaiani Office and Third Judicial Circuit Court	$3,341,008	68.4%	45	20
Hilo Medical Center - Hale Ho‘ola	$3,320,337	61.1%	46	28
Pier 51-53 CFS Shed	$3,139,814	48.8%	47	48
Lāna‘i Community Hospital	$3,127,612	50.0%	48	40
MS/Commodities Bldg	$3,079,880	48.8%	49	47
Hawai‘i State Main Library	$2,879,655	21.4%	50	145
Hilo High School Building B	$2,861,549	66.8%	51	21
Armory	$2,848,576	49.0%	52	45
American Medical Ambulance	$2,838,933	47.5%	53	52
Pier 10 Shed - DOT Harbors Div and Terminal	$2,837,865	19.2%	54	165
Hilo Medical Center - VA Outpatient Clinic	$2,734,211	63.7%	55	26
Waialua High and Intermediate - Gym	$2,366,125	31.1%	56	79
Honaunau Elementary School - Building F	$2,260,637	82.2%	57	11
Leahi Hospital - Young Bldg - District Court	$2,237,069	4.2%	58	241

[27] Martin & Chock, Inc., with UH SRRI, 2010.

Hawai‘i State Buildings	Earthquake Probabilistic Scenario			
DLNR Boating and Ocean Recreation Division	$2,205,984	16.7%	59	197
Kahului Civic Center	$2,184,511	55.6%	60	33
Kapolei High School - Bldg G	$2,066,448	19.5%	61	151
Campbell High School - Bldg D	$2,064,010	19.0%	62	172
Building 302	$2,063,502	38.0%	63	56
McKinley High School for Adults	$2,053,074	30.3%	64	82
Container Freight. Station # 3 - Warehouse	$2,007,403	48.6%	65	49
Hilo High School Building Q - Cafeteria	$1,923,937	65.8%	66	24
Leahi Hospital Young Building - New Wards A&C	$1,839,848	4.2%	67	240
Hilo Airport - Fire Station	$1,831,646	66.4%	68	22
Konawaena High School - Building G	$1,635,072	87.4%	69	6
Ho‘okena Elementary School - Building D	$1,571,432	57.1%	70	31
Hilo Medical Center - Maintenance Bldg	$1,555,978	88.9%	71	5
Kahului Power Plant	$1,534,896	32.0%	72	77
Waiakea High School - Building E	$1,522,180	55.4%	73	34
Waiakea High School - Building F	$1,522,180	55.4%	73	34
Waiakea High School - Building H	$1,522,180	55.4%	73	34
Waiakea High School - Building Q	$1,522,180	55.4%	73	34
Konawaena High School - Building A	$1,519,246	86.9%	77	8
Konawaena High School - Building O	$1,496,240	81.4%	78	14
Plant Quarantine Branch - DOH Offices	$1,493,698	24.5%	79	108
Konawaena High School - Building F	$1,490,801	87.4%	80	7
Alii Aimoku Hale - Court	$1,475,429	12.3%	81	210
Bio Control Facility - Office & Vet Lab	$1,472,575	33.7%	82	73
Leilehua High School - Bldg R	$1,400,170	19.2%	83	161
Lahaina Civic Center	$1,389,686	13.2%	84	205
Building 829	$1,388,779	19.1%	85	167
Waipahu Elderly	$1,388,000	13.9%	86	203
Mililani High School - Bldg B	$1,358,377	19.4%	87	154
Waiakea Elementary School - Building G	$1,340,016	35.6%	88	69
Kahuku High and Intermediate - Bldg W	$1,285,780	18.1%	89	194
Nānākuli High and Intermediate - Bldg E	$1,254,862	18.7%	90	182
Kailua High School - Gym	$1,230,213	17.9%	91	195
Campbell High School - Bldg H	$1,225,799	19.0%	92	168
Hilo High School Building A	$1,223,353	35.6%	93	68
Lahaina Fire Station	$1,202,502	37.2%	94	62
Campbell High School - Bldg G	$1,199,417	19.0%	95	171
Kahuku High and Intermediate - Gym	$1,195,062	18.1%	96	188
Campbell High School - Bldg N	$1,159,950	19.0%	97	170
Kailua High School - Bldg D	$1,159,725	22.1%	98	144
Armory	$1,159,679	22.3%	99	123
Keāhole-Kona Airport - Fire Station	$1,155,732	58.8%	100	30
DOH Laboratory	$1,138,119	3.8%	101	250
Kailua High School - Bldg E	$1,137,723	22.1%	102	140
Kaunakakai Airport	$1,130,080	28.3%	103	99
Kula Hospital - Mental Facility Building	$1,126,800	22.5%	104	114
Campbell High School - Bldg O	$1,108,073	19.0%	105	178
Nanakuli High and Intermediate - Bldg B	$1,107,253	18.7%	106	183
Leahi Hospital Young Building - Lndy, maint,mach	$1,102,248	8.1%	107	222
Waialua High and Intermediate - Bldg S	$1,074,454	31.1%	108	78
Nānākuli High and Intermediate - Bldg C	$1,073,754	18.7%	109	184
Leahi Hospital Young Building - Dining Rm/Occy therapy	$1,066,692	8.1%	110	221
Mākaha Elementary School - Bldg A	$1,055,717	29.4%	111	89
Mākaha Elementary School - Bldg B	$1,048,914	29.4%	112	90
Building 027 Vehicle	$1,043,159	19.2%	113	160
Mililani High School - Bldg L	$1,010,893	19.4%	114	155

7.5 Mitigation Strategies

7.5.1 Previous and Current Mitigation Efforts

7.5.1.1 Hawai‘i State Earthquake Advisory Committee

The Hawai‘i State Earthquake Advisory Committee (HSEAC) was founded in 1990 by the Hawai‘i State Civil Defense Agency (SCD) to bring together seismic expertise from the Hawai‘i scientific, engineering, and emergency management communities. HSEAC serves as a technical advisory committee to SCD for identifying and implementing seismic hazards mitigation programs.

HSEAC identified the need prepare for these earthquakes by developing an understanding and knowledge of potential losses - to humans, buildings, infrastructure, businesses - and potential needs - hospital beds, shelter, transportation and utilities, debris removal - in order to mitigate both short and long term losses.

7.5.1.2 Modern Era Design Earthquake Forces, All Islands

Adoption of the IBC through the State Building Code; the State of Hawai‘i Governor signed new State Building Code April 16, 2010. Counties had a two-year period from the time of the signature to make any amendments and adopt the code. All counties are now compliant with the State Code.

7.5.1.3 HAZUS MH New Model for Disaster Planning

New building inventory data for Hawai‘i and Maui counties make HAZUS MH more capable of producing earthquake damage maps and reports at a much higher spatial resolution, based on the best available building and soil data, and it will perform analysis using ShakeMap output from USGS. The HAZUS MH new model for disaster planning is now used in 2010 and is being implemented in an update of the PDC Earthquake Scenario Atlas.

7.5.1.4 Structural Seismic Retrofit for Residential Post and Pier Homes

A survey of 53 post and pier houses on the island of Hawai‘i was performed to determine the typical structural characteristics and variations in structural properties of these houses in the most vulnerable areas. The survey also investigated the extent of damage of these homes during the 2006 earthquakes along with any attempts to retrofit the houses at the time of survey. Based on this survey, a number of prototypical models of post and pier houses were analyzed for different levels of ground motion. A number of aspects of the houses were found to require retrofitting for even moderate levels of ground motion.

From the analysis, three retrofit options were developed, with the applicability of each retrofit based on the location of the house and its structural properties. The retrofits are presented in a general format that can be applied to a wide range of houses without specific input from a structural engineer, except in special cases. Retrofit Option 1 is primarily a strengthening of connections using the existing post and pier foundation system, applicable in regions of low to

moderate seismic hazard and for houses with moderate differential post heights. Retrofit Option 2 uses additional plywood shear walls between the ground and first floor of a house to provide additional lateral strength and stiffness to the foundation system. Retrofit Option 3 utilizes reinforced masonry shear walls.

7.5.1.5 Public Symposia and Teacher Training Workshops on Natural Hazards (Jan.-May 2010)

CSAV hosted a series of four public symposia and teacher training workshops that addressed the major natural hazards occurring in Hawaiʻi (Volcanic Eruptions, Earthquakes, Tsunamis, and Hurricanes).

7.5.1.6 Power Reliability Improvements

Following the Kīholo Bay Earthquake, associated power system events led to island-wide blackouts for Hawaiian Electric Company, Inc. (HECO) on the island of Oʻahu and for Maui Electric Company, Ltd. (MECO) on the island of Maui. These blackouts occurred although there was little apparent seismic damage to the electric systems on either island. Hawaiian Electric Light Company, Inc. (HELCO) on the island of Hawaiʻi maintained partial service with an isolated section, or "island" of generation and customer load in the Hilo area.

Since these events, efforts have been made to improve the reliability of the power systems on all islands, with the primarily focus on the Island of Oʻahu where the effects of the blackout were greatest.

7.5.1.7 Hawaiian Electric Company (City and County of Honolulu)

In response to the 2006 shutdown following the Kīholo Bay and Māhukona earthquakes, an independent investigation by POWER Engineers, Inc.[28] had the following findings:

- The HECO system was in proper operating condition and appropriately staffed by personnel at the time that the earthquake struck. The unusually strong earthquake was the direct and proximate cause of the island-wide outage, setting in motion a series of events (through the operation of automatic relays and through operators' actions to protect the equipment) which resulted in loss of generation that eventually led to the system shutdown.

- In POWER's opinion, the HECO personnel reacted to the circumstances in a reasonable, responsible and professional manner. They applied training and experience in reacting properly to the changing system conditions based on the existing system configuration and established HECO operating practices to attempt to prevent the island-wide outage and to restore power as quickly as practical.

- In particular, after the complete shutdown of the system, a critical and prudent decision was made to simultaneously back start units at the Kahe Point and Waiau power plants in parallel, which allowed the restoration to proceed as expeditiously as possible without the

[28] Hawaiian Electric Company (HECO), 2006

setbacks that would have resulted from delays that were in fact encountered at the Kahe Point plant.

- In the restoration, HECO operated reasonably and in the public interest by following a systematic, orderly and methodical approach to add customer load to the system, allowing adequate time to inspect the system for earthquake damage, stabilize the operation of the generating units, and stabilize frequency and voltage on the grid.

HECO has repeatedly stated that it needs more capacity and an additional transmission line to meet energy demands, and it has submitted an application to the Public Utilities Commission (PUC) to build a new 110-megawatt bio-diesel generating unit. The new plant was approved by the PUC in May 2007 and construction of the plan was completed in summer 2009 as planned although contracts for supplying the fuel are still being negotiated after the PUC turned down the proposed supplier. Until capacity is increased, it appears that O‘ahu could remain vulnerable to an island-wide blackout under similar circumstances in the future. HECO has 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.

7.5.2 Future Mitigation Efforts

A summary of future mitigation projects are listed and in Table 7.7.

Table 7.7 Future Earthquake Mitigation Efforts

Project	Description
Update the HAZUS MH model to incorporate detailed data on State and County Bridges Current loss models reflect default data that is incomplete and not up to date with present status	Compile detailed data on bridges in Hawai‘i County and Maui County; Update the HAZUS MH model and develop more accurate bridge damage estimates for earthquake scenarios; Formulate priority rankings of higher vulnerability bridges not yet retrofitted
Adopt 2012 IBC and related codes per HRS 107 Part II	
Testing of the Seismic and Wind Performance of Single Wall Construction	
Incentives for homeowners and businesses to retrofit their structures	

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

Appendix 7A

HAZUS Scenario Reports for M6.7 Kiholo Bay and M7.7 Kalapana Earthquakes

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Hazus-MH: Earthquake Event Report

Region Name: hazus cb

Earthquake Scenario: kilholocensusblock

Print Date: January 17, 2013

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

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General Description of the Region

Hazus is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 3 county(ies) from the following state(s):

Hawaii

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 5,198.55 square miles and contains 9,872 census tracts. There are over 96 thousand households in the region which has a total population of 276,918 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 108 thousand buildings in the region with a total building replacement value (excluding contents) of 56,136 (millions of dollars). Approximately 93.00 % of the buildings (and 77.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 7,513 and 2,013 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 108 thousand buildings in the region which have an aggregate total replacement value of 56,136 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 69% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

Hazus breaks critical facilities into two (2) groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 10 hospitals in the region with a total bed capacity of 852 beds. There are 49 schools, 56 fire stations, 14 police stations and 2 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 58 dams identified within the region. Of these, 25 of the dams are classified as 'high hazard'. The inventory also includes 19 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 9,526.00 (millions of dollars). This inventory includes over 2,128 kilometers of highways, 403 bridges, 43,669 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	403	214.90
	Segments	248	7,254.60
	Tunnels	0	0.00
		Subtotal	**7,469.50**
Railways	Bridges	0	0.00
	Facilities	6	15.70
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**15.70**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	0	0.00
		Subtotal	**0.00**
Ferry	Facilities	2	0.00
		Subtotal	**0.00**
Port	Facilities	13	28.30
		Subtotal	**28.30**
Airport	Facilities	10	0.00
	Runways	13	0.00
		Subtotal	**0.00**
		Total	**7,513.60**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	291.10
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**291.10**
Waste Water	Distribution Lines	NA	291.10
	Facilities	2	159.80
	Pipelines	0	0.00
		Subtotal	**451.00**
Natural Gas	Distribution Lines	NA	291.10
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**291.10**
Oil Systems	Facilities	1	0.10
	Pipelines	0	0.00
		Subtotal	**0.10**
Electrical Power	Facilities	14	1,848.00
		Subtotal	**1,848.00**
Communication	Facilities	48	5.80
		Subtotal	**5.80**
		Total	**2,887.10**

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	kilholocensusblock
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	6.70
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

Hazus estimates that about 708 buildings will be at least moderately damaged. This is over 1.00 % of the buildings in the region. There are an estimated 0 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	122	0.12	8	0.11	1	0.18	0	0.33	0	0.00
Commercial	3,369	3.37	235	3.05	38	5.53	1	8.00	0	3.01
Education	564	0.56	24	0.31	4	0.51	0	0.68	0	0.00
Government	646	0.65	75	0.97	34	4.90	2	15.68	0	3.99
Industrial	1,622	1.62	205	2.66	89	12.78	6	35.83	0	66.71
Other Residential	20,528	20.52	3,028	39.24	320	46.22	4	23.39	0	6.10
Religion	221	0.22	15	0.19	2	0.26	0	0.22	0	0.00
Single Family	72,953	72.93	4,126	53.47	205	29.62	2	15.86	0	20.18
Total	**100,026**		**7,717**		**693**		**16**		**0**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	70,543	70.52	4329	56.10	171	24.65	1	3.27	0	0.00
Steel	1,865	1.86	264	3.42	114	16.42	6	38.80	0	40.69
Concrete	411	0.41	32	0.41	6	0.85	0	0.80	0	1.76
Precast	88	0.09	4	0.06	2	0.29	0	0.85	0	1.12
RM	9,576	9.57	234	3.03	91	13.06	5	32.38	0	3.53
URM	1,126	1.13	98	1.27	17	2.51	1	6.03	0	52.90
MH	16,417	16.41	2756	35.71	293	42.22	3	17.88	0	0.00
Total	**100,026**		**7,717**		**693**		**16**		**0**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 852 hospital beds available for use. On the day of the earthquake, the model estimates that only 780 hospital beds (92.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 99.00% of the beds will be back in service. By 30 days, 100.00% will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	10	0	0	10
Schools	49	0	0	49
EOCs	2	0	0	2
PoliceStations	14	0	0	14
FireStations	56	0	0	56

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	248	0	0	248	248
	Bridges	403	0	0	403	403
	Tunnels	0	0	0	0	0
Railways	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	6	0	0	6	6
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	2	0	0	2	2
Port	Facilities	13	0	0	13	13
Airport	Facilities	10	1	0	9	10
	Runways	13	0	0	13	13

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	2	0	0	2	2
Natural Gas	0	0	0	0	0
Oil Systems	1	0	0	1	1
Electrical Power	14	2	0	11	14
Communication	48	0	0	48	48

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	14,556	427	107
Waste Water	14,556	358	89
Natural Gas	14,556	184	46
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	96,607	53	0	0	0	0
Electric Power		1,720	1,138	524	116	2

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0.03 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 53.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 1,120 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 1 households to be displaced due to the earthquake. Of these, 0 people (out of a total population of 276,918) will seek temporary shelter in public shelters.

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	6	0	0	0
	Single Family	5	0	0	0
	Total	**12**	**0**	**0**	**0**
2 PM	Commercial	3	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	1	0	0	0
	Single Family	1	0	0	0
	Total	**6**	**0**	**0**	**0**
5 PM	Commercial	2	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	2	0	0	0
	Single Family	2	0	0	0
	Total	**7**	**0**	**0**	**0**

Economic Loss

The total economic loss estimated for the earthquake is 498.39 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 359.17 (millions of dollars); 5 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 69 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	1.55	1.24	0.18	1.03	4.00
	Capital-Related	0.00	0.68	1.12	0.11	0.07	1.98
	Rental	0.39	4.27	0.94	0.27	0.58	6.45
	Relocation	0.95	1.12	0.85	1.52	1.76	6.19
	Subtotal	**1.34**	**7.61**	**4.14**	**2.08**	**3.44**	**18.61**
Capital Stock Losses							
	Structural	9.88	8.90	2.47	4.49	2.59	28.32
	Non_Structural	104.72	89.87	26.90	18.48	18.39	258.36
	Content	15.30	10.13	11.21	5.74	10.65	53.03
	Inventory	0.00	0.00	0.27	0.56	0.02	0.85
	Subtotal	**129.90**	**108.90**	**40.85**	**29.26**	**31.64**	**340.56**
	Total	**131.24**	**116.51**	**44.99**	**31.35**	**35.08**	**359.17**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Hazus estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	7,254.61	$0.00	0.00
	Bridges	214.92	$0.63	0.29
	Tunnels	0.00	$0.00	0.00
	Subtotal	**7469.50**	**0.60**	
Railways	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	15.70	$0.98	6.25
	Subtotal	**15.70**	**1.00**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	28.34	$2.40	8.45
	Subtotal	**28.30**	**2.40**	
Airport	Facilities	0.00	$0.00	0.00
	Runways	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
	Total	**7513.60**	**4.00**	

Table 13: Utility System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Lines	291.10	$1.92	0.66
	Subtotal	**291.13**	**$1.92**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	159.80	$1.43	0.89
	Distribution Lines	291.10	$1.61	0.55
	Subtotal	**450.97**	**$3.04**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Lines	291.10	$0.83	0.28
	Subtotal	**291.13**	**$0.83**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.10	$0.00	0.92
	Subtotal	**0.12**	**$0.00**	
Electrical Power	Facilities	1,848.00	$129.25	6.99
	Subtotal	**1,848.00**	**$129.25**	
Communication	Facilities	5.80	$0.18	3.07
	Subtotal	**5.76**	**$0.18**	
	Total	**2,887.10**	**$135.21**	

Table 14. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

LOSS		Total	%

Appendix A: County Listing for the Region

Hawaii,HI

Kalawao,HI

Maui,HI

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Hawaii					
	Hawaii	148,677	22,921	6,876	29,797
	Kalawao	147	20	2	23
	Maui	128,094	20,079	6,235	26,315
Total State		**276,918**	**43,020**	**13,113**	**56,135**
Total Region		**276,918**	**43,020**	**13,113**	**56,135**

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Hazus-MH: Earthquake Event Report

Region Name: studyregioncb

Earthquake Scenario: HHA Kalapana M7.7

Print Date: April 29, 2013

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

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General Description of the Region

Hazus is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 3 county(ies) from the following state(s):

Hawaii

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 5,198.55 square miles and contains 9,872 census tracts. There are over 96 thousand households in the region which has a total population of 276,918 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 108 thousand buildings in the region with a total building replacement value (excluding contents) of 56,136 (millions of dollars). Approximately 93.00 % of the buildings (and 77.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 7,513 and 2,013 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 108 thousand buildings in the region which have an aggregate total replacement value of 56,136 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 69% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

Hazus breaks critical facilities into two (2) groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 10 hospitals in the region with a total bed capacity of 852 beds. There are 172 schools, 56 fire stations, 14 police stations and 2 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 58 dams identified within the region. Of these, 25 of the dams are classified as 'high hazard'. The inventory also includes 19 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 9,526.00 (millions of dollars). This inventory includes over 2,128 kilometers of highways, 403 bridges, 43,669 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	403	214.90
	Segments	248	7,254.60
	Tunnels	0	0.00
		Subtotal	**7,469.50**
Railways	Bridges	0	0.00
	Facilities	6	15.70
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**15.70**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	0	0.00
		Subtotal	**0.00**
Ferry	Facilities	2	0.00
		Subtotal	**0.00**
Port	Facilities	13	28.30
		Subtotal	**28.30**
Airport	Facilities	10	0.00
	Runways	13	0.00
		Subtotal	**0.00**
		Total	**7,513.60**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	291.10
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**291.10**
Waste Water	Distribution Lines	NA	291.10
	Facilities	2	159.80
	Pipelines	0	0.00
		Subtotal	**451.00**
Natural Gas	Distribution Lines	NA	291.10
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**291.10**
Oil Systems	Facilities	1	0.10
	Pipelines	0	0.00
		Subtotal	**0.10**
Electrical Power	Facilities	14	1,848.00
		Subtotal	**1,848.00**
Communication	Facilities	48	5.80
		Subtotal	**5.80**
		Total	**2,887.10**

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	HHA Kalapana M7.7
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	7.70
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

Hazus estimates that about 1,898 buildings will be at least moderately damaged. This is over 2.00 % of the buildings in the region. There are an estimated 5 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	112	0.11	12	0.17	6	0.36	1	0.57	0	0.29
Commercial	3,361	3.38	189	2.66	83	4.82	11	6.87	0	5.56
Education	525	0.53	47	0.67	18	1.03	2	1.25	0	0.79
Government	636	0.64	61	0.86	52	2.98	9	5.42	0	4.08
Industrial	1,552	1.56	159	2.24	160	9.24	49	30.22	2	44.74
Other Residential	19,144	19.25	3,549	50.10	1,117	64.48	69	42.77	2	31.40
Religion	215	0.22	17	0.24	6	0.33	0	0.17	0	0.06
Single Family	73,925	74.32	3,050	43.06	290	16.76	21	12.73	1	13.07
Total	**99,469**		**7,084**		**1,732**		**161**		**5**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	71,633	72.02	3162	44.64	243	14.03	5	3.05	0	2.21
Steel	1,802	1.81	184	2.60	202	11.67	58	35.86	3	50.56
Concrete	414	0.42	23	0.32	11	0.65	1	0.62	0	0.35
Precast	90	0.09	3	0.04	2	0.13	0	0.22	0	0.07
RM	9,477	9.53	215	3.03	182	10.50	31	19.28	1	18.29
URM	1,223	1.23	18	0.25	2	0.12	0	0.05	0	0.03
MH	14,831	14.91	3480	49.13	1,089	62.90	66	40.92	1	28.48
Total	**99,469**		**7,084**		**1,732**		**161**		**5**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 852 hospital beds available for use. On the day of the earthquake, the model estimates that only 767 hospital beds (90.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 95.00% of the beds will be back in service. By 30 days, 99.00% will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	10	1	0	9
Schools	172	4	0	151
EOCs	2	0	0	2
PoliceStations	14	0	0	14
FireStations	56	2	0	46

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	248	0	0	248	248
	Bridges	403	0	0	403	403
	Tunnels	0	0	0	0	0
Railways	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	6	0	0	6	6
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	2	0	0	2	2
Port	Facilities	13	0	0	13	13
Airport	Facilities	10	0	0	10	10
	Runways	13	0	0	13	13

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	2	0	0	2	2
Natural Gas	0	0	0	0	0
Oil Systems	1	0	0	1	1
Electrical Power	14	0	0	13	14
Communication	48	0	0	48	48

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	14,556	1073	268
Waste Water	14,556	898	225
Natural Gas	14,556	462	115
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	96,607	2,206	1,162	90	0	0
Electric Power		38	21	7	1	0

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0.05 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 39.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 1,920 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 12 households to be displaced due to the earthquake. Of these, 7 people (out of a total population of 276,918) will seek temporary shelter in public shelters.

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	12	1	0	0
	Single Family	6	0	0	0
	Total	**18**	**1**	**0**	**0**
2 PM	Commercial	7	1	0	0
	Commuting	0	0	0	0
	Educational	1	0	0	0
	Hotels	0	0	0	0
	Industrial	2	0	0	0
	Other-Residential	3	0	0	0
	Single Family	1	0	0	0
	Total	**14**	**1**	**0**	**0**
5 PM	Commercial	5	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	1	0	0	0
	Other-Residential	4	0	0	0
	Single Family	2	0	0	0
	Total	**12**	**1**	**0**	**0**

Economic Loss

The total economic loss estimated for the earthquake is 347.18 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 285.27 (millions of dollars); 10 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 58 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	0.98	2.80	0.46	2.10	6.34
	Capital-Related	0.00	0.42	2.56	0.28	0.26	3.53
	Rental	0.37	2.22	1.68	0.54	1.30	6.11
	Relocation	1.14	2.15	2.16	3.03	5.43	13.91
	Subtotal	**1.51**	**5.77**	**9.21**	**4.31**	**9.09**	**29.90**
Capital Stock Losses							
	Structural	7.06	11.30	4.11	9.76	8.07	40.31
	Non_Structural	59.76	66.98	15.51	15.63	24.00	181.88
	Content	7.84	5.48	5.00	4.16	10.14	32.63
	Inventory	0.00	0.00	0.12	0.42	0.02	0.56
	Subtotal	**74.66**	**83.76**	**24.75**	**29.97**	**42.23**	**255.38**
	Total	**76.17**	**89.53**	**33.96**	**34.28**	**51.32**	**285.27**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Hazus estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	7,254.61	$0.00	0.00
	Bridges	214.92	$0.14	0.07
	Tunnels	0.00	$0.00	0.00
	Subtotal	**7469.50**	**0.10**	
Railways	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	15.70	$0.90	5.73
	Subtotal	**15.70**	**0.90**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	28.34	$1.61	5.68
	Subtotal	**28.30**	**1.60**	
Airport	Facilities	0.00	$0.00	0.00
	Runways	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
	Total	**7513.60**	**2.70**	

Table 13: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Lines	291.10	$4.83	1.66
	Subtotal	**291.13**	**$4.83**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	159.80	$4.15	2.60
	Distribution Lines	291.10	$4.04	1.39
	Subtotal	**450.97**	**$8.19**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Lines	291.10	$2.08	0.71
	Subtotal	**291.13**	**$2.08**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.10	$0.00	0.33
	Subtotal	**0.12**	**$0.00**	
Electrical Power	Facilities	1,848.00	$44.01	2.38
	Subtotal	**1,848.00**	**$44.01**	
Communication	Facilities	5.80	$0.14	2.48
	Subtotal	**5.76**	**$0.14**	
	Total	**2,887.10**	**$59.25**	

Table 14. Indirect Economic Impact with outside aid

(Employment as # of people and Income in millions of $)

LOSS	Total	%

Appendix A: County Listing for the Region

Hawaii,HI

Kalawao,HI

Maui,HI

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Hawaii					
	Hawaii	148,677	22,921	6,876	29,797
	Kalawao	147	20	2	23
	Maui	128,094	20,079	6,235	26,315
Total State		**276,918**	**43,020**	**13,113**	**56,135**
Total Region		**276,918**	**43,020**	**13,113**	**56,135**

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

8. Landslides and Rock Falls

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CHAPTER 8
Landslides and Rock Falls

Description of Updates / Revisions in the 2013 Plan
This chapter is significantly modernized. Hawai‘i 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 downhill slopes and channels. They generally occur during or immediately after severe rainfall of more than 3 inches in a peak 6-hour period. • A new rainfall intensity map is added since high intensity rainfall is the main source of landslide and rockfall initiation. • More data on historic debris flows has been added • The rockfalls and landslides caused by the 2006 Kīholo Bay earthquake are shown as examples of seismically induced landslides. • In 2013, the City and County of Honolulu completed a rock fall hazard study of city roadways. • The State identified a number of highway sites that have a high risk of rockfall or landslide, many of which have been mitigated. There have recently been a number of other mitigation measures funded by various organizations. A significant amount of such rockfall mitigation has been accomplished.

Summary of Mitigation Projects for the State of Hawai‘i	
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.	Medium
Incorporate all-hazard assessments in land development application process	Medium
Mitigation by creation of buffer zones as an alternative or augmentative to fencing and mesh construction to retain rockfalls.	Medium

8.1 Landslides and Rock Falls Hazard Description

8.1.1 General

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 slurry that flow down-slope. These flows generally occur during periods of intense rainfall.

8.1.2 Types of Landslides, Debris Flows, and Rockfalls

Landslides, debris flows, and rockfalls can be categorized according to the mechanics through which the phenomenon initiates as either flows, topples, slumps, slides, creeps, and falls. Figure 8.1 illustrates the mechanisms of landslides, debris flows, and rockfalls in graphical form.

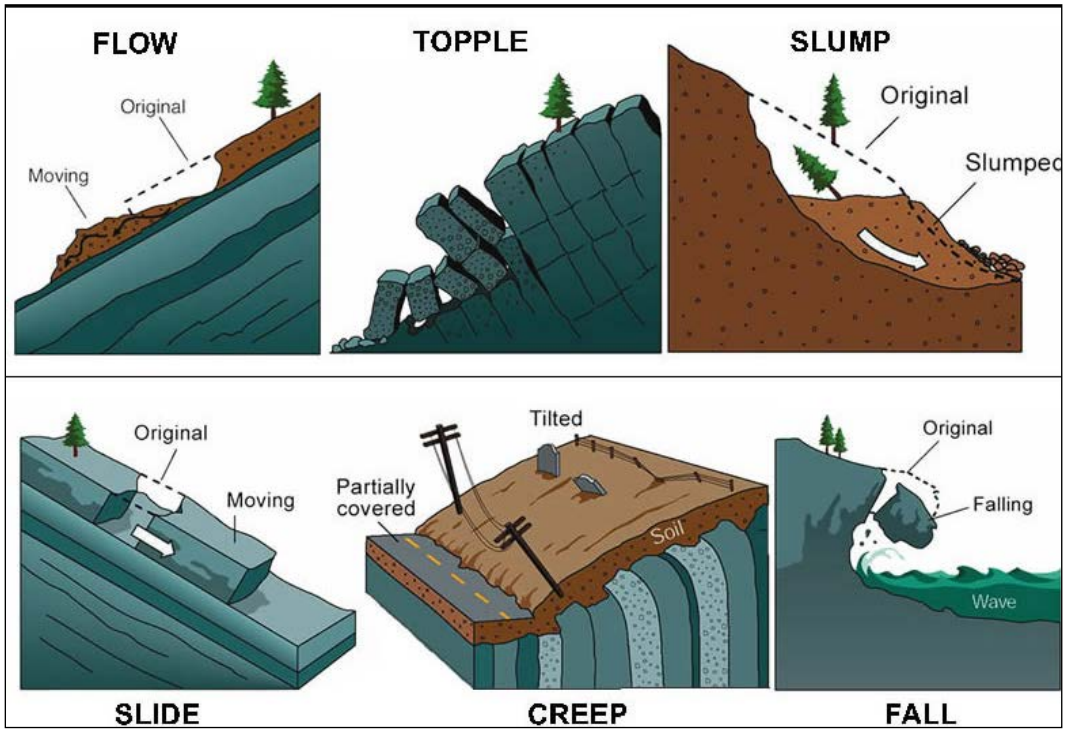

Figure 8.1 Types of Landslides[1]

The consistency of debris flow 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

[1] Image from Australian Government Geoscience Australia Website, Retrieved October 13, 2009 from http://www.ga.gov.au/hazards/landslide/causes.jsp

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 the pathway. 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, debris flows can travel even over gently sloping ground. The most hazardous areas are valley bottoms, stream channels, areas near the outlets of valleys, and slopes excavated for buildings and roads.

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.

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
- Ancillary structures (e.g. decks) tilt or move relative to the house
- Concrete floors or foundations tilt or crack
- Water lines and other underground utilities break
- Telephone poles, trees, retaining walls, or fences tilt
- Roadbeds sink, or drop down

Areas that may be considered prone to landslides may include the following:

- On existing old landslides
- On or at the base of slopes
- In or at the base of minor drainage hollows
- At the base or top of an old fill slope
- At the base or top of a steep cut slope

8.1.3 Steep Slopes and Unstable Soils

Urban development on steep slopes or unstable soils could result in adverse visual impacts or hazardous conditions. Most of the vacant lands in the State Urban District with these characteristics are located in valley and hillside neighborhoods. Where hillside locations have stable soil material, the primary impact is aesthetic, since structures built along the slopes are tend to be visually prominent and can interrupt the silhouette of the natural ridgeline when viewed from below. Building on the lower slopes of valley walls can also have a visual impact. Where these valley locations have deposits of unstable soils, slow-moving landslides can cause property damage, prompting claims against the City and County of Honolulu - as has happened in Mānoa 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. This problem is exacerbated in the

interior reaches of the valleys and hillsides, where rainfall is higher. Over the long term, the cumulative impact of greater lot coverage threatens to erode natural stream banks downstream - requiring expensive, aesthetically and ecologically undesirable structural hardening of the drainage channel - or even to exceed the capacity of the drainage system, resulting in flood conditions.

To prevent inappropriate development, hillside lands should be placed in preservation or low-density residential zoning districts. Such lands should also be subject to stricter development standards - such as maximum lot coverage and structural stability - than those that apply to level land.

Where hillsides and drainage channels have already been adversely affected by inappropriate development, remediation should be pursued by removing or repairing damaged or threatened structures on unstable slopes and selectively modifying drainage channels to introduce more natural elements, such as streamside trees, rip-rap lining and notched or unlined channel bottoms.

8.1.4 Weathering Processes and Rock Alteration

Several natural mechanisms contribute to the alteration and breakdown of rock along Hawai‘i 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. Clinker zones typically making up the margins of flows are more fragmented than the massive cores, causing void spaces and zones of weakness prone to physical weathering. Thermal contraction of rock during cooling of lava flows typically causes fracturing of rock. Dike margins also represent potential zones of weakness.

Rockfall may be initiated through a combination of weathering, fracture, and steep slope. Physical and chemical weathering between rock formation boundaries may be aided by withdrawal of support underlying lava flows. Larger lava tubes may collapse, rendering the surrounding rock unstable and prone to more physical weathering. Wave action occurring during higher sea levels over geologic time may rapidly increase the rate of physical weathering and undermining by removal of loose rock or clinker zones and enlargement of lava tubes and pre-existing fractures. Because of withdrawal of underlying support, stresses on vertical joints and fractures may increase over time, enlarging the fracture/joint spaces, and concurrently increasing the surface area available for chemical weathering.

8.2 Significant Historical Events

8.2.1 County of Kaua‘i

Soil avalanches or landslides taking place on the western side or even northern side of the island of Kaua‘i. Soil avalanches may leave bright scars on the hillside for months. A good example is a slide that occurred in Olokele Canyon in October 1981. The slide face was about 300 meters wide and about 800 meters high (about a thousand feet wide by 2,400 feet high) – a slide of tremendous proportions. This particular slide was caused by a combination of high rainfall and underground water seepage. Features and processes like this are responsible for much of the valley development, cliff faces, and other geologic features in the Hawaiian archipelago.

Landslides in the island of Kaua‘i have also been seen frequently near road cuts. The State of Hawai‘i Department of Transportation mitigates landslides near roadways by erecting a metal mesh covering around the edge of the cliff. The purpose of these meshes is to prevent rocks and other debris from sliding out onto the highway. High-risk areas in the island of Kaua‘i include portions of Kaumuali‘i Highway (State Highway 50) near Kalāheo and Lawa‘i, portions of Kūhiō Highway (State Highway 56) near Anahola and Lumahai, and portions of Kuamoo Road (State Highway 580) near Kapa‘a. The significant historical landslides have occurred along the highway and coastal roads.

8.2.2 City and County of Honolulu

The island of O‘ahu contains 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 downhill slopes and channels. The United States Geological survey (USGS) has performed a number of studies of historical debris flows affecting the island of O‘ahu, particularly in the major populated residential areas of Honolulu. Information sources for the historical accounts were provided by the City & County of Honolulu Department of Emergency Management (formerly O‘ahu Civil Defense Agency), local government storm publications, and the Honolulu’s two daily newspapers.

More than 1,779 landslides and resulting debris flows have been recognized in aerial photographs of the Honolulu District taken during a period of approximately 50 years (USGS Open-File Report 93-514). Most of these debris flows caused relatively little direct property damage because they occurred in undeveloped or relatively inaccessible upland areas. However, some of the areas affected by past debris flows have since been developed, and if development continues in these upland areas, the impacts from debris flows in future storms could become even more frequent and costly. 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 and rock falls.

The hazards of debris flows in the Honolulu District were exhibited during the New Year's Eve storm of 1987-1988. Most of the damage occurred in the eastern part of the Honolulu District. Debris flows directly impacted several homes in Kuliʻouʻou and Hahaʻione valleys. Debris from a number of landslides clogged a drainage structure, and caused severe flooding in Hahaʻione Valley. The storm also triggered a large landslide high in the Kūpaua valley that sent tons of mud, rock, and other debris downstream into lower Niu Valley, obstructing drainage channels and flooding a number of homes and a shopping center. Fortunately, no lives were lost, and the damage to private property was light, in view of the severity of the storm and the hundreds of debris flows it produced. Total damage from the storm nevertheless, sufficient to warrant a federal disaster declaration.

- May 9, 1999 - a landslide killed seven hikers and injured many more at Sacred Falls State Park, near Hauʻula on the north shore of the island. One of the injured hikers later died of injuries received in the landslide. The governor of Hawaiʻi at the time, Ben Cayetano, closed the park due to concern about continuing landslide hazard near the falls.

- March, 2000 - notable rockfalls include a Waimea Bay rockslide 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.

- August 9, 2002 – Dara Rei Onishi, 26 was killed when a 5-ton boulder hit her family's Nuʻuanu home as she slept. This was the worst of two incidents on Henry Street.

- October 15, 2002 - rockslide at Makapuʻu Point closed a lane of highway 72, affecting 10,200 vehicles a day for several months.

- November 28, 2002 - on Thanksgiving Day, a rockslide brought down two boulders from a hillside above the Lalea condominium in Hawaiʻi Kai that slammed into parked cars, prompting the evacuation of 26 families for 11 months.

- February 14, 2003 - a 4-by-3-foot boulder rumbled down a hillside in Waiʻalae Nui and came to rest 20 feet from a house.

- May 11, 2004 – Thi Vo Hamakado of Henry Street was saved when she jumped out of the path of a 1-1/2-ton boulder that barreled out of the tree line behind her Nuʻuanu Valley home.

- April 17, 2006 – The state shut down Kamehameha Highway near Waimea Bay after a slide of rocks and debris, chain-link fencing and netting the state installed after the 2000 slide was in place, but the new slide occurred at an unprotected area.

- August 24, 2007 – A U.S. Army Corps of Engineers project removed five large boulders perched above homes on Ala Mahina Street in Moanalua Valley, at a cost of $309,000.

- November 4, 2007 – A fall rainstorm led to two separate incidents of 4-foot boulders striking homes, one in Pālolo Valley and one in Hao Street in upper ʻĀina Haina.

- January 7, 2009 – A rock 28 inches across slammed into the back of a Kahawalu Drive home in Nuʻuanu.

- January 22, 2010 – Tow large boulders rumbled down a hillside in Kalihi Valley and crashed through a chain-link fence above an apartment complex, hit a wall and came to rest on a patio. Nine families were temporarily displaced.

- April 11, 2012 – Five boulders fell from a steep hillside and caused substantial damage of two homes on Kula Kolea Place, Kalihi Valley. The state appropriated funds to remove remaining boulders from private property above the homes.

Debris flows triggered by the New Year's Eve storm were not a unique occurrence in the history of Honolulu. The most recent disaster involving debris flow on the island of Oʻahu occurred in 2006 when a sustained period of heavy rain from February through April caused a number of instances of flooding and mudslides on Oʻahu and Kauaʻi. On Oʻahu 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 Puʻuhonua Street and flooding in Mānoa. Kahala Mall was also flooded causing closure of many of the stores and theaters for up to 9 months.

8.2.3 County of Maui

8.2.3.1 Island of Maui

The island of Maui has a recurrent history of landslides, debris flows, and rockfalls. Most of these types of events have occurred along coastal highways were the road is right up against mountain slopes. The following is a brief discussion of these noteworthy events.

On September 14, 2004, a female ranger at Haleakalā National Park was fatally injured while trying to clear a rockslide on Piʻilani Highway (State Highway 31) near Kīpahulu. The ranger was on duty when she was hit by a falling rock from the nearby hillside while removing rocks on the narrow road.[2]

On the first week of December of 2007, a strong Kona storm hit the Island of Maui causing runoff induced debris flows across several roads and highways. In the Kīhei area, runoff from gathering from the slopes of Haleakalā volcano pushed boulders and debris onto Piʻilani Highway (State Highway 31) forcing temporary closure of the road. Similarly, the storm's runoff carried debris across portions of Honoapiʻilani Highway (State Highway 30) near Nāpili in East Maui. The storm also generated debris flows in the Kula region of upcountry Maui. For instance, mud, rocks, and loosen vegetation were carried across Lower Kula Road. More noteworthy is the case of a debris flow across Polipoli Road also in the Kula region. In this case, debris including remains of a private residence, forced the closure of the road for several days until county crews removed all the leftovers from the debris flow.

[2] The Honolulu Star Bulletin, Retrieved December 10, 2009 from http://www.encyclopedia.com/doc/1P3-1184742991.html

On March 21, 2009, a mudslide on northeast Maui forced the closure of the Hāna Highway (State Highway 360).[3] The incident occurred at 9:30 a.m. near mile-post 21, approximately two miles on the Keʻanae side of Puaʻa Kaʻa State Wayside Park. State and County public works crew cleared the mud and debris using heavy equipment. The highway reopened five hours after the mudslide. The County said the area had not been identified as a potential slide-problem area, but that wet weather in the few weeks before the incident may have saturated the soil resulting in the slide.[4]

On April 23, 2009, another landslide occurred at the same location of the Hāna Highway following an episode of intense rainfall. The landslide occurred at 10:00 p.m. and forced the closure of the highway in both directions between mile-post 19 near the Wailua lookout and mile-post 21.[5] The cleanup work on both lanes had to be postponed until the morning of the 24th due to unsafe conditions resulting from nighttime wet weather. After the partial removal of rocks and debris on the morning of the 24th, the highway reopened intermittently for a few days until cleanup work was completed.

Also on April 23, 2009, a rockfall occurred on Kahekili Highway (State Highway 340) at around 5:00 p.m. The rockfall resulted in large boulders blocking the highway near Waihale Gulch resulting in the closure of the road near mile-post 15. Debris removal began the morning of the 24th and extended well into the afternoon.

8.2.3.2 Islands of Molokaʻi and Lānaʻi

In 1871, the Lānaʻi Earthquake had a magnitude of 7 or greater. Massive rockfalls and cliff collapse occurred on Lānaʻi as a result of the event. Houses and churches were flattened on the island of Maui and Molokaʻi and land slippage was reported in Waianae and Lahaina. The 1938 Maui Earthquake was assigned a magnitude of 6.7-6.9 with an epicenter located only 6 miles north of the island of Maui. Landslides forced the closure of the road to Hāna, and long sections of the highway collapsed into the sea.

On November 5, 2007, heavy rains resulted in rockfalls and debris flows along different portions of Kamehameha V Highway (State Highway 450) on the east side of the island of Molokaʻi. In the case of the island of Lānaʻi, there are no available records of any historic landslides, debris flows, or rockfalls.

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[3] Maui Now Website, Retrieved December 10, 2009 from http://Mauinow.com/2009/03/23/mudslide-forces-five-hour-closure-of-hana-highway/

[4] KITV Website, Retrieved December 10, 2009 from http://www.kitv.com/news/18986112/detail.html

[5] Maui Now Website, Retrieved December 10, 2009 from http://Mauinow.com/2009/04/24/section-of-hana-highway-closed-due-to-large-mudslide/

8.2.4 County of Hawai‘i

Several areas along the Hāmākua Coast on the island of Hawai‘i are chronic problem areas for landslides particularly during periods of heavy rainfall. In addition to the landslide hazard in this region, the three major gulches of Maulua, Laupāhoehoe and Ka‘awali‘i, which are known for the “horseshoe” turns on Mamalahoa Highway (State Highway 19), present rockfall problems. The rock fall problems arise during times of heavy rain as well as strong winds which sway the trees along the walls of the gulch back and forth and loosen the dirt and rocks underneath it.

The largest Hawaiian earthquake in recorded history occurred in 1868 beneath the Ka‘ū district on the southeast flank of Mauna Loa. The earthquake caused a mudflow that killed 31 people. The second most destructive earthquake in Hawai‘i occurred on Kīlauea's south flank in Kalapana, November 29, 1975. The earthquake caused 11 feet of the Kalapana coast to subside, triggering a tsunami. Damage can be reduced by land-use zoning that restricts building on or near steep slopes that can fail during an earthquake and in areas underlain by materials that are likely to amplify the ground motion of a strong earthquake.

8.2.5 All Counties

8.2.5.1 Landslides and Rockfalls Due to Seismic Activity

In addition to destabilization of rockfall and landslide locations due to rain, the destabilization can be caused by seismic activity. Earthquake induced landslides and rockfalls occurred in a number of locations on the islands of Hawai‘i and Maui during the 2006 Kīholo Bay and Māhukona Earthquakes. For example at Mamalahoa Highway (State Highway 19) a bridge failed due to the collapse of a retaining wall[6].

In the island of Hawai‘i, for example, a bridge on Mamalahoa Highway (State Highway 19) in the Hāmākua region of the island failed due to the collapse of a retaining wall[7]. Landslides of large coastal escarpment were also observed on the Hāmākua coastline. The sea cliffs along the coast northeast of Mauna Kea range in height from 50 to 350 feet. These cliffs are eroded through a continuous process of wave action at the base of the cliff which cuts a notch and undermines the higher section of the cliff which eventually collapses and drops off. A photograph taken following a landslide along the Hāmākua coastline caused by the Kīholo Bay earthquake is shown in Figure 8.2.

Numerous other landslides and rockfalls occurred at roadway cuts, embankments and natural slopes along the Hāmākua coast. Due to the lack of redundancy in the road network on the Island of Hawai‘i, the closure of roads significantly hampered emergency response. All roadways were able to be reopened to at least one lane of traffic within 2 days of the earthquake.

The Kīholo Bay and Māhukona Earthquakes also resulted in several landslides and rockfalls at various locations on the island of Maui (peak ground accelerations of just 10 to 17% g were

[6] Earthquake Engineering Research Institute (EERI), Structural Engineering Association of Hawai‘i (SEAOH), and University of Hawai‘i (UH), 2005

[7] Ibid

experienced on this island). During these earthquakes, several major landslides and rockfalls occurred on the East side of the island of Maui. To illustrate the magnitude of some of these landslides, Figure 8.3 shows a photograph of an in-progress massive landslide immediately south of Kālepa on the southeastern coast of the island.

In a Report titled *Compilation of Observations of the October 15, 2006 Kīholo Bay (Mw 6.7) and Māhukona (Mw 6.0) Earthquakes, Hawai'i*, by the Structural Engineers Association of Hawai'i (SEAOH), the Earthquake Engineering Research Institute (EERI), and the University of Hawai'i Mānoa, the rockfall incidents that occurred in the island of Maui are described as follows:

> *"Pi'ilani Highway [State Highway 31] along the southeastern coast of the island was closed near Manawainui. Rockfall debris at the Kālepa cliffs impacted the highway. About 500 Maui residents were cut-off between an incipient rockfall hazard of that road in the Manawainui area and a bridge closure due to abutment erosion at Pa'ihi. After and engineering evaluation and fast-track design, the installation of a temporary steel truss bridge was completed at the end of November. Sections of that highway along the coastline are inherently vulnerable to rockfalls and landslides. A few days after the opening of the temporary bridge, new rockfalls at Kālepa closed the highway again. The County of Maui is scaling loosened rocks and boulders from several vulnerable slopes. The discontinuous and often contorted inclusions of massive basalt are irregularly fractured."*[8]

There were other road closures on Pi'ilani Highway due to earthquake-induced rockfalls besides those near Manawainui. In the vicinity of Kaupō and Kīpahulu, for instance, a ten mile stretch of road was undermined and blocked to traffic due to another rockfall. The road was finally cleared and reopened in October 5, 2008[9] – taking nearly two years after the earthquakes to make the repairs.

Rockslides caused by the Kīholo Bay and Māhukona Earthquakes were not limited to the southeast coast of the east side of the island of Maui. At Mākena State Park, in the southwest coast of the east side of the island of Maui, at least 10 rockfalls occurred along the rocky coastal cliffs.[10] The rockfalls occurred at three of the major beaches in the park: Black Sand Beach, Big Beach, and Small Beach.

Previous seismic events have also resulted in instability of Hawai'i's steep slopes. Since many of the significant landslides and mudflows affect transportation systems, the State Highways Division is engaging in a Highways Modernization Project, estimated for six years. Several projects on each island will focus on the problems from landslides hazards. There are no additional pieces of information in characterizing the landslide hazard. A review of the transportation system on O'ahu indicates that many miles of highways and roadways pass through mountainous terrain, where steeply cut slopes are found adjacent to the roadways.

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[8] Structural Engineers Association of Hawai'i, Earthquake Engineering Research Institute and University of Hawai'i – Mānoa, *Compilation of Observations of the October 15, 2006 Kiholo Bay (Mw 6.7) and Mahukona (Mw 6.0) Earthquakes, Hawai'i*, December 31, 2006

[9] KGMB 9 Website, Retrieved October 8, 2009

[10] Earth Tech, Inc., *Rockfall Hazard Condition at Mākena State Park, Maui, Hawai'i*, Prepared for the State of Hawai'i Department of Land and Natural Resources Division of State Parks, October 30, 2006.

Figure 8.2 Massive Coastal Escarpment Landslide along the Hāmākua Coast, Island of Hawai‘i[11]

Figure 8.3 Massive Coastal Landslide on the Southeastern Coast of the Island of Maui [12]

[11] Photograph courtesy of Hawai‘i Civil Defense Agency

[12] Compilation of Observations of the October 15, 2006 Kīholo Bay (Mw 6.7) and Mākuhona (Mw 6.0) Earthquakes, Hawai‘i, Structural Engineers Association of Hawai‘i (SEAOH), Earthquake Engineering Institute (EERI), University of Hawai‘i Mānoa, December 32, 2006

8.3 Probability of Occurrence

Landslides and rock falls typically occur as a result of another hazard or force of nature, and due to the multitude of forces that may cause landslides and rock falls assigning or calculating the return period of events of a destructive magnitude would be extremely difficult. However, it is possible to determine areas that have a higher potential of risk for such events as was done in a study was conducted by URS. In this study a categorical slope risk map was prepared for the island of Hawai‘i, using an adaptation of the slope hazard methodology given in the Federal Emergency Management Agency (FEMA) 2007 HAZUS-MH MR3 Technical Manual. The approach involved the interactions of three primary slope hazard input criteria simplified to low, medium and high hazard susceptibility.

HAZUS-MH MR4 provides susceptibility categories combining slope angle, soil type and soil moisture with an assigned yield acceleration to each category. The combined susceptibility categories when mapped thus represent zones of potential landslide triggering under different levels of ground shaking. As an illustration, Figure 8.4 is a conglomerate of spatially assigned topography, geology, and soil moistures relationships with superimposed mapped historical landslides for the County of Hawai‘i.

8.3.1 Topography

A high resolution slope map of the entire island is composed of recent aerial, LIDAR and satellite 10m Digital Elevation Model (DEM) topographic survey data from United States Geological Survey (USGS) and FEMA sources. Slope criteria are categorized as:

1. <20degreees (low hazard susceptibility)
2. <20-40 degrees (medium hazard susceptibility)
3. >40 degrees (high hazard susceptibility)

8.3.2 Geologic Groups

Soil and rock categories assigned based upon strength and susceptibility to landslide was derived from existing United States Department of Agriculture (USDA) Natural Resources Conservation service (NRCS) surface maps and USGS geologic maps. Adapted geologic group assignments for the Island of Hawai‘i include:

1. shallow rock, fresh volcanics (low hazard susceptibility)
2. clay surficial soils, weathered rock (medium hazard susceptibility)
3. weak soft soils, ash deposits, mapped historic slide talus (high hazard susceptibility)

In addition, URS interpreted historic Hawai‘i Department of Transportation (DOT) landslide locations, as medium hazard for locations with preliminary Federal Highway Administration (FHWA) Rockfall Hazard Rating System (RHRS) of less than 200 and high hazard for locations with preliminary RHRS values greater than 200.

8.3.3 Soil Moisture

The HAZUS MH4 slope hazard methodology considers soil moisture as either wet or dry, with wet soils posing increased slope hazard. Soil moisture assignments are derived from recent NOAA rainfall mapping of the island since regional groundwater and soil moisture data is unavailable island wide. Areas receiving greater than 2000 mm annual precipitation are considered wet soil, corresponding largely to the windward side of the island. In addition, coastal areas below elevation 200' are considered wet due to potential groundwater seepage gradients from higher elevations, except in the arid Kona coast areas.

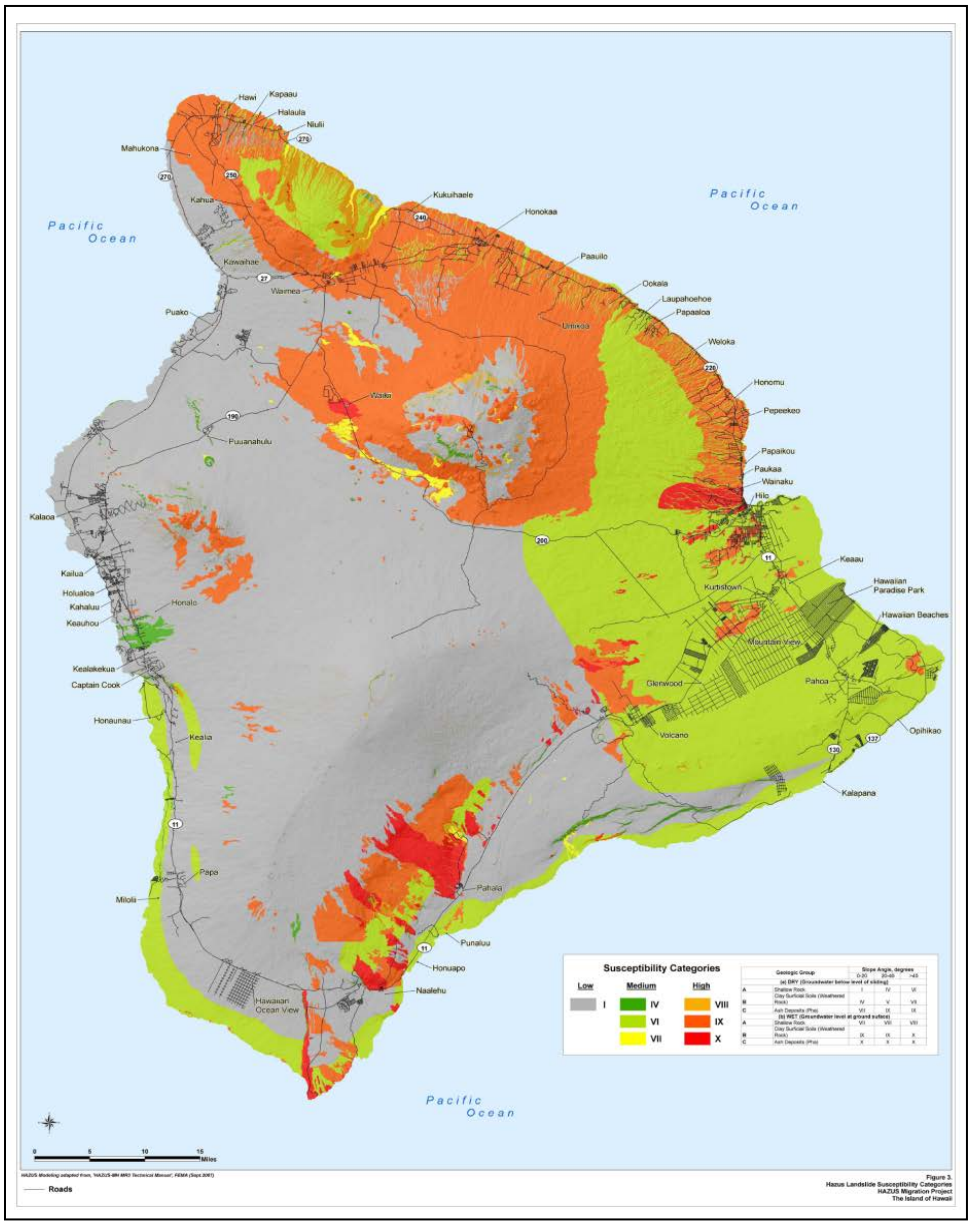

Figure 8.4 HAZUS-assigned Landslide Susceptibility Categories for the County of Hawai'i

8.4 Risk Assessment

8.4.1 State Highways

The State has identified 66 highway sites on O‘ahu that have a high risk of rockfall, or landslide, and acknowledged that fixing all the problems could take years. The purpose of the study prepared by the Earth Tech, Inc. project was to evaluate the existing condition of each potential rockfall site along seventy-nine state highways and roadways on O‘ahu, and to develop a systematic rockfall hazard management system for the State of Hawai‘i. The rockfall study for the Island of O‘ahu was designed and implemented based solely on the guidance presented in the Federal Highway Administration’s *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) reports.[13]

8.4.2 Preliminary Rockfall Rating

The preliminary rockfall rating is a subjective rating that groups the hazard conditions into three classes, as described below:

- 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.

- 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.

- 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.

A number of high and moderate potential rockfall sites were identified along each of the highways as listed in Table 8.1. A detailed evaluation was conducted at the most hazardous sites as described below.

[13] Lim, 2003

Table 8.1 Number of Potential Rockfall Sites along State Highways

Highway Name	Class A	Class B
H-1Freeway#1	10	11
H-3 Freeway # 3	-	5
Pali Highway # 61	12	4
Likelike Highway # 63	2	-
Kāneʻohe Bay Drive # 65	-	3
Kalanianaʻole Highway # 72	13	6
Kamehameha Highway # 80	3	-
Kamehameha Highway # 83	8	7
Farrington Highway # 93	3	4
Kamehameha Highway # 99	8	6
Moanalua Freeway # 201	3	2
Kunia Road # 750	4	1
Puʻuloa Road # 7310	-	1
Jarrette White Road # 7345	-	1

8.4.3 Detailed Rock Fall Rating

The study evaluated each of the potential rockfall sites 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 8.2 below presents the twelve evaluation categories along with the benchmark criteria used to assign scores to a slope. The categories and criteria are from the RHRS, adapted for conditions on the island of Oʻahu. Some categories require subjective evaluation, while others require field measurements. Table 8.3 lists the top ten high-scoring rockfall sites on Oʻahu. The approximate locations of these ten sites are shown in the accompanying Figure 8.5.

Table 8.2 Rating Criteria and Scores, Detailed Rockfall Hazard Rating

Category		Benchmark Criteria			
		Points 3	Points 9	Points 27	Points 81
Slope Height		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		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

Table 8.3 Top Ten High-Scoring Rockfall Hazard Sites on the island of O‘ahu (City and County of Honolulu)

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	Kalaniana‘ole Hwy	72	8.14	8.45	638	$1,500,000	10,179	Retaining wall repair and steel mesh fence installation **Completed**	Draped steel mesh
2	Kamehameha Hwy	83	5.40	5.52	628	$8,400,000	5,973	Rockfalls 3-4 times a year, **Completed**	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

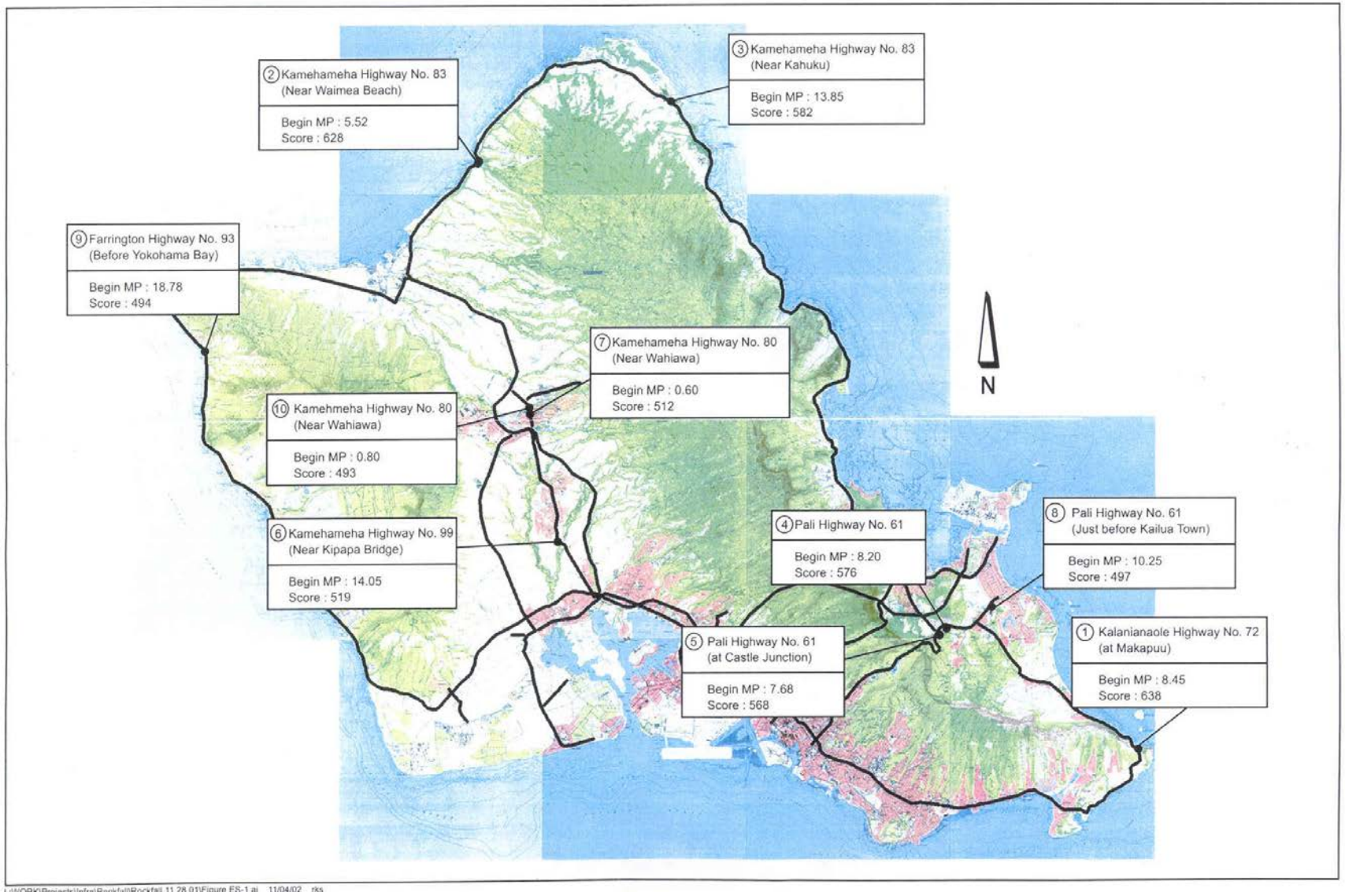

Figure 8.5 Top Ten High-Scoring Rockfall Hazard Sites on the island of O'ahu (City and County of Honolulu)

8.4.4 Rockfall Hazards to City and County of Honolulu Properties

On March 21, 2013, City and County of Honolulu Mayor Kirk Caldwell released a report that identified sites that pose rockfall hazards to city property, and announced that the city has warned about 1,000 private property owners whose land is at high risk of rockfall. The survey was prepared for the city, which already began taking protective measures at several sites owned by the government that the report flagged as hazardous. Caldwell emphasized that the report focused on city roads and city property endangered by rockfalls, not private lands. Nonetheless, it revealed some hazards involving private property.

A Rockfall Hazard Rating System (RHRS) program was initially established in 2002 at various locations adjacent to city streets on the island of O‘ahu. A total of 256 hillslope sites (rockfall sections) within 122 city streets were identified and rated as Class “A” (High), Class “B” (Moderate), or Class “C” (Low) with respect to the level of hazard associated with the potential for rockfall to encroach on the public right-of-way. As of the end of 2012, there were 59 rockfall sections that had been assessed an “A” classification, 93 rockfall sections with a “B” classification, and 104 rockfall sections with a “C” classification.

The project study area only encompasses the public streets under the jurisdiction of the City and County of Honolulu on the island of O‘ahu. *“Many of the streets owned and/or maintained by the city traverse steep hillslope areas in and around the ridge and valley regions of O‘ahu. Due to the steep terrain and location of development in these areas, many of the city streets on O‘ahu are below steep natural slopes and man-made cut slopes that are composed of rock and weathered rock materials. With the passage of time, erosional forces that work to alter and denude the slope faces continually affect these slopes. As a result, the hillslopes are essentially in a slow but constant state of geologic evolution that may generate potential hazards such as falling rock, landslide activity, and slope erosion. These potential hazards can have an adverse effect on development and the public right-of-ways located below the hillslopes.”* In general, the region of the island of O‘ahu with the highest concentration of inventoried rock hillslopes is the Honolulu district due to the high density of development in areas of high topographic relief, which require significant earthwork and grading.

8.5 Mitigation Strategies

8.5.1 Current and Ongoing Efforts

8.5.1.1 General

The Hawai‘i State Department of Transportation tries to address the landslide and rock fall problems through their maintenance budget. Although landslide events are a concern for our roadways, utilities and structures, little data is available in compiled statistical form regarding the frequency and severity of these events. Discussions with State and County highway maintenance agencies have yielded anecdotal information regarding landslide problem areas. Written documentation regarding the extent of the problem or other details of the events was not available.

8.5.1.2 Rockfall Hazard Mitigation in the City and County of Honolulu

Following the Rockfall Hazard Report of March 21, 2013, the City and County of Honolulu has five projects under way to deal with dangers high-lighted in the report.

Completed Projects:

- Pūpūkea Phase 1 ($1.6 million)
- Sierra Drive ($400,000)

Planned Projects ($4.6 million budgeted for three projects below:

- Prospect Street
- Pacific Heights
- Pūpūkea Phase 2

8.5.1.3 Rockfall Restraining Devices

Wire mesh, net fences, and other rockfall restraining devices have been installed in many locations along coastal highways around the islands of all Counties. A summary of recent rockfall mitigation projects by county is tabulated in Table 8.4.

Table 8.4 Status of Rockfall Mitigation Projects by County as of July, 2013

	SPONSOR	PROJECT	COST	STATUS
KAUA'I	DLNR	Kalalau Beach Park	$1.1M	Completed 2010
	DLNR	Hanapēpē Road	$125,000	Completed 2009
	DLNR	Waimea Canyon Ruth's House	$600,000	Completed 2008
HONOLULU	DLNR	Pu'unui Old Quarry	$1.3M	Completed 2007
	DLNR	Diamond Head State Monument	$2M	Completed 2012
	DLNR	Kuahea Street	$600,000	Completed 2010
	DLNR	Komo Mai Drive	$1.6M	Completed 2007
	DLNR	Niu valley Boulder	$300,000	Completed 2009
	DLNR	Ala Noe, Moanalua Valley	$1.1M	Completed 2012
	DLNR	Ahuwale Place, 'Āina Haina	$1.5M	Completed 2013

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

9. Floods

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CHAPTER 9

Floods

Reasons for Updates / Revisions in this 2013 Plan
• The major flooding events in Hawai‘i are caused by storms, storm surge, high surf and tsunamis. This chapter has been significantly reorganized and updated, starting with a description of the hazard and climatology, and distinguishing coastal and inland flooding scenarios. • The effect of coastal erosion on coastal flood hazard increase is described. • Historic flood data has been updated particularly considering the Mānoa flood of 2004 caused by stream flooding. • A rainfall intensity map is provided with discussion of flash floods. • New NFIP flood insurance study maps for the coastal zone is described and exhibited. • Flood ordinances are updated and included in Appendices. • Annual losses and all repetitive loss properties have been updated and mapped. • The repetitive flood loss analysis is also performed on properties only within flood zones. • Recent and mitigation activities are discussed. • New DFIRM flood maps that are hurricane-based for south and west shores. • The FHAT tool is discussed as a decision support tool to enable better compliance with flood regulations • Planning and zoning regulatory measures are detailed. • The State has engaged in extensive mitigation efforts through public awareness, the National Flood Insurance Program, and county floodplain coordinators. • New flood hazard mitigation activities are recommended.

Summary of Mitigation Projects for the State of Hawai‘i	
Project	Priority
Develop rainfall and streamflow gauging system suitable to flood monitoring.	Medium
Develop policies for repetitive loss structures.	Medium
Establish additional flood and debris-flow warning systems on O‘ahu.	Low
Consider participating in the Community Rating System.	Low

9.1 Floods Hazard Description

9.1.1 General

Floods are temporary inundation of land from excessive rainfall or wave action. 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. 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 Hawai‘i County Code Chapter 27. 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.[1]

Although the NFIP has significantly mitigated flood damages, major flood problems exist in older areas developed prior to flood control regulations and building standards, in areas that are subject to flooding but not identified on the FIRMs, and areas with flood control improvements that are inadequate to contain or control larger floods by present standards. Direct economic losses from flooding result from soaking, dislocation, and destruction of property. Economic losses from flooding also result from erosion and scouring or land. Erosion and scouring are caused by the velocity of the flow and by deposition of sediment and debris transported by the water. Dams can exacerbate flooding should they fail; hence, a dam safety program is also an integral part of flood control.

9.1.2 Flood Sources

Major flooding events are caused by rainfall from storms and hurricanes, storm surge, tsunamis, dam failures, and high surf. Floods caused by rainfall from storms and storm surge are discussed in this chapter. There are also floods that have characteristics associated with the geographic areas they are in, such as river, coastal and urban flooding. Floods due to tsunamis, dam failures, and high surf are discussed in Chapters 6, 10, and 11, respectively.

In the State of Hawai‘i, storm related floods occur during both the cool and rainy winter and the warm and dry summer seasons. Major floods typically occur during the rainy winter (October through April) and account for 84 percent of the floods in the islands.[2]

9.1.3 Storm Water Runoff Floods

Storm water runoff floods occur when drainage systems are overwhelmed during intense and/or prolonged periods of precipitation. Drainage systems refer either natural (soils, vegetation, etc.) or manmade (sewers, pipes, ditches, canals, etc.) systems where rainfall and storm water runoff is collected and transported to waterways or bodies of water. Drainage presents itself as a

1 For an overview of the National Flood Insurance Program in Hawai‘i, see State of Hawai‘i Department of Land and Natural Resources, National Flood Insurance Program in Hawai‘i, Circular C90, 1994.

2 State of Hawai‘i Flood Hazard Mitigation Plan, December 1996

problem in the form of flooding due to the development or alteration of natural areas and drainage patterns. Geology and rainfall are the major influences on drainage systems. Runoff is a function of infiltration capacity (soil type), relief, vegetal cover, and type and extent of development (amount of impermeable surface).

9.1.3.1 Flash Floods

Intense rainfall may trigger "flash-floods" which provide little warning (less than six hours) before the affected area experiences flood conditions. Prolonged rainfall may result in an accumulation of water creating flooding conditions that last several days, or even weeks. Flash floods may trigger hazardous events such as mud and landslides, structural bridge failures, and other threatening conditions. Rainfall intensity and duration are the primary source of flash floods. Intensity is the rate of rainfall, and duration is how long the rain lasts. Flash floods are characterized by rapid rise in water level, high velocity, large amounts of debris, and concentration in stream beds that are often normally small or even dry. Factors influencing flooding conditions include rainfall intensity and duration; rain shed area, topography and steepness, soil type, antecedent soil moisture, and ground cover.

Flash floods typically carry large amounts of debris which increase the damage they do, and are very capable of undermining bridges and carrying away vehicles. There is a major public safety hazard from these events, as the National Weather Service (NWS) estimates that over 50% of the flash flood deaths in Hawai‘i involve vehicles. Dam Failure also causes 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.

9.1.3.2 Storm Surge Floods

Storm surge floods from storm surge in immediate coastal areas occur primarily as a result of tropical cyclones and seasonal high waves. During these events, high winds and surf can push water several feet and even hundreds of yards inland. Conditions can be exacerbated by large waves that form on top of rising water. 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 than low tide and can inundate further inland causing more extensive damage. The area of impact of storm surge floods is confined to regions along the immediate coastlines and typically extends to a few hundred feet inland.

9.1.3.3 Riverine Floods

Riverine floods in Hawai‘i are usually triggered by hurricane or tropical storm rains.

9.1.3.4 Urban Floods

Urban floods are triggered because the paved streets cannot absorb the rainfall. In terms of urban land use, construction sites and roadsides expose large areas of bare soils that are highly susceptible to runoff and erosion. Construction sites can contribute significantly to storm water runoff and sediment erosion. Construction and development within the watershed contributes sediments and pollutants to storm water runoff during the grading and construction phase. After

construction is completed, the paved or impermeable surfaces create increased volume and peak rates of storm water runoff flow.

9.1.3.5 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 detail in Chapter 11 – High Surf.

9.1.4 Rainfall Flooding

9.1.4.1 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. These storms reflect orographic influences and are accompanied by widespread precipitation (Figure 9.1).

9.1.4.2 Upper troughs

Upper troughs are low pressure storms over wide areas that cause heavy rain and strong winds.

9.1.4.3 Convective Type Storms

Convective-type thunderstorms can occur at any time of the year. They are most common during periods of relatively high humidity and unstable air conditions. These storms cover comparatively small areas and result in high-intensity rainfall of short duration.

9.1.4.4 Hurricanes or Tropical Storms

Hurricanes and tropical storms cause heavy rains, strong winds, and high surf.

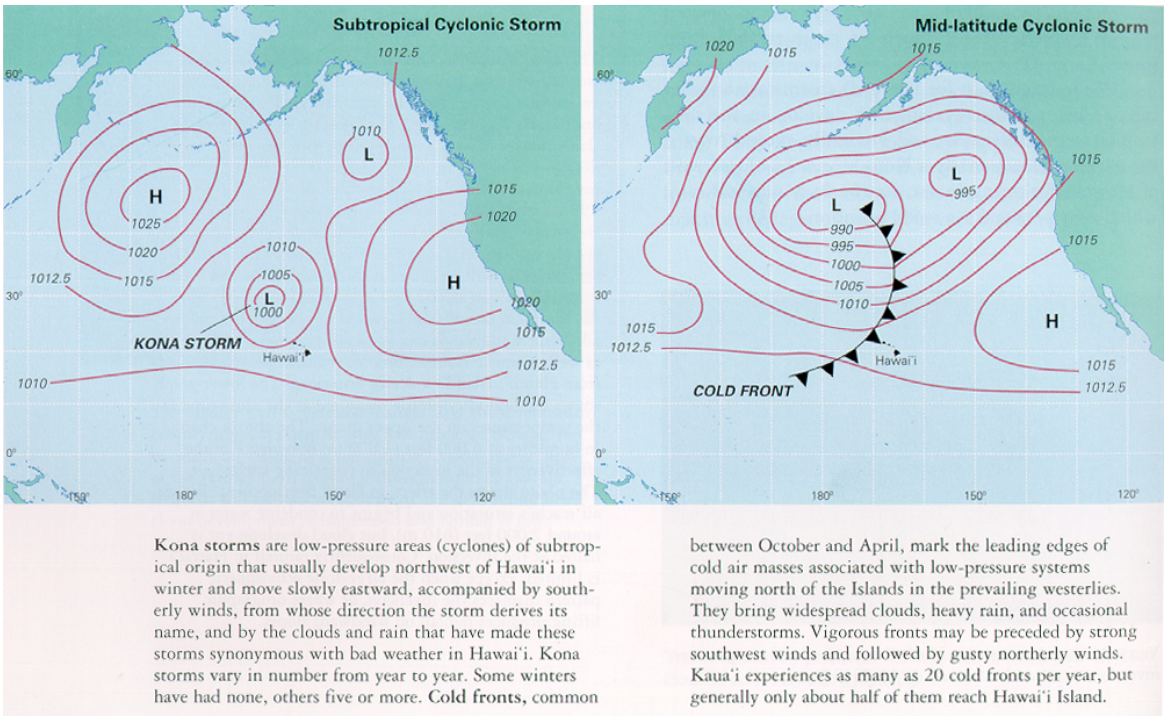

Figure 9.1 Kona Storms and Cold Fronts

Heavy rainfall creates three types of flooding: 1) channel overflow, 2) overland sheet flow, and 3) ponding of standing water in poorly drained low-lying areas. Channel overflow occurs when the carrying capacity of the channel is exceeded, which can be exacerbated by development changes within the drainage basin or clogging by debris or overgrown streambed vegetation. Overland sheet flow occurs primarily in areas with undefined drainage ways. Poorly drained low-lying areas are a problem when flooding occurs even when rainfall is not heavy.

9.1.5 Flood Advisories

The National Weather Service uses specific words when they issue alerts to the public about dangerous flood-related conditions.

Flash flood Watch: A flash flood is possible in the area. Stay alert.

Flash flood Warning: A flash flood is imminent or occurring; take immediate action.

Urban and Small Stream Advisory: Flooding of small streams, streets, urban storm drains, and low-lying areas.

As an example of a particularly active period, from February 19 through April 2, 2006 alone, the National Weather Service Forecast Office in Honolulu issued over 500 non-routine products

providing important information to people in Hawai‘i about imminent or ongoing severe weather[3] These products included the following:

- **111 Flash Flood Warnings** *(means flooding is likely to occur within the next hour or already occurring)*. Flash Flood Warnings were issued on 26 days through the period. Typically there are 2 to 3 flash flood events each year during this same time period across the state.
- **88 Special Marine Warnings** *(for waterspouts and/or strong thunderstorms over the water within 40 miles of land that are capable of producing winds greater than 40 mph or large hail).* Normally we issue about 30 special marine warnings in a year.
- **11 Severe Thunderstorm Warnings** *(means severe thunderstorms will likely occur within the next 30-60 minutes*). Normally we have 2 to 4 severe thunderstorm events statewide each year.
- **5 Winter Weather Advisories** *(means snowfall of 2 to 5 inches is likely in the next 24 hours)*
- **3 Severe Thunderstorm Watches** *(means severe thunderstorms with winds above 58 mph and/or large hail are possible within 6 hours)* on Feb 19, March 24, March 30. Normally the office issues 1 to 2 watches a year.
- **2 Winter Storm Watches** (*means snowfall of 6 inches or more is possible in the next 36 hours).*
- **2 High Wind Warnings** *(means sustained winds above 40 mph and/or gusts above 60 mph)* for the upper summits of Mauna Kea and Mauna Loa. Strong winds are a fairly common event on the summits, especially during the winter.
- **1 Winter Storm Warning** *(means snowfall of 6 inches or more is likely in the next 24 hours).*
- **1 Tornado Warning** (means a tornado is likely within the next 30 minutes). Normally there are 1 or 2 tornadoes each year somewhere in Hawai‘i.

  Flash Flood Watches (means flooding *possible* within the next 36 hours) were in effect.

9.2 Significant Historical Events

9.2.1 General

There have been several flooding events in recent years.

9.2.2 History of Flooding in the County of Kaua‘i

Stream flooding on the island of Kaua‘i is characterized by numerous flash floods as well as prolonged flooding associated with slowly passing rainstorms that saturate the soils. Kaua‘i,

[3] Nash, Rydell, and Kodama 2006, http://www.prh.noaa.gov/hnl/pages/events/weeksrain/weeksrainsummary.php

famous as one of the wettest places on Earth, receives between 20 and 80 inches of annual rainfall along the coast and more than 400 inches at the higher elevations of Mt. Waiʻaleʻale.

Flash floods resulting from a storm on December 14, 1991 that dropped over 20 inches of rain in 12 hours over Anahola, caused five deaths, intense flooding, bank failures, erosion, and slides, totaling more than $5 million in property damages. During recent recorded history, such events are not uncommon. On January 24-25 1956, 42 inches of rain fell in 30 hours on the northeast side of Kauaʻi leading to 10 feet of floodwaters in the streams between Kīlauea and Anahola. The Hanalei River, which most directly drains the wettest region of Mt. Waiʻaleʻale, overflows its banks at the coast nearly every year.

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. On March 14, 2006, unprecedented thunderstorms and heavy rains resulted in the failure of the Ka Loko Dam on Kauaʻi, which killed seven people.

Some years are considerably more damaging than others, for example, November 1955, January 1956, April 1994, and September 1996. In September of 1996 for instance, 9 inches of rain were recorded in 12 hours along the coast, and an uncertain amount fell in the uplands. This event led to flooding of Hanalei town and temporary closure of the Hanalei Bridge, the residents' sole access to the rest of the island. In the western portion of Kauaʻi, the flooding hazard is primarily due to overland flows, especially after storms. The Waimea River, for example, has a long record of flooding dating back to 1916 and includes numerous occasions where its channels overflowed after storm-fed precipitation in Waimea Canyon above.

There have been several flooding events in recent years. Heavy rainfall in October 31 to November 2, 2006 across much of Hawaiʻi during the period was the result of two systems. The first being left over moisture from an old front that pooled along the windward sides of the islands. The light easterly wind flow helped push the moisture over windward sections of the islands, resulting in some showers on October 30. By October 31, the destabilized further as an upper level trough of low pressure moved toward Hawaiʻi. The more unstable conditions resulted in locally heavy rainfall that persisted into the afternoon hours of November 1. Rainfall amounts during the period were quite large, especially along windward sections of Kauaʻi and Oʻahu, with some locations receiving well over 15 inches of rainfall. Some locations received over 3 inches in just a matter of 1 or 2 hours. The excessive rains produced flooding over portions of windward Kauaʻi. Earlier in the year, during the unprecedented extended wet period across Hawaiʻi (Feb 19 to April 2), several location in Kauaʻi experienced flashflood and overflow of streams.[4] Two subsequent High Winds and Flooding Rains weather events occurred on December 4-11, 2007 and December 10-14, 2008 causing widespread flooding in the county.[5]

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[4] National Oceanic and Atmospheric Administration (NOAA) Website, Retrieved February 2010 from http://www.prh.noaa.gov/hnl/pages/events/31Oct2Nov06/HeavyRains.php

[5] National Oceanic and Atmospheric Administration (NOAA) Website, Retrieved February 2010 from http://www.prh.noaa.gov/hnl/pages/events.php

Table 9.1 County of Kaua'i Stream Flooding from Atlas of Natural Hazards in the Hawaiian Coastal Zone (updated with Events from the National Weather Service)[6]

Island wide stream flood because of heavy rains	
1963 Apr 15	
1968 Nov 28	24" in 24 hours
1972 Apr 15	
1974 Apr 19	10" rain
1975 Jan 30-31	
1978 Oct 30-31	8.5" in 4 hours
1980 June 16	
1981 Aug 3-4	5-10" rain
1981 Dec 25-26	Up to 12" in 24 hours
1982 Feb 11	
1982 Oct 26-30	15-20" in 5 days
1982 Dec 23-25	3-5" rain
1986 Nov 10-11	Flash flooding
1987 Oct 15	Flash flooding
1987 Nov 4	Flash flooding
1988 Jan 28-29	10" rain
1988 Aug 2-11	
1989 Jan 10-12	Flash flooding
1989 Apr 24	
1990 Nov 20	
1992 Feb 13-14	
1993 July 21-23	Flooding Hurricane Dora
2003 Nov 29 - Dec 8	Up to 27.10" rain
2004 Aug 3-4	Up to 8.02" rain due to remnants of Darby
2005 Sept 14	Flash floods; more than 10" rain, Hanalei bridge closed
2005 Oct 1	Flash floods, Hanalei bridge closed
2006 Feb 19 - April 2	Unprecedented extended wet period; up to 138.79" rain; flash flooding; Kuhīo Hwy closed; Hanalei River overflowed; Ka Loko Reservoir breached
2006 Aug 7	Flash flooding; Hanalei bridge closed; Kuhīo Hwy closed; Omao Road closed
2006 Oct 31- Nov 2	Up to 10.9" rain
2007 Feb 23	Flash flooding; Hanalei River overflowed; Hanalei bridge closed; Kuhīo Hwy closed
2007 Nov 28	Flash flooding; Hanalei River rises about 12" on Nāwiliwili Road
2007 December 4-11	High winds (60-70 mph gusts) and widespread rains
2008 Feb 3-4	Flash flooding; Hanalei bridge closed; Wainiha bridge closed; Kuhīo Hwy and many roadways closed
2008 Oct 28	Flash flooding; Kawaihau, Kahuna, and Kamalu Roads closed
2008 December 10-14	Several rounds of heavy rainfall
2008 Dec 31	Flash flooding; Kuhīo Hwy closed
2009 Mar 9	Flash flooding; Kuhīo Hwy closed; Hanalei River overflowed

[6] Fletcher III, Charles H., E. Grossman, B. Richmond, A.E. Gibbs. 2002. Atlas of Natural Hazards in the Hawaiian Coastal Zone, United States Department of the Interior, United States Geological Survey - CD-ROM. http://pubs.usgs.gov/imap/i2761/. Updated with information from National Oceanographic and Atmospheric Agency National Weather Service retrieved from http://www.prh.noaa.gov/hnl/pages/events/

Western Watershed **Flooding primarily due to overland flow**	
1963 April 15	2-3 feet
1969 Jan 5	
1975 Dec 1	Kekaha
Wainiha/Lumahaʻi **Since 1956 6 damaging floods of 2-3 feet**	
1956 Feb	40,00cfs, 20' in 24 hours
1968 Nov/Dec	15" in 24 hours
1971 April 6-7	
1974 April 19	10" rain at Wainiha
1975 Jan 30-31	Wainiha
1978 Jun 7	16.2" in 2 days at Hanakapai Stream
1981 Oct 27-28	Wainiha River
1986 Nov 10-11	Lumahaʻi River
1989 Jul 22-23	Wainiha
Hanalei/Waioli, Waipā Streams	
1868, 1877, 1885, 1905, 1921, 1948, 1952, 1963	serious floods
1893 Feb 14	Flash flood, Kilauea Stream
1946-1963	5 damaging floods
1955 Nov 11-12	26.1" rain, 8 ft. flooding
1956 Jan 24-25	7 ft 44,900 cfs
1967 Dec 9	Hanalei River
1971 Apr 6-7	5ft at Hanalei River
1975 Jan 30-31	Hanalei
1981 Oct 27-28	Hanalei River
1982 Dec 6-7	
1986 Aug 11	Hanalei River
1988 Aug 4-11	
1989 Jul22-23	
1990 Nov16-17	
1994 Apr 12-13	10" Flash flood, mudslide
1996 Sep 7	9" in 12 hrs, Hanalei bridge closed
Kahiliwai/ Anahola	
1914 Sept	2 ft at Anahola Stream
1932 Feb	Anahola Stream
1948 Apr 1	Anahola Stream
1956 Jan 24-25	42" in 30 hrs, 10 flooding at Kahiliwai, Aiani, Kilauea
1964 Dec	Anahola Stream
1965 May	Anahola Stream, 6ft overland flows
1968 Nov 28	24" in 24 hours at Anahola Stream
1990 Nov 16-17	15" rain
1991 Dec 14	20" in 12hrs at Anahola Stream
1992 Feb 13-14	Anahola Stream
1993 Oct 2	3-6" rain flash flood
1994 Apr 13	heavy rain, flash flood
Kapaʻa Stream, Wailua River	
1916 Jan 7	Flash flood
1920 Jan	Wailua River
1940 May 13-14	Wailua River
1955 Nov 11-12	Kapaʻa Stream, Wailua River 85,000cfs
1956 Jan 24-25	Kapaʻa Stream, Wailua River
1963 Apr 15	Wailua River

1965 Apr	Kapaʻa Stream
1967 May	Kapaʻa Stream, 5ft
1967 Nov 24-27	Wailua River
1968 Dec 29-31	Kapaʻa Stream, 12,800 cfs, 7ft, 15-20" in 24 hours
1975 Jan 30-31	Wailua River
1981 Oct 27-28	Wailua River
1991 Dec 14	Kapaʻa, flash flood
Hanamāʻulu, Nāwiliwili, Hulēʻia Streams **Flooding is primarily due to runoff/overland flows**	
1965 Aug 2	4.5" in 1 hour at Hanamāʻulu Stream
1968 Dec 5	10ft at Hanamāʻulu, Nāwiliwili, Hulēʻia Streams
1975 Jan 30-31	Nāwiliwili Stream
1978 Oct 30-31	8.5" in 24 hours at Nāwiliwili Stream
Kōloa / Poʻipū **Flooding is due to overland flow**	
1954, 1955, 1957, 1963, thrice 1965, 1968	major floods
1965 Aug 13	Poʻipū
1972 Apr 15	Poʻipū
1989 Aug 20-21	Flash flood, Poʻipū
Hanapēpē River, Wahiawa Stream, Kalāheo Gulch	
1879 Jan	Hanapēpē
1924-1959	11 damaging floods at Hanapēpē River
1949 Dec 17	Flash flood, 4-5 ft at Hanapēpē
1963 Apr 15	5-6 ft at Hanapēpē River
1967 Nov 24-27	Hanapēpē River
1968 Dec 29-31	3-4 ft at Hanapēpē
1975 Jan 30-31	
Makaweli, Waimea **Flooding is due to overland flows after storms**	
1916, 1921, 1927, 1942	Major floods
1949 Feb 7	3-8 ft, 48,000cf at Waimea River
1973 Dec 1	
1993 Oct 2	3-6 in, flash flood
2008 December 10-14	Flooding in Waimea town, and closing the highway to Hanalei.

9.2.3 History of Flooding in the City and County of Honolulu

The most frequent and severe flooding occurs where steep sloping hillsides abruptly meet flat or low-lying coastal plains, such as those found in Wāimanalo, Kailua, Kaneʻohe (November 1992), and Lāiʻe (April 1994). The heaviest rainfall during the last decade in Kaneʻohe occurred in October 1991, when 15 inches fell in 48 hours leading to intense flash flooding.

Stream mouths are also commonly susceptible to flooding, especially during marine storm or high wave events, as runoff from streams reach a sea that is partly elevated by the combination of high waves, winds, and storm surges. Some of the largest rainfall counts and most severe flooding events have occurred in the last several years. During the first 15 days of November 1996, record-breaking rainfall occurred along the Waiʻanae Coast, where 21 inches fell in an area where the average annual rainfall is 2 inches. In ʻEwa, 12.5 inches of rain fell in 7 hours on the 5th day of that month, inducing flooding of the low coastal plain. A series of slow moving storms with prolonged rains that saturated the soils of south-central Oʻahu culminated on New

Year's Day of 1988 in severe runoff and hillside erosion, resulting in catastrophic damage to stream flood mitigation channels, homes, and roads in ʻĀina Haina and Niu Valleys. Other recent severe events on Oʻahu include October 1981 flooding of Wahiawā Stream after heavy rains that lead to $786,000 damage and January 1968 flooding in Pearl City, which caused $1.2 million damage.

During the last few days of November and the first week of December of 2003, several weather systems combined to bring several rounds of heavy rainfall to many parts of the state. A few locations in the Koʻolau Mountains of Oʻahu likely received over 3 feet of rain in just a 10 day period causing flash flooding and stream overruns.[7]

During August 2-4, 2004 the remnant swirl of Darby caused excessive rainfall in all Hawaiian Islands. On August 3, the remnants moved approached Oʻahu, affecting the entire island of Oʻahu and dumping several inches of rain in a few hours. A few streams overflowed their banks and minor landslides occurred, both resulting in some road closures. The main effect was significant ponding of water on the roads, which impacted the morning rush hour.

During the late afternoon on October 30, 2004 an area of showers being pushed west by the low level tradewind flow interacted with the Koʻolau Mountains on the windward (east) side of the island of Oʻahu. As the air was pushed up over the mountains, the unstable environment allowed those showers to rapidly develop into a thunderstorm and remain focused over a small area of southeast Oʻahu. This thunderstorm, locked into place due to the terrain, produced very heavy rainfall totals in just a few hours. The focus of the heaviest rain occurred over the southern portion of the Koʻolau Mountains on the island of Oʻahu, resulting in Mānoa Stream overflowing its banks and causing significant flooding in Mānoa Valley, including the University of Hawaiʻi campus. At the height of the heavy rainfall around 7 pm, rainfall rates recorded at the gauge at the Mānoa Lyon Arboretum, in the upper portion of Mānoa Valley, were over 5 inches per hour. These large rainfall rates are estimated to occur with a return rate of almost 50 years. In other words, in any given year, there is only a 2% probability of such a heavy rainfall event like this occurring in upper Mānoa Valley.[8]

In March 2006, Oʻahu suffered heavy rains, flooding, and severe weather for a period that lasted approximately 40 days. A series of storms around the Hawaiian Islands drew war moist air from the tropics, resulting in continuous torrential rain falling on throughout all regions of the island of Oʻahu. The intense rains resulted in the rupture of a 42-inch diameter sewer line in the tourist district of Waikīkī. As a result of the damaged sewer main, 48 million gallons of raw sewage were spilled into the Ala Wai canal, a canal that forms the northern and western boundary of the district. To repair the damage and to prevent more sewage from spilling over into the canal, an exposed new 48-inch diameter sewer line was installed in the middle and alongside the canal to serve as a temporary bypass line. Seven years later, installation of a secondary 72-inch diameter underground pipe has been completed. The new secondary pipe runs parallel to the temporary

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[7] National Oceanic and Atmospheric Administration (NOAA) Website, Retrieved February 2010 from http://www.prh.noaa.gov/hnl/pages/events/wet_stuff/wet_stuff.php

[8] National Oceanic and Atmospheric Administration (NOAA) National Weather Service Website, Retrieved February 2010 from http://www.prh.noaa.gov/hnl/pages/events/Manoa Flood20041030

exposed bypass line. At a cost of $90 million[9] in 2013, this new secondary line can be used to divert the sewage in case the original main ruptures again. The temporary exposed bypass line is now scheduled to be removed.

Heavy rainfall in October 31 to November 2, 2006 produced flooding over portions of windward O‘ahu and triggered a significant landslide that closed O‘ahu’s Pali Highway[10]. . Two subsequent High Winds and Flooding Rains weather events occurred on December 4-11, 2007 and December 10-14, 2008 causing widespread flooding throughout O‘ahu. The December 2008 events caused severe damage in the north, west, and central sections of the island.[11]

In January 12-13, 2011 an 11-inch rainfall caused a reservoir to overflow into O‘ahu’s municipal landfill, sending medical waste (including syringes and vials) and debris into the ocean north of the Ko Olina Resort, and causing closure of their beaches. The landfill was weeks away from completing a bypass route that would have diverted the storm water from the upper reservoir straight into the drainage way, avoiding the landfill cells. Had the improvements been completed, water still would have ended up in the filtration basin at the base of the landfill, but it would not have gone through the landfill cells. Additional measures were required under the latest permit allowed by the State Land Use Commission. Granted in September 2009 after much debate and controversy, the permit allowed the landfill to expand and continue operating.

Table 9.2 City and County of Honolulu Stream Flooding from Atlas of Natural Hazards in the Hawaiian Coastal Zone (Updated)[12]

Island wide stream flood because of heavy rains	
1900 Nov. 14	
1921 Jan. 16	
1935 Feb. 27	
1947 Feb. 7	
1948 Jan. 23 – 26	
1949 Jan. 15 – 17	
1951 Mar. 26 – 27	
1954 Jan 21	
1954 Nov. 27 – 28	
1956 Jan. 24 – 25	
1957 Dec. 1	
1958 Mar. 5	
1958 Aug. 6 – 7	
1959 Jan. 17 – 18	
1959 Aug. 4 – 7	

9 Honolulu Star Advertiser, ‘Out of the Ala Wai’ News Article, June 1, 2013

10 National Oceanic and Atmospheric Administration (NOAA) Website, Retrieved February 2010 from http://www.prh.noaa.gov/hnl/pages/events/wet_stuff/wet_stuff.php

11 National Oceanic and Atmospheric Administration (NOAA) Website, Retrieved February 2010 from http://www.prh.noaa.gov/hnl/pages/events.php

12 Fletcher III, Charles H., E. Grossman, B. Richmond, A.E. Gibbs. 2002. Atlas of Natural Hazards in the Hawaiian Coastal Zone. US Department of the Interior US Geological Survey. CD-ROM. http://pubs.usgs.gov/imap/i2761/. Updated with information from NOAA National Weather Service http://www.prh.noaa.gov/hnl/pages/events/

1960 May 12 – 13	
1961 Oct. 27	
1962 Jan. 7	
1963 Jan. 15 – 17	
1964 Dec. 19 – 23	
1965 Feb. 4	
1965 Nov. 10 – 15	
1966 Sept. 10 – 12	
1966 Oct. 10	
1967 Jul. 4 – 8	2 to 3 Inches
1967 Jul. 5 – 18	
1967 Jul. 11 – 21	
1967 Aug. 10 – 14	
1967 Dec. 9	
1967 Dec. 17 – 18	
1969 Dec. 27 – 28	
1972 Aug. 8 – 20	
1974 Apr. 19	
1975 Jan. 30 – Feb. 1	
1975 Nov. 23 – 27	
1976 Feb. 5 – 7	
1976 Nov. 6 – 7	
1978 Jun. 26 – Jul. 3	
1978 Oct. 30 – 31	
1980 Mar. 18 – 19	
1981 Aug. 3 – 4	
1981 Dec. 25 – 26	
1982 Sept. 1	
1982 Oct. 26 – 30	
1982 Dec. 23 – 24	
1984 Dec. 24 – 25	
1985 Jan. 29 – 30	
1986 Nov. 10 – 11	
1987 Jul. 21 – 23	
1987 Sept. 2	
1987 Dec. 11 – 19	
1988 Jan. 28 – 29	
1988 Aug. 2 – 3	
1988 Sept. 26 – 27	
1988 Dec. 5 – 6	
1989 Mar. 1 - 4	
1989 Apr. 24	
1989 Jul. 18 – 20	
1990 Jan. 14 – 22	
1991 Oct. 10 – 15	
1993 Jul. 21 – 23	
1993 Oct. 10	
1994 Apr. 13 – 14	
1996 Nov. 5	
1996 Nov. 15	
2003 Nov 29 - Dec 8	Up to 32.98” rain
2004 Aug 3-4	Up to 9.04” rain due to remnants of Darby
2004 Oct 30 - 31	Up to 10.07” rain in 12 hour, Mānoa Stream overflowing its bank causing significant damage to UH Mānoa

2006 Feb 19 - April 2	Up to 87.18” rain
2006 Oct 31- Nov 2	Up to 22.39” rain
2007 December 4-11	High winds (60-70 mph gusts) and widespread rains
2008 December 10-14	Several O‘ahu rain gauges recorded 10 to 13 inches in a 12-hour period.
Hale‘iwa: Since 1874 – 19 Floods	
1932 Feb. 28	Wailua Stream, Flash Flood 26 – 30” in 24 Hrs. at Poamoho, Kikii, Paukauila Stream
1935 Feb 27	20” in 24 Hrs.
1939 Mar. 1 – 2	Lowland Flooding
1939 Oct. 22 – 23	10 – 12” in 24 Hrs.
1956 Feb. 25	Flash Flood, 14” at Wailua
1962 Mar. 13 – 15	Flash Flood
1968 Mar. 13 – 18	12” in 24 Hrs.
1969 Feb. 28	21” in 24 Hrs. at Anahulu, Kaukonahua, Poamoho, Opaeula, Helemano Str.
1974 Apr. 19	Opaeula, Helemano, Poamoho, Kaukonahua River
1976 Feb.5 - 7	
1976 Nov. 6 – 7	
1982 Jan. 6	Waialua
1987 Oct. 11	
Sunset Beach	
1935 Feb. 27	10.24” in 24 Hrs. at Waimea River
1956 Feb. 25	Flash Flood
1962 Mar. 13 – 15	Flash Flood
1968 Mar. 13 – 15	Waimea River; 5,270 cfs
1969 Feb. 1	Waimea River; 3,860 cfs
1996 Nov. 14	Widespread Flooding
1975 Jan. 30 – 31	Flooding
1987 Oct. 11	
1989 Jul. 18 – 20	Waimea River, Sunset Beach
1990 Nov. 20	Waimea River
Kahuku: 7 Major Floods	
1962 Mar. 13 – 15	
1963 Apr. 15	
1982 Feb. 21	Kahawainui
1985 Feb. 14	5 – 10”
Windward Coast	
1918 Apr. 11	Flash Flood, Windward Coast
1924 Oct. 11	Flooding of Lowlands, 11” in 11 Hrs.
1927 Mar. 5 – 6	Flash Flood, Windward Coast
1932 Feb. 13	Flash Flood at Punalu‘u
1956 Jan. 26	Streams Overflowed
1959 Jan. 17 – 18	Windward Side
1963 Apr. 15	19” in 24 Hrs. at Makaua, Ka‘a‘awa, Waiahole Streams
1965 Feb. 3 – 4	Flooding in Lowlands, 18” at Waiahole and Ka‘a‘awa Streams
1965 Mar. 31	Flash Flood, 4.5” in 1.5 Hrs. at Punalu‘u
1965 May 2-3	Flash Flooding, 8.75” in 3 Hrs. at Ka‘a‘awa
1971 Dec. 31	Kaluanui Stream, Sacred Falls, Waiahole
1982 Jan. 6	Flash Floods
1982 Sept. 1	Flash Floods
1984 Mar. 26 – 28	6 – 15”
1985 Feb. 14	5 – 10”

1985 May 6	8 – 10”
1985 Nov. 18	
1986 May 10	
1986 Sept. 28	
1987 Mar. 24	Flash Flood at Sacred Falls
1987 May 5	
1987 Jul. 21 – 23	
1992 Oct. 11	Windward Oʻahu, Minor Flash Flooding
1994 Apr. 12	6” in Kahuku, Flash Flooding
Kahaluʻu: Since 1936 – 20 Floods	
1965 Feb. 4	3 Ft.
1965 May 2 – 3	3 – 4 Ft.
1970 Nov. 24 – 26	11.5” in 4 Hrs. from Kahaluʻu to Wāimanalo
1976 Feb. 5 - 7	
1994 Apr. 13	HAUʻULA to Kahaluʻu, Flash Floods, Heavy Rains, Road Closures
Kāneʻohe: Since 1872 – 9 Major Floods	
1963 Apr. 15	Kāneʻohe
1965 Feb. 4	Kamooalii Stream
1965 May 2 – 3	5,920 cfs at Haʻikū, Lolekaa
1969 Feb. 1	4 – 6 Ft.
1970 Nov. 24 – 26	
1991 Oct. 15 – 16	Kāneʻohe, 15” in 48 Hrs, Flash Flooding
1992 Nov. 26	Kāneʻohe, Heavy Rainfall, Flooding
Kailua	
1951 Mar. 26 – 27	
1963 Mar. 6	
1982 Jul. 23	Flash Flooding
1987 Dec. 31 – Jan 1	Slow Flood, 2 – 5 ft at Kawainui Marsh
Wāimanalo	
1957 Feb. 7	
1958 Mar. 5	13.8” in 24 hrs., 3 Ft.
1963 Mar. 6	
1967 Dec. 9	
1967 Dec 17 - 18	
1970 Nov. 24 – 26	11.5” in 4 Hrs.
1976 Feb. 5 – 7	
1982 Jan. 6	
East Oʻahu: 9 Major Floods	
1957 Jan.	Waiʻalae, Niu Valley
1957 Feb. 7	ʻĀina Haina
1958 Mar. 5	2170 cfs at Waiʻalae Iki Str., Wailupe Str.
1967 Aug 9	Wailupe
1967 Dec. 17 – 18	3600 cfs at Waiʻalae Iki Str., 11” in 8 Hrs at Niu Valley, ʻĀina Haina, Kuliouou
1987 Dec.31 – Jan. 1	Flash Flooding at Waiʻalae Iki Str.
1990 Feb. 28 – Mar. 1	Niu Valley
Mānoa and Pālolo: 12 major Floods	
1904 Feb. 10	Mānoa
1918 Dec. 3 – 4	Mānoa
1927 May 16	Mānoa
1930 Apr. 11	Pālolo
1948 Nov. 17	Mānoa , Pālolo
1950 Dec. 3	Mānoa

1977 Apr. 19	Mānoa , Pālolo
Honolulu	
1898	Flash Flood at Honolulu
1911 Feb. 4 – 5	Flash Flood at Waikīkī, Moiliili
1917 Mar. 19	Flash Flood at Honolulu
1921 Jan. 16	
1927 Dec. 27	Flash Flood
1932 Feb. 13	Pu‘unui
1943 Jan 4 – 5	Kaimukī, Kāhala, Diamond Head, Waikīkī
1957 Feb. 7	
1965 May 2	
1968 Jan. 27	
1968 Oct. 19	
1971 Feb. 1	
1974 Jul. 17	Nu‘uanu, Pu‘unui Str.
1975 Nov. 23 – 25	11” in 4 Days
1976 Feb. 5 – 7	
1982 Dec. 23 – 24	
1983 Feb. 23	Nu‘uanu
1985 Jul. 17	
1991 Sept. 21	Kalihi to Hawai‘i Kai, Street Flooding
1992 Oct. 21	Honolulu to Kaimukī, Localized Minor Flash Flooding
1993 Oct. 25	Honolulu, 2 – 4” of Rain, Thunderstorms, Flash Flooding, Street Flooding
1996 Nov. 14	Honolulu, Widespread Flooding
2004 Oct 30	Mānoa , Widespread Flooding - Up to 10.07” rain in 12 hour, Mānoa Stream overflowing its bank causing significant damage to UH Mānoa
Pearl City and Barbers Point	
1879	Waikele, Honouliuli, Kipapa Str.
1904 Feb. 10	Pearl City, ‘Ewa
1921	Waikele, Kipapa, Honouliuli Str.
1935 Feb. 27	Waikele, Kipapa Str.
1949 Dec. 19	‘Ewa
1954 Nov. 28	Waiawa Str, 13600 cfs, Waikele
1956 Feb. 25	Waiawa Str.
1958 Mar. 5	Pearl Harbor
1960 May 14	3710 cfs at Hālawa Str.
1963 May 14	1 Ft. at Pearl City
1967 May 30	Hālawa Str.
1967 Aug. 2 – 11	Kipapa, Waiawa Str.
1967 Dec. 9	Pearl City
1968 Jan. 5	6 Ft. at Waiawa, Honouliuli
1972	Honouliuli Str.
1981 Oct. 27 – 28	Waiawa Str.
1985 Oct. 23	
1987 Sept. 2	Pearl City, Waipāhu
1996 Nov. 5	‘Ewa, 12.5” in 7 Hrs.
Wai‘anae	
1927 Dec. 27	Flash Flood at Wai‘anae, Wailuku
1954 Nov. 24	Mākaha Str.
1962 Mar. 13	Mākaha Str.
1964 Dec 12, 23	Mākaha Str.
1965 Nov. 13	Mākaha Str.

1976 Feb 5 – 7	Wai‘anae
1985 Jan. 29 – 30	Nānākuli, Wai‘anae
1991 Sept. 8	Mā‘ili Area, Minor Damage
1991 Oct. 15 – 16	Nānākuli, 15” in 48 Hours, Flash Flooding
1996 Nov. 5	Record Breaking 21” Rain for Nov. 1 – 5 (Average in 2”)
1996 Nov. 14	Flash Flood, Mudslide
Wahiawā	
1994 Jul. 18	4.5” in 6 hrs.
1989 Feb. 10 – 11	
1990 Mar. 6	Heavy Rain
1992 Oct. 14	Wahiawā to Wailua, Funnel Clouds and Flash Floods
1994 Apr. 12	6” in Wahiawā and on the North Shore, Flash Flooding

9.2.4 History of Flooding in the County of Maui

Stream flooding in the island of Maui is not only common, but is also the very agent responsible for making it famous as the Valley Island. Annual rainfall is greatest (360 inches) at the summit of west Maui and nearly as high (280 inches) along the eastern flanks of east Maui just below the trade wind inversion. Rainfall is lowest (<15 inches) in the vicinity of Kīhei and Lahaina.

Flooding in areas around Lahaina and Kīhei are in part a result of the abrupt transition in slope at the coastline and the behavior of flash flooding. Many flash floods in these areas occurred after heavy rainfall in higher elevations - in some cases equaling the average annual maximum, like in December 1988.

The north central portions of the island of Maui and the Hāna coast have the greatest stream flooding histories. Nearly once a decade, water sheets into the urban centers of Kahului and Wailuku (e.g., November 1950 and 1960). Along the road to Hāna temporary road closures are common due to flash floods and mudslides from the steeper slopes of East Haleakalā.

In addition, the Lahaina region and Kīhei are vulnerable to standing surface water flooding. This may interrupt transportation and damage low elevation buildings. Standing surface water develops after intense rainfall events where poor soil permeability and urbanization prevent adequate drainage and temporarily disrupting transportation.

Waves from north and northwest swell tend to be highest on an annual basis and generally occur between October and March. Wave heights associated with these swells range between 5-10 feet (Kā‘anapali) and 10-20 feet (Honolua Bay, Waihe‘e to Paia).

Occasionally, waves of 25 feet and greater occur over the deep offshore reefs of the North Shore. Two of the largest wave events occurred February 1993 and January 1998, when waves reached heights of 30 and 40 feet, respectively.

The southern shores of the island of Maui are partly protected from south swell in summer by the islands of Kaho‘olawe and Lāna‘i. Even so, wave heights range between 4 and 6 feet and, at times, reach 8-10 feet. During winter months, Kona Storm waves can reach 5 feet. Trade wind waves, usually between 3 and 4 feet, impact the eastern shores 70% of the time.

In the summer months, tropical storms and hurricanes can generate wave heights of 10-20 feet along any portion of coast on the island of Maui. Hurricanes Susan, Ignacio, and Estelle generated 10-15 foot waves along the north and east shores. Along the west shore, Hurricane Emilia caused wave heights of 6-10 feet.

Fortunately for the island of Maui, much of its coastline has wide fringing reefs that dissipate wave energy offshore of its northern and western shores, where wave heights are highest.

Also, relative to the other islands, there are only a few locations where development along the shore is subject to direct impact by high waves. Unfortunately, however, areas important for tourism and commerce such as Lahaina, Kāʻanapali, Honokōwai, Olowalu, Kīhei, and Kahului are sited on low coastal plains, and so experience periodic wave overwash, causing rapid erosion and temporarily disrupting transportation.

Of particular significance is the flash flood that occurred on April 2003 on Haleakalā National Park (Kīpahulu area) on the island of Maui. The flash flood, which occurred at the bottom of the 184-foot Makahiku Falls, resulted in the death a 39-year old man and an 8-year old girl as they were swept away by a 6-foot wall of water while crossing the stream at the bottom of the waterfall. The deaths led to a federal lawsuit by the family of the victims – ultimately the United States government agreed to pay the $5 million in 2009. According to Haleakalā National Park officials, there have been nine deaths at the falls since 1983.[13]

Several storm events in recent years have caused flash flooding in the island of Maui. During November 29 -December 8, 2003 several weather systems combined to bring several rounds of heavy rainfall to many parts of the state. In December 1, 2003, some locally heavy rains around Olowalu with radar estimating near 10 inches caused roads flooding in the area.[14] Heavy rainfall in October 31 to November 2, 2006 produced flooding over portions of windward Oʻahu. Along with Oʻahu, the thunderstorms brought one last round of flooding to portions of and then to Molokaʻi and Maui.[15]Two subsequent High Winds and Flooding Rains weather events occurred on December 4-11, 2007 and December 10-14, 2008. While the December 2011 event caused widespread flooding, the December 2008 rainfall on those islands brought much needed drought relief.

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[13] Los Angeles Times Website, Retrieved December 30, 2009 from http://travel.latimes.com/daily-deal-blog/index.php/5-million-settlement-5542/

[14] National Oceanic and Atmospheric Administration (NOAA) Website, Retrieved February 2010 from http://www.prh.noaa.gov/hnl/pages/events/wet_stuff/wet_stuff.php

[15] National Oceanic and Atmospheric Administration (NOAA) National Weather Service Website, Retrieved February 2010 from http://www.prh.noaa.gov/hnl/pages/events/31Oct2Nov06/HeavyRains.php

Table 9.3 County of Maui Stream Flooding from Atlas of Natural Hazards in the Hawaiian Coastal Zone (Updated)[16]

Molokaʻi and Lānaʻi - Island wide stream flood because of heavy rains	
1971 Jan 27-28	Storm, flooding
1980 Jan 6-14	Flooding
1981 Oct 27-28	Flash floods
1981 Aug 3-4	Flooding
1981 Dec 25-26	Flooding
1982 Mar 17	Flooding
1982 Mar 30-31	Flooding
1982 Aug 14-16	H Kristy, flash floods
1983 Dec 24-25	Flash floods
1984 Dec 24-25	Flash floods
1985 Feb 14	Flooding
1985 Oct 17-18	Flash flooding
1986 Nov 10-11	Flash floods
1987 Apr 21-22	Flash floods
1987 May 5-6	Flooding
1988 Sep 26-27	Flooding
1988 Nov 4-5	Flooding, up to 10”rain
1988 Dec 5-6	Flooding, over 10” rain
1989 Feb 10-11	Flooding
1993 Jul 21-23	Flooding, remnants of H Dora
2003 Nov 29 - Dec 8	Up to 6.46” rain
2004 Aug 3-4	Up to 1.39” rain due to remnants of Darby
2006 Feb 19 - April 2	Up to 14.93” rain
2006 Oct 31- Nov 2	Up to 6.51” rain
Kaunakakai, Molokaʻi	
1950 Nov 30	Flash flooding at Kaunakakai
1961 Oct 31-Nov 3	Storm, flash flooding
1997 Jan 19-20	Street flooding
Kamalō, Molokaʻi	
1961 Oct 31-Nov 3	Flash flooding at Kamalō
1965 Apr 13	Flash flooding along SE Molokaʻi
Hālawa, Molokaʻi	
1961 Jan 1	Flooding, 10,900 cfs at Hālawa Stream
1961 Oct 31-Nov 3	Flooding at Kawela Gulch
Kualapuʻu Gulch, Molokaʻi	
1916 Jan 1	Flash floods at Kualapuʻu Gulch
Halepalaoa Landing, Lānaʻi	
1985 Oct 17-18	Flash flooding on Lānaʻi
Maui - Island wide stream flood because of heavy rains	
1900 Nov 14	Flash flood
1906 Dec 23	Flash flood
1916 Jan 14	Flash flood
1918 Apr 18	Flash flooding
1930 Nov 18	Flash flooding

[16] Fletcher III, Charles H., E. Grossman, B. Richmond, A.E. Gibbs. 2002. Atlas of Natural Hazards in the Hawaiian Coastal Zone. US Department of the Interior US Geological Survey. CD-ROM. http://pubs.usgs.gov/imap/i2761/. Updated with information from NOAA National Weather Service http://www.prh.noaa.gov/hnl/pages/events/

1946 Jan 2	Flood
1946 Dec 20	Flash flooding
1948 Apr 2	Flash flood
1950 Nov 30	Flash flood
1951 Feb 22	Flash flood
1960 May 12-13	Flooding
1961 Oct 24	Flash flooding
1963 Mar 13	Flooding
1965 Jan 23	Flash flood
1968 Mar 13-16	Flooding
1968 Nov 28	Minor Flooding
1971 Jan 28	Flooding
1974 Apr 19	Flash flooding
1980 Jan 6-14	Flooding
1981 Aug 3-4	Flooding
1981 Oct 27-28	Flooding
1982 Mar 30-31	Flooding
1982 Apr 1-3	Flooding
1982 Jul 16-17	Flooding
1982 Dec 23-24	3-5”rain
1984 May 23	Minor flash floods
1984 Dec 24-25	Flash flooding
1985 Oct 17-18	Flash floods
1985 Nov 18	Minor flash floods
1986 Feb 15	Flash floods
1986 Nov 10-11	Minor flash flooding
1987 Apr 21-22	Minor flash flooding
1987 Apr 26	Flash flooding
1987 May 5-6	10” rain, flash flooding
1988 Jan 28-29	Flash floods
1988 Nov 4-5	Extensive flooding
1988 Dec 5-6	Flash flooding
1989 Feb 10-11	Minor flash flooding
1989 Mar 1-4	Minor flash floods
1990 Jan 14-22	Up to 20” rain, flooding
1991 Jan 27	Flooding
1991 Mar 19-21	Flooding
1993 Jul 21-23	Flooding, remnants of H Dora
2003 Nov 29 - Dec 8	Up to 22.74” rain
2004 Aug 3-4	Up to 5.05” rain due to remnants of Darby
2006 Feb 19 - April 2	Up to 41.93” rain
2006 Oct 31- Nov 2	Up to 14.06” rain
2007 December 4-11	High winds (70-80 mph gusts) and rains, Widespread flooding across portions of central and upcountry Maui
West Maui	Honokōwai and Lahaina are frequently flooded. Since 1879, 19 damaging floods occurred in the Lahaina area.
1916 Jan 26	Lahaina and Olowalu flooded
1950 Nov 30	Flash flooding at Lahaina
1960 May 13	Kahoma Stream
1961 Oct 31-Nov 3	West Maui, Kahoma Stream
1967 Mar 17-18	7” in 5.5 hours at West Maui
1971 Jan	Lahaina, Kaua‘ula Stream (Hale, Cannery, Kelawe Camp)
1972 Feb 24	5-8” in 5 hours at West Maui, Lahaina
1974 Nov 21	Kā‘anapali, Honokōwai

1987 May 5-6	Flash flooding at Lahaina
1988 Dec 5-6	Over 10” of rain
1997 Jan 19-20	Flooding Lahaina
Southwest Maui	Frequent flooding of Kulanihakoi, Waipuilani, Keokia, and Waiakoa streams
1916 Jan 26	Kīhei
1930 Jan 29	Flash flooding at Kulat, Kīhei
1951 Feb 22	Kīhei
1955 Dec 21	Kīhei
1967 Mar 24	6” in 6 hours at Kīhei
1968 Jan 28	Kīhei
1971 Jan 27-28	6 ft at Kīhei
1988 Dec 5-6	Over 10” rain at Kīhei
South Slope Haleakalā	Historical flooding of streams between Kīpahulu and Nu‘u
1968 Apr 15-16	
1986 Nov 10-11	
Windward Haleakalā	Makawao, Kaupakulua, Wailua and Hāna frequently flooded by sheetflows
1965 Apr 25-28	Flash flood at Hāna
1968 Apr 15-16	East Maui esp. Honomaele Stream
1981 Oct. 27-28	Road to Hāna
1982 Mar 30-31	Road to Hāna
1982 Jul 21-22	Flash flooding
1982 Aug 1	Flash flooding esp. Kā‘anapali
1984 May 23	Minor flash flooding, road to Hāna
1987 Feb 15	8-10” at Hāna area
1987 May 5-6	10”
1988 Mar 24	Road to Hāna
1991 Mar 19-21	Road to Hāna
1992 Nov 26-27	Severe flooding
1993 Oct 23	Flash flood, mudslide
1994 Apr 12-13	Flash flood, mudslide
North Central Maui	Wailuku and ‘Īao Stream are frequently flooded. Kahului frequently inundated by sheetflow.
1900 Nov 14	Kahului
1903 Feb 13	Flash flood at Wailuku
1916 Jan 14	17000 cfs at ‘Īao Valley
1920 Dec 24	Storm, flooding at Wailuku
1930 Nov 18	‘Īao Stream
1948 Jan ?	‘Īao Stream
1950 Nov 30	Flash flooding at ‘Īao Valley, Wailuku
1950 Dec 3	7550 cfs, 5” rain in 2 hours at ‘Īao Stream
1961 Nov 2	5700 cfs at ‘Īao Stream
1965 Feb 4	Sheetflow
1971 Jan 27-28	5820 cfs at ‘Īao Stream, 2 ft at Paia
1972 Feb 8	3.5” in 1 hr at Wailuku
1978 Nov 12	Flash flooding at ‘Īao Valley, Kahului
1982 Mar 30-31	‘Īao Valley
1987 Mar 5-6	Over 10” rain, flash flooding at Wailuku, Kahului
1989 Feb 3-5	Flash flooding near Ha‘ikū
1994 Apr 12-13	Flash flood, mudslide
2007 December 4-11	Flash flooding in the Waiohuli area of Maui sweeping a house from its foundation.
Northwest Maui	

1961 Nov 2	Flash flooding at NW Maui, Nāpili, Honolua
1964 Dec 19	NW Maui
1967 Mar 17	Nāpili Bay
1967 Mar 24	Nāpili Bay, heavy rains
1968 Mar 13-16	24" in 48 hours at Nāpili Beach, Honolua, Pa‘akea

9.2.5 History of Flooding in the County of Hawai‘i

According to the data from the last 50 years, on average a damaging flood event occurs on the Island of Hawai‘i every 2 years. During this past 50 years, however, the threat due to stream flooding has increased dramatically because of the risk taken to develop extensively in flood prone areas. Flooding along the wet, windward side of the island is expected due to high annual rainfall (300 inches on the slopes of Mauna Kea above Hilo).

Most of the flooding that has caused damage has been flash flooding during extreme rainfall events that bring about sheet flow between stream channels. In addition, the soils along the Hāmākua Coast readily absorb precipitation - thereby facilitating mudslides and landslides. The Hilo and Puna areas are probably the most frequently flooded and hardest hit by flash floods on Hawai‘i Island and perhaps in the state. The latest severe flooding occurred in November 2000.

The Kohala Coast has had a long and active history of flooding largely due to flash flooding and intense storms. During the last 3 years, the South Kohala and Waikaloa areas have experienced intense flash flooding that has caused considerable damage. Kīlauea and Hualālai volcanoes are located in more arid regions but occasionally do receive intense rainfall that causes flash floods downslope. Annual rainfall ranges between to below 10 and 20 inches in the arid regions of Kawaihae and South Point. The young lavas that comprise the coastal terraces of Mauna Loa, Kīlauea, and portions of Hualālai, are very porous. Often heavy precipitation simply infiltrates into the rock and flows toward the sea in underground streams. As a result, stream flooding is generally less of a hazard on the younger coastlines. Flash floods, however, do happen on the slopes of Kīlauea, Hualālai, and Mauna Loa. During these times of intense rainfall, overland runoff will occur.

On the Island of Hawai‘i, high waves (10-20 feet) arrive from north swell each winter. Occasional extreme wave events do occur. The enormous north swells of February 1993 and January 1998 brought 20-30 foot waves to the north facing shores. Overwash of the Hilo breakwater and flooding of the coastal roads near Hilo, caused damage in November 1996 and January 1998. The summer south swell generally ranges 4-6 feet. Significant south swells also occur, such as in July 1986 and June 1995, producing 8-12 foot surf along southern shores. Ali‘i Drive in Kailua town, for example, is located particularly close to the ocean in many places and suffers periodic overwash. High waves of 6-8 feet can be produced by well-developed trade wind swell, but usually trade wind waves are 2-4 feet. Tropical storms and hurricanes bring damaging high waves of 10-30 feet to any and all shorelines.

Homes were flooded, roads closed, and emergency shelters filled as families flocked to find help during the floods that affected the Big Island from October 28-November 3, 2000. According to the National Weather Service, 26.22 inches fell at Hilo airport in 24-hours on November 1, 2000.

The previous record was 22.3 inches on February19-20, 1979. Damage in Hawai‘i County was estimated to be $20 million. Civil Defense Deputy Bruce Butts said 77 businesses and as many as 300 homes were damaged. At Pahala in the Ka‘ū District, two bridges on the Hawai‘i Belt Road were severely damaged. On November 3, Governor Cayetano declared the islands of Hawai‘i and Maui a disaster area, which authorizes use of major disaster fund, relocation and rehabilitation, housing relief, commercial and personal loan program, and relief to farmers.

On November 9, President Clinton declared Hawai‘i County a federal disaster area, which authorized federal assistance. More than 1,131 Hawai‘i Island flood victims registered for assistance through FEMA's toll-free tele-registration number since November 30, 2000. The US Small Business Administration (SBA) approved $2,210,000.00 in low interest disaster loans. For more information on Federal disaster recovery on Hawai‘i Island, see the County of Hawai‘i Hazard Mitigation Plan.

During August 2-4, 2004 as the remnant swirl of Darby moved closer to the unstable region, thunderstorms began to develop. The first round of thunderstorms occurred just north and east of the Big Island on August 2. That night, additional showers and thunderstorms formed across parts of the Big Island, particularly the normally dry Kona side. Rainfall amounts of 2 to 5 inches over a few hours were reported, and this led to flooding and closures of several roads. Two subsequent High Winds and Flooding Rains weather events occurred on December 4-11, 2007 and December 10-14, 2008. While the December 2011 event caused widespread flooding, the December 2008 rainfall on the island brought much needed drought relief.

Table 9.4 County of Hawai'i Stream Flooding from Atlas of Natural Hazards in the Hawaiian Coastal Zone (Updated)[17]

Hawai'i - Island wide stream flooding because of heavy rains	
1959 Aug 4-7	H Dot
1979 Feb 19-20	Flooding
1979 Dec 14-18	Flooding
1980 Mar 6-25	Episodes of flooding
1981 Oct 27-28	Flash flooding
1982 Jul 21-22	TD Daniel, flash flooding
1984 Dec 24-25	Kona storm, flooding
1986 Apr 8	Flooding
1986 Nov 10-11	Flooding
1987 Jul 21-23	Flooding
1987 Dec 11-19	Flooding
1988 Mar 14-18	Flooding
1988 Aug 4-8	H, flooding
1989 Feb 3-5	Flooding
1989 Mar 1-4	Flooding
1989 Jul 18-20	TS Dalilia, flooding
1990 Jan 14-22	Flooding
1992 Sep 14	TS Orlene, flooding
1992 Nov 29	Widespread flooding
1993 Jul 21-22	TS Dora, flooding
2003 Aug 31 - Sep 1	6 to 10" rain due to Jimena
2003 Nov 29 - Dec 8	Up to 11.01" rain
2004 Aug 3-4	Up to 5.56" rain due to remants of Darby
2006 Feb 19 - April 2	Up to 54.72" rain
2006 Oct 31- Nov 2	Up to 3.38" rain
2007 December 4-11	High winds (70-80 mph gusts) and rains, Widespread flooding across the county
Kohala	
1918 Apr 9-10	Flash flooding
1936 Jan 17	Flash flooding at N. Hi
1966 Nov 20	Flash flooding at S. Kohala
1967 Jan 11	Flooding
1982 Aug 9-10	Flash flooding
1983 Dec 24-26	Flooding
1986 Feb 16	Localized flooding
1986 Apr 8	Flooding at Waimea, Kohala
1989 Feb 3-5	Flash flooding at Pāhala
1989 Apr 28-29	Flash flooding at Waimea
1991 Aug 5-7	Flash flooding
1996 Sep 8-9	Flash flood S. Kohala and Waikaloa
1997 Jan 5	Widespread floods Waikaloa Village
Kailua-Kona	
1918 Apr 9-10	Flash flood at Kona sugar mill
1922 Oct 22	Flash floods at South Kona

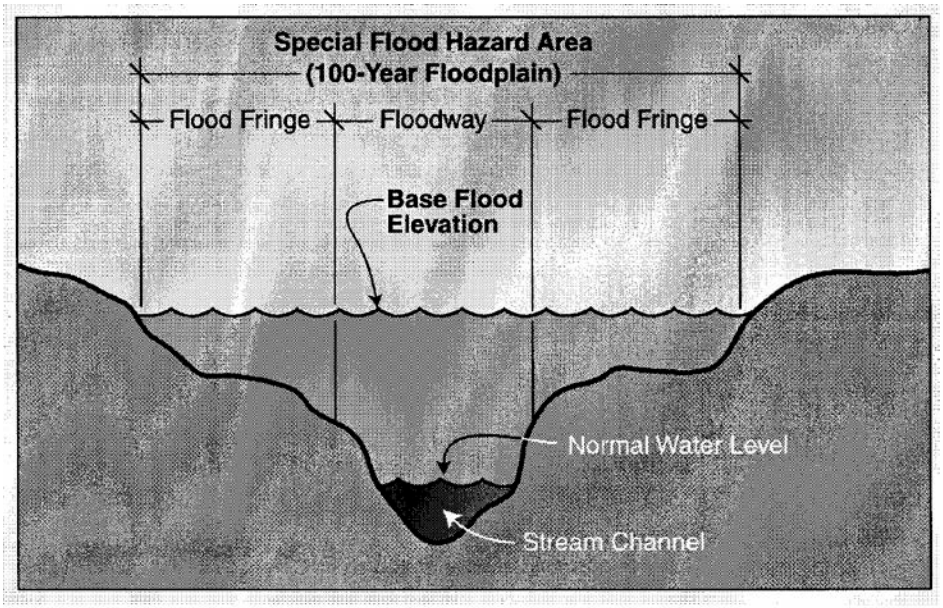
[17] Fletcher III, Charles H., E. Grossman, B. Richmond, A.E. Gibbs. 2002. Atlas of Natural Hazards in the Hawaiian Coastal Zone. US Department of the Interior US Geological Survey. CD-ROM. http://pubs.usgs.gov/imap/i2761/. Updated with information from NOAA National Weather Service http://www.prh.noaa.gov/hnl/pages/events/

1930 Jan 25	Holualua reservoir burst, flash floods
1961 Oct 30	Flash floods at South Kona
1963 Apr 29	Flash floods at Kainaliu
1965 Sep 25	Capt. Cook, Kainaliu
1966 Oct 3-5	Flash floods at Capt. Cook & Holualua
1967 Oct 12	Overland flow at Hoʻokena
1967 Oct 24	N. Kona
1968 Jul 17	Local flash flooding at Kealakekua
1968 Oct 3	Flash floods at N. Kona
1974 Oct 15	Flooding Kaloloa to Hōnaunau, 4.5" in 7 hrs.
1976 Apr 26	Flash flooding Hōnaunau
1982 Mar 17	Minor flooding at Kona
1985 Sep 29	Flash flooding Capt. Cook to Kealakekua
1985 Nov 19	
1986 Feb 16	Localized flooding at N. Kona
1989 Feb 3-5	Flash flooding at S. Kona
1992 Sep 17	Heavy thunderstorms, minor flooding
1996 Jun 22	2.1" in 1 hr., widespread flooding
1997 Jan 5	Widespread floods, Captain Cook to Kona
South Point	
1967 Nov 26-27	Severe flooding at Naalehu
1979 Feb 19-20	Nāʻālehu & Pāhala, 22.3" in 24 hrs.
Kaʻū	
1917 Mar 19	Flash flood
1945 Apr 8	Flash flood
1962 Mar 13-15	Overland flow at Pāhala
1980 Mar 18	Flooding
1982 Jul 16-17	TS Emilia
1982 Aug 1	TS Gilma
1985 Nov 19	Minor flash flooding in Kaʻu district
1986 Nov 8	Flash floods, 10" rain
1989 Jul 18-20	TS Dalilia flooding
1990 Jan 14-22	Flooding, over 20" rain
1990 Sep 14-28	Flooding
1990 Nov 18-20	Flooding, 30" rain
2007 December 4-11	Ten and twelve inches at the Kapāpala Ranch and Hawaiʻi Volcanoes National Park Headquarters gauges. Up to two feet of water covered portions of Highway 11 in the Kaʻu district
Hilo/Puna	
1928 Oct 1	Flash flood of Wailuku R.
1966 Jul 25	Sheet flow
1967 Aug 2-11	Flash flood, 12" rain
1971 Apr 23	Flash floods, 9.66" in 24 hrs.
1979 Feb 19-20	Flooding at Hilo, Keaʻau, Pāhoa, Kurtistown
1980 Mar 18	Flooding
1980 Sep 20-22	Flooding
1982 Mar 30-31	Flooding, 10" rain
1982 Jul 16-17	TS Emilia, flash flooding
1982 Jul 23	Flash flooding, 29" rain in July
1982 Aug 1	TD Gilma, flash flooding
1984 Nov 3-4	Flooding, 4-6" rain
1985 Sep 25	Flash floods
1986 Apr 3	Flash floods

1986 Sep 26	Flash flooding, 6-10” rain
1986 Nov 8	Flash flooding, 10” rain
1987 Oct 1	Flooding, 10-15” rain
1988 Aug 4-8	H Fabio, flooding in Hilo and Kurtistown
1990 Nov 18-20	Flooding, 30” rain
1991 Aug 3-4	Flash flood, 11” at airport
1992 Sep 14	TS Orlene, widespread flood
1993 Oct 3	5-7” rain Puna and Hilo
1994 Apr 11-12	Floods, landslides
2000 Nov 1-2	Flooding, landslides, 25” in 24 hrs.
Hāmākua Coast	
1890 Dec 9	Flash floods at Hāmākua, Honokaʻa
1902 Mar 6	Flash floods at Hāmākua
1965 Aug 4-5	Sheet flows
1982 Jul 16-17	Flash flooding at Hāmākua
1982 Aug 1	TD Gilma, flash flooding
1982 Aug 9-10	TS John, flash flooding at Honokaʻa
1983 Oct 26	Hāmākua Coast
1984 Feb 8	Flooding
1985 Mar 11	Flash flooding
1986 Mar 16	Flash flooding
1986 Apr 3	Flash flooding
1986 Apr 8	Flooding
1986 Sep 26	Flash floods, 6-10” rain
1987 May 5-6	Extensive flash flooding, over 10” rain
1987 Oct 1	Flooding, 10-15” rain
1987 Nov 21	Flash flooding
1988 Mar 14-18	Flooding, 5-10” rain
1989 Apr 28-29	Flooding at Honokaʻa
1989 Aug 20-21	Minor flash floods
1990 Dec 18-20	Flooding
1991 Aug 5-7	Flooding
1994 Apr 11-12	Floods, landslides
Waipiʻo Valley	
1902 Mar 6	Flash flooding
1972 Aug 18- Sep 3	Flash flooding
1978 Dec 6	Flooding
1979 Dec 14-18	Severe flooding
1989 Apr 4-9	Flooding
1991 Aug 5-7	Flooding

9.3 Probability of Occurrence

The recurrence interval of a flood, or flood frequency, is the average time interval within which a flood of a given magnitude will be equaled or exceeded. Flood frequencies can be determined by plotting a graph of the size of all known floods for an area and determining how often floods of a particular size may occur, or gathering hydrologic and hydraulic data from streams and calculating probabilities through models. The FIRM maps identify a flood hazard area as the area that would be inundated by a 100-year flood, or a flood with a 1% chance of occurring annually. The 100-year flood, also referred to as the base flood, is a national standard adopted by the NFIP that represents a compromise between minor floods and the greatest flood likely to occur in a given area (see Figure 9.2). The FIRM maps delineate the 100-year flood zones for rainfall flooding, coastal flooding, shallow flooding, and distinguish areas where detailed studies have been conducted to determine base flood elevations.



Special Flood Hazard Area is the area that has a 1% chance of being flooded in any given year (100-year floodplain). The 100-year flood is also referred to as the **base flood**.
Floodway is the stream channel and that portion of the adjacent flood plain that must remain open to permit passage of the base flood without raising the water surface elevation by more than one foot.
Flood Fringe is the area within the 100-year floodplain other than the floodway.
Base Flood Elevation (BFE) is the elevation of the water surface resulting from a 100-year flood in reference to a defined datum.

Figure 9.2 Flood Insurance Rate Map Terminology

9.4 Risk Assessment

9.4.1 Flood Insurance Maps

The National Flood Insurance Program (NFIP) sets minimum requirements for participating communities' building construction regulations. 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 protected against floods.

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.

Under the NFIP, FEMA is required to develop flood risk data for use in both insurance rating and floodplain management. FEMA develops these data through Flood Insurance Studies (FIS). In FISs, both detailed and approximate analyses are employed. Generally detailed analyses are used to generate flood risk data only for developed or developing areas of communities. For undeveloped areas where little or no development is expected to occur, FEMA uses approximate analyses to generate flood risk data.

Using the results of the FIS, FEMA prepares a Flood Insurance Rate Map (FIRM) that depicts the Special Flood Hazard Areas (SFHAs) within the studied community. SFHAs are areas subject to inundation by a flood having a one percent chance or greater occurring in any given year. The floodplain management and insurance requirements of the NFIP are based on the 100-

year flood (or base flood), which is the national standard. The FIRMS show base flood elevations (BFEs) and flood insurance risk zones. 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 SFHAs identified by approximate analyses, the FIRM shows only the flood insurance zone designation.

The FEMA FIRM zone designations are defined in Table 9.5 and maps of the islands of Kaua‘i, O‘ahu, Maui, Moloka‘i, and Hawai‘i showing the most current FEMA FIRM zone boundaries are included in Figure 9.3 through Figure 9.7. The five FIRM maps are based on information (map layers) provided by the State of Hawai‘i GIS Program.

Table 9.5 Definitions of FEMA Flood Insurance Rate Map (FIRM) Definitions

Zones VE and V1-V30
Zones VE and V1-V30 are the flood insurance rate zones 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.

Zones AE and A1-A30
Zones AE and A1-A30 are 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

Zones B, C, and X
Zones B, C, and X are the flood insurance rate zone that corresponds to areas outside the 1-percent annual chance floodplain. areas of 1-percent annual chance sheet flow flooding, where average depths are less than 1 foot, areas of 1-percent annual chance stream flooding where the contributing drainage area is less than 1 square mile, and- or areas protected from the 1 percent annual chance flood by levees. No base flood elevations or depths are shown within this zone.

Zone D
The Zone D designation is used for areas where there are possible but undetermined flood hazards. In areas designated as Zone D. no analysis of flood hazards has been conducted.

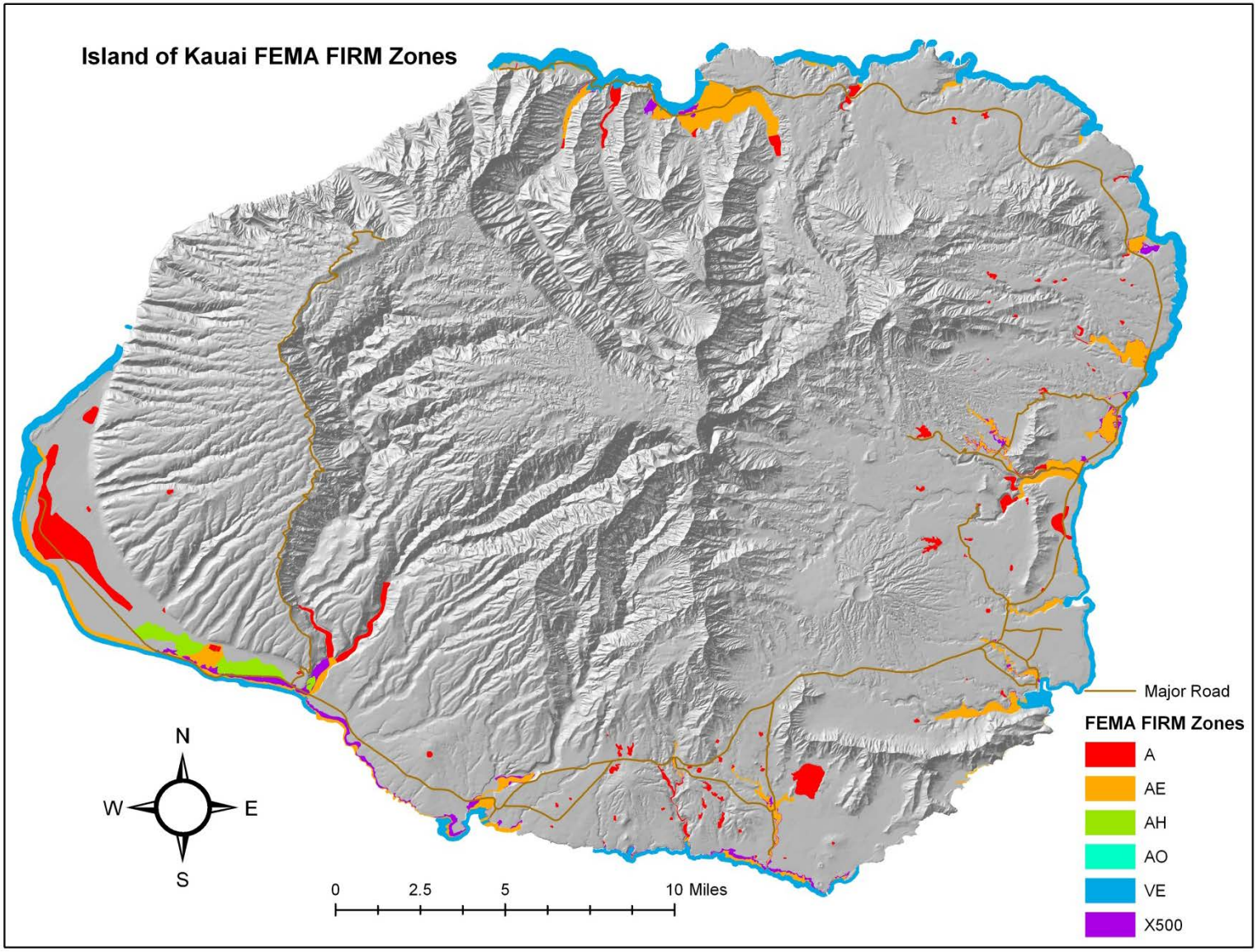


Figure 9.3 Island of Kaua‘i (County of Kaua‘i) FEMA FIRM Zones

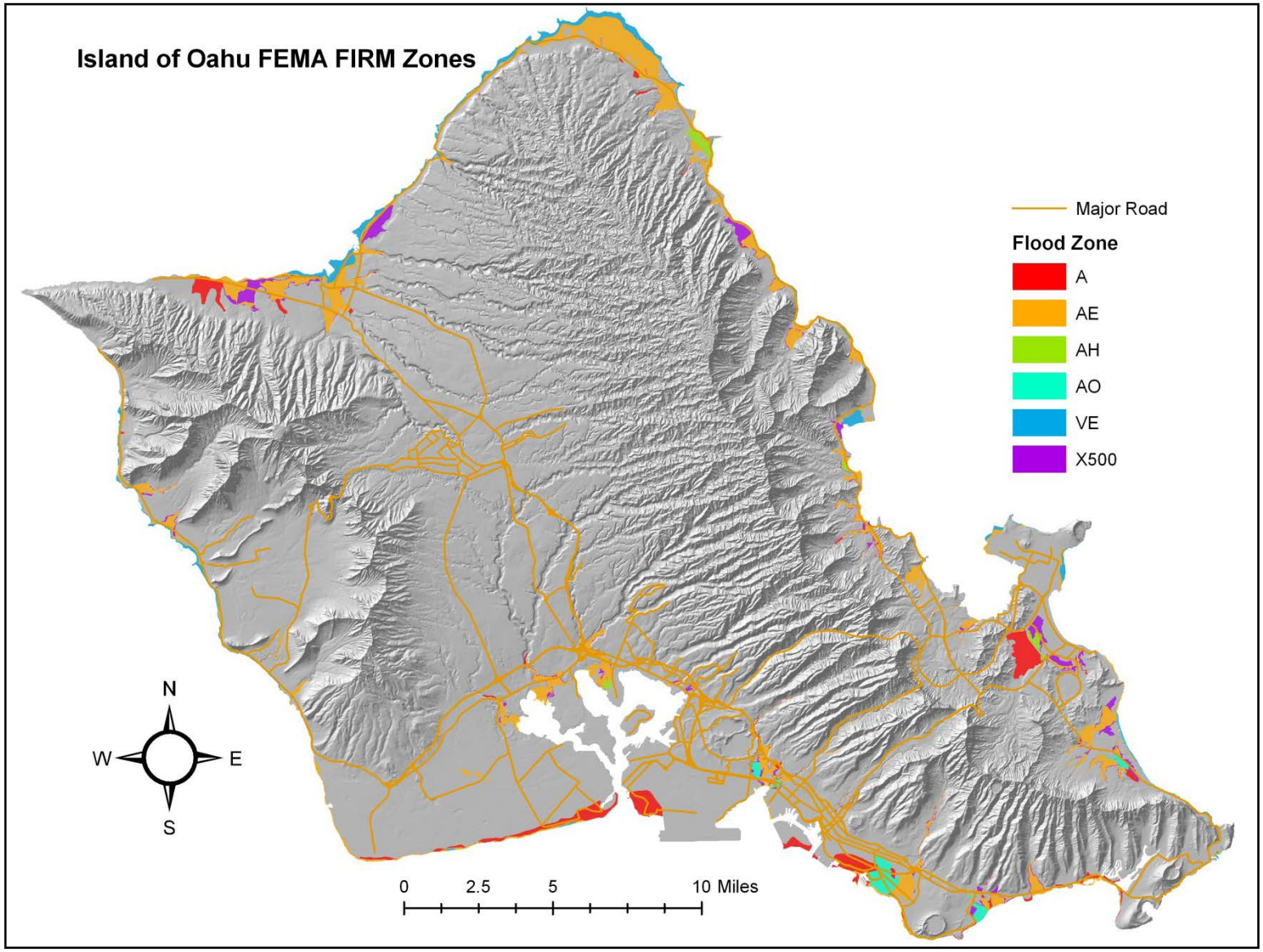


Figure 9.4 Island of O‘ahu (City and County of Honolulu) FEMA FIRM Zones

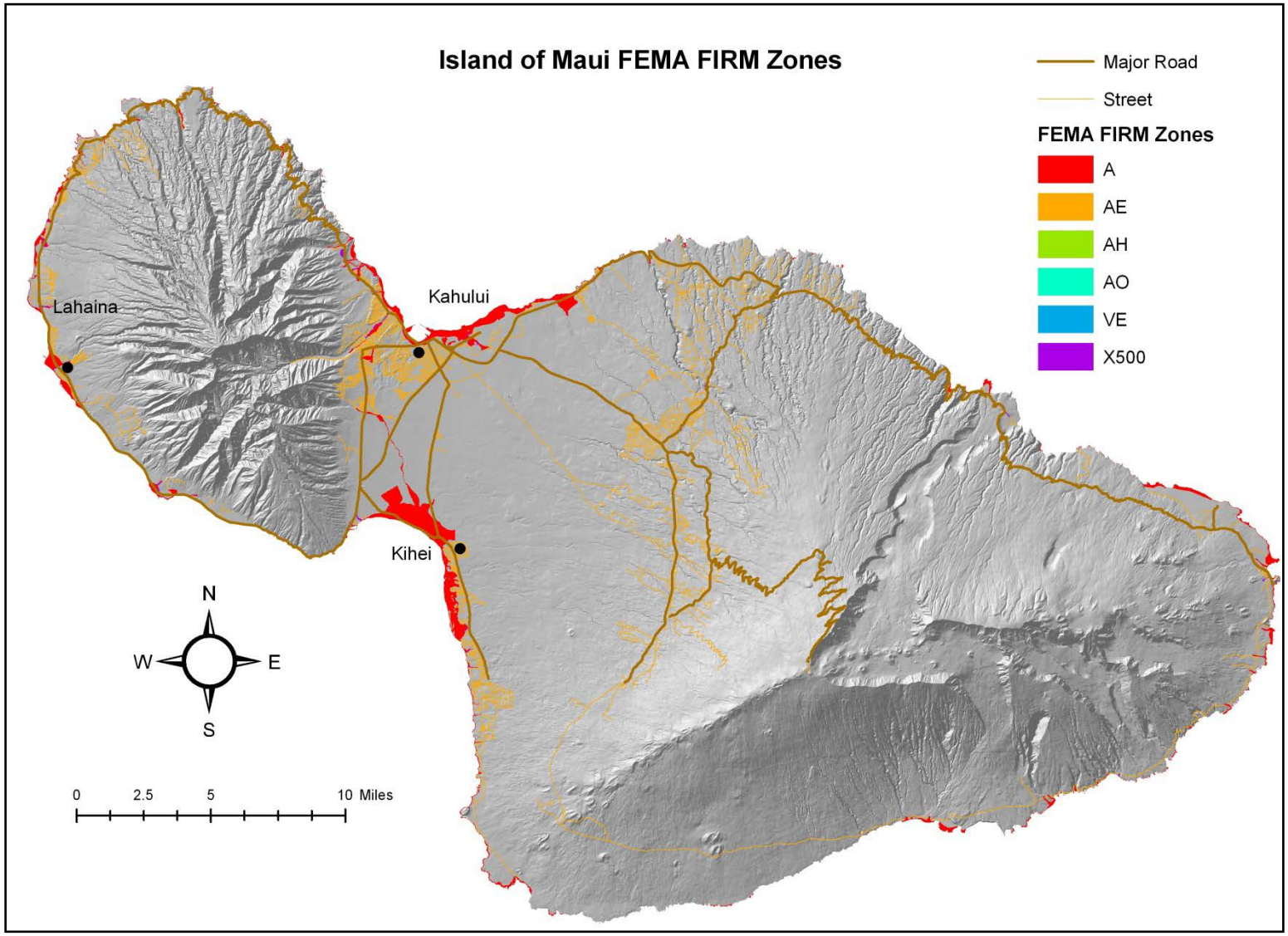


Figure 9.5 Island of Maui (County of Maui) FEMA FIRM Zones

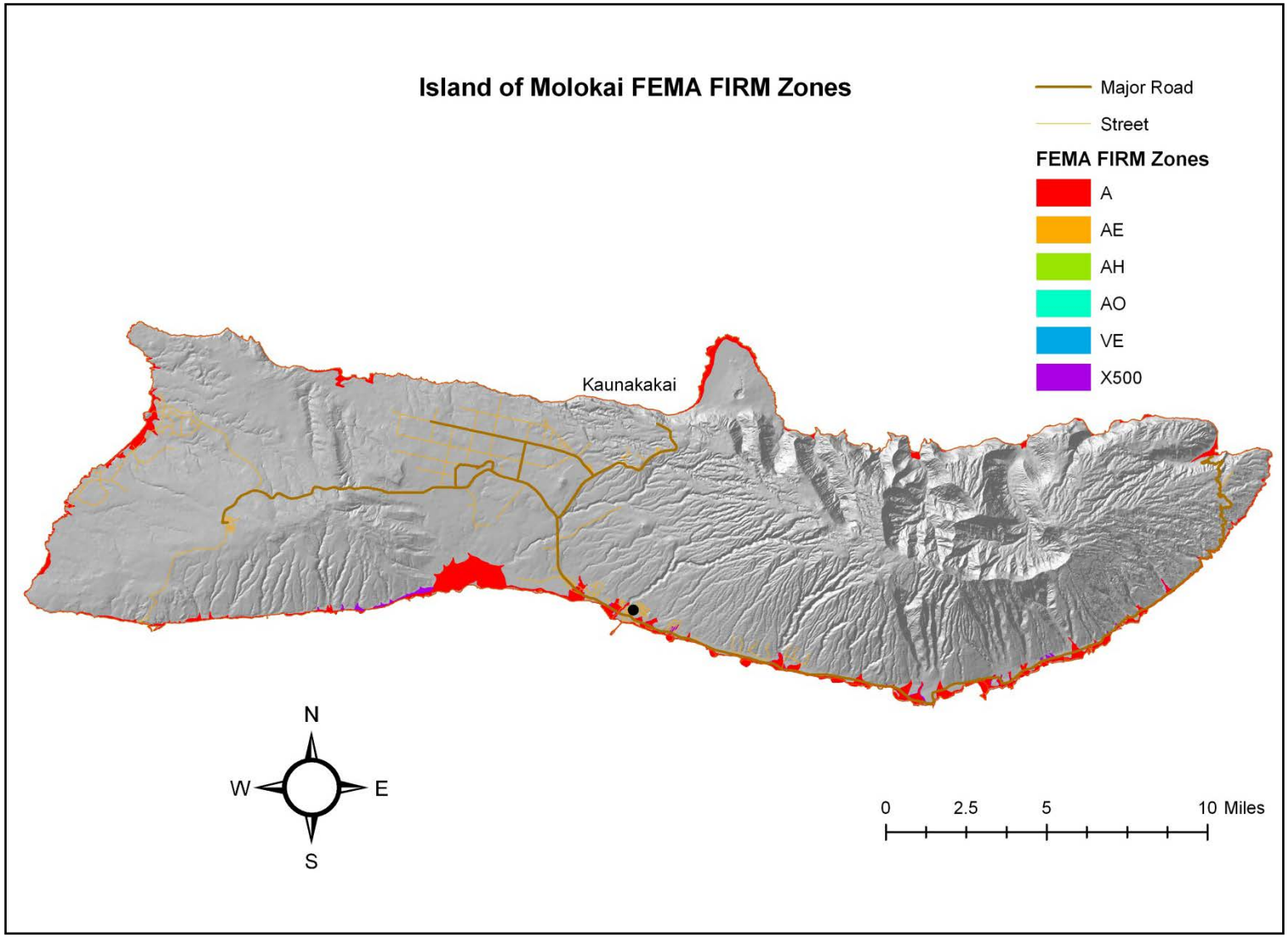


Figure 9.6 Island of Moloka‘i (County of Maui) FEMA FIRM Zones

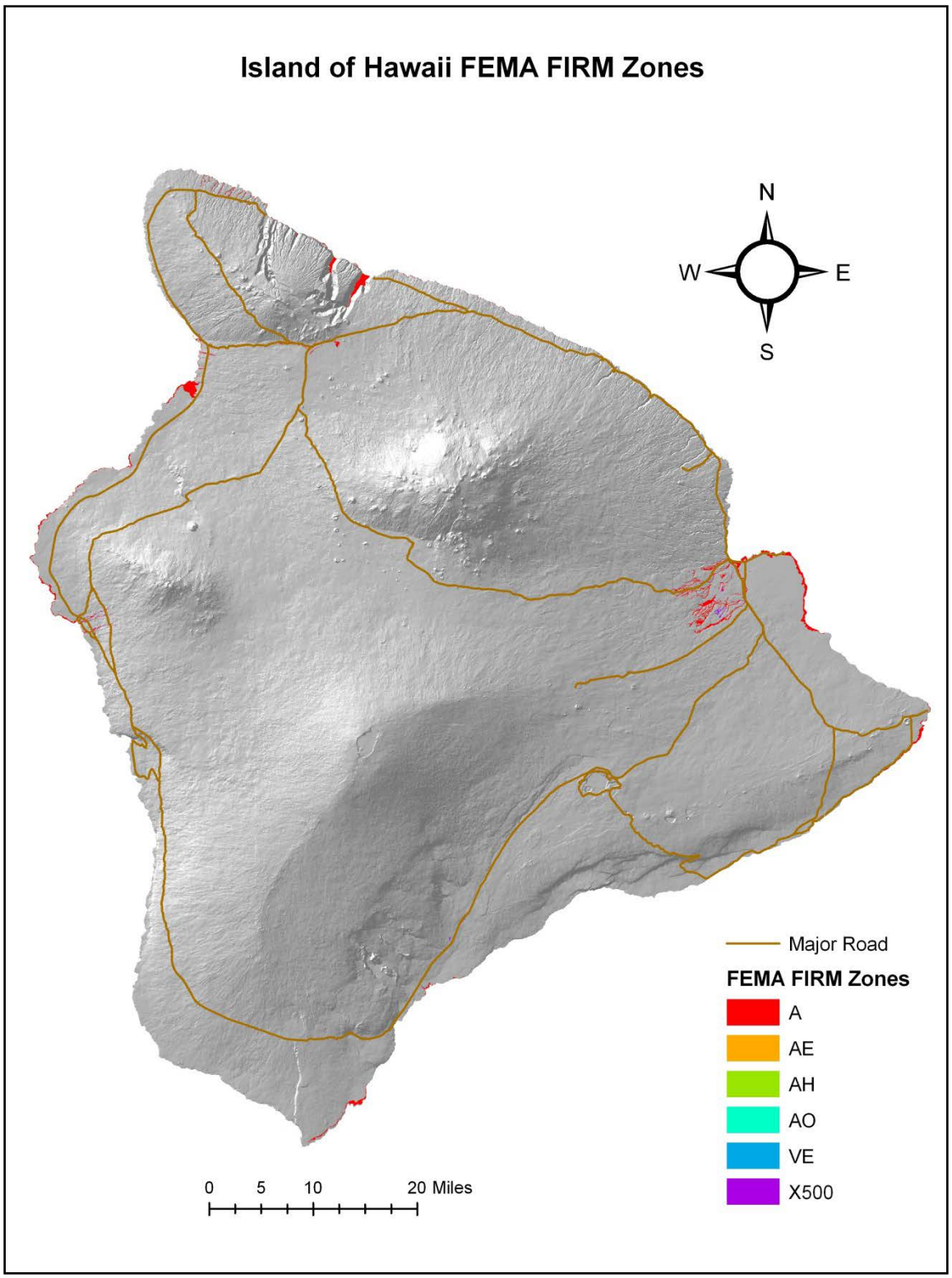


Figure 9.7 Island of Hawai‘i (County of Hawai‘i) FEMA FIRM Zones

Digital FIRM maps (dFIRMS) are currently at different stages of development for each of the four Counties. In the case of the County of Kaua‘i, the maps are readily available. For reference, the dFIRM index map for the County of Kaua‘i is shown in Figure 9.8. The map is based on detailed parcel maps and FIRM Maps that can be used in more detailed planning. The map can be found online at the County of Kaua‘i web portal for building and permitting at the following address: http://www.Kauai.gov/portals/Q7pw_enq/desiqn-permittinq/flood zone maps/lndexPanel.pdf. At this website, users can click on a section of map and get detailed access.

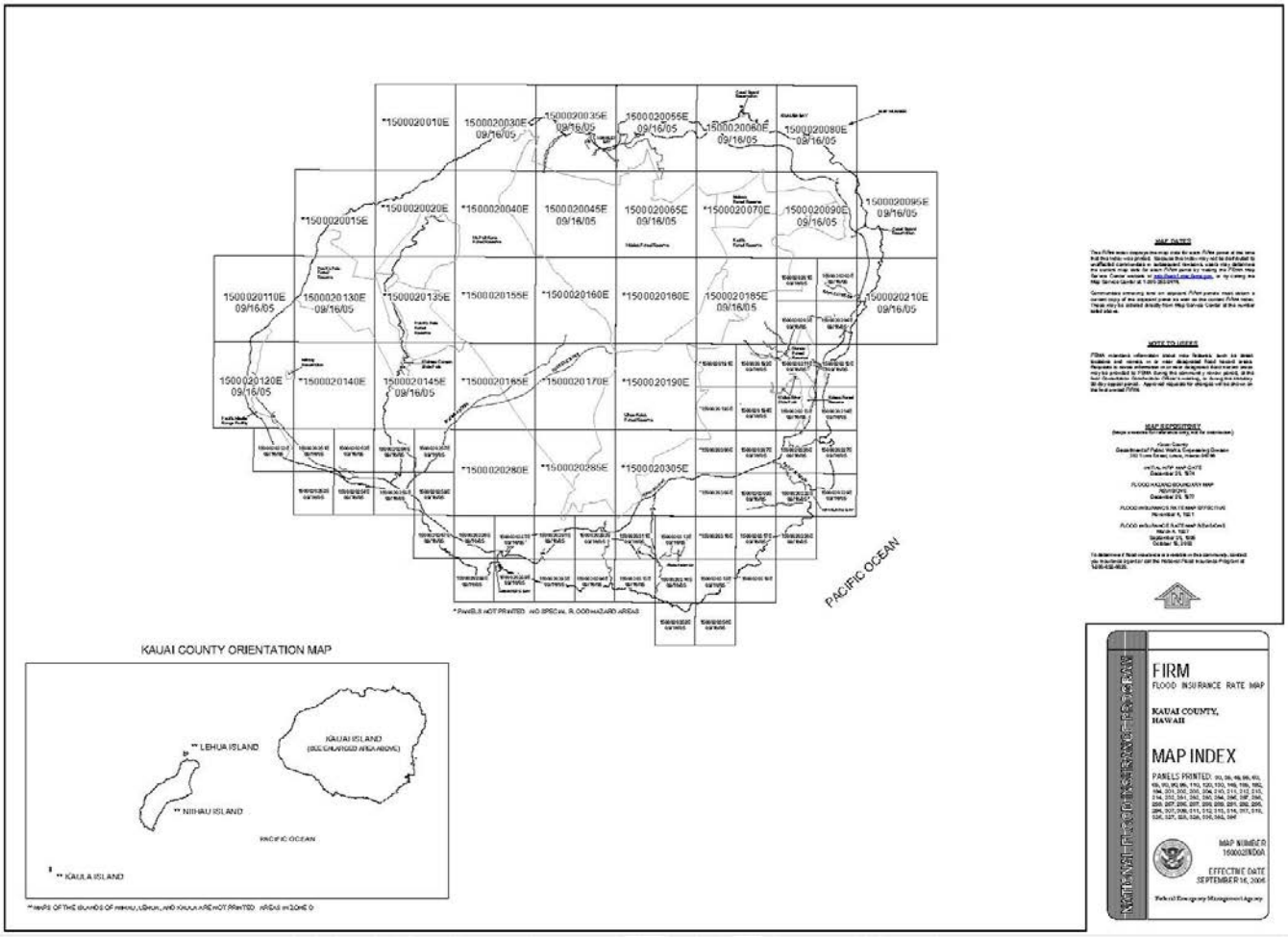


Figure 9.8 County of Kaua‘i dFIRM Zone Map

In the case of the City & County of Honolulu, GIS data including dFIRM zones are available to the public on County’s permit and planning website.[18] The GIS maps on the site enable the applications summarized in Table 9.6 to be shown on maps that can be zoomed in by parcel to see the interaction of the applications with land use, zoning, and utilities.

[18] See http://gis.hicentral.com/website/parcelzoning/viewer.htm.

Table 9.6 GIS Hazard Layers in the System

Topography 5'	☐ Flood	☐ Neighborhood Board	☐ Special Management Areas
☐ Flood Elev Lines	☐ Topography 5'	☐ Flood Elev Polys	☐ USGS Quad Map Mosaic (O‘ahu)
☐ Census Blocks 2000	☐ Council Districts	☑ FIRM Flood Sheets	☑ **Tsunami Evac. Zones**

The County of Maui is currently updating their website, http://mauigis.net/data/, for publicly served data that will include dFIRM maps. The dFIRM maps for the County of Hawai‘i are available on the County of Hawai‘i website at http://www.hawaii-county.com/maps/maps.html. Finally, general dFIRM information for all counties can also be found on FEMA’s website at the following address: https://hazards.fema.gov/wps/portal/mapviewer.

In comparison to the FIRM maps that can be produced from data provided by State of Hawai‘i GIS Program, the DFIRM maps have significantly enhanced detail at all scales. For example, FIRM maps for the County of Kaua‘i and for the City and County of Honolulu do not show the detailed elevation available in their corresponding dFIRM versions. For this plan update FIRM maps for the County of Maui and Hawai‘i are the best available general maps, but these lose detail at a County-wide scale. As the dFIRMs are finalized for the County of Maui and the County of Hawai‘i, the maps will be integrated into the State system and will be used in the modeling programs to assess damage risks.

9.4.2 National Flood Insurance Program

The Community Development and Regulatory Improvement Act was signed into law in 1994. This Act amended the enabling National Flood Insurance Program (NFIP) legislation in order to reduce federal spending on flood losses and to improve the financial status of NFIP. To this end, it directs federal loan agencies and federally regulated or insured lending institutions to "require flood insurance when making, increasing, extending, or renewing loans and to maintain the coverage for the life of the loan" for all homes in special flood hazard areas. The Act also authorizes: (1) mitigation assistance grants for states and communities to protect homes and businesses; and (2) mitigation insurance for rebuilding to meet improved design and construction standards.

In 1994, NFIP regulations were promulgated to require all property owners (including those in high-rise condominiums) in "special flood hazard areas" – as determined by the community’s Flood Insurance Rate Map – to insure their properties against flood damage equal to 80% of replacement value. Changes in NFIP regulations since 1994 have required additional homeowners in Hawai‘i to buy flood insurance. As a result, the number of Hawai‘i’s NFIP policies more than doubled over an eighteen-month period. In December 1994, there were 22,140 flood insurance policies statewide. By July 1996, the number of policies had increased to 47,801 giving the State of Hawai‘i the largest per capita participation in the NFIP in the United States, and third highest number of policies overall. Over the same period, the value of NFIP

policies in Hawai‘i increased from over $2.5 billion to over $5.7 billion. Summaries by county of the number of flood insurance policies in force before and after the NFIP as of March 31, 2013 are included in Table 9.7 and Table 9.8, respectively.

Table 9.7 Summary of Flood Insurance Policies in Force by County (Pre-FIRM)[19]

Zones	Kaua‘i	Honolulu	Maui	Hawai‘i	State
A01-30 & AE	854	7,522	3,759	1,051	13,186
A	12	456	149	76	693
AO	5	1,988	205	2	2,200
AH	103	410	266	6	785
V01-V30 & VE	259	967	846	532	2,604
V	0	0	0	1	1
D	0	421	0	0	421
B,C, & X	1,408	17,233	3,927	1,368	23,936
Standard	*1,169*	*15,301*	*3,508*	*1,134*	*21,112*
Preferred	*249*	*1,932*	*419*	*234*	*2,834*
Pre-FIRM Total	**2,651**	**28,997**	**9,152**	**3,036**	**43,836**

Table 9.8 Summary of Flood Insurance Policies in Force by County (Post-FIRM)[20]

Zones	Kaua‘i	Honolulu	Maui	Hawai‘i	State
A01-30 & AE	897	2,131	924	245	4,197
A	11	1,364	12	39	1,426
AO	8	1,399	217	9	1,633
AH	104	123	260	17	504
V01-V30 & VE	159	246	36	33	474
V	0	0	0	0	0
D	0	274	0	3	277
B,C, & X	1,518	2,861	1,799	670	6,848
Standard	*1,212*	*2,152*	*1,220*	*210*	*4,794*
Preferred	*306*	*709*	*579*	*460*	*2,054*
Pre-FIRM Total	**2,697**	**8,398**	**3,248**	**1,016**	**15,359**

[19] FEMA CIS Data as of 3/31/2013
[20] Ibid

9.4.3 Community Rating System

The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS:

1. Reduce flood losses;
2. Facilitate accurate insurance rating; and
3. 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), see Table 9.9. The CRS classes for local communities are based on 18 creditable activities, organized under four categories:

1. Public Information,
2. Mapping and Regulations,
3. Flood Damage Reduction, and
4. Flood Preparedness.

Table 9.9 National Flood Insurance (NFIP) Community Rating System (CRS)

Credit Points	Class	Premium Reduction SFHA*	Premium Reduction Non-SFHA**
4,500+	1	45%	10%
4,000 – 4,499	2	40%	10%
3,500 – 3,999	3	35%	10%
3,000 – 3,499	4	30%	10%
2,500 – 2,999	5	25%	10%
2,000 – 2,499	6	20%	10%
1,500 – 1,999	7	15%	5%
1,000 – 1,499	8	10%	5%
500 – 999	9	5%	5%
0 – 499	10	0	0

*Special Flood Hazard Area
**Preferred Risk Policies are available only in B, C, and X FIRM Zones for properties that are shown to have a minimal risk of flood damage. The Preferred Risk Policy does not receive premium rate credits under the CRS because it already has a lower premium than other policies. The CRS credit for AR and A99 FIRM Zones are based on non-Special Flood Hazard Areas (non-SFHAs) (B, C, and X FIRM Zones). Credits are: classes 1-6, 10% and classes 7-9, 5%. Premium reductions are subject to change.

As of the May of 2012, the Counties of Maui and Hawai‘i are the only two counties in the State to have thus far joined the CRS. Thanks to the enrollment of these two counties in the program, insurance purchasers throughout both counties currently enjoy a 10% reduction on flood insurance premiums (Communities in both the County of Maui and County of Hawai‘i are considered a Class 8 per Table 9.9). The two counties are currently exploring the feasibility of increasing the number of credit points to achieve Class 7 or better (15% discount or better).

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% 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 assistance is available to repair or restore public infrastructure and buildings in flood hazard areas if damaged by a disaster that is declared by the president.

9.4.4 Certified Flood Plain Manager Program

There is a program developed by State of Hawai'i Department of Land and Natural Resources (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. The State of Hawai‘i currently has 24 CFM listed on their website[21].

[21] http://www.hidlnr.org/eng/nfip/FldplainMgrs

9.4.5 Flood Losses in the State of Hawai‘i

Flooding in the State of Hawai‘i occurs frequently and affects every county. Over time, property damages have been large and many lives have been lost. Increasing development along the scenic coastal areas and shorelines has increased exposure to the risks of flooding and storm surges.

According to the State of Hawai‘i Department of Land and Natural Resources, floods from tsunami, hurricanes, and rainstorms caused more than 350 deaths, over $82 million in property damage, from 1860 until 1962. There is very little known about flooding events in Hawai‘i prior to 1860. Damage from floods from 1963 through 1982 totals about $395 million. From January 1983 to July 1992, twelve deaths have been attributed to flooding. The 1987 New Years' caused an estimated $35 million in damages. Floods in March 1991 resulted in damage estimated at $10-$15 million. Also, in December 1991, flood damages amounted to about $7 million.

In November 1996, heavy rains caused extensive damage along the Wai‘anae Coast and in the ‘Ewa Plains that resulted in a Presidential Disaster Declaration, FEMA-1147-DR-HI. Damages were estimated at $11 million.

Another Federal disaster was declared in November 2000 in Hawai‘i County (FEMA-1348-DR-HI). Heavy rains triggered extensive flooding in Hilo and along Highway 11 in the Ka'ū District. Damage for this disaster was estimated at $110 million.

The Mānoa Flood Disaster (FEMA-1575-DR-HI) in October 2004 resulted in more than $150 million in damages. The Mānoa Flood, which occurred on October 30, 2004, resulted in a disaster when the stream moved off course after being blocked by debris during a flash flood event. Additional costs included increased insurance premiums (nearly doubled) for the University of Hawai‘i. There were individual losses, such as vehicles in trees and home flooding. Additional costs related to loss of research and intellectual property, and the loss of future project opportunities.

The challenge to mitigating the hazard due to stream flooding is in large part one of obtaining adequate warning in the case of flash floods and in improving plans for development in areas of known historical flooding. There were several smaller flooding events, described in previous tables.

The extended wet period from February 19 to April 2, 2006, resulted in more than $80 million in early damage estimates, with mudslides, landslides, floods, and dam failure. For over a month, emergency personnel in state and county agencies were on watch and frequently responded to crises. The full extent of costs due to the hazard has not been fully assessed.

There have been two additional flood disaster declarations that have been assessed at $3.6 million in 2007 and $3.1 million in 2008 for damages assessed by FEMA. The ramifications of the flooding on business losses or areas affected but not devastated have not been included in these rates.

As of September 30, 2006, there were 54,309 National Flood Insurance Policies in effect in the State of Hawai‘i. The National Flood Insurance Program has paid a total of $51.7 million claims since 1974 to Hawai‘i’s policyholders. Since 1994, the number and total value of flood insurance policies have more than doubled in Hawai‘i. In December 1994, there were 22,140 flood insurance policies State-wide. In July 1996, the number of policyholders dramatically increased to 47,801 with the value increasing from $2.5 billion to about $5.7 billion. The foregoing makes Hawai‘i the largest per capital participant in the NFIP in the country and third highest in terms of number of policies. Active public education programs by the State and counties contributed to the rise of NFIP coverage in Hawai‘i. Such efforts are on-going.

9.4.6 Hurricane Flood Insurance Study for the Hawaiian Islands

The Hurricane Flood Insurance Study 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: Kaua‘i (Kaua‘i County), O‘ahu (City and County of Honolulu), Moloka‘i, Maui, Lāna‘i (Maui County), and Hawai‘i (Hawai‘i County). Although the effective (i.e., past) FIRMs for each county have accounted for tsunami hazards, 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 coast of each island. This is due to several factors, including the predominance of tsunami hazards and limited low-lying areas susceptible to hurricane hazards along the north shore of the islands. Table 9.10 provides a summary of study limits while Figure 9.9 shows the study limits in cartographic form.

Table 9.10 Summary of Study Limits

Island	Western Limit	Eastern Limit	Reach Length (Miles)
Hawai‘i	‘Upolu Point	Cape Kumukahi	193
Kaua‘i	Nohili Point	Kua‘ehu Point	56
Lāna‘i	Kaumalapau	Mānele	16
Maui	Honokahua Bay	Koali	69
Moloka‘i	‘Īlio Point	Cape Hālawa	54
O‘ahu	Ka‘ena Point	Kawaihoa Point	60
Total:			448

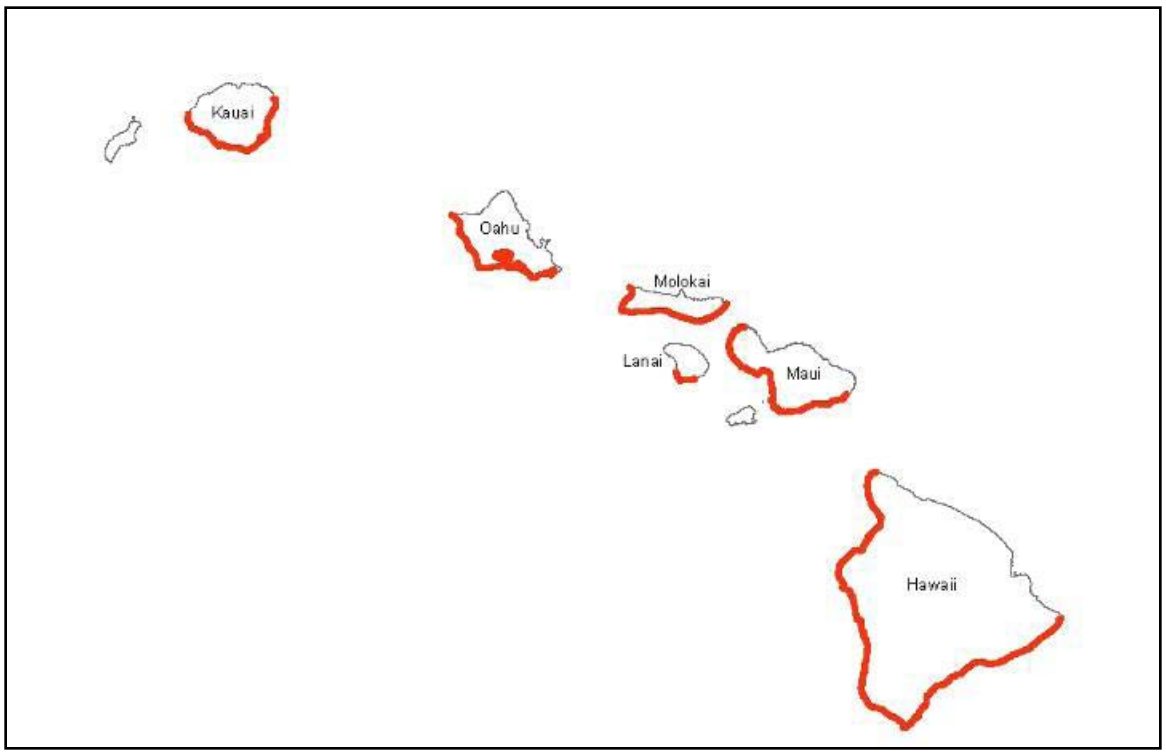


Figure 9.9 Extents of Hurricane Storm Surge Inundation Study

Transects were laid-out within the study limits and representative placement was evaluated during the field reconnaissance performed from July 24th through August 6th, 2007. The topographic base consisted of LiDAR collected under FEMA Task Orders 12 and 26. The LiDAR data were collected in the fall of 2006, post-processed to bare earth and quality controlled to meet FEMA mapping standards. These data were assimilated together with the best available bathymetric datasets, including USACE hydrographic LiDAR, into high-resolution seamless digital elevation models.

The hazard analysis considered the combination of storm surge and hurricane-induced wave hazards. This included independent analysis and/or modeling of storm surge, return frequency flood elevations, wave setup, overland wave hazards, and wave runup. The ADvanced CIRCulation model for coastal ocean hydrodynamics (ADCIRC) was selected to develop the stillwater elevations or storm surge for the study area. The Empirical Simulation Technique (EST), also developed by the USACE, was used to determine the stillwater frequency curves for the 10-, 2-, 1-, and 0.2-percent annual chance stillwater elevations. Deepwater wave conditions were determined using the Shore Protection Manual (SPM) prediction technique and limited fetch analyses were performed in harbor and sheltered areas. Wave setup was differentiated and evaluated for areas with and without fronting reefs. Areas of primary frontal dune were identified, delineated, and eroded. Overland wave propagation hazards were evaluated using the WHAFIS model. Wave obstructions were verified at representative transect locations by field reconnaissance. Wave run-up was evaluated using the RUNUP 2.0 and TAW methodologies, depending of the presence of reefs and local steepness of the bathymetry.

Wave hazard analyses were conducted at FIS transect locations, in addition to more tightly-spaced "mapping transects." These additional transects were facilitated by the application of an integrated GIS toolset that automates repetitive modeling tasks, and enables a more detailed analysis than typical coastal FIS studies. Wave setup values were assigned to these transects according to analysis at adjacent FIS transects. Otherwise, the mapping transects were treated with the same overland wave propagation and wave runup assessments as the FIS transects.

The coastal hazards determined from the above analyses were synthesized in the form of the standard FEMA special flood hazard boundaries for the Zone VE, Zone AE, Zone AO, and Zone X hazard areas. These are presented in the 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 0.2% return frequency stillwater elevation was exceeded by cumulative flood elevation from the 1% stillwater elevation and wave setup, therefore, the boundary of the 0.2% annual chance event was not delineated. In steeper areas where mapping scale limits the gutter placement, the SFHAs are only identified by the position of the 100-yr flood boundary. Mapped Base Flood Elevations (BFEs) 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 BFEs.

A Technical Support Data Notebook (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.

The Federal Emergency Management Agency updated its flood-risk maps, and, as a result, several hundred parcels on Oʻahu were shifted into high-risk flood zones. Those parcels are primarily along Oʻahu's west and south shores, from Kaʻena Point to Portlock, as well as Mekia Street in Wāimanalo and a small portion of Lāʻie. In some cases, such as in ʻEwa Beach, properties were taken out of the high-risk zone. The new flood maps took effect January 19, 2011.

The dFIRMs improves the ability of the state and counties to analyze risks related to the assets described in Chapter 4 to determine risk and vulnerability assessments.

9.4.7 Flood Map Modernization Efforts

With priorities in place, there are efforts underway to improve accuracy and update the flood insurance rate maps.

The State of Hawaiʻi FIRM maps are available on the Hawaiʻi National Flood Insurance Program website as part of a flood hazard assessment tool that enables property owners to determine their flood zone (http://gis.hawaiinfip.org/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 Revisions (LOMR), Conditional Letters of Map Revisions (CLOMR), and Flood Insurance Studies (FIS) are also available at this time through the FHAT.

9.4.8 State Land Use Districts

For Hawai‘i, 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.

9.4.8.1 Role of the Hawai‘i State Plan in State Reclassification Decisions

The Hawai‘i State Plan does contain goals, objectives and policies that influence the land-use district classification stage. In the Hawai‘i 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 Hawai‘i State Plan that are also relevant to proper coastal development and consistent with this manual 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 Hawai‘i'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 Hawai‘i'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 Hawai‘i 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 Hawai‘i State Plan that are recited above influence and guide State district reclassification decisions.

9.4.9 State Functional Plans

The State Functional Plans are part of the Hawai‘i State Planning System and set forth policies, guidelines and objectives within a specific field or activity. In Hawai‘i, 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 1991. If they are updated, specific policies, guidelines and objectives relating to coastal erosion and hazard mitigation could be included.

9.4.10 County General and Development Plans

The Hawai‘i Planning System also includes the county general and development plans. Since these plans are actively updated at the county level, the role of these documents in hazard mitigation is important to the development process relating to localized community planning.

9.4.11 State District Classification System

In Hawai‘i, 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.

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.

9.4.12 Hazard Mitigation in the County Zoning Process

Hazard mitigation can be and should be addressed during the county zoning process. The trigger to address hazard mitigation would occur when there is an amendment to change county zoning for a coastal property from a low-density use to a higher density use.

Key in the decision-making process is having the information for planning. This would require a hazard assessment. The authority for the counties to request a hazard assessment is fourfold. First, the counties may have in their zoning codes, specific provisions that request a county environmental report for a zoning amendment. These reports usually ask for a description of the physical, social and natural resource consequences of a proposed action. Second, the zoning codes require consistency with the general plans and community plans. These plans have objectives, policies and measures for hazard mitigation. Third, the county zoning code may impose criteria for zone change that there are no circumstances that would be adverse to the public health, safety or welfare.

An environmental assessment required under a county rule may have different standards of analysis than an environmental assessment under the State's Environmental Impact Statement Law. Whether it is required under State or county law, it is recommended that the environmental assessment address hazard mitigation issues.

Environmental Assessment Requirements for Various Stages of Development – Regulatory requirements at State and County levels as to when an environmental assessment is required versus the different development stages. The environmental assessment can be used as a justification for the hazard assessment but is not the only justification for a hazard assessment.[22]

[22] Hwang, 2003

Table 9.11 Required Permitting, Environmental and Hazard Assessments At Different Stages of Development

Stage of Development	Special Management Area Permit HRS §205A	Hawai'i 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. No – for agricultural, rural changes to urban	LUC rules require assessment	County reclassification of State districts (land <15 acres). 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

9.4.13 Repetitive Flood Losses

The criteria for repetitive loss are two or more NFIP claims of more $1,000 within any ten-year period since 1978. As of 2013, the State of Hawai‘i has 174 properties on the repetitive loss list (1.2% increase since 2010). With 97 properties (11.5% increase since 2010), the City and County of Honolulu has more than half of the State total. The County of Kaua‘i has 19 repetitive loss properties (18.8% increase since 2010), the County of Maui has 36 properties (100.0% increase since 2010), and the County of Hawai‘i has 45 properties (9.8% decline since 2010).

The number of properties on the Severe Repetitive Loss (SRL) list has only increased by one (1) from the previous 2010 version of this plan. As of July 2013, there are 9 validated and 2 pending repetitive loss properties: County of Kaua‘i-0 with 1 pending; City and County of Honolulu-3; County of Maui-1; and County of Hawai‘i-5 with 1 pending. The total payments for SRL properties as of the same date are estimated at $1,317,676. This figure includes $1,161,103 in building payments and $156,573 in content payments. A map of indicating the location of all SRL properties across the State is included in Figure 9.10.

The State of Hawai‘i Civil Defense (SDC) along with the State of Hawai‘i Department of Land and Natural Resources (DLNR) and the four County Governments will continue to work together to reduce the number of properties remaining on the repetitive loss list, which increased by 1.2% in the 2010 to 2013 period. The State Hazard Mitigation Forum will provide technical and scientific assistance. Mitigation measures to be considered for each property are: acquisition, re-location, elevation, or small flood control project. Due to the scarcity and high cost of land; the most likely solutions will either be elevation or small flood control project.

The following information pertains to the percentage of developed (urbanized) areas located in the 100 year floodplain by county. Source of information is the county NFIP coordinators:

County of Hawai‘i:	5%
County of Kaua‘i:	10%
County of Maui:	10%
City and County of Honolulu:	15%

The repetitive losses in Table 9.12 through Table 9.15 for each County follow, based on the best available data, which has been updated in 2013.

Table 9.12 Repetitive Loss Data for the County of Kaua‘i[23]

	City	Occupancy	Zone	Total Building Payment	Total Contents Payment	Losses	Total Paid	Mitigated?	Insured?
1	WAIMEA	SINGLE FMLY	AH	3,408.08	0.00	3	3,408.08	NO	YES
2	HANALEI	SINGLE FMLY	VE	4,033.88	0.00	2	4,033.88	NO	YES
3	ANAHOLA	SINGLE FMLY	AE	20,610.80	0.00	2	20,610.80	NO	NO
4	KEKAHA	SINGLE FMLY	AHB	8,545.83	0.00	2	8,545.83	NO	YES
5	KAPA‘A	SINGLE FMLY	AE	6,699.83	1,050.23	2	7,750.06	NO	YES
6	KAPA‘A	SINGLE FMLY	A09	11,763.75	1,391.01	2	13,154.76	NO	YES
7	KŌLOA	ASSMD CONDO	C	236,787.51	201,420.00	2	438,207.51	NO	NO
8	KAPA‘A	SINGLE FMLY	C	40,714.92	2,766.61	2	43,481.53	NO	NO
9	LĀWA‘I	NON RESIDNT	X	0.00	34,982.91	2	34,982.91	NO	YES
10	MAKAWELI	SINGLE FMLY	AE	35,652.46	15,349.75	2	51,002.21	NO	YES
11	KŌLOA	SINGLE FMLY	C	203,371.16	60,000.00	2	263,371.16	NO	YES
12	KŌLOA	SINGLE FMLY	C	370,000.00	78,181.80	2	448,181.80	NO	YES
13	KŌLOA	OTHER RESID	A	981,904.93	0.00	2	981,904.93	NO	YES
14	WAIMEA	SINGLE FMLY	A	19,423.83	0.00	2	19,423.83	NO	YES
15	KAPA‘A	SINGLE FMLY	A03	41,477.68	3,064.98	2	44,542.66	NO	YES
16	LIHUE	NON RESIDNT	A	15,903.70	0.00	2	15,903.70	NO	NO
17	HANALEI	NON RESIDNT	AE	0.00	11,889.12	2	11,889.12	NO	NO
18	KAUA‘I	SINGLE FMLY	AE	13,046.10	0.00	3	13,046.10	NO	NO
19	KAUA‘I	SINGLE FMLY	VE	9,462.06	0.00	2	9,462.06	NO	NO
	TOTAL			**2,022,806.52**	**410,096.41**		**2,432,902.93**		

[23] Hawai‘i NFIP Coordinator, Department of Land and Natural Resources Flood Program, 2013

Table 9.13 Repetitive Loss Data for the City and County of Honolulu[24]

	City	Occupancy	Zone	Tot Building Payment	Tot Contents Payment	Losses	Total Paid	Mitigated?	Insured?
1	KAILUA-KONA	2-4 FAMILY	EMG	1,709.81	11,481.93	2	13,191.74	NO	NO
2	PEARL CITY	SINGLE FMLY	A	2,435.13	6,148.25	2	8,583.38	NO	NO
3	HONOLULU	OTHER RESID	A04	189,546.21	0.00	2	189,546.21	NO	NO
4	HONOLULU	NON RESIDNT	EMG	0.00	12,678.46	2	12,678.46	NO	NO
5	HALEʻIWA	SINGLE FMLY	AE	24,694.63	2,300.00	3	26,994.63	NO	YES
6	WAIʻANAE	SINGLE FMLY	A	4,916.94	0.00	2	4,916.94	NO	NO
7	HONOLULU	NON RESIDNT	EMG	0.00	13,489.60	2	13,489.60	NO	NO
8	LĀʻIE	SINGLE FMLY	A	24,276.26	0.00	2	24,276.26	NO	NO
9	WAIʻANAE	SINGLE FMLY	D	8,552.36	0.00	3	8,552.36	NO	NO
10	KAILUA	SINGLE FMLY	C	4,457.70	186.40	2	4,644.10	NO	NO
11	HONOLULU	NON RESIDNT	X	36,808.88	7,645.87	2	44,454.75	NO	NO
12	HONOLULU	NON RESIDNT	A00	93,971.20	118,188.62	10	212,159.82	NO	SDF
13	KAILUA	SINGLE FMLY	AH	14,058.38	7,547.54	2	21,605.92	NO	NO
14	HONOLULU	NON RESIDNT	A06	0.00	104,757.18	2	104,757.18	NO	NO
15	HONLULU	NON RESIDNT	EMG	0.00	12,746.54	4	12,746.54	NO	NO
16	KAILUA KONA	2-4 FAMILY	EMG	93,561.64	0.00	4	93,561.64	NO	NO
17	HONOLULU	OTHER RESID	X	107,643.84	0.00	3	107,643.84	NO	YES
18	ʻEWA BEACH	SINGLE FMLY	A	19,428.53	4,359.01	2	23,787.54	NO	YES
19	HONO	SINGLE FMLY	AO	12,240.16	5,023.97	2	17,264.13	NO	NO
20	KĀNEʻOHE	SINGLE FMLY	X	12,192.76	10,207.77	3	22,400.53	NO	NO
21	HONOLULU	SINGLE FMLY	A	28,019.29	0.00	2	28,019.29	NO	NO
22	KAAWA	SINGLE FMLY	AE	4,896.69	5,351.00	2	10,247.69	NO	NO

[24] Hawaiʻi NFIP Coordinator, Department of Land and Natural Resources Flood Program, 2013

	City	Occupancy	Zone	Tot Building Payment	Tot Contents Payment	Losses	Total Paid	Mitigated?	Insured?
23	WAINAE	OTHER RESID	A04	79,372.50	0.00	2	79,372.50	NO	NO
24	KA‘A‘AWA	SINGLE FMLY	A	8,208.54	0.00	2	8,208.54	NO	NO
25	KA‘A‘AWA	SINGLE FMLY	AE	29,173.03	19,592.09	7	48,765.12	NO	SDF
26	HAU‘ULA	SINGLE FMLY	X	24,484.92	1,619.88	2	26,104.80	NO	YES
27	HAU‘ULA	SINGLE FMLY	X	29,693.51	2,905.50	2	32,599.01	NO	YES
28	HAU‘ULA	SINGLE FMLY	C	24,035.60	14,603.00	2	38,638.60	NO	NO
29	KAILUA	SINGLE FMLY	X	101,374.67	26,459.75	2	127,834.42	NO	YES
30	HONOLULU	NON RESIDNT	EMG	2,173.81	23,552.71	3	25,726.52	NO	NO
31	HALE‘IWA	SINGLE FMLY	A	25,215.75	0.00	3	25,215.75	NO	NO
32	KA‘A‘AWA	SINGLE FMLY	A04	12,788.24	874.39	3	13,662.63	NO	NO
33	PUNALU‘U	SINGLE FMLY	VE	27,056.77	0.00	2	27,056.77	NO	NO
34	HAU‘ULA	SINGLE FMLY	A	3,588.97	0.00	2	3,588.97	NO	NO
35	HAU‘ULA	SINGLE FMLY	VE	3,244.08	0.00	2	3,244.08	NO	NO
36	LĀ‘IE	SINGLE FMLY	A	15,734.83	0.00	2	15,734.83	NO	NO
37	HALE‘IWA	SINGLE FMLY	V24	14,990.77	3,881.79	3	18,872.56	NO	NO
38	KAILUA	ASSMD CONDO	AH	35,812.75	0.00	2	35,812.75	NO	YES
39	KA‘A‘AWA	SINGLE FMLY	AE	7,075.37	0.00	2	7,075.37	NO	YES
40	HALE‘IWA	SINGLE FMLY	X	1,360.00	1,475.00	2	2,835.00	NO	NO
41	KAILUA	SINGLE FMLY	X	4,828.27	0.00	2	4,828.27	NO	YES
42	HONOLULU	NON RESIDNT	B	22,150.08	25,000.00	2	47,150.08	NO	NO
43	HONOLULU	NON RESIDNT	B	429,264.17	0.00	6	429,264.17	NO	SDF
44	HONOLULU	NON RESIDNT	AE	22,176.75	0.00	3	22,176.75	NO	YES
45	HONOLULU	SINGLE FMLY	C	81,321.77	25,599.25	3	106,921.02	NO	YES
46	HONOLULU	SINGLE FMLY	A05	25,317.46	2,021.00	2	27,338.46	NO	YES

	City	Occupancy	Zone	Tot Building Payment	Tot Contents Payment	Losses	Total Paid	Mitigated?	Insured?
47	HONOLULU	SINGLE FMLY	D	52,377.44	0.00	2	52,377.44	NO	NO
48	HONOLULU	SINGLE FMLY	A04	262,732.51	30,102.67	3	292,835.18	NO	YES
49	HONOLULU	SINGLE FMLY	AE	19,701.30	392.08	2	20,093.38	NO	NO
50	HONOLULU	SINGLE FMLY	AE	21,568.43	0.00	4	21,568.43	NO	NO
51	HONOLULU	SINGLE FMLY	A04	12,714.51	40,518.00	2	53,232.51	NO	NO
52	KĀNEʻOHE	SINGLE FMLY	X	31,987.81	2,388.72	2	34,376.53	NO	YES
53	HALEʻIWA	2-4 FAMILY	C	18,925.15	4,585.50	5	23,510.65	NO	NO
54	KAILUA	SINGLE FMLY	EMG	10,427.50	0.00	2	10,427.50	NO	YES
55	WAIMĀNALO	SINGLE FMLY	C	67,383.03	4,071.63	3	71,454.66	NO	YES
56	KAʻAʻAWA	SINGLE FMLY		34,921.66	15,294.92	3	50,216.58	NO	YES
57	KAʻAʻAWA	SINGLE FMLY	AE	28,136.81	9,639.13	4	37,775.94	NO	SDF
58	HAUʻULA	SINGLE FMLY	A06	7,913.84	3,595.42	2	11,509.26	NO	NO
59	HAUʻULA	SINGLE FMLY	VE	94,683.76	90,076.00	2	184,759.76	NO	YES
60	HAUʻULA	SINGLE FMLY	V14	99,678.29	10,032.93	9	109,711.22	NO	SDF
61	HAUʻULA	SINGLE FMLY	AE	53,471.47	0.00	2	53,471.47	NO	YES
62	HONOLULU	NON RESIDNT	A0B	44,798.65	0.00	3	44,798.65	NO	NO
63	KAʻAʻAWA	SINGLE FMLY	V14	38,088.52	4,158.80	5	42,247.32	NO	NO
64	HONOLULU	SINGLE FMLY	X	87,744.78	0.00	2	87,744.78	NO	YES
65	HONOLULU	SINGLE FMLY	X	42,232.26	0.00	2	42,232.26	NO	NO
66	HONOLULU	SINGLE FMLY	AO	46,745.54	30,671.82	3	77,417.36	NO	YES
67	WAIʻANAE	SINGLE FMLY	AE	11,942.40	0.00	2	11,942.40	NO	NO
68	LĀʻIE	SINGLE FMLY	A	97,091.26	0.00	3	97,091.26	NO	YES
69	MĀKAHA	SINGLE FMLY	V22	67,504.57	30,946.92	2	98,451.49	NO	NO
70	WAIʻANAE	SINGLE FMLY	V22	19,381.30	0.00	2	19,381.30	NO	NO

	City	Occupancy	Zone	Tot Building Payment	Tot Contents Payment	Losses	Total Paid	Mitigated?	Insured?
71	MĀKAHA	SINGLE FMLY	V22	148,607.50	35,000.00	2	183,607.50	NO	NO
72	HONOLULU	SINGLE FMLY	AO	67,783.59	1,592.00	4	69,375.59	NO	YES
73	KAILUA	SINGLE FMLY	X	107,339.47	16,317.41	2	123,656.88	NO	YES
74	WAIʻANAE	SINGLE FMLY	AE	4,818.31	0.00	2	4,818.31	NO	YES
75	KAILUA	SINGLE FMLY	X	17,952.27	346.20	3	18,298.47	NO	YES
76	KAILUA	SINGLE FMLY	X	9,024.76	177.50	2	9,202.26	NO	YES
77	KAILUA	SINGLE FMLY	X	6,603.46	0.00	2	6,603.46	NO	YES
78	KAILUA	ASSMD CONDO	A04	59,019.26	35,025.58	4	94,044.84	NO	YES
79	KAILUA	ASSMD CONDO	C	16,810.62	6,659.29	2	23,469.91	NO	NO
80	LĀʻIE	SINGLE FMLY	A	65,506.18	8,129.30	3	73,635.48	NO	NO
81	LĀʻIE	SINGLE FMLY	A	14,250.55	9,775.25	2	24,025.80	NO	YES
82	HONOLULU	SINGLE FMLY	D	18,902.20	9,585.54	2	28,487.74	NO	YES
83	HONOLULU	SINGLE FMLY	AO	5,180.95	0.00	2	5,180.95	NO	YES
84	LĀʻIE	SINGLE FMLY	AH	52,507.85	10,739.74	3	63,247.59	NO	YES
85	LĀʻIE	SINGLE FMLY	AH	64,745.02	0.00	2	64,745.02	NO	NO
86	LĀʻIE	SINGLE FMLY	A	25,008.48	20,599.15	3	45,607.63	NO	YES
87	HONOLULU	NON RESIDNT	X	39,450.83	186,522.30	5	225,973.13	NO	NO
88	HONOLULU	NON RESIDNT	C	0.00	3,563.47	2	3,563.47	NO	NO
89	KAILUA	SINGLE FMLY	A	4,647.23	0.00	2	4,647.23	NO	NO
90	LOS GATOS	2-4 FAMILY	A	0.00	12,170.06	2	12,170.06	NO	NO
91	HONOLULU	SINGLE FMLY	AE	17,345.40	17,615.04	3	34,960.44	NO	NO
92	HONOLULU	SINGLE FMLY	A04	14,507.07	1,356.12	4	15,863.19	NO	NO
93	HONOLULU	SINGLE FMLY	X	24,435.22	14,760.00	2	39,195.22	NO	NO
94	HONOLULU	SINGLE FMLY	AE	44,608.32	0.00	2	44,608.32	NO	NO

	City	Occupancy	Zone	Tot Building Payment	Tot Contents Payment	Losses	Total Paid	Mitigated?	Insured?
95	HALE‘IWA	SINGLE FMLY	AE	25,147.04	0.00	3	25,147.04	NO	NO
96	HONOLULU	OTHER RESID	A04	51,786.12	0.00	2	51,786.12	NO	NO
97	HAU‘ULA	SINGLE FMLY	X	4,199.09	2,046.30	2	6,245.39	YES	NO
	TOTAL			**3,896,192.60**	**1,138,151.29**		**5,034,343.89**		

Table 9.14 Repetitive Loss Data for the County of Maui[25]

	City	Occupancy	Zone	Tot Building Payment	Tot Contents Payment	Losses	Total Paid	Mitigated?	Insured?
1	KAHULUI	SINGLE FMLY	C	38,999.00	5,347.81	3	44,346.81	NO	NO
2	KĪHEI	SINGLE FMLY	AO	3,363.26	753.69	2	4,116.95	NO	YES
3	LAHAINA	SINGLE FMLY	AE	17,933.91	0.00	2	17,933.91	NO	YES
4	WAILUKU	OTHER RESID	B	252,888.82	0.00	2	252,888.82	NO	YES
5	KĪHEI	2-4 FAMILY	A	9,100.00	0.00	2	9,100.00	NO	YES
6	KĪHEI	SINGLE FMLY	A	12,630.00	0.00	2	12,630.00	NO	YES
7	KĪHEI	SINGLE FMLY	AH	11,231.62	0.00	3	11,231.62	NO	YES
8	KĪHEI	SINGLE FMLY	AH	10,669.60	0.00	2	10,669.60	NO	YES
9	KĪHEI	OTHER RESID	V18	95,572.37	0.00	2	95,572.37	NO	YES
10	KĪHEI	OTHER RESID	V18	73,972.10	0.00	2	73,972.10	NO	YES
11	KĪHEI	SINGLE FMLY	AH	16,489.27	0.00	2	16,489.27	NO	YES
12	KĪHEI	SINGLE FMLY	AH	36,584.59	4,652.81	2	41,237.40	NO	NO
13	KĪHEI	SINGLE FMLY	AH	24,811.27	0.00	2	24,811.27	NO	YES
14	KĪHEI	OTHER RESID	V18	52,154.12	0.00	2	52,154.12	NO	YES
15	KĪHEI	ASSMD CONDO	A02	58,874.46	0.00	2	58,874.46	NO	YES
16	LAHAINA	SINGLE FMLY	X	40,439.65	4,104.85	2	44,544.50	NO	NO
17	LAHAINA	NON RESIDNT	X	73,247.19	0.00	3	73,247.19	NO	NO
18	KĪHEI	SINGLE FMLY	X	111,924.66	108,373.19	3	220,297.85	NO	NO
19	LAHAINA	OTHER RESID	A04	9,946.98	0.00	2	9,946.98	NO	NO
20	LAHAINA	OTHER RESID	C	6,022.82	0.00	2	6,022.82	NO	NO
21	LAHAINA	SINGLE FMLY	AE	47,152.40	7,782.00	2	54,934.40	NO	NO
22	KĪHEI	SINGLE FMLY	AO	81,896.87	0.00	2	81,896.87	NO	YES

[25] Hawai‘i NFIP Coordinator, Department of Land and Natural Resources Flood Program, 2013

	City	Occupancy	Zone	Tot Building Payment	Tot Contents Payment	Losses	Total Paid	Mitigated?	Insured?
23	LAHAINA	SINGLE FMLY	VE	40,651.86	11,617.24	2	52,269.10	NO	NO
24	LAHAINA	NON RESIDNT	C	1,318.36	3,904.00	2	5,222.36	NO	YES
25	KĪHEI	SINGLE FMLY	AO	13,974.76	0.00	2	13,974.76	NO	NO
26	KĪHEI	SINGLE FMLY	AO	26,108.44	0.00	2	26,108.44	NO	NO
27	KĪHEI	SINGLE FMLY	AO	135,850.29	0.00	3	135,850.29	NO	YES
28	KĪHEI	SINGLE FMLY	A	57,272.68	4,852.13	3	62,124.81	NO	YES
29	KĪHEI	SINGLE FMLY	AH	119,482.67	865.00	4	120,347.67	NO	YES
30	KĪHEI	ASSMD CONDO	AH	76,337.98	0.00	2	76,337.98	NO	YES
31	KĪHEI	2-4 FAMILY	AO	52,597.69	0.00	4	52,597.69	NO	YES
32	LAHAINA	SINGLE FMLY	C	52,535.73	15,608.91	5	68,144.64	NO	NO
33	LAHAINA	SINGLE FMLY	C	124,180.09	56,008.09	4	180,188.18	NO	NO
34	LAHAINA	SINGLE FMLY	X	172,645.02	52,281.44	5	224,926.46	NO	SDF
35	KĪHEI	SINGLE FMLY	C	4,284.73	0.00	2	4,284.73	YES	NO
36	KĪHEI	SINGLE FMLY	AO	131,841.27	0.00	2	131,841.27	YES	YES
	TOTAL			**2,094,986.53**	**276,151.16**		**2,371,137.69**		

Table 9.15 Repetitive Loss Data for the County of Hawai'i[26]

	City	Occupancy	Zone	Tot Building Payment	Tot Contents Payment	Losses	Total Paid	Mitigated?	Insured?
1	KAILUA KONA	ASSMD CONDO	V15	259,570.01	0.00	9	259,570.01	NO	NO
2	KAILUA KONA	OTHER RESID	V15	137,501.83	0.00	7	137,501.83	NO	NO
3	KAILUA KONA	NON RESIDNT	EMG	9,103.03	705.38	2	9,808.41	NO	NO
4	KAILUA KONA	SINGLE FMLY	V15	0.00	20,444.23	2	20,444.23	NO	NO
5	KAILUA KONA	OTHER RESID	VE	44,996.22	4,908.20	4	49,904.42	NO	YES
6	KAILUA KONA	OTHER RESID	VE	60,479.53	0.00	5	60,479.53	NO	YES
7	KAILUA KONA	OTHER RESID	V15	38,134.12	0.00	2	38,134.12	NO	YES
8	KAILUA KONA	2-4 FAMILY	V15	17,560.40	10,500.00	2	28,060.40	NO	NO
9	KAILUA KONA	OTHER RESID	VE	72,032.82	41,354.46	6	113,387.28	NO	SDF
10	KAILUA KONA	SINGLE FMLY	A04	81,430.85	15,675.10	2	97,105.95	NO	NO
11	KAILUA KONA	SINGLE FMLY	A	62,308.00	5,344.00	2	67,652.00	NO	NO
12	KAILUA KONA	SINGLE FMLY	VE	47,670.38	10,576.60	5	58,246.98	NO	YES
13	KAILUA KONA	SINGLE FMLY	X	194,887.30	23,672.99	7	218,560.29	NO	SDF
14	KAILUA KONA	SINGLE FMLY	V22	123,535.22	63,188.06	4	186,723.28	NO	YES
15	KAILUA KONA	SINGLE FMLY	AE	72,508.52	13,170.44	3	85,678.96	NO	YES
16	KAILUA KONA	SINGLE FMLY	VE	32,833.01	4,295.55	3	37,128.56	NO	YES
17	KAILUA KONA	2-4 FAMILY	VE	236,256.35	26,517.78	12	262,774.13	NO	SDF
18	KAILUA KONA	SINGLE FMLY	VE	0.00	15,544.68	3	15,544.68	NO	SDF
19	KAILUA KONA	2-4 FAMILY	VE	11,785.28	0.00	2	11,785.28	NO	NO
20	KAILUA KONA	2-4 FAMILY	VE	247,900.79	0.00	7	247,900.79	NO	SDF
21	KAILUA KONA	2-4 FAMILY	X	15,546.83	0.00	4	15,546.83	NO	NO
22	KAILUA KONA	OTHER RESID	VE	215,540.54	0.00	6	215,540.54	NO	SDF

[26] Hawai'i NFIP Coordinator, Department of Land and Natural Resources Flood Program, 2013

23	HILO	SINGLE FMLY	A	80,742.42	0.00	3	80,742.42	NO	YES
24	HILO	NON RESIDNT	V27	5,023.92	0.00	2	5,023.92	NO	NO
25	KAILUA KONA	NON RESIDNT	VE	156,647.58	35,467.09	6	192,114.67	NO	NO
26	HILO	NON RESIDNT	D	0.00	7,032.15	2	7,032.15	NO	NO
27	HILO	SINGLE FMLY	A	101,108.79	0.00	2	101,108.79	NO	SDF
28	HILO	SINGLE FMLY	A	62,454.06	891.80	3	63,345.86	NO	NO
29	HILO	SINGLE FMLY	AO	161,892.47	38,292.99	3	200,185.46	NO	NO
30	HILO	SINGLE FMLY	AE	186,503.49	47,578.50	2	234,081.99	NO	NO
31	HILO	NON RESIDNT	A26	0.00	4,658.89	2	4,658.89	NO	NO
32	HILO	SINGLE FMLY	X	49,378.24	14,652.32	2	64,030.56	NO	YES
33	HILO	SINGLE FMLY	D	4,832.01	0.00	2	4,832.01	NO	YES
34	HILO	SINGLE FMLY	AE	12,676.93	0.00	2	12,676.93	NO	NO
35	HILO	SINGLE FMLY	X	40,553.90	0.00	3	40,553.90	NO	YES
36	KAMUELA	NON RESIDNT	X	286,202.86	12,994.20	2	299,197.06	NO	NO
37	HILO	NON RESIDNT	VE	0.00	34,581.21	3	34,581.21	NO	NO
38	HILO	ASSMD CONDO	VE	138,542.61	16,858.43	2	155,401.04	NO	YES
39	HILO	NON RESIDNT	V27	15,671.06	14,442.28	2	30,113.34	NO	YES
40	HILO	OTHER RESID	V27	19,152.98	0.00	2	19,152.98	NO	NO
41	KAMUELA	SINGLE FMLY	V15	6,814.52	5,525.07	2	12,339.59	NO	YES
42	KAMUELA	SINGLE FMLY	A04	40,138.99	28,534.81	3	68,673.80	NO	NO
43	PUAKŌ	2-4 FAMILY	V15	8,541.11	387.04	2	8,928.15	NO	NO
44	PĀHOA	SINGLE FMLY	V24	8,734.86	0.00	2	8,734.86	NO	NO
45	VACATIONLAND	SINGLE FMLY	A	7,528.82	0.00	2	7,528.82	NO	NO
	TOTAL			**3,374,722.65**	**517,794.25**		**3,892,516.90**		

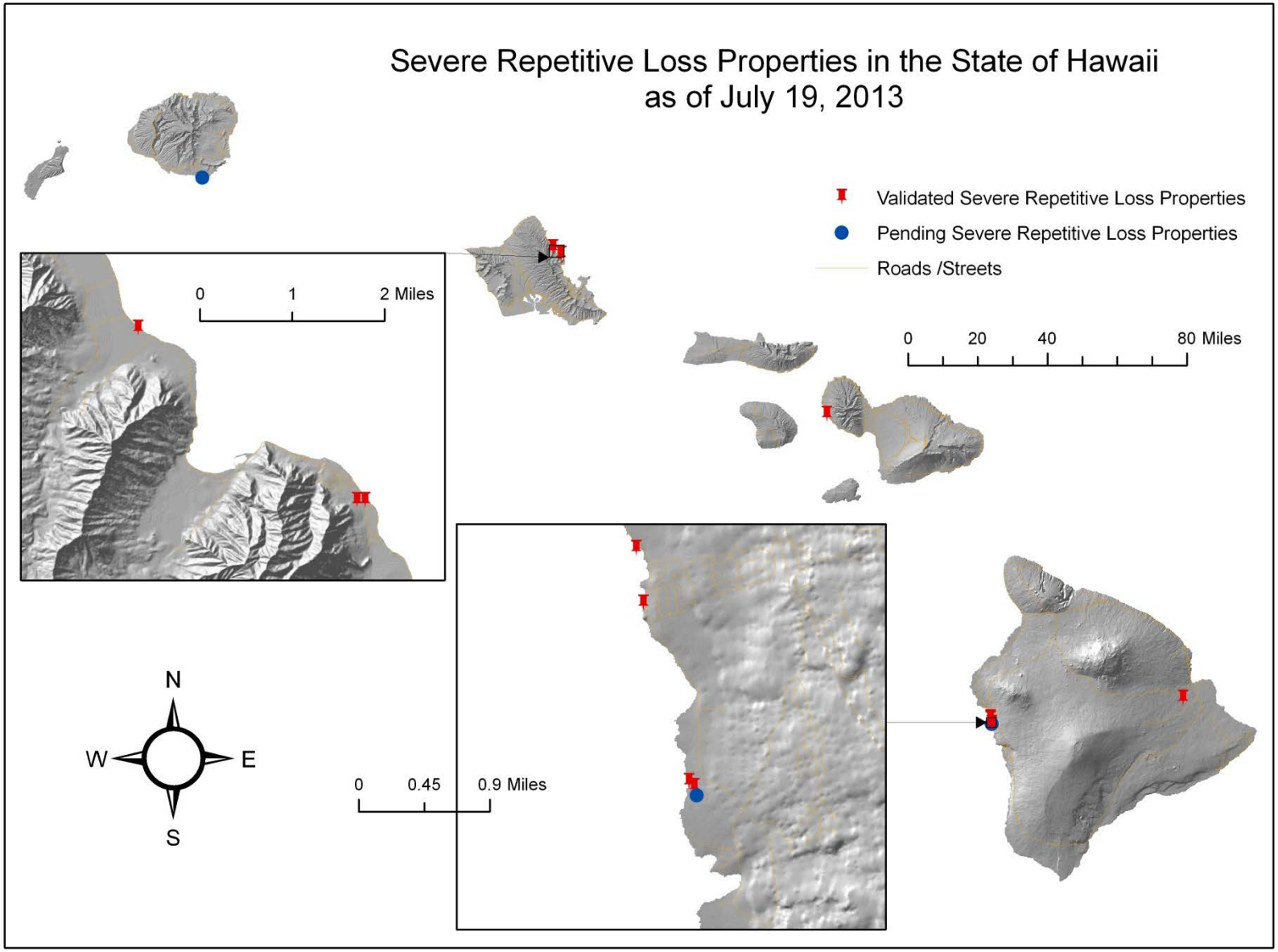


Figure 9.10 State of Hawai‘i Severe Repetitive Losses as of July 19, 2013

9.4.14 Structural Risk and Vulnerability Related to Flood Loss

In the process of preparing the structural risk and vulnerability assessments for the University of Hawai‘i System, flood scenarios were developed using modified analyses of the HAZUS-MH program. The buildings had been visually inspected as part of the engineering survey and data gathering process.

The HAZUS model revealed an average annual flood loss for each campus, with the University of Hawai‘i at Mānoa having the highest risk and Honolulu Community College with the highest risk among community colleges (see Figure 9.11). These results reflect the geographic proximity to streams that have experienced severe flooding. The model predicted losses from theoretical flooding events at the University of Hawai‘i at Mānoa ranging from $3-18 million for return periods between 10-500 years. Figure 9.12 and Figure 9.13 show the typical extent of a flood at the University of Hawai‘i at Mānoa and the buildings that would be primarily affected by such flood. The losses predicted at Honolulu Community College for a 100-year flood by the HAZUS model totaled nearly $20 Million. Without historical evidence to substantiate this value, and with all other uncertainties involved, the value was reduced 75% when computing the average annual loss. The spatial extent and affected buildings at Honolulu Community College are shown in Figure 9.14.

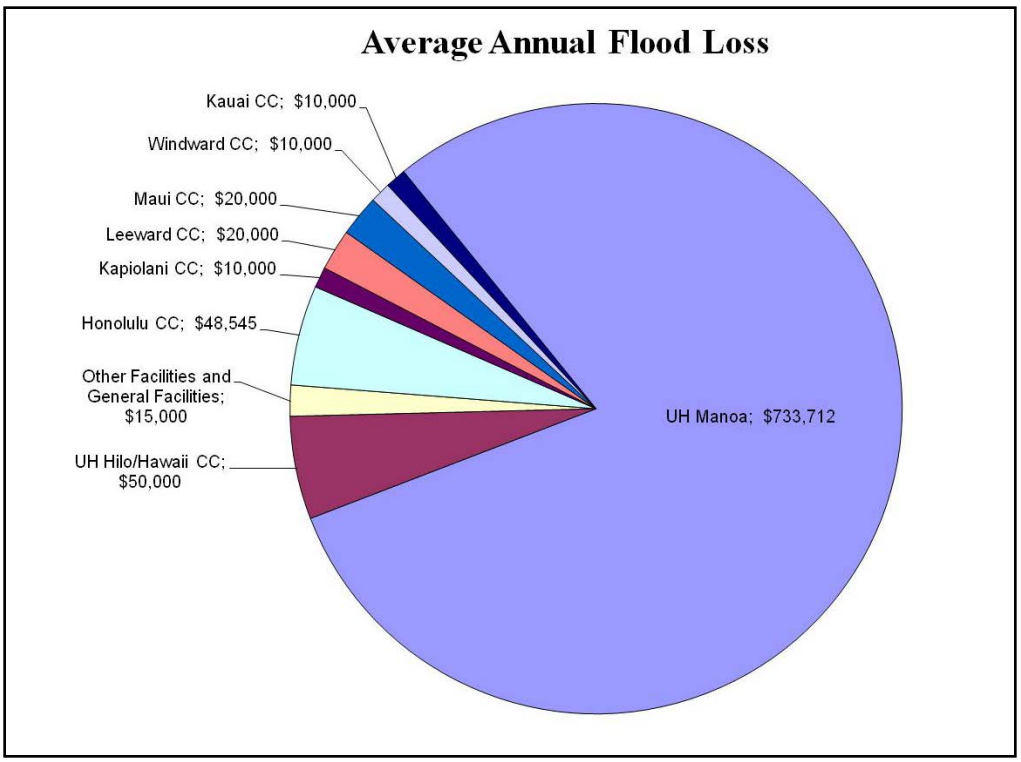


Figure 9.11 Average annual flood loss for all UH campuses

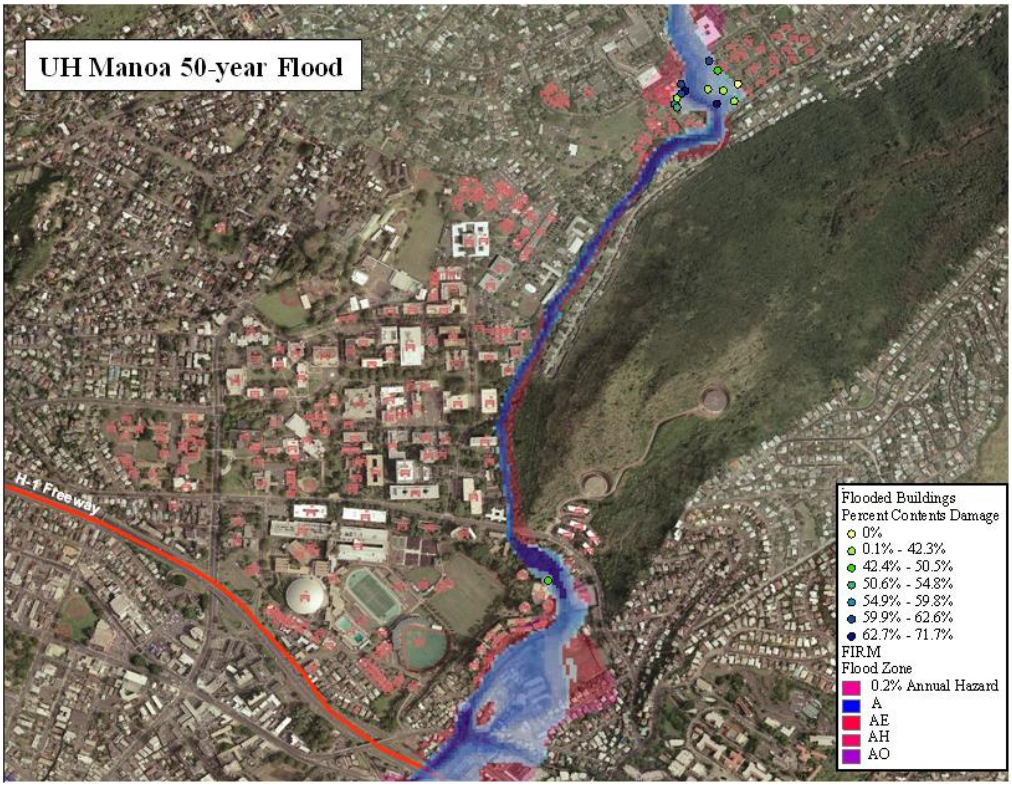


Figure 9.12 Spatial extent and buildings affected by a theoretical 50-year flood at UH Mānoa

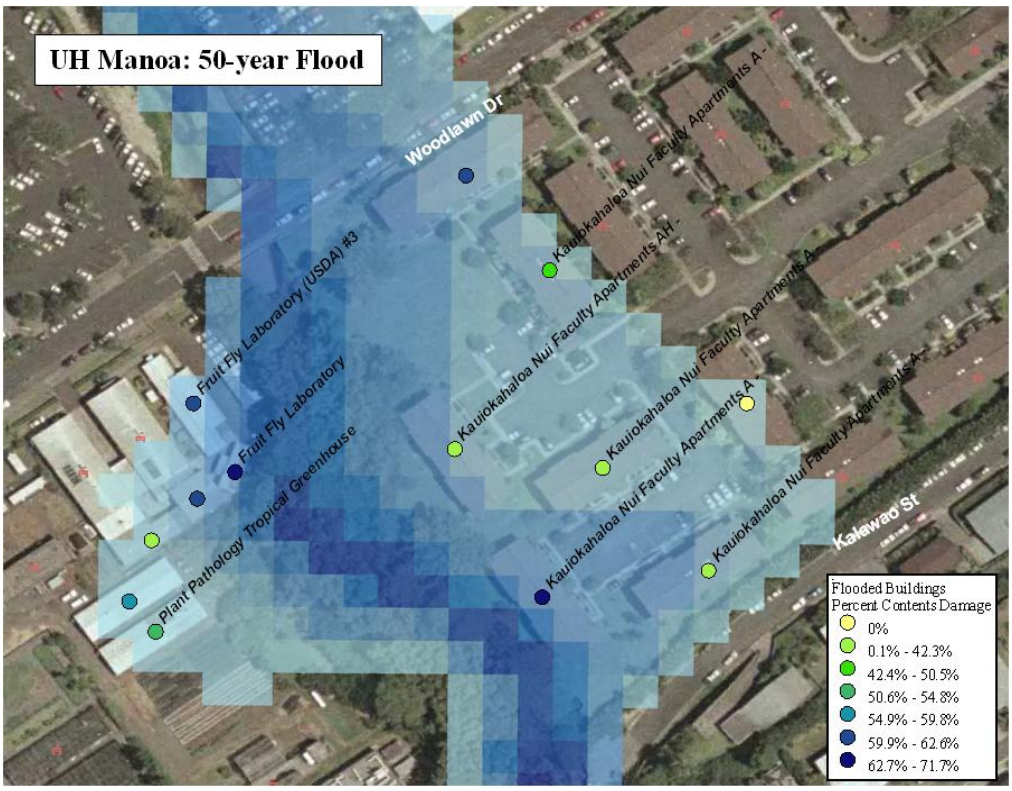


Figure 9.13 Zoom of the area most affected by a 50-year flood at UH Mānoa

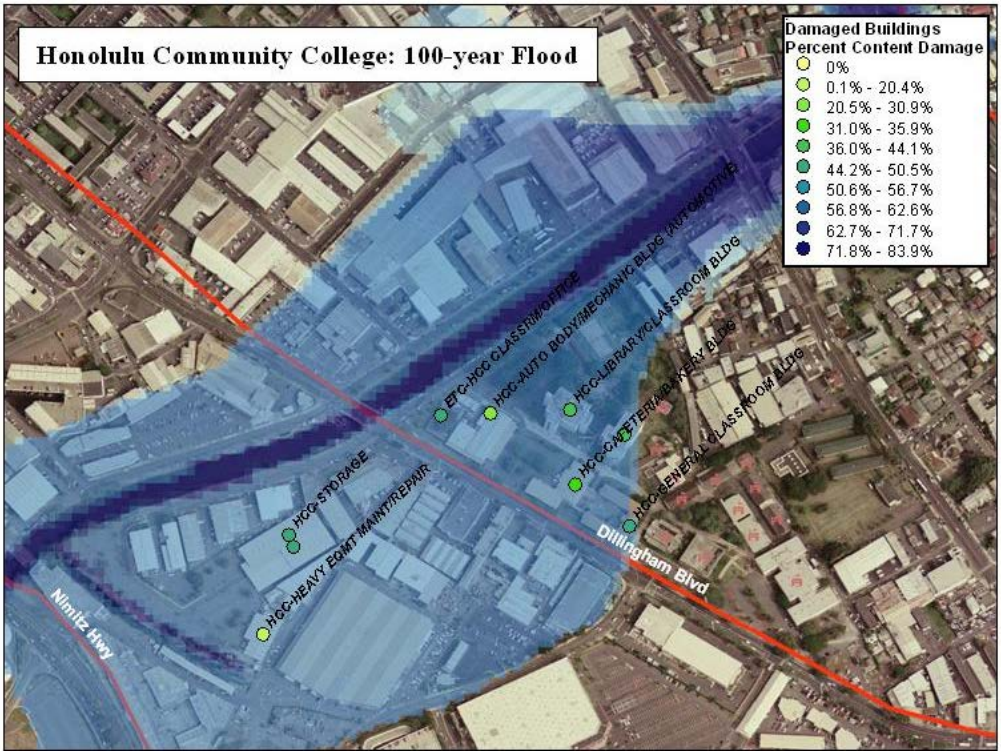


Figure 9.14 Spatial extent and buildings affected by a theoretical 100-year flood at Honolulu CC

9.4.15 Flood Forecasting

In recent years, the NWS has installed more telemetered rain gauges to aid in flood prediction. Two Doppler radars on this island provide rainfall intensity in quantitative graphic form. A corps of human observers is also maintained to report significant events. Warnings for specific areas are broadcast via normal and special radio/TV forecasts and by special County Civil Defense announcements as well as over the NOAA Weather Radio. Thus, short-term mitigation is being addressed. The problem of vehicles being driven across flooding streams must be met by road hazard signs and public education for hunters and others using remote roads.

9.4.16 Pacific Services Center Flood Response Tool

The Hawai‘i Flood Response Tool is an ongoing project to develop a geographic information system (GIS)-based application to provide enhanced flood response in Hawai‘i. The application will centralize access to diverse weather and stream flow data from various locations and sources to allow for timely analysis and response.

This software, which is being developed for local emergency managers, will provide an improved operational picture for flood response activities by automatically logging disparate real-time and near real-time observation data and text products via the Internet. The information will be displayed along with historical and baseline data in an-easy to-interpret format utilizing GIS. This rapid access to new data streams should provide a more realistic picture of on-the-ground conditions and reduce data compilation time. More information on the Hawai‘i Flood Response Tool is available at nos.csc.psc@noaa.gov.

9.4.17 Rainfall Gages and Flood Forecasting

9.4.17.1 Hydronet System

The Hydronet system is a State of Hawai‘i wide network of National Weather Service (NWS) maintained and operated tipping bucket rain gages whose primary purpose is to support the flash flood forecast and warning operations of the Honolulu Forecast Office. Network communications are handled via commercial telephone lines or cellular phones that contact data loggers attached to each rain gage. 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 gage 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. Each gage is also programmed to call 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 gage, 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.

9.4.17.2 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. Output includes hourly basin accumulation rates as well as basin accumulation totals over user-specified periods. Basins have been delineated using 30-meter digital elevation model data processed through a software extension from a Geographic Information System (GIS).

For the State of Hawaiʻi, AMBER output is currently available from the WSR-88D radar on Molokaʻi with basins delineated over the island of Oʻahu 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.

9.5 Mitigation Strategies

9.5.1 Proposed Mitigation Activities

The following are recommended projects that would reduce vulnerability to future flood hazard:

Required Permitting, Environmental and Hazard Assessments At Different Stages of Development

Stage of Development	Special Management Area Permit HRS §205A	Hawai‘i 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. No – for agricultural, rural changes to urban	LUC rules require assessment	County reclassification of State districts (land <15 acres). 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. 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.

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)

9.5.1.1 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 Hawai‘i'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 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)]

The Hawai‘i legislature should consider amendment to the Mandatory Disclosure Law to expressly address erosion. Some 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.

9.5.1.2 Uniform Land Sales Practices Act

The Uniform Land Sales Practices Act ("Land Sales Act") was passed in Hawai‘i 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]

9.5.2 Future Plans

Project	Description	Status
Modernize FIRM maps with local amendments FEMA has revised the DFIRM's and Flood Insurance Study based on hurricane flooding hazard.	See http://gis.hawaiinfip.org/fhat Also included a re-evaluation of the Pu'ukapu Watershed of the Waimea area	On Dec. 12, 2008 and Feb. 26, 2009, FEMA issued Preliminary Digital Flood Insurance Rate Maps (91 panels) for Hawai'i County (Pre-DIRMs). On April 21, 2009, FEMA held its Pre-DIRMs flood hazard mapping community coordination meeting with the County. On April 22, in Kona, and April 23, in Hilo, FEMA and the County held public meetings on the Pre-DIRMs. On June 30, 2009, the County sent a letter to FEMA indicating, until the Pre-DFIRMs are revised to acceptable standards, the County will continue using the County's current floodplain management records to make land use and building permit issuance decisions. On July 7, 2009, FEMA acknowledge the County's June 30 letter and accepted the County's support in preparing improved digital presentations of the riverine flood zones. On Sept. 28, 2009, FEMA approved a $71,300 Cooperative Technical Partners grant to assist in improving the riverine flood zones on the DFIRMs. FEMA will continue to improve the DFIRMs coastal high hazard areas by combining the more protective inundation areas from either FEMA's 2008 hurricane flood study for the County of Hawai'i (refer to Section 10.4.1.3) and the current effective FIRMs' coastal high hazard areas.
Participate in the Community Rating System	Results in reduction in flood insurance premiums	Project requires documentation effort and analysis of repetitive

Project	Description	Status
		loss properties
Adopt 2012 IBC and related codes per HRS 107 Part II		
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.		
Precipitation-Frequency Atlas of the US Hawaiian Islands Includes: precipitation frequency estimates for durations from 5-minutes through 60 days, for return periods of 1-year through 1000 years.	http://hdsc.new.noas.gov/hdsc/pfds	NOAA release May 2009
Develop policies for repetitive loss structures	Policy may or may not make economic sense from a Benefit Cost Analysis	This depends on an analysis of repetitive loss properties
Develop rainfall and streamflow gauging system suitable to flood monitoring	Internet accessible tool to view real-time rainfall and streamflow data	NOAA PSC developing prototype application for emergency managers

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

10. Dam Failures

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CHAPTER 10

Dam Failures

Reasons for Updates / Revisions in this 2013 Plan
• The hazard description has been updated to include the 2006 Ka Loko dam catastrophic failure on the island of Kaua‘i as an example. • Dam sites are mapped in GIS and their properties listed. • Recently completed projects including a condition assessment survey of all dams and dam failure inundation and evacuation maps are described in the aftermath of the Ka Loko Dam failure in 2006 and the Kīholo Bay earthquake of 2006. • New dam inundation and evacuation maps have been developed and examples are exhibited. • New Emergency Action Plan requirements are described.

Summary of Mitigation Projects for the State of Hawai‘i	
Project	Priority
Dam evacuation maps are being finalized	Medium
New Emergency Action Plans are now required of all dam owner entities	Medium

10.1 Dam Failures Hazard Description

10.1.1 General

Hawai‘i’s experience with dam failure resulted in the development of a program to assess the risks of dams throughout the state. While there have been no additional failures since 2006, the state continues to learn from the previous experience. The State has inspected and characterized the hazard risk of all the dams. The potential risk from different flooding scenarios has been developed, and the State is currently mapping the evacuation zones.

10.1.2 Flooding from Dam Failure

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.[1]

In Hawai‘i, a "Dam" is defined in Chapter 179D, Hawai‘i Revised Statutes[2] (as amended by Act 262, SLH 2007) as any artificial barrier, including appurtenant works that impounds or diverts water and that:

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 shall not apply to any artificial barrier that is less than six feet in height regardless of storage capacity or that has a storage capacity at maximum water storage elevation less than fifteen acre-feet regardless of height; or,

3. Meets additional criteria or is specifically exempt as determined pursuant to rules adopted by the board.

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. 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, and 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, and are typically very small. Lake Wilson and Nu‘uanu Reservoir on the island of O‘ahu are examples of local dams constructed for storage.

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[1] Federal Emergency Management Agency (FEMA), Multi-Hazards, 1997

[2] State of Hawai‘i Website, retrieved from http://www.capitol.hawaii.gov/session2007/bills/SB1946_cd1_.htm

Dam failures cause flash flooding. 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.

The threat from dam failures increases as existing dams get older, especially for dams that are not maintained or inspected regularly. More are being built for retention basins and amenity ponds in new developments. Many were not included in flood investigation studies and are not mapped as being in special flood hazard areas, and therefore are not subject to floodplain regulations. Even when the stream is mapped, the floodplain is not based on a dam failure inundation map, sometimes leaving downstream residents unaware of the potential dangers. There is a need for the development of dam inundation evacuation maps that are available to the public.

Dam failures for earthen dams can 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.

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 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.

10.2 Significant Historic Events

10.2.1 Ka Loko Reservoir Dam Failure

Ka Loko Reservoir created by an earthen dam, on the island of Kaua‘i is located on the north side of the island, at 22°10′55″N, 159°22′56″W. The Ka Loko Dam – created to store water for sugar cane irrigation – was built on the north shore of the island of Kaua‘i, County of Kaua‘i, between 1890 and 1920. Figure 10.1 shows a shade relief map of the Ka Loko Dam and its vicinity.

On March 14, 2006, a 120-foot long portion of the dam breached following an unusually prolonged period of torrential rain. In an independent civil investigation of the Ka Loko Dam failure by Robert Godbey, it is acknowledged that starting February 18, 2006, the National Weather Service (NWS) issued flash flood watches for parts of the State of Hawai‘i for 31 of the next 42 days. The Ka Loko Reservoir rainfall data from this period indicates very unusual, but not unprecedented, rainfall. [3]

The approximately 300-million-gallon[4] flood and debris generated by the breach rushed downstream and destroyed several homes, devastated a 300-foot long portion of Kūhiō Highway (State Highway 56), overturned several utility poles and lines, and killed seven people. The flood generated by the Ka Loko Dam failure also affected another dam located downstream from the breach zone – the Morita dam. On March 15, 2006, State of Hawai‘i Civil Defense officials evacuated the area downhill from Morita Dam and forced search and rescue teams to leave the area.[5] According to a press statement by Major General Robert Lee, “the Morita Dam could go any time since half of the width of the dam’s wall was gone along the downslope side”. Luckily, the Morita Dam did not fail and thus subsequent damage to property and loss of life was avoided.

According to Godbey’s independent civil investigation of the Ka Loko Dam failure, the breach of the dam could be attributed several possible conditions and practices: inadequate inspections of the dams by the State of Hawai‘i, non-permitted grading operations at the dam site by the owner, inadequate maintenance of the dam by the owner, and non-enforcement of regulations by the County of Kaua‘i.[6] A civil lawsuit by the victim’s surviving family resulted in a $25 million settlement to which the State of Hawai‘i contributed $1.5 million.

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[3] Godbey, Robert, *Report of the Independent Civil Investigation of the March 14, 2006 Breach of Ka Loko Dam*, 1, January 2007, 13p

[4] Honolulu Advertiser Website, Retrieved October 26, 2009 from http://the.honoluluadvertiser.com/article/2006/Mar/14/br/br05p.html

[5] Star Bulletin Website, Retrieved October 26, 2009 from http://archives.starbulletin.com/2006/03/15/news/story01.html

[6] Godbey, Robert, *Report of the Independent Civil Investigation of the March 14, 2006 Breach of Ka Loko Dam*, 1, January 2007

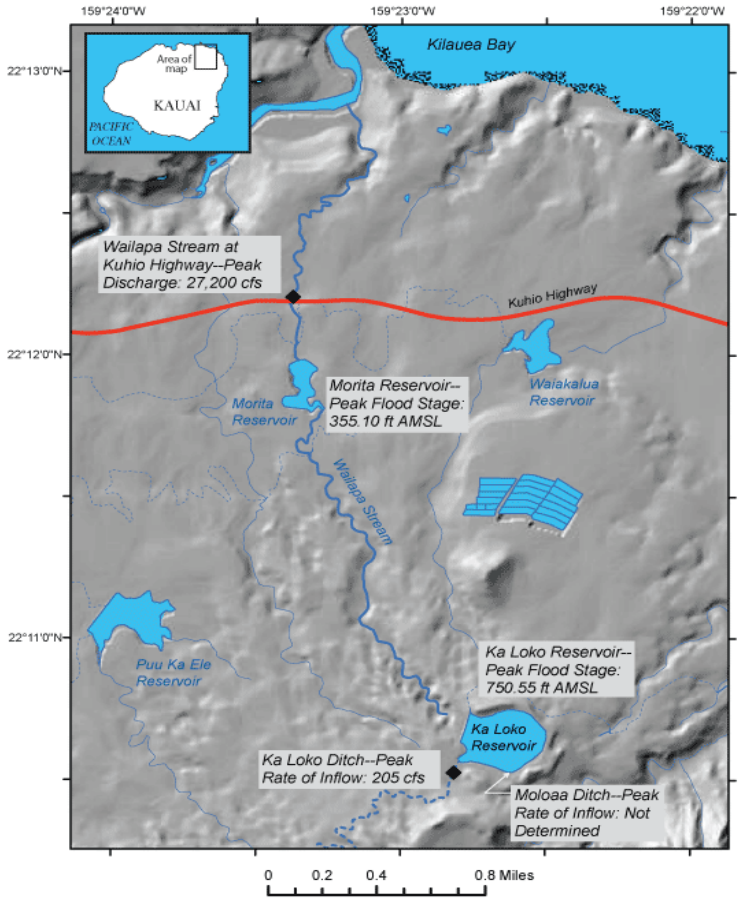

Figure 10.1 Shaded Relief of Ka Loko Dam and Vicinity, Island of Kaua'i[7]

10.2.2 Kīholo Bay Earthquake Damage to Dams

Following the 2006 Kīholo Bay Earthquake some damage occurred to dams and irrigation ditches in the Waimea-Kamuela area of the Island of Hawai'i where recorded peak ground acceleration exceeded 1.0g (soil depths are greater in that region than along the rocky coast nearest the epicenter). At least two dams experienced cracks along their crests, while at least two others showed clear evidence of incipient slope failure on their embankments. The Pacific Disaster Center performed dam break simulations for the County of Hawai'i Civil Defense. Two dams located above Waimea were drained after excessive seepage and "water boils" were observed five days following the earthquakes. The Hawai'i State Department of Land and Natural Resources (DLNR) had in place post-earthquake dam inspection procedures. Since the Hawai'i Dam Safety Guidelines: Seismic Analysis & Post-Earthquake Inspections[8] calls for inspections of dams within 75 miles of the source of an earthquake of magnitude between 6.0 and 7.0. The United States Army Corps of Engineers undertook these comprehensive inspections.

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[7] United States Geological Survey (USGS), retrieved from http://hi.water.usgs.gov/studies/project_ka_loko_res.htm

[8] Brandes, 2004

10.3 Probability of Occurrence

Given the increased monitoring procedures enacted following the breach of the Ka Loko Dam on the island of Kaua‘i, the probability of a dam failure anywhere in the State of Hawai‘i has been significantly reduced. A major dam failure is a very rare event for which there is no defined recurrence interval. However, the potential does exist during an extreme rainfall event or during a major earthquake at any un-maintained or under-maintained location.

10.3.1 Statewide Dam Visual Condition Survey

In coordination with the State of Hawai‘i Department of Land and Natural Resources (DLNR), the United States 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 Ka Loko disaster. Altogether 54 dams in the island of Kaua‘i were inspected. The report classified 24, 8, 15 and 7 dams as high, significant, low and undetermined hazard respectively. The following general recommendations were provided:

- All dams should be inspected by a professional engineering service with experience in design, construction, operation, inspection, and evaluation of dams. The consultant should review this report; previous inspection reports; design and construction documentation; conduct detailed evaluations; and provide detailed recommendations for safe dam operation. Many of the dams are between 80 and more than 100 years old, and therefore not designed and constructed to current safety standards.
- Prepare or update operation plans and emergency action plans.
- Implement a dam safety training program for dam owners and operators.
- Update Hazard Potential Classification of dams in the inventory.
- Institute a program for periodic inspections of dams.
- Install survey monuments and instrumentation for monitoring horizontal and vertical movements and phreatic water levels within the body of the dam embankment, as warranted.

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. The purpose of the Statewide Dam Visual Conditions Survey was to determine whether there existed any imminent danger to life and property based on the dam and reservoir conditions at the time of the inspections. This broad-based visual view was intended to provide a sufficient basis for the State to contact the dam owners for follow-up investigations and potential remedial action to assure safe conditions. The dams inspected were identified from the list of regulated dams in the State’s Dam Safety Program as of March 2006. This Statewide Dam Visual Conditions Survey report consolidates and transmits the visual conditions surveys conducted during the period from April 3, 2006 through April 8, 2006 on the islands of Maui, O‘ahu, Hawai‘i, and Moloka‘i, and re-inspections on the island Kaua‘i.

A total of eighty seven (87) dams were inspected: fifty three (53) on the island of Maui; sixteen (16) on the island of Oʻahu; thirteen (13) on the island of Hawaiʻi; one (1) on the island of Molokaʻi; and four (4) dams were re-inspected on the island of Kauaʻi. The re-inspections of the four (4) selected dams on the island of Kauaʻi were necessary because, although they were identified to be abandoned, these facilities still possessed the ability to impound water. These 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 with 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 each facility were provided in the individual visual conditions surveys report. Recommendations for the facilities inspected ranged from removing vegetation to facilitate further inspections to requiring the owners to take immediate actions to restore the integrity of the facilities.[9]

In 2008 and 2009, the DLNR Dam Safety Office completed a hazard assessment of all the dams and issued fact sheets on each dam. These sheets list dams as having high, medium, or low risk. The detailed maps and hazard assessments are included in the County Local Mitigation Plans.

10.3.2 State of Hawaiʻi Reservoir and Dam Inventory

The County of Kauaʻi has a total of fifty-five dams and reservoirs. An inventory of dams and reservoirs in this County are summarized in Table 10.1 and Figure 10.2. This inventory is based on the Statewide Dam Visual Condition Survey carried out in April of 2006.

In the City and County of Honolulu, there are twenty-one dams and reservoirs located throughout the island of Oʻahu. Table 10.4 and Figure 10.3 tabulate and illustrate the names/identification and locations of all fifty-four dams and reservoirs in the City and County of Honolulu, respectively.

In the case of the County of Maui, there are a total of fifty-four dams and reservoirs (reservoirs will be discussed in the next section). Of the fifty-six total, fifty-three are located on the island of Maui and one is located on the island of Molokaʻi. There are no dams or reservoirs on the island of Lānaʻi. Table 10.2 tabulates the names/identification and locations of all fifty-four dams and reservoirs in the County of Maui. Locations of the dams are shown in the maps Figure 10.4 (island of Maui) and Figure 10.5 (Island of Molokaʻi).

Lastly, the County of Hawaiʻi has thirteen dams, all of which are earth dams.[10] Most dams in this county are old earthen berm reservoirs built during the plantation era originally for irrigation purposes. (see Table 10.3 and Figure 10.6 for a list and location map of all dams in this county).

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[9] State of Hawaiʻi Department of Land and Natural Resources (DLNR), retrieved from http://www.hawaii.gov/dlnr/reports/dam-inspections/Army%20Corps%20-%20Kauaʻi%20Dam%20Report%20Cover%20Letter.pdf and http://www.hawaii.gov/dlnr/reports/dam-inspections/StatewideDamVisualConditionsSurveyReportFinalHawaii.pdf

[10] Goosby, S., Chatman, A., Michaud, J., Kerper, D., Dam Break Inundation Study for the State of Hawaiʻi, Prepared for the State of Hawaiʻi's Department of Land and Natural Resources, ASCE 2008

Table 10.1 County of Kaua‘i Dam and Reservoir Inventory and Hazard Potential Category[11]

ISLAND OF KAUA‘I			
Aahoaka Reservoir	NA	Lower Anahola	NA
Aepo Reservoir	NA	Lower Kapahi Reservoir	NA
Aepoalua Reservoir	NA	Mana Reservoir	NA
Aepoeha Reservoir	NA	Manuhonuhonu Reservoir	NA
Aepoekolu Reservoir	NA	Mau Reservoir	NA
Ahukini Reservoir	NA	Mauka	NA
Aii Reservoir	NA	Mimino	NA
Alexander	NA	Morita	NA
Elima Reservoir	NA	Okinawa Reservoir	NA
Elua Reservoir	NA	Omao Reservoir	NA
Field 1 Kealia	NA	Papuaa Reservoir	NA
Field 2 Kealia	NA	Pia Mill	NA
Hale Nanahu	NA	Piwai	NA
Hanamā‘ulu 21 Reservoir	NA	Puu Ka Ele	NA
Huinawai Reservoir	NA	Puu Lua	NA
Hukiwai Reservoir	NA	Puu O Hewa	NA
Ioleau Reservoir	NA	Puu Opae	NA
Ipuolono Reservoir	NA	Twin Reservoir	NA
Ka Loko	NA	Umi Reservoir	NA
Kaawanui Reservoir	NA	Upper Anahola	NA
Kalihiwai Reservoir	NA	Upper Kapahi Reservoir	NA
Kaneha	NA	Waiakalua	NA
Kapa Reservoir	NA	Waikaia Reservoir	NA
Kapaia	NA	Waikoloi Reservoir	NA
Kaupale Reservoir	NA	Wailua Reservoir	NA
Kepani Reservoir	NA	Waita Reservoir Dike	NA
Kitano	NA	Waita Reservoir Main Dam	NA
Kumano Reservoir	NA		

[11] Dam hazard potential categories are per Section 10.4. In the table, “L” denotes low hazard potential”, “S” denotes significant hazard potential, “H” denotes high hazard potential, “U” denotes undetermined hazard potential, and “NA” denotes that hazard potential is not available.

Table 10.2 County of Maui Dam and Reservoir Inventory and Hazard Potential Category[12]

ISLAND OF MAUI			
MA00046 Waikamoi Dam No. 2	L	MA00086 Maui Reservoir 81	S
MA00047 Pi‘iholo Reservoir	S	MA00087 HC&S Reservoir 82	S
MA00048 Olinda Reservoir	H	MA00088 Maui Reservoir 84	H
MA00054 Horner Reservoir	H	MA00089 HC&S Reservoir 90	S
MA00055 Wahikuli Reservoir	H	MA00090 HC&S Reservoir 92	S
MA00056 Hanaka‘ō‘ō Reservoir	H	MA00091 Peahi Reservoir	U
MA00057 Kahoma Reservoir	H	MA00092 Pāpa‘a‘ea Reservoir	U
MA00058 Honokōwai Reservoir	H	MA00093 Kaupakulua Reservoir	U
MA00059 Upper Field 30 Reservoir	H	MA00094 Kapa‘alalaea Reservoir	U
MA00068 Maui Reservoir 14	H	MA00095 Haiku Reservoir	H
MA00069 Maui Reservoir 15	U	MA00096 Pa‘uwela Reservoir	H
MA00070 HC&S Reservoir 20	H	MA00097 Kōlea Reservoir	U
MA00071 Maui Reservoir 21	H	MA00125 Happy Valley Flood Prevention	H
MA00072 Maui Reservoir 22	H	MA00126 Kahana Reservoir	H
MA00073 Maui Reservoir 24	H	MA00127 Napili 4 and 5 Desilting Basin	S
MA00074 HC&S Reservoir 25	H	MA00128 Napili 2 and 3 Desilting Basin	H
MA00075 Maui Reservoir 30	H	MA00130 Honokōwai Structure #8	H
MA00076 HC&S Reservoir 33	H	MA00132 Pu‘u Koa Reservoir	L
MA00077 HC&S Reservoir 40	H	MA00133 Pukalani Reservoir	L
MA00078 HC&S Reservoir 42	H	MA00134 Koapala Basin	H
MA00079 Maui Reservoir 52	H	MA00138 Kahakapao Reservoirs	H
MA00080 HC&S Reservoir 60	H	MA00139 Maui Field 290 Reservoir	S
MA00081 HC&S Reservoir 61	H	MA00141 Wailuku District Retention Basin	U
MA00082 HC&S Reservoir 70	H	MA00142 Middle Field 14	U
MA00083 HC&S Reservoir 73	H	MA00143 Kaili‘ili Reservoir	L
MA00084 HC&S Reservoir 74	H	MA00144 Maui County Water West	U
MA00085 HC&S Reservoir 80	H		
ISLAND OF MOLOKA‘I			
MA00041Kualapu‘u Reservoir	H		

[12] Dam hazard potential categories are per Section 10.4. In the table, “L” denotes low hazard potential”, “S” denotes significant hazard potential, “H” denotes high hazard potential, “U” denotes undetermined hazard potential, and “NA” denotes that hazard potential is not available.

Table 10.3 County of Hawai‘i Dam and Reservoir Inventory and Hazard Potential Category[13]

ISLAND OF HAWAI‘I			
E-13 Resevoir	NA	Pu‘u Kapu Reservoir	NA
Hāwī 3 Reservoir	NA	Pu‘u Kapu Watershed Retarding Dam R-1	NA
Hāwī 5 Reservoir	NA	Pu‘u Pulehu Reservoir	NA
Keaīwa Reservoir	NA	Waikoloa 50 MG Reservoir 1	NA
Kehena Reservoir	NA	Waikoloa 50 MG Reservoir 2	NA
Lālākea Reservoir	NA	Waikoloa 50 MG Reservoir 3	NA
Pa‘auilo Reservoir	NA		

Table 10.4 City and County of Honolulu Dam and Reservoir Inventory and Hazard Potential Category[14]

ISLAND OF O‘AHU			
HI00023 Helemano 6 Reservoir	S	HI00033 Reservoir 2208	H
HI00045 Helemano 16 Reservoir	S	HI000134 Reservoir 245A	U
HI00124 Kāne‘ohe Dam	H	HI00035 Reservoir 245B	H
HI00021 Kemo‘o 5 Reservoir	S	HI00036 Reservoir 4108	H
HI00025 Ku Tree Reservoir	H	HI00037 Reservoir 510	S
HI0001 Nu‘uanu Dam No. 4	H	HI00038 Reservoir 530	H
HI00031 O‘ahu Reservoir No. 155A	H	HI00039 Reservoir 545A	H
HI00018 ‘Ōpa‘eula 01 Reservoir	S	HI00022 Upper Helemano Reservoir	S
HI00019 ‘Ōpa‘eula 02 Reservoir	S	HI00017 Wahiawā Dam	H
HI 00020 ‘Ōpa‘eula 15 Reservoir	S	HI00129 Waimānalo 60 MG Reservoir	H
HI00032 Reservoir 205A	H		

[13] Dam hazard potential categories are per Section 10.4. In the table, “L” denotes low hazard potential”, “S” denotes significant hazard potential, “H” denotes high hazard potential, “U” denotes undetermined hazard potential, and “NA” denotes that hazard potential is not available.

[14] Ibid

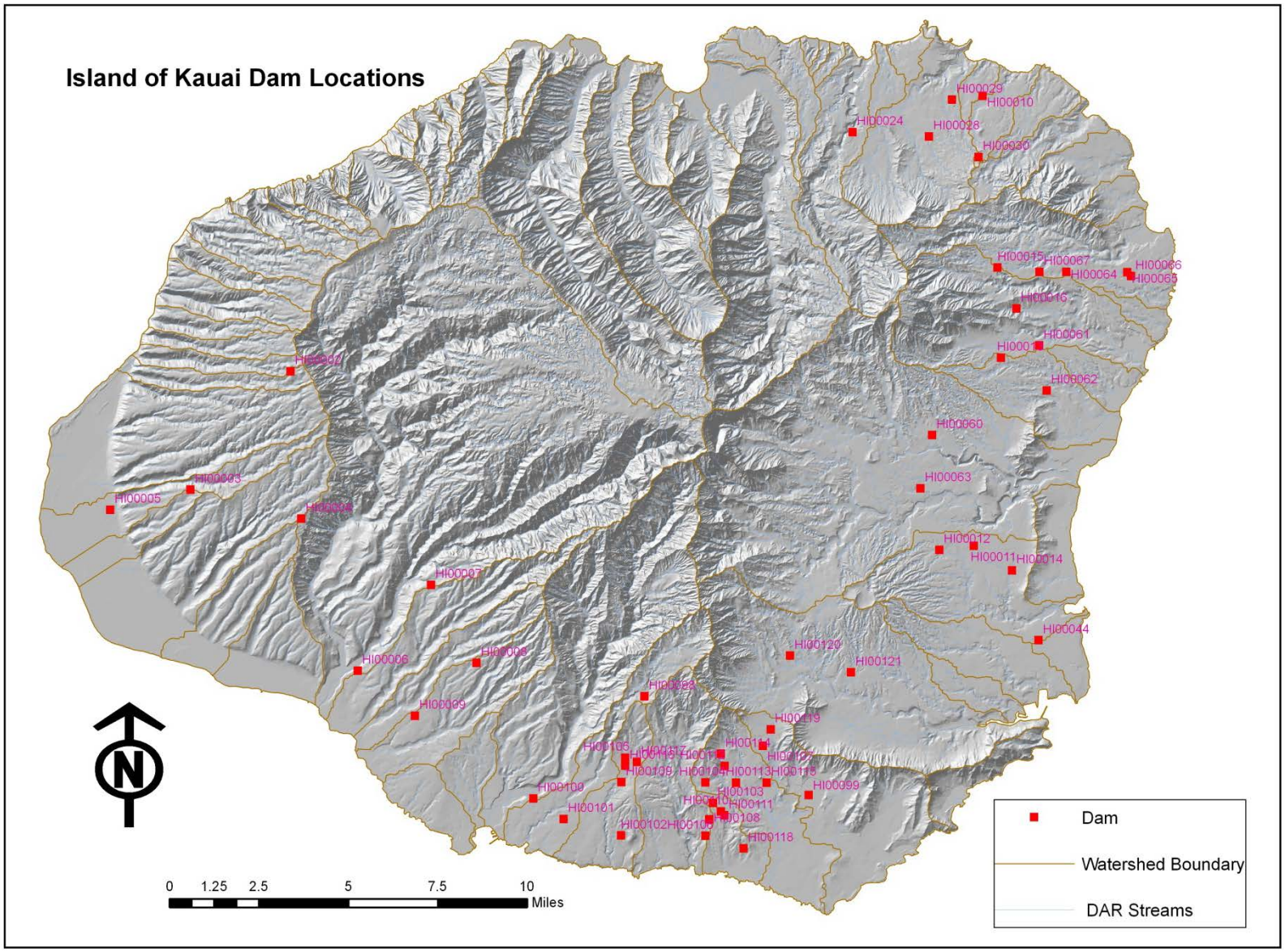

Figure 10.2 Location of Dams and Reservoirs on the Island of Kaua‘i (County of Kaua‘i)

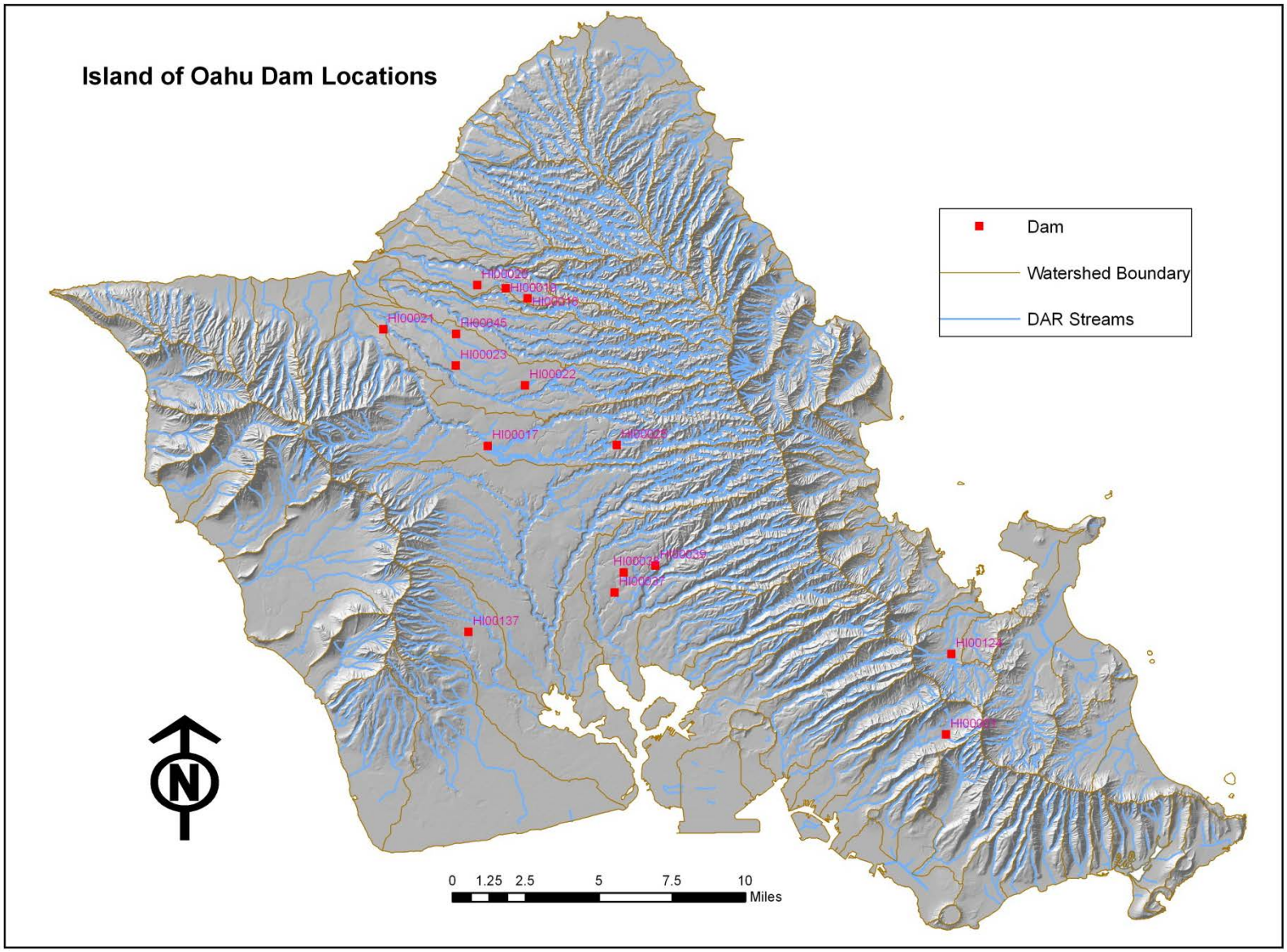

Figure 10.3 Location of Dams and Reservoirs on the Island of O‘ahu (City and County of Honolulu)

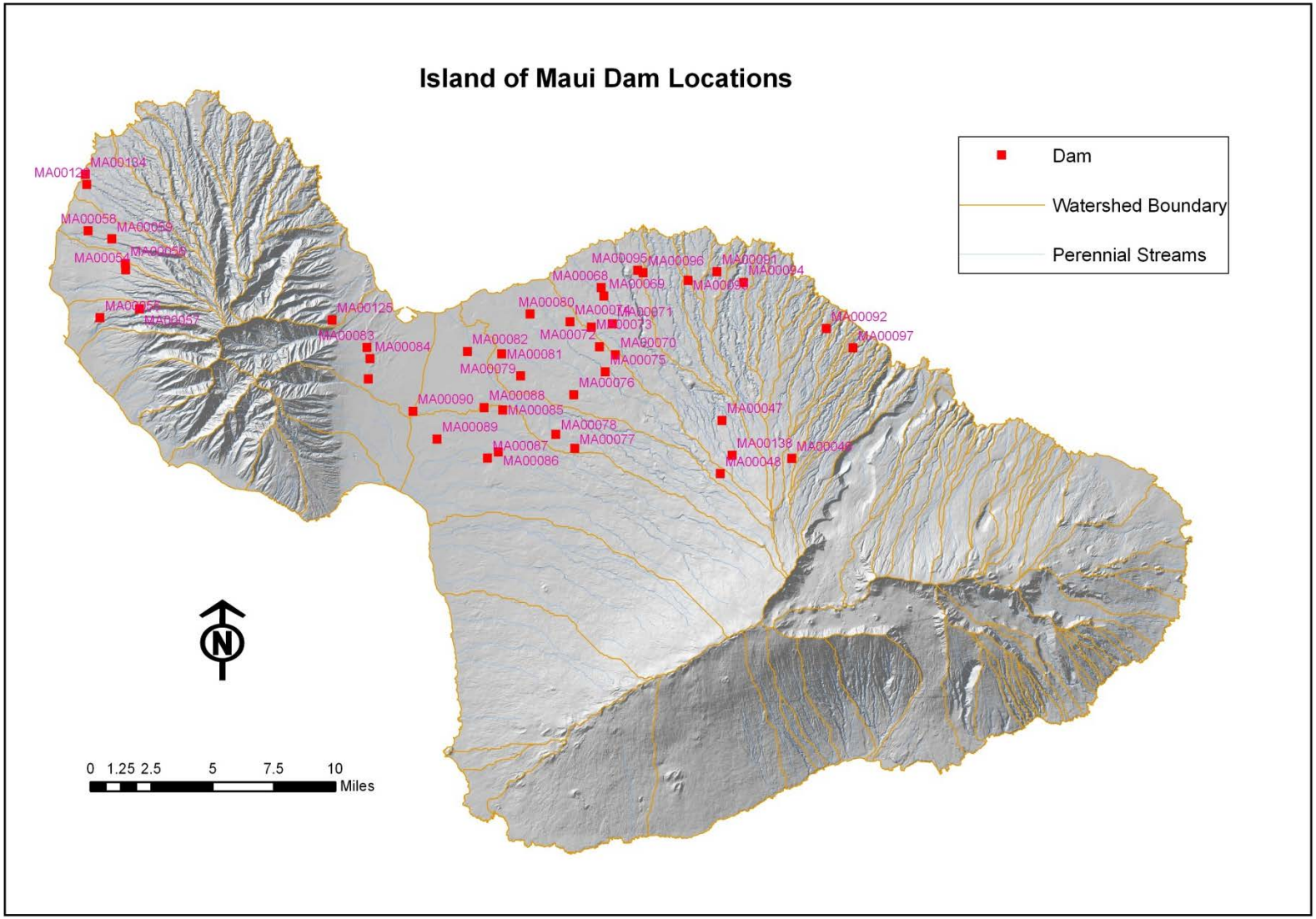

Figure 10.4 Location of Dams and Reservoirs on the Island of Maui (County of Maui)

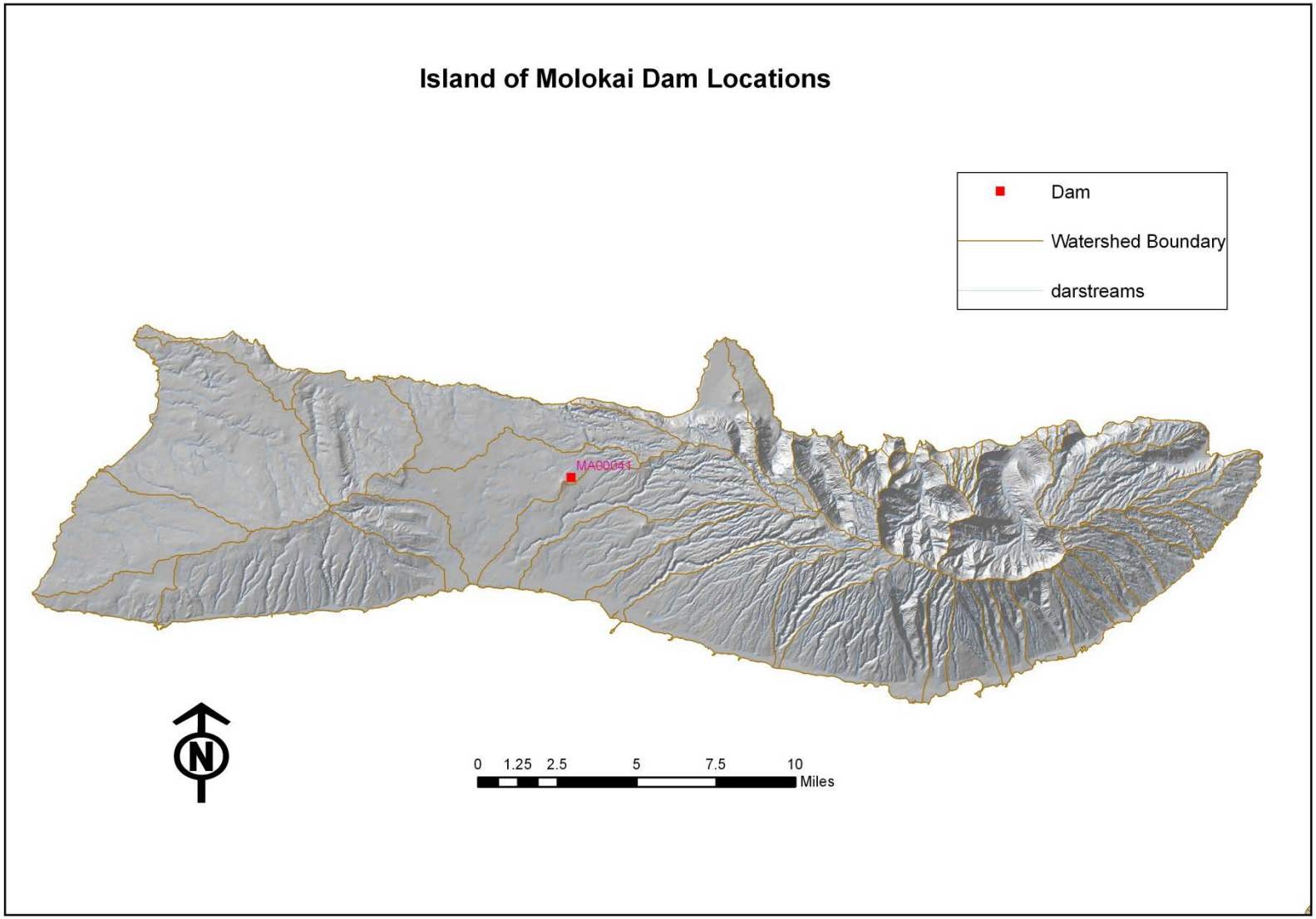

Figure 10.5 Location of Dams and Reservoirs on the Island of Moloka‘i (County of Maui)

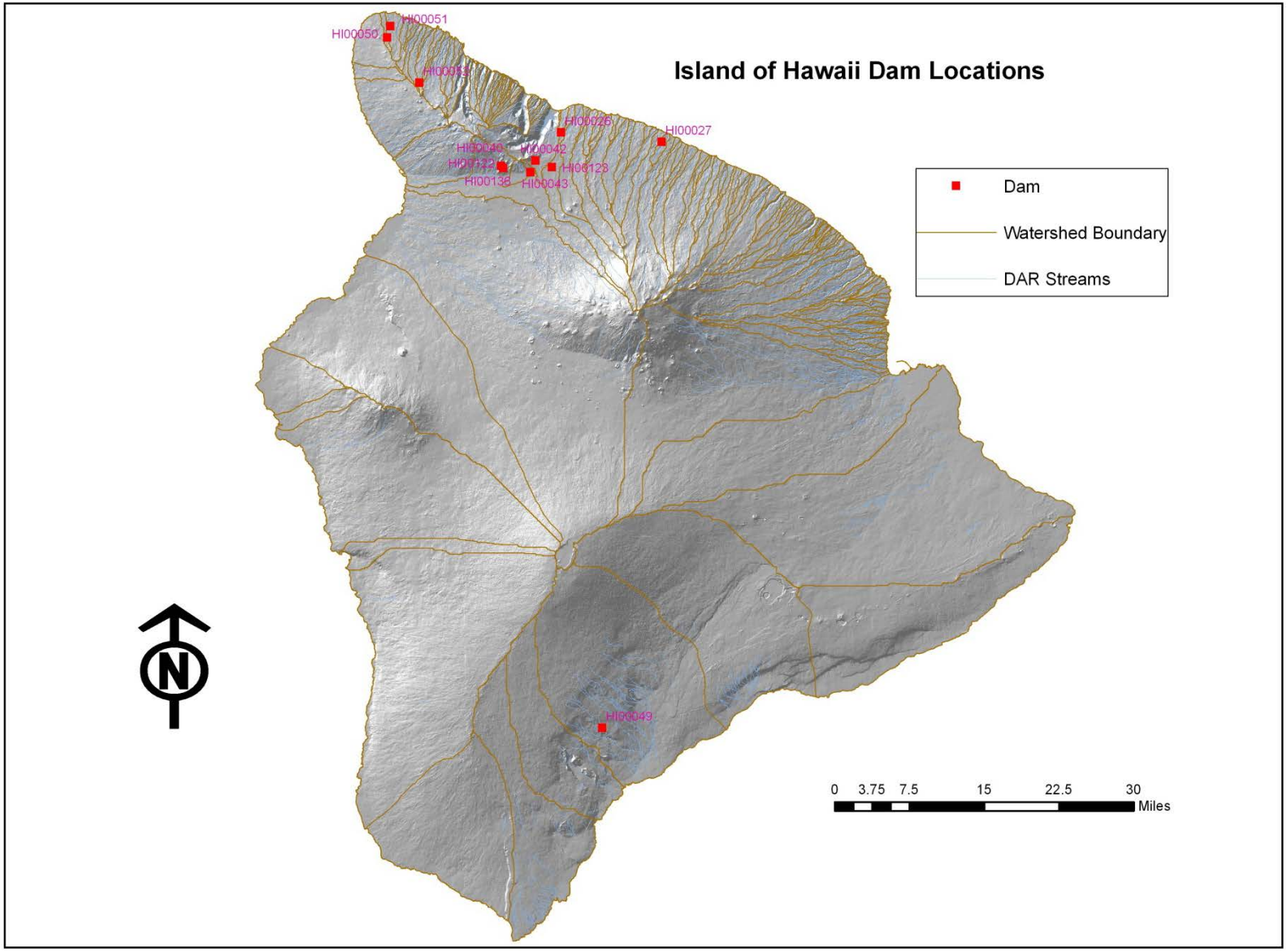

Figure 10.6 Location of Dams and Reservoirs on the Island of Hawai‘i (County of Hawai‘i)

10.4 Risk Assessment

10.4.1 General

The Hawai‘i Dam Safety Program was started in 1987 when the statues was passed by the legislature and was followed up in 1989 with the Hawai‘i Administrative Rules that were set up by the Department of Land and Natural Resources. The majority of existing dams were built by private plantation owners in the early 1900's for irrigation and not for flood control; there were no regulatory construction standards at that time.

The Department of Land and Natural Resources (DLNR), Engineering Branch administers the Hawai‘i Dam Safety Program. DLNR reviews and approves plans and specifications for the construction of new dams or for the enlargement, alteration, repair, or removal of existing dams. Any persons seeking to construct, alter, or remove an existing dam must fill out the *Application for Approval Of Plans And Specifications For Construction, Enlargement, Repair, Alteration, Or Removal Of Dam* with the DLNR, Engineering Branch, Dam Safety Section.

Common practice among federal and state dam safety offices is to classify a dam according to the potential impact a dam failure (breach) or miss-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.

Two factors influence the potential severity of a dam failure: the amount of water impounded and the density, type, and value of development and infrastructure located downstream. 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 10.5.

- **Low Hazard Potential:** Dams assigned the low hazard potential classification are those where failure or miss-operation results in no probable loss of human life and in 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 miss-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 miss-operation will probably cause loss of human life.

Table 10.5 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 structures)	Appreciable (notable developments with a small number of inhabitable structures, agriculture, industry
High	More than five	Excessive (extensive community, industry, or agriculture)

In the County of Kaua‘i, the hazard potential of the fifty-five (55) identified dams and reservoirs is not available at the time of the preparation of this report.

Of the total fifty-four (54)dams in the County of Maui, thirty-four (34) have been rated to be “high” hazard potential, seven (7) are considered “significant” hazard potential, four (4) are rated as having a “low” hazard potential, and nine (9) have an undetermined hazard potential. The hazard potential categories for all fifty-three (53) dams in the County of Maui are listed in Table 10.2.

Of the thirteen (13) dams in the County of Hawai‘i, DLNR has rated two (2) on this island to be “high” hazard potential based on the extent of potential downstream losses to residential and/or commercial structures or agricultural crops. Table 10.3 summarizes the hazard potential for all dams in the County of Hawai‘i.

Lastly, of the twenty-one (21) total dams and reservoirs located within the City and County of Honolulu, twelve (12) are identified to be “high” hazard potential and eight (8) are identified as “significant hazard” potential. The hazard potential of the remaining dam is undetermined. The hazard potential categories for all twenty-one (21) dams in the City and County of Honolulu are listed in Table 10.4.

10.5 Mitigation Strategies

10.5.1 General

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. Further guidelines for specifics in developing the EAP are provided in the template and EAP Development Guidelines[15]

10.5.1.1 National Dam Inspection Act

The National Dam inspection Act (NDIA) of 1972 as expressed in Public Law 92-367 authorized for the first time the federal regulation of privately own dams. Per the NDIA, the United Sates Army Corps of Engineers (Corps) were authorized to inventory and inspect privately owned dams in the United States. The NDIA provided funding for the Honolulu Army Corps of Engineers and the State of Hawai‘i Department of Land and Natural Resources (DLNR) to complete an inventory of dams in the State of Hawai‘i and perform inspections of 53 high-hazard private dams between 1977 and 1981.[16]

10.5.1.2 National Dam Safety Program Act

The purpose of the National Dam Safety Program Act (NDSPA) of 2000, 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."

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;

[15] State of Hawai‘i Department of Land and Natural Resources website, retrieved from http://www.hidlnr.org/eng/dam/forms/EAPDevGuide.pdf

[16] Office of History, United Sates Army Corps of Engineers, The Federal Role in Water Resources Management,, Washington, D.C., 1896, 12p

- 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.

10.5.1.3 State of Hawai‘i Dam Safety Act

The State of Hawai‘i Dam Safety Act was started in 1987 where the rules, statues, and Hawai‘i Administrative Rules were set up by the Department of Land and Natural Resources (HAR, Title 13, Subtitle 7, Chapter 190, Dams and Reservoirs). Private plantation owners built a majority of existing dams in the early 1900’s for irrigation and not flood control; there were no standards at that time. According to the Hawai‘i National Flood Insurance Program (NFIP) Certified Floodplain manager (CFM), during that historical period, when the embankments were built, workers 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.

The DLNR Engineering Branch administers the Hawai‘i Dam Safety Act and reviews and approves plans and specifications for the construction of new dams or for the enlargement, alteration, repair, or removal of existing dams. Any individual or entity seeking to construct, alter, or remove an existing dam must fill out the "Application For Approval Of Plans And Specifications For Construction, Enlargement, Repair, Alteration, or Removal Of Dam" with the DLNR Engineering Branch, Dam Safety Section.

10.5.2 Dam Inundation and Dam Evacuation Maps

In January 2007, the United States Army Corps of Engineers started detailed dam break studies on selected dams throughout the State of Hawai‘i. The eleven dams being studied were selected from a prioritized list of dams identified by DLNR’s Engineering Division Dam Safety Office as being of concern primarily due to downstream urban development. These studies involve evaluating various hydrologic and dam failure scenarios, and hydraulic analysis that will result in maps of the downstream areas that will be adversely affected. The products will be used by the State Dam Safety Office and dam owners in the preparation of required Emergency Action Plans (EAP’s).[17]

In 2009, the DLNR and the Pacific Disaster Center (PDC) engaged in an effort to generate Dam Failure Inundation Maps for all one-hundred-thirty-five (135) dams registered in the State of Hawai‘i at that time. Besides the inundation maps, the project aims at providing basic damage assessment and socioeconomic vulnerability assessments.

By GIS spatial analysis of dam inundation areas with the property database, it is estimated that $2.25 Billion dollars of building inventory are within the potential dam break inundation areas. Thus, dam safety should have a high priority.

The following failure scenarios and assumptions were used to assure conservatism in the preparation of the maps:

- Failure occurs during a sunny day with dry downstream conditions
- Failure occurs when dam is at its maximum capacity
- Failure occurs by piping failure halfway up the face of the dam
- Spillways and dam outlets are inoperable at the time of the breach

In addition to the dam failure inundation maps, the study provides individual dam assessment reports with the following information:

- Total maximum water depth
- Time of maximum water depth
- Time to first inundation
- Depth at first inundation
- Water velocity.
- Impact to population including number of people potentially impacted downstream
- Impact to transportation including water depth and velocity at bridges and road crossings
- Impact to building infrastructure and replacement cost value
- Impact to critical facilities (schools, hospitals, fire and police stations, government buildings, airports/seaports, and shelters)

[17] United States Army Corps of Engineers website, retrieved from http://www.poh.usace.army.mil/pa/Releases/NR20070110-00.pdf

PDC completed the dam failure inundation maps and individual assessment reports for all one hundred-thirty-five (135) dams in 2009. Since, five additional dams have also been studied for a total of 140 register dams in the State of Hawai‘i as of 2013.

Following PDC's dam failure inundation maps and reports, DLNR released these documents for use in the production of dam evacuation maps. Table 10.6 provides a summary of the status of dam inundation and dam evacuation plans by County as of the first quarter of 2013.

Table 10.6 Status of Dam Inundation and Dam Evacuation Maps by County

County	Regulated Dams	Inundation Map Required	Inundation Maps Outstanding	Evacuation Maps Required	Evacuation Maps Outstanding
Kaua‘i	11	54	0	53	0
Honolulu	54	17	0	9	8
Maui	58	57	0	57	0
Hawai‘i	17	11	0	11	0
State Total	140	139	0	130	8

10.5.3 Dam Emergency Action Plans

Hawai‘i Revised Statutes Chapter 179D-30 requires the Owners of State-regulated high and significant hazard potential dams and reservoirs to establish an Emergency Action Plan (EAP) to assist the local community in effectively responding to a dam safety emergency. Owners are also required to provide this EAP to the DLNR, State and County Civil Defense agencies, police department, fire department, and other necessary parties. The DSP has developed a statewide template available for use in updating or preparing an EAP for dams and reservoirs.

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.

The responsibilities of a dam owner for emergency preparedness are:

- Contact and coordinate with local Emergency Management agency (City and County Department of Emergency Management or County Civil Defense) to develop an effective EAP.
- Submit an updated EAP following statewide template to DSP by September 30, 2009 (separate EAP required for each State-regulated high-hazard and significant-hazard facility).
- After concurrence by DSP, distribute Official Copies of EAP to necessary parties.
- Review, update and resubmit changes annually.
- Initiate an EAP call test every 2 years (as described in **“**Appendix C, Training, Testing and Updating” of the EAP template).
- Be trained in monitoring and operating the facility, including during periods of heavy precipitation, flooding, unusual hydrologic or geological events, and other unusual conditions.
- Be prepared to act promptly and efficiently when a dam begins to show signs of distress.

Table 10.7 provides a summary of EAP’s by county. The status of the EAP’s as of 2013 is also included in this table. To compliment Table 10.7, Table 10.8 lists the owners of outstanding dams requiring EAP’s by County.

Table 10.7 Status of Dam Emergency Action Plans by County

County	Regulated Dams	EAP's Required by Statute	EAP's on File	EAP's Outstanding
Kaua‘i	54	48	50	4
Honolulu	17	17	16	1
Maui	58	54	57	0
Hawai‘i	11	9	9	1
State Total	140	128	136	6

Table 10.8 Outstanding Dam Emergency Action Plans by County and by Owner

County	Owner
Kaua‘i	Mary N. Lucas Trust; Pflueger Properties
Kaua‘i	Grove Farm Company
Kaua‘i	County of Kaua‘i – Department of Public Works; Kulana 12D, LLC; Kulana Home Owners Association; Leonard Kaui; Stephen Pianowski; Waipouli Mānoa, LLC; William Hancock – Kapa‘a 382, LLC.
Honolulu	Honolulu Board of Water Supply
Maui	West Maui Investors, LLC
Maui	Spencer Homes
Maui	Wailuku Kuikahi, LLC; Wailuku Water Company
Hawai‘i	Hualua Land LLC; State of Hawai‘i Department of Agriculture

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

11. High Surf

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CHAPTER 11

High Surf

Reasons for Updates / Revisions in this 2013 Plan
• High surf is classified 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 or from tropical storms and hurricanes. The hazards associated with high waves include debris overwash, flooding, erosion, high wave energy and turbulence in the nearshore zone, and strong currents. • The historical occurrences have been described • There is a new section on mitigation strategies moving beyond fixed signage in hazardous area, to leveraging the use of modern wave height prediction tools and new web-based hazard information that is updated every 10 minutes.

Summary of Mitigation Projects for the State of Hawai‘i	
Project	Priority
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.	Medium
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.	Low

11.1 High Surf Hazard Description

11.1.1 General

The most predictable and frequent coastal hazard in the Hawaiian Islands is sudden high waves combined with strong near shore currents.[1] The greatest number of deaths, injuries and rescues in the archipelago are from high waves breaking at the shoreline.

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, Hawai‘i 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, erosion, high wave energy and turbulence in the nearshore zone, and strong currents. Waves that reach the shoreline are determined by the energy inherent in the approaching swell (a function of wave height and wave length-the distance between successive wave crests), shoreline aspect, slope, morphology and geology, and offshore characteristics including seafloor depth, morphology, and barriers (islands, rocks, reefs, sandbars). 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. Rip currents form as the water that is pushed up on the shore by successive large waves, tries to flow back to the sea.

11.1.2 Wave Height Measurement

The conventional wave height scale measures the height of a wave from trough to peak. The conventional scale is given in feet or meters and it is the most widespread approach for measuring waves – the scientific and academic communities use it.

The conventional wave height scale is not to be confused with the Hawaiian wave height scale. In the Hawaiian scale, the measurement is always in feet and scaled such that the actual height on the face of the wave as measured by the conventional scale is roughly twice of the height quoted. The Hawaiian scale is used by surfers and beachgoers in Hawai‘i, Australia, and less commonly in South Africa. Figure 11.1 illustrates the difference between the conventional and Hawaiian wave height scales. All wave heights in this report will be given in the conventional scale.

[1] Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 10p

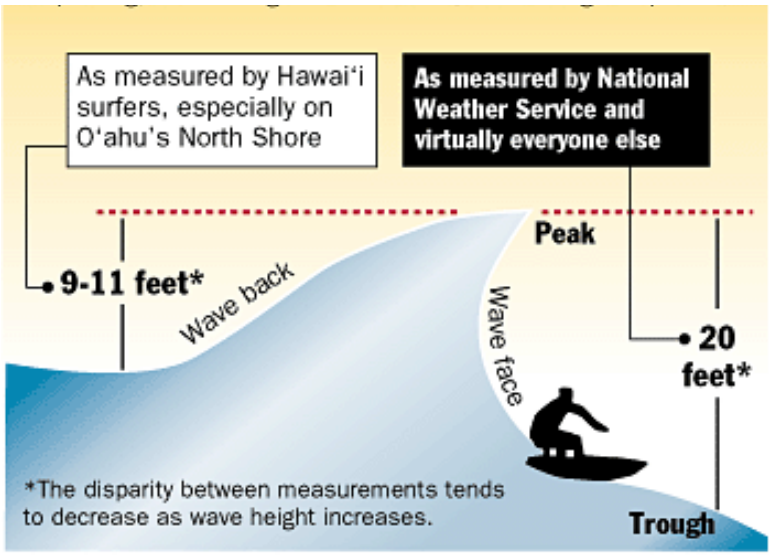

Figure 11.1 Difference between the Conventional and Hawaiian Height Scales[2]

Annually, waves that reach Hawai'i's shores originate from four primary sources, north Pacific swell, northeast trade wind swell, south swell, and Kona storm swell. A graphic with the regions of influence of these regimes and a wave rose depicting annual swell heights and direction is shown in Figure 11.2. Hurricanes and tropical storms are also important sources of waves that impact Hawai'i's coasts on an inter-annual basis. 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 Hawai'i'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.

[2] Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 8p

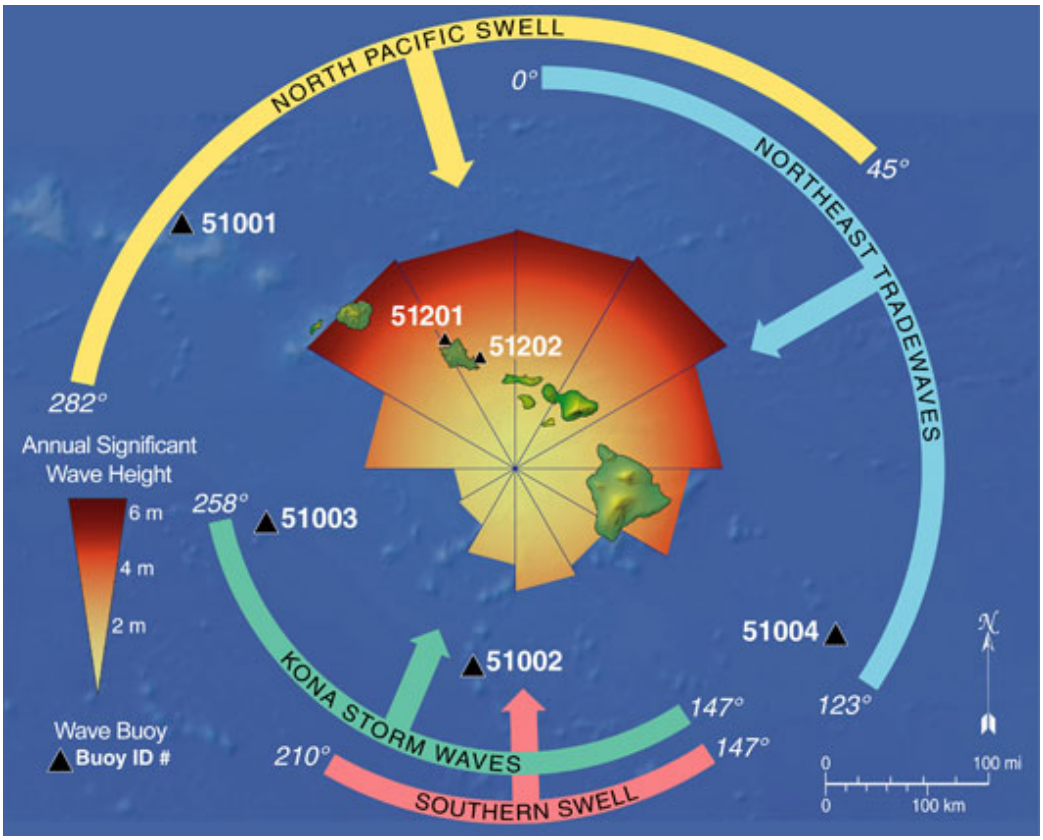

Figure 11.2 Hawai'i dominant Swell Regimes and Wave Monitoring Buoy Locations[3]

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, often catching unaware swimmers, fishermen, and hikers walking along the shoreline. The water level on the coast increases with these sets of large waves and rip currents are generated as this excess water surges seaward.

The wave climate around Hawaiian waters is also influenced by cyclic climatic phenomena like the El Niño Southern Oscillation[4] (ENSO) and the Pacific Decadal Oscillation[5] (PDO). In "*Pu'ukoholā Heiau National Historic Site and Kaloko-Honokōhau Historical Park, Big Island of*

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[3] Vitouesk, S., Barbee, M., Fletcher, C., Richmond, B., and Genz, A., *Pu'ukoholā Heiau National Historic Site and Kaloko-Honokōhau Historical Park, Big Island of Hawai'i: Coastal Hazard Analysis Report, May 20, 2009, 8*p

[4] The El Niño Southern Oscillation (ENSO) is a disruption of the ocean-atmosphere system in the Tropical Pacific having important consequences for weather and climate around the globe. The warm period, known as El Niño, is characterized by unusually warm ocean temperatures in the Equatorial Pacific. The cold period, known as La Niña, on the contrary, manifests itself with unusually cold temperatures in the Equatorial Pacific. El Niño and La Niña have a recurrence interval of three to four years.

[5] The Pacific Decadal Oscillation (PDO) is a pattern of climate variability in the Pacific basin that shifts phases on an inter-decadal time scale of approximately 20 to 30 years. The PDO occurs as warm or cool surface waters are in the Pacific Ocean north of 20 degrees latitude. During a positive or warm PDO, the west Pacific becomes cool and part of the East Pacific warms. Conversely, the opposite pattern occurs during a negative or cold PDO.

Hawai'i: Coastal Hazard Analysis Report", Vitouesk et al point out that strong warm phases of the ENSO are thought to be more active when it comes to high surf because the warmer ocean waters spur stronger and more frequent deep ocean swells and tropical cyclones. Similar conditions can be expected from the warm phases of the PDO.

Figure 11.3 depicts spatial pattern of the anomalies in sea surface temperature (shading, degrees Celsius) and sea level pressure (contours in millibars) associated with the warm phases of the PDO (for the period 1900 to 1992) and the ENSO. Note that the main center of action for the PDO is in the north Pacific, while the main center of action for the ENSO is in the equatorial Pacific. Positive and negative contours are dashed and solid, respectively.

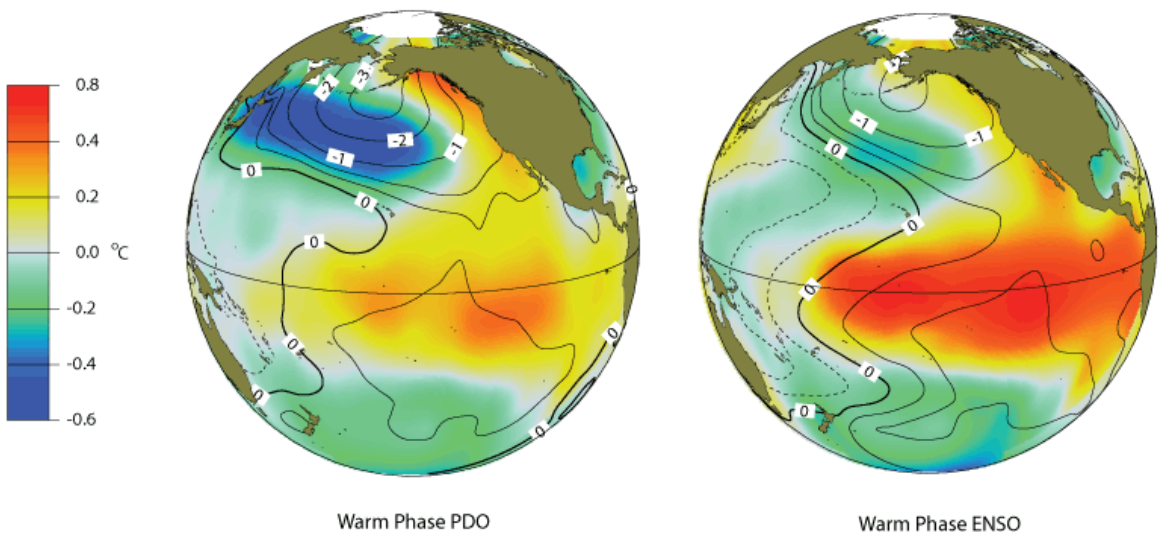

Figure 11.3 Variations in Sea Surface Temperature during Warm Phases of the PDO and ENSO[6]

Jerome Aucan has further studied the influence of the ENSO on high surf in Hawai'i. In "Directional wave climatology for the Hawaiian Islands from buoy data and the influence of the ENSO on extreme wave events from wave model hindcast", Aucan concludes that during strong El Niño events (1965-1966, 1977-1978, 1982-1983, 1986-1987, 1991-1992, 1997-1998) Hawai'i experienced more extreme surf (higher than 4 meters) events than the average trend. Aucan also concludes that La Niña years (1961-1962, 1966-1967, 1970-1971, 1973-1974, 1975-1976, 1988-1989, 1998-1999, 1999-2000, 2000-2001) not necessarily correlate with less extreme surf events. Figure 11.4, taken directly from Aucan's study, shows three maps with average wave heights and directions during El Niño events, during normal conditions, and during La Niña events.

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

[6] Image from the University of Washington Climate Impacts Group Website, Retrieved October 28, 2009 from http://cses.washington.edu/cig/pnwc/aboutpdo.shtml

east, and south-and west-facing shorelines as the storm passes to the south and west. Hurricane generated waves have exceeded 15 feet along east portions of the islands and 20 feet at the island's southern shores. Combined with storm surge and high tides, hurricane waves can overwash coastal roads and properties, as they did for example along the Ka'a'awa and Kāne'ohe coasts of the island of O'ahu during Hurricane Fernanda in 1993 and along the Honolulu and Wai'anae coasts of the island of O'ahu during Hurricane Iniki in 1992.

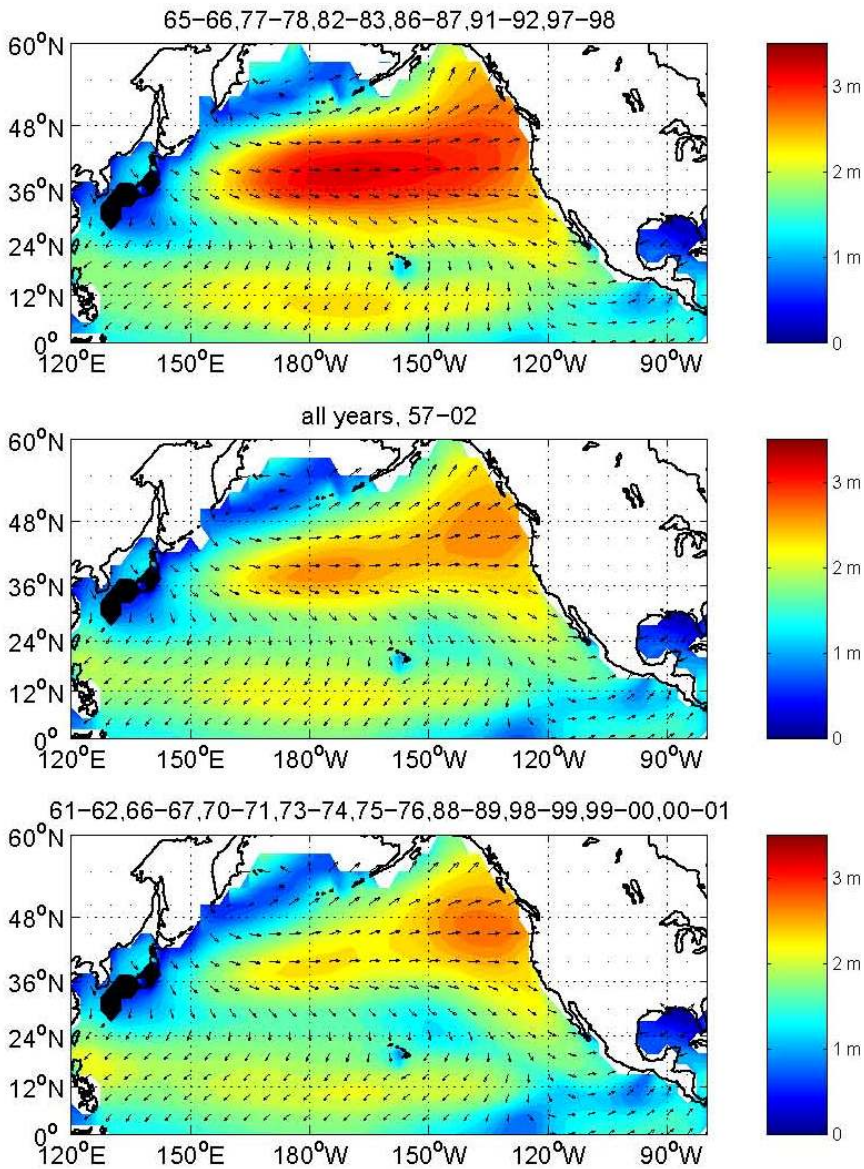

Figure 11.4 Average wave height and direction for the months of November to March, averaged for all El Niño years (top), (winters 65-66, 77-78, 82-83, 86-87, 91-92, 97-98), averaged for all years from 1957 to 2002 (middle), and averaged for La Niña years (bottom) (winters 61-62, 66-67, 70-71, 73-74, 75-76, 88-89, 98-99, 99-00, 00-01).[7]

[7] Aucan, Jerome, *Directional wave climatology for the Hawaiian Islands from buoy data and the influence of ENSO on extreme wave events from wave model hindcast*, October 5, 2006, 20p

11.2 Significant Historic Events

11.2.1 County of Kaua‘i

Extreme surf occurred at the north shore of the island of Kaua‘i on December 14, 2004. A large low pressure complex developed in the northwest Pacific, off the coast of Russia, beginning late on December 11. Pressure in this storm system fell to 964 millibars (28.47 inches) and produced winds approaching hurricane strength (65 knots or 74 mph) in a small area on the south side of the main low (satellite and pressure analysis). Meanwhile, a large area of 40 to 50 knots (45 to 60 mph) winds blew from the northwest over an area almost 1500 miles in length. Such strong winds over such a large area, called a fetch, produced wave heights over 40 feet.

The energy in these waves then moved southeast, away from the strong winds and toward the Hawaiian Islands becoming what is referred to as a swell. Since the earth is round, swells appear to move in a curved route when looking at a "flat" map. These routes are referred to as "Great Circles". To determine whether or not a swell will impact the State of Hawai‘i, we look for wind directions (yellow streamlines in the image) blowing parallel to a great circle path.

This was exactly the situation that set up on December 13. As a swell propagates, the energy within it dissipates resulting in progressively smaller swell wave heights. Over the course of the 500 to 800 miles the swell traveled before reaching Hawai‘i, approximately 50% of the energy was dissipated, meaning the swell had diminished to a little over 20 feet. The swell began reaching Buoy 1 about 200 miles northwest of the island of Kaua‘i during the day on December 14. The swell height peaked at 26 feet just before midnight HST (10 UTC) December 15 and then began to fall (buoy chart). Travel time to the islands from the buoy for such a swell are roughly: 5 hours to Kaua‘i, 8 to O‘ahu, 11 to Maui and 14 to the Big Island. Thus the highest surf occurred on Kaua‘i before daybreak, around sunrise on O‘ahu and late morning and afternoon on Maui and the Big Island. The darkness made it impossible to get observations from the island of Kaua‘i. Figure 11.5, taken from Fletcher’s atlas, lists in graphical form the major deep ocean swell- and tropical cyclone-induced high wave events that have historically affected the County of Kaua‘i until 2002.

11.2.2 City and County of Honolulu

In the case of the City and County of Honolulu, a historic list of damaging high waves on the island of O‘ahu is provided in Figure 11.6, showing that all sides of the island are affected by large waves. During December 1 through 4, of 1969, large winter waves generated from a tropical storm in the North Pacific eroded the vegetation line at Waimea Bay on the north shore of the island of O‘ahu an estimated 50-60 feet, while inundation, as indicated by rocks and sand was more than 750 feet inland.[8] According to Flood Insurance Rate Maps (FIRM) for the City and County of Honolulu, the wave or VE-zones on the north shore of the island of O‘ahu are about 200 feet for Sunset Beach, 700 feet at Kawela Bay, and about 1000 feet inland at Kahuku. For residences displaced by the threat of high surf, shelters may be opened in the affected areas.

[8] State of Hawai‘i Department of Land and Natural Resources (DLNR), 1970

In 1998, wave heights of up to 50 feet were recorded on the north shores of the island of O‘ahu. The prolonged nature of these waves caused significant beach erosion and damage to some homes along the shoreline.[9] The most recent damaging high surf to affect the City and County of Honolulu occurred on December 14, 2004 when 40-foot waves were recorded at Waimea Bay on the north shore of the island of O‘ahu. The high waves were caused by a widespread and intense storm in the northwest Pacific. Although there was no significant damage reported, the high waves resulted in road closures along the island’s North Shore. Prior to this, the last significant waves occurred in January 1998 where the wave heights were up to 50 feet on the north shores of the islands of Kaua‘i and O‘ahu. The prolonged nature of these waves caused significant beach erosion and damage to some homes along the shoreline.[10] A list in graphical form of the major deep ocean swell- and tropical cyclone-induced high wave events that have historically affected the City and County of Honolulu until 2002 is included in Figure 11.6.

11.2.3 County of Maui

According to Fletcher in “Atlas of Natural Hazards in the Hawaiian Coastal Zone”, north Pacific swells generate wave heights reaching 15 to 20 feet on Maui’s north and northwestern shores and, in rare occasion, up to 30 to 40 feet. Location wise, north Pacific swell-induced wave heights typically range between 5 and 10 feet in the vicinity of Kā‘anapali in the northwest coast of the island and between 10 to 20 feet near Honolua Bay also in northwest Maui.[11] North Pacific swell-induced waves can also reach heights of 10 to 20 feet along the island’s north shore between Waihe‘e and Pā‘ia. Historically, some of the highest north Pacific swell-induced high wave events occurred on February 2-4, 1993 and January 23-31, 1998. Per Fletcher, during these two episodes, waves reached heights of 30 and 40 feet, respectively. Figure 11.7, taken from Fletcher’s atlas, lists in graphical form the major deep ocean swell- and tropical cyclone-induced high wave events that have historically affected the island of Maui until 2002.

The highest waves to have impacted the shorelines of the islands of Moloka‘i and Lāna‘i were generated by tropical cyclones that passed nearby the main Hawaiian Islands. Since the 1970’s, several hurricanes have lurked around the Hawaiian Archipelago: Kate in 1976, Fico in 1978, Pauline in 1985, Iniki in 1992, and Fernanda in 1993. According to Fletcher, the wave heights produced by these hurricanes are as follows[12]:

- Hurricane Fernanda generated high waves ranging from 8 to 10 feet that damaged one house on East Moloka‘i.
- While no damage was sustained by high waves induced by Hurricane Iniki, high surf was observed on the east, south and west facing shores of both islands.
- Hurricane Pauline generated 10- to 15-foot waves along east shores of both islands.

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[9] National Weather Service, Honolulu Forecast Office, 2004

[10] National Weather Service, Honolulu Forecast Office, 2004

[11] Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 105p

[12] Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 75p

- Hurricanes Fico and Kate produced waves of 8 to 12 feet and 8 to 15 feet in height, respectively, along coastal segments of both the islands of Molokaʻi and Lānaʻi.

A unique case is that of Hurricane Raymond in 1983, which passed over Molokaʻi as a tropical depression generating 10- to 15-foot high surf along the shores of both islands. Figure 11.7 and Figure 11.8, taken from Fletcher's atlas; list in graphical form the major deep ocean swell- and tropical cyclone-induced high wave events that have historically affected the Islands of Maui and Molokaʻi until 2002.

11.2.4 County of Hawaiʻi

Hurricane Estelle illustrates an example of the susceptibility of the Count of Hawaiʻi to wind and wave setup, as well as storm events. On July 22, 1986, the eye of Estelle passed over 100 miles south of the island of Hawaiʻi. In addition to the high spring tide, high waves generated from Estelle, crashed on the shores of the island. From available reports regarding Hurricane Estelle, major damage in the island of Hawaiʻi occurred at the Vacationland area. The high waves washed away 5 beachfront homes and severely damaged dozens of others. According to records at the County of Hawaiʻi Planning Department, 18 houses suffered minor damage that totaled $42,500. In addition, 12 houses had major damage that totaled $194,000 and 7 houses were completely destroyed with an estimated property damage of $160,883. A list in graphical form of the major deep ocean swell- and tropical cyclone-induced high wave events that have historically affected the County of Hawaiʻi until 2002 is included in Figure 11.9.

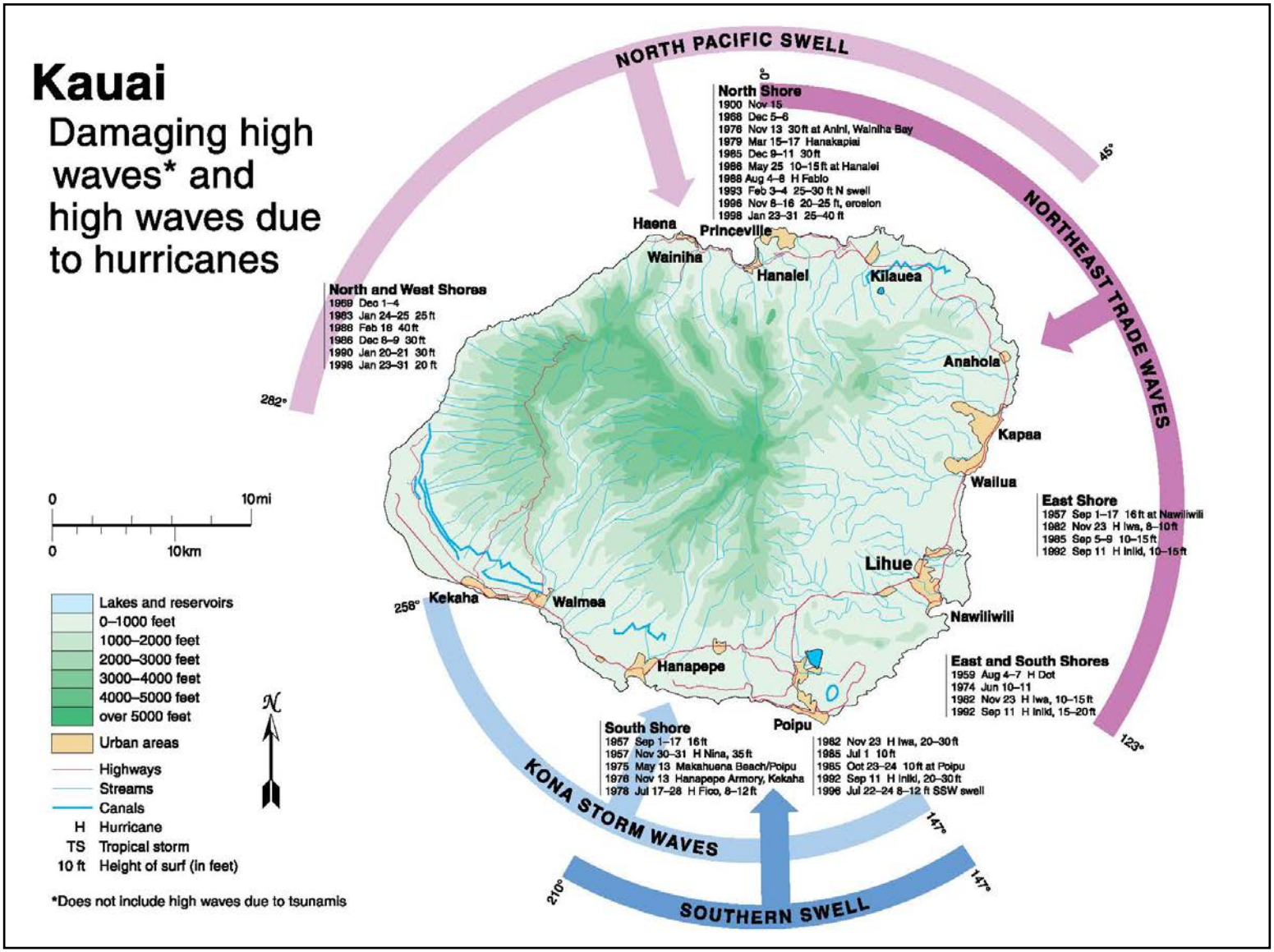

Figure 11.5 Historic Damaging Deep Ocean Swell- and Tropical Cyclone-Induced High Waves for the Island of Kaua'i (County of Kaua'i)[13]

[13] Image courtesy of Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 105p

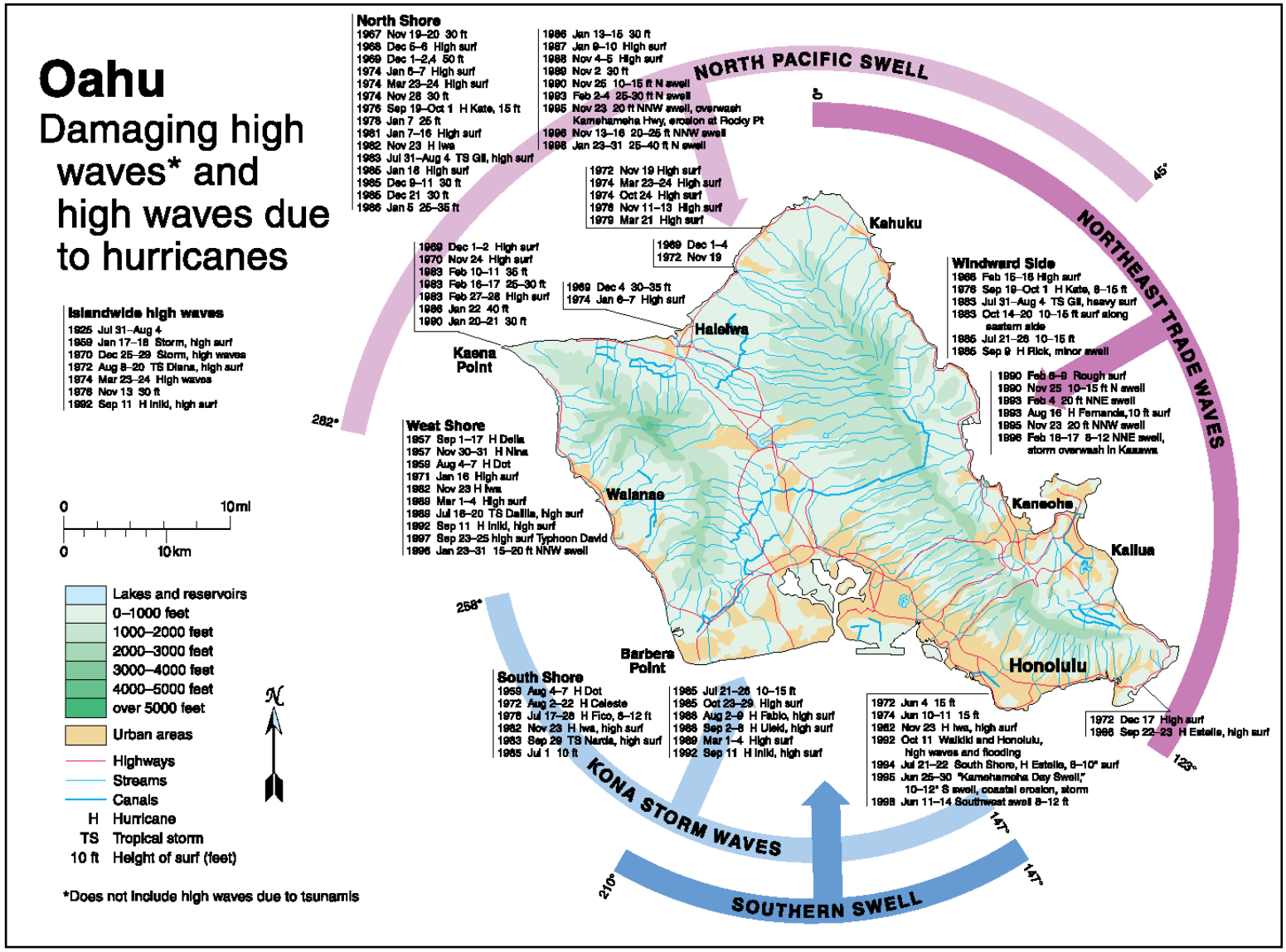

Figure 11.6 Historic Damaging Deep Ocean Swell- and Tropical Cyclone-Induced High Waves for the Island of O'ahu (City and County of Honolulu)[14]

[14] Image courtesy of Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 105p

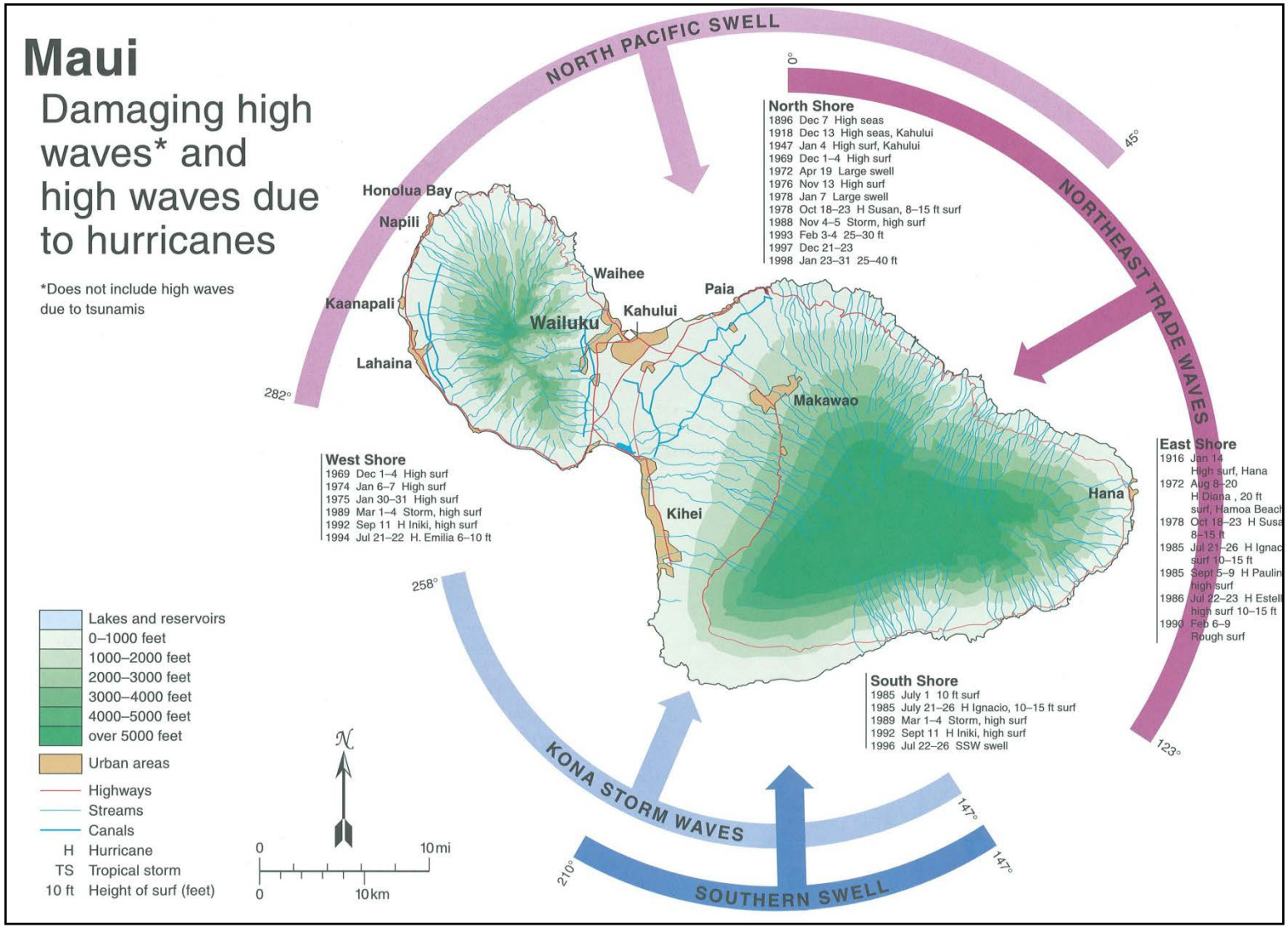

Figure 11.7 Historic Damaging Deep Ocean Swell- and Tropical Cyclone-Induced High Waves for the Island of Maui (County of Maui)[15]

[15] Image courtesy of Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 105p

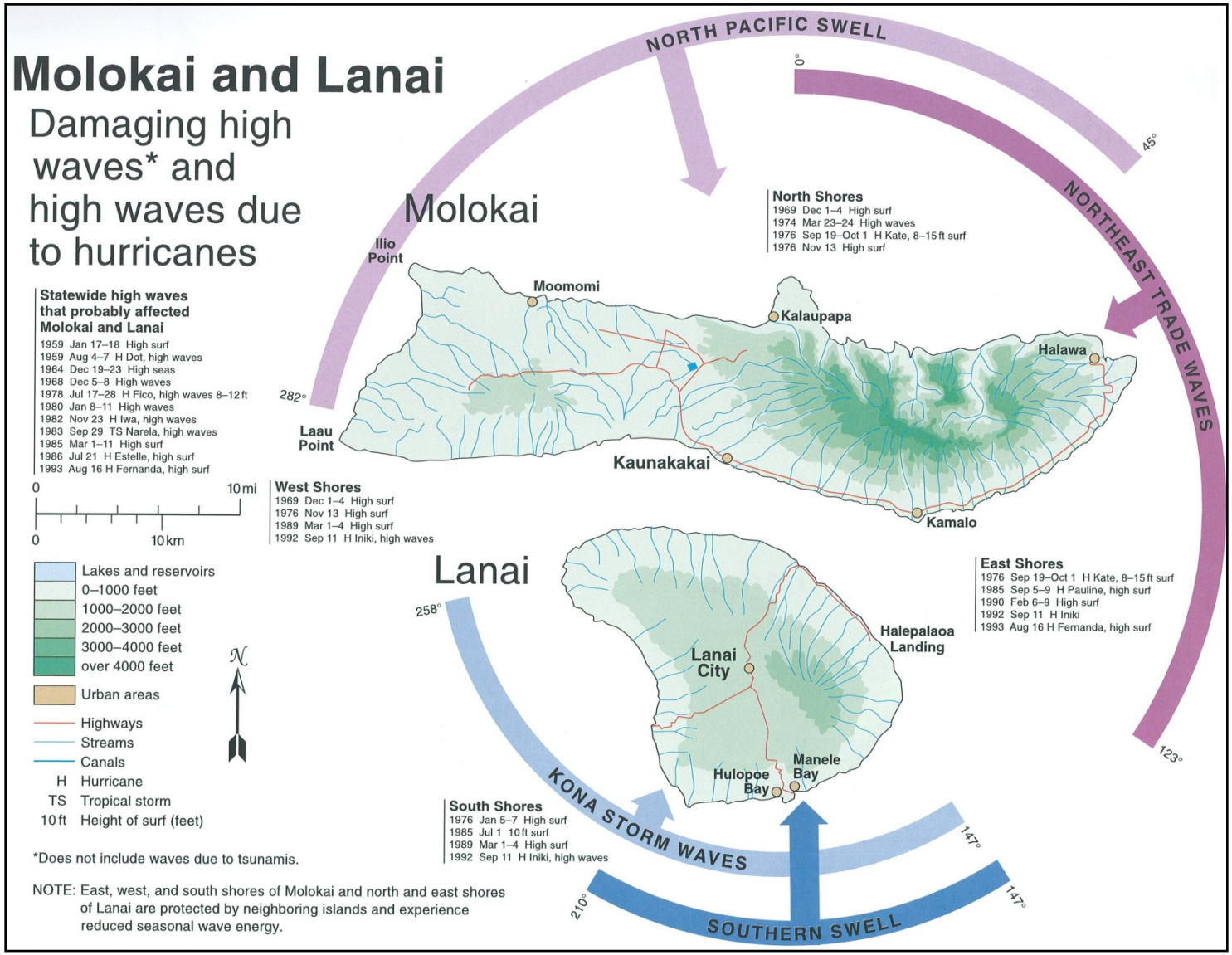

Figure 11.8 Historic Damaging Deep Ocean Swell- and Tropical Cyclone-Induced High Waves for the Islands of Moloka‘i and Lāna‘i (County of Maui)[16]

[16] Image courtesy of Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 105p

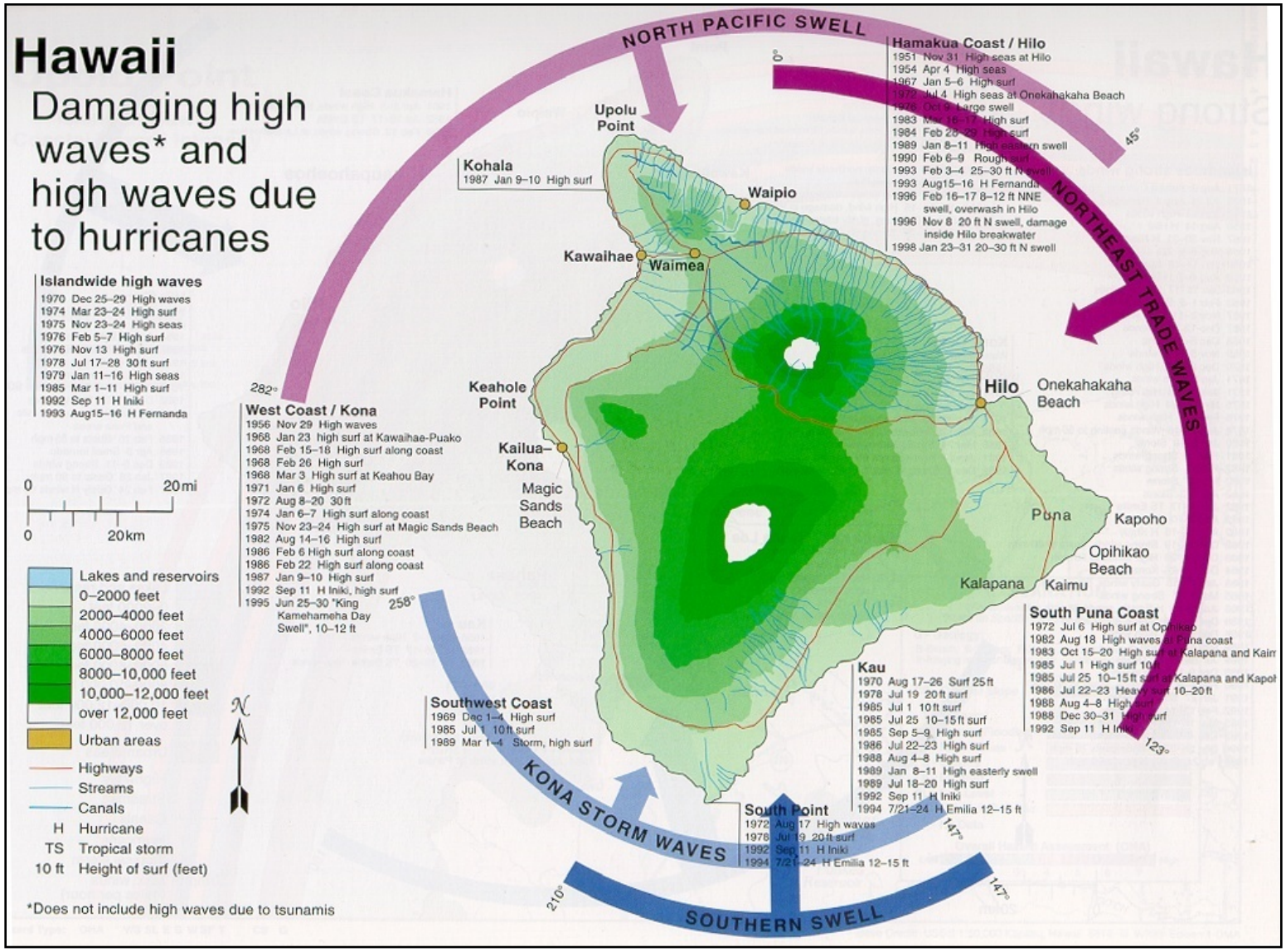

Figure 11.9 Historic Damaging Deep Ocean Swell- and Tropical Cyclone-Induced High Waves for the Island of Hawai'i (County of Hawai'i)[17]

[17] Image courtesy of Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 105p

11.3 Probability of Occurrence

High surf events occur quite frequently on all coasts of all islands in State of Hawai‘i. Nonetheless, events that actually cause damage to property or loss of human life are far less common. The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) zones give probabilities of coastal flooding in zones that may be impacted by episodes of high surf as shown in Table 11.1. Although the coastal flood zones were not developed exclusively to address the impacts high surf, they do provide a conservative delineation of areas that may be at risk.

Table 11.1 FEMA FIRM Coastal Flood Zone Classifications

ZONE	DESCRIPTION
V	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. No base flood elevations are shown within these zones.
VE, V1 - 30	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.

11.4 Risk Assessment

The economic risk associated with the impacts of high surf is encompassed within the loss prediction and risk assessment of the flood hazard.

The highest hazard occurs in most cases for north-facing shorelines of all islands in all counties where north Pacific swells arrive in the winter with regularity in heights exceeding 12 feet (often exceeding 20 feet). Sets of these large waves are characterized by rapid onset so that within a few seconds they can double in size, often catching unaware swimmers, fishermen, and hikers walking along the shoreline. The water level on the coast increases with these large waves and rip currents are generated as this excess water surges seaward.

The wave zone of impact coincides with FEMA’s V and VE FIRM zones. These zones, which are established by the National Flood Insurance Program (NFIP), are subject to flooding and high velocity wave action. Currently, there are no V or VE FIRM zones on the islands of Maui, Moloka‘i, and Hawai‘i. Therefore, the islands most vulnerable to high surf are Kaua‘i and O‘ahu. The inland extent of the wave impact zone is expected to be much greater than the erosion zone. For residences displaced by the threat of high surf, shelters may be opened in or nearby the affected areas.

11.5 Mitigation Strategies

11.5.1 General

Mitigation strategies to address the impacts of high surf are encompassed within the mitigation strategies for the tropical cyclones (storm surge), floods, and tsunami hazards, since all of these will produce similar and likely larger impacts than high surf alone. A few previous/current mitigation strategies particular to high surf, including wave forecasting, will be discussed in the following sections.

11.5.2 Beachfront Signage

Advisory sings can be found in most commonly visited beachfront areas in the sate of Hawai‘i. While some signs are permanent, others get posted when ocean conditions present a threat to beachgoers, recreational swimmers, and water sports enthusiasts. Sings are classified according to warning levels as either dangerous or hazardous. A dangerous warning level means that a potential loss of limb or life exists. Similarly, a hazardous warning level indicates that the potential for severe injuries exists. Figure 11.10 illustrates the most common advisory sings that relate to high surf. The High Surf, Waves Break on Ledge, and Strong Current signs are considered dangerous warning levels while the Dangerous Shorebreak is considered a hazardous warning level.

Figure 11.10 High Surf Related Beach Advisory Signs Used in the State of Hawai‘i (copyrighted by the Hawaiian Lifeguard Association)

11.5.3 Wave Forecasting

11.5.3.1 General

Wave forecasting involves the prediction and evolution of wind-generated waves using numerical models. These mathematical simulations, often known as ocean surface wave models, consider atmospheric and oceanic conditions, wave interaction, and frictional dissipation. The models output typically consists of statistics regarding wave heights and periods that can be used by officials and managers in the shipping industry, emergency response personnel, news media, and the public.

11.5.3.2 National Oceanic and Atmospheric Administration Wavewatch III (NWW3)

This model has a global domain for the Atlantic, Pacific, and Indian Ocean basins with five nested regional grids (Alaskan Waters, Western North Atlantic, North Atlantic Hurricane, Eastern North Pacific, and North Pacific Hurricane) and six local grids (Gulf of Mexico, Key West, Puerto Rico, United States West Coast Zoom 1, United States West Coast Zoom 2, and Hawai‘i).

Physic parameters considered in NWW3 include wave field refraction, nonlinear resonant interactions, sub-grid representations of unresolved islands, and dynamically updated windspeeds and ice coverage. Wind data for WW3 is provided from the operational Global Data Assimilation System (GDAS) for the Global Forecast System (GFS) weather model. In the case of the North Atlantic Hurricane and North Pacific Hurricane regional domains, the wind data is supplemented with NOAA Nation Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory (GFDL) hurricane winds when possible. Ice concentration data is obtained from automated sea ice concentration analysis by the National Centers for Environmental Prediction (NCEP). Lastly, sea temperature data is also obtained from the GDAS.

NWW3 models generate wave forecast maps with wave height and peak direction vectors. Maps available at the full basin, regional, and local levels and can be found at NOAA’s website at http://polar.ncep.noaa.gov/waves/index2.shtml. A sample NWW3 36-hour wave forecast map for the Hawai‘i local grid is shown in Figure 11.11.

11.5.3.3 Naval Oceanographic Office Wave Prediction Model (WAM)

The Naval Oceanographic Office (NAVOCEANO) is a subordinate of the Naval Meteorology and Oceanography Command (NMOC) of the United States Navy. The role of NAVOCEANO is to provide operational oceanographic support to the United Sates Navy Fleet through tailored analysis, real-time data, climatological models, and operational ocean models.

While most tools used by NAVOCEANO are restricted to the military, a few selected tools are available to civilians. Among the unrestricted tools is NAVOCEANO Wave Model, most commonly known as NAVOCEANO WAM and herein referred to as WAM. WAM is a deep-water wave model for bi-daily analysis and forecasts of up to 72 hours. WAM has global coverage but is also available at the regional and local level.

WAM utilizes wind data from the Fleet Numerical Meteorology and Oceanography Center’s (FNMOC) Navy Operational Global Atmospheric Prediction System (NOGAPS) and coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) models.[18] WAM analyses and forecasts produce graphical maps with the following wave parameters: predominant wave direction, significant wave height, swell direction, period and height, wind wave height, and average wave period. WAM maps are available at the global, regional, and local levels. Current condition and forecast maps areas available at the website of NAVOCEANO at https://oceanography. navy.mil/legacy/web/ops.htm.

[18] Naval Oceanographic Office Website, https://oceanography.navy.mil/legacy/web/nipr2006/ modeling.html

For illustration purposes, two WAM forecast maps are provided in Figure 11.12 and Figure 11.13. The map in Figure 11.12 corresponds to a 48-hour forecast during and approaching north Pacific swell on January of 2008. As can be seen in the figure, waves with heights greater than 15 feet were expected in the north and west facing shores of most main Hawaiian Islands. On the other hand, the map in Figure 11.13 corresponds to a 12-hour forecast of waves generated by Hurricane Flossie on August of 2007. In this figure, tropical cyclone induced waves with heights greater than 14 feet were forecasted to ravage the south and east facing shores of the islands of Maui and Hawai‘i.

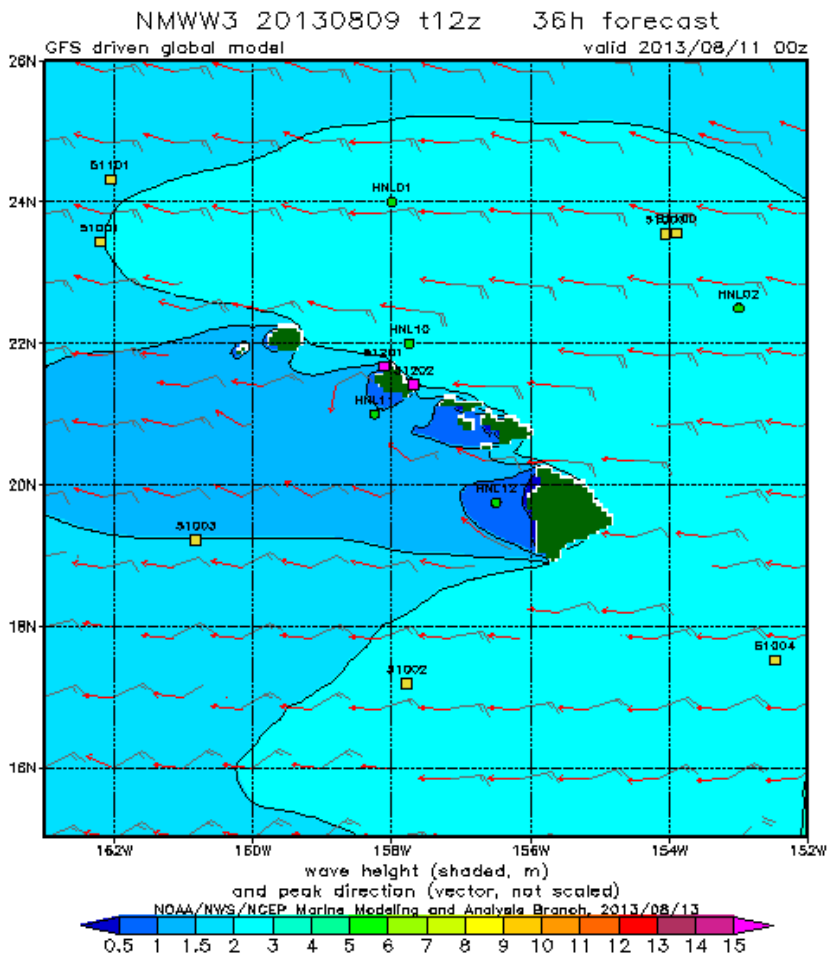

Figure 11.11 Sample 36-hour NOAA WW3 Wave Forecast Map for August 11, 2013[19]

[19] National Oceanic and Atmospheric Administration (NOAA) Website, retrieved August 11, 2013 from http://polar.ncep.noaa.gov/waves/viewer.shtml?-hawaii

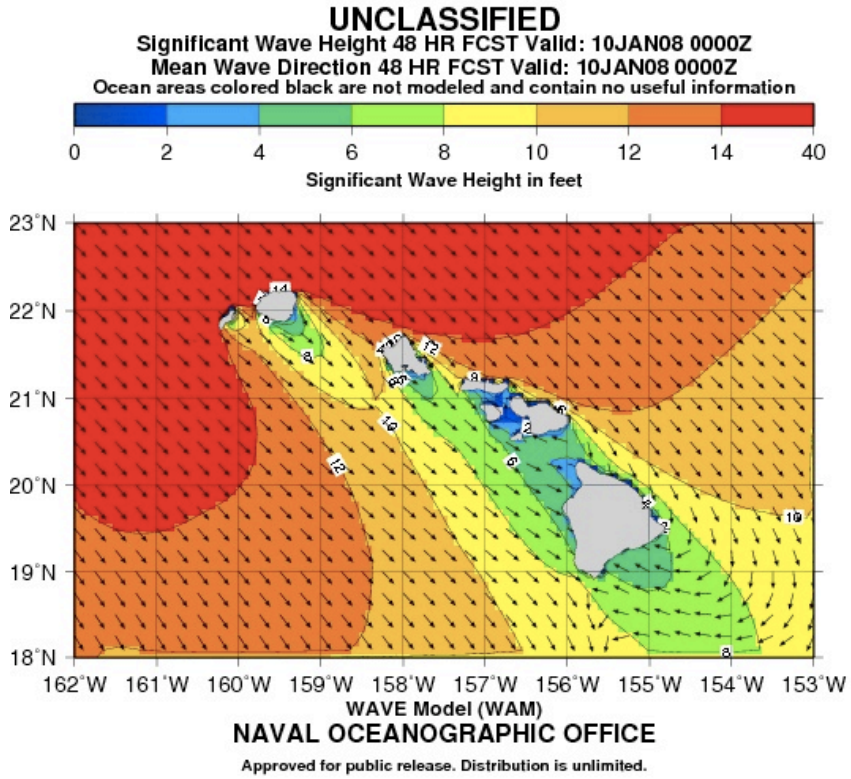

Figure 11.12 Sample WAM Wave Forecast Map Hawai‘i

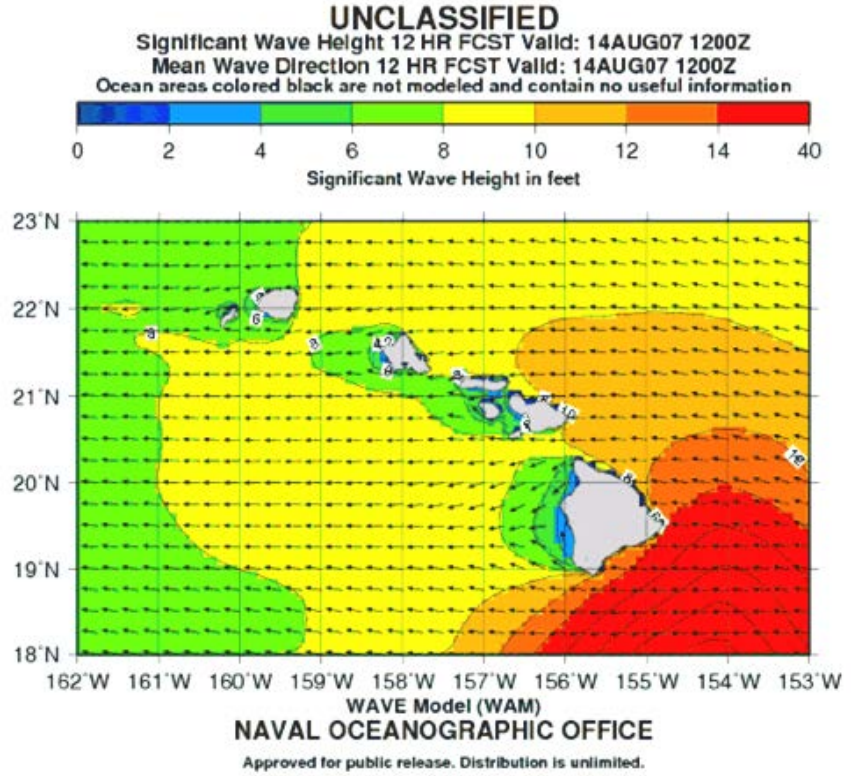

Figure 11.13 Sample WAM Wave Forecast Map Hawai‘i

11.5.3.4 Private Sector Wave Forecast Models

Besides wave forecast models implemented and maintained by national and international governmental agencies, the private sector is producing wind wave simulations and forecasts. Oceanweather Inc. and StormSurf, for example, provide global forecasts for ocean conditions. The former one was developed by and is mostly used by the naval shipping industry while the later one has origins and widespread usage within the surfing community. Figure 11.14 shows a sample Storm Surf 36-hour forecast map indicating wave height and direction and wind for the Hawaiian Islands.

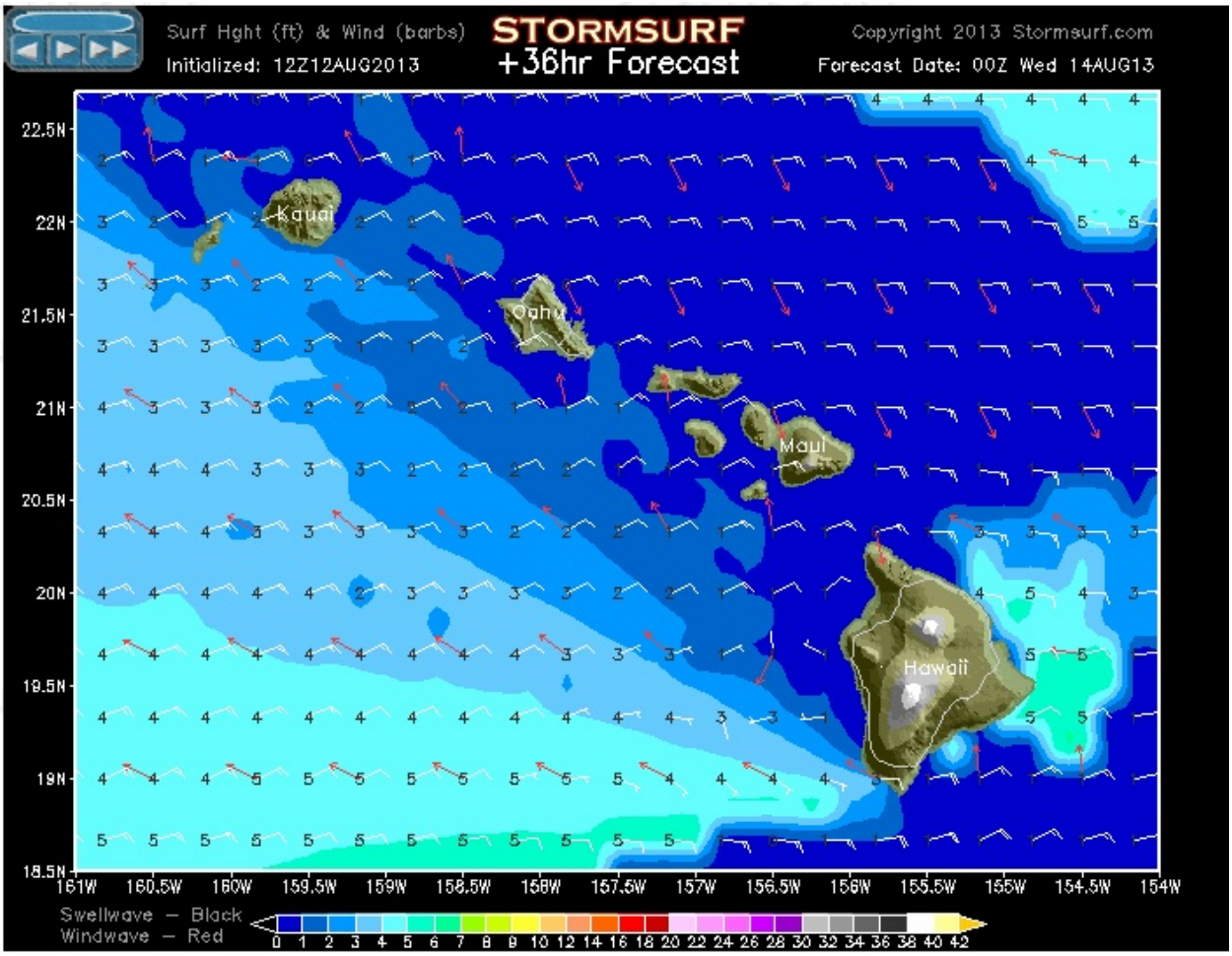

Figure 11.14 Sample Storm Surf 36-hour Forecast Map for August 11, 2013[20]

[20] Storm Surf Website, retrieved August 11, 2013 from http://www.stormsurfing.com/cgi/display.cgi?a=hi

11.5.3.5 Beach Hazard Forecast

Real time information regarding ocean condition at life-guarded beaches is also available at the Hawai‘i Beach Safety Organization Website at http://oceansafety.soest.hawaii.edu. The organization was established through cooperation between the Hawai‘i Lifeguard Association, City and County of Honolulu, County of Maui, Hawai‘i Department of Health, Hawai‘i Tourism Authority, and the University of Hawai‘i School of Ocean and Earth Science and Technology as a non-profit venture.

The Hawai‘i Beach Safety Organization’s website provides wave and beach hazard information that is updated every 10 minutes based on forecasts by the National Weather Service. Three levels of hazard, represented by three types of sings, are employed to rate both beach and nearshore conditions and offshore conditions: Caution, High Hazard, and Extreme Hazard. Every time there is an update, each life-guarded beach gets assigned a level of hazard, and thus a sign, based on a predetermined criterion for each individual beach. A sample beach hazard forecast for the island of O‘ahu (City and County of Honolulu) is shown in Figure 11.15

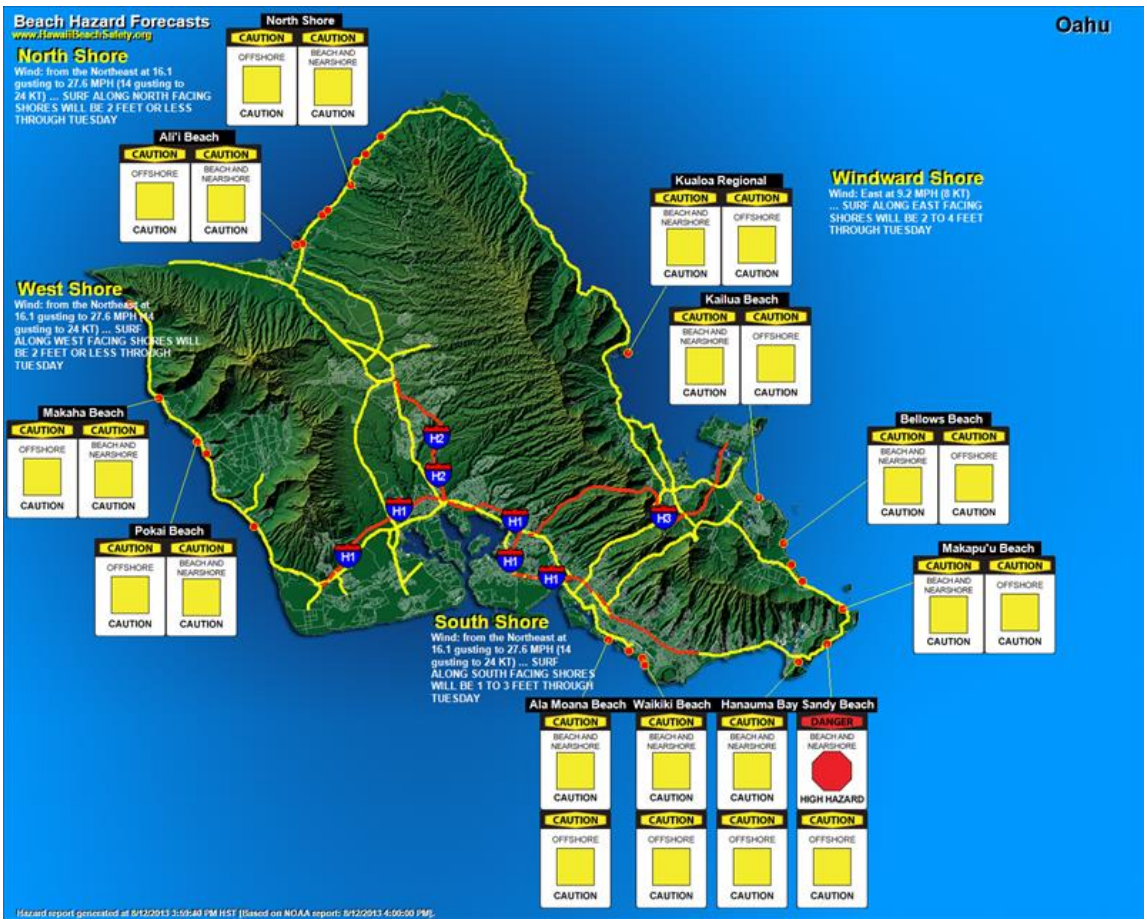

Figure 11.15 Beach Hazard Forecast for the Island of O‘ahu for August 11, 2013[21]

[21] Hawai‘i Beach Safety Website, retrieved August 11, 2013 from oceansafety.ancl.hawaii.edu/v/1.0/index.asp?i=oahu

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

12. Coastal Erosion

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CHAPTER 12

Coastal Erosion

Reasons for Updates / Revisions in this 2013 Plan
• The beaches of the State of Hawai‘i are vital economic, environmental, and cultural resources. A healthy, wide sandy beach provides protection against the effects of storm surge, tsunami flooding, and high surf impacts. Coastal erosion and beach loss are chronic and widespread problems in the Hawaiian Islands. • The cost of the beach loss at Waikīkī Beach on the Island of O‘ahu has been estimated would be about $1 million per year, in order to maintain the beach in its current state. Island-wide annual losses for the island of O‘ahu are estimated at $2-3 million. • The new coastal erosion rate maps developed by the University of Hawai‘i are highlighted to document coastal erosion. Typical erosion rates in Hawai‘i are in the range of 15-30 cm/yr. Recent studies on the island of O‘ahu have shown that nearly 24% or 17 miles of an original 72 miles of sandy shoreline (1940s) has been either significantly narrowed or lost. • This study is a first step towards having the capability to establish setback requirements that would be scientifically based. • Recent wave run-up simulations and the periodic replenishment programs are described.

Summary of Mitigation Projects for the State of Hawai‘i	
Project	Priority
Incorporate all-hazard assessments in land development application process	High
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.	Medium
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.	Low
Waikīkī Beach Sand Restoration to 1985 width (State Office of Conservation and Coastal Lands, DLNR). $2.5 M Project ongoing to pump sand back from offshore accumulation areas.	Medium

12.1 Coastal Erosion Hazard Description

12.1.1 General

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, tropical cyclones, tsunamis and seismic and volcanic activity. In addition to the natural processes that cause coastal erosion, human alterations are affecting erosion rates. In Hawaiʻi, human interference with sand transport processes underlies much of the chronic erosion impacting the islands' shorelines. Long-term coastal erosion threatens developed areas with potential loss of life and millions of dollars in property damage.

As shorelines retreat inland, waterfront homes and public infrastructure such as roads, bridges, wastewater treatment facilities, and storm water drainage systems eventually may become severely damaged beyond use, uninhabitable, or surrender to the ocean. Nationally, the Heinz Center Report on "Evaluation of Erosion Hazards" predicts that over the next 60 years, erosion may claim one out of four houses within 500 feet of the United States shorelines.[1] According to the report, most of the damage will occur in beaches and low-lying areas also subject to the highest risk of flooding. Some additional damage will also occur along eroding coastal bluffs.

In Hawaiʻi, the beaches are vital economic, environmental, and cultural resources. A healthy, wide sandy beach provides protection against the effects of storm surge, tsunami flooding, 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.[2] In addition, the beaches of Hawaiʻi are a public trust resource, whose protection is required by State Statutes and case law.

Beaches change 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 long shore 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.

In all the Hawaiian Islands, beaches serve as natural protective buffers between the ocean and the land. Waves reaching the islands of Kauaʻi, Oʻahu, Molokaʻi, Maui, Lānaʻi and Hawaiʻi from storms across the Pacific Ocean carry tremendous amounts of energy, and beaches absorb much of this energy before it reaches the shoreline and coastal properties. During storm events, beaches are able to modify their slope and overall morphology to dissipate the waves while not

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[1] The H. John Heinz III Center for Science, Economics and the Environment, *Evaluation of Erosion Hazards*, Prepared for the Federal Emergency Management Agency (FEMA),April 2000

[2] State of Hawaiʻi Department of Land and Natural Resources (DLNR), Land Division, Coastal Lands Program, *Hawaiʻi Coastal Erosion Management Plan (COEMAP)*, 2000

destroying themselves. In these scenarios, the beach profile is flattened, and the waves coming inshore shoal further out offshore, thus minimizing further erosion. Beaches recover when sand is moved back onto the shore by smaller waves, and then is blown inland to reestablish the frontal dunes. The final stage of recovery of the beach and dunes occurs when vegetation grows back over these new dunes. Hence, the narrowing of healthy beaches in response to a high wave event is often a temporary condition.[3]

12.1.2 Coastal Erosion versus Beach Erosion

It is important to understand the difference between coastal erosion and beach erosion (the later one is also known as shoreline retreat). Coastal lands may experience long-term erosion under certain conditions. Some of these conditions will be discussed later in this Chapter. Regardless of the source, however, as the coastline erodes, the beach must eventually migrate landward or drown. If there is a sufficient source of sand, the beach, remains wide and healthy as it moves with the eroding coastline. If sand is not available to a beach on an eroding shoreline, then beach erosion will ensue, leading to narrowing and eventually beach loss. Beach narrowing and loss occurs where sand supplies are diminished or discontinued. Beaches on eroding coasts still undergo seasonal profile adjustments, but they slowly shift their position landward as the land erodes. Coastal erosion, then, causes land loss, not beach loss. Figure 12.1 illustrates how eroding shores can maintain their natural width as they slowly retreat landward.

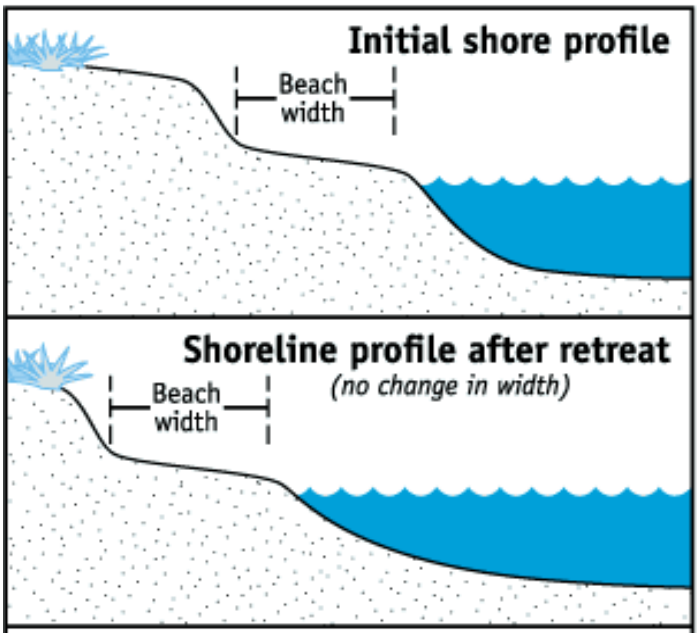

Figure 12.1 Coastal Erosion on a Healthy Beach[4]

[3] University of Hawai‘i Sea Grant Extension Service and County of Maui Planning Department, *Beach Management Plan for Maui*, December 1997

[4] Image from Hawai‘i Department of Land and Natural Resources (DLNR) Website, Retrieved November 3, 2009 from http://www.state.hi.us/dlnr/exhibits/clp/CoastalErosion2.html

12.1.3 Seasonal Coastal Erosion

Seasonal coastal erosion, also known as episodic coastal erosion, occurs when beaches and other coastal areas are exposed to seasonally high waves. In Hawai‘i, seasonal erosion is more severe on beaches that lack fringing reefs. On these beaches a single unusually large wave event or high wave season can cause severe coastal erosion. The vegetation line may retreat as much as 60 or more feet, but if the erosive event is followed by a long period of normal wave conditions, the shoreline can recover, often accreting back to its pre-event location. Figure 12.2 illustrates the process of seasonal coastal erosion on a healthy beach. Beaches subject to seasonal erosion and accretion cycles are referred to as dynamic beaches.[5] Dynamic beaches may have little or no long-term trend of shoreline erosion, but the risk of seasonal erosion remains.

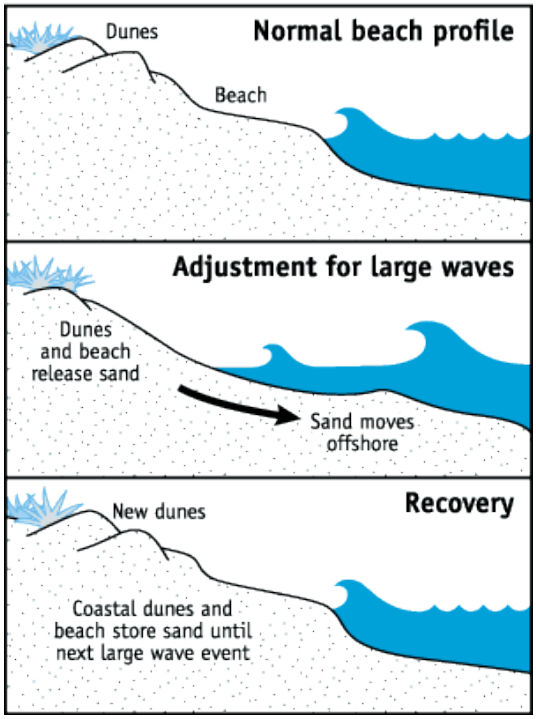

Figure 12.2 Seasonal Coastal Erosion on a Healthy Beach[6]

12.1.4 Effects of Local Wind and Surf Patterns

Highly variable local patterns of wind and wave dynamics can be important keys to dispelling misunderstandings of beach processes. Waves are the key factor in the process of coastal retreat because they are able to reach high onto the beach and into the dunes during certain seasons of the year when they are at their maximum height. This reach allows sand to be transported back

[5] Makai Ocean Engineering Inc. and Sea Engineering Inc., *Aerial Photograph Analysis of Coastal Erosion on the Islands of Kaua‘i, Moloka‘i, Lāna‘i, Maui and Hawai‘i*, Hawai‘i Office of State Planning, Coastal Zone Management Program, Honolulu, Hawai‘i 1991

[6] Ibid

to the beach face to "make deposits into the beach sand budget." In general, on the north shore of the Hawaiian Islands, waves are highest in the winter because they are generated by distant storms in the northern Pacific. On the south side, waves are highest in the summer because they are generated by storms in the southern hemisphere. On the east facing shores, waves are generated by the predominant trade winds and by large north swells that wrap around the coastline. Natural features such as coral reefs, offshore channels, and offshore depth variability, as well as the orientation of the coast relative to the prevailing winds and approach of distant waves, drive waves in different ways. For example, the beaches on the south coastlines of the island of Maui are influenced by trade wind-driven flow so that sand typically moves to the south. But when intense Kona storms from the south and west occur there, sands are driven to the north in large quantities.[7]

12.2 Sources of Coastal Erosion

12.2.1 General

Causes of coastal erosion and beach loss in Hawai‘i are numerous but, unfortunately, are poorly understood by the public and rarely quantified. There are two types of sources contributing to coastal erosion in the shorelines of the Hawaiian Islands: natural sources and human-induced sources.

12.2.2 Natural Sources

Natural sources of coastal erosion include high waves and strong currents, sea-level rise, and land subsidence. These sources are described in detail in the following sections.

12.2.2.1 High Waves and Strong Currents

As high waves and strong currents repeatedly reach the coastline, they lead to natural deficits in sand supply. Repeated episodes of high surf constantly drawing sand stores from the upland area of a beach to feed the beach profile will eventually cause chronic coastal erosion. Along most Hawaiian shorelines, sands stored in dunes and fossil shorelines are moved onto the beach by this process. Beaches benefit from this source of sand, in order to remain wide and healthy, even as the land behind them may erode.

However, when the sand supply is exhausted, coastal erosion ensues and ultimately results in beach erosion and beach loss. In recent decades, climatic phenomena such as the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO)[8] have been correlated with more active tropical cyclone seasons and thus, prolonged higher wave periods in the region surrounding the Hawaiian Islands. These unusually long periods of high waves and strong currents have accelerated the rates at which Hawaiian shorelines erode. Further information on

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[7] COEMAP, *The Coastal Erosion Management Plan*, State of Hawai‘i Department of Land and Natural Resources (DLNR), Honolulu, Hawai‘i, 2000

[8] The effects of the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) on high waves is discussed in detail in Chapter 12 – High Surf

the nature of high waves and their effect on coastal areas are presented in Chapter 11 – High Surf.

12.2.2.2 Sea Level Rise

As sea level rises, shorelines in the Hawaiian Islands experiencing a deficiency in sediment, or those at equilibrium with sediment supply, are likely to experience erosion. However, sea-level rise due to global warming is not presently a cause for alarm. Scientists, planners, and policymakers throughout the 1980s have discussed questions regarding future rates of rise resulting from an enhanced greenhouse effect, 1990s, and 2000s. At present, sea level is projected to rise 2 feet over the 21st century. This is more than twice the rate of rise of the 20th century.

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-sloped coasts will be the most vulnerable to coastal erosion due to sea-level rise. A more complete discussion of future sea levels and their impacts on the coasts of the United States is available in a 1992 publication by Fletcher.[9]

12.2.2.3 Land Subsidence

The State of Hawai‘i has a system of tide gauges, maintained and operated by the National Ocean Service, located on the islands of Kaua‘i, O‘ahu, Maui, and Hawai‘i that record fluctuations in sea level. Analysis of these records provides scientists with rates of long-term sea-level rise around the State. Through this gauging system, it has been possible to realize that each island has its own rate of rising sea level.

The rise in sea level is not due to ocean behavior but rather due to island behavior. On the island of Hawai‘i, for example, the heavy load of geologically young volcanic rocks is flexing the underlying lithosphere causing the island to subside. This phenomenon creates a relatively rapid rate of sea-level rise, on the order of 1.5 inches per decade. Also being geologically youthful, the island of Maui is also affected by the flexure process and is experiencing rapid sea level rise – nearly 1 inch per decade. The islands of O‘ahu and Kaua‘i, on the other hand, lie outside the area of subsidence and have lesser rates of rise – approximately 0.6 inches per decade. A map or the main Hawaiian Islands with their rate of subsidence, and hence rate of sea level rise, is shown in Figure 12.3.

[9] Fletcher, Charles, *Sea Level Trends and Physical Consequences: Applications to the U.S. Shore*, Earth Science Reviews, 1992, 33, 73-109p

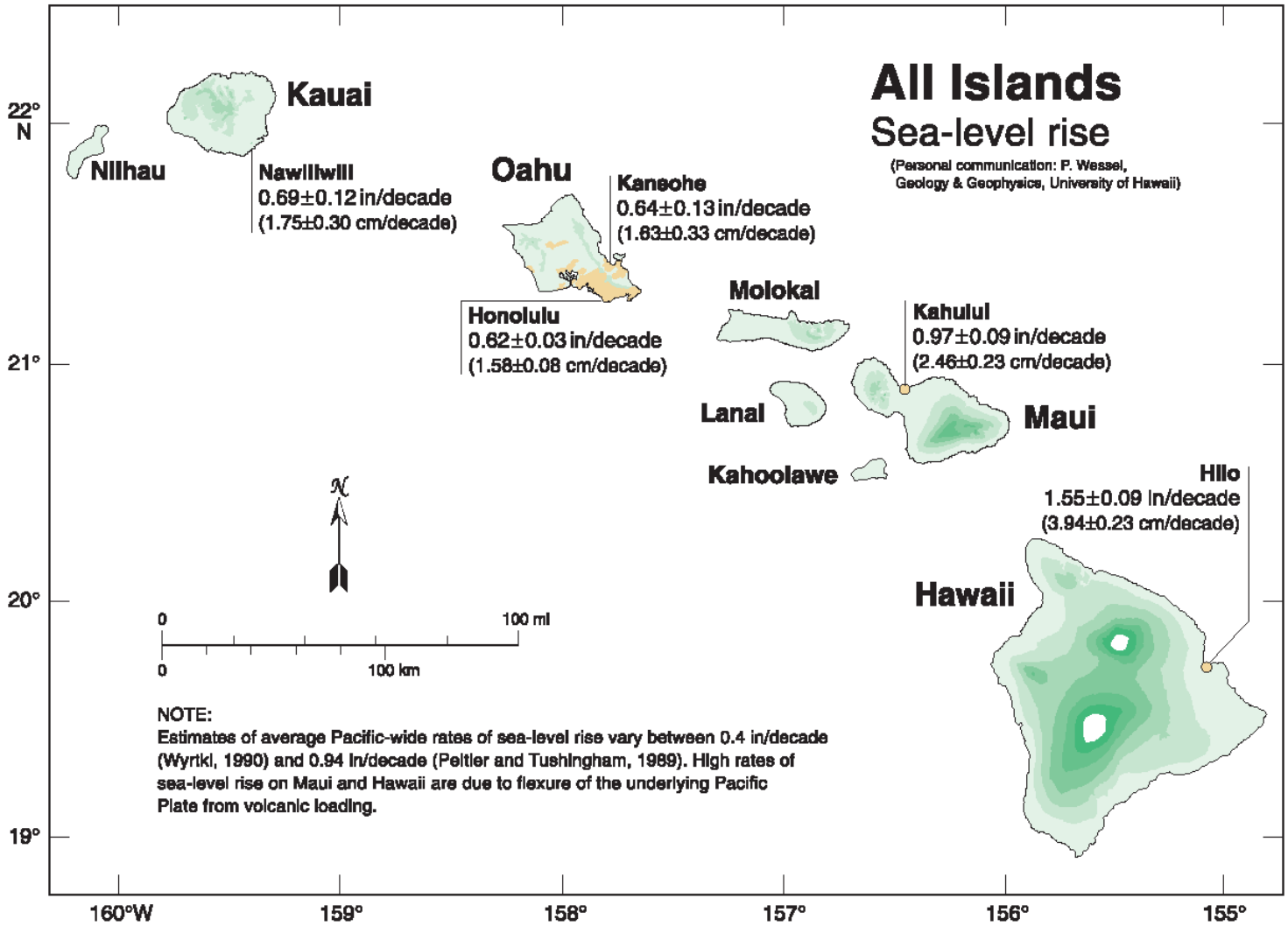

Figure 12.3 Rate of Sea Level Rise for the Hawaiian Islands[10]

[10] Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002

12.2.3 Human Induced Sources

Human interruption of natural sand movement and sand supply in the form of coastal armoring, dune leveling and grading, sand mining, and harbor and waterway dredging have are a significant source of coastal erosion. These human sources will be discussed in detail in the following sections.

12.2.3.1 Coastal Armoring

Coastal armoring, also known as shoreline hardening, is characterized by the impoundment of sediments due to seawalls, revetments, and other similar structures. Sands that would normally be released into coastal waters during high wave events and with seasonal profile fluctuations are trapped behind these structures and prevented from adding to the beach sediment budget. Eventually, the beach narrows until it is ultimately lost.

One seawall may have minimal impact, but along many Hawaiian coastlines, myriads of armoring structures combine to reduce sand availability to nearly zero. Natural coastal erosion does not damage beaches that have access to a robust sediment budget. Beaches on chronically eroding coasts that are not armored remain healthy even during shoreline retreat because sands are released from eroding coastal lands that nourish the adjoining beach. 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. Many beaches eventually disappear simply because they are starved of sand.

12.2.3.2 Breakwaters

Breakwaters are common in Hawaiian shorelines to protection of harbor, marinas, and boat basins. Breakwaters have the potential to cause sediment deficiencies along adjacent beaches because they interfere with patterns of sand flow and accumulation. For this reason, it is important to conduct careful assessments of dynamics and patterns along shorelines in order to minimize the impacts of existing and future breakwaters to coastal resources. Moderate erosion trends can be exacerbated and accreting coastlines caused to erode by poorly conceived civil works projects on the coast that trap sand or alter its movement.

12.2.3.3 Dune Leveling

One of the most important storage sites for sand is the frontal dune system that lines many shores. As was explained in the previous section, coastal armoring traps these sands and thus prevents the replenishment of sand on beaches. Besides coastal armoring, however, sand dune leveling and grading accompanying beachfront development is one of the most destructive practices taking place along the Hawaiian coast.

Dune ecologies in the Hawaiian Islands have been decimated by common landscaping practices that do not seek enhancement of the endemic environment, do not recognize the value of salt tolerant vegetation as a tool for beach and dune preservation, and do not establish dune conservation as a goal of the landscaping effort. Grading of dunes with soil to support short-grass lawns is a source of silt accumulation in coastal waters during erosion events, and acts to

compact and trap dune sands such that the adjacent beach experiences deflation, or a lowering of elevation due to sand removal by waves without replacement by dune sand. Deflated beaches fronting filled dunes provide poor erosion buffering capabilities and are themselves a degraded environment with little to offer the normal coastal ecosystem and its host of organisms with beach-dependent life stages (turtles, various marine larvae, and certain reef fishes.

12.2.3.4 Canalization

As was discussed in detail in Chapter 9 – Floods, many streams that flow intermittently from Hawaiian mountains ranges to the coast are subject to flash flooding during heavy rainfall events. To prevent coastal zone flooding, the most hazardous of these streams have been canalized into concrete canals or gutters so that flooding is contained. Where canals and similar infrastructure open onto the coastal zone, the channel mouths tend to trap sand that is moving along the shoreline. The buildup of sand within the channel mouths increases the upstream flood hazard and creates a sand deficiency on the adjacent beach. Public works departments often clear these accumulations and dispose of the sand in various ways, including trucking it off-site to be used elsewhere (i.e. golf courses). Unless these sands are returned to the immediate beach area, the long-term dredging and clearing is nothing less than a sand-mining effort and it will have a similar impact on the adjacent beach. This process has the potential to reduce available sand volumes and create chronic erosion where none previously existed. In placing cleared sands onto adjacent beaches, it is important to be aware of prevailing sediment transport patterns so that returned sand can function in a manner that will provide nourishment. To ensure proper adjacent beach replenishment, it is necessary to conduct reviews of the ambient littoral processes and develop schedules of transport direction around each channel mouth, with guidelines on the placement of returned sand.

12.2.3.5 Sand Mining

In the past, the beaches of Hawai‘i’s, and especially the beaches of the island of Maui, were subjected to sand mining for lime processing. The calcareous sand (calcium carbonate) is baked to release carbon dioxide and produce simple lime (calcium oxide) for use as a building material. In the island of Maui, for example, Baldwin Beach, Sugar Cove, and other beaches were past sand mining sites. Sand mining is in large part responsible for the retreat of both the vegetation line and the beach foreshore over recent decades along these beaches. Besides loss of vegetation and beach foreshore, sand mining impacts beaches negatively by decreasing sand volumes, steepening the morphology of the shoreline, and reducing the ability of profiles to respond to seasonal wave stresses. Although presently outlawed in Hawai‘i, there are occasional requests to mine remote beaches that are perceived as being of low socioeconomic value and high sand volume.

12.2.3.6 Impoundment

In Hawai‘i, coastal lands such as inland dunes and sandy plains are typically composed of carbonate sand. Therefore, when they 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.

Sediment impoundment often 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 have the cumulative effect of damaging the beach, an erosion prone area, by reducing 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 In Hawai‘i, 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 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.

This “mixed” jurisdiction is the source of Hawai‘i’s complex and inefficient coastal regulatory system. Often one agency’s policies (i.e. infrastructure protection) may be at odds with another agency’s policies (i.e. resource protection). Historically, the protection of private property and public infrastructure has outweighed the protection of the natural resource (beaches).

12.2.3.7 Miscellaneous

There are other human activities that interfere with a beach’s natural sand flow and accumulation. Among these activities are clearing storm drainage channel mouths, dredging

12.3 Probability of Occurrence

A study by the University of Colorado that uses satellite measurements to determine average mean sea level over a determined time period estimates the rate of global sea level rise at approximately 3.2 millimeters per year.[11] This rate is almost two times the rate of the last century. Since August 1992, the satellite altimeters have been measuring sea level on a global basis with unprecedented accuracy. The TOPEX/POSEIDON (T/P) satellite mission provided observations of sea level change from 1992 until 2013 (see Figure 12.4). Jason-1, a satellite for oceanography studies that was launched in late 2001 as the successor to T/P, continues this record by providing an estimate of global mean sea level every 10 days with an uncertainty of 3 to 4 millimeters. The latest mean sea level time series and maps of regional sea level change can be found on the University of Colorado's Sea Level Research Group website. Concurrent tide gauge calibrations are used to estimate altimeter drift. Sea level measurements for specific locations can be obtained from the website's interactive wizard feature. Further, details on how these results are computed can be found in the attached documentation and the bibliography.

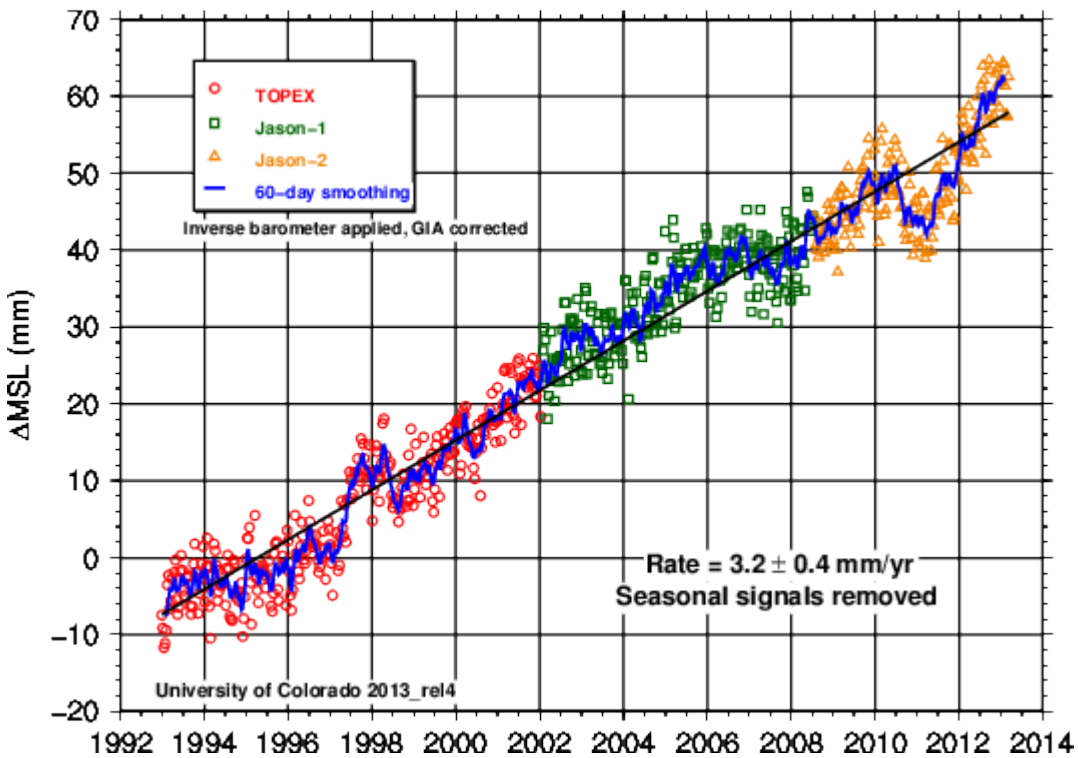

Figure 12.4 Sea Level Change and Acceleration[12]

Sea-level rise is not presently a cause for immediate alarm, although it may present a serious hazard in the future. Questions regarding future rates of rise resulting from an enhanced

[11] University of Colorado (UC) Sea Level Research Group website, retrieved June 21, 2013 from http://sealevel.colorado.edu

[12] Church, J. A. and N. J. White., 2006: A20th century acceleration in global sea-level rise, *Geophys. Res. Lett.*, 33(1), L01602.

greenhouse effect have been discussed by scientists, planners, and policymakers throughout the 1980's and 1990's. At present, sea level is projected to rise 2 ft over the 21st century. This is more than twice the rate of rise of the 1900's. Other researchers predict sea level rise could be 1-2 meters of more this century. 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. (A more complete discussion of future sea levels and impacts is available in Fletcher 1992 and the IPCC Working Group 1 and 2 reports from the Fourth Assessment 2007, www.ipcc.ch.)

12.4 Risk Assessment

Coastal erosion and beach loss are chronic and widespread problems in the Hawaiian archipelago. In the few decades, there have been many quantitative studies to establish erosion rates in the coasts of the Hawaiian Islands. A study by Hwang in 1989, for instance, concluded that typical erosion rates in Hawai‘i are in the range from 15 to 30 centimeters per year (6 to 12 inches per year), with some areas reaching annual average erosion rates of up to 150 to 180 centimeters per year (60 to 72 inches per year).[13]

A more recent study conducted in 2012 by Romine and Fletcher estimated both long- and short-term erosion rates for the three of the main Hawaiian Islands (Kaua‘i, O‘ahu, and Maui). Figure 12.5 plots long- and short-term shoreline change rates for coastal regions as taken from Romine and Fletcher's study. In the figure, the width of a box depicts the upper and lower quartiles (Q1 and Q3) of the distribution of shoreline change rates for a region (i.e., the middle 50% of the data). As can be concluded from the figure, erosion is the dominant trend of shoreline change on the islands, with 70% of the beaches indicating and erosional trend and an overall average shoreline change rate of approximately 11 centimeters per year (4.5 inches per year).[14] The figure also shows that average shoreline changes can reach up to 40 centimeters per year (16 inches per year) depending on the island and on the cardinal location of the coastline.

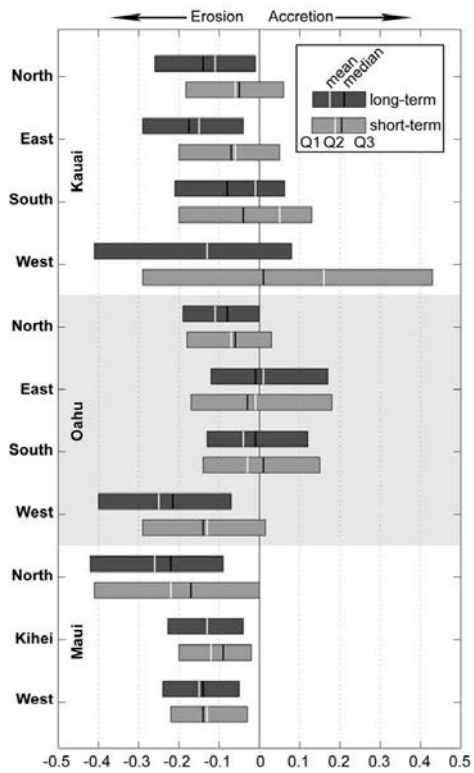

Figure 12.5 Shoreline Change Rate (meter/year) for the Islands of Kaua‘i, O‘ahu, and Maui

[13] Hwang, 1981; Sea Engineering Inc., 1988; Makai Engineering, Inc.; and Sea Engineering Inc., 1991

[14] Romine, B.M. and Fletcher, C.H., 2012, A Summary of Historical Shoreline Changes on Beaches of Kauai, Oahu, and Maui; Hawaii, Journal of Coastal Research, 00(0), 000-000. West Palm Beach, Florida, p. 15

12.4.1 Construction Setbacks

At the state level, shoreline setbacks are required to be not less than 20 feet and no more than 40 feet inland from the shoreline. This requirement is set forth in the State of Hawai‘i Coastal Zone Management Law [HRS §205A-43(a)]. The state level regulation also allows each county to extend the minimum shoreline setback beyond 40 feet [HRS §205A-45]. All of the counties have extended the minimum setback beyond 40 feet to some extent.

12.4.1.1 County of Kaua‘i

In the case of the County of Kaua‘i, shoreline setback regulations are determined by Ordinance No. 887 of the County of Kaua‘i Code. This ordinance, which became effective in early 2008 (initially Ordinance No. 863), establishes a minimum shoreline setback based on the Average Lot Depth (ALD). The requirements based on ALD are listed in Table 12.1. In addition to the minimum shoreline setback based on ALD, the ordinance requires that for lots with ALDs greater than 160 feet, the setback distance be greater than 40 feet plus the Average Annual Erosion Rate (AAER) multiplied by 70 or 100 based on the size of the proposed structure (see Table 12.2). Many experts in the field of climatology, engineering, and urban planning consider the shoreline setback regulations of the County of Kaua‘i to be the most progressive in the United States since it is based on a scientifically determined erosion rate and engineering studies performed on the life span of single family wood construction (70 years) or stone construction (100 years) built on the coastline.

Table 12.1 County of Kaua‘i Minimum Shoreline Setback based on Depth of Lot

Average Depth of Lot	100 feet or less	101 to 120 feet	121 to 140 feet	141 to 160 feet	161 to 180 feet	181 to 200 feet	Greater than 200 feet
Minimum Setback	40 feet	50 feet	60 feet	70 feet	80 feet	90 feet	100 feet

Table 12.2 County of Kaua‘i Minimum Shoreline Setback based on Average Annual Erosion Rate

Structures with a Building Footprint that is	Less than or equal to 5,000 square feet	Greater than 5,000 square feet
Setback distance	40 feet plus 70 times the annual coastal erosion rate	40 feet plus 100 times the annual coastal erosion rate

12.4.1.2 City and County of Honolulu

In the City and County of Honolulu, current regulations require a minimum shoreline of 40 feet (Revised Ordinances of the City and County of Honolulu §23-1.4). The ordinance also permits and adjustment in the minimum shoreline setbacks for small lots as follows: Where the depth of buildable area of the lot, as measured seaward from its inland edge is reduced to less than 30 feet, the shoreline setback shall be adjusted to allow a minimum depth of buildable area of 30 feet, provided that the adjusted shoreline setback shall be no less than 20 feet. Also, a 60-foot minimum setback is required for all new subdivisions across the island of O‘ahu independent of Average Lot Depth (ALD) or size of the structure.

12.4.1.3 County of Maui

The County of Maui has adopted erosion rate-based construction setback rules.[15] The setback requirements for this County are stipulated in Shoreline Rules for the Maui Planning Commission (Title MC-12, Subtitle 02, Chapter 203).

As shown in Figure 12.6, the setbacks enforced in the County of Maui before the Shoreline Rules (1990-2003) were solely based on Average Lot Depth (ALD) that ranged from 25 to 150 feet (average lot depth was determined by dividing the sum of the lot depth at both sides and at the center of the property by three). In contrast, the methodology of the new setbacks stipulated on the Shoreline Rules is based on the erosion maps developed by the University of Hawai‘i Coastal Geology Group (see Sections 12.4.4 and 12.4.6). Essentially, the erosion maps for the sandy shorelines of the island of Maui revealed an average rate of erosion of 1 foot per year and a maximum rate of erosion of 5.5 feet per year. Based on these data, new setbacks were calculated by multiplying the erosion rate at a given property by 50 years and adding a 20-foot buffer (see Figure 12.6). Lastly, final setbacks were determined by calculating the setback using both the old and new methodology, and the greater setback was applied.

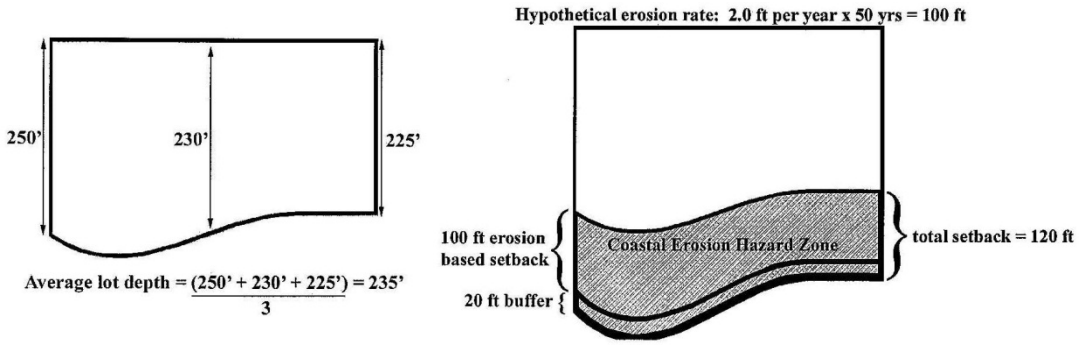

Figure 12.6 County of Maui Minimum Shoreline Setback: Pre-Shoreline Rules of 2006 (left) and Post-Shoreline Rules of 2006 (right)[16]

12.4.1.4 County of Hawai‘i

In In the case of the County of Hawai‘i, the minimum shoreline setback is 40 feet per Rule 11-5 of the County of Hawai‘i Planning Department Rules of Practice and Procedures. The only exception to this requirement is for lots created prior to the date of adoption of the rule and that either have an average lot depth (ALD) of 100 feet or less (see example 1-A on Figure 12.7) or have a buildable area that is less than 50% of the area of the lot after applying the 40-foot minimum shoreline (see example 1-B on Figure 12.8). In this exception case, the minimum shoreline setback can be reduced to 20-feet. Despite the current 40-foot minimum shoreline setback, in many cases the County of Hawai‘i Department of Planning has imposed much greater setbacks.[17]

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[15] Norcorss-Nu‘u, Z. and Abbott, T., *Adoption of Erosion Rate-Based Setbacks in Maui, Hawai‘i: Observations and lessons learned,* ASCE Conference Proceedings 176, 69, 2005

[16] Ibid, Figure Compiled from Figures 2 and 3

[17] Hwang, Dennis and Bukett Maxine, Center of Island Climate Adaptation and Policy, *Shoreline Impacts, Setback Policy, and Sea Level Rise*, April 2009, Honolulu, Hawai‘i, 26p

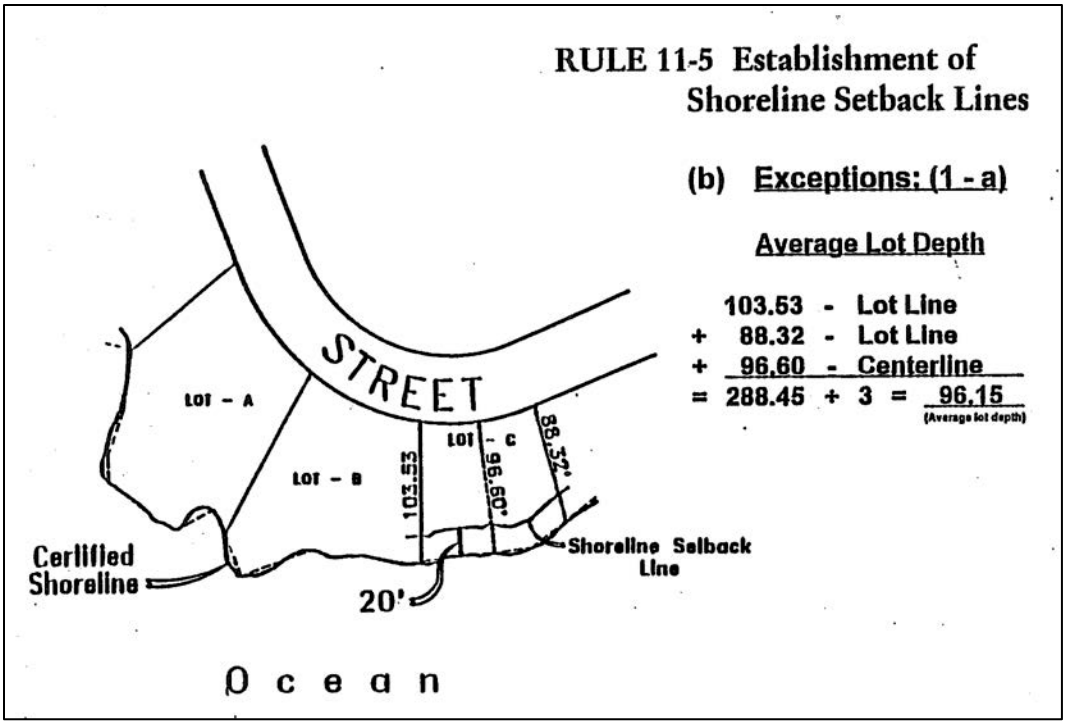

Figure 12.7 County of Hawai'i Minimum Shoreline Setback Exception Example 1-A

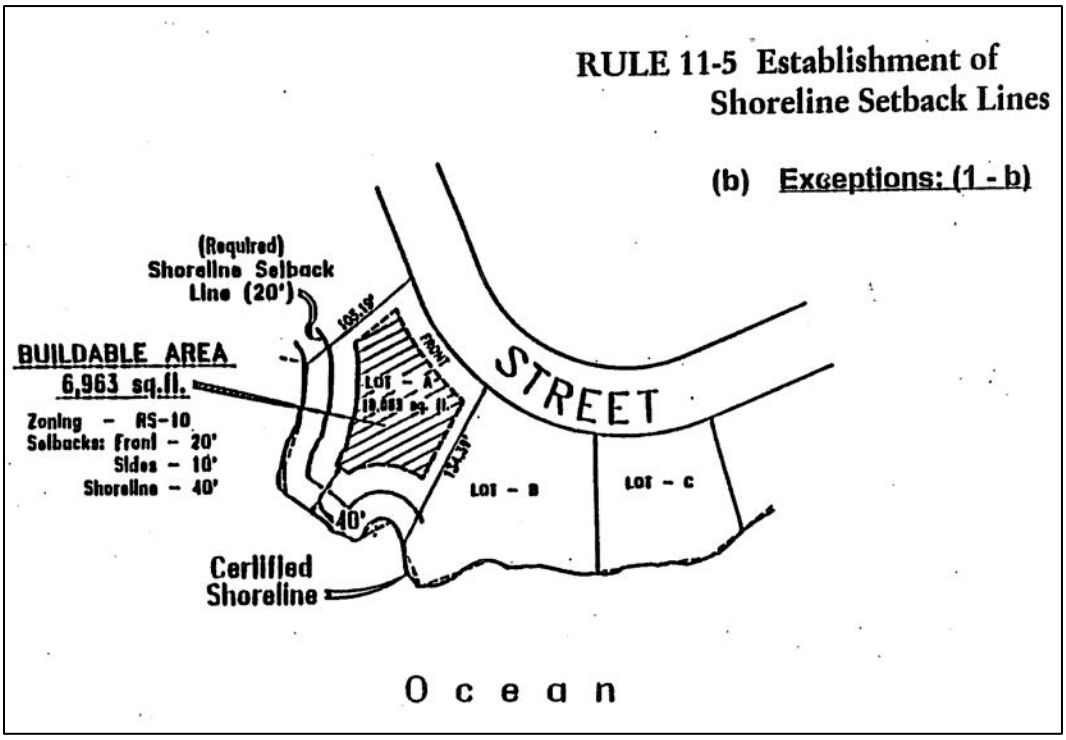

Figure 12.8 County of Hawai'i Minimum Shoreline Setback Exception Example 1-B

12.4.2 Erosion Zone Formula

Present rates of sea level rise play a role in coastal retreat in the Hawaiian Islands. For example, the Bruun Rule[18] (relating the horizontal translation of a shoreline to a given rise in sea-level) predicts a retreat of 4 to 5 feet per decade on the islands of O‘ahu and Maui.[19] This finding is supported by aerial photographic measurements of beach retreat and suggests that presently narrow beaches fronting seawalls on these islands are likely to be lost over the next quarter century. Hwang (2003) has recommended an Erosion Zone Formula that consists of three major factors: the trend risk, the storm erosion event, and a design safety buffer.

Erosion Zone = Trend Risk + Storm Erosion Event + Design Safety Buffer

The Trend Risk is determined by multiplying the planning lifetime of buildings times the erosion rate. The erosion rate is adjusted for errors (FEMA CCM, 2000) and sea level rise[20].

Trend Risk = (Life Expectancy of Structures) x (Erosion Rate x Adjustment for Errors x Adjustment for Accelerated Sea Level Rise)

Thus, the parameters needed to determine the erosion zone are:

- Planning Period – Determined by Life Expectancy of Structures
- Average Annual Erosion Rate
- Adjustment of Erosion Rate for Errors
- Adjustment of Erosion Rate for Accelerated Sea Level Rise
- Storm Erosion Event
- Design Safety Buffer

Using the above formula, the extent of erosion zone for structures with 50- and 70-year life expectancies and different erosion rates can be obtained. Table 12.3 summarizes the extent of erosion zone for different rates of erosion and useful life of structure.

For areas that are accreting, the erosion rate should be treated as zero, since HRS §183-45 prohibits building structures on accreted land. For areas with an erosion rate of 0, the setback is based on an erosion rate of 0.1 feet per year. Factors related to the accelerated sea level rise adjustment or the storm event of 20 feet may be analyzed by a consultant to determine if a different number is warranted for a specific site. This analysis assumes no adjustments for erosion rate variability.

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[18] Bruun, P., *Sea Level Rise as a Cause of Shore Erosion*, Journal of Waterways and Harbors Division, American Society of Civil Engineers (ASCE), 1962, 88, 117-130p

[19] Hwang, D. and Fletcher, C., *Beach Management Plan With Beach Management Districts*, Hawai‘i Office of State Planning, Coastal Zone Management Program, Honolulu, 1992, 146p

[20] Federal Emergency Management Agency Coastal Construction Manual (FEMA P-55), Volume 1, August 2011, retrieved June 21, 2013 from http://www.fema.gov/library/viewRecord.do?id=1671

Table 12.3 Extent of Erosion Zone based on Erosion Rate and Life Expectancy of Structure

Erosion Rate ft./yr.	Adjusted Rate for Errors (20%)	Adjusted Rate for Errors and Accelerated Sea Level Rise (20%) x (10%)	Storm Event	Safety / Design Buffer	Erosion Zone 70-yr. Life of Structure	Erosion Zone 50-yr. Life of Structure
0.0	0.12	.013	20	20	49	35
0.1	0.12	.013	20	20	19	35
0.2	0.24	0.26	20	20	58	41
0.3	0.36	0.39	20	20	67	48
0.4	0.48	0.52	20	20	76	54
0.5	0.60	0.66	20	20	86	61
1.0	1.20	1.32	20	20	132	94
1.5	1.80	1.98	20	20	179	128

To illustrate the relationship between erosion zone and government regulation for shoreline setbacks, let's look at the City and County of Honolulu. As was mentioned in the preceding section, current regulations in the City and County of Honolulu require a 60-foot setback for new subdivisions. Based on the Bruun rule, this distance is comparable to the setback for structures with a 50-year useful life and with an average erosion rate of 0.5 feet per year (5 feet per decade). However, the fixed 60-foot setback would be too small for higher erosion rates or for longer useful building expectancies. For example, if the erosion rate is 0.5 feet per year, the setback for a 70-year structural lifespan should be approximately 86 feet. Additionally, ordinances that allow renovation of structures within their existing footprints substantially lengthen the lifetime of the land use.

For reference, the Federal Emergency Management Agency (FEMA) Coastal Construction Manual (CCM) recommends that for the building lifetime, a minimum of 50 years be utilized. The 70-year extended time frame recommended by Hwang is based on a study conducted for the Federal Insurance Administration, Department of Housing and Urban Development to establish reliable estimates for the life of coastal residential structures.[21]

12.4.3 Hazard Intensity

A quantitative way of assessing risk of coastal erosion is to rank hazard intensity based different categories of the two sources of beach loss: erosion and sea level rise. Based on these criteria, erosion hazard can be classified on a scale ranging from low to high. Table 12.4 includes a description of the hazard intensity rank for coastal erosion.

[21] Anderson, 1978

Table 12.4 Hazard Intensity Rank for Coastal Erosion

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

12.4.4 Risk Assessment for the County of Kaua‘i

The University of Hawai‘i Coastal Geology Group (UHCGG) performed a study historical shoreline and erosion rates for the sandy beaches of the island of Kaua‘i.[22] The study was divided in to mapped areas taken from an original poster map produced at a 1:3000 scale. The results of the study are presented in maps with plots of the shoreline position and annual erosion hazard rates (AEHRs) and end point rates (EPRS). As an illustration, a sample map for the Kapa‘a area is given in Figure 12.9.

The complete set of erosion maps produced UHCGG can be used to determine the anticipated beach loss over time, greatly enhancing the ability of government officials and planners to assess the potential impacts of actions in a physical setting and with knowledge of shoreline change patterns. In addition to the erosion rates determined by UHCGG’s study, sea-level rise for the island of Kaua‘i is reported at 0.7 inches per decade (1.75+ 0.32 millimeters per year).

12.4.5 Risk Assessment for the City and County of Honolulu

UHCGG has also prepared shoreline erosion rate maps for the island of O‘ahu.[23] The study has similar characteristics as the one prepared for the island of Kaua‘i. A sample map for the Waikīkī area is given in Figure 12.10. As of 1991, the island of O‘ahu has lost 6.4 miles of beach and has had narrowing of 10.7 miles due to shoreline hardening (*i.e.*, seawalls and revetments). This reduction in sandy beaches was approximately 24% of the island of O‘ahu’s sandy shoreline (originally 71.6 miles)[24] Numerous shoreline structures have been permitted, or erected without permits, in the interval since the report was written. Many of the beaches of the

[22] University of Hawai‘i Coastal Geology Group website, retrieved June 21, 2013from http://www.soest.hawaii.edu/coasts/kauaicounty/KCounty.html

[23] University of Hawai‘i Coastal Geology Group website, retrieved June 21, 2013from http://www.soest.hawaii.edu/coasts/erosion/oahu/

[24] O‘ahu Shoreline Management Plan-Sea Engineering, Inc., 1991

island of O‘ahu, which have a high public value as a natural resource and are limited in extent, are being destroyed through erosion. Some of the loss is from natural causes, such as waves wind and severe storms, but much of it is associated with man-made developments.[25] Additionally, sea-level rise for O‘ahu is reported at 0.6 inches per decade (1.57 $\pm$ 0.08 millimeters per year).

12.4.6 Risk Assessment for the County of Maui

The County of Maui’s sandy beaches are disappearing as a result of natural shoreline processes, development and hardening along the shoreline, and other human impacts. Reportedly, 5 miles of beach loss (12%), and 20% average beach width decrease has occurred on the island of Maui. Sea-level rise, currently averaging about 2.5 centimeters per decade on the island of Maui, also causes coastal erosion. Examination of a report on shoreline changes from 1949 to 1989 suggests that 62% of the sandy shoreline studied on the island of Maui is eroding at an average rate of 1.25 feet per year[26], and as much as 30% of the island of Maui's shoreline has experienced beach loss or significant narrowing.[27] Based on field and photographic observations, nearly all of this beach degradation is in front of or adjacent to shoreline armoring such as seawalls and revetments. Recognizing the importance of the County of Maui’s beach resources, it is imperative that they be preserved, protected and restored where possible.

UHCGG also prepared shoreline erosion rate maps for the island of Maui.[28] The study has similar characteristics as the one prepared for the island of Kaua‘i. As an illustration, a sample map for the Kīhei area is given in Figure 12.11.

12.4.7 Risk Assessment for the County of Hawai‘i

Overall, the island of Hawai‘i has a moderately low erosion threat. Strong waves along the north shore of the island affect the low-lying coastal areas of Waipi‘o and Waimanu and thus increasing the erosion hazard in these areas to moderately high.[29] The island of Hawai‘i’s erosion is more related to bluff erosion and bench collapse which occurs more episodically and is hard to measure as a trend. Sea-level rise in the County of Hawai‘i is reported at 1.6 inches per decade (3.94 $\pm$ 0.23 millimeters per year). Up to the time of this report, UHCGG has not produced maps with erosion hazard rates for the Island of Hawai‘i.

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[25] Ibid

[26] Hwang and Fletcher, 1992

[27] Makai Ocean Engineering, Inc. and Sea Engineering, Inc., 1991

[28] University of Hawai‘i Coastal Geology Group website, retrieved June 21, 2013from http://www.soest.hawaii.edu/coasts/erosion/maui/

[29] C. Fletcher et al., Atlas of Natural Hazards in the Hawaiian Coastal Zone

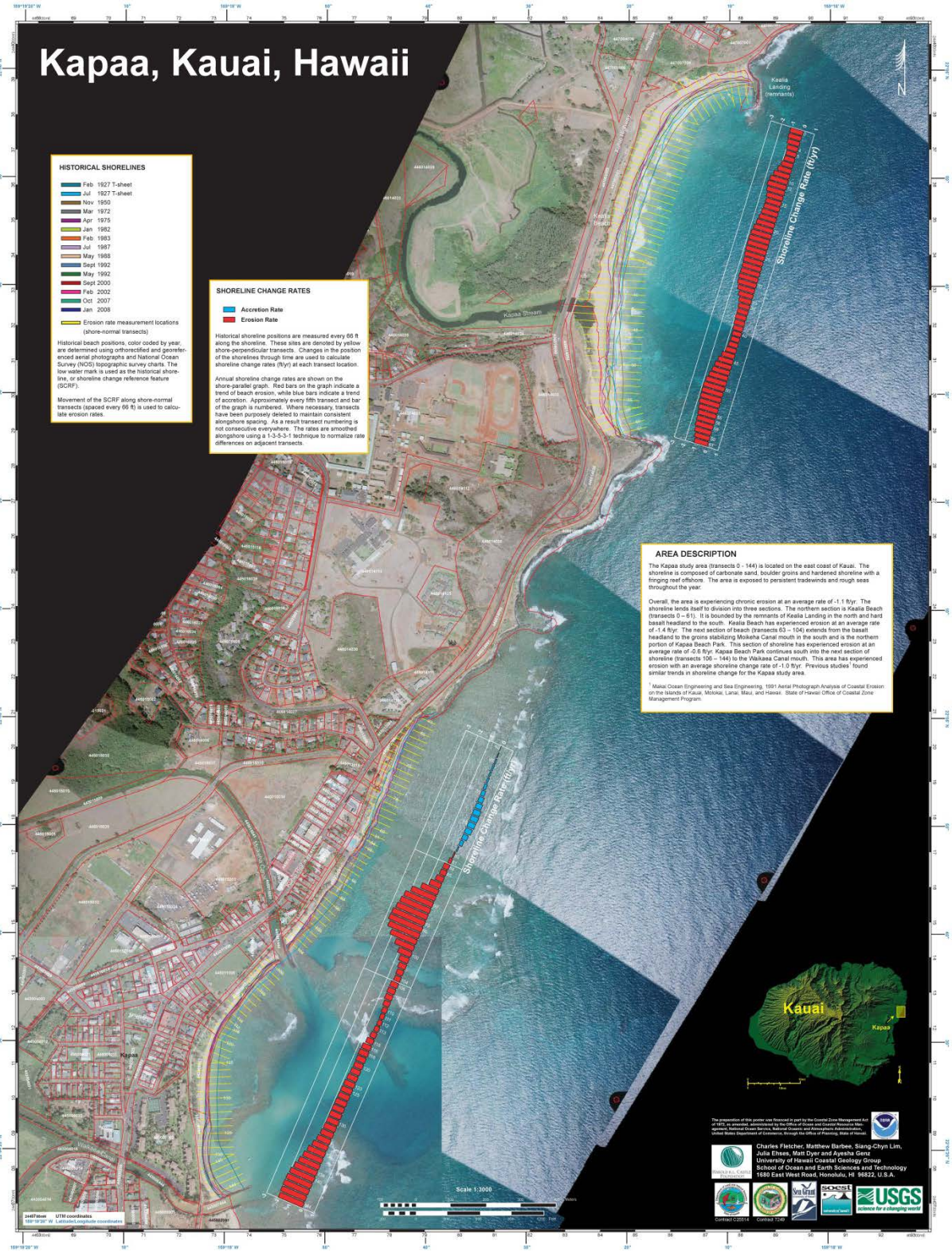

Figure 12.9 Erosion Rate Map for the Kapaʻa Area, Island of Kauaʻi (County of Kauaʻi)

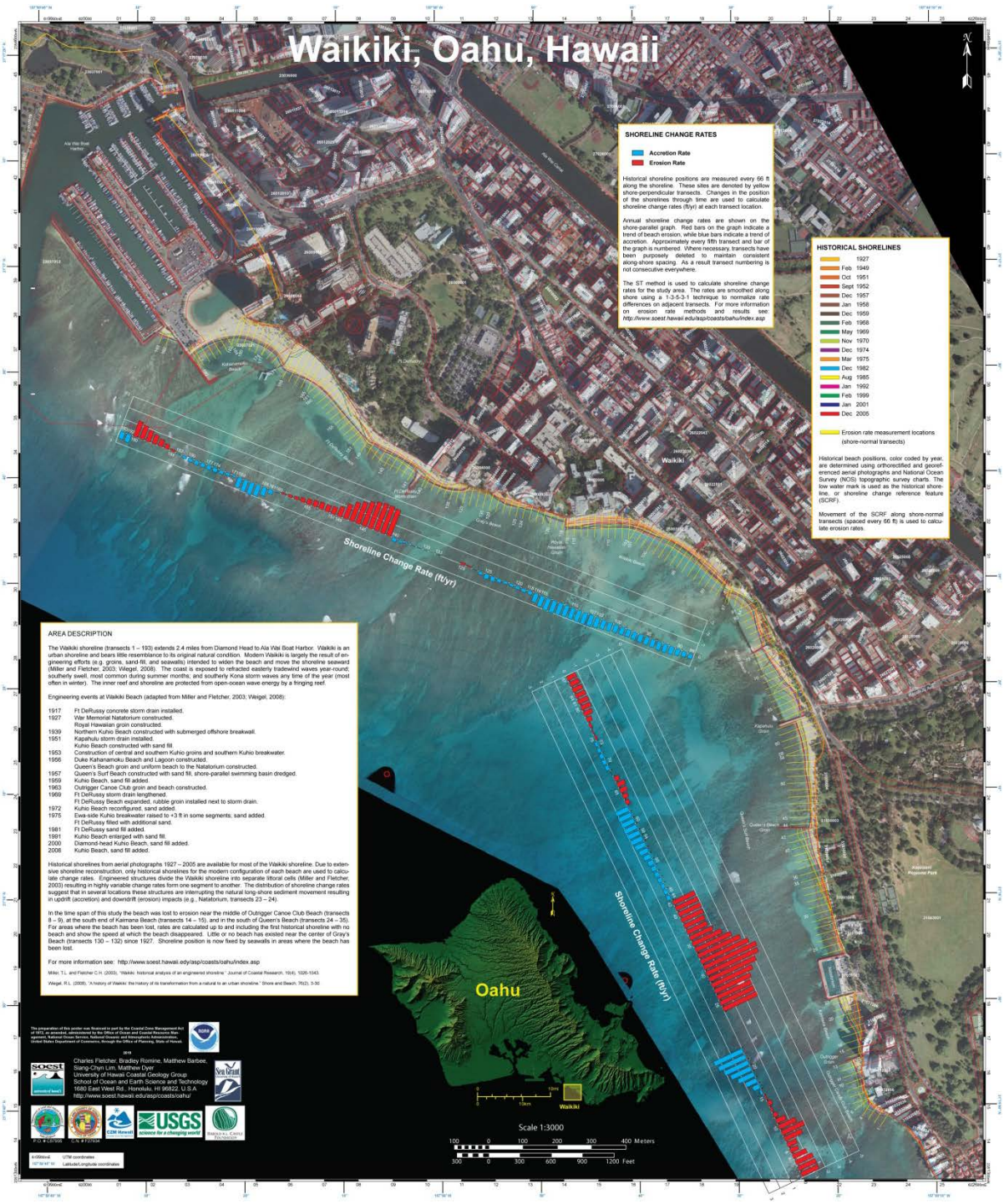

Figure 12.10 Erosion Rate Map for the Waikīkī Area, Island of O'ahu (County of Honolulu)

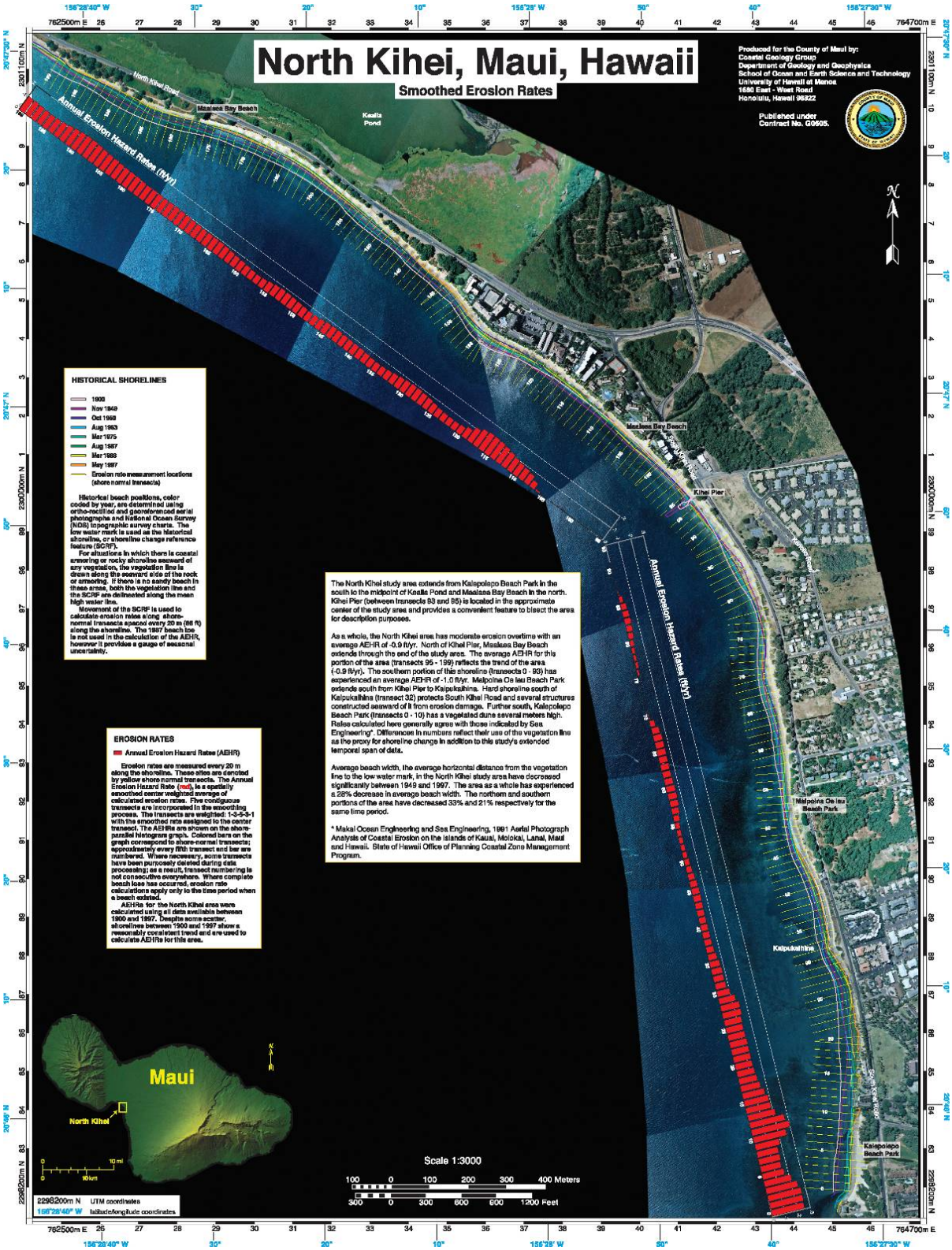

Figure 12.11 Erosion Rate Map for the Kīhei Area, Island of Maui (County of Maui)

12.4.8 Vulnerability and Potential Losses from Erosion

Although coastal erosion continues to be a challenge, there were additional shoreline studies during the period from 2007-2010 that has enabled recommendations for increased variable setbacks in the County of Kaua‘i and the City & County of Honolulu. Unfortunately, there is little new information from economic valuation or analyses. However, the coastal segments of the island have the highest property values, significant infrastructure, and unique environmental features.

Beach loss affects Hawai‘i residents by seriously impacting the visitor economy. Tourism accounts for nearly $12 billion in expenditures and represents 22% of the State's Gross Domestic Product (GDP) (DBEDT 2008). Many of the visitors are drawn to the beautiful shorelines and coastal features of the islands. Beach loss and shoreline hardening restricts public access to ocean recreation areas and natural resources which is protected under Hawai‘i Revised Statute §115. Erosion also causes environmental and ecological damage to natural resources and habitats, which is in direct contrast to the mandates in Hawai‘i Revised Statute §205A, and threatens recreational and spiritual opportunities associated with these resources.

12.4.8.1 Costs of Shoreline Protection

Because of significant beach loss in the Waikīkī area (the area which hosts approximately 44% of the State's tourists) on the island of O‘ahu, the Office of Conservation and Coastal Lands (OCCL) in the Department of Land and Natural Resources (DLNR) initiated a sand nourishment project. The project hydraulically dredged 10,000 cubic yards of sediment 2,000 feet offshore to three designated sites within Kūhiō Beach. The project cost about $475,000, which was considered worth the investment to support the economy.[30]

In 2013, the biggest beach replenishment project ever undertaken in the State will be complete at Iroquois Point, also on the island of O‘ahu. Here, nine big T-shaped rock groins are going in along nearly a mile of shoreline. Approximately 22,000 cubic yards of stone, enough to fill 6-1/2 Olympic-sized swimming; and 80,000 cubic yards of sand, or enough for 27 Olympic pools, will be used in the project. The ‘Ewa Beach effort began in October, 2012. By comparison, the $14 million Iroquios Point beach restoration is about 3-1/2 times bigger than the more than $2.3 million Waikīkī Beach sand nourishment work completed in April, 2012.

More assessments need to be undertaken because the changes from climate and sea level rise have an impact on erosion and beach loss. The projected changes to shorelines could mean losses to many businesses and residential areas in the state.

12.4.8.2 Losses of Coastal Critical Facilities

In Hawai‘i, many of the critical facilities and lifelines are located in coastal areas. This increases the risk of these facilities to coastal hazards. The area of Waikīkī in the island of O‘ahu (City and County of Honolulu) is perhaps one of the best-known shorelines in the nation and a center of urban coastal tourism. Waikīkī was, until the beginning of the 20th century, a wetland and marsh holding only a narrow sandy strand at the shoreline. Massive efforts to divert the inland waters

[30] State of Hawai‘i Department of Land and Natural Resources Office of Conservation and Coastal Lands, 2007

allowed the city to lay down imported sand to create the famous white sand beaches of Waikīkī that are maintained by periodic re-nourishment projects. Although Waikīkī has remained fairly protected from disaster, there are high wave events that periodically overtop the beaches and roads. The most recent disaster occurred in April 2006, when a 42-day rainfall event in the upper watershed caused stream flooding, overflowing drainage and sewer systems, and resulted in pollution that closed Waikīkī beaches for a couple of months, and demonstrated that a disaster in one of the most visited places in the world has a devastating impact on the state's economy. A view of Waikīkī during the August 2009 passage of Hurricane Felicia near the island of O'ahu is included in Figure 12.12.

Figure 12.12 Waikīkī, Island of O'ahu, as Hurricane Felicia Passes and Dissipates, August 2009[31]

[31] Picture courtesy of C. Anderson

12.5 Mitigation Strategies

12.5.1 Federal Regulations

12.5.1.1 United States Army Corps of Engineers

A permit from the United States Army Corps of Engineers (Corps) must be obtained for any dredge, fill, and/or discharge activities regardless of land ownership.[32] 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.[33]

12.5.1.2 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*

12.5.2 State of Hawai‘i Regulations

12.5.2.1 Hawai‘i 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.[34]

The Hawai‘i Coastal Zone Management Program (CZMP) was enacted in 1977 (Chapter 205A, HRS). Hawai‘i’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 Hawai‘i. 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

[32] 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).

[33] The National Environmental Policy Act of 1969 (NEPA) requires the preparation of a federal Environmental Impact Statement (EIS) or Environmental Assessment (EA).

[34] Oceanit, Inc. and Sullivan, J.N., 1990

Department of Land and Natural Resources (DLNR), Conservation District Regulations. The boundary of the SMA is from the ocean generally to the nearest highway or minimum of 300 feet.

12.5.2.2 Land Use/Zoning

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.

12.5.2.3 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. Coastal setbacks in the State of Hawai‘i are 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)

This definition creates problems as there are many variables associated within the measurable limits of building space on the shore. Unfortunately the “edge of vegetation growth” or the landward limit of development, all too often appears to be migrating seaward as commercial interests and homeowners frequently landscape their beachfront in order to gain valuable coastal building space. The cumulative effect of this practice “constitutes a slow but inexorable encroachment of development upon the hazardous and fragile beaches of Hawai‘i.[35] Also, measuring by the variable characteristics of wave run-up does not allow for a more accurate means of measurement, such as a fixed natural monument or datum with measurable characteristics.[36]

Problems also arise when the basis of measurement is determined by unobservable phenomenon identified by the property owner’s surveyor. Although the State Surveyor “certifies” the position of the shoreline on a case-by-case basis, the caseload consists of 200 applications per year, rendering it impossible to visit each application that could be located on any of the seven Hawaiian Islands.

[35] Fletcher, 2000
[36] Ibid

12.5.3 Recent and Ongoing Mitigation Projects

12.5.3.1 Changes to Shoreline Setbacks for State Land

Proposed changes to the Conservation Land Use Rules, Chapter 13-5 of the Hawai‘i Administrative Rules, have been drafted and are in a public consultation process. The proposed changes would prevent development within a 40 foot setback from the certified shoreline plus 70 times the annual coastal erosion rate. The definition of the coastal erosion rate is described below.

12.5.3.2 Definition of Statewide Erosion Hazard Zones

Managers and decision-makers need to have detailed information on the pattern and history of erosion along our coastline. Data on both chronic and episodic erosion hazards is crucial when determining effective building setbacks. The erosion rate maps can be used to determine the anticipated beach loss over time, greatly enhancing the ability of managers to assess the potential impacts of actions in a physical setting and with knowledge of shoreline change patterns. This information can be integrated with the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) that set Base Flood Elevations (BFE) for housing construction in coastal flood zones, which are now readily for a particular site available through the FHAT tool. Tsunami inundation maps are required in separate from the FIRM maps for assessing beach losses resulting from tsunami events.

12.5.3.3 Beach Monitoring Program

The Hawai‘i Beach Monitoring Program of the University of Hawai‘i Coastal Geology Program and the United States Geological Survey (USGS) Coastal and Marine Biology Program collected biannual beach profiles at 42 sites around the island of O‘ahu between 1994 and 1999. Profiles of each of the sites were generated showing the beach and seabed depth at various distances from the shoreline at biannual intervals. The objectives of this study were to document the recent history of shoreline change and determine the causal factors of that erosion, provide high-quality data for other "end-users" in applied studies (i.e. coastal engineers, planners, and managers), and increase our general understanding of low-latitude coastal geologic development. While the data was continuously record over the five year period in the late 90’s, the beach profile locations are given in terms of a common Global Positioning System (GPS) coordinate system so that ongoing future measurements can be taken.

12.5.3.4 Development of Numerical Wave Run-up and Storm Surge Models

Numerical modeling can be a valuable source of information for formulating guidelines 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 the State of Hawai‘i. In the development of the new FIRM maps numerical wave run-up and storm surges were modeled using advanced computer simulation tools.[37] 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 BFEs for currently unmapped regions of the coast in Hawai‘i.

[37] Gangai, 2008

12.5.3.5 Waikīkī Beach Sand Replenishment Program

In response to the beach erosion of Waikīkī beach a sand replenishment project was completed for the Kūhiō beach section in early 2007. Ten thousand cubic yards of sand were pumped from offshore onto the beach. Further areas of the beach replenishment are anticipated in the future.

12.5.4 Mitigation Actions to Reduce Damages Caused by Coastal Erosion

12.5.4.1 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.

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.

12.5.4.2 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.

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 depend 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 is planning to speed up review of sand replenishment requests for beaches that have lost sand. New, quicker permits would not exceed 10,000 cubic yards of sand per project, and the State would ideally take about three months to process the request.

The new process allows the applicant to seek State and Federal approvals under a single permit and for the review to take place simultaneously. The applicant still would 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.

12.5.5 Future Mitigation Projects

The following are recommended projects that would reduce the impact of coastal erosion:

- Consideration of adoption of coastal erosion setbacks per historical rates or disclosure of erosion rate during real estate transactions.

- Disclosure of Hazard Risks as Mandatory Seller Disclosures in Real Estate Transactions Act.

- Sand Restoration of Waikīkī Beach, Island of Oʻahu, to 1985 width (State Office of Conservation and Coastal Lands, State of Hawaiʻi Department of Land and Natural Resources).

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

13. Droughts

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CHAPTER 13
Droughts

Reasons for Updates / Revisions in this 2013 Plan
• 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 are managed through the Hawai‘i Drought Plan steered by the Hawai‘i drought council. • The primary environmental safety concern from drought is the wildfire hazard which is exacerbated during drought conditions, particular at the urban wildland interfaces. • Further rainfall data is provided. • The new Hawai‘i Drought Monitor map website has been developed. • More extensive drought intensity maps for the different sectors are provided. • The status of recent drought mitigation is discussed • New drought mitigation activities are included.

Summary of Mitigation Projects for the State of Hawai‘i	
Project	Priority
Update the Rainfall Atlas of Hawai‘i	Medium
Drought Impact Reporter - Hawai‘i	Medium

13.1 Drought Hazard Description

13.1.1 General

A drought is a period of abnormally dry weather. Drought diminishes natural stream flow and depletes soil moisture, which can cause social, environmental and economic impacts. In general, the term "drought" should be reserved for periods of moisture deficiency that are relatively extensive in both space and time.

Drought can be characterized from the perspectives of meteorology, agriculture, hydrology, and socio-economic impacts. For example, the meteorological perspective would describe drought as a rainfall deficit compared with some normal or expected rainfall amount. The agricultural perspective could describe drought by its impacts on the agricultural industry due to reduced rainfall and water supply (e.g., crop loss, herd culling, etc.). Hydrological descriptions of drought may compare stream flows, ground water, and reservoir levels to normal conditions. Drought can also be described from the socio-economic perspective by the direct and indirect impacts droughts have on society and the economy (e.g., increased unemployment due to failure of an industry because of drought).

Lack of rainfall is not the only factor contributing to the impacts of drought. Both natural events and human activities; such as expanding populations, irrigation, and environmental needs; put pressure on water supplies. Lack of rainfall combined with the demands society place on water systems and supplies contribute to drought impacts.

13.1.2 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 13.1 shows a map of the Main Hawaiian Islands indicating the average annual precipitation for the 30-year time period between 1978 and 2007. The map was produced by the Department of Geography at the University of Hawai‘i at Mānoa[1].

[1] Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte, 2013: Online Rainfall Atlas of Hawai‘i. *Bull. Amer. Meteor. Soc.* 94, 313-316, doi: 10.1175/BAMS-D-11-00228.1, retrieved July 2, 2013 from http://rainfall.geography.hawaii.edu/downloads.html

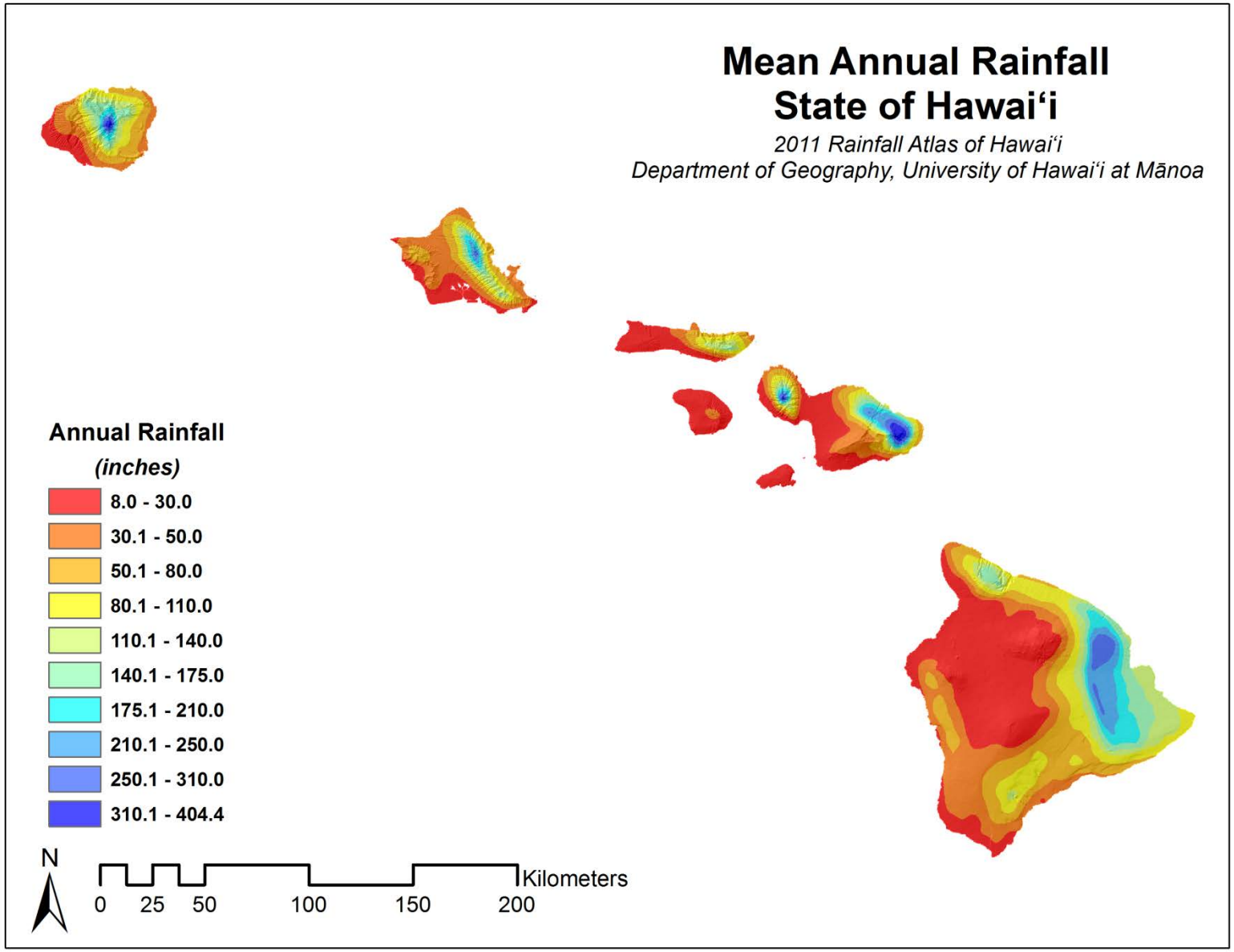

Figure 13.1 Mean Annual Precipitation Rainfall for the Main Hawaiian Islands

13.1.3 El Niño

A large-scale meteorological pattern governs temperature and precipitation trends in the Pacific Ocean. This pattern is called the El Niño Southern Oscillation (ENSO) 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.

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 Niño and Hawaiian rainfall relationship by compositing historical rainfall variations through an El Niño cycle. Based on 20 El Niño events since 1905, it shows that the chance of having a dry winter (spring) following an onset of El Niño is 90% for winter and 80% for spring. Deficient rainfall observed during an El Niño winter is unlikely to have occurred by random chance.

13.1.4 Drought Impact Sectors

Three drought impact sectors are critical to the health and welfare of a population in terms of social, economic, and environmental aspects. These impacts include: the Water Supply Sector, the Agriculture and Commerce Sector, and the Environment, Public Health, and Safety Sector. These sectors are not mutually exclusive and, as such, impacts in one sector may result in secondary or cumulative impacts in other sectors.

13.1.4.1 The 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.

Since Hawai‘i is an island state, this potable water sustainability is particularly critical. Failure to take appropriate action could result in Hawai‘i not having sufficient quantity and quality of water resources to sustain future population and industry.[2] The sectors impacted by drought are discussed in detail in the following section.

13.1.4.2 The Agricultural and Commerce Sector

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. The commerce component of this sector includes impacts to non-agricultural operations and/or industries, such as the tourism and retail industries, which may suffer secondary or cumulative impacts due to drought.

13.1.4.3 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 14 – Wildfires. Other aspects of the environment, public health, and safety sector include impacts to habitat, water quality, endangered species, and other natural resources.

[2] *State of Hawai‘i Drought and Wild Land Fire Mitigation Plan,* Department of Defense, Civil Defense Division, December 1998, Available at http://www.Hawai‘i.gov/dlnr/cwrm/drought/drought.htm

13.1.5 Drought Monitoring and Forecasting

There are two popular drought indices used by scientists and academics to monitor and forecast droughts: The Palmer Drought Severity Index and the Standardized Precipitation Index. The Palmer Drought Severity Index is not deemed appropriate for Hawai‘i so general consensus is that it should be used as an initial drought index only. A third index, the Percent of Normal Rainfall Index, also has widespread use in measuring and forecasting drought in Hawai‘i.

13.1.5.1 The Palmer Drought Severity Index and the Standardized Precipitation Index

The Standardized Precipitation Index (SPI) was developed by Thomas McKee at Colorado State University for use as a drought monitoring tool and has been embraced by agencies such as the National Drought Mitigation Center and the Western Regional Climatic Center. The advantage of this index is its simplicity – it uses only monthly rainfall as its input. This unique feature makes the index ideal for use in Hawai‘i, where there is a relatively dense network of rain gages. In comparison, the Palmer Drought Severity Index (PDSI) – which is in widespread use across the Mainland United States – is much more complex and requires temperature and soil moisture as additional data inputs. These types of additional data are either sparse or non-existent in Hawai‘i. Furthermore, the PDSI is more applicable to broad climatic areas and is not suited for representing conditions in the small-scale climatic zones of the Hawaiian Islands.

Because the SPI values are normalized, the wide range of rainfall conditions across Hawai‘i can be assessed on an equal basis. Furthermore, SPI values can be generated for multiple time scales. This feature is extremely useful for monitoring purposes because the effects of droughts occur over wide ranges of time scales. 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 13.1 is an example of a drought classification scheme based on SPI. According to the SPI values associated with these categories, mild, moderate, severe, and extreme droughts occur 34.1, 9.2, 4.4, and 2.3 percent of the time, respectively.

Table 13.1 Drought Stages Based on Standardized Precipitation Index (SPI)[3]

SPI Values	Drought Stage	Expected Frequency Occurrence
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%

[3] University of Hawai‘i School of Ocean, Earth Science, and Technology (SOEST) Department of Meteorology y and the Social Science Institute (SSRI), *Drought Risk and Vulnerability Assessment and GIS Mapping Project*, Prepared for the State of Hawai‘i Department of Land and Natural Resources Commission on Water Resource Management, September 2003, Table 3.1, 39p

The Honolulu Forecast Office (HFO) of the National Weather Service (NWS) has tailored SPI software for use in Hawai‘i. At present, 59 sites have been selected as part of the SPI monitoring network. These sites are separated into two groups called the "quick-look sites" and the "standard sites". The "quick-look sites" use data from selected real-time reporting stations that comprise the HFO flash flood monitoring network. Only 16 out of 69 real-time reporting stations are available for use in SPI calculations due to the fact that most of these locations have short periods of record that can result in risky statistical inferences. The main benefit of the "quick-look site" is that the data are available immediately after the end of a month so that SPI values can be quickly determined. The "standard sites" are selected locations from the NWS Cooperative Observer Network. Rainfall readings at these sites are taken manually and submitted via mail after the end of the month to the NWS Pacific Region Headquarters for preliminary quality control. The monthly data for the "standard sites" are intercepted at this point and forwarded to HFO for SPI calculations.

The SPI method is designed to be flexible in terms of drought duration specified by users. 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. In Hawai‘i, 3-month and 12-month durations are considered. If 3-month events are desired, a moving average time series is constructed by summing the first three monthly totals. Next, precipitations for months 2, 3, and 4 are summed and then precipitations for months 3, 4, and 5 are summed and so on. The resulting time series is then used to compute the 3-month SPI. The 12-month SPI can be obtained in similar manner. The flexibility of multiple SPI time values makes this index attractive because, as was mentioned earlier, drought affects various sectors across a wide range of time scales.

13.1.5.2 The Percent of Normal Rainfall Index

The Percent of Normal Rainfall Index (PNRI) is based on the percentage of current rainfall value compared against the long-term mean. The PNRI is one of the simplest methods of comparing current precipitation amounts to recorded historical averages. The index is calculated by dividing the actual precipitation amount by a 30-year (typically) precipitation mean. Time scales are generally stated in months or a year. The PNRI is effective for comparing a single region or season in easily understood terms.[4]

One of the disadvantages of using the PNRI is that the mean precipitation is often not the same as the median precipitation, which is the value exceeded by 50% of the precipitation occurrences in a long-term climate record. The reason for this is that precipitation on monthly or seasonal scales does not have a normal distribution while the PNRI implies a normal distribution where the mean and median are considered being the same. Another disadvantage of the PNRI is that due to the variety in the precipitation records over time and location, there is no way to determine the frequency of the departures from normal or compare different locations inhibiting attempts to mitigate drought based on the departures from normal and form a plan of response.[5]

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[4] Wilson Okamoto Corporation, *Hawai‘i Drought Plan 2005 Update*, Prepared for State of Hawai‘i Department of Land and Natural Resources (DLNR), February 2005, Table 5.3 (modified), 5-15p

[5] Willeke, G., Hosking, J., Wallis, J., and Guttman, N., *The National Drought Atlas*, Institute for Water Resources Report 94–NDS–4, United States Army Corps of Engineers, 1994

13.1.5.3 National Drought Mitigation Center and the United States Drought Monitor

The National Drought Mitigation Center (NDMC), established in 1995, is based in the School of Natural Resources at the University of Nebraska-Lincoln. The NDMC's activities include maintaining a drought information portal; drought monitoring; drought planning and mitigation; developing drought policy; advising policy makers; conducting workshops for federal, state, and foreign governments and international organizations; organizing and conducting seminars, workshops, and conferences; and providing data to and answering questions for the media and the general public. The NDMC also participates in numerous international projects, including the establishment of regional drought preparedness networks in collaboration with the United Nations' Secretariat for the International Strategy for Disaster Reduction.

One of the products of the NDMC is the United States Drought Monitor (USDM). This tool is a graphical representation of drought intensity across the continental United States, Hawai‘i, Alaska, and Puerto Rico. The USDM also shows the duration and types of drought impacts that may be occurring. Data from various sources are synthesized into a summary of drought intensity and are depicted graphically. USDM authors update the product weekly and have intensive inputs from state and local representatives. Along with rainfall, stream flow, reservoir levels, and other hydrologic parameters, authors investigate and collect actual drought impact data from informants and stakeholders "on the ground." This impact information helps to validate hydrologic data and to connect these elements to drought's effects on water supply, agriculture, and other sectors. This analysis also helps to fine tune the geographical extent of drought, which is very important in Hawai‘i, where micro-climates dominate the landscape.

The USDM is a robust, well-rounded and accurate depiction of drought and is now an accepted and widely used drought monitoring tool across the United States. Some federal government drought programs are tied to the USDM; in particular, program triggers and the eligibility of assistance recipients. In Hawai‘i, the senior service hydrologist at the National Weather Service, Honolulu Forecast Office, is the lead author for the USDM in Hawai‘i. This individual works closely with local contacts as well as the USDM partners in the continental United States to produce a well-researched product each week.

The USDM is produced in partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture (USDA), and the National Oceanic and Atmospheric Administration (NOAA) of the United States Department of Commerce.

13.2 Historical Events

The most severe drought to affect the Hawaiian Islands since recordkeeping of stream flows 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 droughts, or as long, this drought caused cumulative stream flow deficits at some gaging stations that rank second for the period of record.

The period between late 1997 and early 1998 was also a year of severe drought across the State. In January 1008, for example, 36 out of 73 rain gages set up by the National Weather Service on all islands registered less than 25 percent of the norm for that period.[6] According to the 2005 State of Hawai'i Drought Plan, parts of the island of Hawai'i (County of Hawai'i) received less than 10% of the average rainfall until May 1998.[7] Similarly, rainfall was lower than the average across the island of O'ahu, with many areas receiving less than 30 percent of normal levels.[8] The severe drought of the late 1990's extended well into the first few years of the twenty first century.

The next period of severe drought to affect the State of Hawai'i was declared in 2008. El Niño conditions in the latter part of 2009 and into 2010 resulted in fewer winter storms putting the islands in severe drought conditions. On July 21, 2010, the United States Department of Agriculture designated all counties in the State of Hawai'i a primary disaster area due to drought that began in January 2010. In 2010, the State of Hawai'i was designated as the state with the worst drought in the nation. During the 2012-2013 wet season, increased rainfall helped the western half of the state (County of Kaua'i and City and County of Honolulu) to emerge from drought conditions. However, in the County of Hawai'i, extreme drought conditions have persisted for five seasons, and on Maui for seven.

Because of the severe and serious nature of the problem, government and organizations have focused attention on improved understanding of the drought and on reducing impacts at all levels. Because Hawai'i is at risk from multiple hazards that could impact infrastructure, such as water distribution and irrigation, and because drought persists for periods of months to years, it is critical for Hawai'i to think about developing long-term strategies that increase food security and water availability, especially in the face of potential impacts from climate change. Monitoring of the Hawaiian climate over the last 60 years indicates that there has been trend towards an increase in temperature and decrease in statewide rainfall. According to Pau-Shin Chu, a professor at the University of Hawai'i at Mānoa and also director of the State of Hawai'i Climate Office, "over the last 100 years, Hawai'i has experienced a downward trend in rainfall." Therefore, future incidences and the intensity of drought may be expected to increase.

Table 13.2 provides a summary of drought events that have impacted the State of Hawai'i between 1901 and 2013.

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6 National Weather Service Honolulu Forecast Office

7 State of Hawai'i, Department of Land and Natural Resources (DLNR), Commission on Water Resource Management, Hawai'i Drought Plan, 2005 update, p. 3-2

8 Ibid

Table 13.2 Drought Events and Impacts, 1901-2013[9]

Year	Area	Remarks
1901	North Hawai‘i	Severe drought, destructive forest fires.
1905	Kona, Hawai‘i	Serious drought and forest fires.
1908	Hawai‘i and Maui	Serious drought.
1912	Kohala, Hawai‘i	Serious drought and severe sugarcane crop damage for two years.
1952	Kaua‘i	Long, severe dry spell.
1953	Hawai‘i, Kaua‘i, Maui and O‘ahu	Water rationing on Maui; Water tanks in Kona almost empty; 867 head of cattle died; Pineapple production on Moloka‘i reduced by 30 percent; Rainfall in the islands had been 40 percent less than normal.
1962	Hawai‘i and Maui	State declared disaster for these islands; Crop damage, cattle deaths, and sever fire hazards; Losses totaled $200,000.
1965	Hawai‘i	State water emergency declared; Losses totaled $400,000.
1971	Hawai‘i and Maui	Irrigation and domestic water users sharply curtailed.
1975	Kaua‘i and O‘ahu	Worst drought for sugar plantations in 15 years.
1977-1978	Hawai‘i and Maui	Declared State disaster for these islands.
1980-81	Hawai‘i and Maui	State declared disaster; Heavy agricultural and cattle losses; Damages totaling at least $1.4 million.
1983-1985	Hawai‘i	El Niño effect; State declared disaster; Crop production reduced by 80 percent in Waimea and Kamuela areas; $96,000 spent for drought relief projects.
1996	Hawai‘i, Maui, and Moloka‘i	Declared drought emergency; heavy damages to agriculture and cattle industries; Losses totaling at least $9.4 million.

[9] Hawai‘i Drought Monitor, Commission on Water Resource Management, http://hawaii.gov/dlnr/drought/, retrieved June 11, 2013

Year	Area	Remarks
1998-1999	Hawai‘i and Maui	State declared drought emergency for Maui; County declared emergency for Hawai‘i due to water shortages; heavy damages to agriculture and cattle industries; Statewide cattle losses alone estimated at $6.5 million.
2000-2002	Hawai‘i, Maui, Moloka‘i, O‘ahu, Kaua‘i	Counties declare drought emergencies; Governor proclaims statewide drought emergency (2000); Secretary of the US Department of Interior designates all Counties as primary disaster areas due to drought (2001); East Maui streams at record low levels; Statewide cattle losses alone projected at $9 million.
2003-2004	Hawai‘i, Maui, Moloka‘i, O‘ahu, Kaua‘i	Governor proclaims statewide drought emergency (2003); County of Hawai‘i Mayor issues drought emergency proclamation (2003); Secretary of the U.S. Department of the Interior designates all counties as a primary disaster area due to drought (2004).
2007-2008	Hawai‘i, Maui, Moloka‘i, O‘ahu, Kaua‘i	Counties experience drought emergencies and wildfires associated with drought. County of Hawai‘i Mayor issues drought emergency proclamation (2007); County of Maui Department of Water Supply places 10% mandatory water conservation on Upcountry customers.
2009	Hawai‘i, Maui	Drought lessens in some places, but continues in other areas.
2010	Hawai‘i, Maui, Moloka‘i, O‘ahu, Kaua‘i	U.S. Drought Monitor records Hawai‘i State as worst drought area in country. USDA Designates Four Counties in Hawai‘i as Primary Disaster Areas. All Hawai‘i Counties designated due to losses caused by drought that began January 1, 2010, and continues. The USDA Farm Service Agency is making loan and assistance programs available to qualified farmers and ranchers. All counties implement various water conservation measures (www.hawaiidrought.com).
2012-2013	Hawai‘i, Maui, Moloka‘i,	Increased rainfall helped islands in the western half of the state to emerge from drought during the 2012-2013 wet season. According to the National Weather Service, rainfall produced by late-season cold fronts improved vegetation conditions and remedied what had been a drought. Several rain gauges in West O‘ahu recorded their highest April rainfall totals in more than 20 years, the weather service reported.

As illustrated in Table 13.2, droughts have been and will continue to be a significant concern in the State of Hawai‘i. Planning for and coping with recurring, if unpredictable, drought events is complicated by the inherent water resource limitations of our islands and the uneven range of drought related concerns and relevant priorities across counties. The statewide variability in resources, vulnerability, and risk necessitates a sectoral approach to drought mitigation. Statewide, three sectors were identified as being vulnerable to drought as well as having the potential to be ameliorated through mitigation measures: public water supply; agriculture and commerce; and environment, public health and safety.

13.3 Probability of Occurrence

In support of the State of Hawai‘i Drought Plan, the Commission on Water Resource Management (CWRM), in cooperation with the Hawai‘i Drought Council (HDC), sought the development of a Statewide Drought Risk and Vulnerability Assessment. This statewide assessment, titled *Drought Risk and Vulnerability Assessment and GIS Mapping Project,* was completed in 2003 and utilized geographic information system (GIS) mapping techniques to identify areas at risk of meteorological, hydrologic, and agricultural drought, as well as environmental and socioeconomic impacts that may occur due to drought conditions.

Part of the assessment included the creation of drought frequency maps for all the main Hawaiian Islands. The maps are a graphical representation of the spatial distribution of historical drought occurrences in the islands. The drought frequency analysis carried out to produce the maps was based on the SPI method for two 30-year periods: 1942 to 1971 and 1972 to 2001. The maps for the later 30-year period (1972-2001) were ultimately selected to be the standard drought frequency maps because it is more representative of the current climate and also because most available GIS data are relevant to this period. The maps are available for both a 3-month and 12-month SPI interval for moderate, severe, and extreme drought stages (six maps total) For SPI computations, the historical monthly precipitation records from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) up to the year 2001 were used.

Sample drought frequency maps for the Counties of Maui and Hawai‘i for 3-month and 12-month SPI intervals for the moderate drought stage are included in Figure 13.1 and Figure 13.2. In the maps, contours indicate percentages of time in which moderate drought (based on the SPI classification of drought) occurred during the period of 1972 through 2001. Contours corresponding to percentage values higher than 8% are showed in blue.

The complete collection of drought frequency maps is not included in this section because as will be discussed in the Risk Assessment section of this chapter, the ultimate goal of the Drought Risk and Vulnerability Assessment and GIS Mapping Project was to integrate the drought frequency maps with drought vulnerability maps. The combined maps, referred to as drought risk areas maps, identify areas where the occurrence of drought coincides with the occurrence of vulnerability characteristics for the purpose of risk assessment. The complete collection of drought frequency maps, therefore, is included by default in the drought risk areas maps presented in the Risk Assessment section of this chapter.

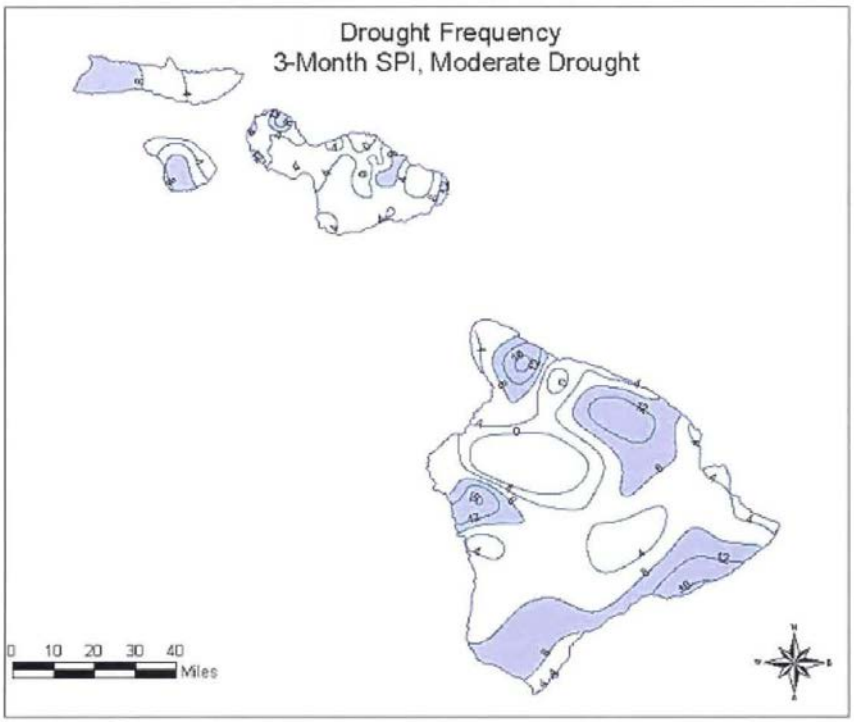

Figure 13.1 Drought Frequency Map for the Counties of Maui and Hawai‘i (3-Month SPI)

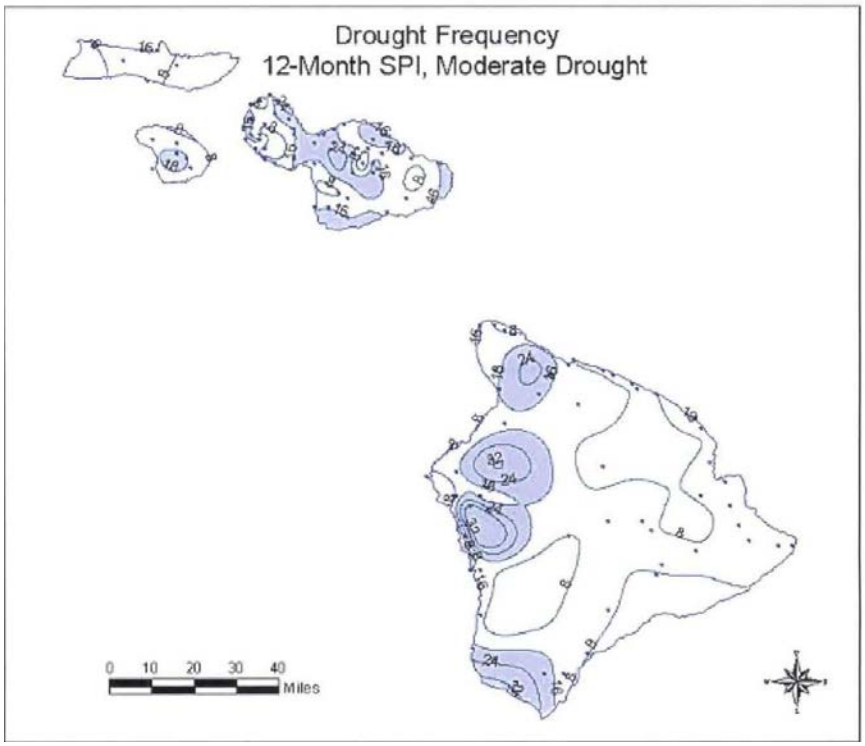

Figure 13.2 Drought Frequency Map for the Counties of Maui and Hawai‘i (12-Month SPI)

13.4 Risk Assessment

The Water Supply Sector encompasses public/private urban and rural drinking water systems, agriculture water systems, and other water networks. Due to the fact that fresh water is crucial to human survival in a variety of direct and indirect ways, one of the most important indirect aspects being maintaining a viable agriculture and commerce sector, minimizing the impact of drought to the State of Hawaiʻi's drinking water supply and other fresh water supplies is very important.

During drought periods, the agriculture and commerce sector is severely negatively impacted due to strain born of dependence on both surface water and rainfall. Rainfall shortage induced impacts are often exacerbated by the limits placed on irrigation system water use during drought periods. A persistent rainfall shortage and resultant lack of soil moisture can result in reduced ground cover and agricultural crop yields. Reduced ground cover places stresses and strains on livestock herd sizes, and is also associated with increased incidence of erosion. Environment, Public Health, and Safety for this project focuses solely on wildfire occurrence. Drought conditions heighten the potential incidence, extent and rapidity of the spread of wildfire. Wildland fires not only endanger human lives at the urban/wildland interfaces, but also endanger species of flora and fauna, which already may be especially susceptible due to drought conditions.

A risk assessment of these sectors should inform clear and concise mitigation measures to be undertaken during drought and non-drought periods. Pursuant to this goal a drought frequency analysis based on the Standardized Precipitation Index method was performed for all four counties in the State of Hawaiʻi, which graphically represents the spatial distribution of drought occurrences. Statewide drought frequency and sector based Geographic Information System (GIS) mapping were then integrated to identify risk areas for each county. For this analysis drought risk is considered a product of drought frequency and location specific vulnerability.

The drought frequency analysis was conducted for three drought stages (moderate, severe, and extreme) and for different drought durations (e.g., 3-month, 12-month). Throughout the various permutations of county, severity, and duration several patterns emerged. For example, a common risk area across all three sectors and three drought stages in the County of Hawaiʻi is found on the western side of the island near Kona. For the County of Maui, the common risk area to the water supply and environmental sectors is within the Kula region. For the City and County of Honolulu, central Oʻahu appears to be the common risk area across all the sectors for two drought stages. For the County of Kauaʻi, a small belt in the southeastern corner appears to be more vulnerable to some sectors and drought levels. An in-depth discussion of the findings can be found in the *Drought Risk and Vulnerability Assessment and GIS Mapping Project*. However, a brief discussion of sector specific trends by county follows.

13.4.1 Drought Risk Associated with the Water Supply Sector

In the case of the County of Kauaʻi, all the heavily populated areas fall within the approximately 75% of the island with the lowest tercile of median annual rainfall. These areas are all serviced by the public water supply system. Thus, it can be inferred that these populations are not

susceptible to meteorological drought but are susceptible to hydrological drought that depletes groundwater.

The City and County of Honolulu has the most extensive public water supply system. According to the Honolulu Board of Water Supply, approximately 92 percent of O‘ahu’s water comes from groundwater. The integrated municipal water system and its inherent flexibility allow the Board to pump water from one district to another, particularly during emergencies, thus drastically reducing vulnerability. 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 in the City and County of Honolulu is not as vulnerable to minor drought conditions. If a severe drought persists for more than one or two years, the ground-water supply would be depleted to a large extent and the entire island would be affected despite the extensive ground-water integrated public water system. The localized regions most vulnerable to future severe and extreme drought are the leeward and central portions of the island where rainfall is low and the development is greatest.

Within the County of Maui, the only area that satisfies the criteria for high vulnerability within the water supply sector is on the island of Lāna‘i. It should be noted that greater than 50 percent of both the islands of Maui and Moloka‘i are in the low tercile of median annual rainfall, and that these areas have the largest density of population within those respective islands, hence increasing the vulnerability of those areas to persistent hydrological drought despite adequate public water supply system coverage.

As for the County of Hawai‘i, the Water Supply Sector is particularly illustrative of the need for drought mitigation as identified through analysis. Over 50 percent of the Island of Hawai‘i is classified in the lowest tercile of median annual rainfall, and, when coupled with the uneven spatial extent of service coverage in populated areas along the Kona Coast and in Pāhoa, clear vulnerability exists. Other locations on the Island of Hawai‘i that fit the vulnerability criteria are areas in South Kohala and South Kona.

GIS mapping of drought risk areas across the State reveal that there are places in each of the counties that experience greater risk from drought. A statewide assessment, titled Drought Risk and Vulnerability Assessment and GIS Mapping Project (completed in 2003) utilized geographic information system (GIS) mapping techniques to identify areas at risk of meteorological, hydrologic, and agricultural drought, as well as environmental and socioeconomic impacts that may occur due to drought conditions. Part of the assessment included the creation of drought frequency maps for all the main Hawaiian Islands. The maps are a graphical representation of the spatial distribution of historical drought occurrences in the islands. Projections about the severity of the drought are based on the amount of anticipated rainfall and the proximity of water resources (see Table 13.4 below).

Table 13.3 Water Supply Sector Drought Risk Areas by County[10]

Water Supply Sector			
County	Drought Stage		
	Moderate	Severe	Extreme
Hawai‘i	Kona, South Point	Kona, Ka‘ū	Kona, windslopes of Hāmākua
Maui	Kula, Kahului, Wailuku, Hāna, Lahaina	Kula, Hāna	Kula
Honolulu	Central O‘ahu (Mililani / Waipi‘o)	Central O‘ahu	‘Ewa, Hale‘iwa

13.4.2 Drought Risk Associated with the Agriculture and Commerce Sector

The County of Kaua‘i is mostly affected by meteorological drought in the agriculture lands along the southern and northwestern parts of the island of Kaua‘i. The majority of the agriculture services are in the intensive category located along the coastal areas in the south from Lāwa‘i to Mānā. All of these lands are in the lowest tercile of mean annual rainfall.

The City and County of Honolulu, has the fewest acreage of all counties that is still dedicated to the agricultural industry, both in terms of intensive and extensive agriculture. However, even these relatively small parcels are vulnerable to meteorological drought in the low rainfall areas of the upper ‘Ewa Plains of Kunia and the areas from Helemano to Hale‘iwa.

The County of Maui’s agriculture sector is also highly vulnerable with over 75 percent of its extensive and intensive agriculture lands falling within low rainfall areas. Areas on the island of Maui that are vulnerable are typically on the western end of the island, areas like Makawao, Kula, Lahaina, ‘Ulupalakua, and Kapalua. The islands of Moloka‘i and Lāna‘i are just as vulnerable within the agriculture and commerce sector. Excluding areas along the eastern and southeastern slopes of the Moloka‘i Forest Reserve, all of the lands on the islands of Moloka‘i and Lāna‘i lands with intensive and extensive agriculture are also very vulnerable to meteorological drought.

The agriculture and commerce sector for the County of Hawai‘i is indicative of the statewide pattern of agriculture and ranching situated in low rainfall areas. The bulk of the extensive and intensive agriculture including the Kona Coast, Lower and Upper Kohala region, and South Point in the District of Ka‘ū all receive relatively low rainfall. It is assumed that a greater proportion of the extensive agriculture lands is solely dependent on rainfall for moisture, as opposed to irrigation, and is thus even more vulnerable than intensive agriculture.

[10] Drought Risk and Vulnerability Assessment and GIS Mapping Project, University of Hawai‘i prepared for DLNR Commission on Water Resources Management 2003, updated 2010.

13.4.3 Drought Risk Associated with the Environment, Public Health, and Safety Sector

The results that pertain to the Environment, Public Health, and Safety Sector are discussed in detail in Chapter 14 – Wildfires.

13.4.4 Potential Losses in Future Events

The average annualized losses due to drought may be estimated statewide by using the estimates of drought losses over the last two decades. Although agricultural losses are the main component of drought related losses in the State of Hawai‘i, most of these agricultural losses come from sectors that rely on rainfall rather than on irrigation. In the State of Hawai‘i, the agricultural water supply is mostly separate from the municipal/domestic drinking water supply. Therefore, most agricultural losses across the islands are in the ranching industry, where the pastures are not irrigated. In other words, the majority of agricultural losses come from areas that rely on rainfall, such as the coffee industry for example. Based on the estimates in the State of Hawai‘i Drought Plan, the statewide agricultural losses summed to $26.4 million between the years of 1980 and 2002. This dollar figure is attributed largely to livestock losses. Therefore, based on the data for these 23 years, the statewide annualized losses due to drought are estimated at approximately $1.1 million dollars. This loss estimate is conservative as it does not include all agricultural and environmental losses which are extremely difficult quantify in terms of dollar value.

13.4.4.1 Losses in the Agriculture Sector (Crops)

One of the best available current data to determine losses due to drought in the agricultural sector can be taken from records of the United States Department of Agriculture (USDA) Farm Service Agency (FSA). One of the mandates of FSA is to provide relief assistance to the agricultural sector for drought. A problem identified in the past with the relief assistance is that it is tied to congressional allocations for drought relief and producer eligibility, which means that the amount of assistance is not tied to a strict formula that accounts for acreage by crop loss. Therefore, payout dollars by the FSA are not an actual drought "loss" metric. This indirect relationship makes the accountability of crop and livestock losses tied to rates of exposure and to sensitivity of location very difficult. However, the severity of a drought can be inferred by the magnitude of the payouts. As can be seen on Table 13.5, the FSA payouts do indicate drought assistance in place over time that can be used as data for understanding risk and vulnerability to drought in the agriculture sector.

Perhaps a more accurate measure of drought losses in the agriculture sector can be provided by insurance claims paid by the USDA Risk Management Agency (RMA). The RMA’s role is to help agricultural producers manage their business risks through effective, market-based risk management solutions. Through the Federal Crop Insurance Corporation (FCIC), RMA provides insurance for many agricultural crops including tropical fruits. In the State of Hawai‘i, RMA insures banana, coffee, macadamias, and papaya. The number of acres of these crops that is insured in the State of Hawai‘i varies from year to year. For the year 2012, for example, approximately 17,000 acres of crops were insured out of a total of 28,500 acres of crops available statewide. In contrast to the FSA payouts, the RMA indemnities are a direct monetary

measure of agricultural loss claims. Agricultural claims paid off by the RMA for the State of Hawai‘i for the years 2002 through 2012 are presented in Table 13.5.

Although both the FSA and the RMA metrics may yield some light in estimating drought losses in the agriculture sector, it is clear that dollar amounts provided in subsidies and response activities are inadequate determinants of losses from drought. Most of the response subsidies are politically determined and distributed based on funding availability in response to losses. Consistent calculations – based on crop, area of loss, length of drought event, and financial hardship – have not been developed into an applied method for determining costs of drought in the agricultural sector.

13.4.4.2 Losses in the Agriculture Sector (Livestock)

One of the best available current data to determine losses due to drought in the agricultural sector can be taken from records of the United Drought has severe impacts on livestock as well as crops (see Table 13.6). Lack of rainfall reduces the availability of forage plants for cattle grazing. During a severe drought, the herd may be culled to ensure that the remaining cattle stock survives during the drought. Once the drought is over, the plants take time to recover and this leads to a lag time in recovery to livestock herds. During a drought year, breeding cows decrease by twenty percent and calving decreases by ten percent. Following the drought, it takes about 2.5 years to recover from the impacts to the herds.[11]

Estimates indicate a 50% reduction in production for cattle ranches, which approximate a decrease in revenue for ranches in the State of Hawai‘i of about $4 million annually through the drought, and subsequently for 2.5 years following the drought while herds are reestablished.[12] Not only are cattle affected by the lack of water, but by the lack of nutritional forage, which results in decreased weights of cattle and declines in reproduction. In October 2011, the FSA reported that various areas of Hawai‘i Island have experienced a 30 percent to 100 percent loss of forage plants for livestock. Indirect costs from being unable to replace equipment, such as vehicles, during drought years compound the direct revenue losses and can extend recovery periods by three or four more years.

The USDA Farm Service Agency has two programs that cover livestock losses: the Livestock Indemnity Payments Program and the Livestock Forage Disaster Program. Due to some inconsistency in reporting across all of the USDA disaster assistance records, there are discrepancies in the data; however, the information remains the best available loss data from drought incidence for the State of Hawai‘i. For the period of 2008 to 2010, the total payments to the State of Hawai‘i are $143,750 for LIP and $8,347,694 for LFP.[13]

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[11] Erdman, The Effects of a Drought on a Hawaiian Cattle Ranch. Report submitted from the President, ‘Ulupalakua Ranch, Inc., 2007

[12] Ibid

[13] United States Department of Agriculture (USDA) Farm Service Agency (FSA) website, retrieved August 2010 from http://www.fsa.usda.gov/Internet/FSA_File/lfp_lip_pmt_totals.pdf

Table 13.4 USDA Farm Service Agency Disaster Benefits Paid by County and by Program

YEAR	COUNTY AND PROGRAM[14]									STATE TOTAL
	Kaua'i		Honolulu		Maui			Hawai'i		
	LAP	LCP	LAP	LCP	LAP	LCP/LFP	NAP/ CDP/ ECP	LAP	LCP	
2002		$192,020		$55,171	$161,473		$219,407		$483,084	$1,111,155
2003			$62,466				$118,653			$181,119
2004	$223,582				$331,147		$1,313	$470,356		$1,026,398
2005	$262,842		$96,824				$10,688	$1,181,433		$1,551,787
2006	$0	$0								
2007	N/A	N/A							$125,000	
2008	N/A	N/A				$87,048	$153,853	$2,500,000		$2,740,901
2009	N/A	N/A				$879,467	$213,897	$2,800,000		$3,893,364
2010	N/A	N/A	$271,511		$331,147	$1,456,515	$574,205	$5,425,000		$8,058,378
2011	N/A	N/A				$13,552	$341,254	$2,870,842	$2,457,831	$5,683,479

Table 13.5 USDA Risk Management Agency Indemnity Paid for all Crops by County[15]

YEAR	COUNTY				STATE TOTAL
	Kaua'i	Honolulu	Maui	Hawai'i	
2002	$0	$0	$0	$727,532	$727,532
2003	$0	$0	$0	$1,118,834	$1,118,834
2004	$0	$76,071	$0	$538,472	$614,543
2005	$0	$24,109	$0	$363,232	$387,341
2006	$0	$0	$0	$170,235	$170,235
2007	$23,241	$0	$0	$4,968	$28,209
2008	$0	$0	$0	$1,809,650	$1,809,650
2009	$0	$0	$0	$717,155	$717,155
2010	$0	$0	$0	$984,974	$984,974
2011	$0	$0	$0	$2,617,456	$2,617,456
2012	$0	$0	$16,866	$768,165	$785,031
TOTAL	$23,241	$100,180	$16,866	$9,820,673	$9,960,960

[14] CDP = Crop Disaster Program, ECP = Emergency Conservation Program, LAP = Livestock Assistance Program, LCP = Livestock Compensation Program, NAP = Non-insured Crop Disaster Assistance Program

[15] Data is taken from the Federal Crop Insurance Corporation's Yearly Statistic Reports. Data is as of July 1, 2013

Table 13.6 Example Estimates of Drought Impacts on a Cattle Ranch[16]

Example Of Drought Effects On Cattle Ranch:		
Normal Year:		
Breeding Cows:	100	
Calving Percentage:	85%	
Total Calves:	85	
Heifers Retained:	12	
Saleable Calves:	73	
Average Weaning Wt.:	450	
Total Saleable Pounds:	32,850	
Drought Year:		**% Difference From Normal**
Breeding Cows:	80	-20%
Calving Percentage:	75%	-10%
Total Calves:	60	-29%
Heifers Retained:	9.6	-20%
Saleable Calves:	50	-31%
Average Weaning Wt.:	325	-28%
Total Saleable Lbs.:	**16,380**	**-50%**
When Drought Ends		**% Difference From Normal**
Breeding Cows:	80	-20%
Calving Percentage:	85%	0%
Total Calves:	68	-20%
Heifers Retained:	29.6	147%
Saleable Calves:	38	-47%
Average Weaning Wt.:	450	0%
Total Saleable Lbs.:	**17,280**	**-47%**

***Note: Replacement Heifers Retained Must Be Increased To Rebuild Herd**
(Also it will take 2.5 years before calves from these heifers are ready for sale)

[16] Sumner Erdman, Ulupalakua Ranch, Inc., Maui Island, prepared 2007.

13.5 Mitigation Strategies

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 the State of Hawai‘i’s 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 can be 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

Summaries of general mitigation measures and responsible agencies based on potential impact are provided in Table 13.7, Table 13.8, and Table 13.9 for the water supply; commerce and agriculture; and environmental, public health, and safety sectors; respectively. This general mitigation measures are a guideline for recent and future mitigation projects.

Table 13.7 Impact of Drought on the Water Supply Sector

Impacts	Response and Mitigation Actions	Response Agency
Reduced or no pumpage from existing water sources that show a high level of chlorides or have a short recharge time with limited storage	• Shut down impacted wells and use other wells to supply water to affected areas. • If pumpage from other sources is limited because of extended drought conditions and/or aquifer levels are at a dangerously low level, implement mandatory restrictions on water use. • If pumpage from other sources is not available, institute mandatory water use restrictions and provide water wagons with the instruction that water is only for health and safety purposes; also fill existing reservoirs and restrict for emergency purposes (fires). • Prior to drought conditions, identify existing sources that would be impacted by high chlorides and identify and install improvements to blend water with more potable sources or to supplement distribution systems.	Water Supply

Table 13.8 Impact of Drought on the Agriculture and Commerce Sector

Impacts	Response and Mitigation Actions	Response Agency
Water Storage and Distribution	• Each individual responds appropriately • Develop new wells • Access to county and district resource information • Incorporate private water systems into overall water distribution programs • Use of military surplus equipment to transport equipment and personnel to drought stricken areas • Develop state policies, rules and guidelines that encourage the use of reclaimed or recycled water • Develop and implement agricultural programs promoting practices that conserve water	DOA CWRM State CD DLNR FWDA DOH DHHL
Erosion and Soil Productivity	• Initiate NRCS/FSA, PL-566 programs, EQIP program, DLNR Forest Stewardship Program, State Tax Credit (farming) • Initiate educational programs • Develop soil suitability maps to identify high potential agriculture areas	DOA SWCD FWDA FSA NRCS
Loss of Biodiversity	• Each individual landowner participate in state tree planting programs, NRCS Forestry Incentives Program I and Wildlife Habitat Incentives Program, DLNR Forest Stewardship Program • Promote wind break planting throughout agriculture areas • Initiate and sustain on-going tree planting programs	DLNR SWCD NRCS
Mental Health	• Initiate FSA drought outreach program during early stages of drought • Local/State mental health agencies provide assistance • Develop educational programs • Develop public information programs on community stress	DOA CWRM State CD SWCD FSA DOH
Employment Losses	• Initiate federal assistance program, low interest state loans, Federal Crop Loss Programs (farming), Agriculture loans. • Extend state loan program • Develop state agricultural revolving fund • Establish state subsidies and improve federal programs • Defer state land lease rent and taxes • Establish new insurance programs for losses • Develop markets that encourage the planting of drought resistant crops	DBEDT DOA DLNR SWCD FSA

Table 13.9 Impact of Drought on the Environmental, Public Health, and Safety Sector

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 firefighting 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 firefighting 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

13.5.1 State of Hawai‘i Drought Council

The Hawai‘i Drought Council is the steering group that oversees the implementation of drought related activities in the State of Hawai‘i. It functions by providing access to services and assistance within existing agencies, with representatives from the Governor’s Office, DLNR, Department of Agriculture, Department of Defense and Four County Government officials. There are also Ex-Officio members from Hawai‘i Association of Conservation Districts, Hawai‘i Farm Bureau, Hawai‘i Cattlemen’s Council and East Maui Irrigation Co. Ltd. It serves as a liaison between the various entities involved in drought planning, response, media relations and the Office of the Governor. The Hawai‘i Drought Council provides leadership to accomplish the following:

- With approval of the Governor, develop, implement and maintain a state drought plan;
- Review and report drought monitoring information to the affected government agencies, organizations and the general public;
- Coordinate timely drought impact assessments;
- Identify areas of the State at risk to drought and target collection and assistance efforts to those areas;
- Support and facilitate the organization of County/Local Drought Committees;
- Authorize State agency staff to provide technical assistance to local drought committees;
- Promote ideas, programs and activities for groups and individuals to implement that may mitigate the impacts and reduce drought vulnerability;
- Propose legislation to State and county legislative bodies in support of drought program activities;
- Facilitate access to federal, State and local assistance programs and assist with acquiring funding for program implementation;
- Act as coordinating entity for application and disbursement of emergency aid/ funding obtained from all sources; and
- Promulgation of statute and/or rules, as may be necessary to implement recommended drought mitigation measures.

13.5.2 State of Hawai‘i Commission on Water Resources Management

The Commission on Water Resource Management (CWRM) administers the State Water Code, which was created by the 1987 State of Hawai‘i Legislature. The general mission of the CWRM is to protect and enhance the water resources of the State of Hawai‘i through wise and responsible management. There are a total of seven members on the Commission. Two are ex-officio (by virtue of office) members and five are appointed by the Governor from lists submitted by a nominating committee, subject to confirmation by the Senate.

The Commission on Water Resource Management is attached to the State of Hawai‘i’s Department of Land and Natural Resources (DLNR) and is under the general direction of the Deputy Director for Water Resource Management.

Among other responsibilities, the CWRM provides staffing and technical support for the Hawaii Drought Council and its various task forces and committees. The CWRM has developed a

website called the "Hawai'i Drought Monitor" that informs the public about the status of drought and encourages mitigation actions[17]. The site posts drought notices, such as the following:

- **County of Hawai'i Department of Water Supply** – May 1, 2013 – 10% voluntary water conservation in the area between Waimea town and Kawaiahe due to ongoing dry weather and exceptionally large water consumption.

- **City and County of Honolulu** – April 23, 2013 – 10% voluntary water conservation of the Waimanalo Irrigation System

- **County of Maui** – April 2, 2013 – 20% mandatory non-homestead water conservation throughout the island of Moloka'i due to low water levels at the Kuakapu'u reservoir and persistent drought in central and leeward areas of the island.

- **County of Hawai'i Department of Water Supply** – February 21, 2012 – 10% voluntary water conservation in the area between Waimea town and Kawaihae and in the areas of upper Pa'auilo and Āhualoa due to low rainfall and ongoing repairs of earthquake damaged reservoirs

- **County of Hawai'i Department of Water Supply** – February 8, 2012 – 10% voluntary water conservation in the area after Honoli'i Bridge in the Pauka'a, Pāpa'ikou, Upper and Lower Kalaoa area due to a schedule repair of the Pāpa'ikou well.

- **County of Hawai'i Department of Water Supply** – October 14, 2010 – 25% mandatory water conservation in the areas of Honoka'a, Āhualoa, Kalōpā, Pōhākea, Upper Pa'auilo, Kukuihaele,and Kapulena to a breakdown of the Haina well pump.

- **All Counties** – July 21, 2010 – USDA Designates Four Counties in Hawai'i as Primary Disaster Areas. All Hawai'i Counties designated due to losses caused by drought that began January 1, 2010, and continues. Farm Service Agency is making loan and assistance programs available to qualified farmers and ranchers.

- **County of Kaua'i Department of Water** – June 5, 2008 – Water conservation requested especially for East Kilauea.

- **Hawai'i Department of Agriculture** – Waimanalo Irrigation System: 30% mandatory water conservation

- **Maui Department of Water Supply** – Upper Kula Water Change Due to Drought Conditions

- **Hawai'i Department of Water Supply** – Drought Information Update

- **County of Kaua'i Department of Water Supply** – June 5, 2007 – Water conservation urged in Kilauea area

- **City & County of Honolulu,** Hawai'i Department of Agriculture – Waimanalo Irrigation System Water Level Notice - 20% mandatory water conservation

[17] The address for the Hawai'i Drought Monitor website is http://hawaii.gov/dlnr/drought

- **County of Maui Department of Water Supply** – June 12, 2007 – Board declares drought warning for Upcountry area - mandatory 10% restriction for non-agriculture customers – 2007 Upcountry Water Supply Update

- **County of Hawai‘i** – Civil Defense Agency – June 7, 2007 – Mayor Kim Issues Emergency Proclamation – County of Hawai‘i Department of Water Supply – Water Conservation Notice Reminder: 1) Waimea Town, 2) Makapala-Niuli Water System –Water Restriction Notice for South Kohala, Hāmākua – Hawai‘i Department of Agriculture –Waimea Irrigation System Water Level Notice – Honokaa-Paauilo Irrigation System Water Level Notice

13.5.3 State of Hawai‘i Drought Plan

The Hawai‘i Drought Plan asserts that the three drought impact sectors are critical to the health and welfare of Hawai‘i's people in terms of the social, economic and environmental arenas. The Hawai‘i Drought Plan (HDP) was prepared for use by the State of Hawai‘i Drought Council to improve and better coordinate drought management strategies for the State of Hawai‘i. The plan lays out a comprehensive vision for how state and local entities can work together to proactively implement mitigation measures and appropriate response actions during periods of drought to reduce and minimize the effects upon the people and natural resources of Hawai‘i.

Experiences with past droughts have shown that the most effective approach to accomplish this goal is to coordinate mitigation response actions between federal, state, and county governments, private sector, and local citizens in a timely manner. It is well recognized that effective drought planning and mitigation programs may well reduce the need for extensive federal, state and county emergency relief expenditures usually draw upon to assist farmers and ranchers, and can assist rebuilding of local economics, and reduce conflicts over competition for water during drought.

The plan is based on a guide by the National Drought and Mitigation Center (NDMC) titled "The Basics of Drought Planning: A 10-Step Process" first published in 1990. The NDMC methodology was used to develop the initial HDP: Phase 1 in August 2000. In conjunction with the development of Phase 1 of the HDP, statewide public workshops were held on each island during the week of August 7-11, 2000. In addition, a 30- day review and comment period was provided to receive additional public input on the plan. The plan was revised and topics that required further research and data during compilation of the Phase 1 plan were inserted to result in the 2005 version of the plan.

The HDP has not been updated since the 2010 edition of the State of Hawai‘i Multi-Hazard Mitigation Plan. However, the plan continues to provide the guideline for drought mitigation activities, and has been reviewed by the Drought Council. The goal of the Hawai‘i Drought Plan was to develop coordinated emergency response mechanisms, while at the same time outlining steps towards mitigating the effects of future drought occurrences. The key elements were outlined as follows:

- A comprehensive rainfall pattern and climate monitoring system to provide early warning of emerging droughts to decision makers, stakeholders, and the general public.

- A network of people and/or organizations that can effectively assess evolving impacts of water shortages on agriculture, recreation, hydropower, municipal and domestic water supplies, wildlife, and other areas sensitive to reduced rainfall and fluctuations in water supply.
- Clear policies and establishment of response entities to implement immediate and short-term response measures to reduce drought impacts and longer-term mitigation measures to reduce the future impacts of drought.

The HDP establishes a leadership structure comprised of the:

- Hawai‘i Drought Council
- State Drought Coordinator
- Water Resources Committee
- County/Local Drought Committees.

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. In addition, the drought plan makes several recommendations regarding performance of risk management assessments pertaining to potential drought impacts.

The goals and objectives of the leadership structure identified above can be briefly described as follows:

- Timely prediction and monitoring of pre- and post-drought conditions;
- Risk assessment of drought-related impacts to agriculture and commerce, municipal water supply, and environment, public health and safety sectors;
- Mitigation of drought effects through effective planning actions during both drought and non-drought periods;
- Timely dissemination of drought-related information and data through the Hawai‘i Drought Monitor website to the general public and affected federal, state and county agencies; and
- Delineation of drought communication and response actions for the leadership structure.

13.5.3.1 The Water Resources Committee

The Water Resources Committee is the core of the Hawai‘i State Drought Plan. The Committee is responsible for monitoring all available climatological data, soil moisture readings, reservoir storage levels, ground water conditions, weather forecasts and other pertinent information necessary to analyze the current status and forecasted level of drought conditions in the State of Hawai‘i. This group of water resource, agricultural and climate professionals assesses information, makes evaluations as to the current and future status of drought in the State, advises other work groups and task force members as to the current status level of drought in the State, and, as necessary, responds to "triggers" to implement further actions by the other task forces.

The Water Resources Committee is co-chaired by the State Commission on Water Resource Management and the Honolulu Board of Water Supply. Other members include representatives from the County water departments, Department of Agriculture, Hawai‘i Agricultural Statistic Service, National Weather Service, State Civil Defense, U.S. Geological Survey and the State Climatologist (University of Hawai‘i).

13.5.3.2 The County Drought Committees

The Drought Committees at the County level (one for each County) are comprised of representatives from key governmental agencies (i.e. Civil Defense Agency, DLNR Division of Forestry and Wildfire, Department of Water Supply, United States Department of Agriculture, etc.) and non-governmental organizations, major landowners, and individuals with an active interest in drought-related issues (i.e. Hawai‘i Farm Bureau Federation, Maui Land and Pine, Moloka‘i Ranch, etc.). Unless required due to drought emergencies, the County Drought Committees typically meet bi-annually to discuss and address all matters related to drought in the County.

13.5.4 Recent and Ongoing Mitigation Activities

The status of a number of ongoing or recent drought mitigation projects by County and by sector is listed in Table 13.10 All drought sectors are included in the table except the Environmental, Public Health, and Safety sector. Recent and ongoing mitigation projects for the Environmental, Public Health, and Safety sector are discussed and Chapter 14 – Wildfires.

Table 13.10 Status of Drought Mitigation Projects by County as of July, 2013

	SPONSOR	SECTOR	PROJECT	COST	STATUS
ALL COUNTIES	CWRM/USACE	All	Update Rainfall Atlas of Hawai‘i	$200,000	Completed
	CWRM	All	Hawai‘i Drought Impact Reporter Website	$100,000	Completed
	CWRM/USACE	All	Rainfall Trends in Hawai‘i	$100,000	Ongoing
	CWRM	All	Evapotranspiration Maps for Hawai‘i	$200,000	Ongoing
	CWRM	All	Update Hawai‘i Drought Monitor Website	N/A	Ongoing
	CWRM	All	Update Project Listing in County Drought Mitigation Strategies	N/A	Ongoing
	DLNR	All	Drought /Wildland Fire Mitigation Plan (all islands)	N/A	Completed
	CWRM/USACE	Water Supply	Hawai‘i Water Conservation Plan	$200,000	Completed
	CWRM	Water Supply	Hawai‘i Water Resource Protection Plan	$250,000	Ongoing
KAUA‘I	County of Kaua‘i Department of Water Supply	Water Supply	Acquisition of Water Leak Detection Equipment	$100,000	Completed
	County of Kaua‘i Department of Water Supply	Water Supply	County-wide Conservation Education Program: Develop a comprehensive State, County, and Private Sector conservation plan including demand and supply-side management	$100,000	Ongoing, Partially Completed
	County of Kaua‘i Department of Water Supply	Water Supply	Kekaha Amfac shaft renovation and replacement pipeline, Kekaha Water System	$2M	Ongoing, Partially Completed

Table 13.10 **(Continued) Status of Drought Mitigation Projects by County as of July, 2013**

HONOLULU	DOFAW	All	Installation of Remote Automated Weather Stations	$50,000	Completed
	West O‘ahu Soil and Water Conservation Districts (SWCD)	Agriculture	Lower Kawailoa Drought Mitigation Planning Study	$45,000	Completed
	DLNR	All	Document Agricultural and other losses due to drought: Assemble a third party agency or entities to develop a methodology, strategy, and cost estimates to implement a system to monitor drought conditions and track losses	$100,000	Ongoing
	Honolulu BWS	Water Supply	Drive By Leak Logger	$110,000	Completed
	Honolulu BWS	Water Supply	Toilet Rebate Program	$100,000	Completed
	CWRM	Water Supply	Ala Wai Boat Harbor Water Conservation	$100,000	Completed
MAUI	Central Maui Soil and Water Conservation District	Water Supply	Island of Maui – Kula Stormwater Capture Planning and Engineering Study	$200,000	Completed
	Maui Office of Economic Development	Water Supply	Island of Maui – Kula Agricultural Park Reservoir Relining Project	$800,000	Ongoing
HAWAI‘I	County of Hawai‘i Department of Water Supply	Agriculture	Dam & Reservoir Improvements. Pu‘u Wa‘awa‘a Reservoir Completed. Other post-earthquake repairs are currently being done/completed on HDWS, DHHL, and HDOA reservoirs	N/A	Ongoing
	County of Hawai‘i Department of Water Supply, State of Hawai‘i Civil Defense Agency	Agriculture	Improvements to the Kohala Ditch Irrigation Aqueduct - Improvements to old plantation irrigation transmission system: Post-earthquake repair completed, continued need for improvements	N/A	Ongoing

Table 13.10 (Continued) Status of Drought Mitigation Projects by County as of July, 2013

HAWAI'I	County of Hawai'i Department of Water Supply	Water Supply	Evaluation of vulnerability of County water systems and water trucking capacity	$1M	Completed
	County of Hawai'i Department of Water Supply	Water Supply	Development and extension of domestic water transmission system for Kawaihae	$10M	Completed
	Department of Hawaiian Homelands	Water Supply	Develop wells, storage, and construct transmission systems for Pu'u Kapu (177 ranch lots encompassing 10,000 acres). Construction has been completed, and operation is pending	$20M	Ongoing
	County of Hawai'i Department of Water Supply	Water Supply	Extension of domestic water transmission system for Oceanview. Well, reservoir, and filling station completed; transmission lines ongoing	N/A	Ongoing

13.5.5 Future Proposed Mitigation Actions

Future drought mitigation plans by drought sector for the each of the four counties in the State of Hawai‘i are listed and described briefly in Table 13.11 through Table 13.14. All drought sectors are included in the tables except the Environmental, Public Health, and Safety sector. Future mitigation projects for the Environmental, Public Health, and Safety sector are discussed and Chapter 14 – Wildfires.

Table 13.11 Future Drought Mitigation Efforts by Sector for the County of Kaua‘i

	PROJECT DESCRIPTION	COST ESTIMATE	STATUS
ALL	Convene sector-based drought workshops to assist stakeholders in developing or improving their individual drought/water conservation plans. Includes retaining experts in respective sectors.	$50,000	Proposed Project
AGRICULTURE	Repair, maintain, and re-establish the Anahola ditch system: Repair Anahola ditch system to support DHHL development east of the airfield, future agriculture, and support during drought.	N/A	Proposed Project
	Maintenance and upgrade of the Kekaha ditch system	$7M	Proposed Project
	Upgrade and maintain Pump 3 ditch system and Alexander Reservoir (hydropower plant)	$3M	Proposed Project
	Emergency Water Supply measures for Māhā‘ulepū-Kipu-Ha‘ikū-Kāhili	$50,000	Proposed Project
WATER SUPPLY	Emergency Interconnection – Kekaha Sugar System and DO Kekaha Water System	$50,000	Proposed Project
	State Kōke‘e System Wells: Develop deeper ground water wells to improve the quantity and quality of potable wells	N/A	Proposed Project
	Emergency Interconnection – DOW Kōlōa Water System – Grove Farm Kōlōa System	$50,000	Proposed Project

Table 13.12 Future Drought Mitigation Efforts by Sector for the City and County of Honolulu

	PROJECT	COST ESTIMATE	STATUS
ALL	Convene sector-based drought workshops to assist stakeholders in developing or improving their individual drought/water conservation plans. Includes retaining experts in respective sectors.	$50,000	Proposed Project
AGRICULTURE	Amend existing Federal and State laws to recognize a comprehensive drought program in Federal and State legislation as a natural disaster with proactive mitigation in response	N/A	Proposed Project
	Increase the amount of effluent available for reuse, develop strategies and pilot projects to reduce institutional hurdles	$3M	Proposed Project
	Improve the use of remote sensing and the City's GIS system to monitor drought and climatic changes	$50,000 to $100,000	Proposed Project
	Maintenance/rehabilitation of viable legacy agricultural irrigation systems to ensure continued operation: Includes renovation, maintenance, and efficiency improvements to collection, conveyance, storage, and delivery components of these systems	N/A	Proposed Project
WATER SUPPLY	Expand the reuse of brackish water and blending implications: Explore methods to expand the use of reclaimed water, such as by using reclaimed water for agricultural purposes and streamlining City administrative functions such as by partnering or combining BWS and City Wastewater Division functions.	$4M to $6M per 1.0M gallons of recycled water supply	Proposed Project
	Expand public education programs and implement measures for demand and resource conservation	$1.5M	Proposed Project
	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 pumpages among the island of O'ahu's primary aquifers and provides for sufficient aquifer recovery post-drought to maintain aquifer health.	N/A	Proposed Project

Table 13.13 Future Drought Mitigation Efforts by Sector for the County of Maui

	PROJECT	COST ESTIMATE	STATUS
ALL	Convene sector-based drought workshops to assist stakeholders in developing or improving their individual drought/water conservation plans. Includes retaining experts in respective sectors.	$50,000	Proposed Project
AGRICULTURE	Island of Moloka‘i – Moloka‘i Irrigation System improvements: Implement various initiatives and projects related to restoring the Moloka‘i Irrigation System to full operation and to ensure its long-term reliability	$3M	Proposed Project
	Island of Maui – Upcountry Maui Agriculture Pipeline Extension: Install a separate agricultural water distribution system to supply untreated water for irrigation purposes to farmers in the upper Kula area. The water source will be Kahakapao Reservoir.	$5M to $8M	Proposed Project
	Island of Maui – Stock water storage and deliver for ranchers: Seventy five (75) polyethylene tanks with 2,500 gallons capacity each plus water deliveries	$275,000	Proposed Project
AGRICULTURE AND WATER SUPPLY	Island of Maui – Construct new 100 to 200 MG storage reservoir: Construct and open lined reservoir after the intakes for the Pi‘iholo WTP. The reservoir would provide continuous supply to DWS customers in times of drought	$30M to $60M	Proposed Project
	Island of Maui – Implement recommendations of Upcountry (Kula) Stormwater Reclamation and Reuse Study: To include further feasibility study, environmental review, planning and design, and construction.	$35M to $60M	Proposed Project
WATER SUPPLY	All Islands – Water Conservation and Watershed Management Education : Mitigate the effects of drought by increasing the public’s awareness of water conservation and watershed management	N/A	Proposed Project
	Island of Maui – Improve Surface Water Sources in Upcountry Maui: Improve existing intakes to capture higher percentage of surface water. This may involve adding intakes at known water sources. The intakes must also be maintained for maximum operational safety.	$5M to $10M	Proposed Project
	Island of Maui – Improve Surface Water Transmission in Upcountry Maui: Improve the surface water transmission system and improve the flow of water for agriculture, domestic supply, and fire protection.	$5M to $10M	Proposed Project

Table 13.14 Future Drought Mitigation Efforts by Sector for the County of Hawai‘i

	PROJECT DESCRIPTION	COST ESTIMATE	STATUS
ALL	Convene sector-based drought workshops to assist stakeholders in developing or improving their individual drought/water conservation plans. Includes retaining experts in respective sectors.	$100,000	Proposed Project
AGRICULTURE	Improvements to old plantation irrigation system tunnels and ditches: Lower Hāmākua Ditch System	$30M	Received partial FEMA funding
	Renovations/improvements to old plantation irrigation system tunnels and ditches: Ka‘ū Sugar System Reactivation	$3M	Proposed Project
	Improvements to old plantation irrigation system tunnels and ditches and new Kauahi reservoir	$26M	Proposed Project
	Renovate and Reactivate old abandoned plantation wells in Pāhala	$2.5M	Proposed Project
	Renovate and Reactivate old Hāmākua Slaughterhouse well for non-potable agricultural use in Honoka‘a/Hāmākua	$100,000	Proposed Project
	Construct new wells, surface water diversions, storage and transmission lines in priority areas	Investigation	Proposed Project
	Irrigating wisely: Promote better irrigation practices and water management.	$100,000	Proposed Project
	Agricultural Water System for Kona and Honomalino: Provide a reliable source of water for agriculture and firefighting assistance.	$25M	In planning
WATER SUPPLY	Develop wells, storage, and construct transmission systems for Puna	Needs planning study	Need to establish improvement district to finance this project.
	Makalei Water System Improvements: Develop additional wells and reservoirs as well as upgrade the transmission system in the area from Keahole to Kailua-Kona for agricultural users.	$5M	Proposed 4-yr Project
	Various Water System Improvements within the County of Hawai‘i: Develop additional sources, storage facilities, as well as upgrade the transmission and distribution systems in high priority areas.	$50M	Proposed 15-yr Project
	Develop a program to improve drought resilience and preparedness for residents relying on rainwater catchment: Including incentives for increasing storage, outreach, and education, and developing community-based catchment storage areas.	$100,000	Proposed Project

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

14. Wildfires

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CHAPTER 14
Wildfires

Reasons for Updates / Revisions in this 2013 Plan
• The wildfire risk is increasing as development encroaches on wildlands without sufficient defensible space at the wildland/urban interface. Many acres of wildlands have been burnt in recent years. The DNLR, Division of Forestry and Wildlife (DOFAW) is responsible for forest reserves, with a co-response in intermediate area. • A new chapter has been broken out at the request of the Hawai‘i Drought Council. • Added 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 DOFAW is provided. • The status of ongoing projects is updated. • A new list of future mitigation projects is proposed.

Summary of Mitigation Projects for the State of Hawai‘i	
Project	Priority
Fire Break Maintenance - Various fuel breaks/fire roads 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.	Medium
Watershed Fire Protection – Four 1000-gallon water tanks for rainfall catchment and storage for fire suppression.	Medium

Wildfires Hazard Description

"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. While sometimes caused by lightning, nine out of ten wildfires are estimated to be human-caused.

Drought is one of many factors contributing to the complexity of forest ecosystems adapted to frequent fires. Although drought increases the potential for catastrophic wildfire, drought cannot be singled out as the sole cause or key determinant in wildfires. Other factors contributing to wildfires include wildland fuels accumulated during many decades of unwise fire suppression, overcrowded tree stands, down trees during heavy winds and storms, and the overgrowth of brushes and grasses mixing with urban fuels at the wildland-urban interface. Therefore, a more appropriate way of characterizing the relationship between wildfires and droughts is that wildland fires tend to be induced by drought rather than being caused by them.

Wildfires are also directly linked to the issues surrounding wildland-urban interface. The wildland urban interface is an area where human settlements such as homes, ranches, and farms adjoin areas considered wildlands. Urban expansion has driven both the increases in incidence and extent of the wildland-urban interface areas. In 2001, the United States Department of the Interior (DOI) and the United States Department of Agriculture (USDA) developed the National Fire Plan (NFP) to provide accountability of hazardous fuels reduction, burned area rehabilitation projects, and community assistance activities.[1] The NFP developed the term "Communities at Risk" to represent precisely such communities that are at the wildland-urban interface and are at risk from wildland fires. Table 14.1 lists a summary of all "Communities at Risk" in the State of Hawai‘i.

A common assumption is that wildland fires tend to occur in the same area time and time again. The crux of the analysis for this sector was that proximity of past wildland fires to the Census Designated Places (CDP) or "Communities at Risk" will provide some indication of how vulnerable a community may be, based on the assumption that wildfires tend to reoccur in the same areas. To tackle this problem, paper maps of wildfires over the past 20 years were gathered and converted to a Geographical Information System (GIS) format so that they could be overlaid on to the "Communities at Risk" layers. In addition, a major roads layer was also included given that roads have multiple functions in relation to wildfire; access by firefighting crews, man–made fire breaks, and in some cases wildfire expansion corridors. An overlay of median annual rainfall terciles of High, Medium, and Low provided further clarification of vulnerability. Communities that are both within low rainfall zones and in close proximity to past wildland fires would were found to be more vulnerable to future wildland fires. Other reference layer information served to flesh out vulnerability and potential burn patterns. For example, wildfires that span multiple land uses, which can be inferred as having different ground cover, tend to be associated with different burn patterns or burn characteristics. GIS maps indicating communities at risk for all four counties are included in Figure 14.1 through Figure 14.4.

[1] United States Department of the Interior (DOI) Website, Retrieved June 14, 2013from http://www.doi.gov/pmb/owf/nfpors.cfm

Table 14.1 Communities at Risk in the Vicinity of Federal Lands[2]

Communities at Risk	County	Information
Aiea, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Aliamanu-Salt Lake, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Ewa, HI	Honolulu	
Fern Acres, HI	Hawai‘i	
Fern Forest, HI	Hawai‘i	
Glenwood, HI	Hawai‘i	
Hawaii Kai, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Kailua-Kona, HI	Hawai‘i	
Kaneohe, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Kapoho, HI	Hawai‘i	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Kaupo, HI	Maui	
Kawaihae, HI	Hawai‘i	
Kekaha, HI	Kaua‘i	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Kilauea, HI	Hawai‘i	
Kipahulu, HI	Hawai‘i	
Kokee, HI	Kaua‘i	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Koolauloa, HI	Honolulu	
Makakilo Mauka, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Makakilo/Kapolei, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Mililani Mauka, HI	Honolulu	
Mililani-Waipio, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Moanalua, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Mokapu, HI		In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
North Shore, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Pearl City, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Volcano, HI	Hawai‘i	
Wahiawa, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Waianae Coast, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Waimanalo, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior
Waipahu, HI	Honolulu	In the vicinity of Federal lands other than those managed by the Departments of Agriculture and the Interior

[2] United States Federal Register, https://www.federalregister.gov/articles/2001/08/17/01-20592/urban-wildland-interface-communities-within-the-vicinity-of-federal-lands-that-are-at-high-risk-from, retrieved June 12, 2013

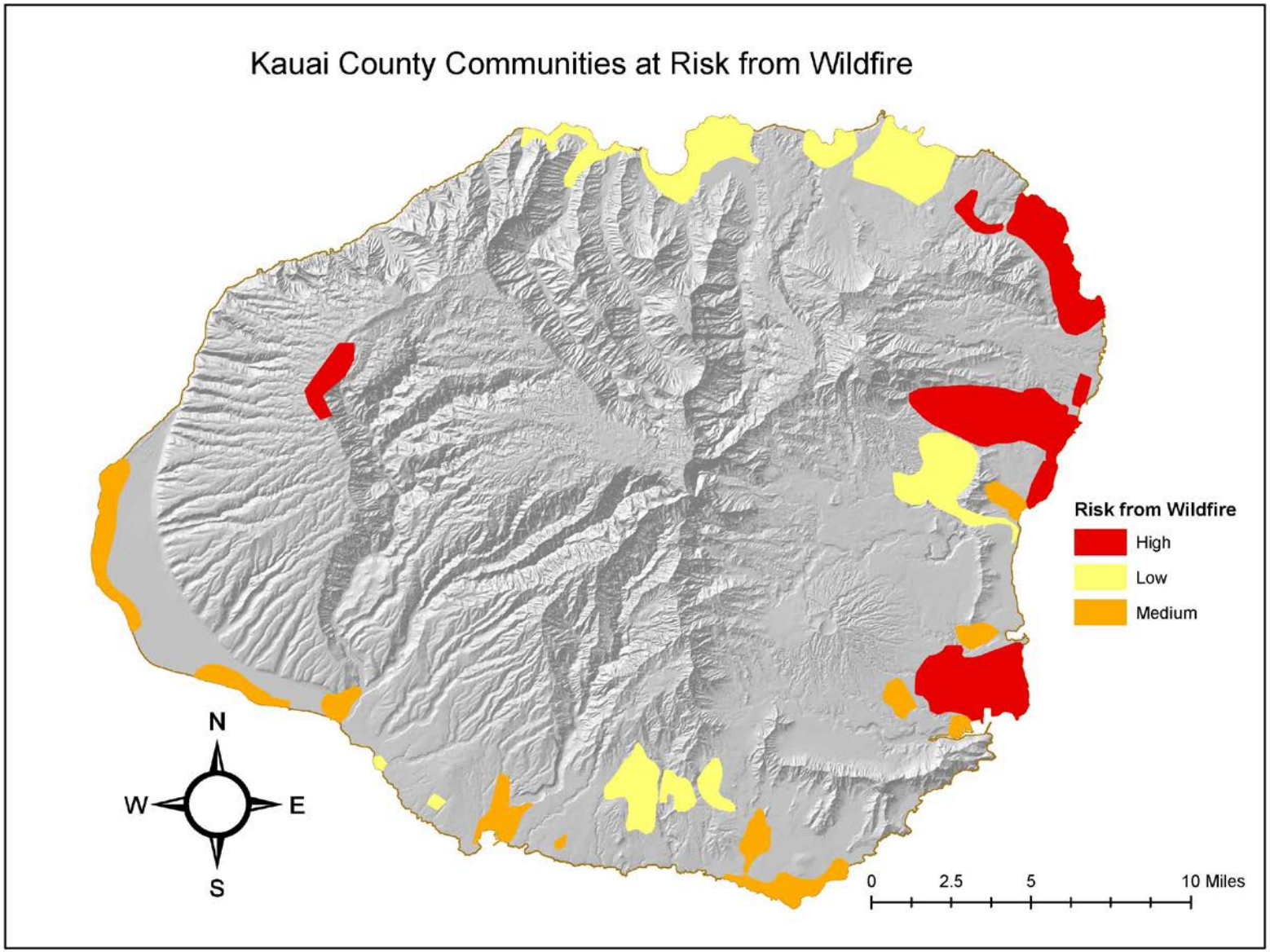

Figure 14.1 Communities at Risk of Wildfire for the County of Kaua'i

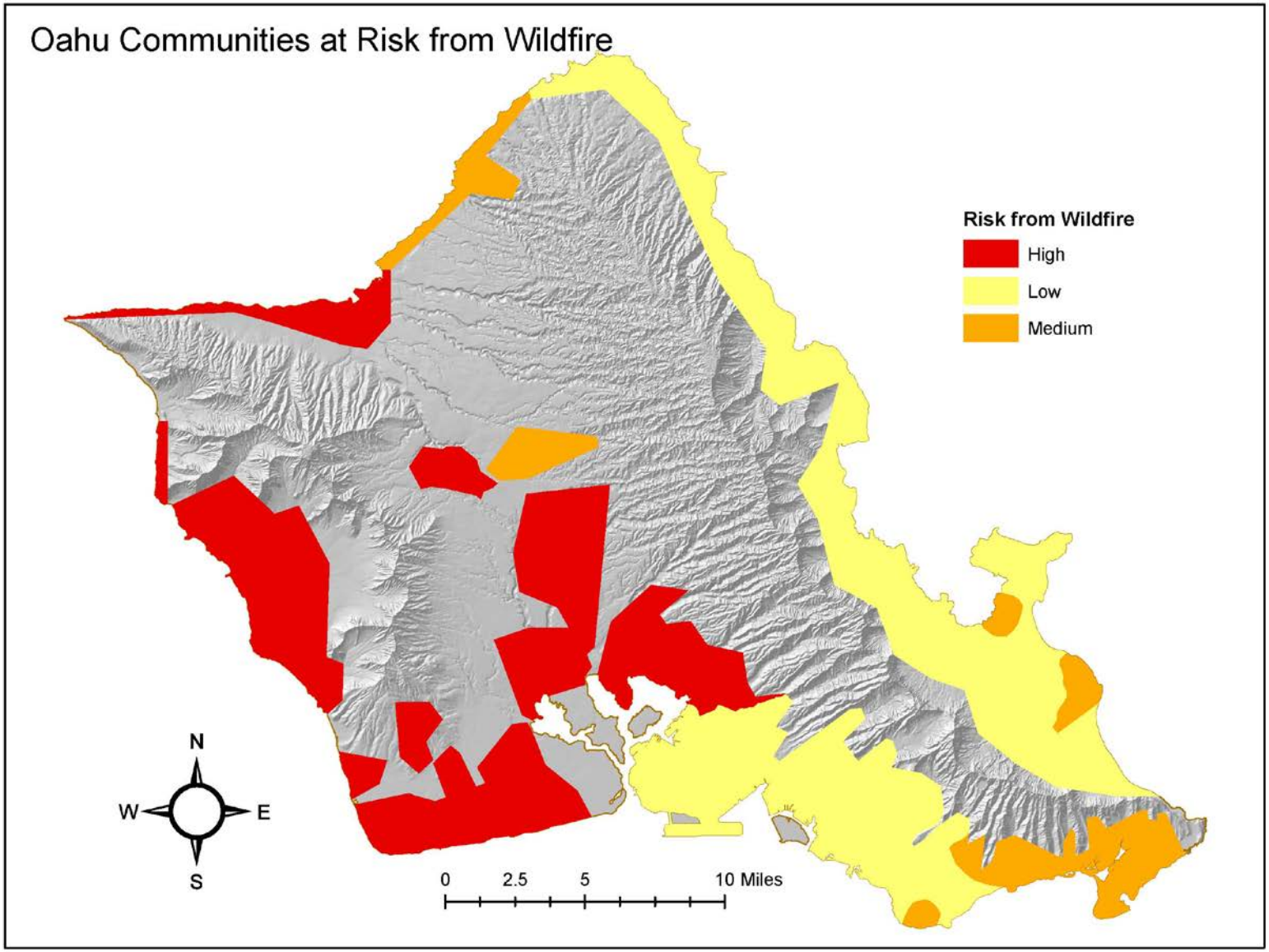

Figure 14.2 Communities at Risk of Wildfire for the City and County of Honolulu

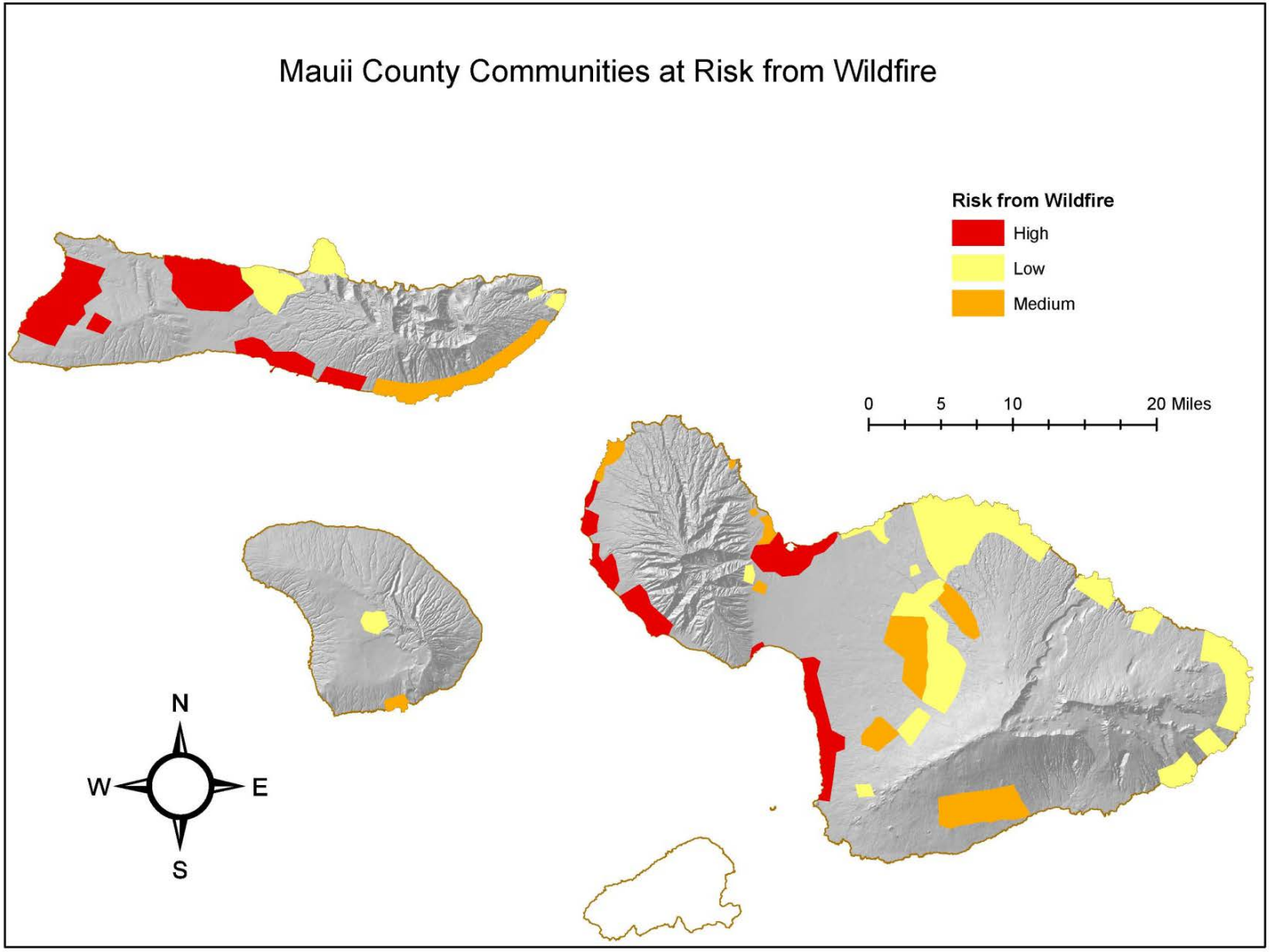

Figure 14.3 Communities at Risk of Wildfire for the County of Maui

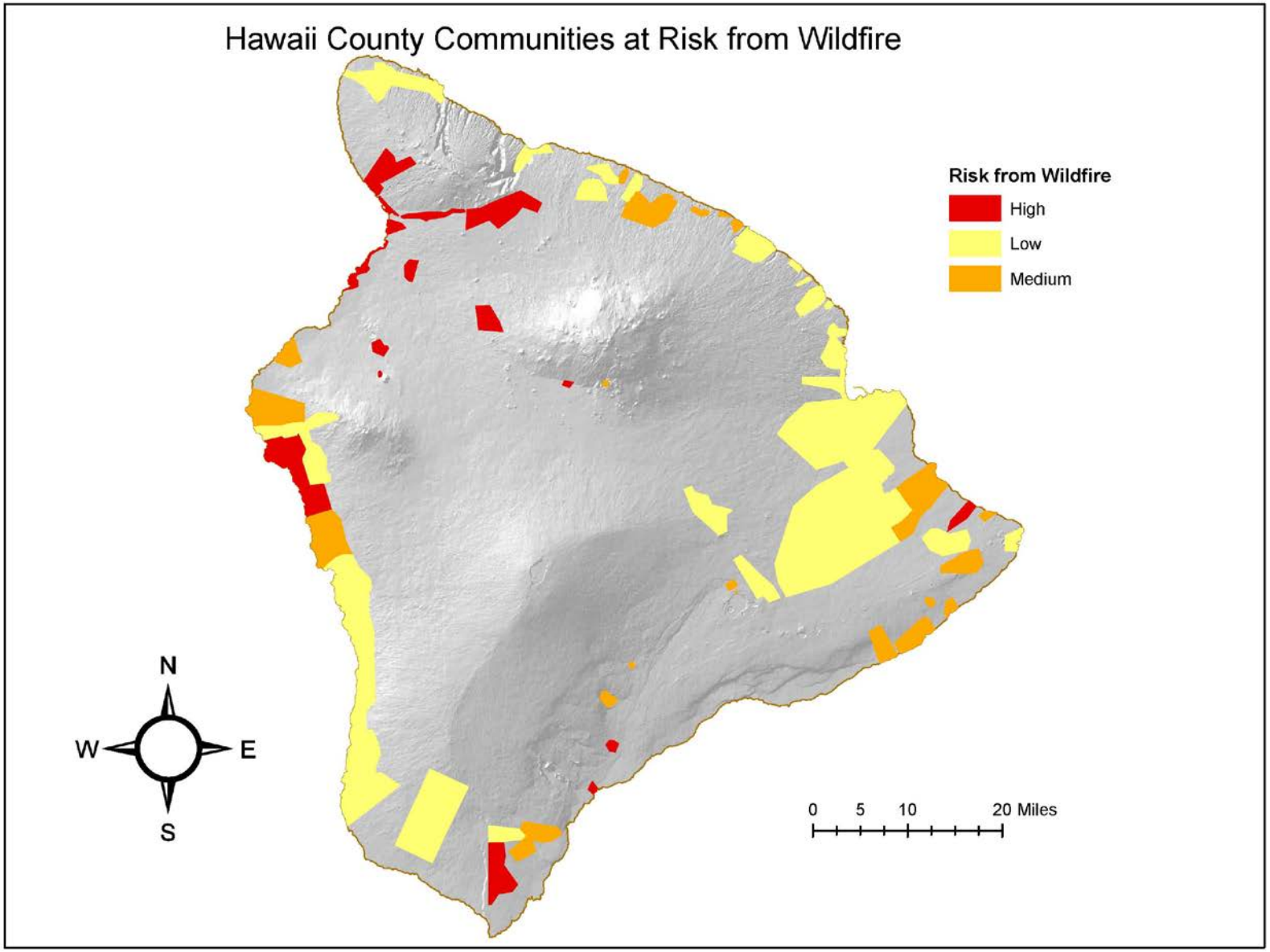

Figure 14.4 Communities at Risk of Wildfire for the County of Hawai'i

Sugarcane Disposal Fires

Each sugarcane field is planted with new cane seedlings only once every eight years. After the first two-year crop is harvested, the old stalks and root systems are permitted to sprout again. This re-sprouting usually is repeated two more times before the field is plowed under completely and planted again with new seedlings. When a field reaches maturity, the cane is set on fire to get rid of the unwanted vegetation that has accumulated on the cane over the previous two years.

While sugarcane burning is typically scheduled to take advantage of favorable winds and weather conditions, sudden wind shifts can direct flames in any direction leading to uncontrolled fires. Although uncommon, there have been several recorded instances in the last decades of uncontrolled sugarcane disposal fires in the State of Hawai‘i, particularly in the island of Maui.

For example, on September 16, 2003, a controlled burn by the Hawaiian Commercial & Sugar Company got out of hand near the locality of Waikapū on the central valley of the island of Maui when the wind carried some of the flames into nearby mountainous terrain. The fire ended up blackening about 1000 acres of parched grassland, to as high as 2000 feet in elevation in the West Maui Mountains.[3] The blaze forced the evacuation of the Sandalwood and Grand Waikapū golf courses for a few hours during the afternoon of the 16th and all day on the 17th. State and federal firefighters, with the help of four water-carrying helicopters (including a large Chinook from the Hawai‘i Army National Guard on the island of O‘ahu), battled the fire over several days. No serious injuries or property damage were reported during this uncontrolled sugar can burn.

Fires Related to Environment, Public Health, and Safety

Due to the fact that the bulk of analysis for this plan relies on the history of past wildfires and spatial extent, clear patterns emerged particularly in the County of Hawai‘i with approximately 48 fires burning a total of 90,159.19 acres from which to draw the following inferences.

Twenty-nine out of the 48 total fires were on the western end of the island, in the proximity of the Waikoloa Village “Community at Risk.” Vulnerability of “Communities at Risk” locations in this analysis is primarily a function of proximity to historical wildfire incidents.

When combining the past burn areas layer and the rainfall tercile layer, it is apparent that “low rainfall” zones increase the odds of wildfire occurrence. A total of 40 of the 48 fires in the County of Hawai‘i from 1953 to 2001 occurred in “low rainfall” zones.

Also, due to the infrequency of fires induced by lightning strikes, and since most of the wildfires occurred in either agriculture or conservation land use zones, it may be assumed that a greater proportion of these fires was started by human negligence or arson, rather than by natural means. Although not broken down by county, Table 14.2 illustrates the range of potential wildfire triggers, as well as substantiates the general assertion that human negligence is the main trigger.

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[3] National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Honolulu Forecast Office (HFO) StormData Website, retrieved December 30, 2009 from http://www.prh.noaa.gov/hnl/pages/stormdata/stormdata_092003.pdf

Table 14.2 Wildland Fire Incidence, Causes, and Extent of Damage in the State of Hawai'i from 2003 to 2012[4]

Year	Lightning		Campfire		Smoking		Debris burning		Arson	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
2003	0.0	0.0	5.0	12.2	5.0	2.4	9.0	372.5	15.0	2.6
2004	2.0	2.0	7.0	8.4	5.0	70.4	4.0	12.7	16.0	48.6
2005	3.0	4.1	8.0	801.7	0.0	0.0	5.0	1.6	12.0	218.2
2006	7.0	3,596.3	4.0	783.1	0.0	0.0	12.0	37.9	27.0	3,104.3
2007	1.0	0.1	5.0	40.1	1.0	2,291.0	11.0	53.9	21.0	6,728.5
2008	0.0	0.0	1.0	5.0	0.0	0.0	1.0	50.0	2.0	50.0
2009	0.0	0.0	2.0	23.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	1.0	900.0	2.0	2.0	0.0	0.0	0.0	0.0	2.0	1,487.0
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	13.0	3,602.5	32.0	1,673.5	11.0	2,363.8	42.0	528.6	93.0	10,152.2

Year	Equipment		Railroads		Children		Miscellaneous	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres
2003	8.0	302.5	0.0	0.0	1.0	0.1	64.0	15,893.1
2004	9.0	16.5	0.0	0.0	1.0	0.1	39.0	1,910.6
2005	6.0	135.9	0.0	0.0	0.0	0.0	75.0	25,331.1
2006	15.0	679.9	0.0	0.0	0.0	0.0	140.0	6,383.3
2007	9.0	255.6	0.0	0.0	0.0	0.0	99.0	20,222.3
2008	3.0	1,500.0	0.0	0.0	0.0	0.0	1.0	2,236.0
2009	3.0	199.0	0.0	0.0	0.0	0.0	2.0	7,852.0
2010	0.0	0.0	0.0	0.0	0.0	0.0	5.0	7,140.0
2011	1.0	1,153.0	0.0	0.0	0.0	0.0	2.0	1,566.0

[4] State of Hawai'i, Department of Land and Natural Resources, Division of Forestry and Wildlife, Fire Statistics, retrieved June 12, 2013 from http://hawaii.gov/dlnr/dofaw/forestry/forest-and-wildland-fire/fire-stats

Significant Historical Events

County of Kaua‘i

The County of Kaua‘i has had the smallest wildfire incidence despite intermittent drought conditions. Although Kaua‘i is known for its relatively wet weather most of the “high rainfall” locations are situated high in the central mountains on conservation land. Much of the “medium rainfall” zones are likewise located in the central area of the island, in remote mountainous areas. As such, a greater portion of the island falls within the “low rainfall” category. The wildfires that have been mapped have actually occurred in conservation or agriculture land, with the distances to “community at risk” ranging from 1.3 miles away to distances of 16.2 miles away. Hence, from this analysis, wildland fires may not appear to be much of a problem on Kaua‘i, but as stated previously, wildland fire vulnerability is not predictive of wildfire occurrence.

City and County of Honolulu

The City and County of Honolulu, from 1998 to 2002, according to the map data had 9 fires, 5 of which were located in the Waipi‘o “Community at Risk”. Four of the fires occurred in 2002 alone, and were fires that were between communities, hence endangering more than one community. The City and County of Honolulu, has the largest number of “Communities at Risk,” primarily due to the fact that 72 percent of the state’s population lives in the City and County of Honolulu, and there is a larger mix of urban/rural land to open land, with approximately 35 percent urban/rural, as compared to Maui County (5%), Kaua‘i County (5%), and Hawai‘i County (2%). This can be interpreted as a density factor or a built-up area to open land ratio, which can be very dangerous during a wildland fire. Most of the wildland fires in the City and County of Honolulu have taken place on the central to western end of the island, either in “low rainfall” locations or between zones of low to medium rainfall within agriculture lands. Some areas, like the Waipi‘o location mentioned previously, abut communities along major road corridors. Unlike other counties, there was a higher incidence of what appeared to be “natural” wildfires, such as Wai‘anae Valley and Ka‘ena Point.

County of Maui

Island of Maui

In the island of Maui, wildfires in the last ten years have been consistent with the concept of “communities at risk” developed during the preparation NFP. As will be discussed in this section, most of the fires in the last decade have occurred near or within populated centers.

The first large fires of the last ten years occurred in 2005. This year was a particularly active year for wildfires in the Island of Maui. The first fire, which occurred in early July, burned 120 acres in the Launiupoko area causing the closure of Honoapi‘ilani Highway (State Highway 30) for three and a half hours.[5] Another July brush fire, this time on the 12th, scorched 200 acres between Mā‘alaea and McGregor Point halted traffic for several hours along Honoapi‘lani

[5] The Honolulu Advertiser Website, Retrieved November 9, 2009 from http://the.honoluluadvertiser.com/article/2007/Jul/06/ln/FP707060371.html

Highway (State Highway 30).[6] Smoke from the fire caused much of the problem. Four separate fires along the route merged into one large blaze that took fire fighters many hours to contain and control. County officials believed that the initial fires were intentionally set. There were no reports of serious property damage or injuries.

Also on July 12 of 2005, a wildfire upslope from Lahainaluna High School in leeward West Maui was of unknown origin and burned over two and a half days.[7] The fire scorched 120 acres of brush and grass land, but for a time threatened native plants and bird habitats. However, no serious injuries or property damage were reported after the blaze was extinguished.

Just a few weeks later, on July 37 of 2005, a grass and brush fire with a suspicious origin scorched 80 acres near Lahaina in leeward West Maui.[8] The blaze came within 50 yards of homes in the Wahikuli residential area, above Kahoma Street on the slopes of the West Maui Mountains. However, no serious injuries or property damage were reported.

The last two fires of 2005 happened simultaneously in the Lahaina area during the month of October. The blazes, which are suspected to have been arson incidents, burned near Lahainaluna High school. One of the two October 2005 fires charred 200 acres of former sugar cane land.[9]

On September 1, 2006, a large wildfire in the Mā‘alaea area charred approximately 2,000 acres of land. The fire threatened residences and businesses in the town of Mā‘alaea. This Mā‘alaea blaze also posed a significant risk to the Kaheawa Wind Power farm perched in the slopes of the West Maui Mountains above Mā‘alaea. A fire Management Assistance Grant (FMAG) was approved by the Federal Emergency Management Agency (FEMA) to assist the County of Maui and the State of Hawai‘i in suppressing this fire.

During 2007, a myriad of wildfires affected the island of Maui. On January 27, 2007, the Upper Waiohuli Wildfire burned approximately 2,300 acres of forested public lands within the Lula Forest Reserve on the western slopes of the Haleakalā volcano on the island's east side. The wildfire, which burned for approximately two weeks, is believed to have been started by a discarded cigarette, most likely from a hiker.[10] According to a report by the State of Hawai‘i Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife, in terms of size and intensity, the Upper Waiohuli Wildfire was one of the most devastating to have occurred for many decades in the Hawaiian Islands.[11] Per the same document, approximately 500 acres within the burn unit were subject to relatively lighter fire intensities, and the forest

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6 National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Honolulu Forecast Office (HFO) StormData Website, Retrieved January 8, 2010 from http://www.prh.noaa.gov/hnl/pages/stormdata/stormdata_072005.pdf

7 Ibid, Retrieved from http://www.prh.noaa.gov/hnl/pages/stormdata/stormdata_072005.pdf

8 Ibid

9 The Honolulu Advertiser Website, Retrieved November 9, 2009 from http://the.honoluluadvertiser.com/article/2007/Jul/06/ln/FP707060371.html

10 State of Hawai‘i Department of Land and Natural Resources (DLNR) Website, Retrieved November 9, 2009 from http://www.state.hi.us/dlnr/chair/pio/HtmlNR/07-N014.htm

11 *Proposed Hazard Reduction and Reforestation Operations in the Aftermath of the Upper Waiohuli Wildfire January 23 – February 5, 2007, Kula Forest Reserve*, State of Hawai‘i Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife, March 5, 2007

areas therein are anticipated to recover. On the other hand, approximately 1,800 acres within the burn unit were severely burned with little remaining live vegetation.

A couple of weeks after the Upper Waiohuli Wildfire, a wildfire struck the Kaua‘ula Valley in the Lahaina area on February 19, 2007. The conflagration, which started above the Puamana subdivision, burned more than 1,000 acres of former sugar cane fields.[12]According to the Honolulu Star Bulletin, the Kaua‘ula Valley Wildfire also entered the fringe of the Panaewa section of the West Maui Natural Area Reserve system.[13] This reserve area is home to endangered species of plants.

On June 27, 2007, two brushfires on the island's west side forced evacuations in the Lahaina and Olowalu areas. The smaller Lahaina brushfire came within 20 feet of homes at the Wahikulu subdivision forcing evacuations of some homes. The much larger Olowalu fire burned approximately 2,600 acres and destroyed one residence. The fire, which started on the mountain side of Honoapi‘ilani Highway (State Highway 30), spread across the road to the ocean side of the highway severely disrupting traffic along a two mile portion of this main arterial road.

Just a few days after the late June 2007 high winds flared up another wildfire in the Lahaina area. The fire, which started on July 3, consumed approximately 180 acres and prompted the evacuation of at least 150 people from a homeless shelter and rental project in the town of Lahaina.[14] The fire also threatened the Lahaina Aquatic Center. The fire is believed to have been sparked by fireworks.[15]

Lastly, in 2009, several brushfires affected the Mā‘alaea area. On June 21st, a brush fire that started near Mā‘alaea Harbor forced the closing of Honoapi‘ilani Highway (State Highway 30) from the town of Mā‘alaea to the Ukumehame gulch area. The brush fire charred approximately 80 acres, damaged one residence, and fully destroyed another residence.[16] Similarly, on November 2nd another blaze resulted in the closure of Honoapi‘ilani Highway.

Island of Moloka‘i

Of the islands that conform the County of Maui, the island of Moloka‘i seems to be the most susceptible to wildfire. There were nine years on record where 1,000 plus acres were burned. The top years for fires in the island of Moloka‘i have been 1981, 1988, 1991, 1998, 2007 and 2009. On July 6, 2005, afire about 2.5 miles south of Ho‘olehua Airport burned 200 acres of brush.[17] The cause of the fire was unknown. There were no reports of serious injuries or property damage.

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[12] Honolulu Star Bulletin Website, Retrieved November 9, 2009 from http://archives.starbulletin.com/2007/02/21/news/story05.html

[13] Ibid

[14] Ibid, retrieved from http://archives.starbulletin.com/2007/07/04/news/story04.html

[15] The Honolulu Advertiser Website, Retrieved November 9, 2009 from, http://the.honoluluadvertiser.com/article/2007/Jul/06/ln/FP707060371.html

[16] Pacific Radio Group (PRG) News Website, Retrieved November 9, 2009 from http://prgnews.wordpress.com/2009/08/30/5000-acres-burned-on-molokai-firefighters-deal-with-shifting-winds/

[17] National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Honolulu Forecast Office (HFO) StormData Website, Retrieved January 8, 2010 from http://www.prh.noaa.gov/hnl/pages/stormdata/stormdata_072005.pdf

In 2007, the Kalua Koi wildfire charred 3,000 acres of bush on the far west end of Molokaʻi. The blaze was first reported on June 7 near mile marker 11 along Maunaloa Highway (State Highway 460). The Kalua Koi wildfire spread quickly on the ocean side of the highway and reached well pass Kalua Koi road. Luckily, the blaze did not pose a threat to any residences.

More recently, during the last days of August and first days of September of 2009, a wildfire consumed approximately 7,800 acres near the town of Kaunakakai on central Molokaʻi. The Kaunakakai fire was first reported on August 29th and burned for 7 days until it was fully contained on September 5th by the combined effort of more than 30 firefighters from the Division of Forestry and Wildlife Management (DOFAW) and the Maui Fire Department (MFD).[18] The fire forced the evacuation of residents from Kalamaula Mauka and threatened 400 primary structures and 80 communication structures.

Island of Lānaʻi

Of The island of Lānaʻi has been the safest island in terms of wildfires with only a few consequential fires in the past two decades. In January 1995, one fire burned 1,204 acres and in December 1999, a fire in the Kaluanui Flats area, approximately 2 miles southeast of Lānaʻi City, burned over 2,000 acres. On November 18, 2008, the Pālāwai Basin wildfire consumed approximately 1,000 acres south of Lānaʻi City.[19] According to County of Maui officials, the Pālāwai Basing conflagration forced the evacuation of 600 visitors and residents from Mānele Bay Hotel and nearby residences.

County of Hawaiʻi

A fire in July, 2007 burned 25 acres adjacent to the entrance road into Puakō. On October 28, 2007, nine fires were set in the Puakō/Kawaihae/Waikoloa area. The community was evacuated as the largest of these fires, in excess of 1,000 acres, approached within a ¼ -mile of Puakō Beach Drive. Only a fortuitous shift in wind prevented a huge loss of property (estimated value in excess of $500 million). Those people who refused to evacuate were also at risk.

South Kona was recently reminded that upland wildfire is a significant threat. It took weeks for firefighters to extinguish the 1800 acre wildfire which began at Kealakekua Ranch on December 27, 2009. Grasses ignited by lightning were fueled by mature *ʻohiʻa* and *koa* trees, hard woods which can burn for weeks. These long burning fuels and rhizomous grasses that can smolder and carry fire underground made the fire extremely challenging to put out. The rugged terrain at the 4,400-foot elevation where the fire broke out, along with lack of access to water, abundant fuel sources, dry conditions, and warm weather causing smoldering to reignite all combined to create difficult and hazardous conditions for the dozens of firefighter who worked 24-hour shifts to battle the blaze and protect the community. Smoke from the fire, trapped by Kona's temperature inversion layer, created health hazards for fire fighters and the entire South Kona community.

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[18] Pacific Radio Group (PRG) News Website, Retrieved November 9, 2009 from http://prgnews.wordpress.com/2009/08/30/5000-acres-burned-on-molokai-firefighters-deal-with-shifting-winds/

[19] KITV Website, Retrieved November 9, 2009 from http://www.kitv.com/news/18011428/detail.html

In July 2013, a brush fire in the Kailua-Kona area forced the evacuation of a condominium multifamily building. The fire, which occurred on Hulikoa drive, scorched about 100-acres of land.[20]

Summary for all Counties

Table 14.3 summarizes all wildfire events statewide and the spatial relationship between wildfire events and relevant CDPs. To complement Table 14.3, summary reports that analyze annual wildfires for the years 2004 through 2008 are included in Table 14.4. The information provided on this last table is available and regularly updated on the State of Hawai‘i Department of Land and Natural Resources Division of Forestry and Wildlife (DOFAW) Fire Management Program website.

Table 14.5 details the number of fires and acres burned by County for the period between 2003 and 2012. Although there are annual dry seasons, the wildfires are more frequent during severe drought. Lastly, Table 14.6 summarizes fire occurrences across the State of Hawai‘i that were declared to Federal Emergency Management Agency for Fire Management Assistance from 2007 through 2012. A summary of each fire is also provided subsequently to the table.

[20] Kona Brush Fire Forces Evacuation of Condo, Honolulu Star Advertiser, retrieved August 1, 2013 from http://www.staradvertiser.com/news/breaking/216320161.html?id=216320161&src=em

Table 14.3 Historic Wildfire Events by County and Impacted CDPs[21]

County	Year	No.	Total Acreage	Closest CDP	Distance	CDP Pop (Year 2000)
Hawai‘i	1953	1	3,681.34	Waimea	10.4 Miles	7,208
	1969	1	2,616.55	Waikoloa Village	3.02 Miles	4,806
	1972	1	8.966	Waimea	5.76 Miles	7,208
	1973	8	7,223.44	Waikoloa Village	4.46 Miles	4,806
	1975	2	342.209	Waimea	11.19 Miles	7,208
	1976	2	5.047	Honalo	12.82 Miles	1,987
	1977	2	1,065.11	Waimea	11.05 Miles	7,208
	1978	1	35.42	Waikoloa Village	11.67 Miles	4,806
	1983	1	5.82	Waikoloa Village	5.10 Miles	4,806
	1985	1	24,270.08	Waikoloa Village	3.28 Miles	4,806
	1987	3	11,701.20	Waikoloa Village	0 Miles	4,806
	1988	1	575.452	Kalaoa	6.15 Miles	6,794
	1989	1	3,318.15	Puakō	2.14 Miles	429
	1991	2	215.831	Kalaoa	6.28 Miles	6,794
	1993	4	1,451.91	Waikoloa Village	6.14 Miles	4,806
	1994	2	714.632	Honalo	12.42 Miles	1,987
	1995	3	1,408.47	Kailua-Kona	2.88 Miles	9,870
	1996	1	72.988	Waikoloa Village	6.23 Miles	4,806
	1998	5	12,666.38	Waikoloa Village	0.84 Miles	4,806
	1999	4	18,709.09	Waikoloa Village	0.38 Miles	4,806
	2001	2	71.106	Kailua-Kona	14.22 Miles	9,870
Maui	1980	4	4,829.06	Kualapu‘u	0 Miles	1,936
	1984	5	2,003.21	Kīhei	0.85 Miles	16,749
	1985	1	0.269	Wailea-Mākena	4.11 Miles	5,761
	1987	4	970.061	Kaunakakai	2.33 Miles	2,726
	1988	2	83.581	Waikapu	0.48 Miles	1,115
	1989	2	31.264	Waikapu	0.39 Miles	1,115
	1990	4	207.659	Lāna‘i City	1.34 Miles	3,164
	1991	6	8,320.79	Waikapu	2.55 Miles	1,115
	1992	3	315.761	Kaunakakai	1.45 Miles	2,726
	1993	3	217.51	Kaunakakai	2.00 Miles	2,726
	1995	1	48.217	Waikapu	1.87 Miles	1,115
	1998	5	12,145.19	Kaunakakai	0 Miles	2,726
	2001	1	547.524	Lahaina	2.27 Miles	9,118
	2002	1	296.384	Lahaina	3.45 Miles	9,118
Kaua‘i	1998	1	1.328	Waimea	5.00 Miles	1,787
	1999	2	16.167	Waimea	6.85 Miles	1,787
	2000	2	12.001	Hanalei	10.44 Miles	478
Honolulu	1998	4	864.808	Mokulē‘ia	1.08 Miles	1,839
	2000	1	272.969	Waipi‘o	0 Miles	11,672
	2002	4	2,765.25	Pearl City, Waipi‘o	0 Miles	30,976/11,672

[21] State of Hawai‘i Department of Land and Natural Resources (DLNR), Commission on Water Resource Management, Drought Risk and Vulnerability

Table 14.4 Annual Wildfire Summary Report[22]

Annual Wildfire Summary Report
Calendar Year: 2008
Total Acres Protected: 3,360,000

Acres Burned By Cause:

Cause	No.	Acres
Lightning	0	0
Campfire	1	5
Smoking	0	0
Debris burning	1	50
Arson	2	50
Equipment	3	1,500
Railroads	0	0
Children	0	0
Miscellaneous	1	2,236
TOTAL:	8	3,841

Acres burned by Size Class:

Size Class	No.	Acres
Class A - 0.25 acres or less	0	0
Class B - 0.26 to 9 acres	1	9
Class C - 10 to 99 acres	3	325
Class D - 100 to 299 acres	2	525
Class E - 300 to 999 acres	0	0
Class F - 1000 to 4999 acres	2	2,982
Class G - 5000 acres or more:	0	0
TOTAL	8	3,841

[22] State of Hawai‘i Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife, Fire Management Program website, retrieved June 14, 2013 from http://www6.hawaii.gov/dlnr/dofaw/fmp/firedata.htm

Table 14.4 (Continued) Annual Wildfire Summary Report[23]

Annual Wildfire Summary Report
Calendar Year: 2009
Total Acres Protected: 3,360,300

Acres Burned By Cause:

Cause	No.	Acres
Lightning	0	0
Campfire	2	23
Smoking	0	0
Debris burning	0	0
Arson	0	0
Equipment	3	199
Railroads	0	0
Children	0	0
Miscellaneous	2	7,852
TOTAL:	7	8,074

Acres burned by Size Class:

Size Class	No.	Acres
Class A - 0.25 acres or less	1	1
Class B - 0.26 to 9 acres	2	18
Class C - 10 to 99 acres	2	143
Class D - 100 to 299 acres	1	110
Class E - 300 to 999 acres	0	0
Class F - 1000 to 4999 acres	0	0
Class G - 5000 acres or more:	1	7,802
TOTAL	7	8,074

[23] State of Hawai‘i Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife, Fire Management Program website, retrieved June 14, 2013 from http://www6.hawaii.gov/dlnr/dofaw/fmp/firedata.htm

Table 14.4 (Continued) Annual Wildfire Summary Report[24]

Annual Wildfire Summary Report
Calendar Year: 2010
Total Acres Protected: 3,306,300

Acres Burned By Cause:

Cause	No.	Acres
Lightning	1	900
Campfire	2	2
Smoking	0	0
Debris burning	0	0
Arson	2	1,487
Equipment	0	0
Railroads	0	0
Children	0	0
Miscellaneous	5	7,140
TOTAL:	10	9,529

Acres burned by Size Class:

Size Class	No.	Acres
Class A - 0.25 acres or less	1	1
Class B - 0.26 to 9 acres	2	28
Class C - 10 to 99 acres	2	175
Class D - 100 to 299 acres	1	100
Class E - 300 to 999 acres	3	3,025
Class F - 1000 to 4999 acres	0	0
Class G - 5000 acres or more:	1	6,200
TOTAL	10	9,529

[24] State of Hawai‘i Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife, Fire Management Program website, retrieved June 14, 2013 from http://www6.hawaii.gov/dlnr/dofaw/fmp/firedata.htm

Table 14.4 (Continued) Annual Wildfire Summary Report[25]

Annual Wildfire Summary Report
Calendar Year: 2011
Total Acres Protected: 3,306,300

Acres Burned By Cause:

Cause	No.	Acres
Lightning	0	0
Campfire	0	0
Smoking	0	0
Debris burning	0	0
Arson	0	0
Equipment	1	1,153
Railroads	0	0
Children	0	0
Miscellaneous	2	413
TOTAL:	3	1,566

Acres burned by Size Class:

Size Class	No.	Acres
Class A - 0.25 acres or less	0	0
Class B - 0.26 to 9 acres	0	0
Class C - 10 to 99 acres	1	75
Class D - 100 to 299 acres	0	0
Class E - 300 to 999 acres	1	338
Class F - 1000 to 4999 acres	1	1,153
Class G - 5000 acres or more:	0	0
TOTAL	3	1,566

[25] State of Hawai‘i Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife, Fire Management Program website, retrieved June 14, 2013 from http://www6.hawaii.gov/dlnr/dofaw/fmp/firedata.htm

Table 14.4 (Continued) Annual Wildfire Summary Report[26]

Annual Wildfire Summary Report
Calendar Year: 2012
Total Acres Protected: 3,306,300

Acres Burned By Cause:

Cause	No.	Acres
Lightning	0	0
Campfire	0	0
Smoking	0	0
Debris burning	0	0
Arson	0	0
Equipment	0	0
Railroads	0	0
Children	0	0
Miscellaneous	17	5,837
TOTAL:	17	5,837

Acres burned by Size Class:

Size Class	No.	Acres
Class A - 0.25 acres or less	0	0
Class B - 0.26 to 9 acres	6	13
Class C - 10 to 99 acres	5	122
Class D - 100 to 299 acres	1	220
Class E - 300 to 999 acres	2	1,152
Class F - 1000 to 4999 acres	3	4,330
Class G - 5000 acres or more:	0	0
TOTAL	17	5,837

[26] State of Hawai‘i Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife, Fire Management Program website, retrieved June 14, 2013 from http://www6.hawaii.gov/dlnr/dofaw/fmp/firedata.htm

Table 14.5 Number of Wildfires and Acres Burned by County from 2003 to 2012[27]

Year	Number of Fires				
	Kaua‘i	Honolulu	Maui	Hawai‘i	Total
2003	6	11	1	2	21
2004	3	2	1	1	7
2005	4	0	0	1	5
2006	1	4	1	5	11
2007	2	3	10	10	25
2008	2	1	3	2	8
2009	1	4	2	0	7
2010	1	2	3	4	10
2011	0	0	1	2	3
2012	3	7	2	5	17

Year	Acres Burned				
	Kaua‘i	Honolulu	Maui	Hawai‘i	Total
2003	9	1,809	60	2,1242	4,002
2004	6	1,790	60	30	1,886
2005	40	0	0	1	41
2006	135	3,270	110	16,000	19,515
2007	292	1,076	16,177	5,980	23,525
2008	55	5	396	3,385	3,841
2009	23	249	7,802	0	8,074
2010	1	506	6,925	2,097	9,529
2011	0	0	75	1,491	1,566
2012	3,002	1,770	30	1,035	5,837

[27] State of Hawai‘i Division of Forestry and Wildlife Annual Reports

Table 14.6 Federal Emergency Management Agency, Declared Fires from 2007 to 2012[28]

FIRE	ACREAGE	NEAREST TOWN	DISTANCE TO POPULATION	POPULATION	COST	CAUSE
OLAWALU Fema-2701 6/27– 7/4/07	**1938**	**Olawalu, Launiopoko**	**0.1 mile**	Lahaina 9118	$359,081, (2 homes destroyed)	**Human, accidental**
WAIALUA FEMA-2720 8/12 – 8/21/07	**8000**	**Waialua, Haleiwa, North Shore**	**0.1 mile**	Waialua 3761 Mokulēʻia 1839 Haleʻiwa 2225	$642,229	**Human, intentional**
KOHALA MTN. FEMA- 2722 8/16 – 8/22/07	**200+**	**Waimea, Kamuela View Estates**	**3miles Waimea ¼ mi. – one house**	WaikoloaVlg. 4806	$111,504	**Unknown**
PUAKŌ FEMA-2740 10/28 – 11/7/07	**1005**	**Puakō, Spenser Park, Mauna Kea Beach**	**¼ mile**	Puakō 429	$320,321	**Unknown**
KAUNAKAKAI FEMA-2834 8/29 – 9/7/09	**10,000**	**Kaunakakai, Kualapuʻu**	**0.1 mile**	Kaunakakai 2726	$880,944 (estimate)	**Unknown**
MĀʻALAEA FEMA-2844 6/7/10 - 6/13/10	**6200**	**Māʻalaea, Harbor area**	**0.5 mile**	Māʻalaea 454	No estimates available yet.	**Unknown**
TOTALS	**27,343**				**$1,433,137**	

Olowalu fire (06/27/2007 through 07/04/2007): The Olowalu fire in Olowalu, Maui started on July 27, 2007, was a particularly destructive fire, ultimately destroying two homes and sending over 330 persons to shelters. The fire was thought to be started accidentally by a backhoe digging behind the Olowalu General Store, hitting something, possibly just a rock, and throwing a spark. One of the homes destroyed was close behind the Store, and the other was just east of the Launiupoko subdivision of Olowalu village. Of those entering the shelters, at Maui High School, over 320 were tourists who had missed flights or had checked out of their hotels. Ten were local residents. Three people were sent to Maui Memorial Hospital Emergency Room and released. Strong winds up to 52 mph hindered firefighters initially and caused the fire to grow and expand its territory. The combination of the high wind and dry grass in the area caused the fire to spread rapidly and race upwards towards the mountain.

[28] Federal Emergency Management Agency, Disaster Declarations for Hawaiʻi, retrieved June 12, 2013 from http://www.fema.gov/disasters/grid/state-tribal-government/78

Waialua Fire (08/12/2007 through 08/21/2007): The fire consumed about 8000 acres of brush land and farm land along the North shore of Hawaiʻi, threatening the town of Waialua and the area between the mountains and the ocean. In addition Dillingham airfield, several camps are in the area and were threatened by the fire. There were also concerns that the Mt. Kaʻala Observatory could be affected. The fire started before noon on the 12th and several homes were quickly evacuated. The mountains above the farms were particularly difficult to work within as access to burning areas was often difficult. The fire was burning uphill in areas of dry brush. The Otake Camp housing area and the Pamoho agricultural area were affected, as well as the local high school and elementary school, 100 homes and about 15 businesses in the Waialua area. As the fire grew, shelters were opened at the Waialua District Park and Liliʻokalani Protestant Church. Ultimately approximately 8000 acres were burned.

Kohala Mountain Road Fire (08/16/ 2007 through 08/22/ 2007): The fire was along Highway 250, or the Kohala Mountain Road near the 4 mile marker, on the ocean side of the highway, in the South Kohala district of Hawaiʻi County. Residents along Mahua Street of Kamuela View Estates were evacuated, with approximately 50 homes being involved, as the fire reached within a quarter-mile of the homes. On the 16th windblown debris caused a short circuit in a 34,000 volt transmission line. There was speculation that the sparking caused by this actually started the fire. This fire also occurred during a period when Hurricane Flossie threatened the Big Island by passing within 100 miles. An earthquake of 5.4 also rattled the island Monday night the 20th, but it resulted in no injuries or major damage.

Puakō fire (10/ 28/2007 through 11/ 7/ 2007): The Puakō fire on the Leeward coast of Big Island occurred when nine runaway fires of varying sizes were burning at the same time, straining County and State resources to their maximum abilities. Puakō along Puakō Beach Drive and Spencer Beach Park in Kawaihae were evacuated and evacuation centers set up at Waiakoloa Elementary School in Waikoloa and the Waimea Community Center. A mandatory evacuation of Puakō was announced on the October 28th. Three hundred homes were directly threatened by the fire, a factor which contributed in the quick declaration by FEMA. By the end of the fire, about 1000 acres were consumed.

Kaunakakai Fire (08/29/2009 through 09/07/2009): The Kaunakakai fire destroyed approximately 10,000 acres of land North of Kaunakakai Town, Island of Molokaʻi, Maui and extended west to the boundaries of the airport. The amount of resources expended for this single fire makes it the largest fire in the state within the last several years. The fire began on the 29th of August and was not declared controlled until September 7.

Kealakekua Ranch on December 27, 2009: Grasses ignited by lightning were fueled by mature *'ohi'a* and *koa* trees, hard woods which can burn for weeks. These long burning fuels and rhizomous grasses that can smolder and carry fire underground made the fire extremely challenging to put out. The rugged terrain at the 4,400-foot elevation where the fire broke out, along with lack of access to water, abundant fuel sources, dry conditions, and warm weather causing smoldering to reignite all combined to create difficult and hazardous conditions for the dozens of firefighter who worked 24-hour shifts to battle the blaze and protect the community. Smoke from the fire, trapped by Kona's temperature inversion layer, created health hazards for fire fighters and the entire South Kona community.

Mā‘alaea Fire (06/07/2010 through 06/14/2010): The fire encompassed an area of approximately 6200 acres in Wailuku, Maui, becoming the first declared fire of the 2010 year. The area affected was around the town of Mā‘alaea up into surrounding hillsides, similar to the Mā‘alaea Fire of 2006. It threatened homes in the direction of Wailuku, near the local King Kamehameha Golf Club. The fire also burned up into the hills toward the Wind electric generating ‘farm’ at the top of the first range of hills, actually causing reported burn damage to at least two of the ‘windmills’

Probability of Occurrence

In Hawai‘i, the fire season typically runs from the dry months of April through October. However, dry periods or periods of drought can extend the season. The possibility of a naturally-occurring wildfire depends on fuel availability, topography, the time of year, and weather conditions. Nonetheless, because naturally-occurring wildfires are most likely to happen in dry periods or periods of drought, the hazard is often considered as a component of the drought hazard. With drought and dry seasons, there is increased likelihood of wildland fires. The Hawai‘i Drought Monitor website displayed the following drought news and related information for the period between July 2010 and March 2013[29]:

- March 18, 2013 – Water Director: Drought Canceled in Upcountry Maui, Online News Article – Maui Now
- March 8, 2013 – Leeward Maui County Remains Under Extreme Drought, Online News Article – Maui Now
- December 11, 2012 – Waterless Rainbow Falls Stirs Debate, Online News Article – Big Island News
- December 3, 2012 – Hilo’s Famed Waterfall Runs Dry, Online News Article – Hawaii News Now
- August 21, 2012 – Meteorologists Hawaii Drought Likely to Worsen, News Article – Honolulu Civil Beat
- August 16, 2012 – Drought Now Covers Half of the State, News Article – Honolulu Star-Advertiser
- August 15, 2012 – Hawaii Ranches Struggle Under Drought Conditions, News Article – Associated Press
- May9, 2012 – USDA: County Drought Disaster Area, News Article – Maui News
- June 26, 2011 – Big Island Drought Eases, News Article – Hawaii Tribune Herald
- June 17, 2011- Below Normal Rainfall Expected Through the Summer, Public Information Statement – National Weather Service Honolulu

[29] State of Hawai‘i Commission on Water Resource Management, Hawai‘i Drought Monitor website, retrieved June 14, 2013from http://hawaii.gov/dlnr/drought/news.htm

- January 7, 2011 – Drought Eases, but Farms and Ranches Still Suffering, News Article – Honolulu Star-Advertiser
- November 23, 2010 – Rain Eases Drought but not Where Most Needed, News Article, The Maui News
- November 22, 2010 – Rain does Little to Ease Drought, News Article – Honolulu Star-Advertiser
- November 18, 2010 – Dry Days in Ka‘u – Cattle Industry particularly Hard-Hit by Record Drought, News Article – West Hawaii Today
- October 6, 2010 – Wet Season Rainfall Outlook for Hawaii, Media Advisory – NOAA, national Weather Service, Honolulu Forecast Office
- September 29, 2010 – Big Island Drought has National Park Officials and Others on Alert for Wildfires, News Article – Honolulu Star-Advertiser
- September 12, 2010 – Donkey Problems Increasing, News Article – Honolulu Star-Advertiser
- September 6, 2010 – Rainbarrels and Soakers Aid in Water Conservation, News Article – Honolulu Star-Advertiser
- September 3, 2010 – Farmers Hit by ‘Most Intense’ Recorded Drought, News Article – West Hawaii Today
- September 1, 2010 – Trouble in Paradise: Hawaii Waits for Drought Relief, News Article – Hawaii Public Radio
- August 16, 2010 – Persistent Drought Draining Big Island Resident’s Wallets, News Article – Honolulu Star-Advertiser
- August 13, 2010 – ML Macadamia Losses 4118K as Drought Cancels Harvest, News Article – Honolulu Star-Advertiser
- August 4, 2010 – ‘Its Dry, Dry, Dry’, News Article – The Maui News
- August 1, 2010 – Looking Back and Ahead: Extreme Drought in West Hawaii, News Article – West Hawaii Today
- July 26, 2010 – Water 101: Where it Comes From, How we Use it, Graphic – Honolulu Star-Advertiser
- July 26, 2010 – Dry Conditions Leave Isle Farms Parched, News Article – Honolulu Star-Advertiser
- July20, 2010 – Drought Puts Far Disaster Label on Counties, News Article – Honolulu Star-Advertiser

Risk Assessment

Vulnerability and Costs from Wildfires

The costs associated with fire management include personnel, equipment, and indirect impacts associated with lost use of the area, threats to ecosystems, and increased potential for future landslides and sedimentation. In the Olowalu Fire (island of Maui) in late June 2007 for example, the fire caused tourists and residents to be stranded and the government had to evacuate people, operate shelters, and find alternative transportation methods (via ferry). Of those entering the shelters, at Maui High School, over 320 were tourists who had missed flights or had checked out of their hotels. Ten were local residents. Three people were sent to Maui Memorial Hospital Emergency Room and released. The losses have not been quantified. A series of wildfires in the same area along the highway in East Maui in 2010 have resulted in similar road closures.

The most vulnerable groups appear to be farmers and ranchers in the leeward sides of the islands, where fires tend to be more prevalent. The Waialua Fire (island of O‘ahu) in August 2007 burned more than 7,000 acres in nine days with the primary threat to farmers and homeowners. On one day alone, two Chinook helicopters from Wheeler Army Airfield put in 9.4 hours of flight time battling the blaze. The Chinooks made 87 water drops equaling 174,000 gallons. One rancher spent days trying to herd his cattle out of the fire, with estimated losses to grazing land and cattle at more than a hundred thousand dollars. The fire burned utility poles and resulted in loss of service to cable communication, including television, phone, and internet service. The costs seem to include evacuation, equipment and labor in firefighting, and ecological losses. Agencies involved were Department of Land and Natural Resources’ Division of Forestry and Wildlife, Honolulu Fire Department, Honolulu Police Department and Honolulu Department of Facilities Maintenance. In addition the Hawai‘i National Guard was contracted through DOFAW, for bucket drops. Both the Fire and Police Departments also contracted with private companies for water bucket drops. Total expenses for the fire from these agencies totaled $642,320.

At the same time as the Waialua Fire, a fire erupted in the Kohala Mountains (island of Hawai‘i), just south of Kohala. The total firefighting expenses amounted to $320,321. The Puakō Fire, also on the Island of Hawai‘i occurred just after approval of the 2007 State Multi-Hazard Mitigation Plan, from October 28 – November 7, 2007. By the end of the fire, about 1000 acres were consumed, with firefighting costs amounting to approximately $240,240.

In 2009, the Kaunakakai Fire (island of Moloka‘i) destroyed approximately 10,000 acres of land North of Kaunakakai and extending west to the boundaries of the airport. The 2010 Mā‘alaea Fire (island of Maui) burned approximately 6,200 acres. It threatened homes in the direction of Wailuku, near the local King Kamehameha Golf Club. The fire also burned up into the hills toward the Wind electric generating ‘farm’ at the top of the first range of hills, actually causing reported burn damage to at least two of the windmills.

Wildfire Risk Associated with the Environment, Public Health, and Safety Sector

Fire effects are the physical, chemical, and biological impacts of fire on ecosystem resources and the environment.[30] According to the Forest Encyclopedia Network, "The abiotic effects of fire include its role in changing air quality, water quality, soil properties, and nutrient cycling. Biotic effects include altering vegetation and related impacts on wildlife. Fire effects are the result of an interaction between the heat regime created by fire and ecosystem properties. The particular effect of fire on any one of these components (e.g., the fire severity) is not fixed, but will vary according to site characteristics and fire behavior. For example, the effects of a fire burning under the same conditions may be very different on soils of different textures. Likewise, the effects of fires burning under different fuel and weather conditions can be very different on similar soils." [31]

Fire Effects on Air Quality

While fire is essential in maintaining many ecosystems, air pollutants emitted from fires can be harmful to human health and welfare. As a result of these risks, increasingly effective smoke management policies and air quality standards are being implemented. This section covers the components of smoke, how smoke affects air quality, how to characterize and predict the amount and movement of emissions from fire, and air quality regulations.

Fire Effects on Water

Fire can effect water quality both directly, by increasing temperature and nutrients, or indirectly, by increasing sedimentation and turbidity, and altering channel morphology. This section summarizes these physical and chemical effects of fire on water quality and relates how these changes influence the biology of aquatic systems.

Fire Effects on Soil

Fires affect physical, chemical, and biological soil properties directly by transferring heat into soil and indirectly by changing vegetation and the dynamics of nutrients and organic matter. This section explains the process of heat transfer to soil and summarizes the effects of fire on soil physical, chemical, and biological properties and how these impact surface runoff and soil erosion.

Fire Effects on Plants

Fires affect plants directly, by injury and mortality, and indirectly, by changing resource availability. These effects translate into vegetation changes at the plant, population, and community level. This section summarizes general adaptations and responses of plants to fire and provides specific examples for many southern plant species. For a discussion of how fire effects vegetation types in the south, please see Fire Ecology.

Fire Effects on Animals

Fire can affect wildlife directly through injury and mortality however the most profound effects of fire are caused indirectly by altering wildlife habitat. This section summarizes the general

[30] DeBano et al. 1998

[31] Forest Encyclopedia Network, retrieved from http://www.forestencyclopedia.net/p/p138

adaptations and responses of birds, mammals, amphibians, reptiles, fish, and insects to fire and provides specific examples for many southern plant species.

Calculating Losses from Wildfires

Calculating actual costs from wildfires is difficult unless there are damages to property and structures in the agriculture and urban interfaces. The costs of impacts to water systems, wildlife, and ecosystem functions and services can be extraordinary and difficult to place monetary value on the long-term effects and impacts.

The ramifications of wildfire contribute to additional disaster threats. The wildfires erode topsoil. During periods of heavy rainfall, the burned areas erode, becoming mud flows, debris flows, and sedimentation in rivers and the ocean. Further impacts include stream bank destabilization, which could worsen impacts of heavy rainfall and lead to riparian flooding.

The Western State Fire Managers and other organizations are working on methods to address risk and vulnerability assessment and loss reduction. Even though they collect data for annual reporting, it still remains difficult to account for the losses from each fire, and to quantify the longer term costs and impacts.

Mitigation Strategies

Hazard Priorities

Purpose and Methods

Priority action items have been developed from a number of sources, including input from community and agency participants in the planning process, noted deficiencies in local firefighting capabilities, and issues identified through the risk assessment. These actions address the following goals:

1. Enhance wildfire response capabilities.

2. Reduce risk and hazards through pro-active wildfire mitigation, including:

   - Increasing stakeholder knowledge about wildfire risk through education and
   - outreach;
   - Encouraging the treatment of structural ignitability;
   - Prioritizing fuel reduction projects; and
   - Increasing opportunities for collaboration and coordination to implement wildfire mitigation projects.

3. Address the list of community concerns.

These priority action items follow the guidelines for the Healthy Forest Restoration Act[32] (HFRA), which requires:

- Step 6a- Community Hazard Reduction Priorities
  - Priority Actions (General)
  - Hazardous Fuels Reduction
- Step 6b- Recommendations to Reduce Structural Ignitability

Priority Actions

Action items addressing wildfire issues are listed below, in order of priority:

1. Install pre-staged static water and helicopter dip tanks.

2. Acquire adequate resources for first responders:
   a. Appropriate technology resources for mapping at each fire station and on location;
   b. Water tanker/tenders (minimum 2000 gallon tanker/tender with high wheel base for off-highway capabilities).

[32] The Healthy Forests Restoration Act is the central legislative component of the Healthy Forests Initiative (HFI). The HFI is a Federal-level law that aims at mitigating wildfires across the United States. The legislation contains a variety of provisions aimed at expediting the preparation and implementation of hazardous fuels reduction projects on federal land and assisting rural communities, States and landowners in restoring healthy forest and watershed conditions on state, private and tribal lands.

3. Wise development in fire prone areas. Create development standards and implement community planning that requires the mitigation of wildfire risks at the regional, community/subdivision, roads/highways, and individual structure levels.

4. Reduce fuel load and/or appropriately convert fuels along road sides, in community open areas, around individual homes:

    a. Appropriate conversion would include transition to vegetation with low ignition potential and low ability to carry fire, especially native plants. This can be accomplished through installing/ establishing living fuel breaks.

    b. Reduce fuels through well-managed grazing, mechanical reduction, herbicide, or combinations of all treatments.

    c. Encourage/educate large landowners to reduce fuels on private property.

    d. Identify opportunities to assist vulnerable populations (elderly, disabled) in creating defensible space around homes and property.
    e. Develop and or enforce fuels mitigation requirements within communities (to include developed and vacant lots, permanent resident and absentee landowners).

5. Continue fire prevention education and outreach, including arson prevention education:

    a. Hold community workshops;

    b. Implement the fire danger rating system;

    c. Provide individual home and neighborhood assessments;

    d. Increase public service announcements during high fire hazard periods; and

    e. Develop wildland fire materials for youth and implement educational programs in local schools.

6. Increase communication capabilities between state, federal, and county agencies, particularly to maximize initial attack capabilities in wildfire events:

    a. Integrate current and future communication equipment utilized by federal, state, and county fire suppression personnel to increase effective firefighting response.

    b. Develop protocols for multi-agency involvement to utilize available specialized wildland fire expertise and equipment/resources.

7. Reduce and/or control invasive species that increase fire risk and, where appropriate, convert to vegetation as described in priority number three.

8. Advocate for increased penalties for arson and some level of amnesty for reporting fire.

9. Develop emergency staging areas and safety zones within communities and promote awareness of such areas within the community, including holding mock disaster drills.

10. Create/improve secondary access roads for those communities with only one means of ingress/egress; identify evacuation routes within subdivisions, especially in neighborhoods where secondary access roads are not available.

Well-managed grazing and other fuels management practices (mechanical/chemical/ combination) reduce the risk of wildfire in WUI areas. Sporadic or no fuels management creates high risk. Unmanaged grasses (above left) are found along roads in areas with little to no grazing, including neighborhoods. At times, these fuels can reach 8-12 feet, posing considerable risk of roadside ignition. Note the differences in fuel in above right photo: pasture in foreground has active grazing; areas in background are not currently grazed and are at a higher risk of wildfire occurrence.

Reducing Structural Ignitability

Individuals and community associations can reduce structural ignitability throughout their community by taking the following measures recommended by the National Fire Protection Association (NFPA) Firewise Community Program[33] as outlined below. However, due to the abundance of native vegetation, it is highly recommended that individuals and communities conduct a simple native vegetation assessment and/or consult with appropriate biologists or foresters before clearing trees and significant amounts of vegetation that may be important to protect.

- Create a buffer zone of defensible space around a property of at least 30 feet or to the property line if the house has less than 30 feet of yard. Remove flammable vegetation and combustible growth within 30 feet of the house. Where there is native habitat, please consult with a biologist or forester first.
- Prune tree limbs 6 – 10 feet above the ground.
- Space trees and shrubs ten feet apart in the yard.
- Make sure that plants closest to the house are low-lying.
- Whenever possible use fire-resistant Native Hawaiian species. Succulent plants are also good choices for converting fire fuels into landscaping
- Routinely remove dead leaves and other organic matter from the yard.
- Sweep and/or clean gutters, eaves, and roofs regularly to prevent the build-up of leaves and other matter.
- Use fire-resistant building materials for the roof, siding, and decks, such as metal, stucco, tile, brick, and cement.
- Install firebrand-proof ceiling vents to prevent structure fires caused by wind-blown firebrands.

[33] NFPA's Firewise Communities Program encourages local solutions for safety by involving homeowners in taking individual responsibility for preparing their homes from the risk of wildfire

State of Hawai‘i Division of Forestry and Wildlife Management

The State of Hawai‘i Division of Forestry and Wildlife Management (DOFAW) is under the umbrella of the State of Hawai‘i Department of Land and Natural Resources (DLNR). The mission of the DOFAW is to provide protection to forest reserves, natural area reserves, wildlife and plant sanctuaries, and public hunting areas. DOFAW also cooperates with established fire control agencies for the protection of other wild land not within department protection areas to the extent needed to provide for public safety. DOFAW holds environmental damage below the level at which it would interfere with the high level, sustained yield of services, and commodities from these lands.

By virtue of its core mission, DOFAW plays a pivotal role in protecting the State's watersheds and unique forest resources (i.e. forest products), and threatened and endangered species. Because wildfire is a threat to Hawai‘i's economy, society, and natural resources, all levels of government have established fire services to guard against the ravages of uncontrolled conflagration.

Combined with cooperative zones, DOFAW is involved with each of the five counties in the State of Hawai‘i in the protection of 3,360,300 acres statewide, which are approximately 81% of the State's land area. The remainder is managed by various military fire departments and the Department of Interior (National Park Service and the Fish & Wildlife Service) and The Nature Conservancy of Hawai‘i.

DOFAW has established formal agreements with all county and federal land management agencies for responding to wildlands fires. DOFAW is the primary response agency for 3,360,000 acres of combined cooperative zones (81% of the State). Figure 14.5 depicts areas where DOFAW is the designated first responder (orange-coded areas), areas where DOFAW may assist federal and county agencies according to the terms of the agreements with those agencies (yellow-coded areas), and areas where no formal agreement exists and are generally out of the DOFAW's jurisdiction (white-coded areas). Note that in the map, areas shaded in green indicate forested areas that could be under any of the three color-coded response jurisdictions.

For DOFAW to respond to fires that occur outside of its jurisdiction (white-coded areas of the map), the following must occur:

- The request for assistance must come from the County's Fire Department (through the County's Civil Defense) to the State of Hawai‘i Civil Defense that DOFAW assistance is needed.

- State of Hawai‘i Civil Defense will then contact the DOFAW Administrator or the State of Hawai‘i Protection Forester that DOFAW assistance is needed.

- State of Hawai‘i Civil Defense will notify the Adjutant General as soon as possible of the request made to DOFAW. The Adjutant General will notify the State of Hawai‘i Governor as soon as possible and keep him periodically informed of the situation.

- The DOFAW Administrator or State of Hawai‘i Protection Forester will then contact the respective DOFAW Branch Manager who will then mobilize his/her resources to assist MFD.

- The DOFAW Administrator will notify the State of Hawai‘i DLNR Chair as soon as possible of the request made by State of Hawai‘i Civil Defense.

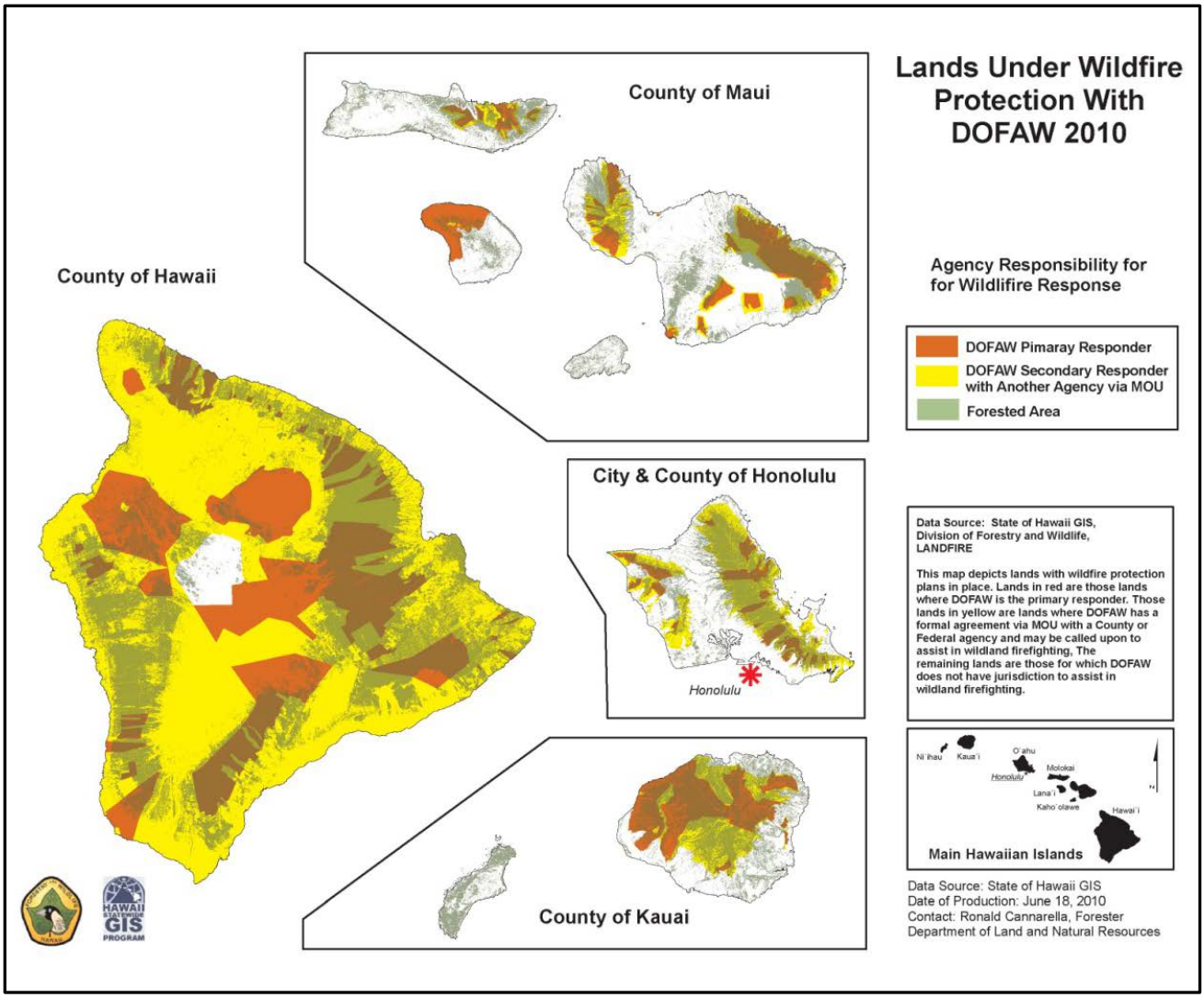

Figure 14.5 Lands under Wildfire Protection by DOFAW and Other Federal and County Agencies

General Mitigation Actions

A summary of general mitigations activities that would reduce the vulnerability to wildfires are categorized in Table 14.6.

Table 14.7 General Mitigation Actions to Reduce Wildfire Vulnerability

IMPACT	RESPONSE AND MITIGATION ACTION	RESPONE 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 firefighting 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 firefighting 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

Previous and Current Efforts

The status of a number of ongoing or recent wildfire mitigation projects are listed in Table 14.7. Further activities that could reduce the vulnerability to wildfire are categorized in Table 14.6

Table 14.8 Status of Wildfire Mitigation Projects by County as of July, 2013

	SPONSOR	PROJECT	COST	STATUS
ALL COUNTIES	DLNR	Drought/Wildland Fire Mitigation Plan (all islands)	N/A	Completed
		Identify wildfire hazard areas: See GIS maps in Drought Risk and Vulnerability Assessment and GIS Mapping Project, UHSOEST and SSRI, 2003	N/A	Completed
KAUA'I		Installation of Remote Automatic Weather Stations (RAWS): Need for more weather stations on the west side of the island of Kaua'i to capture microclimate data for area closures and pre-stage for mobilization of fire units.	$20,000 each station	Ongoing
	DOFAW	Roadside Fuel Treatments: Roadside fuel treatment and maintenance on the west side of the island of Kaua'i. Firebreaks are maintained to protect the wildland urban interface zone that borders Kōke'e State Park. Heavy equipment for this task has been purchased	$150,000	Ongoing
		Fire Prevention Education: Firewise Program, wildland-urban interface, County Fair, garden fair. Community wildlife Protection Plan has been completed.	$12,000	Ongoing.
		Maintain and Expand Firebreaks at Anahola: Firebreaks established, quarterly maintenance being undertaken, Firewise Program underway	$12,000	Ongoing

	SPONSOR	PROJECT	COST	STATUS
HONOLULU	DOFAW	Fuel Hazard Reduction in the Wildland Urban Interface	$100,000	Completed
	DOFAW	Fuel Reduction Equipment Purchase	$45,000	Completed
		Inventory and maintain firefighting water sources and consideration for threatened and endangered species and develop protocols for salt water use and use of GIS supporting technology. (Note: ongoing helicopter dip tank pad design)	$100,000 to $125000	Ongoing
		Installation of Remote Automatic Weather Stations (RAWS): Purchase and install twelve weather stations to capture microclimate data for area closures and pre-stage for mobilization of fire units.	$210,000	Ongoing
HAWAI'I		Installation of Remote Automatic Weather Stations (RAWS): Purchase and install weather stations in the districts of North Kohala, South Kohala, Ka'u, Kona, and Mauna Kea to capture microclimate data for area closures and pre-stage for mobilization of fire units. Three new stations have been installed in South Kohala and Kona	$85,000	Ongoing

Future Proposed Mitigation Projects

Future mitigation plans for wildfires by county are listed and described briefly in Table 14.8 through Table 14.12.

Table 14.9 Future Wildfire Mitigation Efforts for all Counties

PROJECT	COST ESTIMATE	STATUS
Wildland Fire Mitigation Resource Mapping and Inventory Program: Continue the development and maintenance of a GIS map and database to identify the location, type, and contact information for various wildland fire protection resources. Periodic updates are needed every 18 months. Hawai‘i Wildfire Management Organization (HWMO) does these updates. HWMO is also working on a portable version for first responders. Core resource inventory has been completed.	N/A	Proposed Project
Install pre-staged static water and helicopter dip tanks	$828,000	Funding
Reduce and/or convert fuel load along roadsides, community open areas, and individual homes and lots	$850,000	Funding
Create development standards and conduct community planning that requires the mitigation of wildfire risks	$150,000	Funding
Increase mapping technologies and capabilities for fire agencies	$100,000	Funding
Install street signage identifying evacuation routes	$50,000	Funding
Develop emergency staging areas within communities, promoting awareness of such areas within the community, including holding mock disaster drills	$33,000	Funding
Reduce, control, and or convert invasive species	$1,500,000	Funding
Continue fire prevention education and outreach, including arson prevention education	$30,000	Funding
Increase effective integrated communication and initial attack protocol between federal, state, and county fire suppression agencies	$150,000	Funding

Table 14.10 Future Wildfire Mitigation Efforts for the County of Kauaʻi

PROJECT DESCRIPTION	COST ESTIMATE	STATUS
Maintain Kōkeʻe Ditch System and Reservoirs (Puʻulu, Kitano, Puʻuopae): Need to maintain Kōkeʻe ditch system and reseroirs for functioning and fire suppression	$750,000	Proposed Project

Table 14.11 Future Wildfire Mitigation Efforts for the City and County of Honolulu

PROJECT	COST ESTIMATE	STATUS
Firewise Coordinator: Contract a Firewise Coordinator who will provide guidance and leadership to the island of Oʻahu's communities at risk by providing information and conduction workshops pertaining to fire prevention and Firewise.	$50,000	Proposed Project
Fuel hazard reduction within the wildland urban interface: Prioritize and conduct fuel hazard reduction projects within the wildland/urban interface; assist communities at risk with projects by applying for Federal grants targeting fuel hazard reduction projects.	$500,000 annually	Proposed Project
Firebreak and Fire Road Maintenance: Maintain firebreaks and fire roads on State-owned lands, especially in the Waiʻanae mountains.	$200,000	Proposed Project
Waiʻanae Watershed Fire Protection: Establish rain water catchment and storage for firefighting.	$12,000	Proposed Project

Table 14.12 Future Wildfire Mitigation Efforts for the County of Maui

PROJECT	COST ESTIMATE	STATUS
Island of Maui – Improve vehicular access in mauka Kalamaula-Makakupaia and Kula Forests: Improve and maintain about 3 miles of Waipoli Road in Kula Forest and 2 miles of road in the mauka Kalamaula-Makakupaia area. The roads will need to be maintained at least annually and possibly more frequently depending on erosion and vegetation growth. Annual costs will be significantly less once initial improvements are completed.	$200,000 to $400,000	Proposed Project
Island of Maui – Conservation Management Plan and Implementation: Develop and implement a conservation management plan to reduce wildland fire risk through appropriate best management practices. The plan will cover the subdivions from Makakupaia to Kalamaula, portions of Ukumehame, and Kula State Forest.	$2M to $3M	Proposed Project
Island of Maui – Develop and implement fuel reduction grazing plan for appropriate West Maui wildland fire risk areas.	N/A	Proposed Project
Island of Maui – Install remote automated weather stations for South Maui and West Maui	$63,000	Proposed Project
Islands of Maui and Molokaʻi – Procure, construct, and provide access to open water storage facilities for wildland fire suppression in South Maui, West Maui, Kahikinu (island of Maui), West Molokaʻi, and other high risk areas.	N/A	Proposed Project
Island of Lānaʻi – Install thirteen (13) fire hose connections to agricultural water system in Paliwai Basin. Partnership between Lānaʻi Fire Department and Lānaʻi Water Company.	$10,000	Proposed Project
All Islands – Maui Fire Prevention Campaign: Conduct a campaign to educate and inform the public about fire risk and personal responsibilities to reduce fire risk.	$15,000 annually	Proposed Project
All Islands – Community Wildfire Protection Plans for Communities at Risk	$100,000	Proposed Project

Table 14.13 Future Wildfire Mitigation Efforts for the County of Hawai‘i

PROJECT DESCRIPTION	COST ESTIMATE	STATUS
Establish and maintain firebreaks around roads and communities in North and south Kohala districts (includes Kawaihae, Waikoloa, and Waimea communities).	$2.2M	Proposed Project
Install dry hydrants and develop static water sources: the water source/dry hydrant will allow fire trucks to refill their water tanks when fighting forest and grassland fires in the Hāmākua area.	$10,000	Proposed Project
Roadside Fuel Management: Develop and maintain a roadside fuel management program along and identified corridor of Māmalahoa Highway (State Highway 190) on the South Kohala/North Kona area.	N/A	Proposed Project
Agricultural Practices to Mitigate Wildland Fires in Communities and Subdivisions: Continue to investigate and expand agricultural practices to mitigate wildfire impacts on communities and subdivisions. For example, grazing in Pu‘u Kapu.	N/A	Proposed Project
Pu‘u Wa‘awa‘a – Po‘ohoho‘o Reservoir Relining and Pipeline: Replace reservoir lining in Po‘ohoho‘o Reservoir #1, clear adjacent rainfall catchment surface, and install 1.4-inch diameter pipeline.	$250,000	Proposed Project
Mitigate Wildfire Threat Along Strategic Corridors in the Puakō Forest. Mitigation would reduce the threat of a catastrophic crown fire that could destroy the forest and homes as well as threaten nearby resort communities. Note that wildfire mitigation for the Puakō forest is an element in the South Kohala Community Development Plan, which was adopted by ordinance by the County of Hawai‘i in 2008.	$500,000	Proposed Project
Use of prescribed burns to reduce fuel loads in fire prone areas throughout the County: Use prescribed burns in fire prone areas including the communities of Waimea, Kawaihae, Puakō, Waikoloa, Pu‘uanahulu, and Kailua-Kona. Note that the proposed activity may be in conflict in areas of native forests	$1.1M annually for 500-acres	15-yr Proposed Project

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

15. Volcanic Hazards

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CHAPTER 15
Volcanic Hazards

Reasons for Updates / Revisions in this 2013 Plan
• VOG is used to describe hazy conditions caused by gaseous emissions from three primary sources from Kīlauea volcano. The chemistry of these emissions is given. • VOG impacts are described, in which over time, sulfur dioxide levels are greatly reduced as the gas goes through several chemical reactions to form ammonium sulfate which eventually settles out of the atmosphere. The direct volcanic hazard from gaseous emission is minimal on islands away from the Big Island of Hawai‘i. • No mitigation projects are currently considered necessary on O‘ahu and Kaua‘i due to the research on chemical transformation from the Center for the Study of Active Volcanoes (at the University of Hawai‘i at Hilo).

15.1 Volcanic Hazards Description

15.1.1 Volcanoes and Related Airborne Hazards

Hawaiian Volcanoes continue to be an important part of the literal and figurative landscape of our state. A symbol of the power and majesty of our island's natural environment, the reshaping of our islands is not without significant implications for impacted communities. Kīlauea volcano, on the island of Hawai'i, has been erupting for 26 years. Mauna Loa volcano, also on the island of Hawai'i, is certain to have another eruption although per the United States Geological Survey (USGS), "the time frame is difficult to forecast." USGS believes "Mauna Loa eruptions and lava flows could cut transportation arteries or inundate communities with lava in a matter of hours." As the Kīlauea eruption has continued since 1983, the Hawaiian Islands have experienced severe volcanic gases (VOG) more frequently. VOG has resulted in closures of the Hawai'i Volcanoes National Park several times. More recent investigations reveal that VOG has affected the ecosystem, becoming detrimental to cattle and wildlife. Corrosion has increased, which increases the economic burden on ranchers and farmers in the midst of drought.

15.1.2 Lava Flows

The Island of Hawai'i is composed of five volcanoes, two of which (Mauna Loa and Kīlauea) 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. Mauna Kea last erupted approximately 3,500 years ago. Kohala, considered extinct, is the oldest volcano on the island and last erupted approximately 60,000 years ago. The island of Maui is composed of two volcanoes joint by a flat isthmus of land. On the east portion of the island of Maui is Haleakalā volcano which dominates the landscape of the island with a summit elevation of 10,023 feet. On the west portion of the island, on the other hand, lies the West Maui volcano. This last volcano, as well as the volcanoes that make up the remaining six major Hawaiian Islands, are extinct and therefore do not pose potential lava hazards.

Most of the eruptions of volcanoes in the Hawaiian Islands are not explosive (therefore ash fall is not a major concern) and are characterized by relatively quiet outflow of very fluid lava. These eruptions, however, can still be quite hazardous because they may be erupted in huge volumes, and on steeper slopes, the fluid lava can rapidly travel many miles from its source.[1] Lava flows present potential threats to homes, infrastructure, natural and historic resources and entire communities. The areas exposed to the highest risk from lava flows are those situated downslope and in close proximity to the active rift zones of the active Mauna Loa and Kīlauea volcanes. Steep slopes may allow lava flows to move quickly from the summit to the ocean in a matter of hours. Besides the direct threat of inundation, lava flows may also cut across a community's single roadway escape route limiting the amount of time available for evacuation.

Hawaiian volcanoes can either erupt at their summits or on their flanks. Young Hawaiian volcanoes, such as Kīlauea and Mauna Loa have summit calderas. A caldera is a crater several miles in diameter that forms as the result of a collapse when magma drains from beneath the summit (Magma is the term used for molten rock that is still beneath the earth's surface; it is

1 USGS Fact Sheet 074-97.

called lava when it reaches the surface). Summit eruptions of Kīlauea and Mauna Loa occur within or near their calderas. Flank eruptions usually take place along rift zones, which are highly fractured zones of weakness within the volcano that typically extend from the summit of a volcano toward the coastline and may continue under the sea.

Lava flows may endanger people's property, livelihood, and peace of mind, but seldom their lives. The leading edge of Hawaiian lava flows generally move more slowly than the speed at which people walk, although the lava in the channel behind the front may be flowing much faster. On steep slopes a large flow could travel rapidly enough to endanger persons in its path. During the 1950 eruption of Mauna Loa, a flow front advanced at an average speed of almost 6 mph for over 2 hours.

The speed of a lava flow is determined not only by the steepness of the terrain, but also by the volume of lava that is erupted, with larger flows advancing more rapidly. The distance that a flow travels ultimately depends both on the eruption rate and on the duration of the eruption.

The chemical composition of lava will also affect how rapidly a flow travels. Most Hawaiian lavas are classified as basalts, but this category subsumes many types. Some basalts are more fluid and will flow at greater speeds than others. The eruption of Hualalai in 1800-1801, for example, produced lava flows that appear to have been more fluid than flows from similar eruptions on Kīlauea and Mauna Loa.

The continuing eruption on Kīlauea's east rift zone, which began in 1983, provides good examples of two common, but very different, types of eruptive behavior: rapidly-moving flows produced during brief, high-volume eruptions, and slow-moving flows created by a prolonged low-volume eruption. The episodic eruptions at the Puʻu ʻŌʻō vent, which was active from June 1983 through June 1986, produced a large volume of lava within a few hours. These outbursts were characterized by spectacular lava fountains and lava flows that moved rapidly down the volcano's south flank. The flows entered the Royal Gardens subdivision during 7 episodes and destroyed 16 homes. Each flow was short-lived, however, and stagnated soon after the lava fountains died. None of these flows reached the coastline.

In July 1986, the site of the eruption shifted to the Kupaianaha vent, 1.8 miles to the northeast of Puʻu ʻŌʻō. Kupaianaha erupted almost continuously for over 5 years but at a much lower rate than Puʻu ʻŌʻō. During the first few months of activity at Kupaianaha, the lava flows did not advance more than a mile beyond the vent. But after months of continuous eruption, a lava tube system formed as channeled lava flows gradually formed roofs, enclosing the rivers of lava within. Lava tubes are of significance as they have the potential to increase hazard impacts by insulating the lava and allowing it to flow much farther before cooling and stopping.

The hazards posed by a prolonged low-volume eruption soon became apparent as lava tubes from Kupaianaha extended toward the Kalapana coast. From November 1986 to October 1991, tube-fed flows repeatedly engulfed residential areas on the coastal plain, destroying 165 houses. Although these flows buried many acres within a single day, there was ample time to evacuate residents. Warnings issued by the Hawaiʻi County Civil Defense allowed people enough time to remove most of their belongings and, in some cases, even to dismantle and move their homes. In

1992, the threat to inhabited areas eased when the eruption shifted to new vents on the southwest flank of the Puʻu ʻŌʻō cone, inside Hawaiʻi Volcanoes National Park.

The chief threat of lava flows to property owners is that the flows may burn structures and bury land. There are other effects, however, that may be almost as disruptive, as the Kalapana community discovered during the repeated inundations of the area by lava. In addition to destroying homes, the flows covered almost 2 miles of the coastal highway. Some residents were forced to move when the highway closure increased their daily commute by nearly 100 miles. Many more residents of the Kalapana area were faced with financial losses as land values dropped and insurance companies refused to issue new homeowners policies.

The following section briefly profiles the volcanoes that pose potential hazards to communities in the Hawaiian Islands.

15.1.2.1 Mauna Loa, Island of Hawaiʻi

Like most Hawaiian volcanoes, Mauna Loa has a summit caldera and two radiating rift or fracture zones. Comprising approximately 50% of the island of, Mauna Loa poses a lava hazard threat to the districts of South Hilo, Puna, Kaʻu, South Kona, North Kona and South Kohala. Mauna Loa eruptions can occur at the summit, from vents on the southwest rift zone and the east rift zone and on the north and northwest flanks of the volcano.

15.1.2.2 Kīlauea, Island of Hawaiʻi

Kīlauea is one of the world's most active volcanoes and over 90% of its surface is covered by lava less than 1,100 years old. All of Kīlauea's eruptions have occurred either at its summit, or along one of two rift zones that extend from the summit to the coastline on the east and southwest flanks of the volcanoes. Eruptions on the east flank of Kīlauea are a threat to portions of the Puna district. Eruptions on the southwest flank of Kīlauea are a threat to land within the Hawaiʻi Volcanoes National Park and the district of Kaʻu.

15.1.2.3 Hualalai, Island of Hawaiʻi

Hualalai is much older than Kīlauea and Mauna Loa and has not erupted since 1800-1801. Eruption activity on Hualalai has been far less frequent with 25% of the volcano covered by flows less than 1,000 years old. Hualalai has erupted near its summit, along the northwest and south-southeast rift zones and from vents on the north flank of the volcano. Eruptions on Hualalai threaten land within the North Kona district.

15.1.2.4 Haleakalā, Island of Maui

Although the islands that make up the County of Maui do not have any active volcanoes[2], active seismicity on the apparently dormant volcano of Haleakalā on the island of Maui indicates that

[2] According to Wikipedia, active volcanoes are those have erupt frequently, dormant volcanoes are those that have erupted in historical times but are now quiet, and extinct volcanoes are those that have not erupted in historical times.

this volcano should continue to be perceived as potentially hazardous.[3] Haleakalā's last summit eruption is believed to have occurred approximately 800 to 1,500 years ago.[4] The most recent flank eruption (south flank) occurred in the late 1700's during the volcano's rejuvenated stage. Figure 15.1 shows a map of the island of Maui indicating Haleakalā's lava flows and vent deposits that date from the last 1,500 years. The floor of the crater has been mantled by lava flows in the past 5,000 years. Although the frequency of Haleakalā's eruptions is not well established, it is believed that the volcano may erupt every several hundred years. Therefore, Haleakalā should be considered a potentially dangerous volcano that could erupt in the next 100 years and affect the populated areas of the island of Maui.

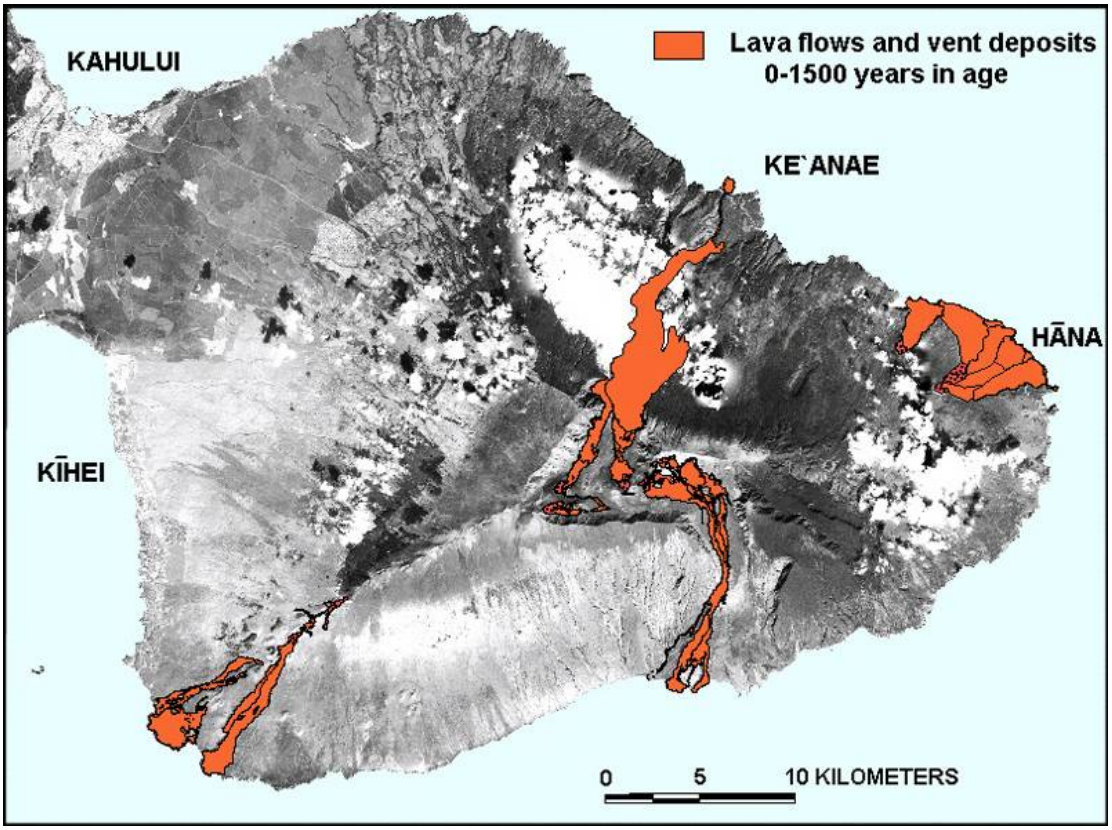

Figure 15.1 Haleakalā's Lava Flows and Vent Deposits Younger than 1,500Years[5]

[3] Fletcher, Charles, Grossman, Eric, Richmond, Bruce, and Gibbs, Ann, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*, United States Department of the Interior and United States Geological Survey (USGS), 2002, 24p

[4] Juvik, Sonia and Juvik, James, Department of Geography, University of Hawai'i at Hilo, Atlas of Hawai'i, 1998, 14p

[5] Image taken from United States Geological Survey (USGS) Hawai'i Volcano Observatory Website, Retrieved on October 12, 2009 from http://hvo.wr.usgs.gov/volcanoes/haleakala/newmapping.html

15.1.3 Ashfall

Most volcanic eruptions produce fragments of lava that are airborne for at least a short time before being deposited on the ground. These fragments are called "tephra," and include ash, cinders, and Pele's hair. In Hawai'i, tephra is usually ejected by lava fountains and poses a serious hazard only in the immediate vicinity of an erupting vent. Windborne tephra, however, can be disruptive at greater distances. The combination of high lava fountains and strong winds may result in tephra being carried many miles downwind of the eruption site. During lava fountaining episodes at Pu'u 'O'o from 1984 to 1986, the prevailing trade winds deposited most of the tephra in remote areas of Hawai'i Volcanoes National Park, but small particles reached the town of Naalehu 39 miles away. During the same episodes, Kona winds (from the southwest) occasionally carried tephra to Hilo, 22 miles from the vent. The ongoing Kīlauea summit eruption has been persistently producing small amounts of ash punctuated by brief periods of increased production. HVO ash leachate analyses of samples collected near Halema'uma'u after explosive events in March and April found high levels of fluoride and some metals (cadmium, copper, lead, and chromium for example). These levels were elevated but not high enough to warrant immediate concern because of the low ash emission rate measured, even during explosive events. Substances like fluoride could be of concern downwind of any eruption if substantial accumulation occurs, either by increased ash deposition or by a significantly prolonged eruption.

The small amount of tephra that fell on inhabited areas was not harmful to most people, but it was a source of irritation to those with respiratory problems and an inconvenience to the many residents with rain-water-catchment systems. Following at least three high-fountaining episodes, Hawai'i County Civil Defense recommended that people disconnect and clean their rain-water catchment systems to prevent the particles from washing into their water supply.

15.1.4 Volcanic Gases and VOG

Volcanoes can be persistent sources of a range of potentially damaging gases throughout their active lifetimes. During periods of eruptive quiescence, volcanoes emit modest amounts of carbon dioxide, sulfur dioxide, sulfuric acid, hydrogen chloride, hydrogen fluoride, and hydrogen sulfide along with an array of trace gases and much larger quantities of steam derived from local groundwater. During periods of volcanic unrest and active eruption, gas emission rates can increase by several tens of times to a few hundred times their quiescent discharge rates. Whereas a quantitative relationship between the volume of gases discharged and the volume of juvenile magma erupted has been difficult to establish for more explosive – subduction type - volcanoes, in Hawai'i, there appears to be a reasonably robust relationship between the emission rate of sulfur dioxide and the volume of magma being erupted. Hence, more voluminous eruptions, or higher lava effusion rates, such as occur from Mauna Loa, can be expected to generate correspondingly higher rates of gas discharge than less voluminous eruption rates from Kīlauea. The latest sulfur dioxide emission rate at Halema'uma'u Crater and Pu'u 'Ō'ō is more than 1,000 metric tons per day – 300 metric tons at Pu'u 'Ō'ō and at least 700 metric tons at Halema'uma'u. "VOG," coined from "volcanic smog" but standing for "Volcanic Gas", is a term used by the public in Hawai'i to describe hazy conditions caused by gaseous emissions from Kīlauea volcano (Figure 15.2). VOG is created when Volcanic Gases (primarily oxides of sulfur, SO_2) react with sunlight, oxygen and moisture. The result includes sulfuric acid and other sulfates.

Figure 15.2 Volcanic Gas Emissions at Kīlauea Volcano's Summit Vent on May, 2009[6]

The concentrations sulfur dioxide gas in VOG are typically greater near the sources at the of the Kīlauea volcano in the island of Hawai'i. Sulfur Dioxide levels are lessened further away or upwind from the vents. As was previously mentioned, VOG mostly affects the Kona coast on the west side of the Island of Hawai'i, where the prevailing trade winds blow the VOG to the southwest and southern winds then blow it north up the island's west coast. During episodes of Kona or non-trade wind conditions, the VOG can diffuse further north towards the island of Maui. Because of the island of Maui's unique topography, VOG is funneled through the central valley between Haleakalā volcano and the West Maui Mountains. Therefore, the effects of VOG are not limited to urban areas in the island's southern coast like Kīhei and Mākena but can extend as far as the agricultural areas of central and upcountry Maui and the densely populated areas of Wailuku and Kahului on the island's northern shore. Episodes of VOG of the islands of Lāna'i and Moloka'i are much less common because these islands are further away from the sources at the island of Hawai'i. The islands of Lāna'i and Moloka'i are also shielded from wind-blown VOG by the massive mountains of the island of Maui.

Although the haze caused by VOG may be at times heavy on the west side of the island of Hawai'i and moderate on the south side of the island of Maui, sulfur dioxide levels at these locations are typically lower than expected due to the geographic distance from the sources. Also, the quantities of sulfur dioxide in the air and the danger they present humans, animals, and

[6] Image taken from United States Geological Survey (USGS) Hawai'i Volcano Observatory Website, retrieved on October 10, 2009 from http://hvo.wr.usgs.gov/kilauea/timeline

plants cannot be directly correlated to the appearance of VOG (sparse, thick, dense, etc.) as sulfur dioxide levels have been measured to the high with only light VOG.

VOG can also affect O‘ahu when southerly Kona winds bring the gas plume and particulate matter further north from the Island of Hawai‘i, although O‘ahu is not expected to experience the elevated SO_2 levels that may be experienced on Hawai‘i (Hawai‘i 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 sulphuric acid and then with ammonia to form ammonium sulfate which is eventually washed or settles out of the atmosphere. In some places that have naturally alkaline soil, ammonium sulfate may be used as a fertilizer to reduce the pH of soil and provide nitrogen for plant growth. The natural occurrence of it in Hawai‘i and other volcanic places, typically results in soil with a relatively low pH. 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.

15.1.4.1 Effects of VOG on Public Health

Sulfur dioxide is irritating to the eyes, nose, throat and respiratory tract. Short-term exposure to elevated levels of Sulfur Dioxide may cause inflammation and irritation, resulting in burning of the eyes, coughing, difficulty in breathing and a feeling of chest tightness. When it comes to VOG, “Sensitive groups” include children and individuals with pre-existing respiratory conditions such as asthma, emphysema, bronchitis, and chronic lung or heart disease. Individuals who belong to “Sensitive Groups” may respond to very low levels of Sulfur Dioxide 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 acute health threats posed by the gas discharges are largely associated with the acid gases; sulfur dioxide being the greatest threat because it is discharged at the highest rates and is also accompanied by sulfuric and hydrochloric acid aerosols. The acute threats (to human health) typically fall off rapidly with distance from the vent and, given the distances between existing discharge vents at the Kīlauea summit and east rift zone and residential communities, the potential for acute health impacts on the average healthy adult is largely restricted to National Park employees and those employees living in the Park itself. However, a modest fraction of the population suffers from reactive airway syndrome (e.g. asthma) and for those individuals the acute effects of exposure to sulfur dioxide and sulfate aerosols can be much more severe. Although epidemiological data demonstrating the adverse impacts of gas exposure have been difficult to develop, anecdotal reports of families and individuals moving out of the exposed communities to avoid the effects of the gases are quite common. Future threats from these gases will also be dependent on the location of future eruptions: should Kīlauea or Mauna Loa

experience flank eruptions near populated areas, the impacts of these events may be severe on nearby communities.

As with the acute effects, documentation of the human health impacts of lower level chronic exposure to the volcanic gases in downwind communities has proven difficult: epidemiological studies have documented only relatively minor impacts from sulfur dioxide and sulfate exposure, but anecdotal reports of respiratory discomfort and eye irritation are extremely common and extend beyond the Big Island to Oʻahu during weather conditions conducive to transport of the plume along the island chain.

Of more concern is the presence of fluoride ion in the gas discharges. Because the use of roof-catchment of rainfall for domestic water consumption is a common practice in Hawaiʻi-island communities around and downwind of Kīlauea, there is the potential for accumulation of fluoride in these systems.

In late 1980's, studies conducted on private rainfall-catchment systems in the South Kona area revealed higher than average acidity in several water samples. Drinking the acidic water does not pose a health hazard, but such water can leach lead from the lead roof flashings, lead-headed nails, and solder connections found in many plumbing systems, resulting in unsafe levels of lead in the drinking water. Extensive testing in 1988 determined that many rainfall catchment systems on the island of Hawaiʻi, particularly those in the districts adjacent to or downwind of the active vent, contained elevated levels of lead.

More recent studies by Donald Thomas and Trisha Macomber on public on health hazards associated with rainfall-catchment systems exposed to VOG emitted from Kīlauea's Halemaʻumaʻu crater have shown that there is a clear influence on the emissions of VOG on rainfall-catchment systems located downwind from the source[7]. Thomas and Mcomber's study indicates that an increase in fluoride and sulfate concentrations arise from dry deposition of VOG plumes. The study, however, found that levels of these compounds did not exceed the World Health Organization standards for drinking water. This finding however, precludes possible exceedance in the levels of the compounds in the catchment systems due to variations in the levels of the compounds in the plume of VOG or exceedance in the levels of the compounds in catchment systems not sampled in the study.

Other recent studies and test on rainfall catchment systems suggest that although fluoride levels were not found to be above the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) for fluoride, several systems showed levels that were quite near the recommended drinking water limits and suggest that relatively small changes in gas discharge rates, in wind trajectories, or rainfall rates in the downwind communities could bring about fluoride levels that exceed drinking water standards. It is also noteworthy that the testing showed pH levels as low as pH=3 were present that could enhance heavy metal leaching from the catchment system and domestic plumbing. Older homes, which may contain lead-based paint, lead-based solder or lead-gasketed roofing nails are at particularly high risk of mobilization of lead into the domestic water supply by the acidic rainwater.

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[7] Thomas, Donald and Macomber, Trisha (2010), A Preliminary Survey of Rainfall Catchment Systems for Impacts Associated with Halemaʻumaʻu Gas Discharge

15.1.4.2 Effects of VOG on Wildlife and Livestock

Besides respiratory track health effects similar to humans, VOG can cause the death of wildlife and livestock because of contaminated food consumption. Wildlife and livestock that graze, for example, can die after ingesting water or grass that has been heavily contaminated by falling ash and other volcanic particles. Another effect of VOG on wildlife that has been noted particularly on the island of Hawaiʻi is the interruption of pollination by bees during heavy VOG fallout.[8]

Also of great concern to wildlife and livestock is the deposition of fluoride salts carried by VOG 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 acute exposure as well as chronic exposure and accumulation of fluoride salts by grazing animals. Although there have been a few anecdotal reports of symptoms of fluorosis by some ranchers on the island of Hawaiʻi, further investigations will be necessary to determine whether the forage crops are accumulating sufficient fluoride to be of concern in the downwind communities.

In 2010, Donald Thomas from the Center for the Study of Active Volcanoes and Trisha Macomber from the University of Hawaiʻi's College of Tropical Agriculture (CTAHR) produce a study on the effects of fluoride and sulfates on forage lands downwind of Kīlauea's Halemaʻumaʻu crater[9]. The study shows that forage samples contained fluoride and sulfate values higher than recommended by the World Health Organization. The study also indicates that although elevated concentrations of fluoride and sulfate do induce adverse health/nutritional effects on grazing animals, the high levels of these compounds do not impact the quality of meat from those animals that would be used for public consumption.

15.1.4.3 Effects of VOG on Plants

Sulfur dioxide must enter leaf mesophyll tissue, through stomata (natural openings in leaf surfaces that regulate gas exchange), to cause plant injury. 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 other diseases
- foliar necrosis (spots, blight)
- epicuticular wax erosion
- rupture of epidermis, plasmolysis
- reduced chlorophyll content
- increased membrane permeability of plant leaves
- decreased plant growth (root length, shoot length, leaf numbers)
- plant organ or entire plant death

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8 Big Island Weekly News Website, Retrieved on October 12, 2009 from http://www.bigislandweekly.com/articles/2009/01/14/read/news/news01.txt

9 Thomas, Donald and Macomber, Trisha (2010), A Preliminary Survey of Rainfall Catchment Systems for Impacts Associated with Halemaʻumaʻu Gas Discharge

Whereas the human health impacts resulting from increased emission of gases from Kīlauea have been somewhat limited, the economic impacts have been more immediate and more serious. Downwind of Kīlauea, farmers growing food crops, foliage crops, and cut flowers have all experienced immediate and severe losses due to damage arising from exposure to high concentrations of sulfur dioxide and sulfuric acid aerosols. Although downwind ranches didn't encounter as immediate impacts, over time, they have found that horses, cattle, and goats have developed serious adverse health impairment consistent with chronic fluoride exposure as well as severe mineral deficiencies. At the present time, the mediating factors in these health impacts are not well understood, although excess bone fluoride has been measured and therefore chronic exposure to and intake of fluoride is clearly one aspect of the problem. A secondary economic issue has been greatly accelerated corrosion of fencing, pipelines, and deterioration of ranching equipment as well. Anecdotal reports of service life losses of 60% to 70% suggest that the economic impacts of these losses could be severe.

A less tangible economic impact of the gas discharge is associated with the persistence of the emission source. In the far downwind community, on the western side of the island, weather conditions tend to accumulate the VOG discharge into a thick haze that results in persistently overcast skies. The economy in the communities on the western side of the island is heavily dependent on tourism; the primary attraction was balmy weather, blue skies, and access to ocean activities. Some in the community believe that the adverse air quality associated with the ongoing eruption is reducing the attractiveness of this area as a vacation spot resulting in a loss of income to all the businesses that rely on tourism for their success. With no practical methods of mitigating the adverse air quality, the State has few options other than to work to promote non-tourism dependent economic activity within the Kona community.

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

15.1.5 Explosive Eruptions

The rare explosive eruptions in Hawai‘i are generally caused by the interaction of magma and ground water. The magnitude of the resulting steam explosion varies from harmless to catastrophic. Small steam-blast explosions occurred during the 1960 Kapoho eruption when the magma beneath the vents, which were near sea level, encountered saltwater trapped in the surrounding rocks. These steam blasts ejected black clouds of pulverized rock fragments but were of little hazard except to scientists working close to the vents.

A much larger steam-blast eruption occurred at the summit of Kīlauea in 1924, when ground water apparently flowed into the heated rocks beneath the Halema‘uma‘u vent, which had been erupting nearly continuously for over a century. The explosions continued at intervals for 2 weeks, carpeting the area around Halema‘uma‘u crater with large rocks and a thin layer of ash. Boulders weighing several tons were thrown as far as 3,000 feet from the crater. The greatest hazard posed by this type of activity is that it may start abruptly and endanger unwary onlookers.

The 1924 eruption claimed one fatality--a man who ventured too close to the vent between explosions to take photographs and was struck by a rock when the activity suddenly resumed.

The largest explosive eruption in the State of Hawaiʻi within recorded history occurred in 1790. This eruption produced pyroclastic surges (turbulent clouds of hot gas and rock fragments) that originated at Kīlauea's summit and flowed several miles to the southwest. Pyroclastic surges are extremely dangerous because they move at speeds of 30 to 200 mph, and humans and animals caught in their path are killed by either asphyxiation or heat. A band of Hawaiian warriors traveling from Hilo to the Kaʻu district to battle with Chief Kamehameha were overtaken by one of the 1790 pyroclastic surges, and about 80 of them were killed. The 1790 eruption left deposits of rock fragments and ash up to 30 feet thick on the rim of Kīlauea's summit caldera.

The thick deposits of ash exposed at many sites on the island indicate that even larger explosive eruptions occurred in prehistoric times and probably originated from Mauna Kea as well as from Kīlauea. Explosive eruptions of any size take place infrequently in Hawaiʻi, but the possibility of one occurring in our lifetime should not be totally discounted. However, such eruptions are unlikely to begin without some warning. The most widespread hazard from an explosive eruption would be windborne ash, which could damage structures, machinery, and agricultural crops.

15.1.6 Ground Cracks and Settling

Ground cracks and settling are commonly associated with volcanic activity; both generally occur near active or recently active volcanic vents as the result of shallow underground movement of magma. The beginning of an eruption at a new site is preceded by cracking of the ground as magma is forcefully injected into the area. The cracks may be as much as 6 feet wide and over a mile long; typically they form within a period of hours. The Kapoho area on Kīlauea's lower east rift zone experienced such ground breakage prior to eruptions in 1924, 1955, and 1960.

Ground settling may occur near a vent at the end of an eruption as magma drains away from beneath the vent area. This process produces both small depressions and large collapse features, such as the pit craters and summit calderas of Kīlauea and Mauna Loa. In either case, the subsidence may be gradual or abrupt.

The hazard presented by ground cracks and settling associated with eruptions is usually limited to areas near the active vent and thus is overshadowed by the hazard posed by lava flows. Man-made structures that escape other damage from an eruption, however, can be damaged or destroyed by cracking, tilting, or settling of the ground beneath them. Ground cracks will remain after the eruption is over and can pose a threat to unwary people and animals if the cracks are obscured by heavy vegetation.

15.2 Significant Historic Events

The recorded history of volcanic activity in Hawai‘i begins with the arrival of the Christian missionaries in the early 1800’s and those that are known from oral traditions of the Hawaiians. Additional information on prehistoric eruptions is based on geologic mapping and dating of old lava flows.

15.2.1 Mauna Loa, Island of Hawai‘i

Mauna Loa has had 33 historically recorded eruptions, most of which have occurred at the summit. Approximately 25% of the eruptions have started on the east-northeast rift zone and another 25% began in the southwest rift zone.[10] During the period from 1832 to 1950, Mauna Loa averaged one eruption every 3.6 years.[11] Since 1950, eruption activity on Mauna Loa has slowed considerably. The two eruptions since 1950 include a 1-day summit eruption in 1975 and a 3-week eruption on the northeast rift zone which advanced to within 4 miles of Hilo.

Six eruptions from Mauna Loa have reached the ocean since 1859. The 1859 eruption on the northwest flank of Mauna Loa lasted approximately 300 days and reached the ocean north of Kīholo Bay in the North Kona district. Between 1868 and 1950, 5 lava flows have reached the ocean from eruptions on the southwest rift zone of Mauna Loa. These flows traveled quickly with 4 out of the 5 reaching the ocean in 3 to 48 hours.[12] These flows entered the ocean in the South Kona and Ka‘u districts. The eruption of 1950 destroyed the Ho‘okena-Mauka village in South Kona with the swiftly flowing lava traveling 14 miles in only 3 hours. Although the lava flow also crossed the area’s only highway in two places, the residents escaped unharmed.[13]

15.2.2 Kīlauea, Island of Hawai‘i

Kīlauea was almost continuously erupting at its summit caldera from the beginning of historic records up until 1924. Since 1955, most of the activity has occurred along the east rift zone. In January 1960, the volcano erupted; destroying villages of of Koa‘e and Kapoho (see Figure 15.3). The latest eruption of the east rift zone began in 1983 and is still ongoing as of the date of this report. The southwest rift zone has been less active with only 5 eruptions in the past 200 years; the latest was in 1974.[14]

The recorded eruption history of Kīlauea (Figure 15.3) demonstrates the degree of variability in eruption type, duration, and other aspects of volcanoes. Although voluminous records covering various facets of volcano activity obviously exist, it is important to note that they do not necessarily inform our mitigation strategies, as most directly impacted areas are uninhabited federal lands under the jurisdiction of the National Park Service. In turn, the brunt of the mitigation focus is on indirect impacts that have implications for population settlements.

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10 Draft Lava Flow Hazard Mitigation Plan, 2002

11 Macdonald, G.A., A. T. Abbott, F.L. Peterson, Volcanoes in the Sea (2d ed.), University of Hawai‘i Press, 1983.

12 Heliker, 1990

13 USGS Fact Sheet 074-97

14 Heliker, 1990.

Figure 15.3 Photograph of the Kīlauea eruption taken 10:00 am January 14, 1960

Year	Start (mo-day)	Duration (days)	Eruptive Subdivision	Area Covered (km^2)	Volume (km^3)
1983	3-Jan	>6,200 (s)(v)	ER (u)	102	1.9
1982	25-Sep	<1	C	0.8	0.003
1982	30-Apr	<1	C	0.3	0.0005
1979	16-Nov	1	ER	0.3	0.00058
1977	13-Sep	18	ER	7.8	0.0329
1975	Nov-29 (bb)	<1	C	0.3	0.00022
1974	31-Dec	<1	SWR	7.5	0.0143 (w)
1974	19-Sep	<1	C	1	0.0102 (aa)
1974	19-Jul	3	C, ER	3.1	0.0066
1973	10-Nov	30	ER (z)	1	0.0027
1973	5-May	<1	ER (x)	0.3	0.0012 (y)
1972	3-Feb	900 (s)	ER (t)	46	0.162
1971	24-Sep	5	C, SWR	3.9	0.0077 (w)
1971	14-Aug	<1	C	3.1	0.0091
1969	24-May	874 (s)	ER (t)	50	0.185
1969	22-Feb	6	ER (r)	6	0.0161
1968	7-Oct	15	ER (q)	2.1	0.0066
1968	22-Aug	5	ER (o)	0.1	0.00013 (p)
1967	5-Nov	251	H	0.7	0.0803
1965	24-Dec	<1	ER (n)	0.6	0.00085
1965	5-Mar	10	ER (m)	7.8	0.0168
1963	5-Oct	1	ER (l)	3.4	0.0066

Table 15.1 Summary of Historical Eruptions at Kīlauea from 1790 to Present

Year	Start (mo-day)	Duration (days)	Eruptive Subdivision	Area Covered (km^2)	Volume (km^3)
1963	21-Aug	2	ER (k)	0.2	0.0008
1962	7-Dec	2	ER (j)	0.1	0.00031
1961	22-Sep	3	ER (i)	0.8	0.0022
1961	10-Jul	7	H	1	0.0126
1961	3-Mar	2	H	0.3	0.00026
1961	24-Feb	1	H	0.1	0.000022 (h)
1960	13-Jan	36	ER	10.7	0.1132
1959	14-Nov	36	KI	0.6	0.0372
1955	28-Feb	88	ER	15.9	0.0876
1954	31-May	3	H, C	1.1	0.0062
1952	27-Jun	136	H	0.6	0.0467
1934	6-Sep	33	H	0.4	0.0069
1931	23-Dec	14	H	0.3	0.007
1930	19-Nov	19	H	0.2	0.0062
1929	25-Jul	4	H	0.2	0.0026
1929	20-Feb	2	H	0.2	0.0014
1927	7-Jul	13	H	0.1	0.0023 (g)
1924	19-Jul	11	H	0.1	0.000234
1924 (g)	10-May	17	C	No lava	No lava
1923	25-Aug	1	ER	0.5	0.000073
1922	28-May	2	MC, NC	0.1	NA
1921	18-Mar	7	C	2	0.0064
1919	21-Dec	221	SWR	13	0.0453
1919	7-Feb	294 (f)	C	4.2	0.0252 ?
1918	23-Feb	14	C	0.1	0.000183
1894	7-Jul	4 ?	C	NA	NA
1894	21-Mar	6+	C	NA	NA
1885	Mar	80	C	NA	NA
1884	Jan-22 (e)	1	ER	0.1	NA
1877	21-May	-	K	0.1	NA
1877	4-May	1	CW	NA	NA
1868	2-Apr	Short	SWR	0.1	0.000183
1868	2-Apr	Short	KI	0.2	NA
1840	30-May	26	ER	17.2 (d)	0.205
1832	14-Jan	Short	east rim of C	NA	NA
1823	Feb-Jul	Short	SWR	10.0 (d)	0.0110 (d)
Nearly continuous lava-lake activity on the caldera floor characterized the period from before 1823 until 1924. (a)					
1790 (c)	Nov	-	C	No lava flow	No lava flow
1790 ?	-	-	ER	7.9	0.0275
1750 ?	-	-	ER	4.1	0.0142

Table 15.1 (Continued) Summary of Historical Eruptions at Kīlauea from 1790 to Present

- C = summit caldera
- CW = caldera wall
- SWR = southwest rift zone
- ER = east rift zone
- ER = east rift zone
- H = Halema`uma`u
- K = Keanakako`i

(a) Written records begin in July-August 1823, when the first European visited the summit of Kīlauea. Thereafter until 1924, lava-lake eruptive activity was almost continuous in the caldera. Before the mid-1800s, however, records of the many overflows from the lava lake are sparse. The table lists the periods of major overflows only.

15.3 Probability of Occurrence

15.3.1 Lava Inundation Hazard Zones

15.3.1.1 County of Hawai'i

The U.S. Geological Survey has prepared maps showing volcanic hazard zones in the County of Hawai'i. The "Volcanic and Seismic Hazards on the Island of Hawai'i," 1990, authored by Christina Heliker and published by the U. S. Geological Survey, describes the lava flow hazard zone maps as follows (see Figure 15.4):

Maps showing volcanic hazard zones on the island of Hawai'i were first prepared in 1974 by Donal Mullineaux and Donald Petersen of the U.S. Geological Survey and were revised in 1987. The current map divides the island into zones that are ranked from 1 through 9 based on the probability of coverage by lava flows. Other direct hazards from eruptions, such as tephra fallout and ground cracking and settling, are not specifically considered on this map; however, these hazards also tend to be greatest in the areas of highest hazard from lava flows.

Hazard zones from lava flows are based chiefly on the location and frequency of both historic and prehistoric eruptions. The hazard zones also take into account the larger topographic features of the volcanoes that will affect the distribution of lava flows. Finally, any hazard assessment is based on the assumption that future eruptions will be similar to those in the past.

It is important to note that hazard zone boundaries are approximate. The change in the degree of hazard from one zone to the next is generally gradual rather than abrupt, and the change can occur over the distance of a mile or more. Within a single hazard zone, the severity of hazard may vary on a scale too fine to map. These variations may be the result of gradual changes that extend across the entire zone. For example, the hazard posed by lava flow decreases gradually as the distance from vents increases.

There may be abrupt changes, however, in the relative hazard because of the local topography. For example, the hills behind Nīnole in the northeastern portion of the island stand high above the adjacent slopes of Mauna Loa and consequently are at a much lower risk from lava flows than the surrounding area, even though the entire area is included in a single zone. To determine the hazard differences within a single zone, more detailed studies are required.

Table 15.2 provides the legend for the Lava Flow Hazard Zone Map. Zone 1 is the most hazardous area and includes the summits and the rift zones of Mauna Loa and Kīlauea which have been the most active in historic time. Zone 2 includes those areas adjacent and down-slope of active rift zones. Zone 3 areas are gradually less hazardous than Zone 2 because of greater distance from the recently active vents and/or topographic conditions make it less likely to be covered by lava. Zone 4 includes all of Hualalai where the frequency of eruptions is lower than on Kīlauea or Mauna Loa.[15] It is anticipated that volcanic gases will also be a significant hazard during the next eruptions of Mauna Loa and Hualalai.

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15 Heliker, 1990

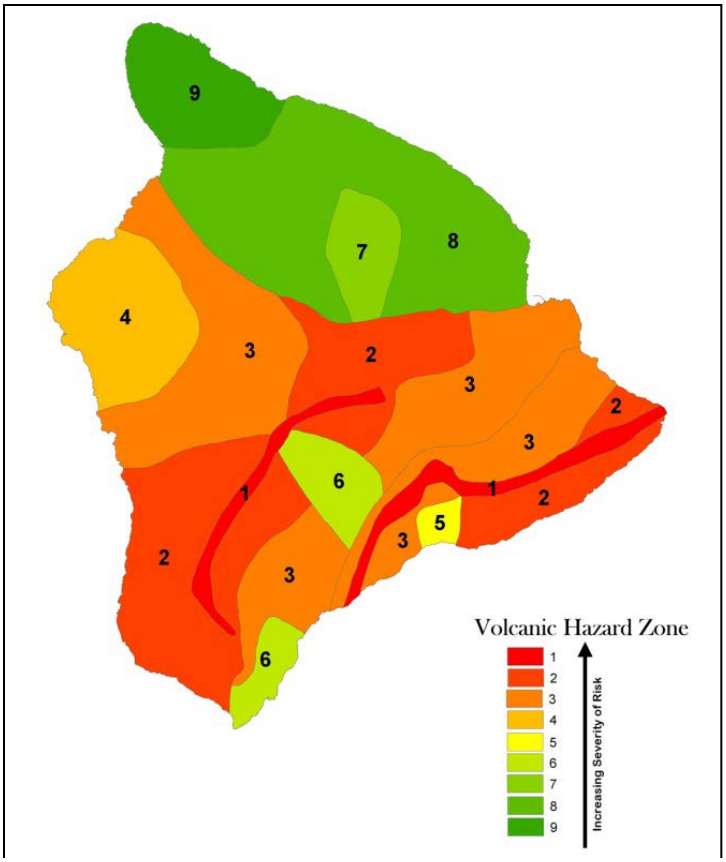

Figure 15.4 Lava Inundation Hazard Zone Map for the County of Hawai‘i

Hazard Zones for Lava Flows (County of Hawai‘i)			
Zone	**Percentage of area covered by lava since 1800**	**Percentage of area covered by lava in last 750 years**	**Explanation**
Zone 1	>25%	>65%	Includes the summits and rift zones of Kīlauea and Mauna Loa where vents have been repeatedly active in historic time.
Zone 2	18-25%	25-75%	Areas adjacent to and downslope of active rift zones.
Zone 3	1-5%	15-75%	Areas gradationally less hazardous than zone 2 because of greater distance from recently active vents and/or because the topography makes it less likely that flows will cover these areas.
Zone 4	approx. 5%	<15%	Includes all of Hualalai, where the frequency of eruptions is lower than on Kīlauea and Mauna Low. Flows typically cover large areas.
Zone 5	none	approx. 50%	Areas currently protected from lava flows by the topography of the volcano.
Zone 6	none	very little	Same as Zone 5.
Zone 7	none	none	20% of this area covered by lava 3,500-5,000 years ago.
Zone 8	none	none	Only a few percent of this area covered in the past 10,000 years.
Zone 9	none	none	No eruption in this area for the last 60,000 years.

Table 15.2 Legend for Lava Inundation Hazard Zone Map for the County of Hawai‘i

15.3.1.2 County of Maui

The most recent studies on lava flow hazard zones for the island of Maui were produced and published by David Sherrod et al in 2006. In the study, lava inundation maps are based on the age of existing lava flows and vent deposits. Similar to hazard maps for the volcanoes of the island of Hawai‘i, the maps take in consideration rift zones as possible sites of eruption, downslope areas that lie within the lava shed of rift zone vents, and topographic areas that would impede the flow of lava. Sherrod's lava inundation hazard map is shown in Figure 15.5. In the map, zones are labeled from 1 to 4 with Zone 1 having with the highest hazard of lava inundation and Zone 4 having virtually no hazard under most lava inundation scenarios. The following expert from Sherrod's publication describes all four zones in detail:

> ***"Zone 1*** *encompasses the lower and middle-altitude reaches of the southwest and east rift zones, Haleakalā crater itself, and an area on the northern flank of the east rift zone—all areas where eruptions have occurred frequently in the past 1500 years. At least five eruptive events, each encompassing several lava flows, have occurred in each of the designated areas. The attention drawn to zone 1 hazards presumes that the volcano's short-term future will be similar to that of the past 1500 years.*
>
> ***Zone 2*** *encompasses the volcano's flanks downslope of the southwest and east rift zone axes, chiefly areas where lava has encroached at least once in the past 13,000 years. Included are some areas that have never been inundated during the past 50,000–100,000 years but that lie within the topographic boundaries of lava sheds for vents that could be expected to form along the rift zone axes.*
>
> ***Zone 3*** *demarcates downslope reaches centered low on the Kaupō and Ko‘olau lava fans. These areas, although within potentially active lava sheds, have become sheltered by topographic buildup during the past 40,000 years that now would deflect new lava toward the margins of the fans. These areas may become vulnerable during future prolonged eruptions.*
>
> ***Zone 4*** *encompasses those flanks shielded from lava during the past 100,000 years or for which the sparse eruptive products found are the consequence of off-rift cinder cones from random, infrequent eruptive events. Zone 4 areas correspond to essentially no hazard under most lava inundation conditions."*[16]

As a supplement to the map on Figure 15.5, statistics about lava coverage areas derived from the geologic and hazard zonation mapping are provided in Table 15.3. Sherrod's lava inundation hazard map is slightly at variance with previous published maps by Crandell in 1983 and Mullineaux in 1988 because the new map incorporates more current geologic mapping and more extensive dating. Sherrod highlights and discusses the differences between his map and the earlier maps in his study.

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[16] Sherrod, David, Hagstrum, Jonathan, McGeehin,John, Champion, Duane, and Trusdell, Frank (2006), Distribution, ^{14}C chronology, and paleomagnetism of latest Pleistocene and Holocene lava flows at Haleakalā volcano, Island of Maui, Hawai‘i: A revision of lava flow hazard zones, Journal of Geophysical Research, 111, 19p

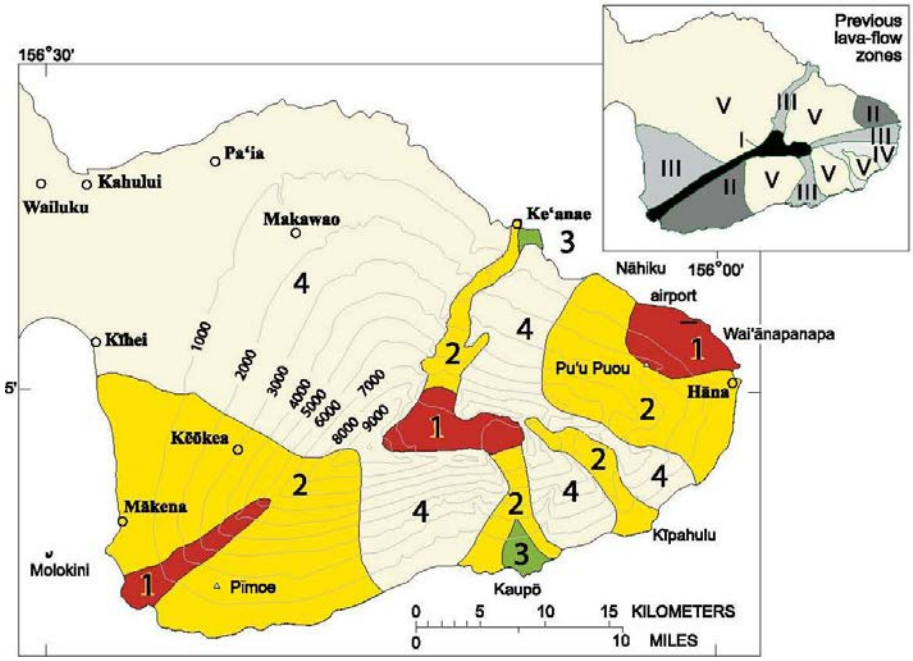

Figure 15.5 Lava Inundation Hazard Map for the Island of Maui. Inset shows previously defined lava flow zones by Roman numerals previously published by Crandell and Mullineaux in 1983 and 1987, respectively.[17]

Hazard Zones for Lava Flows (County of Maui)			
Section	**Area [km^2]**	**Area Covered [km^2]**	**Percent Covered**
Zone 1 Statistics, past 1,500 years			
Southwest Rift Zone	25.0	9.5	38
Haleakalā Crater	31.5	11.5	37
Wai'ānapanapa	32.3	21.0	65
Total	88.8	42.0	
Zone 2 Statistics for Southwest Rift Zone	277		
For Period 0-5,000 years		44.8	16
For Period 5,000-13,000 years		71.0	26
Zone 2 Statistics for East Rift Zone	118		
For Period 0-5,000 years		5.40	5
For Period 5,000-13,000 years		30.2	26
Southwest Rift Zone, South Flank Versus North Flank			
For period 3,000-5,000 years			
South Flank	27.8		
North Flank	3.8		
For period 5,000-12,000 years			
South Flank	37.3		
North Flank	30.8		

Table 15.3 Legend for Lava Inundation Hazard Zone Map for the County of Maui[18]

[17] Sherrod, David, Hagstrum, Jonathan, McGeehin,John, Champion, Duane, and Trusdell, Frank (2006), Distribution, ^{14}C chronology, and paleomagnetism of latest Pleistocene and Holocene lava flows at Haleakalā volcano, Island of Maui, Hawai'i: A revision of lava flow hazard zones, Journal of Geophysical Research, 111, 19p

15.4 Risk Assessment

15.4.1 Vulnerability and Potential Losses from Lava Flow and VOG

From 2007-2010, the lava flows have produced increased amounts of volcanic ash and VOG, which is now resulting in significant impacts for farmers and ranchers in Hawai‘i County, with additional respiratory impacts to people in all of the Hawaiian Islands. Kīlauea Volcano on the Island of Hawai‘i has been erupting more or less continually since 1983 from Pu‘u ‘Ō‘ō vent, and has destroyed close to 200 homes in the Kalapana area of the island. Mauna Loa, also on the Island of Hawai‘i, last erupted in 1984, when it sent flows within four miles of the city limits of Hilo. Hualalai, the Island of Hawai‘i’s third volcano, had its last eruption in 1801. The Keāhole Airport serving Kailua-Kona is built on these lava flows of Hualalai.

15.4.2 Risk and Vulnerability from Lava Flow

15.4.2.1 County of Hawai‘i

Lava risk can be assessed fairly easily, at any property where lava inundation occurs a total loss is assumed. Therefore if the theoretical recurrence interval of lava inundation at an area is known the annual loss (AAL) can be computed by multiplying the total value of the exposed properties by the annual probability of lava inundation. The results of this analysis are included in Table 15.4. The projected AAL for lava inundation for the County of Hawai‘i is about $24 Million/year.

15.4.2.2 County of Maui

Projected ALL for the County of Maui are calculated with the same methodology as those for the County of Hawai‘i. The results of this analysis are included in Table 15.5. The projected AAL for lava inundation is approximately $174,000/year. This is very low risk.

[18] Table 6 from Sherrod, David, Hagstrum, Jonathan, McGeehin,John, Champion, Duane, and Trusdell, Frank (2006), Distribution, ^{14}C chronology, and paleomagnetism of latest Pleistocene and Holocene lava flows at Haleakalā volcano, Island of Maui, Hawai‘i: A revision of lava flow hazard zones, Journal of Geophysical Research, 111, 20p

		% of Building Stock in Hazard Zone											
Tract	District	1	2	3	4	5	6	7	8	9	Exposure Value ($)	AAL	ALLR by Tract
15001020100	Papaikou-Wailea	0%	0%	0%	0%	0%	0%	0%	100%	0%	$ 520,302,382	$ 1,051	0.0002%
15001020200	Hilo: Upper Waiakea Forest Reserve	0%	0%	0%	0%	0%	0%	0%	100%	0%	$ 232,608,007	$ 470	0.0002%
15001020300	Hilo: Puueo-Downtown	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 758,039,632	$ 782,052	0.1032%
15001020400	Hilo: Villa Franca-Kaiko'o	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 632,534,825	$ 652,572	0.1032%
15001020500	Hilo: University-Houselots	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 1,386,852,781	$ 1,430,784	0.1032%
15001020600	Hilo: Keaukaha-Panaewa	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 1,176,770,100	$ 1,214,046	0.1032%
15001020701	Hilo: Puainako	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 554,714,650	$ 572,286	0.1032%
15001020702	Hilo: Kawailani	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 555,696,175	$ 573,299	0.1032%
15001020801	Hilo: Kukuau-Kaumana	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 504,970,475	$ 520,966	0.1032%
15001020802	Hilo: Piihonua-Kaumana	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 717,253,225	$ 739,974	0.1032%
15001020900	Hilo: Haihai	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 568,778,950	$ 586,796	0.1032%
15001021001	Lower Keaau	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 1,699,785,371	$ 1,753,629	0.1032%
15001021002	Keaau-Volcano	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 1,448,609,457	$ 1,494,497	0.1032%
15001021100	Pahoa-Kalapana	45%	45%	10%	0%	0%	0%	0%	0%	0%	$ 1,082,017,600	$ 7,629,913	0.7052%
15001021200	Ka'u	0%	50%	25%	0%	0%	25%	0%	0%	0%	$ 767,986,750	$ 778,265	0.1013%
15001021300	South Kona	0%	55%	45%	0%	0%	0%	0%	0%	0%	$ 658,165,575	$ 709,210	0.1078%
15001021400	Kealakekua-Captain Cook	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 442,919,125	$ 456,949	0.1032%
15001021501	Kalaoa	0%	0%	0%	100%	0%	0%	0%	0%	0%	$ 2,535,736,450	$ 274,707	0.0108%
15001021502	Hualalai	0%	0%	0%	100%	0%	0%	0%	0%	0%	$ 609,567,725	$ 66,037	0.0108%
15001021503	Kaumalumau-Kealakekua	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 1,422,217,132	$ 1,467,268	0.1032%
15001021601	Kailua	0%	0%	100%	0%	0%	0%	0%	0%	0%	$ 1,615,167,275	$ 1,666,331	0.1032%
15001021602	Kahului-Kaumalumalu	0%	0%	0%	100%	0%	0%	0%	0%	0%	$ 1,369,362,350	$ 148,349	0.0108%
15001021701	Kawaihae-Waikoloa	0%	0%	0%	100%	0%	0%	0%	0%	0%	$ 3,439,194,975	$ 372,582	0.0108%
15001021702	Waimea-Puu Anahulu	0%	0%	10%	0%	0%	0%	0%	80%	10%	$ 1,278,321,125	$ 135,013	0.0106%
15001021800	North Kohala	0%	0%	0%	0%	0%	0%	0%	0%	100%	$ 717,123,807	$ 5,976	0.0008%
15001021900	Honokaa-Kukuihaele	0%	0%	0%	0%	0%	0%	0%	100%	0%	$ 431,633,500	$ 872	0.0002%
15001022000	Paahau-Paauilo	0%	0%	0%	0%	0%	0%	0%	100%	0%	$ 259,500,950	$ 524	0.0002%
15001022100	North Hilo	0%	0%	0%	0%	0%	0%	0%	100%	0%	$ 222,181,475	$ 449	0.0002%
										Total	**$ 27,608,011,843**	**$ 24,034,868**	**0.0871%**

Table 15.4 Lava Inundation AAL for the County of Hawai'i[19]

[19] In the table, AAL = Average Annualized Loss and ALLR = Average Lava Loss Ratio = AAL / $ Exposure

		% Building Stock In Hazard Zone						
Tract	District	1	2	3	Area (mi^2)	Hazard Exposure ($)	AAL	ALLR by Tract
15009030100	Hana	0.1	0.4	0.02	16.79	$ 946,893,000	$ 54,604	0.0058%
15009030200	Haiku-Pauwela	0	0	0	5.59	$ 2,816,832,000	$ -	0.0000%
15009030301	Kula	0.05	0.08	0	16.09	$ 1,836,841,000	$ 49,216	0.0027%
15009030302	Wailea	0.1	0.9	0	4.25	$ 662,102,000	$ 43,668	0.0066%
15009030401	Makawao	0	0	0	1.68	$ 1,006,031,000	$ -	0.0000%
15009030402	Pukalani	0	0	0	1.66	$ 1,103,781,000	$ -	0.0000%
15009030500	Paia	0	0	0	0.70	$ 362,937,000	$ -	0.0000%
15009030600	Spreckelsville	0	0	0	1.85	$ 336,086,000	$ -	0.0000%
15009030701	Maalaea	0	0.02	0	3.26	$ 652,238,000	$ 218	0.0000%
15009030702	North Kihei	0	0.02	0	0.17	$ 889,030,000	$ 297	0.0000%
15009030703	South Kihei	0	1	0	0.19	$ 1,561,573,000	$ 26,094	0.0017%
15009030800	Waihee-Waikapu	0	0	0	5.08	$ 1,361,329,000	$ -	0.0000%
15009030901	West Central Wailuku	0	0	0	0.03	$ 1,651,616,000	$ -	0.0000%
15009030902	East Central Wailuku	0	0	0	0.05	$ 394,273,000	$ -	0.0000%
15009030903	North Wailuku	0	0	0	0.10	$ 826,416,000	$ -	0.0000%
15009031000	South Wailuku	0	0	0	0.32	$ 1,590,094,000	$ -	0.0000%
15009031101	West Kahului	0	0	0	0.27	$ 1,526,879,000	$ -	0.0000%
15009031102	Central Kahului	0	0	0	0.06	$ 1,063,272,000	$ -	0.0000%
15009031103	Southeast Kahului	0	0	0	0.09	$ 539,408,000	$ -	0.0000%
15009031200	Northeast Kahului	0	0	0	0.12	$ 673,675,000	$ -	0.0000%
15009031300	Puunene	0	0	0	0.43	$ 37,600,000	$ -	0.0000%
15009031401	Lahaina Town	0	0	0	0.05	$ 2,020,025,000	$ -	0.0000%
15009031402	North Lahaina	0	0	0	0.83	$ 1,155,034,000	$ -	0.0000%
15009031403	South Lahaina	0	0	0	3.37	$ 858,536,000	$ -	0.0000%
15009031500	Honokahua	0	0	0	4.67	$ 3,302,610,000	$ -	0.0000%
15009031600	Lanai	0	0	0	13.11	$ 633,271,000	$ -	0.0000%
15009031700	East Molokai	0	0	0	11.12	$ 739,399,000	$ -	0.0000%
15009031800	West Molokai	0	0	0	11.88	$ 480,767,000	$ -	0.0000%
					Total	$ 29,808,382,000	**$ 174,097**	**= AAL**

Table 15.5 Lava Inundation AAL for the County of Maui[20]

[20] In the table, AAL = Average Annualized Loss and ALLR = Average Lava Loss Ratio = AAL / $ Exposure

15.4.3 Risk and Vulnerability from Volcanic Ash and VOG

The potential risk posed by volcanic ash and VOG span a range of impacts including: acute health impacts; chronic health impacts; short and longer term economic losses; and what might be termed intangible or quality of life impacts. And, while these losses may not be as severe as those associated with lava flow inundation, their effects are distributed over a much broader community than the immediate threats of lava flows.

Whereas the human health impacts resulting from increased emission of gases from Kīlauea have been somewhat limited, the economic impacts have been more immediate and more serious. Downwind of Kīlauea, farmers growing food crops, foliage crops, and cut flowers have all experienced immediate and severe losses due to damage arising from exposure to high concentrations of sulfur dioxide and sulfuric acid aerosols. Although downwind ranches did not encounter as immediate impacts, over time, they have found that horses, cattle, and goats have developed serious adverse health impairment consistent with chronic fluoride exposure as well as severe mineral deficiencies. At the present time, the mediating factors in these health impacts are not well understood, although excess bone fluoride has been measured and therefore chronic exposure to and intake of fluoride is clearly one aspect of the problem. A secondary economic issue has been greatly accelerated corrosion of fencing, pipelines, and deterioration of ranching equipment as well. Anecdotal reports of service life losses of 60% to 70% suggest that the economic impacts of these losses could be severe. In August 2010, USDA announced that it would be providing loan assistance to farmers from losses associated with losses from volcanic gases.

A less tangible economic impact of the gas discharge is associated with the persistence of the emission source. In the far downwind community, on the western side of the island, weather conditions tend to accumulate the VOG discharge into a thick haze that results in persistently overcast skies. The economy in the communities on the western side of the island is heavily dependent on tourism; the primary attraction was balmy weather, blue skies, and access to ocean activities. Some in the community believe that the adverse air quality associated with the ongoing eruption is reducing the attractiveness of this area as a vacation spot resulting in a loss of income to all the businesses that rely on tourism for their success. With no practical methods of mitigating the adverse air quality, the State has few options other than to work to promote non-tourism dependent economic activity within the Kona community.

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

15.5 Mitigation Strategies

15.5.1 Previous and Current Efforts

The Hawaiian Volcano Observatory (HVO) is at the forefront in advancing our capabilities to address volcanic hazards. HVO was established in 1912 at the summit of Kīlauea and has been operated continuously by the U.S. Geological Survey (USGS) since 1947. The HVO studies current geologic activity at Hawai‘i's volcanoes, past eruptions, earthquakes and other volcanic hazards. This information is utilized to provide timely warnings to local officials and the public, to assess long-term volcano hazards, and to make hazard-zone maps that help guide land-use planning decisions. Current eruptions are tracked by HVO scientists and the information provided on projected lava flow movements help public safety officials determine the need for evacuation or other precautions.[21] In order to coordinate the efforts of HVO and other involved agencies, the "Lava Flow Hazard Mitigation Plan" (November 2002) identified several tools to improve planning and emergency response for lava flow hazards.

15.5.2 Monitoring and Warning Capabilities

Volcanic monitoring and surveillance are based on the movement of molten rock or magma and/or volcanic gas beneath a volcano that will precede any large eruption. HVO uses three primary techniques to detect magma and monitor its movements:

1. *Monitoring of volcanic earthquakes.* Any movement of magma requires it to push its way through the rocks of the earth's crust. This causes fracturing of rock, and movement along faults, resulting in earthquakes that can be detected at the earth's surface. Specific types of seismicity can be "mapped" to particular regions under the volcano allowing scientists to plot the passage of magma.

2. *Monitoring of ground deformation.* As the magma approaches the surface of the earth, and moves into the conduit below the vent of a volcano, the displacement of the surrounding rocks to make way for the magma causes the ground surface to move and the volcano to swell. This rising or swelling can then be used to assess the depth of the magma body and often give some idea of its volume.

3. *Monitoring of the chemistry of volcanic gases.* Magma deep in the earth contains gases dissolved in it. As the magma rises to shallow levels, these gases are released and, because they are mobile when compared to the sluggish liquid magma, they rise more rapidly to the surface and are discharged through gas vents. The composition and temperature of these gases give clues as to how close magma is to the surface.

HVO aims to provide weeks to months warning guidance of potential eruptions at Mauna Loa and hours to days warning at Kīlauea. Precursors before an eruption of Hualalai may last for hours to weeks, though this time period has not been tested because no eruption has occurred since monitoring was started on Hualalai. HVO has 65 seismic stations on the island of Hawai‘i to monitor volcanic earthquake activity. Moreover, HVO has scores of ground-movement

21 USGS Fact Sheet 074-97

monitoring stations, of which more than 20 are continuously reporting GPS systems, 11 are electronic borehole tilt-meters, and 4 are electronic deep borehole strain-meters. All field instruments radio signals to HVO in real time for evaluation and interpretation.

15.5.3 Future Plans

Project	Description	Status
NOAA HYSPLIT Model tries to forecast SO2 hourly based on meteorological conditions and emission rates of the Halemaʻumaʻu and Puʻu ʻŌʻo sources.	Based on wind modeling of dispersion over the course of each day.	Being used in an evaluation trial at HCDA and USGS HVO. NOAA HYSPLIT modeling was initiated by John Rays of the National Park Service with Roland Draxier from NOAA. The current effort is a 2-yr cooperative agreement between HVO and UHM (Steve Businger). There are two other parts to the current gas dispersion study: a) UHM will develop a pilot near real-time gas emission rate monitoring deployment and b) HVO will install a dense SO2 and meteorological monitoring network to better understand near-vent gas dispersion.

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

16. Hazardous Materials

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CHAPTER 16
Hazardous Materials

Reasons for Updates / Revisions in this 2013 Plan
• 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 Hawai‘i Emergency Planning and Community Right-to-Know Act became law in 1993 (HRS 128E). A Hawai‘i 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 CLEAN local emergency action network is included. • HAZMAT sites are mapped and discussed. • Recent and ongoing mitigation and preparedness activities are listed.

16.1 General

The importance of considering these risks is because the potential impact can be severe to the environment and people living in harm's way. In addition, the combination of hazardous materials with a natural hazard could result in catastrophe. Incidents, such as oil spills, threaten entire ecosystems. Any of these threats can result in decreased resilience and problems with long-term recovery. These hazards have been included because of the significant impacts from the combination of hazardous materials with hazards.

16.2 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 Hawai‘i Emergency Planning and Community Right-to-Know Act became law in 1993 (HRS 128E), and promulgated SARA Title III in the State of Hawai‘i.

The State of Hawai‘i Department of Health (DOH) Office of Hazard Evaluation and Emergency Response 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. The DOH Hawai‘i Site Rehabilitation Prioritization (SRP) List of Priority Sites shows 464 sites with potential or known hazardous substance or petroleum contamination. 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 Hawai‘i State Emergency Response Commission (HSERC) was formed and each of the four counties in Hawai‘i 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.

16.3 Organization of the State and Local Emergency Planning

16.3.1 Hawai‘i 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.

Federal:	USCINCPAC
Private:	Brewer Environmental Chevron
	Healthcare Association of Hawai‘i
	Tesoro Hawai‘i
	American Red Cross
	Hawaiian Electric Company (HECO)
	Hawai‘i Agricultural Research Center

16.3.2 Hazardous Chemical Release

Chemicals are found everywhere. They purify drinking water, increase crop production, and simplify household chores. But chemicals also can be hazardous to humans or the environment if used or released improperly. Hazards can occur during production, storage, transportation, use, or disposal. The community is at risk if a chemical is used unsafely or released in harmful amounts into the environment where people live, work, or play.

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes routinely. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines. In the late 1990s, there were several incidents of airborne chemicals near Campbell Industrial Park impacting schools and resulting in evacuations, and some hospitalizations.

Chemical manufacturers are one source of hazardous materials, but there are many others, including service stations, hospitals, hardware stores, research institutions, and hazardous materials waste sites.

The Hawai‘i State Response Program Release Notification Log is a listing of all chemical and petroleum release notifications received by the HEER Office emergency response team during the fiscal year. The Release Notification Log is sorted in order of Island, Locality, and the Case Name. HEER Office State On Scene Coordinators (SOSCs) performed direct oversight on 56 cases requiring on-site visits or off-scene coordination. Twenty cases were referred to the HEER Office Site Discovery, Assessment and Remediation (SDAR) Section for follow-on non-emergency cleanup prioritization and 17 cases were referred to other agencies.

Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in plants.

The University of Hawai‘i System-wide Multi-Hazard Mitigation Plan conducted a structural risk and vulnerability assessment of the campuses. For labs and operations, there are numerous chemical storage areas. When developing prioritization for retrofits, the proximity of chemicals became a factor of analysis in determining greater risks for facilities.

CAMEO (Computer-Aided Management of Emergency Operations):

CAMEO is a system of software applications used widely to plan for and respond to chemical emergencies. It is one of the tools developed by EPA’s Office of Emergency Management (OEM) and the National Oceanic and Atmospheric Administration Office of Response and Restoration (NOAA), to assist front-line chemical emergency planners and responders. They can use CAMEO to access, store, and evaluate information critical for developing emergency plans. In addition, CAMEO supports regulatory compliance by helping users meet the chemical inventory reporting requirements of EPCRA. The CAMEO system integrates a chemical

database and a method to manage the data, an air dispersion model, and a mapping capability. All modules work interactively to share and display critical information in a timely fashion.

The State maintains a central database and provides the data to each county for import into CAMEO. The Honolulu LEPC worked with the Hawai‘i State Emergency Response Commission (HSERC) to establish data entry standards and helped establish the initial database for O‘ahu facilities. This system standardizes reporting facility data statewide and eliminates duplicate data entry from several sources. Facility data for the County of Maui have been imported into CAMEO and plotted on Marplot by the LEPC, and subsequently exported to the Maui Fire Department. MARPLOT is a GIS mapping program that was developed jointly by NOAA and the Environmental Protection Agency (EPA).

In 2006, the rainfall anomaly for 42 days resulted in sewage overflows because the aging infrastructure was ill-prepared to handle the impacts. The result was that sewage was channeled into the Ala Wai Canal. The degraded water quality and contamination meant beach closures in Waikīkī for months, which severely impacted the State’s most important area for tourism.

16.3.3 Oil Spills

Due to the reliance on imported goods and fuels for energy, the State of Hawai‘i is at increased risk from oil spills in the ocean and nearshore areas. There have been no significant instances of spills in Hawai‘i, but the Gulf Coast oil release heightens the reason for considering potential impacts. The Hawai‘i Area Response Committee, a consortium of multiple federal and state agencies, works to ensure security of threats such as these.

Hawai‘i has sensitive marine and coastal ecosystems. Oil and chemicals would be deadly to the environment, which would further impact the economy. Lessons learned from other places have demonstrated the importance of factoring potential human-induced threats.

16.3.4 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.

The following is an expert from the Hawai‘i Emergency Planning and Community Right to Know Act:

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAI‘I:

SECTION 1. The purpose of this Act is to clarify the Emergency Planning and Community Right-to-Know Act reporting requirements.

SECTION 2. Section 128E-6, Hawai‘i Revised Statutes, is amended by amending subsection (a) to read as follows:

"(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."

16.3.5 State of Hawai‘i Response Program Site Lists

Chapter 128D, HRS, Environmental Response Law requires that the department publish a listing to identify sites in the State of Hawai‘i that are eligible for remedial action under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) administered by the Environmental Response Agency (EPA).[1]

There are currently three (3) sites in the State of Hawai‘i listed on EPA's CERCLA National Priority List (NPL) for cleanup. All three (3) sites all located on the island O‘ahu (City and County of Honolulu) as indicated in Table 16.1 below (Schofield Barracks was de-listed on August 10, 2000):

Table 16.1 Environmental Protection Agency National Priority List Sites – FY 2012[2]

County	Island	Locality	Facility Site Name
Honolulu	O‘ahu	Kunia	Del Monte O‘ahu Plantation NPL Site
Honolulu	O‘ahu	Pearl Harbor	Naval Computer and Telecommunication Area Master Station (NCTAMS)
Honolulu	O‘ahu	Pearl Harbor	Pearl Harbor Naval Complex

The NPL also enumerates sites that may be eligible for possible listing under CERCLA. These potential sites (see Table 16.2) are managed by the Hazard Evaluation and Emergency Response (HEER) Office Preliminary Assessment/Site Inspection (PA/SI) Program Remedial Project Managers (RPMs). Of the nine (9) potential sites, two (2) is located in the County of Kaua‘i, five (5) are located in the City and County of Honolulu, one (1) is located in the County of Maui, and one (1) is located in the County of Hawai‘i.

In addition to the sites listed by County on Table 16.2, the State of Hawai‘i has a list of sites with potential or known hazards. Sites are managed within the Hazard Evaluation and Emergency Response (HEER) Office under four program areas depending upon eligibility, funding, and level of responsible party participation as:

1. State Sites,
2. Hawai‘i Brownfields Revitalization Sites (Brownfields),
3. Hawai‘i Voluntary Response Program (VRP) Sites, and
4. EPA CERCLA Preliminary Assessment/Site Inspection (PA/SI) Sites.

[1] United States Department of Health, 2008

[2] Table data is for the fiscal year 2012. Table compiled from State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.2 List of Sites Eligible for Possible Listing under EPA CERCLA – FY 2012[3]

County	Island	Locality	Facility Site Name
Kaua‘i	Kaua‘i	Kekaha	Kekaha Sugar Mill
Kaua‘i	Kaua‘i	Puhi	Brewer Environmental Industries – Kaumualii Highway
Honolulu	O‘ahu	Waialua	Waialua Sugar Company Inc, and Waialua Sugar Mill Settling Ponds
Honolulu	O‘ahu	Kailua	Kapa‘a Landfill - Kapa‘a Quarry Road
Honolulu	O‘ahu	Honolulu	Kapalama Incinerator and Kapalama Incinerator Off Site Contamination
Honolulu	O‘ahu	Kailua	Honolulu Skeet Club
Honolulu	O‘ahu	Honolulu	Pukoloa Wood Treating Site
Maui	Moloka‘i	West Moloka‘i	Kalamaula Landfill
Hawai‘i	Hawai‘i	Hilo	Hawai‘i Crane Products Plant – Waiakea Pond

16.3.6 State of Hawai‘i Response Program List of Priority Sites

The State of Hawai‘i Department of Health (DOH) Response Program List of Priority Sites presents all sites in the State identified for potential or known non-emergency response actions managed by the HEER Office Site Discovery, Assessment, and Remediation Section Remedial Project Managers (RPMs). Sites are categorized as a potential hazard when sampling data indicate that contaminant concentrations exceed Hawai‘i Environmental Action Levels. The list for the fiscal year 2012 includes 451 sites statewide that are managed within the HEER Office (see Table 16.2). The DOH Hawai‘i SRP Priority List of Sites shows 50 sites on the County of Maui (44 on the island of Maui and 6 on the island of Moloka‘i) with potential or known hazardous substance or petroleum contamination. Of the total 50 sites on the County of Maui, 3 sites (2 on the island of Maui and 1 on the island of Moloka‘i) were determined to require No Further Action (NFA). HEER Office RPMs continue active oversight on the remaining active 47 assessment and response actions.

[3] Table data is for the fiscal year 2012. Table compiled from State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 State of Hawai'i Response Program List of Priority Sites– FY 2012[4]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
1	Hawaii	Hakalau	Hakalau Sugar Mill	Low	Assessment	Hazard Undetermined	Ongoing	State
2	Hawaii	Hakalau	Hakalau Sugar Plantation	High	Response	Hazard Present	Ongoing	State
3	Hawaii	Hamakua	Agent Orange Application	Low	Assessment	Hazard Undetermined	Ongoing	State
4	Hawaii	Hilo	Aloha Petroleum Hilo Bulk Plant	Medium	Response	Hazard Undetermined	Ongoing	State
5	Hawaii	Hilo	Big Island Asphalt Co Inc	Medium	Response	Hazard Present	Ongoing	State
6	Hawaii	Hilo	Equilon Enterprises LLC - Hilo Terminal (Shell Oil Co)	Low	Response	Hazard Present	Ongoing	State
7	Hawaii	Hilo	Hatada Bakery (Former)	Low	Response	Hazard Managed With Institutional Controls	Inactive	State
8	Hawaii	Hilo	Hawaii Cane Products Plant - Waiakea Pond	High	Response	Hazard Present	Ongoing	State
9	Hawaii	Hilo	Hawaii Pest Control	High	Response	Hazard Present	Ongoing	State
10	Hawaii	Hilo	HELCO Generating Station: Hill/Kanoelehua	NFA	Response	No Hazard	NFA	State
11	Hawaii	Hilo	HELCO Hill Generating Station Transformer 15923 at Kanoelehua Switching Station	NFA	Response	No Hazard	NFA	State
12	Hawaii	Hilo	HELCO pipeline anomaly at Northeast side of Seaside Hotel	NFA	Response	No Hazard	NFA	State
13	Hawaii	Hilo	HELCO Pole-Mounted Transformer no. 20938	NFA	Response	No Hazard	NFA	State
14	Hawaii	Hilo	HELCO Pole-Mounted Transformer no. 39022	NFA	Response	No Hazard	NFA	State
15	Hawaii	Hilo	HELCO Substation: Kuhio	Medium	Assessment	Hazard Present	Ongoing	State
16	Hawaii	Hilo	Highway 19, Mile Marker 28.5	Low	Assessment	Hazard Undetermined	Ongoing	State
17	Hawaii	Hilo	Hilo Memorial Hospital	Low	Response	Hazard Undetermined	Ongoing	State
18	Hawaii	Hilo	Hilo Quality Washerette	Low	Response	Hazard Managed With Institutional Controls	Ongoing	State
19	Hawaii	Hilo	Hilo Rubbish Dump	Low	Assessment	Hazard Undetermined	Inactive	Brownfields
20	Hawaii	Hilo	Hilo Terminal 666 Kalanianaole Avenue	Medium	Response	Hazard Present	Ongoing	State
21	Hawaii	Hilo	Kanoelehua Industrial Warehouse	Low	Assessment	Hazard Undetermined	Inactive	Brownfields Site
22	Hawaii	Hilo	Kawailani Central Office	Medium	Assessment	Hazard Undetermined	Ongoing	State
23	Hawaii	Hilo	Keaukaha Military Reservation Container Disposal	Low	Assessment	Hazard Undetermined	Ongoing	HIANG Site

[4] State of Hawai'i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai'i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[5]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
24	Hawaii	Hilo	Larry's Waiakea Chevron	Medium	Assessment	Hazard Present	Ongoing	State
25	Hawaii	Hilo	Mauna Kea Sugar - Onomea Seed Dipping Area	Low	Assessment	Hazard Present	Ongoing	Site Discovery
26	Hawaii	Hilo	Mauna Kea Sugar Company - Hilo Sugar Pesticide Mixing Area	High	Response	Hazard Present	Ongoing	State
27	Hawaii	Hilo	SFC Minoru Kunieda U.S. Army Reserve Center	NFA	Response	No Hazard	NFA	State
28	Hawaii	Honokaa	Hamakua Sugar Company Inc - Kawela Pesticide Mixing Area	Low	Response	Hazard Present	Ongoing	Site Discovery
29	Hawaii	Honokaa	Hamakua Sugar Company, Inc - Honokaa Haina Mill Pesticide Mixing Area	Low	Assessment	Hazard Undetermined	Ongoing	PA/SI
30	Hawaii	Honokaa	HELCO Honokaa Substation	NFA	Response	No Hazard	NFA	State
31	Hawaii	Honokaa	Honokaa Wastewater Treatment Plant	Low	Assessment	Hazard Present	Ongoing	State
32	Hawaii	Kailua-Kona	Hawaii Petroleum- Kona Branch (Kona Warehouse & Cardlock)	Low	Assessment	Hazard Undetermined	Ongoing	State
33	Hawaii	Kailua-Kona	HELCO Pole-Mount Transformer 32014	NFA	Response	No Hazard	NFA	State
34	Hawaii	Kailua-Kona	Honokohau Industrial Park-Lower Boat Park Soil Contamination	Low	Assessment	Hazard Undetermined	Ongoing	State
35	Hawaii	Kailua-Kona	Kailua Candy Co.	NFA	Response	No Hazard	NFA	State
36	Hawaii	Kamuela	HELCO Pole-Mounted Transformer #33807	NFA	Response	No Hazard	NFA	State
37	Hawaii	Kamuela	HELCO Substation: Ouli Substation	Medium	Assessment	Hazard Undetermined	Ongoing	State
38	Hawaii	Kamuela	Kamuela Baseyard	Low	Assessment	Hazard Undetermined	Inactive	State
39	Hawaii	Kamuela	Waimea Quarry	Low	Response	Hazard Undetermined	Ongoing	State
40	Hawaii	Kawaihae	Akana Petroleum, Inc-Kawaihae Harbor	Medium	Assessment	Hazard Undetermined	Ongoing	State
41	Hawaii	Keaau	Kamehameha Schools Keaau Campus	Low	Response	Hazard Undetermined	Ongoing	State
42	Hawaii	Keaau	Keaau Hotel Site	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
43	Hawaii	Keaau	Keaau Middle School	High	Response	Hazard Managed With Institutional Controls	Inactive	State
44	Hawaii	Keaau	Keaau Pahoa Road 118 Acre Parcel	High	Response	Hazard Present	Inactive	State
45	Hawaii	Keaau	Keaau Triangle Lot	High	Response	Hazard Present	Inactive	State
46	Hawaii	Keaau	Puna Sugar Mill	Medium	Assessment	Hazard Undetermined	Ongoing	PA/SI
47	Hawaii	Kealakekua	Kealakekua Heritage Ranch	Low	Response	Hazard Present	Ongoing	State

[5] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[6]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
48	Hawaii	Keauhou	Keauhou Mechanics Yard	Low	Assessment	Hazard Undetermined	Inactive	State
49	Hawaii	Kohala	Kohala Sugar Company	High	Assessment	Hazard Present	Ongoing	State
50	Hawaii	Laupahoehoe	Hamakua Sugar Company, Inc - Papaaloa Pesticide Mixing Area	Low	Assessment	Hazard Present	Ongoing	Site Discovery
51	Hawaii	Milolii	Abandoned Milolii Gas Station	NFA	Response	No Hazard	NFA	State
52	Hawaii	Mountain View	HELCO Pole-Mounted Transformer	NFA	Response	No Hazard	NFA	State
53	Hawaii	Naalehu	Hawaii Petroleum Distributors, Inc 200 Gallon Fuel Spill	Low	Assessment	Hazard Present	Inactive	State
54	Hawaii	North Kohala	Kohala Sugar Company Transformers	Low	Assessment	No Hazard	Ongoing	State
55	Hawaii	Ookala	Ookala Gym and Ball Park	Low	Assessment	Hazard Present	Inactive	Brownfields
56	Hawaii	Paauhau	Hamakua Sugar Company, Inc - Paauhau Sugar Mill	Medium	Response	Hazard Present	Ongoing	Site Discovery
57	Hawaii	Paauilo	Hamakua Sugar Company, Inc - Asbestos Disposal Site	Low	Assessment	Hazard Present	Ongoing	State
58	Hawaii	Paauilo	Hamakua Sugar Company, Inc - Ookala Fuel Station	Low	Assessment	Hazard Present	Ongoing	State
59	Hawaii	Paauilo	Hamakua Sugar Company, Inc - Paauilo Sugar Mill	Medium	Assessment	Hazard Present	Ongoing	PA/SI
60	Hawaii	Paauilo	Mauna Kea Ranch Overspill Spillage	Low	Assessment	Hazard Undetermined	Inactive	State
61	Hawaii	Pahala	Kau Sugar Mill	Medium	Response	Hazard Present	Ongoing	State
62	Hawaii	Pahala	ML Macadamia Orchards, LP (Kau Div)	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
63	Hawaii	Pahoa	HELCO Pole-Mounted Transformer no. 27553	NFA	Response	No Hazard	NFA	State
64	Hawaii	Papaikou	27-0330 Mamalahoa Highway Collision	Low	Response	Hazard Undetermined	Ongoing	State
65	Hawaii	Papaikou	Mauna Kea Sugar/Onomea Sugar Papaikou Mill Pesticide Mixing Area	Medium	Response	Hazard Present	Ongoing	Site Discovery
66	Hawaii	Pepeekeo	Black Oil and Drum Sites	Low	Response	Hazard Present	Ongoing	State
67	Hawaii	Pepeekeo	Hilo Coast Power Company Diesel Fuel Storage Tank	Low	Assessment	Hazard Undetermined	Inactive	State
68	Hawaii	Pepeekeo	Kraus Property	Medium	Assessment	Hazard Present	Ongoing	State
69	Hawaii	Pepeekeo	Petroleum Impacted Soil Downslope of Former HCPC Maintenance Garage	Medium	Response	Hazard Present	Ongoing	State
70	Hawaii	South Kona	Kamehameha Schools Estoy Property	Medium	Response	Hazard Present	Ongoing	State

[6] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[7]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
71	Hawaii	Waiakea	Waiakea Upland Arsenic Site	High	Assessment	Hazard Present	Inactive	State
72	Hawaii	Waipunalei	Hamakua Sugar Company, Inc - Waipunalei	Medium	Assessment	Hazard Managed With Engineering Controls	Ongoing	Site Discovery
73	Kauai	Barking Sands	Kauai Test Facility	Low	Assessment	Hazard Present	Ongoing	State
74	Kauai	Eleele	McBryde Sugar Numila Pesticide Mixing Area	Medium	Assessment	Hazard Present	Ongoing	State
75	Kauai	Hanamaulu	Lihue Plantation Co, Ltd - Lihue Herbicide Mixing Plant	Medium	Response	Hazard Undetermined	Ongoing	State
76	Kauai	Hanapepe	Sakoda Garage	Low	Response	Hazard Present	Ongoing	State
77	Kauai	Kalaheo	Kalaheo Elementary Phase 1	Low	Assessment	Hazard Undetermined	Ongoing	State
78	Kauai	Kapaa	Leonard's, Inc	Low	Assessment	Hazard Undetermined	Inactive	State
79	Kauai	Kapaa	Wailua Homestead Wells 0421-01& 02	Low	Response	Hazard Present	Inactive	State
80	Kauai	Kekaha	HIANG Kekaha	Low	Assessment	Hazard Undetermined	Inactive	HIANG Site
81	Kauai	Kekaha	Kekaha Diesel Generator	Medium	Response	Hazard Undetermined	Ongoing	State
82	Kauai	Kekaha	Kekaha Sugar Co, Ltd	Low	Response	Hazard Present	Ongoing	State
83	Kauai	Kekaha	Kekaha Sugar Co, Ltd - Kekaha Wood Treatment Plant	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
84	Kauai	Kilauea	Hale Hoolulu-Kilauea	Low	Response	Hazard Present	Ongoing	State
85	Kauai	Kilauea	Kilauea Sugar Company Pesticide Mixing and Storage Area	High	Response	Hazard Managed with Engineering Controls	NFA for surrounding properties	Site Discovery
86	Kauai	Koloa	Koloa Mill Pesticide Mixing Area Pre-1974	NFA	Assessment	No Hazard	NFA	Site Discovery
87	Kauai	Lihue	Former Ahukini Dump	Low	Assessment	Hazard Present	Ongoing	State
88	Kauai	Lihue	Grace Pacific Corporation - Hanamaulu Facility	High	Assessment	Hazard Undetermined	Ongoing	State
89	Kauai	Lihue	Kauai Beverage and Ice Cream Company	NFA	Response	No Hazard	NFA	State
90	Kauai	Lihue	Koamalu Plantation LLC Condominium	Medium	Response	Hazard Undetermined	Ongoing	State
91	Kauai	Lihue	Lihue Plantation Co, Ltd	High	Response	Hazard Present	Ongoing	Brownfields
92	Kauai	Lihue	Lihue Plantation Co, Ltd - Lihue Sugar Mill and Power Plant	Medium	Assessment	Hazard Undetermined	Ongoing	Brownfields
93	Kauai	Lihue	Nawiliwili Fuel Distribution Terminal	Low	Response	Hazard Undetermined	Ongoing	State
94	Kauai	Lihue	Nawiliwili Harbor Pier 1 Fuel Contamination	Low	Assessment	Hazard Undetermined	Ongoing	State

[7] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[8]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
95	Kauai	Lihue	Nawiliwili Harbor Pier 2 Oil Spill	Low	Assessment	Hazard Undetermined	Inactive	State
96	Kauai	Lihue	Nawiliwili Harbor Pier 3 Bollard Foundation Construction	Low	Assessment	Hazard Undetermined	Inactive	State
97	Kauai	Lihue	Nawiliwili Harbor Pier 3 Improvements	Low	Response	Hazard Present	Ongoing	State
98	Kauai	Puhi	Grove Farm Company at Puhi	Medium	Assessment	Hazard Present	Ongoing	State
99	Kauai	Wailua	Coco Palms Sewage Pump Station	Low	Assessment	Hazard Undetermined	Inactive	State
100	Kauai	Waimea	Meadow Gold Dairies, Inc- Waimea	Low	Response	Hazard Present	Inactive	State
101	Kauai	Waimea	Navy MFH PMRF Barking Sands	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
102	Kure Atoll	Kure Atoll	Kure Atoll, U.S. Coast Guard	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
103	Lanai	Lanai City	MECO Pole-Mount Transformer no. 0012	NFA	Response	No Hazard	NFA	State
104	Maui	Haiku	MECO Pole-Mount Transformer (unknown number)	NFA	Response	No Hazard	NFA	State
105	Maui	Haiku	MECO Pole-Mount Transformer 5492	NFA	Response	No Hazard	NFA	State
106	Maui	Haiku	MECO Pole-Mount Transformer 8857	NFA	Response	No Hazard	NFA	State
107	Maui	Hana	Kaeleku Plantation Company Mill	Low	Assessment	Hazard Undetermined	Ongoing	Site Discovery
108	Maui	Hana	Kipahulu Sugar Company Mill	NFA	Assessment	No Hazard	NFA	Site Discovery
109	Maui	Hana	MECO Pole E-31A - Hana Hwy	NFA	Response	No Hazard	NFA	State
110	Maui	Hana	MECO Pole-Mount Transformer no. 3449	NFA	Response	No Hazard	NFA	State
111	Maui	Kahului	A&B Central Power Plant Pipelines	Medium	Assessment	Hazard Undetermined	Ongoing	State
112	Maui	Kahului	Alii Linen Service (fka Snow White Linen)	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
113	Maui	Kahului	Costco #119 Maui Addition Lot 21A	Medium	Assessment	Hazard Undetermined	Ongoing	VRP
114	Maui	Kahului	Fong Construction	Low	Assessment	Hazard Undetermined	Inactive	State
115	Maui	Kahului	HIANG Kahului	Low	Assessment	Hazard Undetermined	Inactive	HIANG Site
116	Maui	Kahului	Hobron Ave Area (Kahului)	Low	Response	Hazard Present	Ongoing	State
117	Maui	Kahului	Kahului Fuel Distribution Terminal	Low	Response	Hazard Present	Ongoing	State
118	Maui	Kahului	Kahului Terminal	Low	Response	Hazard Present	Ongoing	State
119	Maui	Kahului	Lot F3 South Wakea Avenue	NFA	Response	Hazard Managed With Engineering Controls	NFA	State

[8] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[9]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
120	Maui	Kahului	Lot F4 Kane Street	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
121	Maui	Kahului	Maui Pineapple Co Ltd, Kane Street	Medium	Response	Hazard Undetermined	Ongoing	State
122	Maui	Kahului	Maui Pineapple Co Ltd, Seed Treatment Facility	NFA	Response	No Hazard	NFA	State
123	Maui	Kahului	Maui Pineapple Co Ltd, Suspected Former Agricultural Deep Soil Dump	Low	Assessment	Hazard Undetermined	Inactive	State
124	Maui	Kahului	MECO Pad-Mount Transformer no. 21813	NFA	Response	No Hazard	NFA	State
125	Maui	Kahului	MECO Pole-Mount Transformer no. 6748	NFA	Response	No Hazard	NFA	State
126	Maui	Kahului	MECO Pole-Mount Transformer No. 6930	Low	Assessment	Hazard Undetermined	Inactive	State
127	Maui	Kahului	MECO Station-Class Transformer No. 6369	NFA	Response	No Hazard	NFA	State
128	Maui	Kahului	Pad-Mount Transformer MECO	NFA	Response	No Hazard	NFA	State
129	Maui	Kahului	Sears Auto Center	Low	Assessment	Hazard Undetermined	Inactive	State
130	Maui	Kahului	Six Coast Guard Housing Lots	NFA	Assessment	No Hazard	NFA	State
131	Maui	Kahului	VIP Warehouse	Low	Assessment	Hazard Present	Ongoing	State
132	Maui	Kihei	Maui Electric - Substation 35, Kihei	NFA	Response	No Hazard	NFA	State
133	Maui	Kihei	MECO Pad-Mount Transformer no. 15683	NFA	Response	No Hazard	NFA	State
134	Maui	Kihei	MECO Transformer No 8554	NFA	Response	No Hazard	NFA	State
135	Maui	Kihei	MECO Transformer No 8811	NFA	Response	No Hazard	NFA	State
136	Maui	Kihei	MECO Transformer No. 8537	NFA	Response	No Hazard	NFA	State
137	Maui	Kihei	Selland Construction Inc, Kihei Base Yard	Low	Response	Hazard Undetermined	Inactive	State
138	Maui	Kula	MECO Pad-Mount Transformer 6324	NFA	Response	No Hazard	NFA	State
139	Maui	Kula	MECO Transformer 6371	NFA	Response	No Hazard	NFA	State
140	Maui	Kula	MECO Transformers Kula	Low	Response	Hazard Undetermined	Ongoing	State
141	Maui	Lahaina	Kapalua Resort Company	Low	Assessment	Hazard Undetermined	Ongoing	State
142	Maui	Lahaina	MECO Pad-Mount Transformer 4172	NFA	Response	No Hazard	NFA	State
143	Maui	Lahaina	MECO Pad-Mount Transformer No. 10327	NFA	Response	No Hazard	NFA	State
144	Maui	Lahaina	MECO Pad-Mount Transformer No. 16019	NFA	Response	No Hazard	NFA	State
145	Maui	Lahaina	MECO Pad-Mount Transformer no. 8290	NFA	Response	No Hazard	NFA	State
146	Maui	Lahaina	MECO submersible Transformer No. 4726	Low	Assessment	Hazard Undetermined	Inactive	State

[9] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[10]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
147	Maui	Lahaina	Olowalu Company Sugar Mill	Low	Assessment	Hazard Undetermined	Ongoing	Site Discovery
148	Maui	Makawao	MECO Pole-Mount Transformer no. 6159	NFA	Response	No Hazard	NFA	State
149	Maui	Paia	MECO Pole-Mount Transformer no. 9353	NFA	Response	No Hazard	NFA	State
150	Maui	Paia	Paia Sugar Mill	Medium	Assessment	Hazard Present	Ongoing	PA/SI
151	Maui	Pukalani	Maui Pineapple Co Ltd, Corn Mill Camp	High	Assessment	Hazard Present	Ongoing	State
152	Maui	Puunene	Old Puunene Airport Soil Contamination	Low	Assessment	Hazard Undetermined	Ongoing	State
153	Maui	Wailea	MECO Pad-Mount Transformer No. 8338	NFA	Response	No Hazard	NFA	State
154	Maui	Wailea	MECO Pad-Mount Transformer no. 9322	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
155	Maui	Wailuku	Maui Disposal	NFA	Response	No Hazard	NFA	State
156	Maui	Wailuku	MECO Pole-Mount Transformer no. 8804	NFA	Response	No Hazard	NFA	State
157	Maui	Wailuku	Organizational Maintenance Shop #3 (OMS #3)	Low	Assessment	Hazard Undetermined	Ongoing	HIANG Site
158	Maui	Wailuku	Waiale Ash Pile	Low	Response	Hazard Present	Ongoing	State
159	Maui	Wailuku	Wailuku Sugar Agricultural Department Pesticide Mixing	Medium	Assessment	Hazard Managed With Institutional Controls	Ongoing	Site Discovery
160	Maui	Wailuku	Wailuku Sugar Company Pesticide Mixing Area	High	Assessment	Hazard Undetermined	Ongoing	Site Discovery
161	Molokai	Hoolehua	Grace Pacific Corporation Manawainui, Molokai Facility	Low	Response	Hazard Present	Ongoing	State
162	Molokai	Ilio Point	Long Range Navigation Station Ilio Point	High	Response	Hazard Present	Ongoing	State
163	Molokai	Ilio Point	Long Range Navigation Station Ilio Point UST	Low	Assessment	Hazard Undetermined	Ongoing	State
164	Molokai	Kaunakakai	Galiher-Ono Property	Medium	Assessment	Hazard Present	Ongoing	State
165	Molokai	Kaunakakai	Hawaiian Eye Center	Low	Assessment	Hazard Undetermined	Inactive	State
166	Molokai	Kaunakakai	Island Petroleum, Inc (Kaunakakai Terminal)	Low	Response	Hazard Present	Ongoing	State
167	Molokai	Kaunakakai	Kaunakakai Drainage System B	Medium	Assessment	Hazard Undetermined	Ongoing	State
168	Molokai	Kaunakakai	MECO Generating Station: Palaau	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
169	Molokai	Kaunakakai	Molokai Community Service Center	Medium	Response	Hazard Present	Ongoing	State
170	Molokai	Kaunakakai	Rawlins' Chevron Service	NFA	Response	Hazard Managed With Engineering Controls	NFA	State

[10] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[11]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
171	Molokai	Kaunakakai	Rawlins' Chevron Service Hydraulic Hoist and Sand-And-Grease Trap	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
172	Molokai	Maunaloa	Molokai Ranch Pineapple Pesticide and Maintenance Operations	Medium	Assessment	Hazard Undetermined	Ongoing	Site Discovery
173	Molokai	Molokai	Blue Hawaiian Helicopter Impact Location (Molokai)	NFA	Response	No Hazard	NFA	State
174	Molokai	Wailua	MECO Pole-Mount Transformer no. 11543	NFA	Response	No Hazard	NFA	State
175	Oahu	Aiea	98-121 Lipoa Place	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
176	Oahu	Aiea	98-151 Lipoa Place	Medium	Response	Hazard Present	Ongoing	State
177	Oahu	Aiea	Aiea Stream	Low	Response	Hazard Managed With Engineering Controls	Ongoing	State
178	Oahu	Aiea	Aiea Sugar Mill Lot 15	High	Response	Hazard Managed With Engineering Controls	Ongoing	VRP
179	Oahu	Aiea	Former JC Penny Auto Center	NFA	Response	No Hazard	NFA	State
180	Oahu	Aiea	Grace Pacific Corporation - Halawa Valley Street	Low	Response	Hazard Present	Ongoing	State
181	Oahu	Aiea	Hawaii Baking Company	Low	Assessment	Hazard Undetermined	Inactive	State
182	Oahu	Aiea	HECO Transformer 52091	Low	Assessment	Hazard Undetermined	Inactive	State
183	Oahu	Aiea	Navy MFH Halawa	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
184	Oahu	Aiea	Navy MFH McGrew Point	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
185	Oahu	Aiea	Sears Facility #1578 at Pearlridge Mall Elevator Jack	Low	Response	Hazard Present	Ongoing	State
186	Oahu	Aiea	Sears Facility #1578 at Pearlridge Mall Hydraulic Hoist	Low	Response	Hazard Present	Ongoing	State
187	Oahu	Barbers Point	Aloha Petroleum, Barbers Pt Sales Terminal (Formerly Texaco/Equilon)	Low	Response	Hazard Present	Ongoing	State
188	Oahu	Barbers Point	Barbers Point Harbor Expansion	Low	Response	Hazard Undetermined	Ongoing	State
189	Oahu	Barbers Point	Barbers Point Harbor Pier 5	Low	Assessment	Hazard Undetermined	Inactive	State
190	Oahu	Barbers Point	Barbers Point Harbor Pier 7 and Storage Yard S-6	Low	Assessment	Hazard Undetermined	Inactive	State
191	Oahu	Camp HM Smith	Marines MFH Camp Smith	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State

[11] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[12]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
192	Oahu	Ewa	Ewa Mill Manager's Mansion and Three-House Camp	Low	Response	Hazard Undetermined	Inactive	Brownfields
193	Oahu	Ewa	Waipahu Garden Center	Low	Assessment	Hazard Undetermined	Ongoing	Brownfields
194	Oahu	Ewa Beach	BHP Gas Express Station 43 Ewa Repair Shop	Low	Assessment	Hazard Undetermined	Ongoing	State
195	Oahu	Ewa Beach	Palailai Landfill	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
196	Oahu	Fort Shafter	Army MFH FS Funston Village	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
197	Oahu	Fort Shafter	Army MFH FS Hauoli Heights North	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
198	Oahu	Fort Shafter	Army MFH FS Hauoli Heights South	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
199	Oahu	Fort Shafter	Army MFH FS Palm Circle	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
200	Oahu	Fort Shafter	Army MFH FS Radar Hill	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
201	Oahu	Fort Shafter	Army MFH FS Rice Manor	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
202	Oahu	Fort Shafter	Army MFH FS Simpson-Wisser Community Center	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
203	Oahu	Fort Shafter	Army MFH FS Simpson-Wisser Neighborhood	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
204	Oahu	Haleiwa	Twin Bridge Road Drum Dumping-Haleiwa	Low	Response	Hazard Present	Ongoing	State
205	Oahu	Helemano MR	Army MFH HMR Kalapana	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
206	Oahu	Helemano MR	Army MFH HMR Kekona	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
207	Oahu	Helemano MR	Army MFH HMR Kuapale	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
208	Oahu	Hickam AFB	Air Force MFH HAFB CGO-FGO Minor Renovation	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
209	Oahu	Hickam AFB	Air Force MFH HAFB Challenger Loop Minor Renovations	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
210	Oahu	Hickam AFB	Air Force MFH HAFB Earhart I-1	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
211	Oahu	Hickam AFB	Air Force MFH HAFB Earhart I-2	High	Response	Hazard Managed With Engineering	Ongoing	State

[12] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[13]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
212	Oahu	Hickam AFB	Air Force MFH HAFB Earhart I-3	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
213	Oahu	Hickam AFB	Air Force MFH HAFB Earhart I-4	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
214	Oahu	Hickam AFB	Air Force MFH HAFB Earhart Minor Renovations	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
215	Oahu	Hickam AFB	Air Force MFH HAFB Earhart Village Park II-1	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
216	Oahu	Hickam AFB	Air Force MFH HAFB Earhart Village Park II-4	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
217	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 01	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
218	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 02	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
219	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 03	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
220	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 04	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
221	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 05	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
222`	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 06	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
223	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 07	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
224	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 08	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
225	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 08 South	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
226	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 09	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
227	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 10	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
228	Oahu	Hickam AFB	Air Force MFH HAFB FGO Block 11	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
229	Oahu	Hickam AFB	Air Force MFH HAFB GO-SO Historic Renovations	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
230	Oahu	Hickam AFB	Air Force MFH HAFB Hale Na Koa I-1	High	Response	Hazard Managed With Engineering Controls	Ongoing	State

[13] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[14]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
231	Oahu	Hickam AFB	Air Force MFH HAFB Hale Na Koa Minor Renovations	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
232	Oahu	Hickam AFB	Air Force MFH HAFB Hickam Field NCO Area	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
233	Oahu	Hickam AFB	Air Force MFH HAFB Hickam Field Officer Area	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
234	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 01	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
235	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 02	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
236	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 03	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
237	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 04	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
238	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 05	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
239	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 06	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
240	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 07	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
241	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 08	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
242	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 09	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
243	Oahu	Hickam AFB	Air Force MFH HAFB JNCO Block 10	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
244	Oahu	Hickam AFB	Air Force MFH HAFB Onizuka II-1	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
245	Oahu	Hickam AFB	Air Force MFH HAFB Onizuka II-2	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
246	Oahu	Hickam AFB	Air Force MFH HAFB Onizuka II-3	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
247	Oahu	Hickam AFB	Air Force MFH HAFB SNCO Block 1	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
248	Oahu	Hickam AFB	Air Force MFH HAFB SNCO Block 2	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
249	Oahu	Hickam AFB	Air Force MFH HAFB SNCO Block 3	High	Response	Hazard Managed With Engineering Controls	Ongoing	State

[14] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[15]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
250	Oahu	Hickam AFB	Air Force MFH HAFB SO Minor Renovation	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
251	Oahu	Hickam AFB	Air Force MFH Hickam Communities Remedial Action	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
252	Oahu	Honolulu	1310 Pensacola Street	NFA	Response	No Hazard	NFA	State
253	Oahu	Honolulu	158 Sand Island Access Rd	Medium	Response	Hazard Present	Ongoing	State
254	Oahu	Honolulu	180 Sand Island Access Rd	Medium	Response	Hazard Present	Ongoing	State
255	Oahu	Honolulu	1800 Vancouver Drive	Medium	Assessment	Hazard Undetermined	Ongoing	State
256	Oahu	Honolulu	1950 Homerule Street	Low	Assessment	Hazard Present	Ongoing	State
257	Oahu	Honolulu	2135 Auiki St	Medium	Response	Hazard Present	Ongoing	State
258	Oahu	Honolulu	218 Mohonua Place	Medium	Response	Hazard Present	Ongoing	State
259	Oahu	Honolulu	2250 Pahounui Drive	Medium	Assessment	Hazard Present	Ongoing	State
260	Oahu	Honolulu	373 North Nimitz Highway	Medium	Response	Hazard Present	Ongoing	State
261	Oahu	Honolulu	420-470 North Nimitz Highway	Low	Response	Hazard Managed With Engineering Controls	Ongoing	State
262	Oahu	Honolulu	580 North Nimitz Highway	Low	Response	Hazard Managed With Engineering Controls	Inactive	State
263	Oahu	Honolulu	595 Ala Moana Black Oil Pipeline	Low	Assessment	Hazard Undetermined	Ongoing	State
264	Oahu	Honolulu	700 N Nimitz IDPP Release	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
265	Oahu	Honolulu	755 N Nimitz Hwy	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
266	Oahu	Honolulu	775 North Nimitz Highway	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
267	Oahu	Honolulu	836 Kawaiahao Street	Low	Response	Hazard Undetermined	Ongoing	State
268	Oahu	Honolulu	Ala Moana WWPS Force Main #3 and #4	Medium	Assessment	Hazard Undetermined	Ongoing	State
269	Oahu	Honolulu	Ala Wai Harbor Boat Repair Yard	NFA	Assessment	No Hazard	NFA	State
270	Oahu	Honolulu	Ala Wai Harbor Fuel Dock	Medium	Response	Hazard Present	Ongoing	State
271	Oahu	Honolulu	Alii #3282	Medium	Response	Hazard Present	Ongoing	State
272	Oahu	Honolulu	Allstate Industrial & Marine Cleaning, Inc.	Low	Response	Hazard Managed With Engineering Controls	Ongoing	State
273	Oahu	Honolulu	Aloha Petroleum Terminal	Medium	Response	Hazard Present	Ongoing	State
274	Oahu	Honolulu	Aloha Tower Development	Low	Assessment	Hazard Present	Ongoing	State

[15] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[16]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
275	Oahu	Honolulu	Aloha/King Self Storage	NFA	Response	Hazard Managed With Engineering Controls	NFA	VRP
276	Oahu	Honolulu	ARCO AM/PM #82102 (Texaco 61-100-0043)	Low	Response	Hazard Present	Ongoing	State
277	Oahu	Honolulu	Army MFH AMR Bougainville	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
278	Oahu	Honolulu	Army MFH AMR Hibiscus	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
279	Oahu	Honolulu	Army MFH AMR Makai View	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
280	Oahu	Honolulu	Army MFH AMR Plumeria	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
281	Oahu	Honolulu	Army MFH AMR Rim Loop	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
282	Oahu	Honolulu	Army MFH AMR Skyview	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
283	Oahu	Honolulu	Army MFH AMR Valley View	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
284	Oahu	Honolulu	BHP Gasco Benzene Site	High	Response	Hazard Managed With Institutional Controls	Ongoing	State
285	Oahu	Honolulu	Brewer Environmental Industries-Pacific Street	High	Assessment	Hazard Present	Ongoing	VRP
286	Oahu	Honolulu	BTU Storage Tanks Pier 19	Medium	Response	Hazard Present	Ongoing	State
287	Oahu	Honolulu	Chevron Honolulu Terminal Marine	Medium	Response	Hazard Present	Ongoing	State
288	Oahu	Honolulu	Chevron Honolulu Transportation Terminal	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
289	Oahu	Honolulu	Chevron Kapalama Northeast Parcel	Medium	Response	Hazard Present	Ongoing	State
290	Oahu	Honolulu	Chevron Kapalama Northwest Parcel	Low	Response	Hazard Present	Ongoing	State
291	Oahu	Honolulu	Chevron Kapalama Terminal	Medium	Response	Hazard Present	Ongoing	State
292	Oahu	Honolulu	Chevron Pier 35 Pipeline Release	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
293	Oahu	Honolulu	Chevron Tanker Truck Loading Rack (TTLR)	High	Assessment	Hazard Undetermined	Ongoing	State
294	Oahu	Honolulu	Citizens Energy Services Pier 38	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
295	Oahu	Honolulu	Coast Guard MFH Red Hill Makai	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State

[16] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[17]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
296	Oahu	Honolulu	Coast Guard MFH Red Hill Mauka	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
297	Oahu	Honolulu	DLNR Buried Drum Site	Low	Assessment	Hazard Managed With Institutional Controls	Inactive	State
298	Oahu	Honolulu	Dole Iwilei	Medium	Assessment	Hazard Present	Ongoing	State
299	Oahu	Honolulu	Domestic Commercial Fishing Village	Low	Response	Hazard Managed With Engineering Controls	Ongoing	State
300	Oahu	Honolulu	Former Kapalama Military Reservation Piers 39 and 40 Pipelines	Medium	Assessment	Hazard Undetermined	Ongoing	State
301	Oahu	Honolulu	Hale Pua Nui UST Removal	Medium	Response	Hazard Undetermined	Ongoing	State
302	Oahu	Honolulu	Hart Street WWPS	Low	Response	Hazard Present	Ongoing	State
303	Oahu	Honolulu	Hawaii Fueling Facilities Corporation-Airport	Low	Assessment	Hazard Present	Ongoing	State
304	Oahu	Honolulu	Hawaii Fueling Facilities Corporation-Airport Relief Valve Release	Low	Assessment	Hazard Undetermined	Ongoing	State
305	Oahu	Honolulu	Hawaii Fueling Facilities Corporation-Sand Island Access Road	Low	Assessment	Hazard Undetermined	Inactive	State
306	Oahu	Honolulu	Hawaii Fueling Facilities Corporation-Sand Island Oil/Water Drain Line Release	Low	Response	Hazard Present	Ongoing	State
307	Oahu	Honolulu	Hawaii Fueling Facilities Corporation-Sand Island Slurry Wall Trenching Activity	Medium	Response	Hazard Present	Ongoing	State
308	Oahu	Honolulu	Hawaii Grain Corporation	Low	Assessment	Hazard Undetermined	Ongoing	State
309	Oahu	Honolulu	Hawaii Instrumentation & Controls, Inc	Medium	Response	Hazard Managed With Engineering Controls	Inactive	State
310	Oahu	Honolulu	Hawaii Metal Recycling Company Pier 35	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
311	Oahu	Honolulu	Hawaii Stevedores	Low	Response	Hazard Present	Ongoing	State
312	Oahu	Honolulu	Hawaii Transfer Company, Ltd Pier 36	Low	Response	Hazard Present	Ongoing	State
313	Oahu	Honolulu	Hawaiian Electric Company (HECO) - Iwilei Tank Yard	Low	Response	Hazard Managed With Engineering Controls	Ongoing	State
314	Oahu	Honolulu	Hawaiian Electric Company (HECO)-Honolulu Generating Station	Low	Assessment	Hazard Undetermined	Inactive	State Response Program
315	Oahu	Honolulu	Hawaiian Flour Mill	Medium	Response	Hazard Present	Ongoing	State
316	Oahu	Honolulu	Hawaiian Fluid Power Company	Low	Response	Hazard Present	Ongoing	State
317	Oahu	Honolulu	Hawaiian Tug & Barge Corporation	Low	Assessment	Hazard Undetermined	Inactive	State

[17] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[18]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
318	Oahu	Honolulu	HECO Fuel Oil Pipeline Route State Energy Corridor	Low	Assessment	Hazard Undetermined	Ongoing	State
319	Oahu	Honolulu	HECO Pad-Mount Transformer No. 57270	NFA	Response	No Hazard	NFA	State
320	Oahu	Honolulu	HECO Pole-Mount Transformer 52849	NFA	Response	No Hazard	NFA	State
321	Oahu	Honolulu	HECO Pole-Mount Transformers No. 51098 (15), 51099 (15), 51100 (3)	NFA	Response	No Hazard	NFA	State
322	Oahu	Honolulu	HECO Substation: Pukele Substation	Low	Assessment	Hazard Undetermined	Ongoing	State
323	Oahu	Honolulu	HECO Transformer 27266	NFA	Response	No Hazard	NFA	State
324	Oahu	Honolulu	HECO Transformer 26127	NFA	Response	No Hazard	NFA	TSCA
325	Oahu	Honolulu	Honolulu Harbor Iwilei District Operating Parties	Medium	Assessment	Hazard Undetermined	Ongoing	State
326	Oahu	Honolulu	Honolulu Harbor Iwilei Unit OU1A	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
327	Oahu	Honolulu	Honolulu Harbor Iwilei Unit OU1C	Low	Assessment	Hazard Undetermined	Ongoing	State
328	Oahu	Honolulu	Honolulu High-Capacity Transit Corridor Project	Medium	Assessment	Hazard Present	Ongoing	State
329	Oahu	Honolulu	Honolulu Marine Small Boat Shipyard at Keehi Lagoon	Low	Assessment	Hazard Undetermined	Ongoing	State
330	Oahu	Honolulu	Honolulu Seawater Air Conditioning Project	High	Response	Hazard Undetermined	Ongoing	State
331	Oahu	Honolulu	Honolulu Shipyard, Inc	Low	Response	Hazard Undetermined	Inactive	State
332	Oahu	Honolulu	Interisland Maintenance Facility Site Elliot Street	Low	Response	Hazard Undetermined	Ongoing	State
333	Oahu	Honolulu	Island Movers, Inc	Low	Assessment	Hazard Undetermined	Inactive	State
334	Oahu	Honolulu	Iwilei Fruits and Produce	Low	Response	Hazard Undetermined	Ongoing	State
335	Oahu	Honolulu	Iwilei Project Site (Iwilei Brownfields)	Low	Response	Hazard Present	Inactive	State
336	Oahu	Honolulu	K&Y Auto Service and Wayne's Auto Electric	Medium	Assessment	Hazard Present	Ongoing	State
337	Oahu	Honolulu	Kakaako Brownfield Project	High	Response	Hazard Managed With Institutional Controls	Ongoing	State
338	Oahu	Honolulu	Kakaako Brownfield Project - Unit 10	Low	Assessment	Hazard Managed With Engineering Controls	Ongoing	Brownfields Site
339	Oahu	Honolulu	Kakaako Brownfield Project - Unit 2	Low	Assessment	Hazard Managed With Engineering Controls	Ongoing	Brownfields Site
340	Oahu	Honolulu	Kakaako Brownfield Project - Unit 4	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	Brownfields Site

[18] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[19]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
341	Oahu	Honolulu	Kakaako Brownfield Project - Unit 5	Medium	Assessment	Hazard Managed With Engineering Controls	Ongoing	Brownfields Site
342	Oahu	Honolulu	Kakaako Brownfield Project - Unit 6	Low	Assessment	Hazard Managed With Engineering Controls	Ongoing	Brownfields Site
343	Oahu	Honolulu	Kakaako Brownfield Project - Unit 7	Low	Assessment	Hazard Managed With Engineering Controls	Ongoing	Brownfields Site
344	Oahu	Honolulu	Kakaako Brownfield Project - Unit 8	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
345	Oahu	Honolulu	Kakaako Brownfield Project - Unit 9	Medium	Assessment	Hazard Managed With Engineering Controls	Ongoing	Brownfields Site
346	Oahu	Honolulu	Kakaako Makai District John Dominis	Medium	Assessment	Hazard Undetermined	Ongoing	State
347	Oahu	Honolulu	Kakaako Makai District Parking Garage-Unit 1and 3	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
348	Oahu	Honolulu	Kakaako Makai District Units 2 and 4	Medium	Response	Hazard Present	Ongoing	State
349	Oahu	Honolulu	Kakaako Makai District Units 6 and 7	High	Response	Hazard Present	Ongoing	Brownfields
350	Oahu	Honolulu	Kakaako Pump Station	Low	Response	Hazard Present	Ongoing	State
351	Oahu	Honolulu	Kamehameha Schools - 1336 Dillingham Boulevard	Medium	Response	Hazard Present	Ongoing	State
352	Oahu	Honolulu	Kapalama Incinerator Off-Site Contamination	Medium	Response	Hazard Managed With Institutional Controls	Ongoing	State
353	Oahu	Honolulu	Keeaumoku Superblock Project	Low	Assessment	No Hazard	Inactive	State
354	Oahu	Honolulu	Koko Head District Park	Low	Assessment	Hazard Managed With Institutional Controls	Inactive	Site Discovery
355	Oahu	Honolulu	Kokua Kalihi Valley Active Living Center	Low	Response	Hazard Undetermined	Inactive	Brownfields
356	Oahu	Honolulu	Kuakini Medical Center	Low	Response	Hazard Undetermined	Ongoing	State
357	Oahu	Honolulu	Kuhio Park Terrace Units D1 and D2	High	Response	No Hazard	Ongoing	State
358	Oahu	Honolulu	Lance Goya's Chevron Service (Tom Tomita's Chevron)	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
359	Oahu	Honolulu	Lockheed Air Terminal, Inc	Low	Assessment	Hazard Undetermined	Inactive	State
360	Oahu	Honolulu	Longs Drug Stores Warehouse	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
361	Oahu	Honolulu	McCabe, Hamilton, & Renny Company, Ltd	Low	Response	Hazard Undetermined	Inactive	State
362	Oahu	Honolulu	McDonald's Restaurant Soil & Groundwater Contamination	Low	Assessment	Hazard Present	Ongoing	State

[19] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[20]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
363	Oahu	Honolulu	Miyazaki Honolulu Airport Service Station (Airways Service Station Inc)	Low	Assessment	Hazard Undetermined	Inactive	State
364	Oahu	Honolulu	Moanalua Medical Center and Clinic	Medium	Response	Hazard Present	Ongoing	State
365	Oahu	Honolulu	Navy MFH Camp Stover	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
366	Oahu	Honolulu	Navy MFH Catlin Park	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
367	Oahu	Honolulu	Navy MFH Doris Miller Park	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
368	Oahu	Honolulu	Navy MFH Hale Alii	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
369	Oahu	Honolulu	Navy MFH Hale Moku	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
370	Oahu	Honolulu	Navy MFH Halsey Terrace	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
371	Oahu	Honolulu	Navy MFH Hokulani	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
372	Oahu	Honolulu	Navy MFH Hospital Point	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
373	Oahu	Honolulu	Navy MFH Little Makalapa	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
374	Oahu	Honolulu	Navy MFH Makalapa	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
375	Oahu	Honolulu	Navy MFH Maloelap	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
376	Oahu	Honolulu	Navy MFH Marine Barracks	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
377	Oahu	Honolulu	Navy MFH Moanalua Terrace	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
378	Oahu	Honolulu	Navy MFH Radford Terrace	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
379	Oahu	Honolulu	Navy MFH Red Hill Terrace	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
380	Oahu	Honolulu	Nimitz Highway Water Improvement Project Sumner to Queen	Low	Response	Hazard Present	Ongoing	State
381	Oahu	Honolulu	Nuuanu Auto Company LTD	Low	Assessment	Hazard Undetermined	Ongoing	State
382	Oahu	Honolulu	Pacifica Condominiums	NFA	Response	No Hazard	NFA	State

[20] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[21]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
383	Oahu	Honolulu	Palolo Elementary School	Medium	Response	Hazard Undetermined	Inactive	State
384	Oahu	Honolulu	Parking Lot C and J Transformer Replacement	Low	Response	Hazard Undetermined	Ongoing	State
385	Oahu	Honolulu	PHT, Inc. dba Polynesian Hospitality	Low	Response	Hazard Undetermined	Inactive	State
386	Oahu	Honolulu	Pukoloa Wood Treating Site	Medium	Response	Hazard Present	Ongoing	State
387	Oahu	Honolulu	Richard's Chevron	NFA	Response	Hazard Managed With Institutional Controls	NFA	State
388	Oahu	Honolulu	Rubber Stamp Plantation	NFA	Response	No Hazard	NFA	PA/SI
389	Oahu	Honolulu	Safeway 1234 South Beretania Street	NFA	Response	Hazard Managed With Institutional Controls	NFA	State
390	Oahu	Honolulu	Sause Brothers	Low	Response	Hazard Present	Ongoing	State
391	Oahu	Honolulu	Senior Residences at Iwilei	NFA	Response	Hazard Managed With Institutional Controls	NFA	State
392	Oahu	Honolulu	Servco Pacific, Inc- Kalihi	Low	Assessment	Hazard Undetermined	Inactive	State
393	Oahu	Honolulu	Shell Service Station (Sierra Shell Service)	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
394	Oahu	Honolulu	Shidler College of Business Site Improvements	Low	Assessment	Hazard Undetermined	Inactive	State
395	Oahu	Honolulu	Tesoro Hawaii Corporation, Terminal Department-Sand Island	Medium	Response	Hazard Present	Ongoing	State
396	Oahu	Honolulu	The Honolulu Advertiser (Hawaii Newspaper Agency)	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
397	Oahu	Honolulu	Theo Davies Caterpillar Repair Site	Low	Response	Hazard Managed With Engineering Controls	Inactive	State
398	Oahu	Honolulu	Tosco Honolulu Bulk Distribution Terminal	High	Response	Hazard Present	Ongoing	VRP
399	Oahu	Honolulu	Towco - Sand Island	Low	Assessment	Hazard Undetermined	Inactive	State
400	Oahu	Honolulu	USPS Vehicle Maintenance Facility	Low	Response	Hazard Present	Ongoing	State
401	Oahu	Honolulu	Waikiki Sand Villa II	Low	Assessment	Hazard Undetermined	Inactive	State
402	Oahu	Honolulu	Wallys Garden Center	Medium	Assessment	Hazard Present	Inactive	State
403	Oahu	Honolulu	Weyerhaeuser	Low	Response	Hazard Present	Inactive	State
404	Oahu	Honolulu	Yee Hop Building Maunakea Street	Low	Response	Hazard Present	Ongoing	State
405	Oahu	Honolulu	Yee Hop Property	Low	Assessment	Hazard Undetermined	Ongoing	State
406	Oahu	Honolulu	Young Brothers, Ltd Piers 24-28	Medium	Response	Hazard Present	Ongoing	State

[21] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[22]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
407	Oahu	Honolulu	Young Brothers, Ltd. Piers 39, 40	Low	Assessment	Hazard Undetermined	Inactive	State
408	Oahu	Honolulu	Zippy's 634 N Nimitz Highway	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
409	Oahu	Kahaluu	HECO Transformer 56646	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
410	Oahu	Kailua	C&C Facility Maintenance Kapaa Quarry Rd. Baseyard	Medium	Response	Hazard Present	Ongoing	State
411	Oahu	Kailua	Hamakua Hillside Preservation Land	NFA	Assessment	No Hazard	NFA	State
412	Oahu	Kailua	Hawaii Youth Correctional Facility	Low	Assessment	Hazard Present	Ongoing	State
413	Oahu	Kailua	Honolulu Skeet Club	Medium	Response	Hazard Managed With Institutional Controls	Ongoing	State
414	Oahu	Kailua	Ironwoods at Kailua	Low	Response	Hazard Present	Ongoing	Fast Track
415	Oahu	Kailua	Kapaa Landfill - Kapaa Quarry Road	Medium	Response	Hazard Undetermined	Inactive	State
416	Oahu	Kailua	Malunui Avenue Oil Contamination	Low	Assessment	Hazard Undetermined	Inactive	State
417	Oahu	Kaneohe	Caesar's Cleaners	Medium	Response	Hazard Managed With Engineering Controls	Inactive	State
418	Oahu	Kaneohe	Heeia Agricultural Company Mill	NFA	Assessment	No Hazard	NFA	Site Discovery
419	Oahu	Kaneohe MCBH	Marines MFH MCBH Hawaii Loa	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
420	Oahu	Kaneohe MCBH	Marines MFH MCBH Heleloa	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
421	Oahu	Kaneohe MCBH	Marines MFH MCBH Kaluapuni	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
422	Oahu	Kaneohe MCBH	Marines MFH MCBH Kaneohe ADMIN FILE	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
423	Oahu	Kaneohe MCBH	Marines MFH MCBH Kapoho Hillside	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
424	Oahu	Kaneohe MCBH	Marines MFH MCBH Mololani	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
425	Oahu	Kaneohe MCBH	Marines MFH MCBH Nani Ulupau	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
426	Oahu	Kaneohe MCBH	Marines MFH MCBH Pa Honua III	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
427	Oahu	Kaneohe MCBH	Marines MFH MCBH Ulupau	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State

[22] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai'i Response Program List of Priority Sites– FY 2012[23]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
428	Oahu	Kaneohe MCBH	Marines MFH MCBH Waikulu Manning	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
429	Oahu	Kaneohe MCBH	Marines MFH MCBH Waikulu NCO Row	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
430	Oahu	Kaneohe MCBH	Marines MFH MCBH Waikulu Rainbow	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
431	Oahu	Kapolei	Barge Harbor Soil Contamination	Medium	Assessment	Hazard Undetermined	Inactive	State
432	Oahu	Kapolei	Chevron USA Products Co., Hawaii Refinery Tank Sludge	Medium	Assessment	Hazard Undetermined	Inactive	State
433	Oahu	Kapolei	Chevron USA Products Co., Hawaii Refinery, Marine Line Release	Low	Response	Hazard Present	Inactive	State
434	Oahu	Kapolei	Con-Fab Hawaii Corporation	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
435	Oahu	Kapolei	CoVan Warehouse	Low	Response	Hazard Present	Inactive	State
436	Oahu	Kapolei	East Kapolei Hoopili	NFA	Assessment	No Hazard	NFA	State
437	Oahu	Kapolei	Ewa Feedlot Property	Medium	Response	Hazard Present	Ongoing	Brownfields
438	Oahu	Kapolei	Hanua Street Fugitive Oil	Low	Assessment	Hazard Undetermined	Inactive	State
439	Oahu	Kapolei	HECO - Campbell Industrial Park Substation	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
440	Oahu	Kapolei	HECO Generating Station: Kahe Power Plant	NFA	Response	No Hazard	NFA	State
441	Oahu	Kapolei	HECO Pad-mount Transformer 45530	Low	Assessment	Hazard Undetermined	Ongoing	State
442	Oahu	Kapolei	Honolulu Wood Treating Company, Ltd	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	VRP
443	Oahu	Kapolei	Kalaeloa Cogeneration Plant	Low	Assessment	Hazard Undetermined	Inactive	State
444	Oahu	Kapolei	Tileco, Inc	Medium	Response	Hazard Undetermined	Ongoing	State
445	Oahu	Kapolei	UH West Oahu Campus	NFA	Assessment	No Hazard	NFA	State
446	Oahu	Kualoa	Kualoa Plantation Mill	NFA	Assessment	No Hazard	NFA	Site Discovery
447	Oahu	Kunia	Central Oahu Wells	Low	Assessment	Hazard Undetermined	Ongoing	State
448	Oahu	Kunia	Del Monte Kunia Former Maintenance Shop	Low	Response	Hazard Present	Ongoing	State
449	Oahu	Kunia	Ewa Sugar Mill/Oahu Sugar Co. - Kunia Staging Area	Medium	Response	Hazard Present	Ongoing	State
450	Oahu	Kunia	Kunia Wells I	Low	Assessment	Hazard Undetermined	Ongoing	State

[23] State of Hawai'i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai'i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[24]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
451	Oahu	Kunia	Kunia Wells II	Low	Assessment	Hazard Undetermined	Ongoing	State
452	Oahu	Laie	Laie Plantation Mill	Low	Assessment	No Hazard	Ongoing	Site Discovery
453	Oahu	Maili	84-Acre Portion of the Former Voice of America Site	Low	Assessment	Hazard Undetermined	Ongoing	State
454	Oahu	Makakilo	Grace Pacific Corporation - Makakilo Quarry	Low	Assessment	Hazard Undetermined	Ongoing	VRP
455	Oahu	Mililani	Mililani Wells I	Low	Assessment	Hazard Undetermined	Ongoing	State
456	Oahu	Mililani Mauka	Mililani Mauka Commercial C Property	NFA	Assessment	No Hazard	NFA	State
457	Oahu	Nanakuli	Kaiser Cement Corp Waianae Point	NFA	Response	Hazard Managed With Institutional Controls	NFA	State
458	Oahu	Pearl City	96-1217 Waihona Street	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
459	Oahu	Pearl City	Hawaii Army National Guard Waiawa Gulch	Low	Response	Hazard Present	Ongoing	State
460	Oahu	Pearl City	HECO Generating Station: Waiau	Medium	Response	Hazard Undetermined	Inactive	State
461	Oahu	Pearl City	HECO Waiau Generating Station Tank 4	Low	Response	Hazard Present	Ongoing	State
462	Oahu	Pearl City	Marines MFH Manana	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
463	Oahu	Pearl City	Navy MFH Manana	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
464	Oahu	Pearl City	Navy MFH Pearl City Peninsula	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
465	Oahu	Pearl City	Pearl City Urban Garden Center	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
466	Oahu	Pearl City	Waiawa Shaft	Low	Assessment	Hazard Undetermined	Ongoing	State
467	Oahu	Pearl City	Waimano Home Campus	Low	Assessment	Hazard Managed With Engineering Controls	Inactive	Brownfields Site
468	Oahu	Pearl Harbor	Ewa Junction Fuel Drumming Facility	High	Assessment	Hazard Managed With Institutional Controls	Ongoing	State
469	Oahu	Schofield Barracks	Army MFH SB Akolea	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
470	Oahu	Schofield Barracks	Army MFH SB Aloala	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
471	Oahu	Schofield Barracks	Army MFH SB Canby	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State

[24] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[25]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
472	Oahu	Schofield Barracks	Army MFH SB Generals Loop	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
473	Oahu	Schofield Barracks	Army MFH SB Hamilton	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
474	Oahu	Schofield Barracks	Army MFH SB Kaena	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
475	Oahu	Schofield Barracks	Army MFH SB Leader Field	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
476	Oahu	Schofield Barracks	Army MFH SB Mendonca Park	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
477	Oahu	Schofield Barracks	Army MFH SB Moyer	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
478	Oahu	Schofield Barracks	Army MFH SB Patriot	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
479	Oahu	Schofield Barracks	Army MFH SB Porter	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
480	Oahu	Schofield Barracks	Army MFH SB Ralston	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
481	Oahu	Schofield Barracks	Army MFH SB Santa Fe	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
482	Oahu	Schofield Barracks	Army MFH SB Solomon	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
483	Oahu	Tripler AMC	Army MFH TAMC Rainbow Village	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
484	Oahu	Wahiawa	410 Olive Avenue	Medium	Assessment	Hazard Managed With Engineering Controls	Ongoing	State
485	Oahu	Wahiawa	95 South Kamehameha Highway	Medium	Assessment	Hazard Undetermined	Ongoing	State
486	Oahu	Wahiawa	Galbraith Estate Property	NFA	Response	Hazard Managed With Engineering Controls	NFA	State
487	Oahu	Wahiawa	Navy MFH NCTAMS PAC Wahiawa	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
488	Oahu	Waialua	Mount Kaala Natural Area Reserve	NFA	Response	No Hazard	NFA	State
489	Oahu	Waialua	Waialua Sugar Mill Settling Ponds	Medium	Assessment	Hazard Managed With Engineering Controls	Ongoing	VRP
490	Oahu	Waialua	Waialua Sugar Mill VRP Site	High	Response	Hazard Present	Ongoing	VRP
491	Oahu	Waianae	HECO Substation: Mikilua Substation	Medium	Response	Hazard Undetermined	Inactive	State
492	Oahu	Waianae	Industrial Technology Tire Pile	Medium	Assessment	Hazard Undetermined	Ongoing	State

[25] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.3 (Continued) State of Hawai‘i Response Program List of Priority Sites– FY 2012[26]

	Island	Locality Name	Site Name	Priority	Action	Potential Hazard and Controls	Site Status	Cleanup Program
493	Oahu	Waimanalo	Air Force MFH Bellows Renovation	High	Response	Hazard Managed With Engineering Controls	Ongoing	State
494	Oahu	Waimanalo	HECO Transformer 27728 (Vault 3032)	Medium	Response	Hazard Undetermined	Inactive	State
495	Oahu	Waimanalo	University of Hawaii, Waimanalo Experimental Farm	Low	Assessment	Hazard Undetermined	Inactive	State
496	Oahu	Waimanalo	Waimanalo Areawide Groundwater Contamination	Low	Assessment	Hazard Present	Inactive	PA/SI
497	Oahu	Waimanalo	Waimanalo Sugar Company	Low	Assessment	No Hazard	Ongoing	Site Discovery
498	Oahu	Waipahu	Navy MFH Ford Island	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
499	Oahu	Waipahu	Waipio Heights Wells II	Low	Assessment	Hazard Undetermined	Ongoing	State
500	Oahu	Waipio	Ewa Sugar Mill/Oahu Sugar Co. - Waipio Peninsula	High	Assessment	Hazard Managed With Engineering Controls	Ongoing	State
501	Oahu	Wheeler AAF	Army MFH WAAF Kunia	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
502	Oahu	Wheeler AAF	Army MFH WAAF Puali North	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
503	Oahu	Wheeler AAF	Army MFH WAAF Puali South	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State
504	Oahu	Wheeler AAF	Army MFH WAAF Wiliwili	Medium	Response	Hazard Managed With Engineering Controls	Ongoing	State

[26] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

16.3.7 State of Hawai‘i Response Program Emergenc Response Notification List

The State of Hawai‘i Response Program Release Notification Log presented in this section (see Table 16.3) shows a listing of all chemical and petroleum release notifications received by the HEER Office emergency response team during the fiscal year 2012. The Release Notification Log is sorted in order of Locality and Case Name. During this year, the HEER office of Emergency Response Actions received a total of 295 notifications statewide. As can be seen on the table, of the total statewide 295 notifications, 35 corresponded to the island of Maui, 1 corresponded to the island of Moloka‘i, and 2 corresponded to the island of Lāna‘i. Also, of the total statewide 295 notifications, 225 were directly related to the release of petroleum related substances.

Table 16.4 State of Hawai‘i Response Program Release Notification Log– FY 2012[27]

	Islands	Locality	Unit Name	Case Number	Substances	Media
1	Hawaii	Captain Cook	HELCO hydraulic line release	20120217-1410	Hydraulic Oil	Soil
2	Hawaii	Haiku	MECO pole-mounted transformer 9971 release	20110701-1427	Transformer Oil	Soil
3	Hawaii	Hilo	Aloha Petroleum Hilo Bulk Plant NRC 994251	20111101-1100LG	Diesel Fuel	Soil
4	Hawaii	Hilo	Fungicide Spill in Hilo on Hwy 11	20120315-1010	Kumulus DF	Soil
5	Hawaii	Hilo	HELCO used transformer oil leak from storage tote	20120609-1638	Transformer Oil	Soil
6	Hawaii	Hilo	HELCO POLE-MOUNTED #689790 TRANSFORMER RELEASE	20110915-1117	Transformer Oil	Soil
7	Hawaii	Hilo	NRC 986201	20110816-1306	Unknown	Ocean
8	Hawaii	Hilo	Sailing Vessel Grounded in Hilo	20120620-0900	Oil	Ocean
9	Hawaii	Kailua	HELCO	20110722-1430	Transformer Oil	Soil
10	Hawaii	Kailua	HELCO pad-mounted transformer #26280 release	20111215-1011	Transformer Oil	Soil
11	Hawaii	Kailua	HELCO pad-mounted transformer #547003 release	20111206-1341	Transformer Oil	Soil
12	Hawaii	Kailua	HELCO POLE-MOUNTED TRANSFORMER #961076686 RELEASE	201111301142	Transformer Oil	Soil
13	Hawaii	Kailua	HELCO transformer pad-mount #547003 release	20110915-1118	Transformer Oil	Soil
14	Hawaii	Kailua	HELCO used oil release	20111103-1323	Used transformer oil	Soil
15	Hawaii	Kailua Kona	HELCO pole-mounted transformer #15243 release	20120417-1304	Transformer Oil	Soil
16	Hawaii	Kailua Kona	HELCO sump oily water release	20111115-1054	Oily Water Mixture	Soil
17	Hawaii	Kailua Kona	HELCO transformer pad-mounted #28697 release	20111125-1200	Transformer Oil	Soil
18	Hawaii	Kailua-Kona	HELCO Keahole Generating Power Plant diesel tank #4 overfill	20120316-1644	Diesel Fuel	Within Facility
19	Hawaii	Kailua-Kona	HELCO Pad mount Transformer Release 3T237	20110722-1431	Transformer Oil	Soil
20	Hawaii	Kailua-Kona	HELCO transformer pad-mounted #39903 release	20120412-1457	Transformer Oil	Soil
21	Hawaii	Kailua-Kona	HELCO transformer pole-mounted #15243 release	20120301-0811	Transformer Oil	Soil
22	Hawaii	Kailua-Kona	HELCO transformer switch#94154c release	20120423-1340	Transformer Oil	Soil
23	Hawaii	Kailua-Kona	NRC 1010659	20120507-0807	Oil	Ocean
24	Hawaii	Kamuela	HELCO pole-mounted transformer #12853 release	20120620-1318	Transformer Oil	Soil
25	Hawaii	Keauhou	HELCO pad-mounted transformer #12908 RELEASE	20120119-1048	Transformer Oil	Soil
26	Hawaii	Keauhou	HELCO transformer #518185 release	20111206-1345	Transformer Oil	Soil
27	Hawaii	Keauhou	HELCO transformer substation release	20111004-1226	Transformer Oil	Soil
28	Hawaii	Mililani	HELCO transformer pad-mounted #46506 release	20111013-1318	Transformer Oil	Soil
29	Hawaii	North Kohala	North Kohala	20110711-1000	Mercury, Oily Water	Other

[27] State of Hawai‘i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai‘i 2003, December 20012

Table 16.4 (continued) State of Hawai'i Response Program Release Notification Log– FY 2012[28]

	Islands	Locality	Unit Name	Case Number	Substances	Media
30	Hawaii	Ocean	Oscar Elton Sette NRC 981679	20110705-0717	Motor Oil	Ocean
31	Hawaii	Ocean	Unknown Sheen 981559	20110702-1930	Unknown	Ocean
32	Hawaii	Ocean	Unknown Sheen 991972	20111008-1400	Unknown	Ocean
33	Hawaii	Paauilo	HELCO pole-mounted transformer #41566 release	20110829-1252	Transformer Oil	Soil
34	Hawaii	Paauilo	HELCO Transformer #41566 Release	20110908-1314	Transformer Oil	Soil
35	Hawaii	Paauilo	HELCO transformer #951017155 release	20111202-1350	Transformer Oil	Soil
36	Hawaii	Pahoa	HELCO transformer pole mounted #110583 release	20111213-1058	Transformer Oil	Soil
37	Hawaii	Pahoa	HELCO transformer pole-mounted # k454312k71a release	20111004-1227	Transformer Oil	Soil
38	Hawaii	Pahoa	Puna Geothermal Venture Turbine oil release	20120119-0650	Turbine 68 Oil	Soil
39	Hawaii	Pepeekeo	HELCO transformer substation #92042 release	20120210-1252	Transformer Oil	Soil
40	Hawaii	Puna	HELCO pole-mounted transformer #99A254603 release	20110715-1501	Transformer Oil	Soil
41	Hawaii	Waimea	Waimea Hawaii Mercury	20120328-1410	Mercury	Concrete/Air
42	Kauai	Kekaha	Bradley Pacific Aviation fuel tanker rollover	20120627-1036	Jet Fuel A	Soil
43	Kauai	Kekaha	NRC 986827	20110822-1524	Unknown	Ocean
44	Kauai	Kekaha	Pacific Missile Range Auto Fuel Spill	20120606-0930	Auto Fuel	Asphalt
45	Kauai	Lihue	Air Services Fuel Spill	20120304-1700	Jet Fuel A	Soil
46	Kauai	Lihue	Aloha Cargo hydraulic oil spill Lihue	20111028-0930	hydraulic Oil (Chevron AW)	Concrete
47	Kauai	Lihue	ILWU Union Hall vandalism	20110830-1318	Muriatic Acid	Other
48	Kauai	Lihue	Kauai Petroleum	20110721-1528	Petroleum (type unknown)	Soil
49	Kauai	Lihue	Sapphire Princess releasing Grey Water	20120212-1540	Greywater	Ocean
50	Kauai	Polihale	Oil Globules 983208	20110719-1600	Oil	Ocean
51	Lanai	Lanai City	Pete's Auto NRC 986562	20110819-1600	Unknown	Soil
52	Maui	Haiku	MECO pole-mounted Transformer # 7513 release	20120313-1437	Transformer Oil	Soil
53	Maui	Hana	Hawaiian Commercial and Sugar Company, Generator Spill	20120419-0700	Oil, Motor	Soil
54	Maui	Hana	Koki Beach - Abandoned Drum	20110926-0557	Unknown	Drum or Other Container
55	Maui	Hana	MECO Pole-mounted Transformer #6940	20110711-1346	Ergon Hy-Volt II Insulating Oil	Soil
56	Maui	Kahului	MECO Pad-mount Transformer #17290	20111008-0350	Transformer Oil	Soil
57	Maui	Kahului	MECO pad-mounted #15382 transformer release	20110811-1318	Transformer Oil	Concrete
58	Maui	Kahului	MECO silicone grease release	20111031-0947	Silicon grease	Soil

[28] State of Hawai'i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai'i 2003, December 20012

Table 16.4 (continued) State of Hawai'i Response Program Release Notification Log– FY 2012[29]

	Islands	Locality	Unit Name	Case Number	Substances	Media
59	Maui	Kahului	MECO sub transformer#4934 release	20110922-1240	Transformer Oil	Soil
60	Maui	Kahului	MECO Transformer 4926 Release	20110913-0809	Transformer Oil	Soil
61	Maui	Kaunakakai	MECO pole-mounted transformer #329 release	20120302-0923	Transformer Oil	Soil
62	Maui	Keauhou	HECO sub-station transformer release	20120522-1134	Transformer Oil	Soil
63	Maui	Kihei	MECO generator diesel fuel release	20120118-1414	Diesel Fuel	Soil
64	Maui	Kihei	MECO TRANSFORMER #7742 release	20111230-0951	Transformer Oil	Soil
65	Maui	Kihei	MECO transformer pad-mounted #9750 release	20120228-1407	Transformer Oil	Soil
66	Maui	Lahaina	Gas Tank Fuel Release - Lahaina Small Boat	20110926-1118	Fuel Gas	Ocean
67	Maui	Lahaina	Hammerhead Metals radiation NRC 986566	20110819-1605	Radium	Air
68	Maui	Lahaina	Hyatt Regency Maui Resort diesel spill	20110907-0800	Diesel #2	Soil
69	Maui	Lahaina	MECO Pad-mount Transformer #10376 Release	20110831-1023	Ergon Hy-Volt II Insulating Oil	Concrete
70	Maui	Lahaina	MECO pad-mounted transformer #8943 release	20111213-1057	Transformer Oil	Soil
71	Maui	Lahaina	MECO pole-mounted #9844 transformer release	20110913-0810	Transformer Oil	Soil
72	Maui	Lahaina	MECO transformer pad-mounted # 8943 release	20111201-1148	Transformer Oil	Soil
73	Maui	Lahaina	MV Pacific Maid	20120207-0940	Diesel Fuel	Ocean
74	Maui	Lahaina	Trespassing at the Restricted Zone - Lahaina Harbor Pier	20111031-0554	Unknown	Ocean
75	Maui	Lahaina	Vessel Pacific Maid	20120207-0940LG	Diesel Fuel	Ocean
76	Maui	Makawao	MECO pad-mounted transformer #5269 release	20120314-1242	Transformer Oil	Soil
77	Maui	Makawao	MECO transformer pad-mounted # 6423 release	20120314-1243	Transformer Oil	Soil
78	Maui	Makawao	MECO transformer pad-mounted #7951 release	20111223-1110	Transformer Oil	Soil
79	Maui	Makawao	MECO transformer pad-mounted #8111 release	20120202-1200	Transformer Oil	Soil
80	Maui	Ocean	Engine Oil Release in Pacific Ocean	20110926-0556	Oil, Engine	Ocean
81	Maui	Ocean	Unknown Sheen NRC 1003098	20120205-1546	Unknown oil	Ocean
82	Maui	Ocean	USS Sea Commander	20110926-1220	Engine oil	Ocean
83	Maui	Wailea	Mercury in Mayonnaise Jar	20111101-1224	Mercury	Within Facility
84	Maui	Wailuku	MECO submersible transformer #9870 release	20111215-1010	Transformer Oil	Soil
85	Maui	Wailuku	MECO TRANSFORMER PAD-MOUNTED #16667 RELEASE	20120125-1104	Transformer Oil	Soil
86	Maui	Wailuku	MECO transformer pad-mounted #17494 RELEASE	20111128-1132	Transformer Oil	Soil
87	Molokai	Kaunakakai	Molokai trench pipe work	20120626-1400	Oil	Groundwater
88	Molokai	Maunaloa	MECO transformer #n355793yhta pad-mounted release	20110930-1539	Transformer Oil	Soil

[29] State of Hawai'i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai'i 2003, December 20012

Table 16.4 (continued) State of Hawai'i Response Program Release Notification Log– FY 2012[30]

	Islands	Locality	Unit Name	Case Number	Substances	Media
89	Oahu	Aiea	98-087 Kamehameha Highway Fugitive Drums	20120207-1030	Unknown	Soil
90	Oahu	Aiea	98-1005 Moanalua Road Hydraulic Oil release	20120409-1509LG	Hydraulic	Soil
91	Oahu	Aiea	HECO pad-mounted transformer #49975 release	20120607-1421	Transformer Oil	Soil
92	Oahu	Aiea	HECO transformer pad-mounted #63351 release	20120622-1004	Transformer Oil	Concrete
93	Oahu	Aiea	HECO vault #7171 transformer release	20120507-1112	Transformer Oil	Soil
94	Oahu	Barbers Point	Aloha petroleum gas release	20110927-2125	gasoline	Concrete
95	Oahu	Barbers Point	ALOHA PETROLEUM GASOLLINE RELEASE	20110927-2126	Gasoline	Concrete
96	Oahu	Barbers Point	Trespassing at Pier 5 & 6 Barbers Point	20111005-0635	Unknown	Ocean
97	Oahu	Barbers Point	USCG Air Base fuel spill	20110824-1340	JP-8	Asphalt
98	Oahu	Ewa Beach	HECO pad-mounted transformer #68530 release	20120410-1321	Transformer Oil	Soil
99	Oahu	Haleiwa	Gordon Saker	20120223-1425	Unknown	Soil
100	Oahu	Hilo	Chevron Hilo Terminal excavation discovery of FO#6	20111202-0859	Chevron Fuel Oil #6	Soil
101	Oahu	Hilo	Hawaii Community College hydraulic oil leak	20110718-1212	Hydraulic Oil	Concrete
102	Oahu	Honolulu	106 Lumahai HECO leaking transformer	20111130-1521	Transformer Oil	Asphalt
103	Oahu	Honolulu	1623 Kilohana Street dumping	20111209-2109	Kerosene	Soil
104	Oahu	Honolulu	3 Phase Pole Mount Transformers - 955 Kawaiahao	20111211-1252LG	Mineral Oil	Soil
105	Oahu	Honolulu	41-650 Waikupanaha Asbestos Pipes	20120120-1630	Asbestos (Pipe insulation)	Soil
106	Oahu	Honolulu	Ala Wai Canal Oil Release	20120530-1530	Oil	Stream
107	Oahu	Honolulu	BEI - #7 pipeline release	20110824-1130LG	Oil	Soil
108	Oahu	Honolulu	Boat Grounding Ala Wai Channel	20120224-2300	boat	Ocean
109	Oahu	Honolulu	Boat Grounding at Magic Island	20120125-1410	None	Ocean
110	Oahu	Honolulu	Bradley Pacific Aviation fuel spill gate 11 United Airlines	20110718-0950	Jet Fuel A	Asphalt
111	Oahu	Honolulu	Brown Slick in the Ala Wai Canal	20120511-1700	Unknown	Ocean
112	Oahu	Honolulu	C & C 7313 Pesticides	20120327-0930CCFM	Pesticides & Disinfectants	Air
113	Oahu	Honolulu	C&C of HONOLULU POLE-MOUNTED TRANSFORMER RELEASE	20111021-0803	Transformer Oil	Soil
114	Oahu	Honolulu	Copper thief caught stealing abandon transformer	20120515-0030	Transformer Oil	Soil and asphalt
115	Oahu	Honolulu	Diesel Fuel Release from the Barge Tara	20110919-0656	Diesel Fuel #2 Low Sulfur	Ocean
116	Oahu	Honolulu	DOT-H Tractor tire liquid	20120516-0856	Water + unknown	Asphalt
117	Oahu	Honolulu	Dumping of 5 gallon containers on H-3	20120607-1045	Unknown	Soil

[30] State of Hawai'i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai'i 2003, December 20012

Table 16.4 (continued) State of Hawai'i Response Program Release Notification Log– FY 2012[31]

	Islands	Locality	Unit Name	Case Number	Substances	Media
118	Oahu	Honolulu	Flame retardants in plastic flowers	20111212-1000	Flame Retardants	Soil
119	Oahu	Honolulu	Fluid Release from Crane at Pier 51	20110913-0655	Blake Fluid, Power Steering Fluid, Transmission Fluid	Ocean
120	Oahu	Honolulu	Gexpro	20111202-1310	Hydraulic	Ocean
121	Oahu	Honolulu	Grace Pacific Cold Planer Equipment 02651	20110916-1042LG	Hydraulic Fluid	Asphalt
122	Oahu	Honolulu	Grey Substance Behind Nimitz Center	20120211-0948	Unknown	Stream
123	Oahu	Honolulu	HART Boring BH-14	20111101-1250	petroleum	Soil
124	Oahu	Honolulu	HART Boring K2-286	20120112-1124	Petroleum contaminated soil	Soil
125	Oahu	Honolulu	HART Boring TP-D6	20111101-1253	Petroleum odor	Soil
126	Oahu	Honolulu	HART discovery of petroleum contamination	20120319-1500	Petroleum	Soil
127	Oahu	Honolulu	HART Project Soil Samples	20120328-2300	Oil	Soil
128	Oahu	Honolulu	HART Soil Boring 406	20111123-1028	Petroleum Hydrocarbon	Soil
129	Oahu	Honolulu	Hawaii Opera Theatre Prop Warehouse	20120201-1355	Benzopyrene, TPH	Soil
130	Oahu	Honolulu	Hawaiian Airlines NRC 986073	20110815-1900	Jet Fuel A	Concrete
131	Oahu	Honolulu	HECO pad-mounted transformer #31745 release	20120302-0921	Transformer Oil	Soil
132	Oahu	Honolulu	HECO pad-mounted #60393 transformer release	20110927-1310	Transformer Oil	Soil
133	Oahu	Honolulu	HECO pad-mounted #68059 transformer release	20110927-1309	Transformer Oil	Soil
134	Oahu	Honolulu	HECO pad-mounted release transformer#60398	20120125-1103	Transformer Oil	Soil
135	Oahu	Honolulu	HECO pad-mounted transformer # 56605 release	20120223-1408	Transformer Oil	Soil
136	Oahu	Honolulu	HECO pad-mounted transformer #24777 release	20120327-1329	Transformer Oil	Soil
137	Oahu	Honolulu	HECO pad-mounted transformer #45038 release	20120302- 0924	Transformer Oil	Soil
138	Oahu	Honolulu	HECO pad-mounted transformer #48969 release	20111216-1128	Transformer Oil	Soil
139	Oahu	Honolulu	HECO pad-mounted transformer #50100 release	20111216-1129	Transformer Oil	Soil
140	Oahu	Honolulu	HECO pad-mounted transformer #56500 release	20120401-1317	Transformer Oil	Concrete
141	Oahu	Honolulu	HECO pad-mounted transformer #60329 release	20111213-1056	Transformer Oil	Concrete
142	Oahu	Honolulu	HECO pad-mounted transformer #61514 release	20120419-1346	Transformer Oil	Soil
143	Oahu	Honolulu	HECO pad-mounted transformer #64949 release	20120628-1133	Transformer Oil	Concrete
144	Oahu	Honolulu	HECO pad-mounted transformer #68133 release	20120403-1356	Transformer Oil	Soil
145	Oahu	Honolulu	HECO pad-mounted transformer #68679 release	20120529-1308	Transformer Oil	Concrete
146	Oahu	Honolulu	HECO pad-mounted transformer #71387 release	20120607-1420	Transformer Oil	Soil

[31] State of Hawai'i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai'i 2003, December 20012

Table 16.4 (continued) State of Hawai'i Response Program Release Notification Log– FY 2012[32]

	Islands	Locality	Unit Name	Case Number	Substances	Media
99147	Oahu	Honolulu	HECO pad-mounted transformer release #71440	20111125-1159	Transformer Oil	Soil
148	Oahu	Honolulu	HECO pole mounted transformer #54138 release	20120604-1138	Transformer Oil	Soil
149	Oahu	Honolulu	HECO pole-mounted transformer #59734,5,6 release	20120113-1342	Transformer Oil	Asphalt
150	Oahu	Honolulu	HECO transformer #45808 pad-mounted release	20120127-1332	Transformer Oil	Soil
151	Oahu	Honolulu	HECO Transformer oil release	20120426-1204	Transformer Oil	Storm Drain
152	Oahu	Honolulu	HECO transformer pad-mount #61619 release	20120618-1009	Transformer Oil	Soil
153	Oahu	Honolulu	HECO transformer pad-mounted #35519 release	20120207-1251	Transformer Oil	Concrete
154	Oahu	Honolulu	HECO transformer pad-mounted #47071 release	20111223-1109	Transformer Oil	Soil
155	Oahu	Honolulu	HECO transformer pad-mounted #71203 release	20120629-0944	Transformer Oil	Concrete
156	Oahu	Honolulu	HECO transformer pad-mounted release #50107	20120127-1333	Transformer Oil	Concrete
157	Oahu	Honolulu	HECO transformer pad-mounted#46208 release	20120621-1117	Transformer Oil	Soil
158	Oahu	Honolulu	HFD gag cylinder report	20120122-0650	Compressed gas cylinder	Drum or Other Container
159	Oahu	Honolulu	Hickam JP8 spill at 10B	20111031-1445	JP-8	Asphalt
160	Oahu	Honolulu	Homemade disturbance at Old Stadium Park	20111207-0520	Corrosives	Other
161	Oahu	Honolulu	Honolulu Harbor Fishing Village petroleum discovery in grease trap excavation	20110712-1045	Petroleum	Groundwater
162	Oahu	Honolulu	Honolulu International Airport	20111219-1335	Unknown	Soil
163	Oahu	Honolulu	IDPP Nimitz Highway and Ala Kawa Street Water Main Break	20120306-1136LG	Crude Oil	Soil
164	Oahu	Honolulu	Iwilei and Pacific street power poles install/oil discovery	20120229-1127	Oil	Groundwater
165	Oahu	Honolulu	Jet Fuel Spilled at Gate 61	20111006-0632	Jet Fuel	Storm Drain
166	Oahu	Honolulu	Kiana Pt. small boat gas release	20111201-2138	Gasoline	Ocean
167	Oahu	Honolulu	Kokohead DAGS diesel spill	20120103-1000	Diesel fuel (Off-road)	Soil
168	Oahu	Honolulu	Kokohead Regional Park transformer	20110711-1635	Transformer Oil	Soil
169	Oahu	Honolulu	MATSON NAVIGATION oil release	20110723-1100	Hydraulic Oil	Ocean
170	Oahu	Honolulu	Mid-Pac petroleum gasoline release	20120521-1420	Gasoline	Concrete
171	Oahu	Honolulu	Neighbor fixing cars and fumes are stink	20120605-1122	Petroleum Hydrocarbon	Air
172	Oahu	Honolulu	Nimitz Highway oil discovery at 3'	20110831-1116	Oil	Soil
173	Oahu	Honolulu	NOAA pier air compressor explosion	20120111-0815	Compressor oil	Water, pier, and vessel
174	Oahu	Honolulu	NRC 1010442	20120503-0852	Oil	Ocean

[32] State of Hawai'i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai'i 2003, December 20012

Table 16.4 (continued) State of Hawai'i Response Program Release Notification Log– FY 2012[33]

	Islands	Locality	Unit Name	Case Number	Substances	Media
175	Oahu	Honolulu	NRC 1010664	20120507-0808	None	Within Facility
176	Oahu	Honolulu	NRC 988163	20110901-1621	None	Within Facility
177	Oahu	Honolulu	NRC 989873	20110916-1152	Diesel Fuel	Within Facility
178	Oahu	Honolulu	Oil spill from NOAA's ship Hi'ialakani	20111026-1452	Vegetable oil used as hydraulic oil	Ocean
179	Oahu	Honolulu	Pacific Shipyards International hydraulic oil spill	20120629-1558	Hydraulic Oil	Ocean
180	Oahu	Honolulu	Parson Brinkerhoft Release Notification	20120217-1305	Oil	Soil
181	Oahu	Honolulu	PCS Oil Drum Spill	20120307-1400	Oil, Used	Drum or Other Container
182	Oahu	Honolulu	Pearl Harbor B15 pier	20120525-1314	Diesel Fuel	Ocean
183	Oahu	Honolulu	Petroleum Product Discovered by Honolulu Rapid Transit Project	20120214-1140	Petroleum Oil	Soil
184	Oahu	Honolulu	Pride of America NRC 998112	20111214-1035LG	Hydraulic Oil	Ocean
185	Oahu	Honolulu	Prince Edward Street dumping	20110712-0800CCFM	Unknown	Drum or Other Container
186	Oahu	Honolulu	Quik Fix Cycles	20120105-1404	Oil sheen	Storm Drain
187	Oahu	Honolulu	R22 Release at Aliamanu Military Reservation	20120227-1157	R-22	Air
188	Oahu	Honolulu	Rainbow Sheen by Pier 19	20120209-1338	Oily Water Mixture	Ocean
189	Oahu	Honolulu	Reported Oil Dumping in Ala Wai Park	20120227-1210	Oil	Soil
190	Oahu	Honolulu	Robello Lane drums	20110725-0838	Petroleum	Soil
191	Oahu	Honolulu	Rock Star Mercury	20120416-1230	Mercury	Other
192	Oahu	Honolulu	Sample Disposal	20110728-0930	Various	Within Facility
193	Oahu	Honolulu	Sewer gas at Keahole Street	20120113-0735	Sewer gas	Air
194	Oahu	Honolulu	Sheen from a fishing vessel in Kewalo Basin	20120420-0853	Oil	Ocean
195	Oahu	Honolulu	Soil Potholing for disposal - rail transit	20120620-1535	Lead, Oil	Soil
196	Oahu	Honolulu	Station K2-292	20120423-1140LG	Petroleum	Soil
197	Oahu	Honolulu	TESORO refinery gas oil release	20111025-1728	Gasoil	Soil
198	Oahu	Honolulu	Transformer oil spill	20120126-1403	Transformer Oil	Soil
199	Oahu	Honolulu	Unknown Historical Petroleum Release at North School St	20110919-1524	Petroleum	Soil
200	Oahu	Honolulu	Unknown Sheen 996924	20111201-0951	Unknown	Ocean
201	Oahu	Honolulu	Unknown Sheen at Ala Wai Harbor	20120314-0800	Oil	Ocean
202	Oahu	Honolulu	Unknown Sheen at Ala Wai Boat Harbor	20110927-0733	Oil	Ocean

[33] State of Hawai'i Department of Health, Report to the Twenty-Seventh Legislature, State of Hawai'i 2003, December 20012

16.4 Mitigation Strategies

16.4.1 Previous, Ongoing, and Future Projects

1. The Hazardous Materials Emergency Response Plan was last updated in 2010. The plan is periodically reviewed and the next update is projected for 2015.

2. *Training and Exercises are periodically conducted across all counties in the State. Types of training and exercises include, but are not limited, to the following:*

    - Introduction to CAMEO
    - Advanced CAMEO Applications for All Hazards
    - Hazmat IQ Training
    - Hazmat First Responder Operations Training
    - Hazmat Technician Certification Course
    - Fire Department/Police Department/CST Joint Training and Exercise

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

17. Health Risk and Vulnerability Assessment

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CHAPTER 17
Health Risk and Vulnerability Assessment

17.1 Health Risk Description

17.1.1 General

Health-related impacts have occurred with natural hazards, especially where water quality is compromised. Climate-related extreme events have resulted in gastrointestinal illness, respiratory problems (especially from wildfires), and vector-borne outbreaks, such as dengue. In the 2009 tsunami in American Samoa, there were reports of dengue hemorrhagic fever outbreaks. It is important to consider potential health-related disasters, and to factor these considerations in disaster risk reduction efforts and hazard mitigation planning.

17.1.2 Infectious Diseases

17.1.2.1 Dengue Fever

An outbreak that occurred in 2001 and 2002 involved a statewide effort to provide information and testing to the public. Response to the outbreak in 2001-2002 required coordination among the county government, the State Department of Health, State Civil Defense, and the Centers for Disease Control. Excerpts of an article covering the event, prepared by the State of Hawai‘i Department of Health and the Centers for Disease Control follow[1]

In September 2001, the State of Hawai‘i Department of Health was notified of an unusual febrile illness in a resident with no travel history; and shortly thereafter dengue fever was confirmed. During the investigation, 1,644 persons with locally acquired dengue-like illness were evaluated, 122 (7%) laboratory-positive dengue infections were identified; and dengue virus serotype 1 was isolated from 15 patients. No cases of dengue hemorrhagic fever or shock syndrome were reported. In 3 instances autochthonous infections were linked to a person who reported dengue-like illness after travel to French Polynesia. Phylogenetic analyses showed the Hawaiian isolates were closely associated with contemporaneous isolates from Tahiti in French Polynesia.

17.1.2.2 Leptospirosis

[1] Effler P, Pang L, Kitsutani P, Vorndam V, Nakata M, Ayers T, et al., Dengue fever, Hawai‘i, 2001–2002, retrieved from http://www.cdc.gov/ncidod/EID/vol11no05/04-1063.htm

Leptospirosis is a bacterial disease that affects humans and animals. It is caused by bacteria of the genus *Leptospira*. In humans it causes a wide range of symptoms, and some infected persons may have no symptoms at all. Symptoms of leptospirosis include high fever, severe headache, chills, muscle aches, and vomiting, and may include jaundice (yellow skin and eyes), red eyes, abdominal pain, diarrhea, or a rash. If the disease is not treated, the patient could develop kidney damage, meningitis (inflammation of the membrane around the brain and spinal cord), liver failure, and respiratory distress. In rare cases death occurs. Many of these symptoms can be mistaken for other diseases. Leptospirosis is confirmed by laboratory testing of a blood or urine sample.

Leptospirosis occurs worldwide but is most common in temperate or tropical climates. It is an occupational hazard for many people who work outdoors or with animals, for example, farmers, sewer workers, veterinarians, fish workers, dairy farmers, or military personnel. It is a recreational hazard for campers or those who participate in outdoor sports in contaminated areas and has been associated with swimming, wading, and whitewater rafting in contaminated lakes and rivers. The incidence is also increasing among urban children.

17.1.3 Pandemic Flu

There are numerous types of pandemic flu and the strains of the virus continue to mutate and change. Each county has been required to develop procedures for dealing with this type of "disaster" threat. With many of the recommendations being social distancing, it is important to plan for the eventuality of a pandemic to determine how to maintain businesses and services to prevent economic collapse in addition to the health threats.

17.1.3.1 H5N1 or Avian Flu

Avian influenza is an infection caused by avian influenza (bird flu) viruses. These influenza viruses occur naturally among birds. Wild birds worldwide carry the viruses in their intestines, but usually do not get sick from them. However, avian influenza is very contagious among birds and can make some domesticated birds, including chickens, ducks, and turkeys, very sick and kill them.

Infected birds shed influenza virus in their saliva, nasal secretions, and feces. Susceptible birds become infected when they have contact with contaminated secretions or excretions or with surfaces that are contaminated with secretions or excretions from infected birds. Domesticated birds may become infected with avian influenza virus through direct contact with infected waterfowl or other infected poultry, or through contact with surfaces (such as dirt or cages) or materials (such as water or feed) that have been contaminated with the virus.

Infection with avian influenza viruses in domestic poultry causes two main forms of disease that are distinguished by low and high extremes of virulence. The "low pathogenic" form may go undetected and usually causes only mild symptoms (such as ruffled feathers and a drop in egg production). However, the highly pathogenic form spreads more rapidly through flocks of poultry. This form may cause disease that affects multiple internal organs and has a mortality rate that can reach 90-100% often within 48 hours.

While there has been some human-to-human spread of H5N1, it has been limited and unsustained. For example, in 2004 in Thailand, probable human-to-human spread in a family resulting from prolonged and very close contact between an ill child and her mother was reported. Most recently, in June 2006, the World Health Organization (WHO) reported evidence of human-to-human spread of the virus in Indonesia. In this situation, eight people in one family were infected. The first family member to be infected is thought to have become ill through contact with infected poultry. This person then infected six family members. One of those six people (a child) then infected another family member (his father). No further spread outside of the exposed family was documented or suspected.

Nonetheless, because all influenza viruses have the ability to change, scientists are concerned that H5N1 virus one day could be able to infect humans and spread easily from one person to another. Because these viruses do not commonly infect humans, there is little or no immune protection against them in the human population. If H5N1 virus were to gain the capacity to spread easily from person to person, an influenza pandemic (worldwide outbreak of disease) could begin. For more information about influenza pandemics, see the United States Government webpage dedicated to the flu virus at www.flu.gov.

17.1.3.2 H1N1 or Swine Flu

During the period from 2007 to 2010, there were incidents of swine flu (H1N1) outbreaks in the State of Hawai‘i. Of particular concern is the 2009 the outbreak of H1N1 Pandemic that resulted in several deaths from the flu. Similar to other outbreaks, the virus spread with international travelers. This is particularly concerning for the state since it is among the most remote places on the planet, and it will be difficult to sustain livelihoods should the state lose connection with the United States mainland or international travel.

17.1.4 Bioterrorism

The Center for Disease Control (CDC) defines a bioterrorism attack as the deliberate release of viruses, bacteria, or other germs (agents) used to cause illness or death in people, animals, or plants. These agents are typically found in nature, but it is possible that they could be changed to increase their ability to cause disease, make them resistant to current medicines, or to increase their ability to be spread into the environment. Biological agents can be spread through the air, through water, or in food. Terrorists may use biological agents because they can be extremely difficult to detect and do not cause illness for several hours to several days. Some bioterrorism agents, like the smallpox virus, can be spread from person to person and some, like anthrax, cannot.[2]

[2] United Stats Center for Disease Control (CDC), 2007

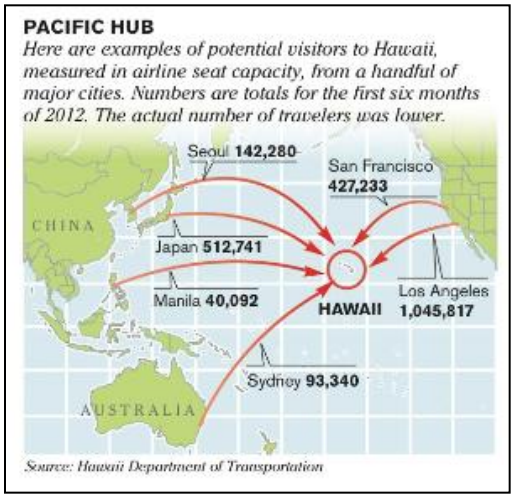
17.2 Significant Historical Events

The first large-scale dengue fever epidemic in the State of Hawai‘i occurred in the late 1840s. A second outbreak occurred at the turn of the century, with an estimated 30,000 cases. Epidemic dengue occurred again on the island of O‘ahu between 1943 and 1944, when 1,498 infections were reported, mostly in urban areas of the city of Honolulu. *Aedes albopictus* had been introduced into the Hawaiian Islands at the beginning of the century, and by 1940 it was the dominant day-biting *Stegomyia* mosquito species in the islands.[3]

17.3 Probability of Occurrence

The Honolulu International Airport on the island of O‘ahu (City and County of Honolulu) is ranked 25th in the nation in terms of number of passengers. Nonetheless, this airport ranks third highest in the nation for the risk of spreading the next pandemic because of three factors; its preponderance or long-distance flights that can allow germs to incubate and spread en route; its central location between Asia and the United States mainland; and regular connections to “other massive hubs, which are themselves powerful spreaders.” Figure 17-1 depicts passenger statistics passengers and ranking for the Honolulu International Airport. Tourists and returning residents sometimes board Hawai‘i-bound flights while feeling ill and try to avoid detection when they arrive in Honolulu, State of Hawai‘i epidemiologist Sarah Park said. State of Hawai‘i health officials rely on airline flight crews and federal Transportation Security Administration (TSA), customs and border protection agents to spot passengers at Honolulu Airport who may be sick while arriving or departing, Park also said. Once a patient is identified on an inbound flight by a crew member, the airport’s medical staff on the ground will keep everyone on board while they spend 5 to 10 minutes assessing the ill passenger.

Figure 17-1 Honolulu International Airport Ranking[4]



U.S. airports judged as posing the greatest risk of spreading a pandemic:

1. New York John F. Kennedy
2. Los Angeles
3. Honolulu
4. San Francisco
5. Newark Liberty
6. Chicago O’Hare
7. Washington Dulles

[3] Effler et al. 2002
[4] Massachusetts Institute of Technology (MIT) online journal, PLoS ONE, July, 2012

17.4 Risk Assessment

The risks from health-related hazards have not changed significantly since 2007. As during the previous three years, new types of pandemic threats have emerged and this involves the attention of State and County civil defense agencies. Therefore, it is important to consider the types of risks and impacts in order to inform hazard mitigation.

17.4.1 Costs of Addressing Health-Related Disasters

Health risks may increase with the occurrence of natural and human-induced disasters. During the stream flooding disasters, people working in cleaning the debris became exposed to leptospirosis (a bacterial disease resulting from exposure to water contaminated with urine of infected animals that could result in a range of problems, including kidney damage, meningitis, and death). Studies at the University of Hawai‘i at Mānoa and at the East-West Center have demonstrated links between climate variability and El Niño Southern Oscillation (ENSO) cycles with outbreaks of dengue fever.

Efforts to address the dengue outbreak in 2001-2002 in the State of Hawai‘i (the end of a La Niña event), resulted in an extensive public health effort, including: active surveillance at public health facilities, increased monitoring efforts, free testing provided to the public, and increased public awareness through the press.[5] Coordination occurred among state and county governments, the Department of Health, State Civil Defense, County Civil Defense agencies, and the Centers for Disease Control. The cost of this response effort has not been fully assessed. With increased climate extremes associated with climate change, there may be increased efforts such as this in the future.

Health-related hazards may also include mental health and post-traumatic stress disorders associated with disasters. There will be increased vulnerability from populations already at risk-----those with special needs, those with mental illnesses, those with severe illnesses, and those who might be homeless. First responders to disasters will also require monitoring for post-traumatic stress, depending on the characteristics of the disaster. For example, responders during the 9-11 World Trade Center (New York City) crisis witnessed tremendous death and injury, and months later many suffered respiratory and other illnesses from toxins released in the burning. Society has to bear the long-term costs on the physical and mental health of crises on first responders and the general population.

Scenarios suggested with avian flu or other disease scares, such as SARS and H1N1, would have a significant impact on tourism as people decrease their travel. Following the September 11, 2001 terrorism event in New York City, the State of Hawai‘i experienced significant declines in tourism to Hawai‘i because of the fear of flying.

The United States Congress estimated that H1N1 resulted in significant costs in lost work: “Data from our National Center for Health Statistics in 2008 show, for example, that employed adults 18 years of age and over experienced an average of 4.4 work-loss days per person due to illness

[5] Effler et al 2002

or injury in the past 12 months, for a total of approximately 698 million work-loss days".[6] The United Kingdom estimated that the cost of H1N1 was approximately $1.8 billion.[7] Data does not exist for the costs of H1N1 response in the State of Hawai'i; however, visitor arrivals were fewer during the period of the outbreak (although it is uncertain whether this was attributed to the downward economy or H1N1), and ultimately the State of Hawai'i lost critical revenue.

It took almost a decade for tourism to rebound on the County of Kaua'i after Hurricane Iniki. Scares of infectious disease and pandemic flu could collapse the economy. Efforts to include risk and vulnerability for health-related disasters need to be incorporated into risk reduction efforts.

[6] Anne Schuchat, M.D., Acting Deputy Director for Science and Program Centers for Disease Control and Prevention Assistant Surgeon General, U.S. Public Health Service, U.S. Department of Health and Human Services (HHS)

[7] Wise 2010

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18. Climate Change Effects

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CHAPTER 18
Climate Change Effects

18.1 Climate Change Effects Description

18.1.1 General

This section on climate variability and change has been incorporated as a separate section of the plan beginning with the 2007 Plan Update. Climate Variability and Climate Change can each result in hazards, or they can exacerbate and facilitate impacts from other hazards included in this Mitigation Plan. The release of the Intergovernmental Panel on Climate Change (IPCC) scientific assessment reports in early 2007, the publication of the U.S. Global Change Report in 2009, and the growing public awareness on the issue of climate change have drawn international public attention to changes in climate that could potentially precipitate natural disasters.

For islands, climate change is expected to result in increases in temperature, extreme variation in precipitation (resulting in drought or flooding), potential changes in storm systems (possibly more frequent or increased magnitude), and rise in sea levels.

Near- and long-term climate risks from these changes will have significant impacts on the Hawaiian Islands in terms of: changes to ecosystem and ecosystem services, survival of community settlements, and security of water and food resources. Development choices in combination with these changes will have consequences on the degree of severity and costs associated with future hazard events. One reason that this section is separated from the other hazards is to avoid confusion in causality, as the other hazards have occurred independently of correlation with periods of climate variability. Although some of the other hazards addressed in this plan (hurricanes, floods, droughts, and wildfires) may be related to seasonal and inter-annual climate variation, global warming is without doubt related to long-term changes in climate that can lead to increased disaster occurrence or increased losses.

In order to address a range of climate risks for the State of Hawai‘i in this mitigation plan, the plan developers and the members of the Hawai‘i State Hazard Mitigation Forum (SHMF) decided to incorporate the discussion of climate change into a separate section of the plan that includes discussions of climate variability and change and sea level rise. For this chapter, the inclusion of this section enables the State to think about the characteristics and science of the climate system, and to think about the full range of climate-related impacts.

Coastal shorelines and ecosystems are at risk from climate change, which may have significant impacts on geological hazards such as erosion, landslides, and sea level rise. 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.

18.1.2 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 and inter-annual climate in periods that deviate significantly from the "normal" 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 explanations have been copied directly following from the NOAA Pacific Marine Environmental Laboratory website: http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html.

18.1.3 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. Among these consequences are increased rainfalls beginning at the southern tier of the continental United States and extending south all the way to Peru. While El Niño brings increased rainfall to the east of the Pacific basin, drought occurs at locations in the west of the Pacific basin, such as Australia. Therefore, El Niño is typically responsible for destructive flooding in the East Pacific and drought in the West Pacific, sometimes associated with devastating brush fires in Australia. Observations of conditions in the tropical Pacific are considered essential for the prediction of short term (a few months to 1 year) climate variations. To provide necessary data, the National Oceanic and Atmospheric Administration (NOAA) operates a network of buoys which measure temperature, currents and winds in the equatorial band. These buoys daily transmit data which are available to researchers and forecasters around the world in real time.

In normal, non-El Niño conditions (see Figure 18.1, 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 sea surface is 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. The observations at 110 W (left diagram of 110 W conditions) show that the cool water (below about 17 degrees C, the black band in these plots) is within 50m of the surface.

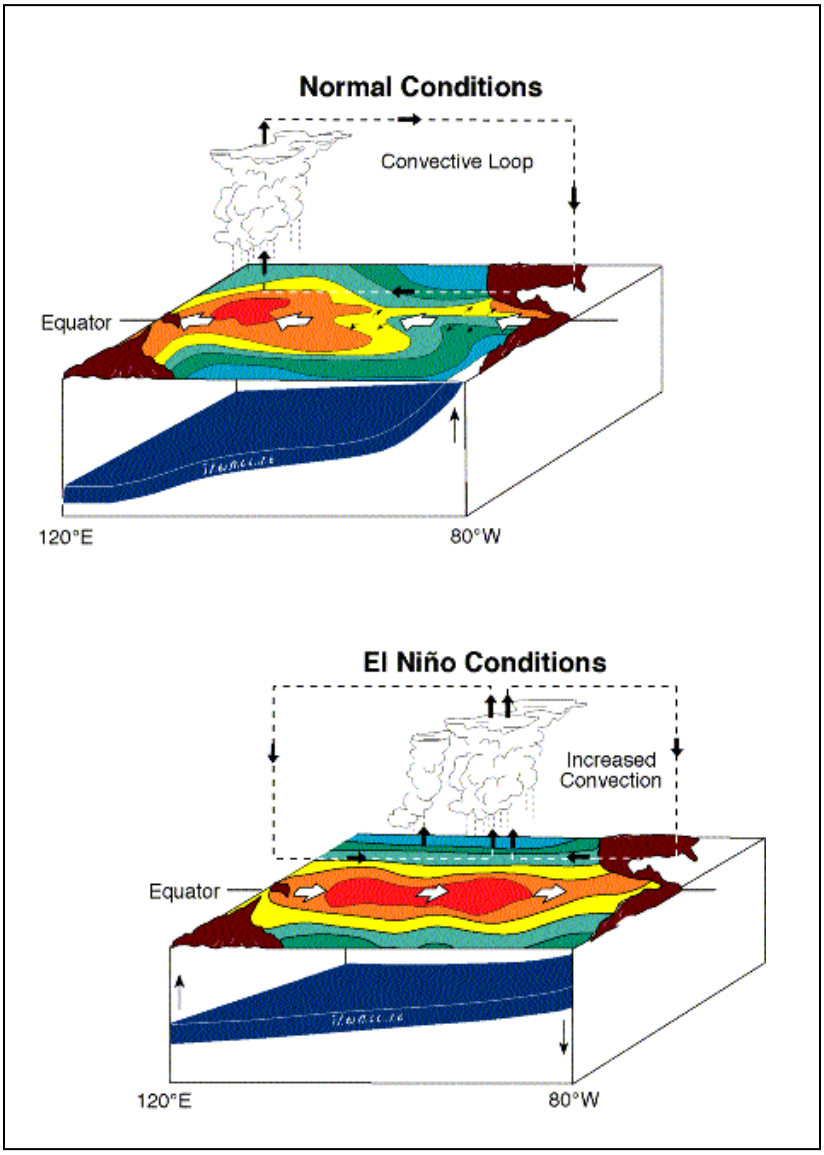

Figure 18.1 Depictions of El Niño Southern Oscillation (ENSO) Warm and Normal in the Cycle[1]

During El Niño (see Figure 18.1, 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. The observations at 110W show, for example, that during 1982-1983, the 17-degree isotherm dropped to about 150m depth. This reduced the efficiency of upwelling to cool the surface and cut off the supply of nutrient rich thermocline water to the euphotic zone. The result was a rise in sea surface temperature and a

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

drastic decline in primary productivity, the latter of which adversely affected higher trophic levels of the food chain, including commercial fisheries in this region. The weakening of easterly trade winds during El Niño is evident in Figure 18.1 as well. Rainfall follows the warm water eastward, with associated flooding in Peru and drought in Indonesia and Australia. The eastward displacement of the atmospheric heat source overlaying the warmest water results in large changes in the global atmospheric circulation, which in turn force changes in weather in regions far removed from the tropical Pacific.

18.1.4 Pacific Effects of El Niño

ENSO events vary during each event 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, which sit amidst the Earth's climate system, 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 have been effects that during that period dominate over the trends in climate change. As mentioned above, temperature increases and results in a greater number of hotter days during El Niño.

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.

18.1.5 El Niño and Global Warming

There has been abundant research on the correlation between El Niño and global warming. Recent research at the University of Hawai'i at Mānoa found that El Niño activity in the late 20th century was anomalously high over the past seven centuries and is thus suggestive of a response to continuing global warming[2]. The research, led by Jinbao Li and Shang-Ping Xie, analyzed over 2,000 tree-ring growth records from around the Pacific Basin. As the authors explain, evidence of El Niño activity encoded in the tree rings corresponded closely with data from equatorial Pacific corals and other temperature reconstruction data. The scientists also analyzed volcanic activity over the centuries to assess how changes in the composition of the Earth's atmosphere might affect El Niño. Following a major eruption, they found that temperatures dropped because volcanic ash blocked the sun, followed by unusual warming the following year. Li explains that similarly to greenhouse gasses, volcanic aerosols disturb the planet's radiation

[2] Essoyan, Susan, UH Research ties stronger El Niño to Global Warming, Honolulu Star Advertiser, July 7, 2013

balance. This finding supports the idea that the unusually high El Niño activity observed in the late 20th century is a footprint of global warming. Xie, also a climate science professor at Scripps Institution of Oceanography, insists that climate models diverge on the correlation of El Niño and global warming and that his and Li's study adds more evidence to support a connection between the two phenomena. The results from this study are expected to serve as a guide to improve the accuracy of climate models and their projections of future El Niño activity.

18.2 Significant Historical Events

18.2.1 Recognizing El Niño

El Niño can be seen in measurements of the sea surface temperature (see Figure 18.2), which were made from the TAO Array of moored buoys. In December 1993, the sea surface temperatures and the winds were near normal, with warm water in the Western Pacific Ocean (in red on the top panel of December 1993 plot), and cool water, called the "cold tongue" in the Eastern Pacific Ocean (in green on the top panel of the December 1993 plot). The winds in the Western Pacific are very weak (see the arrows pointing in the direction the wind is blowing towards), and the winds in the Eastern Pacific are blowing towards the west (towards Indonesia). The bottom panel of the December 1993 plot shows anomalies, the way the sea surface temperature and wind differs from a normal December. In this plot, the anomalies are very small (yellow/green), indicating a normal December. December 1997 was near the peak of a strong El Niño year. In December 1997, the warm water (red in the top panel of the December 1997 plot) has spread from the western Pacific Ocean towards the east (in the direction of South America), the "cold tongue" (green color in the top panel of the December 1997 plot) has weakened, and the winds in the western Pacific, usually weak, are blowing strongly towards the east, pushing the warm water eastward. The anomalies show clearly that the water in the center of Pacific Ocean is much warmer (red) than in a normal December.

December 1998 was a strong La Niña (cold) event. The cold tongue (blue) is cooler than usual by about 3° Centigrade. The cold La Niña events sometimes (but not always) follow El Niño events.[3] The most recent El Niño appeared throughout 2010 with contributions to drought impacts.

[3] National Oceanographic and Atmospheric Administration (NOAA) Pacific Marine Environmental Laboratory (PMEL) website, retrieved August 7, 2013 from http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html

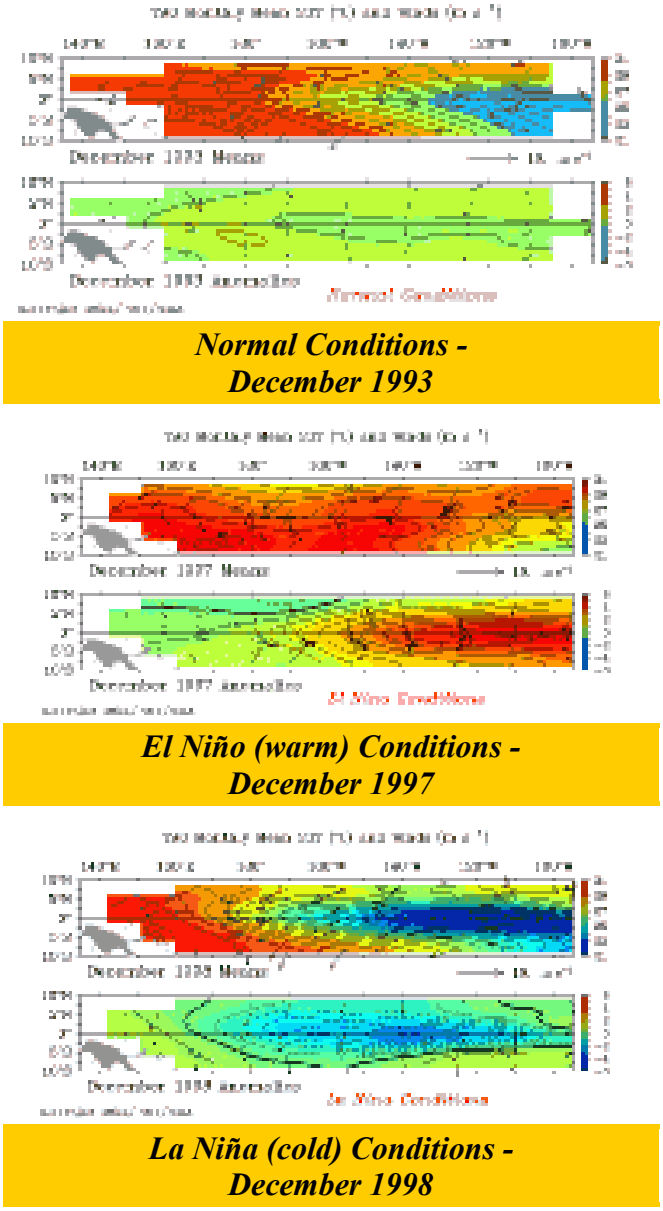

Figure 18.2 Correlation Between El Niño and Sea Surface Temperature in the Equatorial Pacific

18.3 Probability of Occurrence

Hawai‘i experiences a range of impacts to the environment, ecosystems, and ultimately the economy as a result of climate variation. These impacts identified at workshops and in a report Pacific Regional Assessment on the Consequences of Climate Variability and Change[4]. These impacts have been updated in the United States Global Change report that was published in 2009. The focus was on understanding sectoral impacts, yet the framework for the workshop tried to address issues in a proactive way, and enabled participants with different knowledge to work together and bring many perspectives, from business people, climate scientists, and cultural practitioners. An updated report from the United States Global Change is currently in progress and expected to be released in late 2013. In addition to the report by the United States Global Change, the University of Hawai‘i Sea Grant developed a simple fact sheet in 2010 that briefs on the impacts of Climate Change[5]. These two documents set the framework for the probability of occurrence and impacts of climate change in the State of Hawai‘i.

Water issues have been identified as the largest problem for the state. The State has already experienced severe drought, especially during ENSO periods. The changes in rainfall will have ramifications on ecosystem functions and on water security, and impact most sectors -- agriculture, health, public safety/fire suppression, and tourism. Currently, estimates of water availability in the future are uncertain. The Global Climate Models have not been scaled to assess local impacts adequately, although they work better for larger land masses than they do for islands in the Pacific Ocean. Researchers at the University of Hawai‘i are currently investigating the ways the climate will affect hydrology.

The Summary for Policymakers of the IPCC Working Group II report on Impacts, Adaptation and Vulnerability have observed the following impacts that are currently taking place. The document can be found online in full at the IPCC Fourth Assessment report website (http://www.ipcc.ch). The main points are copies below, with sub-points of major relevance to the State of Hawai‘i in the context of disaster risk reduction.

- ***Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.***
- ***A global assessment of data since 1970 has shown it is likely that anthropogenic warming has had a discernible influence on many physical and biological systems.***
- ***Other effects of regional climate changes on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers.***
- ***More specific information is now available across a wide range of systems and sectors concerning the nature of future impacts, including for some fields not covered in previous assessments.***

[4] Shea et al, 2001, www.pacificrisa.org

[5] University of Hawai‘i Sea Grant College Program, retrieved August 5, 2013, from http://seagrant.soest.hawaii.edu/sites/seagrant.soest.hawaii.edu/files/publications/ClimateBriefing__web.pdf

- Fresh water resources and their management
- Ecosystems
- Food, fiber, and forest products
- Industry, settlement, and society
- Health
- Coastal systems and low-lying areas
  - Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise. The effect will be exacerbated by increasing human-induced pressures on coastal areas.
  - Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1-3°C are projected to result in more frequent coral bleaching events and
  - widespread mortality in corals, unless there is thermal adaptation or acclimatization
  - Those densely-populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk.

- ***More specific information is now available across the regions of the world concerning the nature of future impacts, including for some places not covered in previous assessments.***
  - Small islands, whether located in the tropics or higher latitudes, have characteristics which make them especially vulnerable to the effects of climate change, sea level rise and extreme events.
  - Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources, e.g., fisheries, and reduce the value of these destinations for tourism.
  - Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities.

- ***Magnitudes of impact can now be estimated more systematically for a range of possible increases in global average temperature.***

The following Figure 18.3 comes from the same report. Impacts 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 18.3 shows, there are predictions of increased hazards. The graphic also indicates that rising global temperatures in tropical areas will result in decreased water availability. Health of many ecosystems, such as the coral reefs that provide shoreline protection, will be compromised and many species will not survive.

The illustrative examples of global impacts projected for climate changes included in Figure 18.3 (and sea-level and atmospheric carbon dioxide where relevant) are associated with different amounts of 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 approximate onset of a given impact. Quantitative entries for water scarcity and flooding represent the additional impacts of climate change relative to the conditions projected across the range of Special Report on Scenarios (SRES) scenarios. Adaptation to climate change is not included in these estimations.

Table 18.1 Examples of possible impacts of climate change due to changes in extreme weather and climate events, based on projections to the mid to late 21st century. These do not take into account any changes or developments in adaptive capacity. Examples of all entries are to be found in chapters in the full Assessment (see source at top of columns). The first two columns of this table are taken directly from the Working Group I Fourth Assessment (Table SPM-2). The likelihood estimates in Column 2 relate to the phenomena listed in Column 1. The direction of trend and likelihood of phenomena are for IPCC SRES projections of climate change.

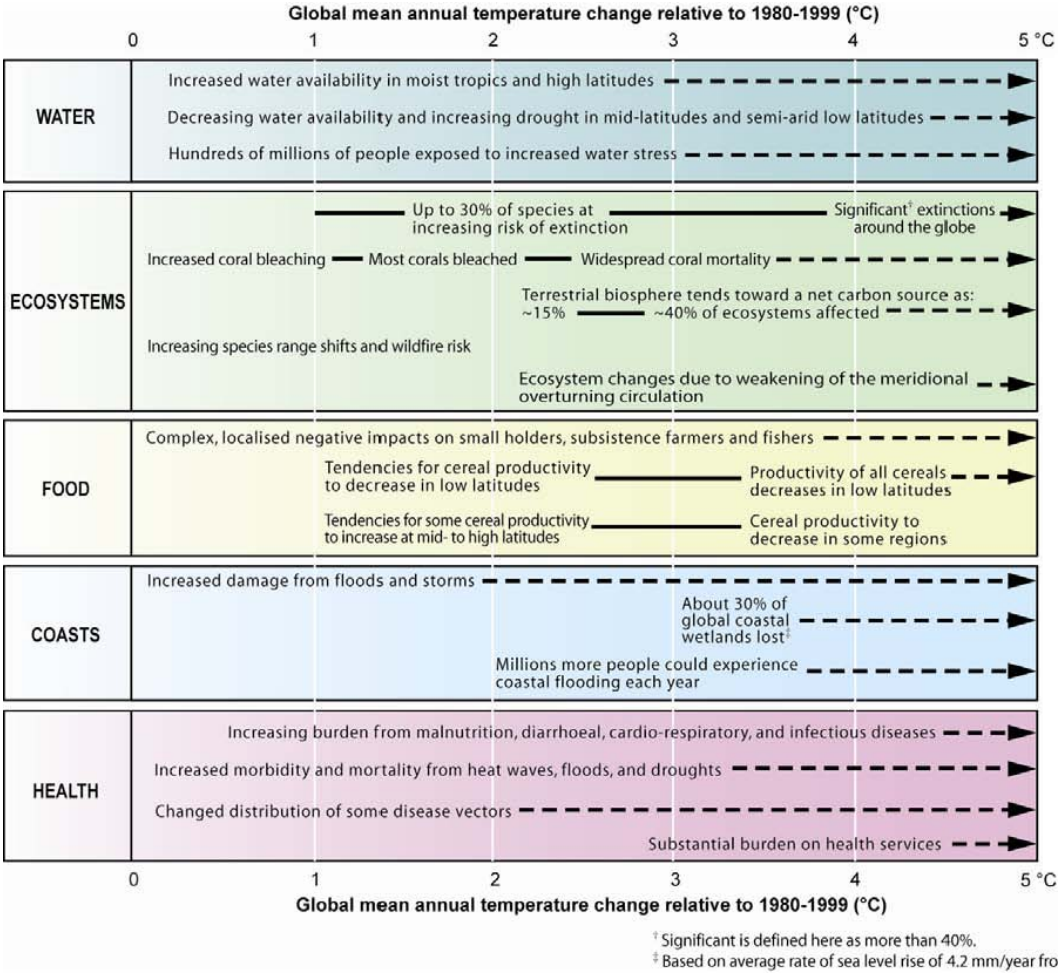

Figure 18.3 Key Impacts as a Function of Increasing Global Average Temperature Change[6]

[6] 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/

Table 18.1 Impacts Due to Altered Frequencies and Intensities of Extreme Weather, Climate, and Sea Level Events are Very Likely to Change[7]

Phenomena and direction of trend	Likelihood of future trends based on projections for 21st century using SRES scenarios	Examples of Major Projected Impacts by Sector			
		Agriculture, forestry and ecosystems	Water resources	Human health	Industry, settlement and society
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	Virtually certain[b]	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snow melt; effects on some water supply	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves. Frequency increases over most land areas	Very likely	Reduced yields in warmer regions due to heat stress; wild fire danger increase	Increased water demand; water quality problems, e.g., algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially-isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on elderly, very young and poor.
Heavy precipitation events. Frequency increases over most areas	Very likely	Damage to crops; soil erosion, inability to cultivate land due to water logging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries, infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property

[7] 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.18, April 2007, accessed from http://www.ipcc.ch/

Area affected by drought increases	Likely	Land degradation, lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water- and food-borne diseases	Water shortages for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	Likely	Damage to crops; uprooting of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of death, injuries, water- and food-borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers, potential for population migrations, loss of property
Increased incidence of extreme high sea level (excludes tsunamis) [e]	Likely	Salinization of irrigation water, estuaries, and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of death and injuries by drowning in floods; migration-related health effects	Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure; also see tropical cyclones above.

[a] See Working Group I Fourth Assessment Table 3.7 for further details regarding definitions
[b] Warming of the most extreme days and nights each year
[c] Extreme high sea level depends on average sea level and on regional weather systems. It is defined as the highest 1% of hourly values of observed sea level at a station for a given reference period.
[d] In all scenarios, the projected global average sea level at 2100 is higher than in the reference period [Working Group I Fourth Assessment 10.6]. The effect of changes in regional weather systems on sea level extremes has not been assessed.

18.4 Risk Assessment

18.4.1 Sea Level Rise

Global and local sea level change is of profound interest to researchers and planners due to it enormous potential impact on human populations living in coastal regions. Global sea level is projected to rise during the 21st century at a greater rate than during 1961 to 2003. One estimate from the IPCC Special Report on Emission Scenarios (SRES) A1B scenario by the mid- 2090s, forecasts that global sea level will be 0.44 meters above 1990 levels, and continue rising at about 4 millimeters per year. As we have seen in the past, sea level change in the future will not be geographically uniform, with some model projections predicting regional sea level change varying about ±0.15 meters of the mean (see Figure 18.4). Thermal expansion is projected to contribute more than half of the average rise, but land ice would lose mass increasingly rapidly as the century progresses.

A brief evaluation of current sea level rise model projections for this century produces an extremely wide range of possible estimates. Table 18.2 offers a summary of relevant research on some sea level projections.

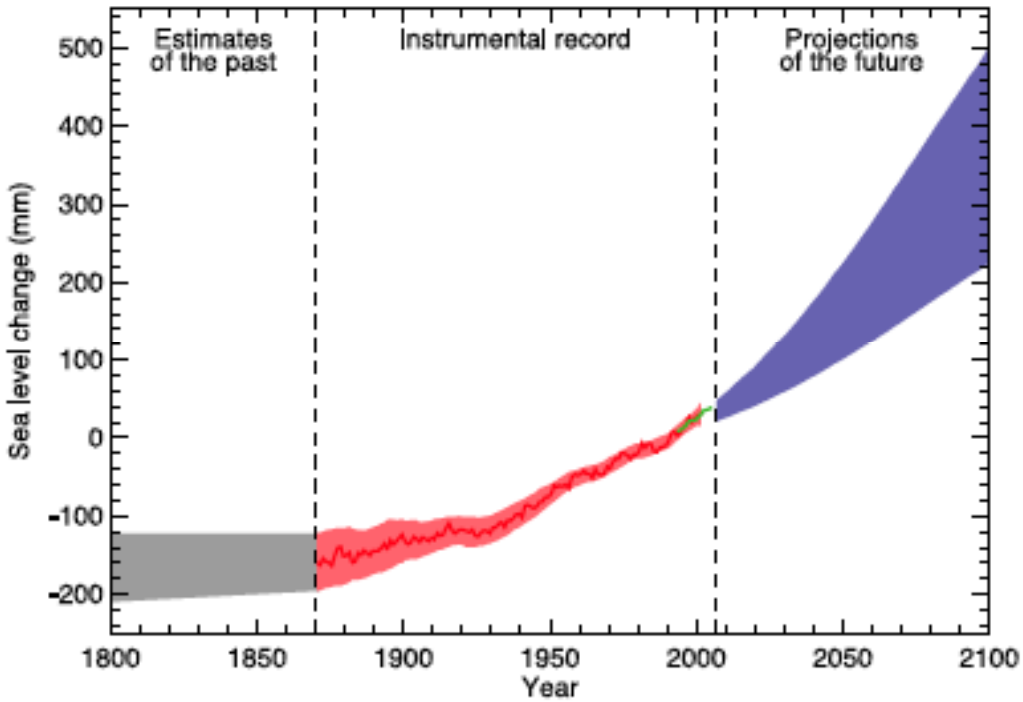

Figure 18.4 Time series of global mean sea level (deviation from the 1980-1999 mean) in the past and as projected for the future (IPCC, 2007b)

Table 18.2 Sea Level Rise Estimates

Sea level Rise Estimate	Source	Notes
0.2m to 0.6m.	IPCC (2007)	Estimate recognizes lack of modeled contribution from ice sheet wasting.
0.5m. to 1.5m	Rahmstorf (2007)	Uses linear projection of sea level based on temperature correlations from past century to produce sea level rise estimate this century.
2.0 to 3.0 m	Otto-Blienser, 2006	
3.0 to 5.0 m	Overpeck, *et al* 2006	Lead author for IPCC Working Group I report Paleo climate and Geologic records indicate ice sheet disintegration can yield sea level rise on the order several meters per century.

Sea level changes may be due to a variety of factors. Impacts may be seen in changes to shorelines and in coastal erosion. Whereas sea level changes occurring as a result of global climate change will impact all (US) coastal areas, Hawai‘i’s shorelines will be unique uniquely affected as a result of island subsidence processes. Because of loading of the Pacific tectonic plate by the growth of Hawai‘i’s volcanoes, lithostatic flexure (down-bowing) of the plate, as well as compaction of the volcanic products, causes the islands to sink at a measurable rate. The southern half of the island of Hawai‘i is subsiding at a rate of 2.5 mm/year (25 cm/100 years); the older islands are subsiding at a somewhat slower rate. All these rates are additive to the rise in sea level resulting from those associated with global climate change.

Since the release of the IPCC Fourth Assessment Report (AR4) in 2007, scientists have continued to study and publish results on climate change. The measurements on rates of increase of carbon in the atmosphere, the number of days of increased temperatures, and the rise of sea levels have exceeded the projected ranges from the IPCC AR4. The sea level rise projections in the IPCC AR4 ranged from 18-59 cm (0.18-0.59m) by 2100 (IPCC 2007); however, more recent studies indicate that trends will be far greater, on the order of 80-200cm (0.8-2.0 m) (Pfeffer et al. 2008) or up to 600 cm (6.0 m) with the contribution from Greenland and Antarctica ice sheets and averages of all projections targeting approximately 1.63 meters by 2100 (Otto-Bliesner et al. 2006; Overpeck et al. 2006; Rahmstorf et al. 2007; Vermeer and Rahmstorf 2009). Each coastline and each island will expect different rates of sea level rise due to the physical geography, geology, and bathymetry of the ocean. The Alliance of Small Island States (AOSIS) is looking at sea levels greater than one meter based on recent science, the continued warming trends, and non-binding agreements to reduce and limit greenhouse gases to well below 350 parts per million (ppm) and limit global average temperature increases to well below 1.5°C above pre-industrial levels (AOSIS 2010).

These ranges vary and since sea level rise is influenced by external global factors, it is important for local PACC teams to have a sense of the rate of sea level rise to set for planning purposes. Since infrastructure and development planning often has 30-50 year projected life, the research suggests that planning should consider at least a meter of rise by mid-century. Not only will plans need to consider sea level rise, but account for the additional saltwater from coastal inundation, high waves, tsunami, and extreme tides.

18.4.2 Tropical Cyclones and Global Warming

A recent Hawai‘i-focused study on global warming and the incidence of tropical cyclones predicts an increase in tropical cyclone frequency of occurrence around the Hawaiian Islands. This prediction, thus, highlights possible future increases in storm-related socio-economic and ecosystem damage for the Hawaiian Islands. While many studies have focused on the genesis of tropical cyclones in tropical central Pacific, this Hawai‘i-specific study concentrates on the effect of the surface warming n tropical cyclone activity in the subtropical region. The study, published by Murakami, Wang, Li and Kitoh in May 2013, analyses the results of an ensemble simulation of the future using the state-of-the-art high resolution Meteorological Research Institute Atmospheric General Circulation Model. The target projection for the future climate used in the study corresponds to the last quarter of the 21st century (2075-2099) under the Special Report on Emission Scenarios. The results of the study coincide with previous studies in that surface water arming would result in a decrease of tropical cyclone genesis in the eastern tropical Pacific. However, the results of the study also indicate that an increase in tropical cyclone frequency is likely in the subtropical central Pacific including the Hawaiian Islands[8].

18.4.3 Vulnerability and Potential Losses from Climate Change

Based on results of IPCC AR4 (2007) and the US Global Change Research Program assessment (2009), 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.

Reinsurance companies and governments are particularly concerned with the costs and have moved to develop impact assessments and models to assess and plan for future costs. In 2006, Sir Nicholas Stern of Munich Re, and formerly of the World Bank, predicted that “by the middle of this century, climate change will account for a loss of at least 5% in global growth (US$ 2,200 billion at current values) each year. If we also take its impact on environment and health and knock-on effects into account, it could be as much as 20% of annual global GDP (around US$ 9,000 billion[9])” A significant part of the estimated financial costs will be the costs associated with disasters.

18.4.4 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

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[8] Murakami, Hiroyuki; Wang, Bin; Li, Tim; and Kitoh, Akio, Projected Increase in Tropical Cyclones near Hawai‘i, Nature Climate Change 2013, May 5, 2013

[9] Munich Re Group, The Economic Sector and Climate Change, 2007

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.

18.4.5 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) and taking the City and County of Honolulu as an example, as seas rise, they 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, per Rotzoll and Fletcher.

Sea level rise and coastal erosion could threaten the coastal built environment and significantly increase loss of beaches, coastal ecosystems, and buildings. Tourism resources along the beach could be reduced and this would impact the economy. More data and assessment are needed to understand the full reach of the impacts from climate change. Under the scenario depicted in the view of the south shore of O‘ahu, including Waikīkī, in Figure 18.5, the State would suffer severe economic losses from sustained sea level rise.

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 by landslides and flash floods and which also add cost if damaged. Water lines, sewer lines, and utilities follow the path of coastal highways.

The airports and harbor infrastructure are also 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. The cost of protection for these critical facilities will be millions of dollars.

Figure 18.5 Sea Level Rise in South Shore O‘ahu, 1 Meter Projected Rise[10]

18.4.6 Losses to Environment and Ecosystems

Studies are currently being conducted on the vulnerability of the environment and ecosystems to climate change. Changes in temperature will have effects on plants, insects, and animals. Warmer water temperatures will result in coral bleaching, which would have further ramifications on nearshore habitat functions. With ocean acidification, the loss to habitat and shorelines could be greater, but the degree of impact is still uncertain. Effects on precipitation will likely decrease rainfall and result in a lack of water. It is unclear the effects of climate change on water budgets, evapotranspiration in forests, and ecosystem services. As species of flora and fauna become unable to adapt to changes, there may be loss of important natural ecosystems that contribute to the sustainability of local cultural practice.

[10] Chip Fletcher and the UH Coastal Geology Group 2008, http://www.soest.hawaii.edu/coasts/.

18.4.7 Losses to Economic Sectors

The Pacific Regional Assessment of the Consequences of Climate variability and Change in 2001 provides indicators for sectors that will be impacted[11]. The initial assessment looked at water resource management, public safety and infrastructure, public health, agriculture, tourism, and coastal and marine ecosystems as areas where island environments were 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.

Through these regional assessments, Hawai‘i is trying to ultimately understand its long-term risk and vulnerability to climate change as better data that is localized for island risk assessments and new methods of addressing risks become available.

[11] Shea et al, 2001

18.5 Mitigation Strategies

18.5.1 State of Hawai‘i Renewable Portfolio Standard

The Renewable Portfolio Standard (RPS) was established by the State of Hawai‘i upon enactment of SB 2474 (Act 95, Session Laws of Hawai‘i 2004) in June 2004. The bill requires that each of the electric utility companies in the State (such as Kaua‘i Island Utility Cooperative in the County of Kaua‘i, Hawaiian Electric Company in the City and County of Honolulu, Maui Electric Company in the County of Maui, and Hawai‘i Electric Light Company in the County of Hawai‘i to name a few) establish goals to meet a target of net renewable energy sales equivalent to 20% of generated electricity by the end of 2020. Amendments in 2006 (SB 3185) allowed electrical energy savings generated by renewables including solar water heating and seawater air-conditioning district cooling systems, among others, to count towards the RPS. The 2006 amendments also allowed electrical energy savings generated by certain energy efficiency technologies to count towards the goals of the RPS. The goals of the RPS were substantially expanded by legislation passed in 2009. HB 1464, enacted in June 2009, increased the amount of renewable electricity generation required by utility companies to 40% by 2030. The target renewable energy goals of the RPS are as follows[12]:

1. 10% of net electricity sales by December 31, 2010

2. 15% of net electricity sales by December 31, 2015

3. 25% of net electricity sales by December 31, 2020

4. 40% of net electricity sales by December 31, 2030

Per the RPS, “renewable energy” includes energy generated or produced using the following sources: wind; sun; falling water; biogas (including landfill and sewage-based digester gas); geothermal; ocean water, currents, and waves (including ocean thermal energy conversion); biomass (including biomass crops, agricultural and animal residues and wastes, and municipal solid waste and other solid waste); biofuels; and hydrogen produced from renewable energy sources.
Similarly, in the context of the RPS, “renewable electrical energy” means:

1. Electrical energy generated using renewable energy as the source, and beginning January 1, 2015, includes customer-sited, grid-connected renewable energy generation

2. Electrical energy savings brought about by:

   A) The use of renewable displacement or off-set technologies, including solar water heating, seawater air-conditioning district cooling systems, solar air-conditioning, and customer-sited, grid-connected renewable energy systems; provided that, beginning January 1, 2015, electrical energy savings shall not include customer-sited, grid-connected renewable energy system

[12] State of Hawai‘i Public Utilities Commission (PUC)

B) The use of energy efficiency technologies, including heat pump water heating, ice storage, ratepayer-funded energy efficiency programs, and use of rejected heat from co-generation and combined heat and power systems, excluding fossil-fueled qualifying facilities that sell electricity to utility companies or central power projects.

18.5.2 Hawaiian Electric Company Integrated Resource Plan

The Integrated Resource Plan (IRP) is a five-year action plan by the Hawaiian Electric Company (HECO) and its subsidiaries (Maui Electric Company, and Hawaiʻi Electric Light Company) that details strategies to meet the future electricity demands for the State of Hawaiʻi. The structure of the IRP is based on a scenario-type process where action plans must be flexible enough to address the dynamic conditions of today's global and local energy sector[13].

The IRP, which was filed to the State of Hawaiʻi Public Utilities Commission (PUC) on June 28, 2013, marks the culmination of more than a year of Work by HECO on how to achieve the legal requirement of the RPS to generate 40 percent of its electricity from renewable sources by the year 2030.[14]

One of the most important components of the IRP is the deactivation of older, inefficient power plants that provide about 14% of HECO-owned electricity generation. Among these power plants are portions of Kahului Plant on the island of Maui (County of Maui), Waiau and Aloha Tower Plants on the island of Oʻahu (City and County of Honolulu), and the Shipman Plant on the island of Hawaiʻi (County of Hawaiʻi). Under the IRP, HECO will also convert or replace its remaining generation units to use cost-effective, cleaner fuels, including, but not limited, to biomass, biofuel, or liquefied natural gas.

The IRP also calls for implementing a smart metering system for all of HECO's customers on the islands of Oʻahu, Maui, and Hawaiʻi. Some of the advantages of smart meters are remote control of appliances and real time alert and notification of energy consumption and power outages.

18.5.3 Oʻahu Metropolitan Planning Organization: Transportation Asset and Climate Change Risk Assessment Project

The Oʻahu Metropolitan Planning Organization[15] (OʻahuMPO) 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

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[13] Hawaiian Electric Company Integrated Resource Planning Website, retrieved August 7, 2013 from http://www.hawaiianelectric.com/portal/site/heco/menuitem.8e4610c1e23714340b4c0610c510b1ca/?vgnextoid=b71bf2b154da9010VgnVCM10000053011bacRCRD&vgnextfmt=defaul

[14] Marcellus, Krystel, The Honolulu Star Advertiser

[15] OʻahuMPO was created by State of Hawaiʻi 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.

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:[16]

1. Understand climate change factors as they apply specifically to O‘ahu [City and County of Honolulu] 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. Conduct 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. Analyze the vulnerability of the selected assets based on the climate stressors that were identified during the workshop.

The five assets included in O‘ahuMPO's study are:

1. Honolulu Harbor Area

2. Honolulu 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

3. Kalaeloa Airport, Kalaeloa Barbers Point Harbor, and Campbell Industrial Park

4. Ala Moana Boulevard, Kalākaua Avenue, and McCully Street bridges to Waikīkī

5. 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 18.3 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).

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

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 18.4.

Finally, once the consequences to society were determined, each of the five asset groups was assigned an integrated risk score. The integrated risk combined scores for vulnerability, impact, and consequences to society, using the two planning horizon years of 2050 and 2100. Table 18.5 summarizes the integrated risk scores for all asset groups.

Table 18.3 Risk Assessment of Asset Group[17]

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 Rain: Moderate	Drought: High Rain: Moderate
	2100	High	High	High	High	High	High

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

Table 18.4 Importance of Asset Group to Society[18]

Asset	Overall Value	Impact to Society from:		
		Storm Surge	Sea Level Rise	Heavy Rain/Storm Events
Honolulu Harbor		Moderate	Low	Low
Honolulu International Airport				
TheBus (811 Middle Street)	High	Low	Low	Low
Oahu Baseyard (727 Kakoi Street)	Low	Low	High	Low
Honolulu International Airport and Access	High	High	Low	Low
Kalaeloa/Barbers Point				
Kalaeloa Airport	Low	Low	High	Low
Campbell Industrial Park	High	High	Low	Low
Kalaeloa Barbers Point Harbor	High	High	Low	Low
Three Waikiki Bridges	Moderate	High	High	Low
Farrington Highway on Waianae Coast	High	High	High	Low

Table 18.5 Integrated Risk Assessment of Asset Group[19]

Asset	2050	2100
Honolulu Harbor	High	High
Honolulu International Airport	High	High
TheBus (811 Middle Street)	Low-Moderate	Moderate-High
Oahu Baseyard (727 Kakoi Street)	Moderate-High	Moderate-High
Honolulu International Airport and Access	Low-Moderate	Low-Moderate
Kalaeloa Barbers Point		
Kalaeloa Airport	Low	Low
Campbell Industrial Park	Moderate	High
Kalaeloa Barbers Point Harbor	Moderate	High
Access Roads	Low	Low-Moderate
Three Waikiki Bridges	Moderate	High
Ala Moana Boulevard Bridge	Moderate	High
Kalakaua Avenue Bridge	Moderate	High
McCully Street Bridge	Moderate	High
Farrington Highway on Waianae Coast	High	High

[18] SSFM International, Transportation Asset Climate Change Risk Assessment, O‘ahu Metropolitan Planning Organization, November 2011, Table 5, p.71

[19] Ibid

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

19. Risk Assessment

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CHAPTER 19

Risk Assessment

19.1 Introduction

The State of Hawai‘i includes many features that residents and government would consider assets. Important assets include our natural environment, the built environment, the cultural environment, and the people who live here. In addition, the visitor populations become assets as they contribute to the economy in the State. The integration of the economic, social, and environmental systems provides the basis of livelihoods that we seek to protect and preserve with this mitigation plan. To best understand how to protect our assets, it is important to identify them and to consider the ways in which these assets might be susceptible to hazard risks.

In the scope of this chapter, there is attention to the underlying socioeconomic factors that contribute to risk and vulnerability to particular hazards. Research for the last three decades demonstrates that natural hazards result in disasters upon interaction with human populations and environments in places where socioeconomic conditions expose them to a hazard where there are sensitive to the impacts, and they do not have the ability to recover.[1] Poverty tends to be an overwhelming indicator in every country for disasters, which shows that socioeconomic conditions in locations contribute significantly to the disaster. Examples of this in the United States were witnessed in the impacts of Hurricane Katrina, where the people who lived in poorer sections of town had less access to information and transportation for evacuation. They also lived in houses that were located in harm’s way to a greater extent and in homes that were built with materials less likely to withstand disasters. Therefore, it is important to consider the overall socioeconomic status of the state and its population to address potential causes of disasters.

The assets identified in this section were selected, mapped and included in the Geographic Information System (GIS) based on information provided through public meetings statewide, responses to surveys of state agencies, and referenced in the county mitigation strategies. The county plans will have significantly greater detail than the information provided here, which is an overview. The State of Hawai‘i recognizes that our assets lie in each county, and while there may be distinctions made for land use, zoning, and taxation, all of these assets are part of the state. Although the assets of the state are all important to the quality of life in Hawai‘i, this plan chooses to focus primarily on the ***critical facilities*** *and* ***critical assets*** that would result in the greatest impacts to life and economy in the event of a natural hazard. These critical assets are considered imperative to the sustainability of the State of Hawai‘i. As updates to this plan are

[1] Blaikie et. al. 1994; Mileti 1999

pursued in the coming years, additional information and detail will be incorporated into this planning document.

This chapter of the hazard mitigation plan focuses on identifying assets in the state and in counties. These assets can be used to quantify and qualify risks in the next chapter. By recognizing the assets and features that need protection from hazards, it is possible to outline policies, programs, and plans that focus on reducing hazard risks.

19.2 Overview of the State of Hawai‘i

The State of Hawai‘i extends across miles of ocean on small lands separated from the US continent by thousands of miles. Planning in this context takes place in the coastal zone, with the furthest point anywhere in the state about twenty-six miles from the ocean. The natural island ecosystem is defined by the flow of water from the mountaintops to the sea and protective reef system. The unique ecosystems respond differently to natural hazards. Planning to reduce or mitigate the impact of these hazards must first consider the context of geography. When a hurricane or tsunami happens, people cannot retreat hundreds of miles to a safety zone, and therefore islands are more vulnerable to hazards. To identify hazard risks that affect the State of Hawai‘i and to understand the impact of the hazards, it is essential to consider the assets and features of each county that encourage its citizens to protect and preserve their island. A review of the geography and topography of the islands provides a better understanding of how the hazards will react and what types of problems may result. The first part of this chapter will provide an overview of the State of Hawai‘i.

The State of Hawai‘i is unique amongst all the states. It is a state composed of Island Counties, completely surrounded by international borders, and is the most isolated major island chain in the world. It is a state principally of rural demographics; an economy primarily reliant on tourism and lifelines virtually 100% dependent on maritime shipping. While over 80% of all maritime cargo shipments transit O‘ahu’s Honolulu Harbor (City and County of Honolulu), close to 100% of all goods are shipped by maritime cargo to the outer island ports. Hawai‘i is exceptionally vulnerable to terrorist attacks because it is a world famous international and domestic tourist destination while also being the closest and first point of entry into the United States from known centers of terrorism. Hawai‘i is also subject to a number of extreme natural hazard dangers including earthquakes, major category hurricanes, large scale tsunamis as well as volcanic activity. A significant event created by human-induced or natural hazard could potentially create a situation where the provision of water, food, shelter and medical support could be impaired or paralyzed for days or weeks.

If a catastrophic event were to occur, Hawai‘i would be solely dependent on heavy maritime lift for emergency relief supplies from the mainland. In addition to the time it would take to organize materials to be lifted, the transit time to Hawai‘i would be at least four days. Given this prospect, the identification, protection, defense, response requirements and implementation of our long range strategic plan for our critical infrastructure and key resources is vital to our economic and human survival.

19.3 Emergency Services Infrastructure

Emergency Services Infrastructure refers to critical facilities required during a disaster and first response units capable of addressing any type of disaster. The location of the emergency services infrastructure has been recorded in the GIS database. These include: the emergency operations center; police stations; fire stations; hospitals, clinics, and dispensaries; civil defense sirens; and community shelters.

The State has a very proactive emergency management structure and governances in place for disaster response and recovery operations. Each state department has a State Emergency Response Team representative that trains and conducts exercises along with Civil Defense partners. Major exercises bring in the regional Civil Defense Agencies which also have a similar structure for their response and recovery networks.

Assisting key agencies in improving their Departmental Operations Centers (DOC) is necessary for improved response – the American Red Cross is providing additional space for the State Emergency Operations Center (EOC) in the event the EOC must relocate (at this time minimal space is available at alternate sites). The Department of Education requires support to complete their departmental DOC. The university system, especially the University of Hawai‘i at Mānoa, which during any given day has a population of approximately 45,000, must have a DOC to manage day-to-day activities and to be an effective partner during a disaster response.

Evacuation planning during a catastrophic event cannot be initiated in the same context as the States in the United States mainland. Due to the nature of being an island State, any evacuation will be accomplished by air. In the event of a catastrophic event occurring on the Island of O‘ahu (the most populated island under the jurisdiction of the City and County of Honolulu), there are insufficient aircraft, both commercial and military, available to move in excess of one million people. Mitigation and disaster planners must look within to strengthen the State’s ability to provide shelters, food, water, and other emergency services.

A risk assessment study on potential losses and damages to emergency services infrastructure from high winds was conducted in 2010. The study looked at 274 structures in all of the four Counties. Details, results, and conclusions of this study are included in Section 5.4.6 in Chapter 5 – Tropical Cyclones.

19.3.1 State Civil Defense: Emergency Operations Center

The current Emergency Operations Center for the State of Hawai‘i is located in Diamond Head Crater on the southeast corner of the island of O‘ahu (City and County of Honolulu). All emergency operations and networks are coordinated from this location. The State facility maintains contact with county emergency operations centers during any period of threat within the State. The locations provide some physical protection from natural hazards, and its proximity to the Army National Guard facilities helps in mobilizing assistance during a crisis.

Each county operates its own EOC facility. The EOC for the County of Kaua‘i is located in downtown L‘hu‘e. This EOC houses the Kaua‘i Civil Defense Agency, the Kaua‘i Police

Department, and the Attorney General's office (with facilities for operating a first response center and shelter for personnel during disasters). The EOC for the City & County of Honolulu is located in the basement of the Hawai‘i Municipal Building in downtown Honolulu. The EOC for the County of Maui is located in the basement of the County of Maui Building in Wailuku and must coordinate not only operations in the island of Maui, but operations on the islands of Moloka‘i and Lāna‘i as well. Lastly, the County of Hawai‘i EOC is located in Hilo near the main police station.

Part of the emergency warning system managed by the State Civil Defense includes the sirens that warn of impending events, such as a tsunami. The sirens are tested on the first weekday of each month. The sirens alert citizens to the disasters and instruct the public to listen to the radio station warning network for information. The infrastructure for the siren and warning system are considered part of the critical facilities infrastructure.

19.3.2 Hawai‘i Army National Guard (HIARNG)

The Hawai‘i Army National Guard (HIARNG) is composed of a Headquarters, State Area Command, and three major commands: the 29th Separate Infantry Brigade; the 103rd Troop Command; and the 298th Regiment, Regional Training Institute. The Headquarters, State Area Command (HQ STARC) is the headquarters of the Hawai‘i Army National Guard (HIARNG). It consists of primary staff offices which are responsible for establishing command directives and guidance in the functional areas of military personnel including: recruiting and retention; plans, operations, and training; logistics; surface maintenance; Army aviation; facility management; information management; and safety and occupational health. The State headquarters also includes four detachments: Detachment 3, HQ STARC (Selective Service Section); Detachment 4, HQ STARC (Medical); 117th Mobile Public Affairs Detachment; and the Headquarters Detachment that provides all unit-level activities and support to staff sections and detachments. The command and control functions and services provided by HQ STARC are at an organizational level and in support of the three HIARNG major commands and their subordinate units across the state.

Table 19.1 Army National Guard Unit Stations in the State of Hawai‘i

Unit	Location	Federal Recognition
HQ & HQ Detachment	Honolulu, O‘ahu	Sept. 10, 1946
Detachment 3, Selective Service Section		Sept. 9 1946
Detachment 4, Medical Detachment		March 6, 1999
117th Mobile Public Affairs Detachment	Honolulu, O‘ahu	May 10, 1960
Detachment 55 Operational Support Airlift Command	Wheeler Army Airfield, Wahiawa, O‘ahu	To be determined
93rd Civil Support Team (Weapons of Mass Destruction)	Honolulu, O‘ahu	To be determined

19.3.3 Shelters

Hawai‘i State Civil Defense maintains a list of surveyed shelter spaces throughout the State, with approved sites listed according to hazard. Recommended retrofits and hardening activities that are needed in order to designate sites as suitable for sheltering during disasters are also included. Each island lacks thousands of suitable shelter spaces for high wind and hurricane hazards. It is estimated that about 30% of the population would have adequate sheltering in the city of and County of Honolulu. These figures may be worse for some areas, like the northern coast of Hawai‘i Island where there is a lack of public emergency shelter facilities. Maps of each county indicating location of emergency shelters as of 2010 are included in Figure 19.1 through Figure 19.4.

Currently, the State of Hawai‘i has passed legislation that organizes the State Building Code Council to review and investigate amendments for adopting improved IBC codes for the State, especially in regard to disaster-resistant shelters. By January 1, 2006, the State issued a recommendation for adoption of interim shelter criteria. Each county adopts its own building codes as well as rules for inspection and enforcement. In 2007, the City and County of Honolulu passed its code updates from the 1997 Uniform Building Code (UBC) to the 2003 International Building Code (IBC), which took several years of preparation to adopt the code and amendments that will best protect O‘ahu. The other counties often follow the lead of the City & County; however, the earthquake experience has urged the Hawai‘i County Council to try to adopt the 2006 International Building Code (IBC).

The Department of Education, in conjunction with Department of Accounting and General Services, normally complies with each county’s building code in which the school facility is being constructed. With the experience of the 2006 earthquake, the State and County learned that public assistance funding for repairing building damage will only fund work that meets the building code in place, which meant that the State Department of Education and the County of Hawai‘i were forced to build back only to the 1991 Uniform Building Codes in place when the earthquake hit, even though structural engineers and the council had engaged in discussions to upgrade the building code. Therefore, the State learned that it needed to be more proactive in adopting improved building codes and more supportive in helping the counties to implement these codes.

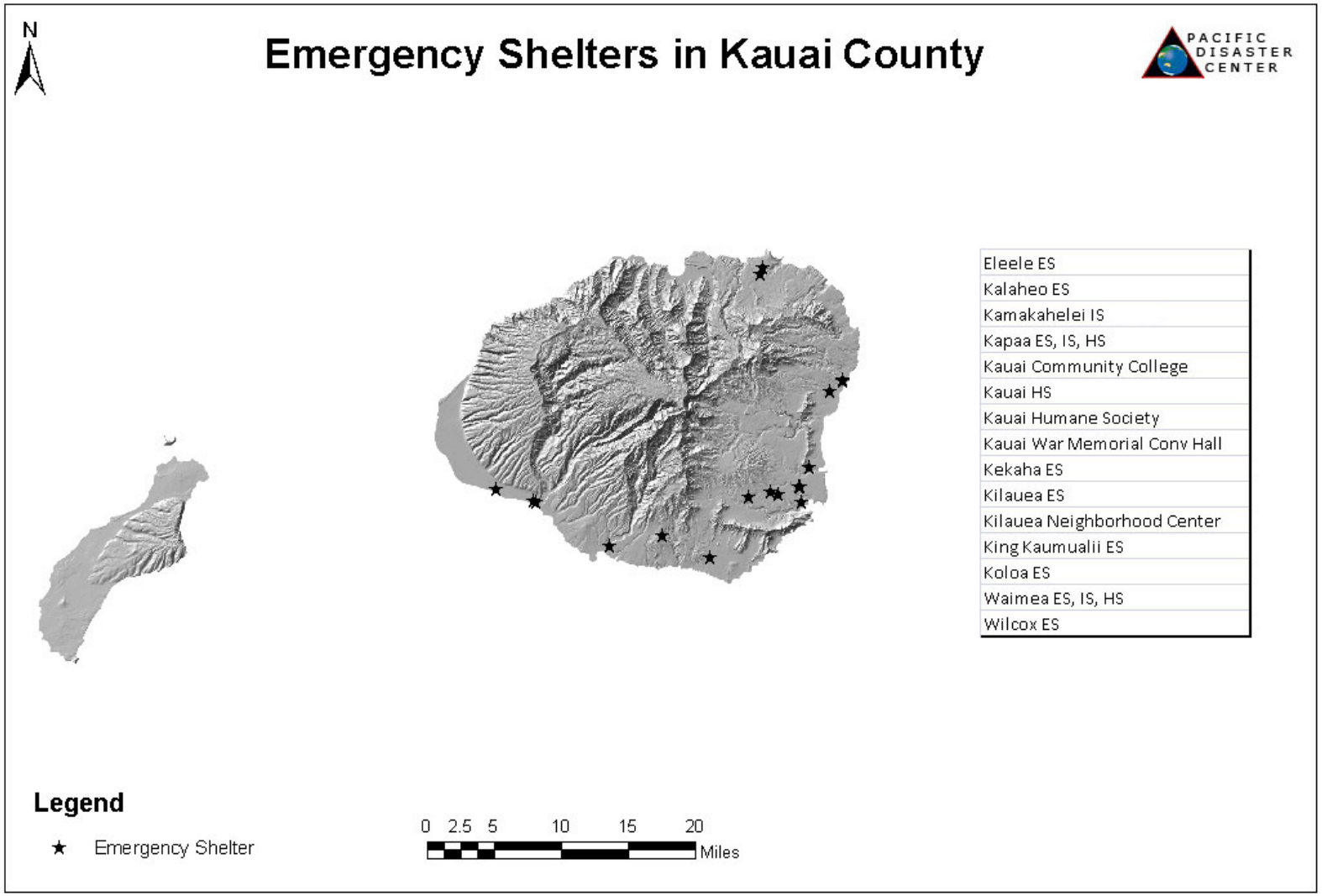
The County of Kaua‘i was the first county in the State to develop a partnership with the Kaua‘i Humane Society in 2001. The new facility was built to high wind specifications and will provide shelter to pets. Space in the basement has also been developed to increase the number of shelter spaces for humans in the county. Following Hurricane Katrina where many pets were abandoned or many people refused to go to shelters because they owned pets, the State of Hawai‘i began to think about this issue more critically. The Building Code Council needs to determine criteria for pet shelters, in addition to general shelters and special needs facilities.

Millions of dollars have been allocated by the State Legislature to improve the level of shelters to include shelters of special populations and pets. Important to this effort is the need to increase the number of shelter-in-place facilities and to ensure that settings which provide care to the elderly and special residential care populations have effective disaster plans including: facilities that are fully cognizant of the risks and vulnerabilities of the State and their facility and have

individual kits in the event they must evacuate to a shelter. For special groups that may require extra care, it is important that all the Level II shelters be more robust to provide the level of care required to reduce the hospital intake numbers during disaster situations.

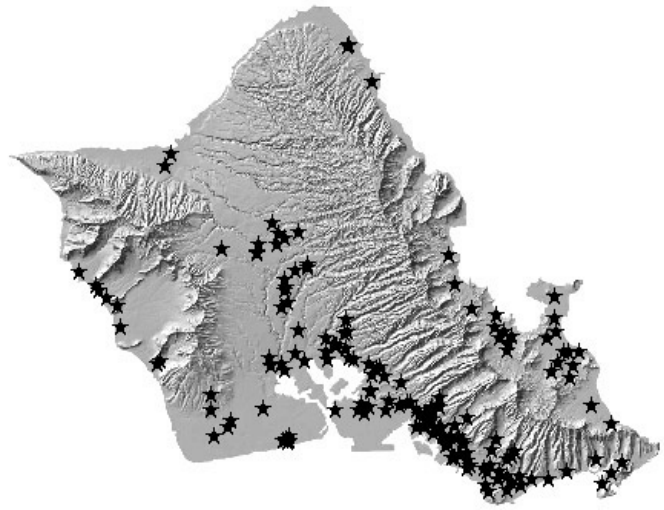
In 2005, the Hawai‘i State Legislature enacted the Disaster Emergency Preparedness Act of 2005 that instructed the State Department of Defense to develop public shelter and residential safe room criteria by January 1, 2006. The criteria included the development of performance based standards for enhanced hurricane protection. The State also provided funding at $4 million per year to upgrade shelters. The new shelter criteria has helped in the development of new public facilities and encouraged retrofitting of existing facilities as improved building codes are considered and adopted in the counties and the state.

Figure 19.1 Emergency Shelters in the County of Kaua'i[2]



2 Pacific Disaster Center, 2010

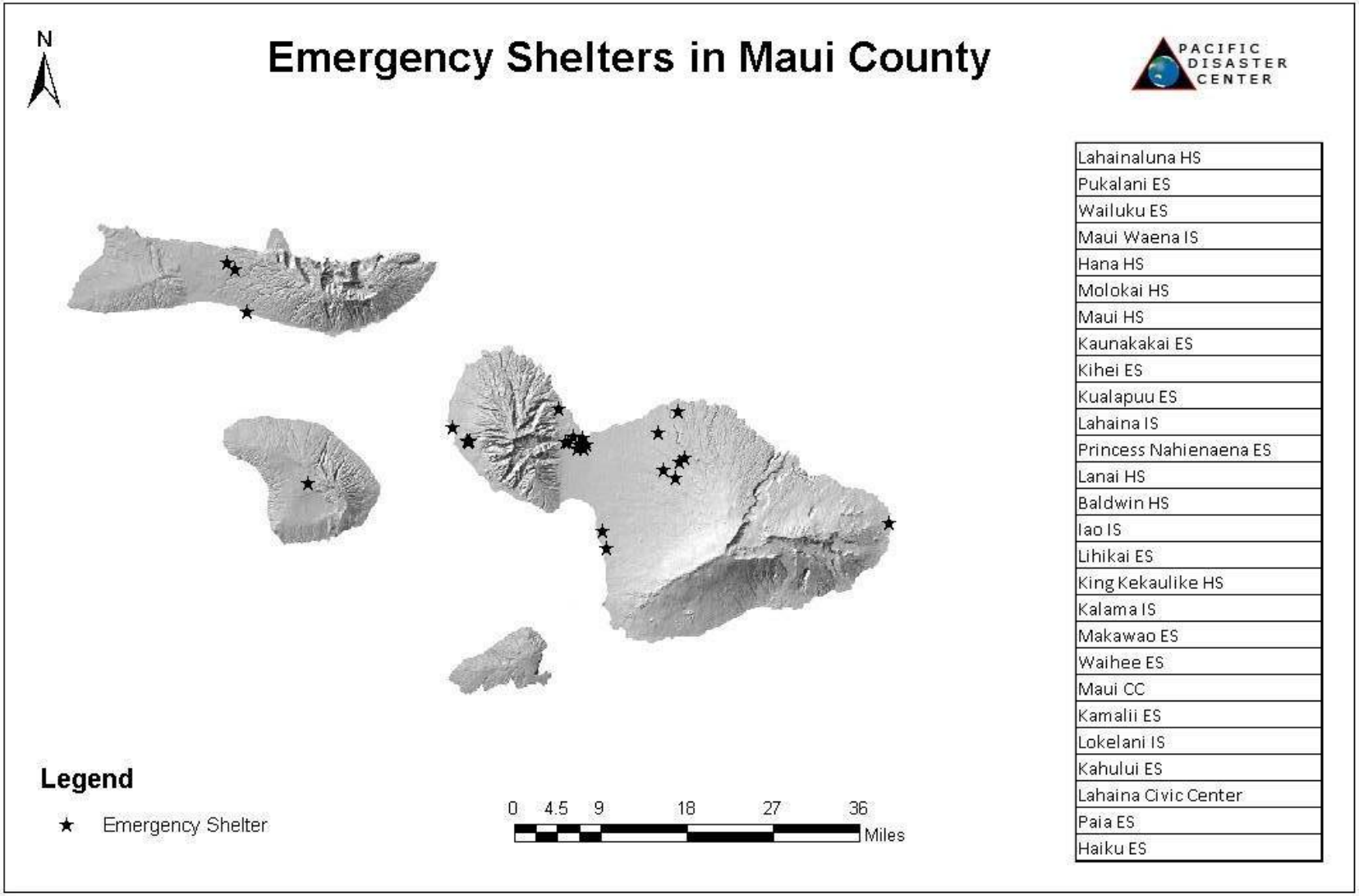
Figure 19.2 Emergency Shelters in the City & County of Honolulu[3]



Ahuimanu ES	Kahala ES	Leihoku ES	Pauoa ES
Aiea ES, IS, HS	Kahaluu ES	Leilehua HS	Pearl City DP
Aikahi ES	Kahuku ES	Liholiho ES	Pearl City ES, HS
Aina Haina ES	Kahuku IS, HS	Likelike ES	Pearl City Highlands ES
Aliamanu ES, IS	Kailua ES, IS, HS	Liliuokalani ES	Pearl Harbor ES
Aliiolani ES	Kaimiloa ES	Linapuni ES	Pearl Harbor Kai ES
Anuenue ES	Kaimuki IS, HS	Lincoln ES	Pearlridge ES
August Ahrens ES	Kainalu ES	Lunalilo ES	Pohakea ES
Barber's Point ES	Kaiser HS	Maemae ES	Pope ES
Benjamin Parker ES	Kaiulani ES	Maili ES	Puohala ES
BYU	Kalaheo HS	Makaha ES	Puuhale ES
Campbell HS	Kalakaua IS	Makakilo ES	Radford HS
Castle HS	Kalani HS	Makalapa ES	Red Hill ES
Central IS	Kaleiopuu ES	Makiki DP	Roosevelt HS
Dole IS	Kalihi Kai ES	Manana ES	Royal ES
Enchanted Lake ES	Kalihi Uka ES	Manoa ES	Salt Lake ES
Ewa Beach ES	Kalihi Valley DP	Mauka Lani ES	Shafter ES
Ewa ES	Kalihi Waena ES	Maunawili ES	Solomon ES
Farrington HS	Kalilhi ES	McKinley HS	Stevenson IS
Fern ES	Kamaile ES	Mililani Ike ES	Wahiawa ES, IS
Hahaione ES	Kamiloiki ES	Mililani IS, HS	Waiahole ES
Halawa DP	Kaneohe ES	Mililani Mauka ES	Waialae ES
Hanalani ES	Kanoelani ES	Mililani Uka ES	Waialua ES
Hawaii Conv Center	Kapalama ES	Mililani Waena ES	Waialua IS, HS
Heeia ES	Kapolei ES, HS	Moanalua ES, IS, HS	Waianae ES, IS
Helemano ES	Kapunahala ES	Mokapu ES	Waiau ES
Hickam ES	Kauluwela ES	Mokulele ES	Waikiki ES
Highlands IS	Kawananakoa IS	Momilani ES	Waimalu ES
Hokulani ES	Keolu ES	Nanakuli ES	Waimanalo ES, IS
Honowai ES	King IS	Nanakuli IS, HS	Waipahu ES, IS, HS
Iliahi ES	Kipapa ES	Neal Blaisdell Center	Washington IS
Ilima IS	Koko Head ES	Nimitz ES	Webling ES
Jarrett IS	Kuhio ES	Niu Valley IS	Wheeler ES, IS
Jefferson ES	Lanakila DP	Noelani ES	Wilson ES
Kaahumanu ES	Lanakila ES	Nuuanu ES	
Kaala ES	Lanikai ES	Palisades ES	
Kaewai ES	Lehua ES	Palolo ES	

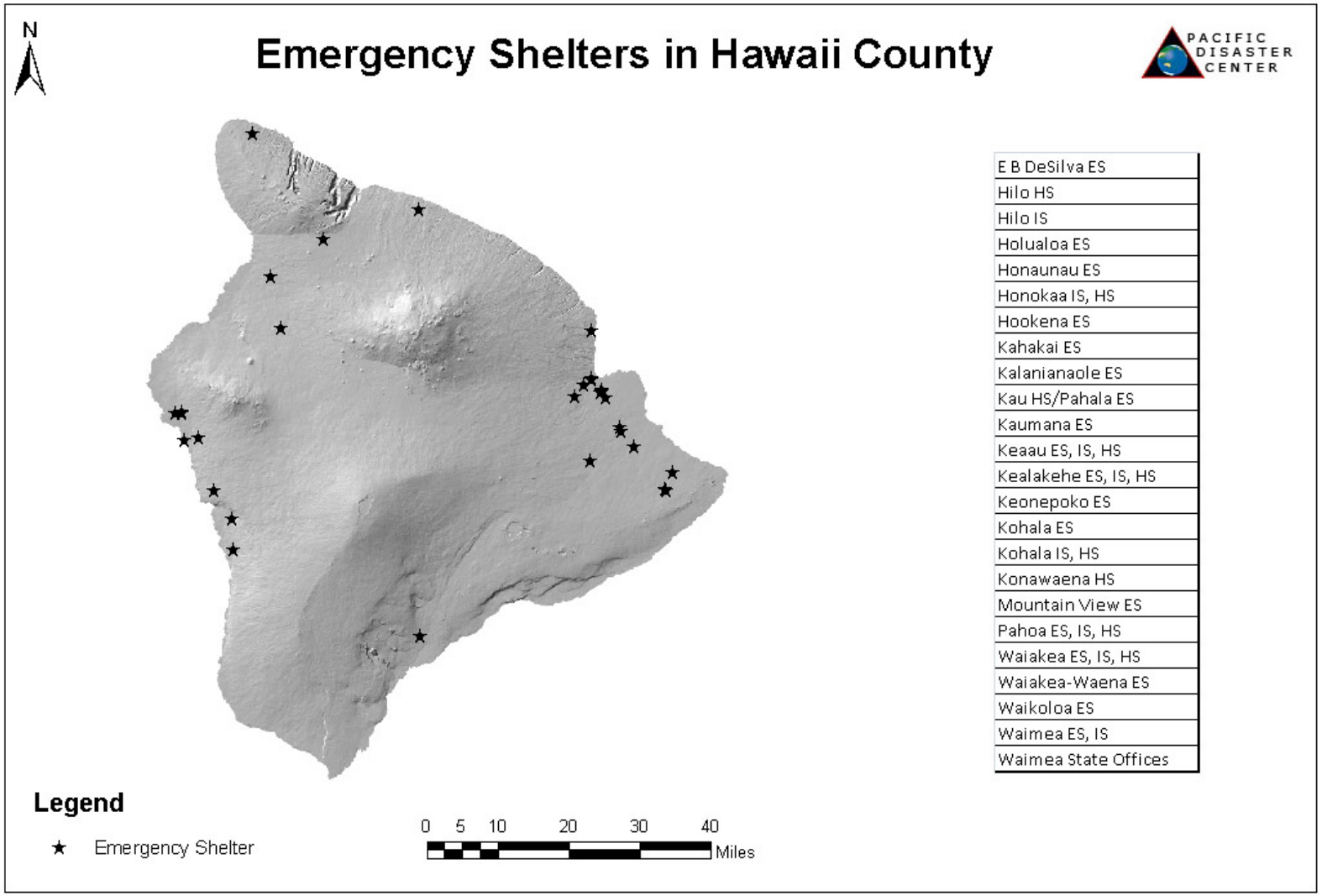
[3] Pacific Disaster Center, 2010

Figure 19.3 Emergency Shelters in the County of Maui[4]



[4] Pacific Disaster Center, 2010

Figure 19.4 Emergency Shelters in the County of Hawai'i[5]



[5] Pacific Disaster Center, 2010

19.3.4 Police and Fire Stations

Police and fire operations are run through county operations. Each county has mapped the location of their facilities and included these in their mitigation plans and in their County GIS systems. The police and fire departments must have good communication systems that link with the County and State disaster responders because the local crews and officers will be the first responders to any incident.

The Department of Land and Natural Resources Division of Forestry and Wildlife manages wildland fires in coordination with the county public safety personnel. It is the policy of the Division of Forestry and Wildlife that the basis for all wildland firefighting positions and organizational structure will follow the Incident Command System (ICS). The DOFAW Administrator is responsible for coordinating the work of Branch Managers and reviewing their plans for fire protection and control. The Branch Manager is in charge of planning, coordinating, and executing wildland fire protection and control for all incidents contained within the meaning of fires in Chapter 185 HRS. Firefighting facilities and equipment must be protected and accessible during any hazard event.

For homeland security and hazardous materials threats the police and fire departments will be first responders. They will secure the areas and try to keep the population safe. The fire stations, especially, are located in neighborhoods throughout the islands and have specialized equipment for dealing with emergencies. During disaster threats, it is important to have hardened, secure stations for equipment that may be needed for response and recovery following the disaster impact.

19.3.5 Primary Medical Facilities

The medical facilities are primarily managed by private interests, and operate in each county. Details of these facilities have been included in each of the approved county mitigation plans, which are included by reference in this State Mitigation Plan. These sites are geocoded and located in the County GIS systems. A list of medical facilities in the State of Hawaiʻi grouped by County is included in Table 19.2.

Surveys of critical facilities have revealed that hospitals have not been located in floodplain areas in any of the counties. The facilities are at risk to high winds, although they have all been constructed according to the best available building standards at the time of construction. The following table lists the hospital and major medical facilities throughout the State of Hawaiʻi, including their locations. In the City and County of Honolulu, Leʻahi Hospital has been shown to be in an area on Diamond Head Crater that will be subject to increased wind speed-up during high winds. The Hawaiʻi State Hospital, in Kāneʻohe, is also subject to wind speed acceleration due to its proximity to the base of the steep slopes of the Koʻolau Mountains. One action to mitigate this has been for the Legislature to approve funding to improve the roofing.

Table 19.2 State of Hawai‘i Medical Facilities by County

County of Kaua‘i	Island	Location
Wilcox Memorial Hospital	Kaua‘i	Līhu‘e
Kaua‘i Veterans Memorial		Waimea
Samuel Mahelona Memorial Hospital		Kapa‘a

City & County of Honolulu	Island	Location
Kahi Mohala	O‘ahu	‘Ewa Beach
Kaiser Foundation Hospital		Honolulu
Kapi‘olani Medical Center for Women		Honolulu
Rehabilitation Hospital of the Pacific		Honolulu
Kuakini Medical Center		Honolulu
Le‘ahi Hospital		Honolulu
Queen's Medical Center		Honolulu
St. Francis Medical Center		Honolulu
Shriner's Hospital for Children		Honolulu
Straub Clinic and Hospital		Honolulu
Tripler Army Medical Center		Honolulu
Kahuku Hospital		Kahuku
Castle Medical Center		Kailua
Hawai‘i State Hospital		Kāne‘ohe
Wahiawā General Hospital		Wahiawā
Kapi‘olani Medical Center at Pali Momi		‘Aiea
St. Francis Medical Center - West		‘Ewa Beach

County of Maui	Island	Location
Kula Hospital	Maui	Kula
Lāna‘i Community Hospital	Lāna‘i	Lāna‘i
Dialysis Center	Lāna‘i	Lāna‘i
Maui Memorial Medical Center	Maui	Wailuku
Moloka‘i General Hospital	Moloka‘i	Kaunakakai
St. Francis Medical Center		
Maui Dialysis Satellite Facility	Maui	Wailuku
Kahana Dialysis Facility	Maui	Kahana
Moloka‘i Dialysis Satellite Facility	Moloka‘i	Kaunakakai

County of Hawai‘i	Island	Location
Kona Community Hospital	Hawai‘i	Kona
Ka’ū Hospital		Ka‘ū
Hilo Medical Center		Hilo
North Hawai‘i Community Hospital		Kamuela
Kohala Hospital		Kohala
St Francis Medical Center Dialysis		
Hilo Dialysis Center		Hilo
Kona Dialysis Center		Kealakekua

19.3.6 Maritime and Port Security

Eighty percent of all goods and materials entering the State must transit Honolulu Harbor. It is imperative that the Department of Transportation and private enterprises work in concert with the United States Coast Guard to ensure compliance with the International Ship and Port Facility Security Code, which specifies risk management concepts to improve port security. The intent is to ensure that Hawaiian waters remain safe.

The FY 2007 Port Security Grant, coupled with previous initiatives, will serve to improve the security and safety of the Port of Honolulu. The Port Security Grants continue to support efforts to reduce maritime vulnerabilities. The investments for FY 2007 are based on the Department of Transportation Master Security Plan:

- IED Threat Prevention Program and Transportation Workers Identification Credentialing Implementation
- Hawai‘i Homeland Security Command Information System (H2SCIS) for Port of Honolulu, Kahului Harbor
- Passive Search System
- Improve security, protection and detections around all harbors
- Improve water security with new vessels

19.4 Government Facilities and Services

The government facilities are all important for maintaining daily operations and preserving the state economy. Facilities for the federal, state, and county governments will be critical. Most of these facilities lay in wind risk areas; however, they have been designed to meet building standards. Maintaining communications infrastructure among these facilities is also critical.

A risk assessment study on potential losses and damages to emergency services infrastructure from high winds was conducted in 2010. The study looked at 274 structures in all of the four Counties. Details, results, and conclusions of this study are included in Section 5.4.6 in Chapter 5 – Tropical Cyclones.

19.4.1 State Department of Education and Public Schools

In the 2009-2010 school year, the State of Hawai‘i had 286 public schools serving approximately 178,649 students. There are 257 regular schools, 2 special schools, and 31 “New Century” public charter schools. (See the inventory of public schools, many of which operate as shelter facilities in Chapter 4 Appendix A.)

Hawai‘i’s public schools are grouped into *complexes* consisting of a high school and all of the middle and elementary schools that feed into it. For administrative and support purposes, 2-4 complexes may be grouped together to form what is called a *complex area*, or *mini-district.* Public Charter Schools provide a public alternative to regular public schools. The direction of each of these publicly funded schools is determined by its "board." Community Schools (aka

"Adult Ed") provide basic classes for adult literacy, high school degree programs, citizenship training, and English for Second Language Learners classes as well as non-academic "interest" courses.

The Department of Education (DOE) plays a key role in the critical facilities infrastructure because the schools provide sheltering spaces for communities during natural hazards. The State works with the Red Cross, who provides staff to open and monitor the shelters during natural hazards. The State is currently engaged in several projects to retrofit and upgrade shelters to provide more spaces for citizens.

The DOE requires all public schools to have off-site evacuation plans, with two off-site locations. They run drills to prepare staff and students for emergencies. Education about hazards and about preparedness has also been integrated into the school curriculums.

19.4.2 State Department of Health

The State of Hawaiʻi Department of Health (DOH) is the primary provider and coordinator of medical, health and welfare related services to the general public, in the State of Hawaiʻi. The DOH is also active in developing health related public policy, provides oversight, monitoring and regulation of medical, human and environmental services, and serves the general public through the collection and storage of health related data. The DOH consists of 14 divisions, under three administrative branches whose duties include: development of planning, policy and protocol to mitigate, protect and respond to outbreak of disease, pandemic virus or terrorist attack; the development provision and facilitation of face to face services to adolescents and adults suffering from Severe and Persistent Mental Illness (SPMI) and behavioral disorders; the facilitation of nursing and public health services to the indigent and elderly; the regulation of waste water and potable water resources; the regulation of hazardous materials and waste; the regulation and control of medication and food and beverage; and, the regulation and control of domesticated and feral animals and wildlife.

The DOH is comprised of the Director, Office of the Director and the Deputy Director of the DOH, the branches and divisions that contribute to its operation. The Administrative Branches, which contain the divisions and associated branches and offices, are categorized by their exclusive responsibility to the community. The Administrative Branches are the: 1) Environmental Health Administration 2) Health Resources Administration and the 3) Behavioral Health Administration. The Administrative Branches are divided into three component systems that contribute to the health and welfare of the community through regulation, enforcement, monitoring, mitigation, preparedness and direct service purveyance.

19.4.3 State Department of Accounting and General Services

The Department of Accounting and General Services, commonly known as DAGS, is headed by the State Comptroller, who concurrently serves as the director of DAGS. The department is responsible for managing and supervising a wide range of State programs and activities. DAGS includes the following divisions: Accounting Division; Administrative Services Office; Archives; Audit Division; Automotive Management Office; Central Services Division;

Information & Communication Services Division; Land Survey Division; Personnel Office; Public Works Division; and the Systems and Procedures Office

DAGS has considerable responsibilities related to reducing disaster risk in the State of Hawai‘i. DAGS manages the accounting and financial system for the entire state. It further ensures procurement of equipment used in the state. DAGS maintains information, archives, and records that ensure functionality of state departments and overall operations. One of the divisions maintains operations of all the state-owned vehicle and equipment, including insurance and risk management. DAGS works with the insurance industry to make sure that the state owned buildings and facilities (more than 7,500) have insurance in case of emergencies and hazards, and works with FEMA, State Civil Defense, and the insurance industry during declared disasters to conduct damage assessments.

The Information and Communication Services Division (ICSD) is the lead agency for information technology in the Executive Branch. It is responsible for comprehensively managing the information processing and telecommunication systems in order to provide services to all agencies of the State of Hawai‘i. The ICSD plans, coordinates, organizes, directs and administers services to insure the efficient and effective development of systems. This division has responsibility for critical lifeline management as telecommunications are a major requirement during crises.

The Land Survey Division’s mission is to provide field and office land survey assistance for state agencies, including Land Court and other government jurisdictions. This division prepares, furnishes and maintains maps and descriptions of all public lands required by other State agencies for the issuance of Governor's Executive Orders, general leases, and grants of easements as well as the sale of government lands or purchase of private lands for public purposes. The division prepares, certifies, and reviews shoreline maps, maintains maps and records, and provides surveys to establish boundaries of government parcels.

The Public Works Division plans, coordinates, organizes, directs and controls a variety of engineering and architectural services for the State including land acquisition; planning, designing, inspecting and managing construction projects; facilitating quality control; contracting; construction management; equipping facilities; and other improvements for State agencies. The Division, through its Leasing Branch, locates, negotiates and leases office space in non-state buildings for user agencies. The Public Works Division takes the lead in implementing sheltering upgrades for public facilities to withstand disasters. The Public Works Division has also taken the lead in constructing temporary living facilities for homeless populations.

19.4.4 State Department of Land and Natural Resources

The Department of Land and Natural Resources (DLNR) has a considerable number of divisions with responsibilities for maintaining the health and preservation of the state’s natural resources. Divisions include: the Office of the Chairperson, the Division of Aquatic Resources that helps manage the state’s fisheries and marine resources, the Division of Boating and Ocean Recreation, the Division of Conservation and Resource Enforcement, the Bureau of

Conveyances, the Division of Forestry and Wildlife, the Historic Preservation Office, the Land Division, the Office of Conservation and Coastal Lands, the Division of State Parks, the Administrative Services Office, the Personnel Office, and the Public Information Office. DLNR also has several boards and commissions that include: the Board of Land and Natural Resources, the Commission on Water Resource Management, the Kahoʻolawe Island Reserve Commission, the Natural Area Reserves Commission, Hawaiʻi Historic Places Review Board, and the Island Burial Councils.

The Division of Boating and Ocean Recreation is responsible for the management and administration of statewide ocean recreation and coastal areas programs pertaining to the ocean waters and navigable streams of the State (exclusive of commercial harbors) which include 21 small boat harbors, 54 launching ramps, 13 offshore mooring areas, 10 designated ocean water areas, 108 designated ocean recreation management areas, associated aids to navigation throughout the State, and beaches encumbered with easements in favor of the public.

The Engineering Division provides technical support for managing resources. The engineers oversee the National Flood Insurance Program (NFIP). They respond to flooding disasters, working with the Army Corps of Engineers to ensure floodplain management, as in the October 2004 Mānoa Flood. The Engineering Division has also conducted inspections of the state's dams and developed a strategy to address weaknesses found in dam structures.

The Commission on Water Resources Management works with the Board of Water Supply, the counties, and the Division of Forestry and Wildlife (DOFAW) to develop drought and wildland fire response, preparedness, and mitigation plans. The CWRM works to preserve and enhance water resources.

DOFAW is also working on plans to maintain vegetation to protect shoreline areas from storms, coastal inundation, and tsunami. The Land Division ensures protection of conservation lands also maintain the integrity of watersheds.

The Office of Conservation and Coastal Lands provides resources for shoreline protection and works with communities to prevent erosion. It is the mission of the Office of Conservation and Coastal Lands (OCCL) to protect and conserve Conservation District lands and beaches within the State of Hawaiʻi for the benefit of present and future generations, pursuant to Article XI, Section 1, of the Hawaiʻi State Constitution. These lands encompass our State's terrestrial and marine environments, with special emphasis on coastal areas and beaches. OCCL provides tools for landowners and orchestrated the beach nourishment project in Waikīkī.

19.4.5 State Department of Business, Economic Development & Tourism

The Department of Business, Economic Development & Tourism is Hawaiʻi's resource center for economic and statistical data, business development opportunities, energy and conservation information, and foreign trade advantages.

The Office of Planning works to maintain an overall framework to guide the development of the State through a continuous process of comprehensive, long-range, and strategic planning to meet

the physical, economic, and social needs of Hawai‘i’s people, and provide for the wise use of Hawai‘i’s resources in a coordinated, efficient, and economical manner - including the conservation of natural, environmental, recreational, scenic, historic, and other limited and irreplaceable resources which are required for future generations. The Office of Planning's 3 main objectives are: 1) fix responsibility and accountability to successfully carry out statewide programs, policies and priorities; 2) improve the efficiency and effectiveness of the operations of the executive branch; and 3) ensure comprehensive planning and coordination to enhance the quality of life of the people of Hawai‘i. The Hawai‘i Coastal Zone Management Program works with the Land Division in the Office of Planning. One of the areas that CZM has concentrated significant resources has been in reducing impacts from coastal hazards.

The Land Use Commission works with the State Legislature, County Planning Departments, interest groups and landowners to define constitutionally mandated standards and criteria for protecting important agricultural lands in the State of Hawai‘i. The Commission also engages the county planning departments in enhancing and clarifying the special permit process in the Agricultural Land Use District.

19.4.6 State Department of Transportation

Department of Transportation (DOT) is responsible to plan, design, construct, operate, and maintain State facilities in all modes of transportation, including air, water, and land. Coordination with other State, County, and Federal programs is maintained in order to achieve the objective. The Department currently provides, operates, and maintains eleven (11) commercial service airports, four (4) general aviation airports; nine (9) commercial harbors; and two thousand four hundred fifty (2,450) lane miles of highway. Four of the five major airports now serve domestic overseas carriers.

The Department of Transportation was formed shortly after Hawai‘i became a state in 1959. It has three divisions, Airports, Harbors and Highways, which are supported by 10 departmental staff offices. The offices are: Statewide Transportation Planning, Special Compliances, Public Affairs, Visitor Information, PPB Management and Analytical, Personnel, Business Management, Contracts, Computer Systems and Services, and Property Management. The DOT is composed of four principle sub-programs: Air Transportation Facilities and Services, Water Transportation Facilities and Services. Land Transportation Facilities and Services, and Overall Program Support for Transportation Facilities and Services. A total of 35 individual, lower-level programs and their associated plans are included in the Multi-Year Program and Financial Plan for the period 1999-2005.

The three divisions of DOT: Airports, Harbors and Highways, work with their Federal counterparts---Federal Aviation Administration, United States Coast Guard and Federal Highways Administration, in order to keep Hawai‘i coordinated with overall United States standards. Closer to home, since county transportation systems must complement the State system, the counties' Planning Commission and Department of Public Works assist in determining the needs and priorities of transportation facilities. In addition, the City and County of Honolulu performs maintenance activities on all traffic lights on the island of O‘ahu and provides an abandoned vehicle removal service from State highways on the island of O‘ahu.

19.4.7 State Department of Agriculture

The Hawai‘i Department of Agriculture (HDOA) encompasses 300 employees statewide work to support, enhance, and promote agriculture and aquaculture industries in the State of Hawai‘i. Hawai‘i’s transition from mono-crop plantations, such as pineapple and sugarcane, to diversified agriculture, including nursery products, seed crops and other vegetable and fruit crops, is important to the state’s economy, environment, and lifestyle. Agriculture not only feeds the state, but it also keeps the unique working landscape green – a feature appreciated by residents, as well as the millions of visitors to these islands. With the development of biofuels, Hawai‘i’s agricultural lands now contribute to promoting energy efficiency in the state.

Hawai‘i’s agricultural products are valued around the world for superior quality. Hawai‘i is also a recognized world leader in aquaculture, producing the finest seafood products for Hawai‘i consumers and export markets. HDOA helps to support the state’s economy and to support the development of food security. In addition, HDOA protects our agricultural interests with inspection for invasive species of incoming plant material and animals, safeguarding animal and plant health, supporting farmers with affordable land and water, providing financial assistance to farmers, and assuring quality of produce. HDOA is critical for inspection of goods brought into Hawai‘i to prepare for and cope with disasters to ensure that contagion and diseases, invasive species, and plant and animal diseases do not get into the state. HDOA maintains quarantine facilities.

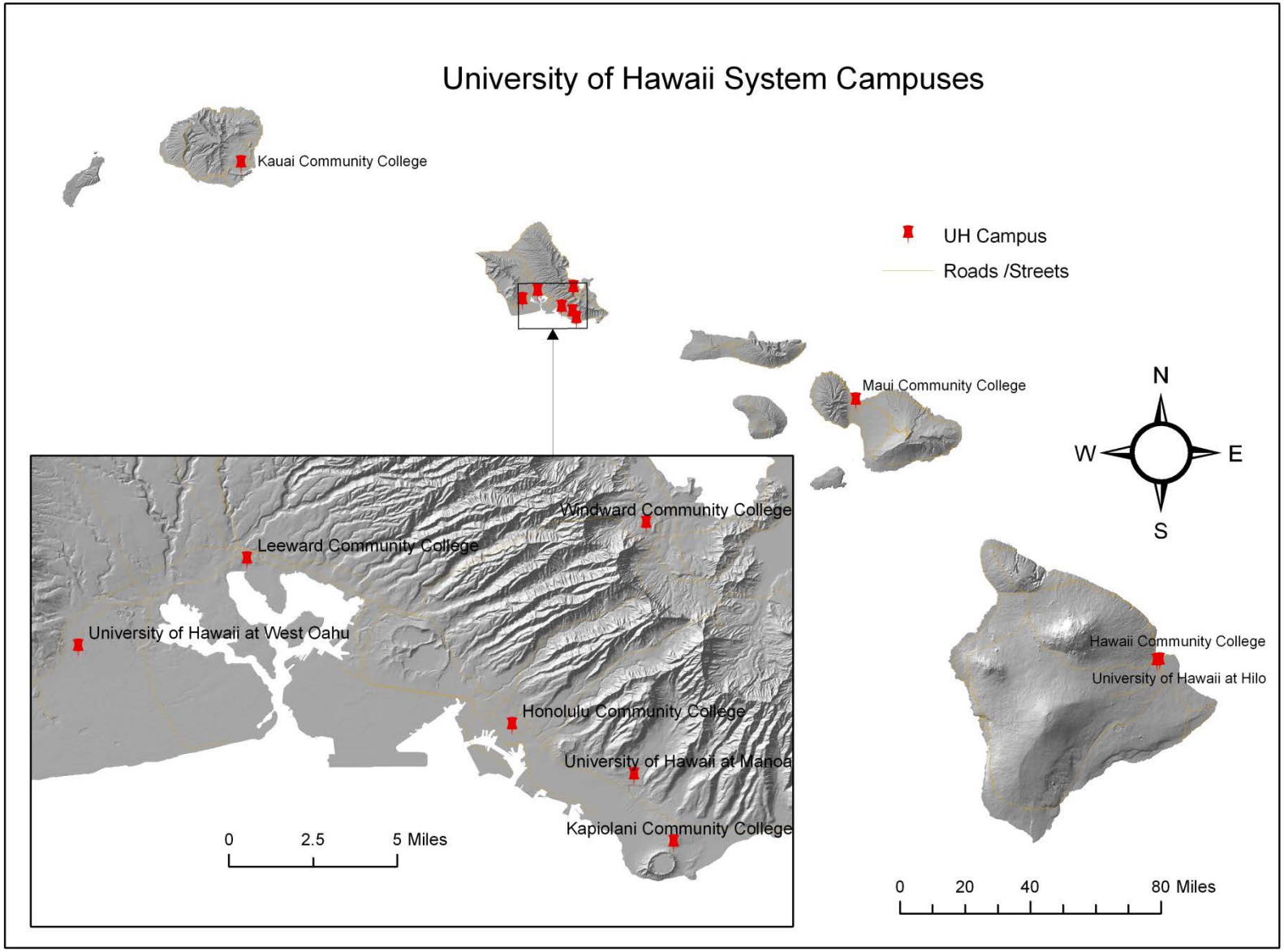
19.4.8 University of Hawai‘i System

The University of Hawai‘i (UH) is the only public system of higher education in Hawai‘i, and is classified as an instrumentality of the state, established by law under Hawai‘i Revised Statute §304-2, and as such is statutorily exempt from income taxes under IRS Code §115. UH holds legal title to all facilities. A Land-Grant University System with 10 campuses and research facilities that provides affordable higher education, including undergraduate, graduate and post-doctorate research opportunities and that serves as the primary research institution for the State of Hawai‘i. The System includes approximately 730 buildings or facilities and 11,126,000 gross square feet of building space valued at approximately $1.6 billion. The UH system also includes dozens of educational, training, and research centers across the Hawaiian Islands, with one campus in the County of Kaua‘i, six campuses on the City and County of Honolulu, one campus on the County of Maui, and three on the County of Hawai‘i.

UH professors and researchers contribute to knowledge about disasters affecting the state. Much of the information that contributes to understanding and profiling hazards has been attained through ongoing research. In addition, UH contributes to the development of professionals who work in disaster management as researchers, first responders, and service providers in recovery and rehabilitation. The State has tapped into this resource with voluntary experts serving on the State’s various hazard advisory committees.

A study on the vulnerability of the UH Mānoa and Honolulu Community College campuses (City and County of Honolulu) to flood was competed in 2010. Details and findings of this study are included in Section 9.4.14 in Chapter 9 – Floods.

Figure 19.5 University of Hawai‘i System Campuses



19.5 Critical Infrastructure and Lifelines

Critical infrastructure covers a wide range of activities and lifelines that support the daily state activities and operations, and are essential in any emergency situation. These lifelines include transportation and points of entry, water infrastructure, energy, telecommunications, and solid and hazardous waste disposal. A risk assessment study on potential losses and damages to critical facilities from high winds was conducted in 2010. The study looked at 274 structures in all of the four Counties. Details, results, and conclusions of this study are included in Section 5.4.6 in Chapter 5 – Tropical Cyclones.

19.5.1 Transportation and Ports of Entry

Transportation data is important for emergency operations during any type of disaster and for providing relief and recovery. Failure of these lifelines could be a great impediment to dealing with the impacts of a hazard. The information recorded in the GIS database includes: roads and bridges; airports, landing strips and helicopter pads; ports; vehicle and heavy equipment base yards, and car rental agencies.

19.5.1.1 Airports and Airstrips

The State Department of Transportation, Airports Division, operates the airports throughout the State of Hawai‘i with the following organizational information. Additional security requirements at airports, decreased travel overseas because of war, terrorism, SARS or other health epidemics, fewer daily interisland flights and local changes to make interisland travel less commuter-friendly may alter the original projections. A list of commercial airports and airstrips in the State of Hawai‘i as well as their administration structure is shown on the chart in Figure 19.6. The airports and airstrips are also shown on the map of Figure 19.7.

Figure 19.6 State of Hawai‘i Airport Administration and list of Ports of Entry

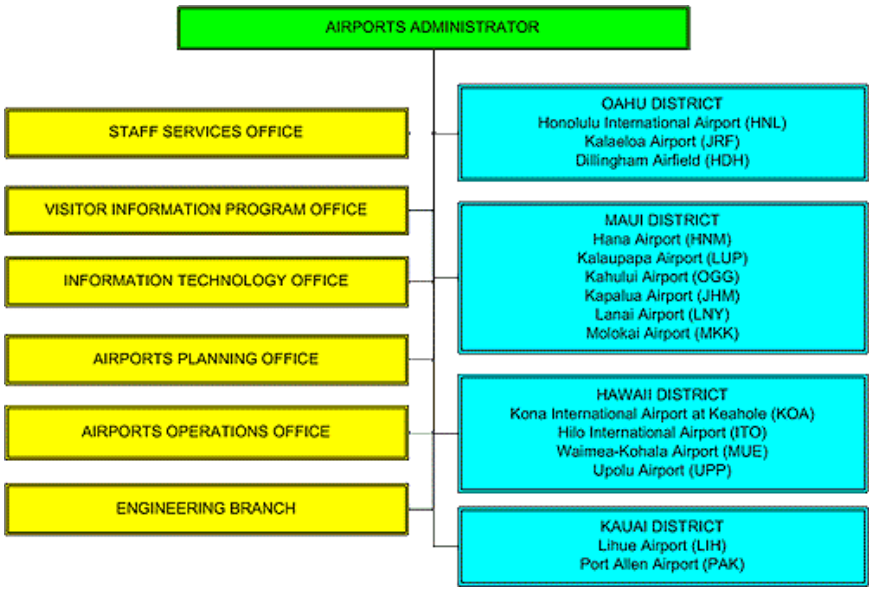
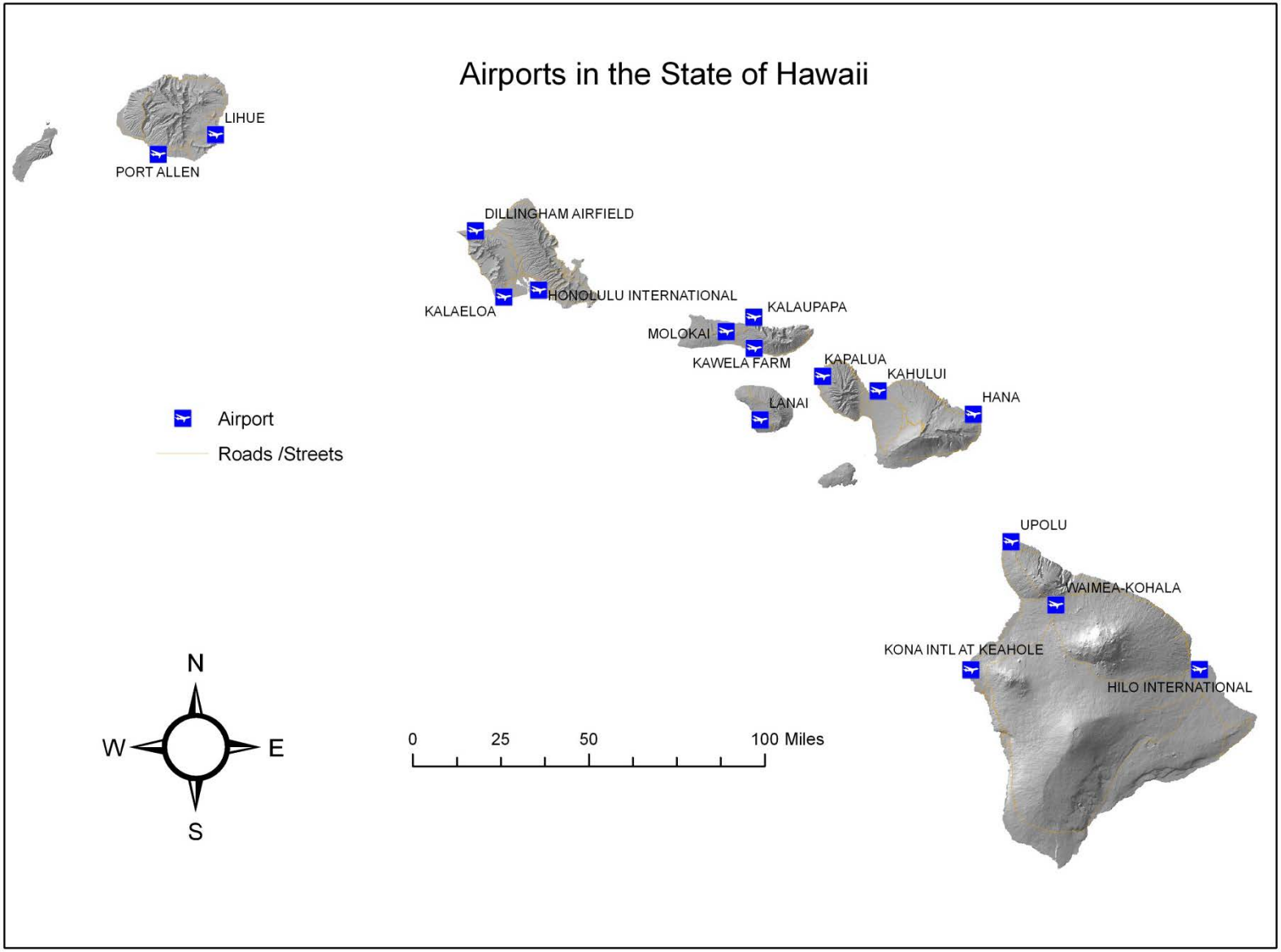


Figure 19.7 State of Hawai‘i Commercial Airport and Airstrips



19.5.1.2 Harbors

The State of Hawai‘i Department of Transportation-Harbors Division (DOT-H) administers the statewide commercial harbor system for the State which consists of 10 commercial harbors.

Barbers Point Harbor, and Kewalo Basin on the island of O‘ahu; Port Allen and Nawiliwili Harbors on the island of Kaua‘i; Kahului Harbor on the island of Maui; Hilo Harbor and Kawaihae Harbor on the island of Hawai‘i; Kaunakakai Harbor on the island of Moloka‘i; and Kaumalapau Harbor on the island of Lāna‘i.

Honolulu Harbor is the primary harbor and the hub of the commercial harbor system. Essentially all of Hawai‘i State’s overseas waterborne traffic enters and leaves this harbor. It is also the focal point for inter-island cargo transportation. Hawai‘i is a port of destination where large volumes of cargo pass over its piers for consumption in the state. Hawai‘i imports 80% of its required goods with 98% of those goods shipped via water.

DOT-H operates the harbor system on a self-sustaining basis, i.e., by imposing rates, rentals, fees and charges, or combination thereof, for the use and services of the harbor system, which are necessary to pay all expenses of the harbor system. DOT-H is self-supporting and not reliant on the state’s General Fund.

The function of the DOT-H is to service the O‘ahu (Honolulu Harbor, Kalaeloa Barbers Point Harbor and Kewalo Basin), Maui (Kahului, Kaumalapau, and Kaunakakai Harbors), Kaua‘i (Nawiliwili and Port Allen Harbors) and Hawai‘i (Hilo and Kawaihae Harbors) Districts.

Maintaining operations in the harbors is critical during emergencies, as Kaua‘i experienced during Hurricane Iniki. All of the major relief supplies and equipment would need to be transported through this harbor by Young Brothers cargo transporters. Agreements have been made among the Matson Corporation, State Civil Defense, the Honolulu Electric Company (HECO), and Young Brothers to maintain port operations during emergencies in Honolulu, where most of the imports to Hawai‘i, including fuel and equipment, arrive, and to make sure that SCD can control the manifest for deliveries of relief assistance and necessities to the neighbor islands.

The State Department of Land and Natural Resources Division of Boating and Ocean Recreation (DOBOR) owns small boat harbors on all islands. Local fishers and residents use most of these small boat harbors. Charter boats and tour operators use these smaller boat harbors as well. Figure 19.8 through Figure 19.11 include maps of all counties indicating the location of State-operated commercial harbors and other boating related facilities.

Figure 19.8 Commercial Harbors and Small Boat Facilities in the County of Kaua‘i

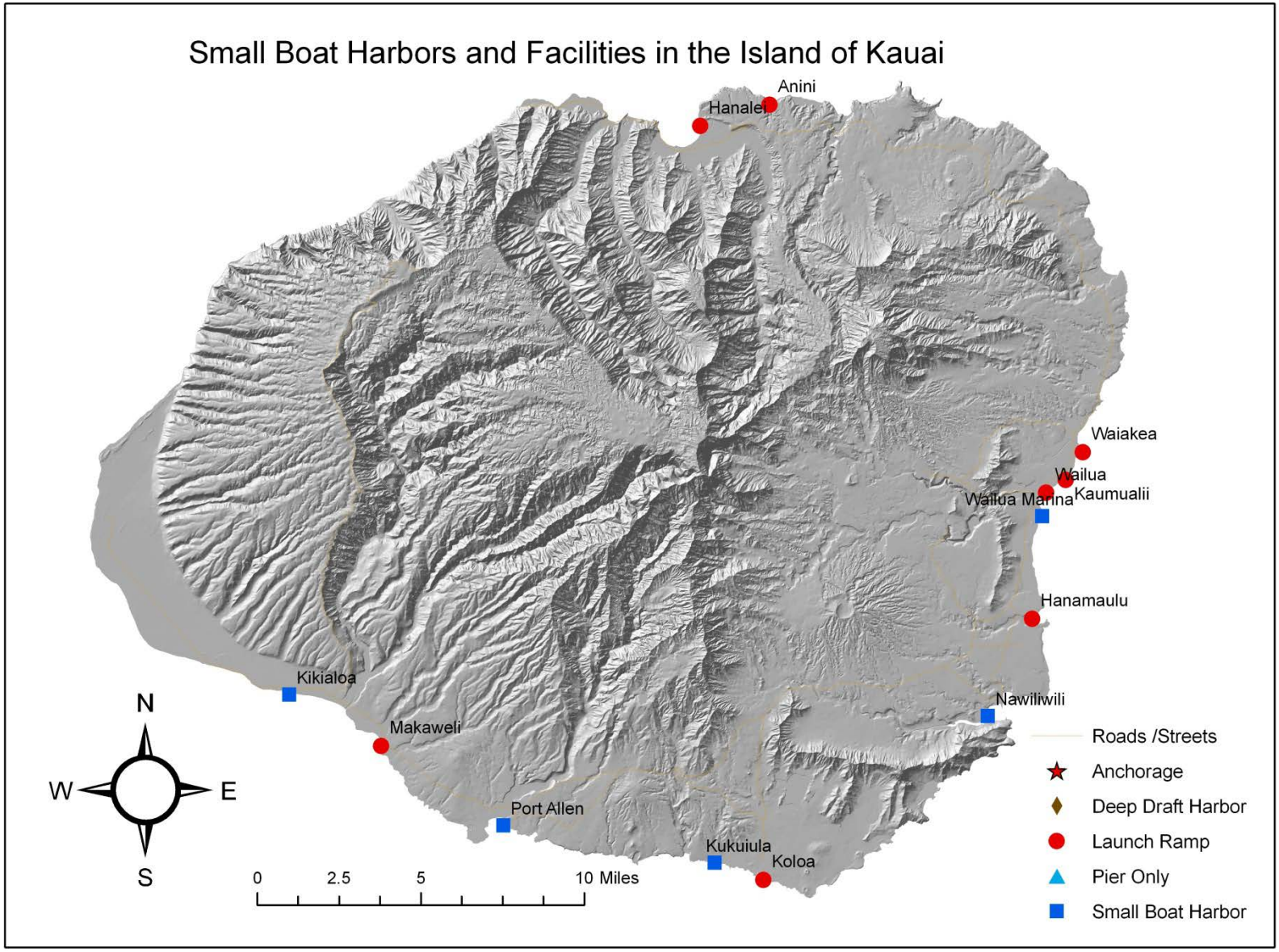


Figure 19.9 Commercial Harbors and Small Boat Facilities in the City and County of Honolulu

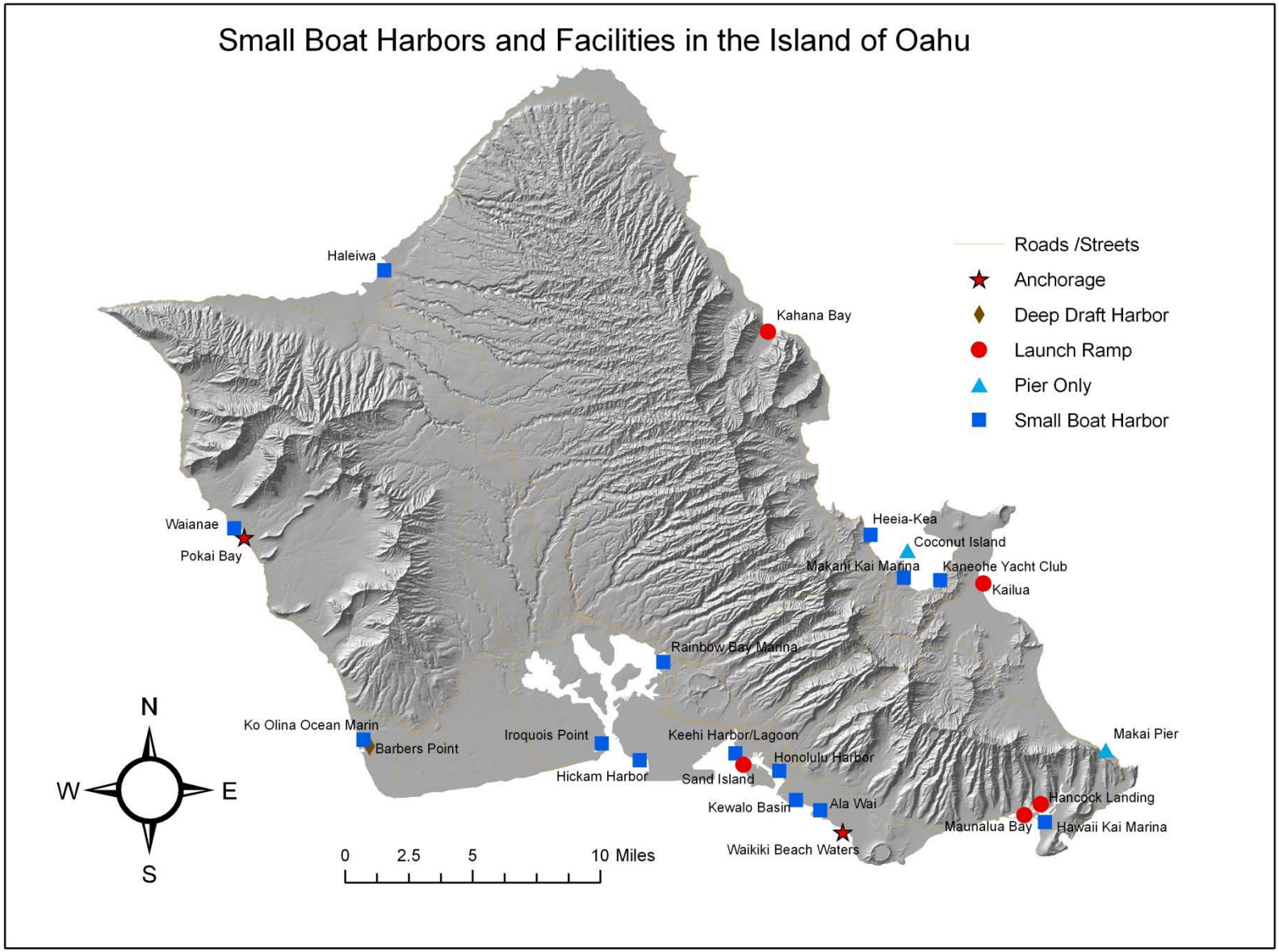


Figure 19.10 Commercial Harbors and Small Boat Facilities in the County of Maui

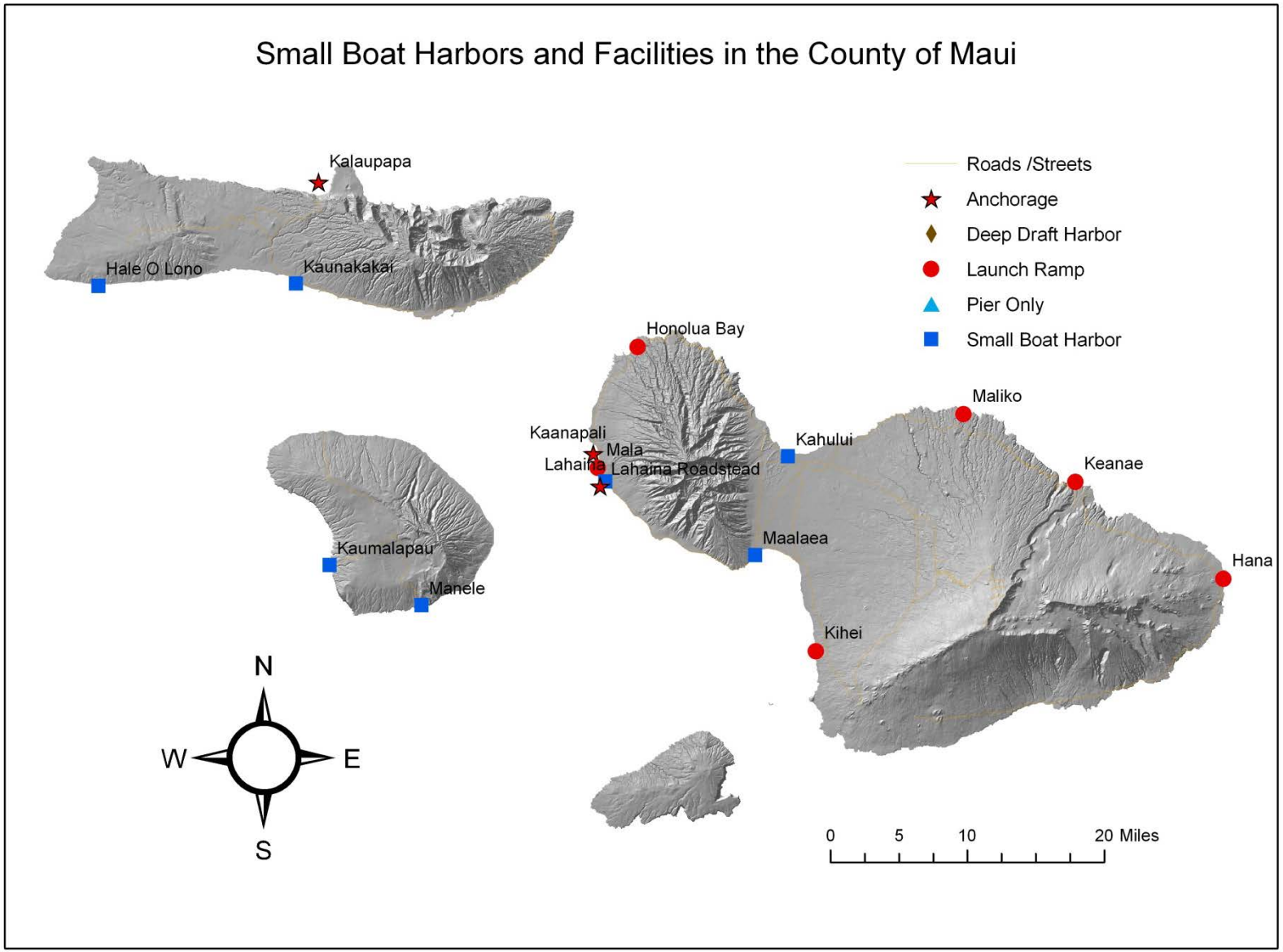
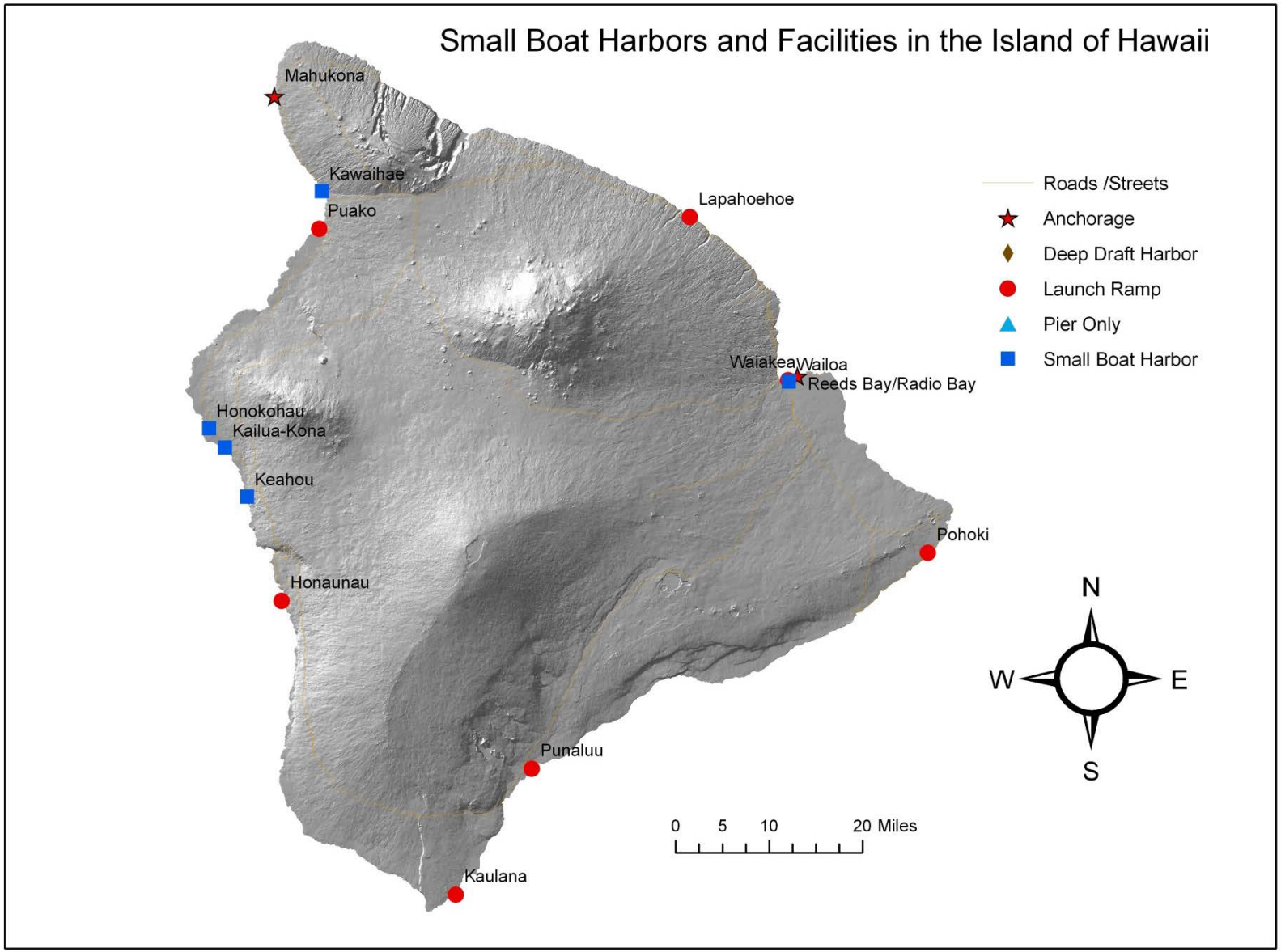


Figure 19.11 Commercial Harbors and Small Boat Facilities in the County of Hawai‘i



19.5.1.3 Roadways

Hawai‘i State Department of Transportation maintains data and information pertaining to the roadway system in the state.

All of the islands have sections where traffic flow is poor and peak hours in the morning and late afternoon result in extreme congestion. Traffic congestion makes residents and visitors extremely vulnerable to the impacts of disasters. Heavy rains will make the roads slick. Congestion and few arterial roads may make it difficult to evacuate risky areas. Large segments of the roadway run along the coastline, and many of these roadways could be engulfed in a tsunami. Cars sitting on the road trying to evacuate combined with the slow movement of traffic could result in high numbers of death and injury.

The Department of Transportation and the O‘ahu Metropolitan Planning Organization have made efforts to improve levels of service to reduce congestion. As populations continue to grow, this will be an ongoing difficulty. Alternative transportation may offer some solutions.

Maps of each of the populated islands depicting the State-operated roadway system are included in Figure 19.12 through Figure 19.16. To complement the maps, a list of all the roads with a brief description is provided as follows:

<u>Island of Kaua‘i</u>

a) Route 50, Kaumuali‘i Highway, Ahukini Road (Route 570) to Mānā
b) Route 51, Kapule Highway, Rice Street to Kūhiō Highway (Route 56)
c) Route 56, Kūhiō Highway, Ahukini Highway (Route 570) to Princeville
d) Route 58, Rice Street to Kaumuali‘i Highway (Route 50)
e) Route 540, Halewili Road off of Kaumuali‘i Highway (Route 50)
f) Route 541, Waialo Road off of Kaumuali‘i Highway (Route 50)
g) Route 550, Waimea Canyon Drive off of Kaumuali‘i Highway (Route 50)
h) Route 560, Kūhiō Highway, Princeville to Hā‘ena
i) Route 570, Ahukini Road Kūhiō Highway (Route 56) to Kapule Highway (Route 51)
j) Route 580, Kuamo‘o Road off of Kūhiō Highway (Route 56)
k) Route 583, Ma‘alo Road off of Kūhiō Highway (Route 56)

<u>Island of O‘ahu</u>

a) Interstate Route H-1, Connection with Kalaniana‘ole Highway in Wai‘alae to connection with Farrington Highway in Makakilo
b) Interstate Route H-2, Intersection with Interstate Route H-1 at Wahiawā Interchange to Wahiawā
c) Interstate Route H-3, Marine Corps Base Hawai‘i to Intersection with Interstate Route H-1 at Hālawa Interchange
d) Route 61, Pali Highway, Honolulu to Kailua
e) Route 63, Likelike Highway, Kalihi to Intersection with Kamehameha Highway (Route 83) in Kāne‘ohe

f) Route 64, Sand Island Access Road
g) Route 65, Kāneʻohe Bay Drive, Intersection with Kamehameha Highway (Route 83) in Kāneʻohe to Kailua
h) Route 72, Kalanianaʻole Highway, Intersection with Interstate Route H-1 to Intersection with Pali Highway (Route 61)
i) Route 76, Fort Weaver Road, Intersection with Interstate Route H-1 to ʻEwa Beach
j) Route H201, Moanalua Freeway, Middle Street to Hālawa Interchange
k) Route 80, Kamehameha Highway, Wahiawā to Intersection with Kamehameha Highway (Route 99)
l) Route 83, Kamehameha Highway, Intersection with Pali Highway (Route 61) to Intersection with Kāneʻohe Bay Drive (Route 65)
m) Route 83, Kahekili Highway, Intersection with Likelike Highway (Route 63) to Kahaluʻu
n) Route 83, Kamehameha Highway, Kahaluʻu to Haleʻiwa
o) Route 92, Nimitz Highway, Pearl Harbor to Honolulu Harbor
p) Route 92, Ala Moana Boulevard, Honolulu Harbor to Waikīkī
q) Route 93, Farrington Highway, Wahiawā Interchange to Makua
r) Route 95, Kalaeloa Boulevard, Intersection with Interstate Route H-1, Makakilo Interchange to Barbers Point Harbor
s) Route 99, Kamehameha Highway, Schofield Barracks to Waialua
t) Route 750, Kunia Road, Intersection with Interstate Route H-1 to Schofield Barracks
u) Route 930, Farrington Highway Waialua to Dillingham Airfield

Island of Maui

a) Route 30, Honoapiʻilani Highway, Intersection with Kaʻahumanu Avenue (Route 32) in Wailuku to Keawaʻula
b) Route 31, Piʻilani Highway, Intersection with Mokulele Highway (Route 311) to Wailea
c) Route 32, Kaʻahumanu Avenue, Intersection with Hāna Highway (Route 36) near Kahului Harbor to Wailuku
d) Route 36, Hāna Highway, Kahului Harbor to Intersection with Kaupakulua Road
e) Route 37, Haleakalā Highway, Kahului Airport to Intersection with Route 377 in Kula then continues on as Kula Highway
f) Route 310, North Kīhei Road, Intersection with Honoapiʻilani Highway (Route 30) to Intersection with Mokulele Highway (Route 311) and Piʻilani Highway (Route 31)
g) Route 311, Mokulele Highway, Intersection with Kuihelani Highway (Route 380) to Intersection with North Kīhei Road (Route 310)
h) Route 340, Kahekili Highway, Intersection with Waiehu Beach Road to Camp Maluhia
i) Route 360, Hāna Highway, Continuation of Hāna Highway Route 36 at Intersection with Kaupakulua Road to Hāna
j) Route 377, Haleakalā Highway, Junction of Kula Highway (Route 37) to Junction with Kekaulike Avenue
k) Route 378, Haleakalā Crater Road, Junction with Kekaulike Avenue to Haleakalā National Park
l) Route 380, Kuihelani Highway, Intersection with Honoapiʻilani Highway (Route 30) to Intersection with Mokulele Highway (Route 311)

Island of Molokaʻi

a) Route 450, Kamehameha V Highway, Kaunakakai to Hālawa Valley
b) Route 460, Maunaloa Highway, Maunaloa Village to Kaunakakai
c) Route 465, Airport Loop off of Maunaloa Highway (Route 460)
d) Route 470, Kalaʻe Highway, Intersection with Maunaloa Highway (Route 460) to Kalaupapa Lookout
e) Route 480, Puʻupeʻelua Avenue, Intersection with Maunaloa Highway to Intersection with Farrington Avenue.

Island of Lānaʻi

a) Route 440, Kaumalapau Highway, Kaumalapau Harbor to intersection with Mānele Road in Lānaʻi City continuing on Mānele Road to Hulopoʻe Beach Park

Island of Hawaiʻi[6]

a) Route 11, Hawaiʻi Belt Road, Intersection with Route 19 to Kailua Kona
b) Route 19, Hawaiʻi Belt Road, Hilo Harbor to Kailua Kona
c) Route 130, Keaʻau-Pāhoa Road, Intersection with Hawaiʻi Belt Road (Route 11) at Keaʻau towards Kalapana
d) Route 190, Palani Highway and Mamalahoa Highway, Kailua Kona to Intersection with Hawaiʻi Belt Road (Route 19) in Waimea
e) Route 220, Akaka Falls Road, Intersection with Hawaiʻi Belt Road (Route 19) to Akaka Falls Park
f) Route 240, Honokaʻa Waipiʻo Road, Intersection with Hawaiʻi Belt Road (Route 19) to Waipiʻo Valley
g) Route 250, Kohala Mountain Road, Intersection with Hawaiʻi Belt Road in Waimea to Hāwī
h) Route 270, Akoni Pule Highway, Kawaihae to Hāwī

[6] Route 200 (Saddle Road, Intersection with Mamalahoa Highway to Hilo) may become part of the State's jurisdiction in the future.

Figure 19.12 State Roadways on the Island of Kaua‘i (County of Kaua‘i)

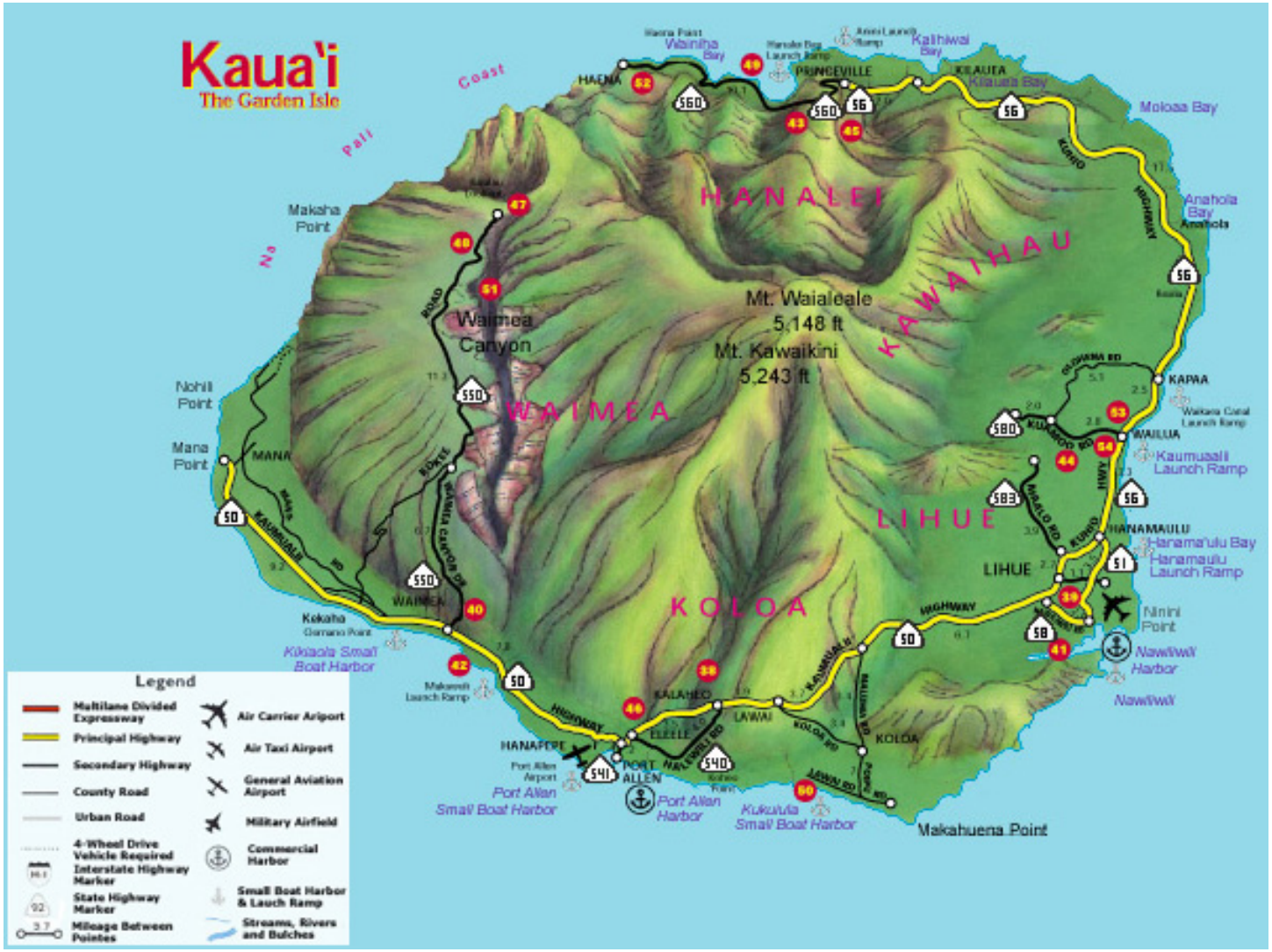


Figure 19.13 State Roadways on the Island of O‘ahu (City and County of Honolulu)

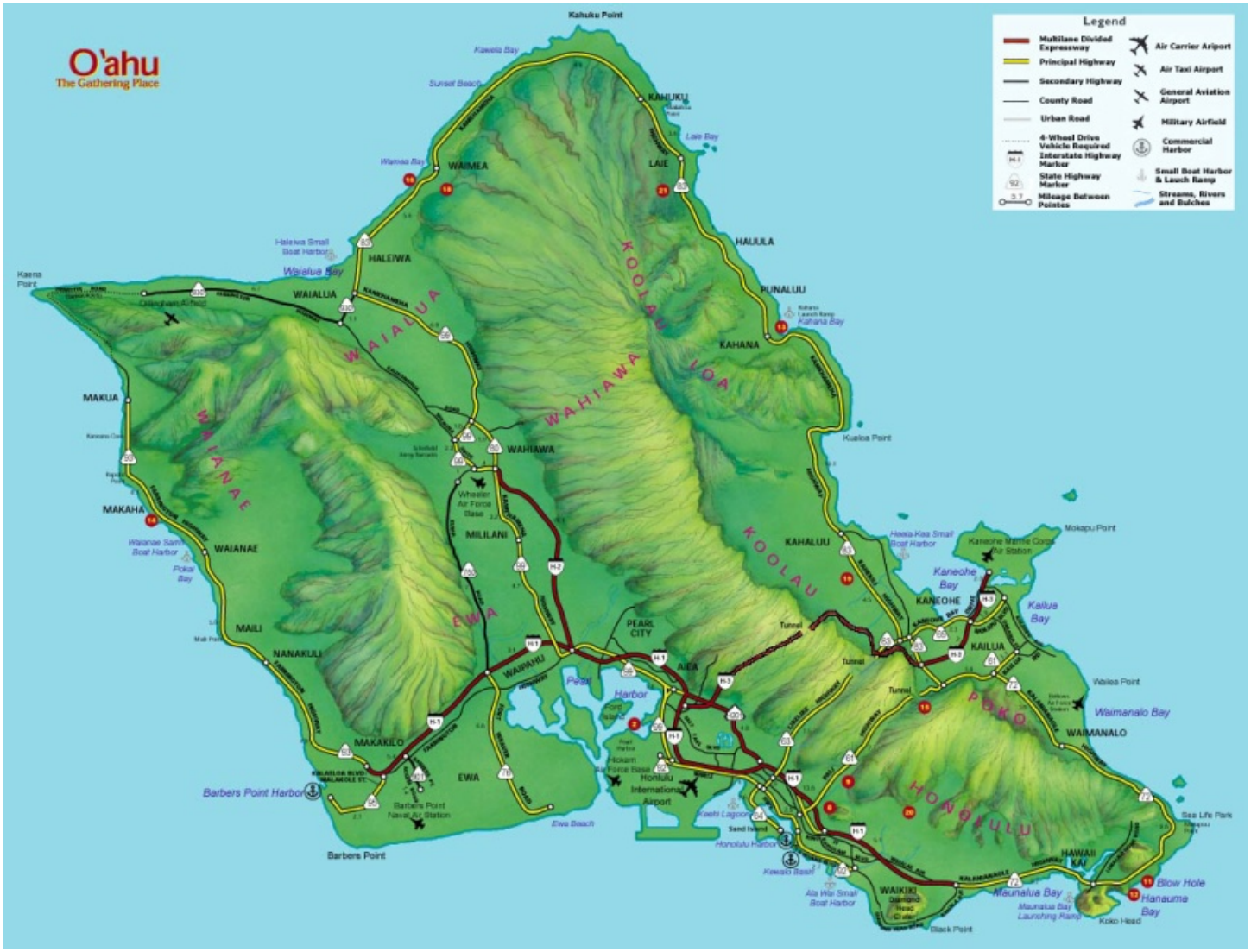


Figure 19.14 State Roadways on the Island of Maui (County of Maui)

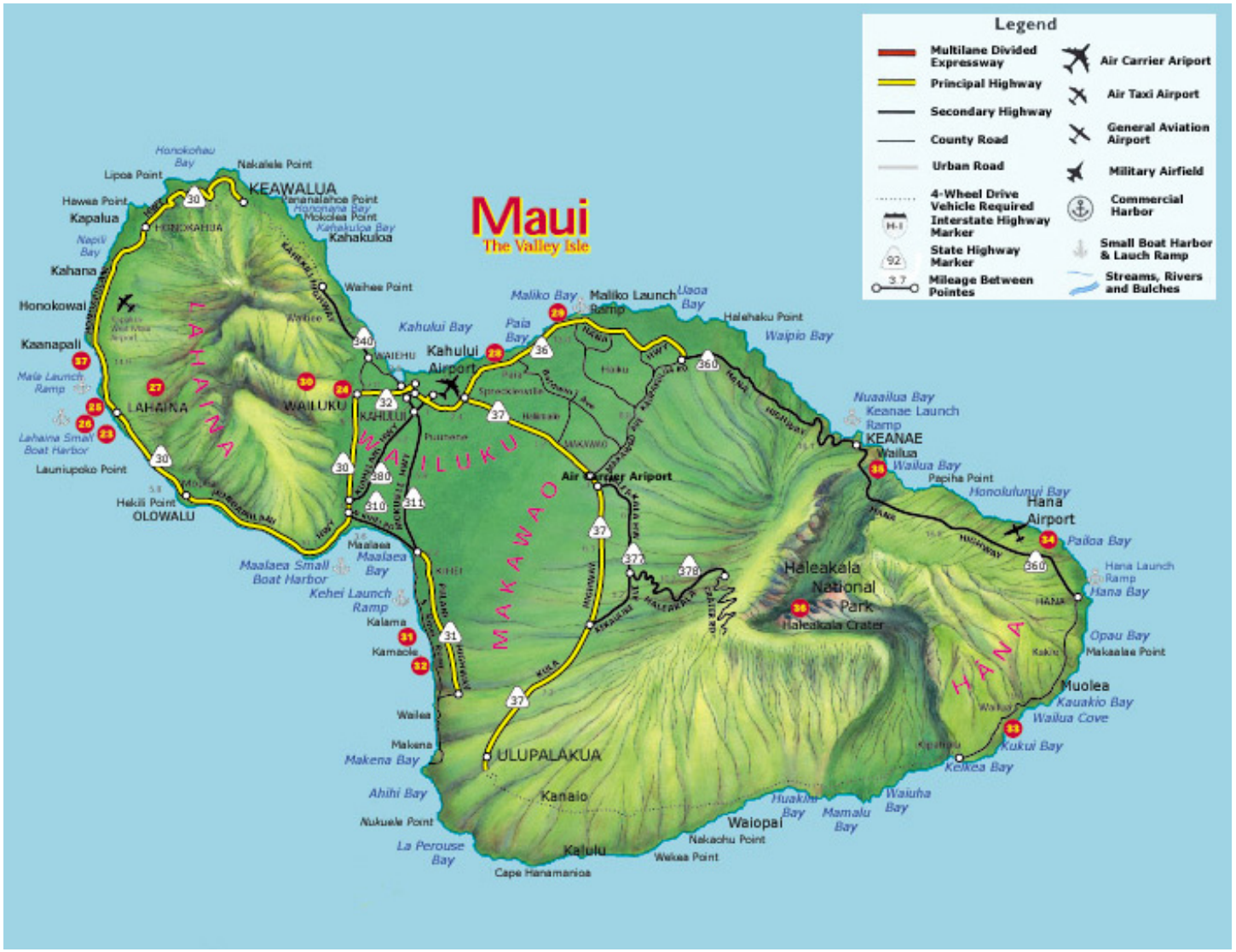
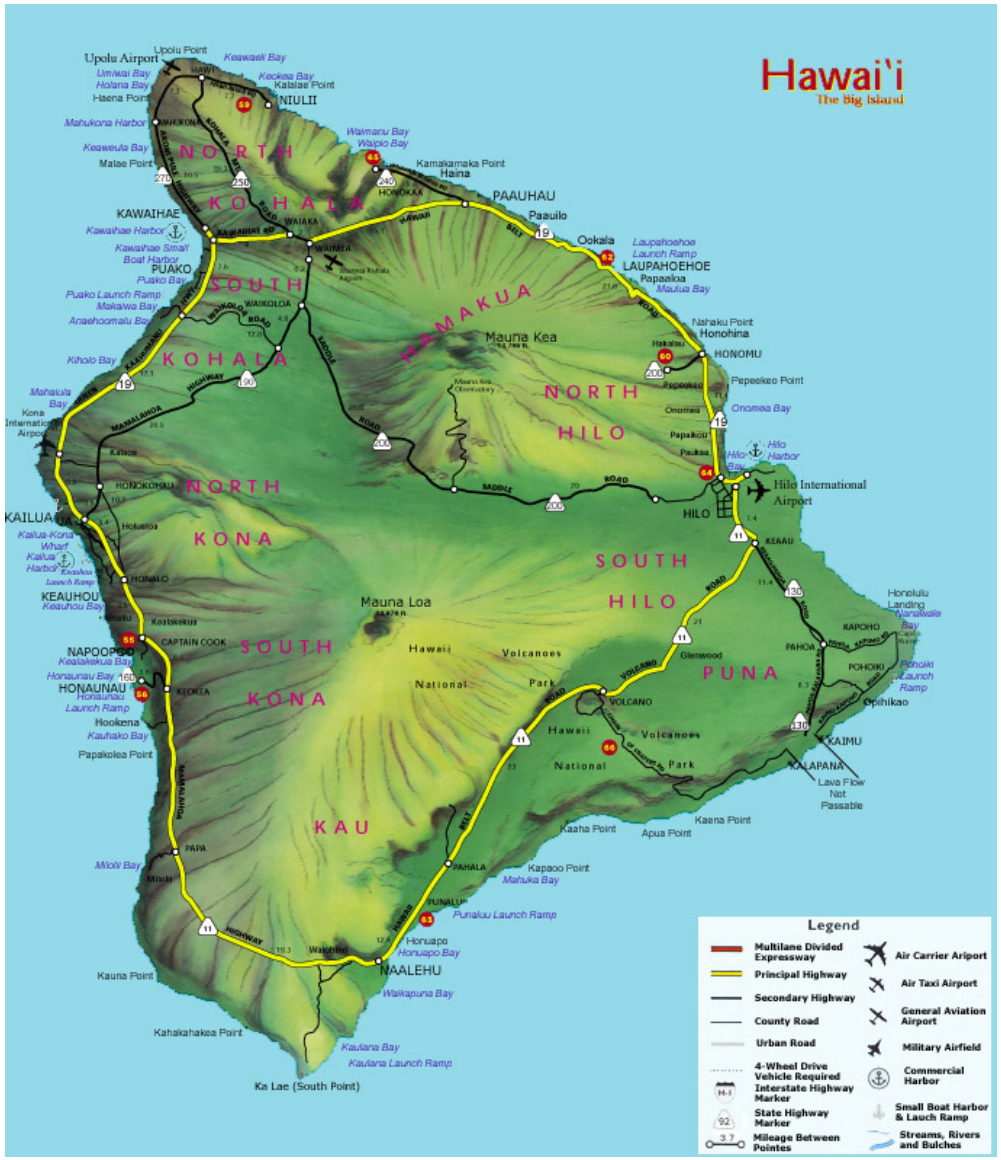


Figure 19.15 State Roadways on the Islands of Moloka‘i and Lānai (County of Maui)

Figure 19.16 State Roadways on the Island of Hawai'i (County of Hawai'i)



19.5.1.4 Bridges

Reports reviewing the infrastructure in Hawai‘i find that many of the state’s bridges require retrofits and rehabilitation. The qualification for bridges is structures that exceed 20 feet in length. Federal law requires inspections once every two years. If the sufficiency rating of the structures falls below 80, then the bridge is eligible for rehabilitation. If the bridge’s rating is less than 50, then the bridge is eligible for rebuilding. These structures become listed for federal funding, but there is limited funding available each year and it requires the state or county to provide 20% matching funds with the grants.

In Hawai‘i, many of the bridges qualify as historical bridges because they are older than 50 years. As the bridges age, they cannot handle heavy load capacities. The Department of Transportation works with the Historic Preservation Office to ensure that they attend to the preservation of historical bridges while doing the best to ensure that these bridges do not pose a threat, especially during disasters. The number and location of bridges listed by County is included in Table 19.3. The condition of the bridges according to the Federal Highway Administration is listed in Table 19.4.

Seismic retrofits for major bridges were completed in the County of Hawai‘i, prior to the October 2006 earthquake, which meant that they withstood the earthquake. The bridges are built to federal codes called Load Resistance Factor Design (LRFD) by the American Association of State Highway and Transportation Officials (AASHTO). The design codes were developed based on studies of the 1971 earthquake in California. Modifications have continuously been developed using lessons from the 1989 Loma Prieta and 1994 Northridge earthquakes in California. Of the lists of most critical bridges in the State, about 30% of the work on the most critical bridges has been completed. As mentioned, rehabilitation and retrofits were completed for the County of Hawai‘i and major projects for the City and County of Honolulu have been underway.

The County of Maui has been aggressive in pursuing replacement of bridges. Along the highway to Hāna (State Route 360), there are a number of historical bridges, but with the more than 700 visitors in addition to residents who travel the highway daily it is important to the county to make certain that the bridges will hold the transportation loads. The state has worked closely with the historic preservation offices to replace and rehabilitate structures where necessary to ensure public safety.

In addition to inspections that occur every year, the state has implemented a system of photographic logs that shoot 25-foot segments of the entire highway system every two to three years so that engineers can review the system and address problems. The entire system of roadways and bridges undergoes mitigation for floods, seismic hazards, and wind. These actions extend to signage, lighting, and poles included in the transportation system.

Following the bridge collapse in Minnesota in August 2007, renewed attention was turned to the structural safety of the nation’s bridges. The State of Hawai‘i has been monitoring its bridges. Most of the bridges in Hawai‘i County had been retrofit for seismic standards. The State does have a number of bridges declared “structurally deficient,” and this pertains in large part to the historical status of bridges preventing upgrades and retrofits. There are quite a few projects

waiting for funding, but the United States Department of Transportation estimated that it would require more than S65 billion to repair all bridges currently identified as "structurally deficient." and this funding is not available. Therefore, the State of Hawai'i continues to inspect and monitor its bridges and to reduce loading should the bridge require upgrades. The most important focus is ensuring the safety of the public using critical infrastructure.

Table 19.3 State of Hawai'i Highway Bridges by Island as of December 31, 2002[7]

Island	Number of bridges 1/	Longest bridge		Highest bridge	
		Location	Length (feet)	Location	Height (feet)
State	760	Airport Viaduct	14,890	Nanue	208
Hawaii	133	Hakalau	775	Nanue	208
Maui	99	Honokahua	600	Uaoa	79
Lanai	-	None	-	None	-
Molokai	19	Manawainui	360	Manawainui	50
Oahu	455	Airport Viaduct	14,890	Kipapa	156
Kauai	54	Hanamaulu	1,150	Wahiawa, Koloa	90

Table 19.4 State of Hawai'i Highway Bridge Condition by Island as of August, 2009[8]

County	# Bridges	# SD	#FO	Tot Def	Area	SD Area	FO Area	Def Area
HAWAII	236	40	51	91	83,546	4,577	14,310	18,887
HONOLULU	661	52	205	257	1,171,825	32,957	118,982	151,939
KAUAI	75	16	27	43	32,431	4,022	6,574	10,596
MAUI	158	35	63	98	33,694	3,379	7,381	10,760
NULL	3	0	1	1	319	0	68	68
TOTALS	1,133	143	347	490	1,321,814	44,935	147,316	192,251

Area is in SqM
SD = Structurally Deficient
FO = Functionally Obsolete

[7] Limited to bridges under State jurisdiction and with spans longer than 20 feet

[8] United States Department of Transportation Federal Highway Administration, August 2009, accessed August 9, 2013 from http://ww.fhwa.dot.gov/bridge/nbi/county09.cfm#hi

19.5.2 Electrical Power Plants and Fuel Centers

The Strategic Industries Division, formerly the Energy, Resource, and Technology Division, of the Department of Business, Economic Development, and Tourism functions as Hawai‘i’s State Energy Office and, as such, is the agency responsible for applying for and administering Federal funds received by Hawai‘i under the United States Department of Energy’s State Energy Program. This office has been responsible for developing the State’s Energy Preparedness and Mitigation Plans.

To support the implementation of Emergency Support Function (ESF) -12, Energy, which is consistent with the *State’s Administrative Plan for State and Federal Coordination, Enclosure 7 to Volume III, State Plan for Emergency Preparedness*. The primary responsibility of the State of Hawai‘i Energy Council (EC) will be to coordinate activities necessary to facilitate the affected energy utilities’ safe, rapid restoration of the commercial energy grid, and provide temporary emergency generators to safely and rapidly provide and sustain electricity for essential and emergency facilities and services until commercial energy utility service can be restored, and facilitate the availability and adequacy of fuel supplies, storage, and distribution. A State’s EC will be fully activated only when State and/or Federal disaster assistance is requested and approved.

Homeland Security has also made planning for the security of utilities essential. The energy facilities and utilities in each county have taken additional precautions to secure access to facilities. Quite a bit of the utility data has not been classified for inclusion in the geographic information system, although the information available has been included in more detail in the county plans. Transmission lines and pole locations are not included. The following positions and information have been recorded in the Geographic Information System (GIS) database: power plants; booster stations; fuel storage and supply; propane tanks, and above ground fuel pipelines.

Given the isolation of the islands, it is critical for the islands to develop sustainability in regard to energy. More recently, additional emphasis has focused on the development of renewable energy, with increased numbers of wind farms, solar energy, and exploration of biofuels. The renewable energy will help the island become more sustainable and less dependent on imported fuels for energy, which would be problematic in response to disasters and during the recovery process.

19.5.3 Communication Systems

The development of the Hawai‘i Wireless Interoperable Communications Network (HWIN) is of vital importance for the effective control and monitoring of emergency management operations and the capability of our response community to communicate during times of disaster. HWIN will support the rapid coordination of emergency response assets and ensure better decision-making.

Communications interoperability will make for improved statewide response to immediate disasters and life threatening situations. Having a mobile communications repeater system will serve a common platform for all response agencies across the state. Ensuring that the system is compatible with 700 and 800 MHz capability is being developed throughout the state. Building redundancy into the communications connectivity program is an important feature for our program to ensure interoperability.

The State Law Enforcement Coalition and the Department of Accounting and General Services have put in place a communications system and infrastructure that links the Public Safety Communications for State responders and provides a means of interconnecting the various county systems. Funding to complete this system is a major concern as it is for the entire State's communications interoperability needs. Completion of the Statewide Communications Plan will integrate the communications backbone and the communications infrastructure into one. Developing a Tactical Interoperability Plan by jurisdiction will provide the resource file for the Statewide Communications Plan.

During any type of disaster, the ability to communicate across the island, within the county, and within the state remains critical. It is important to record the locations of telecommunications equipment and lines, and to be able to maintain operability. The overall system involves public facilities, private companies, most specifically Hawaiian Telcom, and various cell phone companies. Because of privacy issues, not all of the information is available for inclusion in the GIS database. To the extent possible, the GIS database and maps include: telephone switching stations; satellite dishes; microwave repeaters; cellular phone antenna; telephone lines; cable television lines; and, radio stations and transmission towers. The telephone pole lines are rated at about 60 to 80 mph.

For the island of Kaua‘i, except for the Līhu‘e to Kalāheo route, and the Līhu‘e to Kapa‘a route, most fiber routes in the island are more than 90% overhead. The Līhu‘e to Kalāheo route is approximately 90% underground. The Līhu‘e to Kapa‘a route is 85% underground.

The Pacific Telecommunications Council (PTC) members use telecom and Information and Communication Technologies (ICT) to improve commerce, governance, education, health, safety, and the human condition. A superb environment for business networking draws thousands to Honolulu each January during the annual conference. In their annual conferences to improve telecommunications, the council sponsors discussions and helps to build strategies to address emergency management issues.[9]

[9] Pacific Telecommunications Council Webpage: http://www.ptc.org/

19.5.4 Water Systems

19.5.4.1 Water Supply

Critical components of statewide water supply systems are vulnerable to hazard-related events, which may affect a utility's ability to provide a reliable supply and quantity of safe water for drinking, food preparation, sanitary needs and other purposes. Such emergency events include both natural disasters, such as floods, earthquakes, tsunami, hurricanes, and high winds, and human induced emergencies caused by theft, vandalism, accidents, and terrorism.

Water utilities should prepare and initiate proactive measures to protect their critical assets, both fixed and movable. Stationary assets include, but are not limited to, raw water supply facilities, treatment facilities, distribution facilities, and operation/control facilities and systems. Movable assets include equipment, trucks, etc. but also include staffing resources that will be responsible for response and repair of damaged water system facilities. These assets should be evaluated for vulnerability to disruption and protected as much as possible.

The specific threat to statewide water utilities will depend on the unique characteristics of each utility (e.g., stand-alone systems versus multiple integrated water systems). Nonetheless, the critical nature of such systems and the potential impacts which may arise from any disruption of water supply systems reinforces the need for preparation and appropriate mitigation actions.

As an example, the service area of the Honolulu Board of Water Supply (HBWS), City and County of Honolulu, encompasses 606 square miles. The HBWS operates and maintains an integrated water system comprised of 230 sources, 166 storage facilities, and over 2,100 miles of transmission and distribution lines. Vulnerable components of such a water supply system can be rendered less susceptible to harm through the development and regular updating of Emergency Response Plans to minimize the impacts of a disaster event or to mitigate its impact.

19.5.4.2 Sanitation and Wastewater Treatment

The Hawai'i State Department of Health is the organization in charge of overseeing water quality and compliance with sanitation and wastewater treatment laws. Each county oversees sanitation and wastewater treatment. These facilities have been included in the county GIS databases.

Because of the critical importance of wastewater treatment and sanitation, the federal government began requiring that maintenance and pipe repair records were digitally recorded with geocoding to improve the ability to respond to line breaks. These records are kept in each of the wastewater offices. In 2006, during the extensive rain that led to the FEMA-DR-1640-HI declaration, the drainage and wastewater lines malfunctioned. Tons of sewage escaped into Waikiki Beach areas and the south shore beaches were closed for several weeks for repair and cleaning. As a major tourist destination and primary hotspot for tourism activities, the beach closures resulted in thousands of dollars in lost revenue. The City and County of Honolulu renewed its efforts to inspect and maintain its drainage system following the disaster.

As shown in Figure 19.17, most of the sewer lines on the island of O‘ahu are offshore following wastewater treatment. The problem came when the wastewater pipes overflowed and went into regular storm drains. The Department of Health Clean Water Branch monitors the water in beach areas to ensure public safety and prevent illness from Exposure to contaminated water.

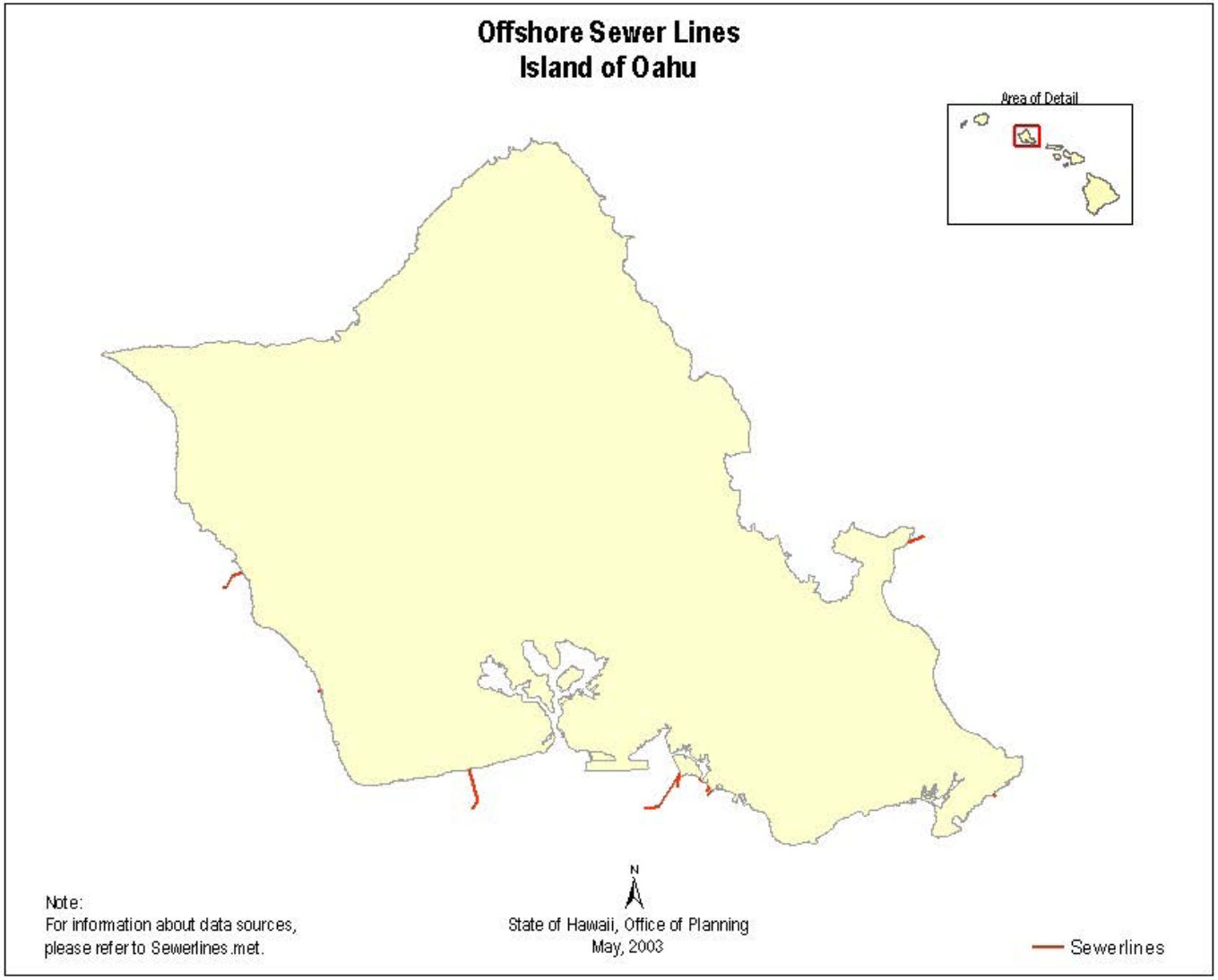
19.5.5 Solid and Hazardous Waste

The Hawai‘i State Department of Health Solid and Hazardous Waste Branch oversee the implementation of rules to safely store and dispose of solid and hazardous waste materials. This department maintains official records stored in its database. Critical sites and facilities have been recorded with Civil Defense in their database for emergencies. Rules and regulations as well as lists of sites are available on their website.[10] These records include sites for underground storage tanks, solid waste, and hazardous waste. Additional information on siting of wastewater treatment facilities has been recorded by each county in their GIS databases for county mitigation plans.

The waste that needs to be dumped also includes significant materials from military operations, including ordnance used for training exercises and remaining unexploded ordnance from World War II, as well. Figure 19.18 shows offshore dumping areas for the island of O‘ahu (City and County of Honolulu).

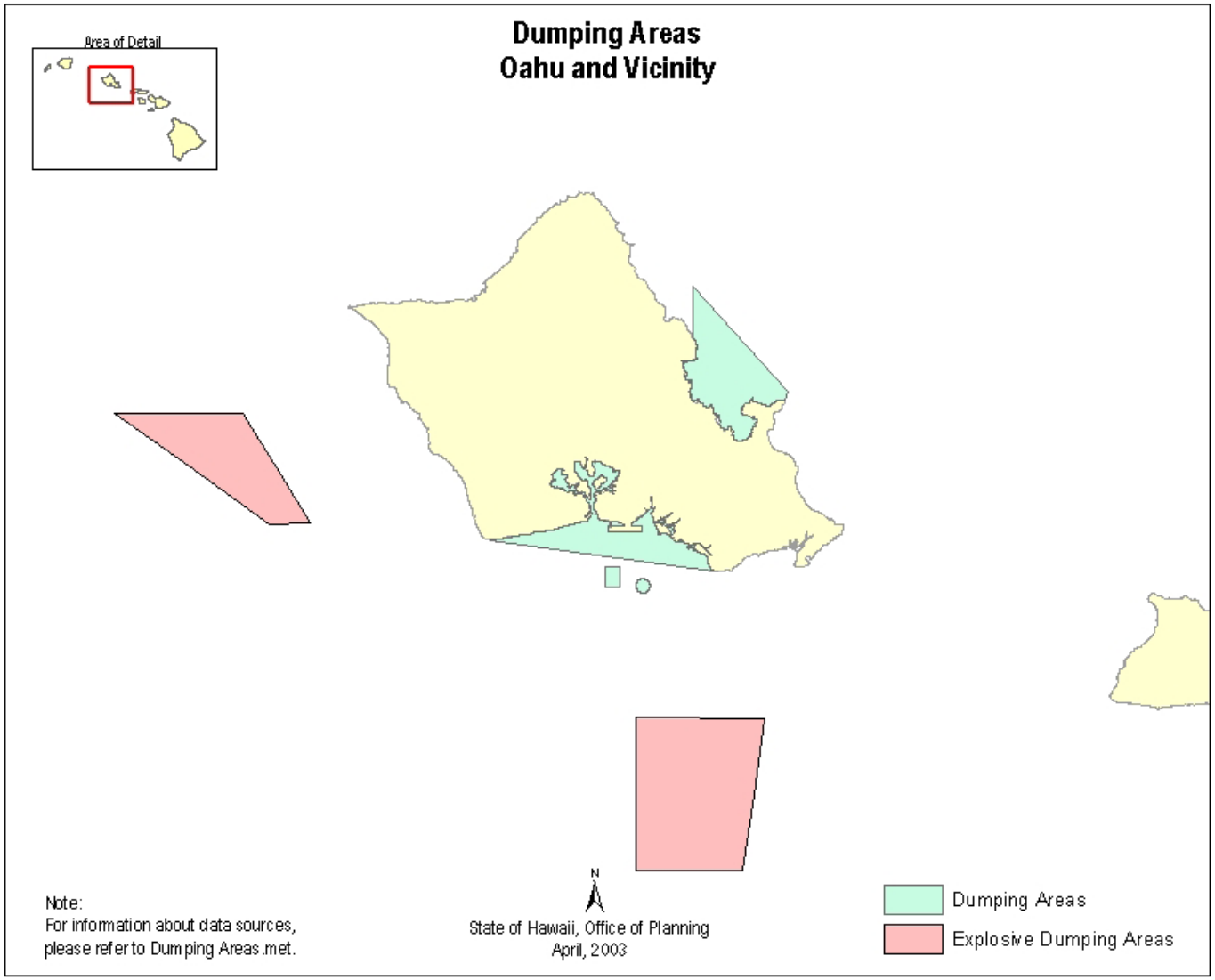
[10] Sate of Hawai‘i Department of Health Solid and Hazardous Waste Branch Website: http://www.hawaii.gov/health/eh/shwb/index.html

Figure 19.17 Offshore Sewer Lines, Island of O‘ahu[11]



[11] State of Hawai‘i GIS Program, access 2010 (best available data).

Figure 19.18 Offshore Dumping Areas, Island of O‘ahu[12]



[12] State of Hawai‘i GIS Program, access 2010 (best available data).

19.6 Economically Important Assets

The Small Business Administration (SBA), the Federal Emergency Management Agency (FEMA), and the Institute for Business and Home Safety (IBHS) have researched business failures following disasters. They have found that 43% of businesses that do not reopen within 48 hours do not ever reopen. The experience of the County of Kaua‘i following Hurricane Iniki in 1992 demonstrated the detrimental effects of disasters for the entire state. Almost a decade after the disaster, the economy was still struggling. Therefore, it is important to ensure that critical facilities relating to the economy should be protected.

The State relies heavily on the tourism industry, and depends on the beauty of the natural resources as well as facilities to house tourists. Critical facilities, such as the airports, and critical infrastructure, such as roadways and utilities, support the tourism industry as well as the economic viability of other sectors. It is important to have all facilities operating as quickly as possible following a disaster. The agricultural sector and food security are also important for the state’s economy as well as the survival of residents and visitors.

The viability of financial institutions is critical. Even though these institutions are private, they ensure the economy continues to function. Following a disaster, people would still need access to cash to purchase food and other goods and services. Financial institutions are managed primarily from the island of O‘ahu (City and County of Honolulu). It is important to ensure secured transportation to the neighbor islands to maintain cash supply for automatic teller machines, stores, and local banks. Not only are the financial institutions considered critical, but the transportation corridors through which these institutions operate are considered critical.

The GIS databases at the county levels include information on economically important assets throughout the State, including: financial institutions; hotels and tourism facilities; building supplies; supermarkets; and, commercial and industrial areas.

19.6.1 Housing

The following inventory of housing units by county through 2000 has changed dramatically in the past couple of years. Declining interest rates enabled more families to purchase homes, increasing the demand for housing. This increased demand has caused the price of housing to increase significantly. The higher demand for affordable housing has resulted in rapid development of single family homes and townhouses on former agricultural lands – which have extended taxed infrastructure and services to these previously undeveloped and less populated areas. As interest rates began to creep upwards in 2006 and 2007, the housing market slowed. Many people have balloon payments due because they used different financing schemes to purchase homes, and there have been growth in foreclosures in 2007. Table 19.5 lists housing estimates by county for the period between 2000 and 2009.

The economy of the state has improved in terms of construction employment; however, the scarcity of housing stock has resulted in higher rents, unaccompanied by salary increases at the same rate. Should these development trends increase, household pressures to meet the increased costs of living will be taxed significantly during any disaster event.

Table 19.5 State of Hawai‘i Housing Units by County[13]

Table 4. Annual Estimates of Housing Units for Counties in Hawai‘i: April 1, 2000 to July 1, 2009												
Geographic Area	Housing Unit Estimates										April 1, 2000	
	July 1, 2009	July 1, 2008	July 1, 2007	July 1, 2006	July 1, 2005	July 1, 2004	July 1, 2003	July 1, 2002	July 1, 2001	July 1, 2000	Estimates Base	Census
Hawai‘i	515,538	512,277	506,345	499,799	490,935	482,767	476,296	470,739	466,268	461,685	460,541	460,542
Hawai‘i County	80,631	79,338	77,444	75,064	71,917	69,043	66,999	65,677	64,404	63,019	62,673	62,674
Honolulu County	337,991	337,099	334,792	332,726	329,300	325,775	322,845	320,256	318,356	316,461	315,988	315,988
Kalawao County	175	175	176	176	177	176	173	172	172	172	172	172
Kaua‘i County	30,123	29,698	29,130	28,287	27,429	27,039	26,540	25,982	25,648	25,394	25,331	25,331
Maui County	66,618	65,967	64,803	63,546	62,112	60,734	59,739	58,652	57,688	56,639	56,377	56,377
Note: The April 1, 2000 Housing Unit Estimates Base reflects changes to the Census 2000 housing units from the Count Question Resolution program and geographic program revisions.												

19.7 Socially, Culturally, and Environmentally Important Assets

Although these assets usually appear at the bottom of the list of assets for a risk and vulnerability assessment, these are the things that make up the character and uniqueness of the islands of Hawai‘i. To the extent that data exists and has been developed and maintained, the GIS database includes: churches, historic sites and buildings, archaeological sites, wetlands, unique environmental habitats and resources, trails (Nā Ala Hele State trail system), firebreaks,

[13] Annual Estimates of Housing Units for Counties in Hawai‘i: April 1, 2000 to July 1, 2009 (HU-EST2009-04-15), United States Census Bureau, Population Division, Release Date: June 2010, Table 4

hazardous materials storage, protective sand dune and coral reef systems, cemeteries and burial lands, heiau, hālau, and community and cultural centers.

The assets discussed in this section are the aspects that contribute to the development of resiliency to the impacts of disasters. Often, these areas are overlooked, but problems in society that increase vulnerability of populations and that degrade environments contribute to disasters, if all aspects of the society and the environment were in harmony, the natural hazards would be less likely to cause disasters.

19.7.1 Social Assets

Social assets are the range of services and organization of society that ensure its viability. These include non-profit organizations that focus on poverty, education, health, environment, literacy, children's well-being, women's issues, violence reduction, and community welfare. Addressing the well-being of underrepresented individuals and their needs helps to strengthen society.

Inequalities and injustices in society will be exacerbated in crisis situations. For example, in Hawaiʻi, single parent women tend to fall below the poverty line more than other groups in society, in Hawaiʻi, when the women is of native Hawaiian ancestry, her risk increases from 20.6% to 37% of living below the poverty line.[14] Responses to polls on domestic violence in Hawaiʻi show a higher incidence than compared with the results of national survey conducted in 2002.[15] High incidence of substance abuse recorded in Hawaiʻi decreases overall resilience of the population.[16] Programs and organizations that address everyday crises in society contribute to building societal resilience that will strengthen society in crisis.

These non-profit organizations and social services need to be considered part of the disaster risk reduction community. By focusing on reduction of everyday crises, these organizations improve individual lives that instill survival skills that can be employed in disasters as coping strategies.

19.7.2 Cultural Assets

Many of the cultural features that will be considered assets are the people who retain wisdom and knowledge of living in island environments and using resources wisely. In addition to previously mentioned places, such as burial sites, heiau, and hālau, the people of Hawaiʻi who retain particular knowledge in how to manage their ecosystems provide an invaluable assets to Hawaiʻi.

Practical aspects of cultural knowledge have been applied to survival in disasters. For example, in the community of Kīpahulu on the east side of the island of Maui, the local elders still practice food preservation techniques. For hundreds of years, people preserved fruits and vegetables for use in rough weather, when it may be too difficult to fish or winds and rains were too heavy to garden. Preserved breadfruit and taro provided sustenance.

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[14] Anderson, 2005, p 201

[15] Ibid

[16] Ibid, p 202

During recent risk reduction efforts in East Maui, the community applied evolved cultural knowledge, blending cultural knowledge and mitigation planning to develop strategies to reduce risks in disasters.[17] The community mapped their local assets, such as medical knowledge, access to gardens, generators, wells, and heavy equipment for moving debris, using geographic information systems. The maps were held by the community to ensure that neighborhoods and population segments that might be isolated would have access to resources for survival. Much of the cultural knowledge may be gender based and relies on providing public awareness and access to information to different segments of society. Disaster planning efforts that blend these knowledge bases increase community resilience to disaster.

19.7.3 Environmental Assets

The health of the environment is critical for survival of the islands. The Department of Land and Natural Resources has the primary responsibility for managing the conservation lands and natural resources. The health of conservation lands is important for replenishing the aquifer and mitigating drought. The quality and quantity of the water helps prevent pollution, runoff, and sedimentation, offering protection against landslides and erosion. The coral reef ecosystem sustains marine life and provides protection from waves and storms. Ensuring the quality of the environment through best management practices and conservation helps to mitigate the impact of natural hazards, and increases the resilience of the ecosystems in the event of disaster.

The following maps of the islands show coral reef research areas. The research and work to ensure a healthy coral reef ecosystem in Hawai‘i contributes to building a healthy coastal environment that provides critical habitat for marine resources. In addition, the coral reefs mitigate wave impacts and protect shorelines from storm inundation.

Changes in climate have already increased the vulnerability of the island’s environment to coastal threats, including sea level rise, loss of beaches, and inundation in coastal built environments. Current seasonal variation in water levels have impacted shorelines and increased coastal flooding in low-lying areas of the islands. In the long-term, the changes could impact infrastructure, especially coastal roads, and built environments, in addition, the sea level rise may threaten near-shore tourism development and therefore impact the State’s economy. Impacts on island resources can be detrimental to the local economies.

[17] Anderson, 2005,, p 242-256

19.8 Loss Estimation and Hazard Ranking

In order to prioritize hazard mitigation measures, the relative risk of the natural hazards needs to be quantified. Average Annualized Loss (AAL) is an objective measure of future losses averaged on an annual basis. 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 Average Annualized Loss Ratio (ALR) is defined as the AAL divided by total building exposure value. AAL's for the each of the significant natural hazards for State of Hawai'i and for each of the four counties are listed in Table 19.6 through Table 19.10. Average Annualized Loss estimates are used in Executive Branch, Legislative Branch, and Departmental briefings 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. Detailed Benefit Cost Analysis can be developed in future planning prior to specific project submissions for funding.

Table 19.6 State of Hawai'i Estimated Average Annual Loss[18]

Hazard	AAL
Tropical Cyclone	$390 Million / Year
Tsunami	$168 Million / Year
Earthquake	$106 Million / Year
Lava Flow	$24 Million / Year
Flood	$16 Million / Year
Coastal Erosion	$10 to $11 Million / Year
Debris Flow and Rockfall	$3 to $7 Million / Year

[18] AAL based on Table 19.7 through Table 19.10 of this chapter

Table 19.7 County of Kaua‘i Estimated Average Annual Loss[19]

Hazard	AAL
Tropical Cyclone	$40.0 Million / Year
Tsunami	$19.0 Million / Year
Coastal Erosion	$3.0 Million / Year
Flood	$1.0 Million / Year
Debris Flow and Rockfall	<$0.5 Million / Year
Earthquake	$0.2 Million / Year

Table 19.8 City and County of Honolulu Estimated Average Annual Loss[20]

Hazard	AAL
Tropical Cyclone	$216.0 Million / Year
Tsunami	$67.0 Million / Year
Earthquake	$21.0 Million / Year
Flood	$13.0 Million / Year
Debris Flow and Rockfall	$1.0 to $5.0 Million / Year
Coastal Erosion	$2.0 to $3.0 Million / Year based on sand replenishment projects
Wildfire	$1.0 Million / Year
Dam Failure	less than $1.0 Million / Year
High Surf	less than $0.5 Million / Year
HAZMAT	less than $0.1 Million / Year

[19] AAL based on State of Hawaii Multi-Hazard Mitigation Plan, 2010. Tsunami AAL based on analysis performed in August 2013 by Martin & Chock, Inc.

[20] AAL based on Multi-Hazard Pre-Disaster Mitigation Plan for the City and County of Honolulu; August 2012. Tsunami AAL based on analysis performed in August 2013 by Martin & Chock, Inc.

Table 19.9 County of Maui Estimated Average Annual Loss[21]

Hazard	AAL
Tropical Cyclone	$65.0 Million / Year
Tsunami	$42.0 Million / Year
Earthquake	$20.0 Million / Year
Coastal Erosion	Estimated $5 Million / Year based on shoreline protection to highways; (has not yet been comprehensively studied)
Flood	~$1.0 Million / Year
Debris Flow and Rockfall	<$0.5 Million / Year
Theoretically Possible Lava Flow	$0.17 Million / Year

Table 19.10 County of Hawai‘i Estimated Average Annual Loss[22]

Hazard	AAL
Tropical Cyclone	$69.0 Million / Year
Earthquake	$65.1 Million / Year
Tsunami	$40.0 Million / Year
Lava Flow	$24.0 Million
Flood	$0.5 Million / Year
Debris Flow and Rockfall	$0.5 Million / Year

[21] AAL based on County of Maui Hazard Mitigation Plan, September 2010; Tsunami AAL based on analysis performed in August 2013 by Martin & Chock, Inc.

[22] AAL based on County of Hawai‘i Multi-Hazard Mitigation Plan, August 2010; Tsunami AAL based on analysis performed in August 2013 by Martin & Chock, Inc.; Debris Flow and Rockfalls AAL based on State of Hawaii Multi-Hazard Mitigation Plan, 2010.

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

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20. Mitigation Strategy

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CHAPTER 20

Mitigation Strategy

2010 Plan	Reasons for Updates / Revisions in this 2013 Plan
The 2003 Plan discussed mitigation goals and the project selection process for federal grant applications. It also describes the benefit-cost analysis process and provided a list of proposed mitigation projects.	• The planning process information was mostly moved into the mitigation planning chapter. • The status of ongoing mitigation projects from the 2010 plan and later developed are reported. • Since the individual mitigation projects proposed were developed in each hazard section previously as well as within the County hazard mitigation plans, this chapter can be more overarching in a coordination and prioritization of the strategic approach of the state with the counties. • This chapter focuses on the prioritized mitigation strategy recommended moving forward as determined through a State Disaster Resiliency Strategy Workshop. • An updated list of proposed mitigation actions is included and categorized by type of mitigation activity, ranked by the participants of the State Disaster Resiliency Strategy Workshop 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 • The State of Hawai‘i Mitigation Goals and Objectives are accordingly updated.

Mitigation Strategy, Goals and Objectives, and Actions

Requirement §201.4(c) (3) A Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment. This section shall include:

Requirement §201.4(c)(3)(i): *A description of State goals to guide the selection of activities to mitigate and reduce potential losses.*

Requirement §201.4(c)(3)(ii) *A discussion of the State's pre- and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas; a discussion of State funding capabilities for*

hazard mitigation projects; and a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.

Requirement §201.4(c)(3)(iii): *An identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section should be linked to local plans, where specific local actions and projects are identified.*

Funding Sources

Requirement §201.4(c)(3)(iv): *Identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities.*

Requirement §201.4(c)(4) *A section on the Coordination of Local Mitigation Planning that includes the following:*
(i) A description of the State process to support, through funding and technical assistance, the development of local mitigation plans.
(ii) A description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the State Mitigation Plan.
(iii) Criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which should include consideration for communities with the highest risks, repetitive loss properties, and most intense development pressures. Further, that for non-planning grants, a principal criterion for prioritizing grants shall be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.

20.1 Introduction to the Hazard Mitigation Strategy

MITIGATION STRATEGY: *§201.4(c)(3) [To be effective the plan must include a] Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment.*

The State of Hawai‘i Mitigation Plan, originally published in October 2004 and updated in October 2007 and October 2010, is pursued actively as guided by State Civil Defense, through recommendations of the State Hazard Mitigation Forum and through the ongoing actions of state and county agencies. This chapter includes the goals and objectives for hazard mitigation determined by the State of Hawai‘i as recommended by the Hazard Mitigation Forum. Overall planning incorporates information from each county's hazard mitigation plans as well as state preparedness capabilities and goals of multiple agencies, as well as input from the private economic sectors.

The State Plan acknowledges that each county in the state has different geography, topography, hazard risks, local vulnerabilities, data, and analyses. As such, the state continues to advise and

support its four counties in their local mitigation planning efforts. Each county benefits from the expertise and advice of county mitigation committees, planning teams, and state technical assistance. The county governments regulate urban growth and development, building permitting, and building codes. The County governments determine shoreline setbacks and provide enforcement. The counties provide the first responders and manage the county's emergency management organization and operations. With the extensive level of critical facilities and public safety responsibilities, the state acknowledges that the counties are best-positioned to determine mitigation priorities and actions that will be most effective in their jurisdictions. The State Plan appreciates the county mitigation efforts and recognizes these priorities, and incorporates into the 2013 update all of the local mitigation plans. The integration of local hazard mitigation planning also includes the coordination of the hazard mitigation plan into a standardized organizational framework for plan content and data between the state and counties. This will enable easier coordination of the state and county mitigation plans in the future.

The mitigation strategy for the State of Hawai‘i is not static, but is consistently being updated with better information as the State benefits from new technologies, models and analyses. A key end product of the plan is the development of a Hawai‘i strategy for mitigating future disasters to enable improved response and quicker recovery. In this 2013 Plan Update, the goals and objectives have remained constant with greater attention towards specific measures and policies to improve the safety and security of Hawai‘i from natural and human-induced disaster threats. This 2013 update has been formulated with a more overarching disaster resilient strategy roadmap that is based on the input of a much larger group of federal, state, county, nongovernmental organizations, and private sector stakeholders that focused on key areas of consideration. The plan outlined in this chapter has been developed as a longer-term strategy for reducing risk from hazards in prioritized areas, which reflects a broader level of support and one that has now been additionally vetted through a process that was more expansive beyond the capabilities of just the Forum itself.

As discussed in ***Chapter 21: Mitigation Planning Process and Update Procedures***, the Hawai‘i State Hazard Mitigation Forum served the role of an oversight committee to the State on the development of the updated Hazard Mitigation Plan. The Forum also recommends and endorses actions that can be incorporated into disaster mitigation and resilience policies of public agencies. The Forum provided input and review of the hazard-specific data updates. Then, it was involved in planning and conducting a **State Disaster Resilience Strategy Workshop**, when a diverse group of invited stakeholders were briefed on the risk analysis for hazards and the **THIRA and State Preparedness Report of Core Capabilities of 2012**. Then, they were asked to evaluate, introduce, and prioritized disaster resilient measures towards establishing key directions and actions to improve disaster resilience in Hawai‘i. Disaster resilience is the "ability to prepare and plan for, absorb, recover from, and more successfully adapt to actual or potential adverse events[1]."

The State Disaster Resilience Strategy Workshop (July 9-10, 2013) included principal stakeholder groups with broad perspectives, including:

1. Hurricanes, High Winds, and Floods

[1] National Research Council, 2012

2. Tsunami and Earthquakes
3. Droughts and Wildfires
4. Other hazards: Volcanic Hazards; Landslide/Rockfall; Coastal Erosion/High Surf / Dam Failures; Hazardous Material
5. Health Vulnerability and Risk
6. Climate Change Adaptation
7. Multi-Hazard Actions
8. Land Use and Building Requirements
9. Infrastructure Resilience
10. Recovery and Macro-Economic Effects
11. Threat Identification and Risk Analysis (THIRA) Implementation

From this, recommended measures and actions for the state are detailed, all of which have emerged in consistency with the goals and objectives set forth by the state. The prioritization for state hazard mitigation and disaster resilient strategy actions were facilitated by members of the Hawai‘i State Hazard Mitigation Forum, but the prioritization itself was developed by the workshop stakeholders as recommendations to SCD. Each County had input into the plan through the county plans that were last updated in 2009 (Kaua‘i), 2010 (Maui and Hawai‘i), and 2012 (Honolulu). Hazard-specific priorities and actions are determined based on extensive knowledge, expertise, and input into the process. The plan is thereby enabled to further identify specific recommendations for mitigation in hazard areas. As discussed in Chapter 2, the Hawai‘i State Earthquake Advisory Committee is an example of a hazard-specific committee that actively researches specific topics and provides recommendations to State Civil Defense. In addition, State Civil Defense and the Forum encourage new land use, planning, and construction projects to review hazards risks and to incorporate mitigation actions into the projects to take advantage of opportunities for funding resources and mitigation.

This chapter includes contributions and recommended actions based on an assessment of over recent declared disasters and in flood watches and tsunami warnings. Lessons have been learned from disaster experiences in addition to occurrences in Hawai‘i. Some of these include the 2009 American Samoa Earthquake, the 2010 Chile Earthquake, the 2011 Great East Japan Earthquake, and 2012 Superstorm Sandy. An effective mitigation venue can be during a recovery effort when policies of Building Back Better are applied. During recoveries, entire geographic regions may be redesigned to meet the most modern hazard mitigation requirements, minimizing future losses and allowing for alternative land uses in high hazard or repetitive loss areas. By incorporating hazard mitigation strategies and policies in specific recovery plans, government agencies will be able to regulate reconstruction while still fostering an environment of rapid recovery. This will assist in eliminating inappropriate or high-risk construction during the chaotic, post-disaster recovery phases.

This 2013 Plan update includes a number of activities that have taken place to mitigate hazard risks since the 2010 update, such as the adoption of a statewide building code in 2012 and the ongoing development of a new generation of tsunami evacuation maps in 2012-2014. However, it is acknowledged that there will still be considerable efforts that need counties will continue their work on implementing these actions to ensure safety of the people in Hawai‘i. This will be discussed in Chapter 21 Planning Processes & Update Procedures.

20.2 Hazard Mitigation Goals and Objectives

This section outlines the goals and objectives of the state mitigation program. They are an integral aspect of the State's overall mitigation strategy as they are part of the prioritization process of proposed mitigation actions. By establishing reasonable goals and objectives, those involved in the planning process can see their efforts implemented, which can then encourage other mitigation efforts. The results of these mitigation efforts are important to state and local governments, public-private partnerships, and the general public.

The State's hazard mitigation program is organized into six primary areas of goals and objectives. The goals and objectives reflect the mature nature of SCD's established statewide hazard mitigation program and have evolved over several years of state mitigation planning efforts. SCD encourages its local, state, and federal partners to consider these mitigation goals when developing local mitigation plans and other plans, and examination of the local county hazard mitigation plans shows close consistency with the state program.

The State Hazard Mitigation Forum conducted a review of the goals and objectives and determined the goals and objectives are achievable and complement both state and local mitigation strategies. There was consensus that these goals and objectives outline the direction for risk reduction that Hawai‘i wishes to pursue. Several of the goals listed originally emerged from the 2004 mitigation planning process where the planning subcommittee of the State Hazard Mitigation Forum suggested the goals and objectives. In 2007, the Forum reviewed the goals and objectives, and added several additional objectives. There were no changes made in the 2010 update of the Plan. In 2013, the goals and objectives were further refined to emphasize whole community disaster resilience and building Core Capabilities to address the hazards of greatest risk. The order of the goals and objectives do not necessarily follow in order of priority;, the goals and objectives address current conditions and anticipated future needs, and represent a long-term vision for hazard reduction and enhancement of mitigation capabilities for the State of Hawai‘i.

Goal 1: Protect life and property of the people in Hawai‘i

1.1: Improve the resilience of lifelines, critical infrastructure, ports and airports, critical facilities, and supply chain and transportation networks, and reduce their vulnerability to disruption of function from hazards
1.2: Work with the Counties to assist in improvements of building codes and building inventories and risk assessments.
1.3: Ensure knowledge and accessibility of response plans, evacuation routes, and shelters and refuge areas.
1.4: Ensure adequate public sheltering space or alternative refuge structures for residents
1.5: Ensure adequate public sheltering space or alternative refuge structures for visitors
1.6: Ensure emergency services and medical facilities can provide acute care for victims of disasters.
1.7: Ensure that all lifeline and critical utility infrastructures are able to withstand hazard events or have contingency plans to quickly recover after a disaster
1.8: Ensure that all emergency response critical facilities and communication systems remain operational during hazard events

1.9: Encourage appropriate coastal development that reduces risks from coastal hazards at all stages of development.

1.10 Reduce risk by addressing the target capability gaps identified in the state Threat and Hazard Identification and Risk Assessment (THIRA) and the strategic planning process. Emphasis shall be placed on building and sustaining Core Capabilities that address high-consequence events that pose the greatest risk, and Core Capabilities that can be used to address multiple threats and hazards.

Goal 2: Continually strive to improve the state of the art for the identification of hazard areas, prediction capabilities, and warning systems.

2.1: Prepare GIS maps for all hazards with the best available information and formulate a strategy to maintain/upgrade the data.

2.2: Improve applicability of modeling systems to Hawai‘i conditions for hazard mapping, mitigation planning, and scenario training purposes.

2.3: Improve flood prediction and field-monitoring systems.

2.4: 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.

2.5: 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.

Goal 3 Produce comprehensive, multi-hazard risk and vulnerability assessments

3.1: Identify and map assets, including sensitive environmental features and natural habitats, buildings and urban developments, historical buildings and properties, and cultural sites and use areas.

3.2: Maintain and update databases on new and improved data and technology with attention to securing data that should not be shared publicly

3.3 Develop a statewide risk and vulnerability assessment (RVA)

3.4: Maintain and update RVA based on new and improved data and technology

3.5: Develop appropriate protocols for data sharing and management at federal, state, and local levels

3.6: Use HAZUS and RVA models and scenarios to identify risks and develop improvements

3.7: Continue to monitor, evaluate, and update the assessments.

Goal 4: Protect the State’s natural, built, historical, and cultural assets

4.1: Incorporate indigenous cultural and natural environmental protection themes into hazard mitigation planning

4.2: Update state building codes, regulations, and design standards and specifications to cost-effectively reduce susceptibility to high wind storms, tropical cyclone, earthquakes, floods, and tsunamis.

4.3: Ensure adequacy of land use regulations and zoning standards to mitigate risks to natural hazards. Periodically review their effectiveness and update them as necessary.

4.4: Encourage and support the adoption, enforcement, training in, and updating of building codes and standards that minimize the threat to life, health, and property damage caused by natural hazards
4.5: Encourage and support the adoption, implementation, and updating of plans (including land use, resource management, and other state and county plans) that incorporate natural hazard elements (including risk and vulnerability, hazard maps, hazard mitigation best practices and standards)
4.6 Minimize environmental degradation and ensure habitat recovery

Goal 5: Minimize post-disaster recovery disruption and rebuild businesses and restore economic activity to ensure the long-term sustainability of the State's economic base

5.1: Assess economic risk and vulnerability for multiple hazards
5.2: Develop strategies to ensure that financial institutions and other critical businesses can operate during crises
5.3: Develop small business strategies and contingency plans to help businesses reopen quickly following crises
5.4: Develop reconstruction and rehabilitation plans to ensure rapid recovery from disasters that achieves a greater level of disaster resilience.
5.5: Make plans with the Hawai'i Visitors and Convention Bureau to ensure the rapid restoration of the visitor industry to prevent long-term repercussions to the tourism industry, which is critical to the economy of Hawai'i.

Goal 6: Ensure public awareness of risks, vulnerability, and multi-hazard mitigation actions through public education, that results in efficient evacuations, self-reliant disaster preparation, 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: Provide updated risk and vulnerability assessments and plans for information distribution.
6.4: Run training exercises to make enable organizations, community-based groups, and emergency services to know how to respond during crises.
6.5: Ensure that non-structural mitigation measures are incorporated into mitigation public awareness programs.
6.6: Ensure adequate understanding of characteristics and dangers associated with natural hazards.

20.3 Disaster Resilient Mitigation Actions

20.3.1 Determining a Mitigation Action Strategy Aligned with Goals and Objectives

The State Civil Defense Division in collaboration with the State Hazard Mitigation Forum establishes the criteria for reviews and determination of eligibility and selection of all multi-hazard mitigation measures and projects submitted by county governments and State agencies.

Projects included in this plan have been evolving over years of mitigation planning in Hawai‘i as directed by State Civil Defense and supported by the State Hazard Mitigation Forum, the Hawai‘i State Earthquake Advisory Committee, the State Civil Defense Advisory Council, partner State and Local agencies, and private entities. The more recent disasters would often reactively dictate the project types and hazards addressed. For example, flood events, tsunami threats, and hurricane threats in recent years have focused local interest on shelter retrofit programs, vulnerability of critical infrastructure to tsunami, and building codes. Identification of specific local mitigation actions typically have reactively come from counties impacted by a past disaster. **In this plan update cycle we implement a paradigm shift to a more proactive and overarching philosophy for communities and agencies to plan for strategically implementing community disaster resilience in key areas of higher effectiveness** (see Figure 20.1).

Hazards (examples)	Direct Damage	Indirect Damage	Immediate Social & Economic Effects	Long-Term Consequences
Hurricane	Housing, Buildings, and Contents	Fire	Casualties and Fatalities	Long-term Psychological Impact
Flooding	Critical Facilities and Emergency Response	Debris	Displaced population and relocation / sheltering costs	Abandonment
Earthquake	Infrastructure	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	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	Environmental Damage	Losses in wages, salaries, rental income. fraud and waste	Fiscal impacts of loss of tax revenues

Figure 20.1 How the disaster resilience of structures and infrastructure relates to community resilience.

The costs of disasters include:

- Direct Damage
- Indirect Damage
- Social Losses
- Direct Economic Losses
- Indirect Economic Losses
- Extension of the above over time, that can lead to the loss of economic growth opportunities, and macro-economic and fiscal decay

"Resilience is *the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events.*

- Enhanced resilience allows better anticipation of disasters and better planning to reduce disaster losses—rather than waiting for an event to occur and paying for it afterward."

  [Disaster Resilience: A National Imperative, 2012. Committee on Increasing National Resilience to Hazards and Disasters; Committee on Science, Engineering, and Public Policy; The National Academies]

With a strategy based on long-term disaster resilience,

- Buildings and Infrastructure can better withstand disaster events
- Critical infrastructure and essential services return to functional status more quickly
- Reduce emergency response demands and have greater capacity to respond more effectively
- Enable faster recovery and become economically sustainable without massive outside aid

Critical Facilities and Lifeline Systems are essential for community response and recovery after a disaster.

- Critical Facilities
  - Maintain the public's health and safety
  - e.g., hospitals, police, fire, and emergency medical services buildings, essential government buildings, ports, airports, water supply, wastewater treatment plants, power generating stations, fuel depot and refineries
- Lifelines
  - Power transmission and distribution, transportation systems, and storage, treatment, and distribution systems of water, fuel, IT services and communications, and sewage systems

Increasing community resilience entails the following approaches to be strategically implemented:

- Move from reactive to proactive actions
- Community planning engagement in developing disaster policies;
- Establish goals linking public and private infrastructure performance and business survival interests to resilience;
- Improving public and private infrastructure and essential services;
- Communicating risks and economic burdens of disasters, to promote a culture of resilience and risk awareness;

- Organizing communities to prepare for disasters;
- Adopting sound land-use planning practices;
- Adopting and enforcing building codes and standards appropriate to hazards, and
- Addressing THIRA and State Preparedness Report Gaps in Core Capabilities

20.3.2 Risk Assessment Context for the Strategy

Throughout the 2013 update, the average annualized loss methodology is still in use by the state and counties to conduct cost-benefit analyses and evaluate risk by taking vulnerability and hazard probability into account (Table 20.1). These methods are consistent with analyses using HAZUS MH and utilize the results of that model, continue to provide reasonable risk estimations which can be used to evaluate the priority of implementing proposed mitigation actions.

Table 20.1 Ranking of Risks based on Average Annual Loss[2]

Kaua‘i	Honolulu	Maui	Hawai‘i
Tropical Cyclone	Tropical Cyclone	Tropical Cyclone	Tropical Cyclone
Tsunami	Tsunami	Tsunami	Earthquake
Coastal Erosion	Earthquake	Earthquake	Tsunami
Flood	Flood	Coastal Erosion	Lava Flow
Landslide and Rockfall	Landslide and Rockfall	Flood	Flood

From the State Civil Defense Strategic Plan 2011 - 2015, and independent assessment of Hawai‘i’s Hazard Profile (Figure 20.2) ranks as its top six highest risks: 1) Hurricane, 2) Flash Flood, 3) Tsunami, 4) Earthquake, 5) Volcano/Lava, and 6) Landslide/Rockfall. The hazard to be mitigated is one of several items that is a factor in the final overall score of proposed mitigation actions as tabulated during the State Disaster Resiliency Strategy Workshop.

[2] Risk is the expected losses from an evaluation of the probabilities of hazards with their potential to cause adverse effects on our life; health; economic well-being; social, environmental, and cultural assets; infrastructure; and the services expected from institutions and the environment. Average Annual Losses (AAL) in this table are based on the Mitigation Plan for each County and analysis performed in August, 2013 by Martin & Chock, Inc. See Tables 19.7 through 19.10 in Chapter 19 of this Mitigation Plan.

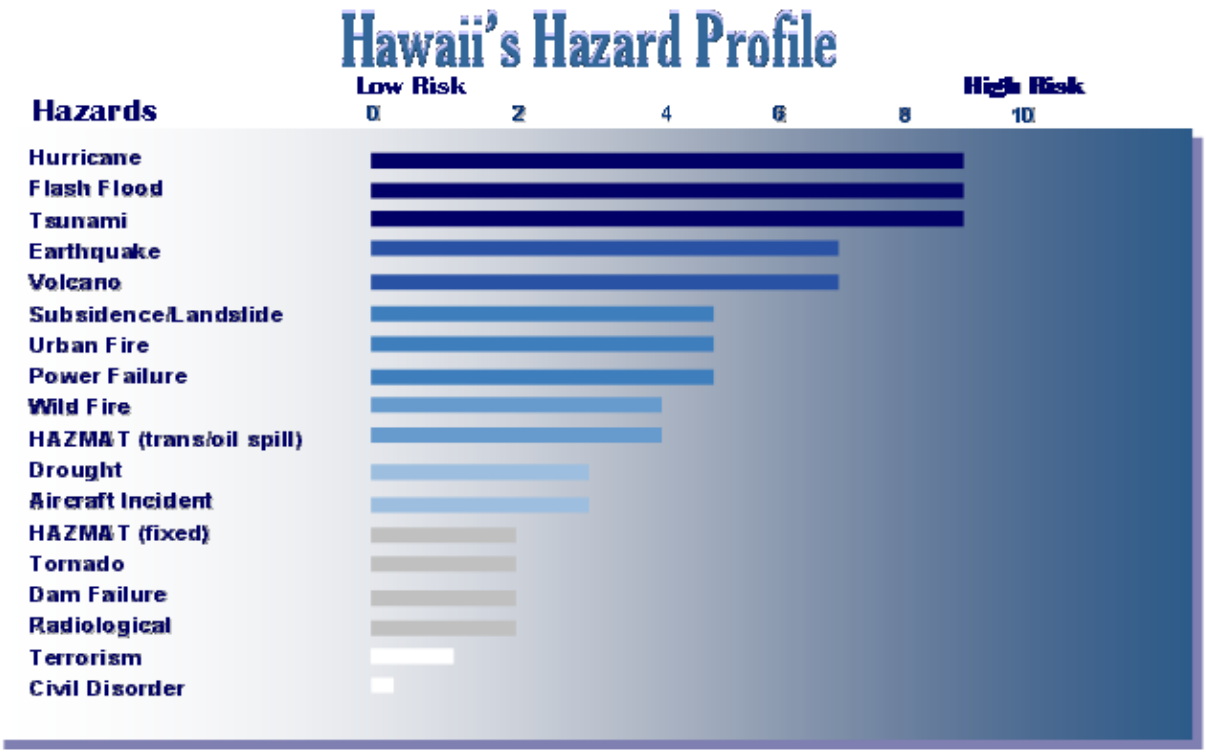

Figure 20.2 Assessment of Hawai'i's Hazard Profile[3]

20.3.3 Key Strategic Areas for Mitigation Actions

As explained in the Chapter 2 regarding the process for developing the mitigation plan, the State Hazard Mitigation Forum and the State Civil Defense Hazard Mitigation Officer oversee the development of mitigation actions and measures. Within the 2013 update of the State Plan, a total of 11key areas of Mitigation Action are identified as components for a more comprehensive disaster resilient strategy for the state, some by hazard and some by type of policy. Some of these measures have been designed as policy enhancement activities that will improve land use, building codes, administration, and regulation. Some of these activities will require long-term strategies for implementation, but will reduce the future impacts of disasters in the State of Hawai'i. Per DHS, the THIRA process is also to be used in follow-on vulnerability analysis, and be incorporated into the jurisdiction's Hazard Mitigation Plan. The 2012 Threat Identification and Risk Assessment and State Preparedness Report identified gaps in Core Capabilities that largely influence disaster outcomes in the Planning, Mitigation, Response, and Recovery missions. The State Preparedness Report (SPR) assessed current capability against these targets and documented any gaps that exist. The key implementation areas of the strategy are listed below:

1. Hurricanes, High Winds, and Floods
2. Tsunami and Earthquakes
3. Droughts and Wildfires

[3] Risk Ranking includes likelihood and effect on population and property

4. Other hazards: Volcanic Hazards; Landslide/Rockfall; Coastal Erosion/High Surf / Dam Failures; Hazardous Material
5. Health Vulnerability and Risk
6. Climate Change Adaptation
7. Multi-Hazard Actions
8. Land Use and Building Requirements
9. Infrastructure Resilience
10. Recovery and Macro-Economic Effects
11. Threat Identification and Risk Analysis (THIRA) Implementation

Mitigation Actions were considered within the following categories:

- Prevention: Government administrative and regulatory actions or processes that influence the way land and buildings are developed and built
- Property Protection: Actions that involve the modification of existing structures to protect them from a hazard, or removal from the hazard area
- Public Education and Awareness: Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigate them
- Natural Resource Protection: Actions that minimize hazard losses while also preserving or restoring the functions of natural systems
- Emergency Services: Actions that protect people and property during and immediately after a disaster or hazard event
- Structural Projects: Actions that involve the construction of structures to reduce the impact of a hazard

All measures considered would comply with the applicable requirements listed below:

1. Addresses a problem that poses a significant threat/risk to public health and safety.
2. Results in a long-term solution or mitigation that substantially reduce the risk of future loss, damage, hardship, or suffering.
3. Be cost-effective. For construction projects Achieve a cost-benefit ratio of at least 1 to 1 or better using FEMA (or a risk-consistent equivalent methodology of) Benefit Cost Analysis.
4. Applicant must be in good standing with the National Flood Insurance Program.
5. Jurisdiction has an approved multi-hazard mitigation plan.
6. Must comply with Floodplain Management, Historical Preservation, and Protection of Wetlands, and Endangered Species laws and regulations.
7. Mitigation actions must also comply with all applicable Federal, State, and county laws and regulations.

20.3.4 State Disaster Resiliency Strategy Workshop to Evaluate and Rank Mitigation Actions

The State Disaster Resiliency Strategy Workshop had a central theme of ***Resilience: Developing a state strategy for disaster mitigation and long-term community resilience to enable improved response and quicker recovery***. The objective of the workshop was to identify and evaluate *Likely or Necessary Key Actions and Near to Intermediate-Term Policy Recommendations for Disaster Resilience*. A group of over 60 stakeholders invited from state and federal agencies,

military, county governments, utilities, private nonprofit organizations, financial institutions, private sector, academia, and representatives of the State Hazard Mitigation Forum and Hawai‘i State Earthquake Advisory Committee evaluated and prioritized hazard mitigation actions identified within the hazard chapters as ongoing or proposed activities by responsible agencies and subject matter experts. Over 90% of participants had prior experience participating in hazard mitigation planning activities, such as the county hazard mitigation plans, the Hawai‘i Mass Care Council, the Hawai‘i State Earthquake Advisory Committee, the State Hazard Mitigation Forum, THIRA 2012, and a 2012 O‘ahu Disaster Aftermath Conference.

The prioritization for state hazard mitigation and disaster resilient strategy actions was facilitated by members of the Hawai‘i State Hazard Mitigation Forum, but the prioritization itself was developed by the workshop stakeholders as recommendations to SCD. Participants engaged in key subject matter groups to discuss, clarify, and modify or amend as necessary proposed mitigation actions and policies developed in the draft hazard mitigation plan. Then, they were asked to evaluate and prioritize disaster resilient measures towards establishing key directions and actions to improve disaster resilience in Hawai‘i. The ranking of earthquake-specific projects in the five-year plan of the Hawai‘i State Earthquake Advisory Committee was also considered within the Earthquake and Tsunami group.

The ranking system used during this State Disaster Resilience Strategy Workshop emphasized projects that effectively address high risk to public safety, state and local priorities are timely, and technically sound. Specifically, and in addition to the background of the risk assessments, projects were evaluated subject to the following:

Solution to address and mitigate an identified priority problem that poses a significant risk to public health and safety, that is:

- Feasible: the approach can be implemented or is required to be implemented
- Timely: can result in some disaster risk reduction starting within a five-year period
- Effective: appears to be a strategically sound measure that can have sufficiently broad application resulting in the improvement of community resilience to disasters and substantially reduce the risk of future damage, loss, hardship, or suffering from a major disaster.

Participants were instructed to independently rank actions for each category with a rating of High, Medium, or Low for feasibility, timeliness, and effectiveness. Projects receiving the highest composite score from the ballots gathered within each key area group were then ranked to have a higher priority level.

<u>Consensus strategic priority directions expressed by the participant groups include</u>:

1. Update and adopt codes and design standards for tsunami, hurricane, and severe storms
2. Produce needed probabilistic design maps for tsunami for application towards mitigation for critical facilities, major buildings, bridges, and key infrastructure such as power plants and ports.
3. Develop coordinated evacuation and public information products to account for Great Aleutian Tsunami scenarios when no more than 3-1/2 hours of warning time is possible.

4. Provide greater public education on their role in disaster preparedness in the context of the limitations of what can be provided in the aftermath of a major disaster (such as a hurricane or tsunami), given Hawai‘i’s geographic isolation and dependence on an oversea supply chain.
5. Invest in additional and improved capabilities for more reliable monitoring / warning of hazards and improve the modeling of hazard impacts by taking into account Hawai‘i-specific data (particularly for incorporating Hawai‘i-specific conditions and building and bridge types into hurricane and earthquake models).
6. Adopt more preventive community impact-based mitigation policies using more advanced hazard maps developed for use earlier in the land use and development process. Incorporate longer-term environmental trends, particularly in the coastal zone.
7. Conduct multi-hazard assessments and vulnerability evaluations of critical infrastructure to include fuel storage facilities, power plants, water systems, communications sites, sewage treatment plants, water storage tanks and other facilities providing critical services and supply chain critical facilities, then implement protection and mitigation to provide greater resiliency against disasters.
8. Conduct multi-hazard assessments and vulnerability evaluations needed to ensure post-disaster adequacy of critical transportation components and systems, such as highways, bridges, ports and harbors, and airports, then implement policies and mitigation to provide greater resiliency against disasters.
9. Develop policies for using alternative types of buildings (in addition to public sector school buildings) for greater capacity for sheltering and evacuation from coastal communities.
10. Increase emergency operational plan and logistical coordination amongst agencies and responders, NGO’s, and private sector service providers and key economic sectors.
11. Improve response and recovery capabilities and arrange the availability of key resources as necessary to accommodate demand surge in critical services after a disaster.
12. Develop a post-disaster recovery and reconstruction plan integrating green technology and building code compliance to Build Back Better disaster resilience. Develop Hawai‘i-specific mitigation and retrofit techniques.

Examples of significant recent or ongoing 2011-2014 state projects consistent with these strategic areas include:

- Hawai‘i Mass Care Council (2013 SCD): A large working group convened to plan for mass care delivery of food and shelter essential living needs for residents displaced over several months due to damage to their homes – addressing a THIRA Core Capability.

- RCPG - Regional Catastrophic Preparedness Grant – County Hurricane Catastrophic Planning Project – Operations and Logistics (2012-2013, DEM): This RCGP project is managed by the Honolulu Department of Emergency Management, but involves planning of the emergency supply chain for delivery of goods and services to all counties after a major (Category 4) hurricane disaster. This project is linked to the Hawai‘i Mass Care Council that is developing the resource needed for the logistical plan to deliver.

- Aleutian Tsunami Inundation Modeling (2013 SCD): The inundation resulting from a large magnitude earthquake (Mw 9.0 or greater) on a previously disregarded section of

the Aleutain subduction zone is now being modeled for utilization in an update of tsunami evacuation plans and maps.

- O‘ahu Coastal Communities Evacuation Planning Project (2012-2013 Honolulu DEM): This project is paired with the Aleutian Tsunami Inundation Modeling to develop appropriate plans for “second line of fallback” evacuation zones for Great Aleutian Tsunami scenarios, develop more optimized routing and evacuation signage, and locate tsunami refuge areas that have close enough proximity to each region of the inundated coastline in order to enable public safety within a short time frame (within 4 hours at a maximum). A subsequent project would install tsunami evacuation signage on O‘ahu for the first time.
- SDOT Hurricane and Tsunami Vulnerability of Coastal Bridges and Commercial Ports throughout Hawai‘i (2012-2013 HDOT): State Department of Transportation (Highway and Harbor Divisions) is evaluating the vulnerability of coastal bridges and ports to storm surge and tsunami inundation, considering the structural characteristics and the criticality of the structure in the transportation network and harbor functionality.
- State Bridge Seismic Retrofits (HDOT): For several years, the Hawai‘i Department of Transportation has been performing seismic retrofitting of older vintage bridges that were vulnerable due to lack of modern seismic design detailing or insufficient accommodation of movement and lack of anchorage and ties at joints.
- THIRA (2012-2013 , SCD) : The THIRA is an all-hazards Core Capability-based assessment that establishes a foundation to justify and guide preparedness activities and investments toward achieving capability targets in the Prevention, Protection, Mitigation, Response, and Recovery Missions. The Hawai‘i THIRA emphasized high risk events.
- State of Hawai‘i Building Code (2007-2012): 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. “The legislature finds that . . . The adoption of a uniform set of statewide building codes applicable to one and two family dwellings, all other residential uses, and commercial and industrial buildings, and state buildings would make it possible for building owners, designers, contactors, and code enforcers within the State to apply consistent standards. The International Building Codes is currently being considered for adoption by all counties. The health and safety considerations related to the codes are of statewide interest, especially relating to emergency disaster preparedness.” This law requires the State and counties to adopt life-safety codes such as the International Building Code and Uniform Fire Code, as well as design and construction standards for hurricane shelters and essential facilities. The State Building Code Council adopted the first ever statewide building code, and by 2012 the statute had resulted in a nearly uniform building code throughout all four counties. Hawai‘i-specific wind microzonation maps, taking the effect of topography into account, were adopted as local Hawai‘i amendments; these Hawai‘i wind design maps were awarded the 2010 Outstanding Civil Engineering Achievement Award by the American Society of Civil Engineers Hawai‘i Chapter.
- As of 2012, the Mass Management System tool now Include topographic wind effects in the output of the model, to allow identification of the topographically-amplified wind

speeds for any individually defined storm scenario. Estimated peak gust wind speeds are calculated at each "zone" at representative sites selected for planning and emergency response purposes within the Hurrevac/MMS planning and response tool.

- Hurricane Shelter Assessments and Retrofits ongoing at various sites (ongoing, SCD and DAGS): The state legislature previously appropriated funding of $3.8 million to enable dozens of deficient public hurricane shelter buildings at public schools to be retrofitted to address structural issues and enclosure protection.
- State General Flood Control Plan Update (2013, DLNR): The plan is undergoing a re-organization and integration of information for all counties into an online format.
- New Digital Flood Insurance Rate Maps (2009-2012): The DFIRM's have been adopted based on FEMA's 2008 Flood Insurance Study of hurricane inundation boundaries for the west and south coasts of all islands. The Hurricane Flood Insurance Study for the Hawaiian Islands was conducted under the Federal Emergency Management Agency (FEMA) contract number EMW-2003-CO-0046, RMTC/URS Task Order 013. The hazard analysis considered the combination of storm surge and hurricane-induced wave hazards.
- Dam evacuation zones and Emergency Action Plans (DLNR): through the actions of the State Department of Land and Natural Resources (DLNR), almost all regulated dams in the state now have Emergency Actions Plans submitted by the owners of the dams, and nearly all dams have contingency evacuation maps prepared by the counties based on modeling developed under DLNR.

	Regulated Dams	EAPs Req'd by Statute	EAPs on file	EAPs Outstanding		Inundation Map	Inundation Map Outstanding	Evacuation Maps	Evacuation Maps Outstanding
Hawaii County	11	9	9	1		11	0	11	0
Kauai County	54	48	50	4		54	0	53	0
Maui County	58	54	57	0		57	0	57	0
City and County of Honolulu	17	17	16	1		17	0	9	8
Total Statewide	140	128	132	6		139	0	130	8

Emergency Action Plan and Evacuation Map Status of Regulated Dams

- Rockfall Mitigation along State Roadways and Highways (SDOT): Rockfall and landslide mitigation is being addressed through rock clearing, anchoring of fall mitigation meshes, and slope stabilization.
- Flood Control projects and infrastructure improvements (DLNR): these have been implemented in the Maili Basin (City and County of Honolulu), Hāmākua Ditch (County of Hawai'i), Ala Wai Canal watershed (City and County of Honolulu). Flood warning system for the Lake Wilson reservoir and dam (City and County of Honolulu) was implemented along with more proactive control of lake levels to allow more margin of safety against overtopping the spillway.
- Waikīkī Beach restoration (City and County of Honolulu): This project periodically pumps offshore natural sand deposits and emplaces areas with the more significant erosion of beach frontage.

- Hardening of American Red Cross Headquarters EOC and the Department of Education EOC in the City and County of Honolulu: These projects addressed some vulnerability to windborne debris.
- Modernization of the warning sirens (2012-2014): The State of Hawai‘i is performing a $25 million upgrade of its emergency warning sirens and using satellite machine-to-machine (M2M) devices .To transmit warnings ranging from tsunamis, hurricanes and earthquakes to hazardous material spills and explosions, the State was relying on decades old VHF/800MHz radio transmitters that were breaking down and were failing to communicate about emergency situations. Hawai‘i State Civil Defense developed a system running new sirens on solar panels, satellite terminals, cellular backup and batteries. The new system includes the ability to query and change the status of specific sirens; confirm that sirens operate as expected during tests and emergencies; monitor the solar charger, battery voltage; and alert authorities if someone intrudes into the system. The project also addresses some areas in siren gaps.

- Post & Pier Retrofit Expert Tool (2010-2012),: In response to the damage experience by post and pier homes during the Kiholo Bay and Māhukona Earthquakes of September 15, 2006, a survey of 53 post and pier houses on the island of Hawai‘i was performed to investigate the vulnerability of this type of light-frame residential construction. Based on this survey, a number of prototypical models of post and pier houses were analyzed for different levels of ground motion. From the analysis, three retrofit options were developed, with the applicability of each retrofit based on the location of the house and its structural properties. The retrofits are presented in a general format that can be applied to a wide range of houses anywhere on the State of Hawai‘i without specific input from a structural engineer (except in special cases). The retrofit designs were then incorporated in an internet tool by which homeowners can obtain the most appropriate retrofit options for their home. The homeowner inputs key characteristics and dimensions into the webtool, and the retrofit drawings as well as a summary of material are output.

- HAZUS MH MR4 with Hawai‘i Enhanced Data (2008-2010); New building inventory data for the County of Maui and County of Hawai‘i makes HAZUS MH capable of producing earthquake damage maps and reports at a much higher spatial resolution, based on the best available building inventory and soil data, and it will perform this analysis using ShakeMap output from USGS. The Hawai‘i Enhanced Data included customized fragility modeling of Hawai‘i residential construction, including “post and pier” homes. The final product incorporates the 2006 building inventory data, including indigenous Hawai‘i construction types and Hawai‘i construction costs, hazard and geologic information, and methodology improvements, into compatible data files for use with HAZUS-MH. Accordingly, the data improvements from this study enabled improved operational use of HAZUS-MH with the present-day enhanced dataset using ShakeMap in future earthquakes.

- Updated Hawai‘i HAZUS Atlas (2013): Working in close collaboration with the Hawai‘i State Civil Defense (SCD) and Hawai‘i State Earthquake Advisory Committee (HSEAC), PDC updated the **Hawai‘i HAZUS Atlas (HHA)** to incorporate the HAZUS MH MR4 with Hawai‘i Enhanced Data. HHA is designed to provide a better understanding of

potential future earthquake scenarios and expected damage loss estimates for the Counties of Maui and Hawai‘i. HHA contains a range of historical and credible earthquake scenarios located in and around the State of Hawai‘i. Using FEMA's loss estimation model, Hazards U.S. (also known as HAZUS), HHA contains damage loss calculations for each scenario as estimated by the HAZUS model. With HHA, communities can use HAZUS results to assist in disaster planning before, during, and after a destructive earthquake.

- Many studies and projects were initiated as a result of observing needs in recent disasters. Most of the projects and studies are finalized in late 2010 and into late 2013. The improved information will enable much better analyses and will contribute to better informed mitigation actions. As these analyses become available, the SHMF and hazard advisory committees will review information and make recommendations that will undoubtedly improve information for the next County plan updates, which are on a five-year cycle (County of Kaua‘i – December 2013; City & County of Honolulu – August, 2017; County of Maui – August 2015; County of Hawai‘i – June 2015; University of Hawai‘i System - 2015).

20.4 Multi-Hazard Mitigation Actions of a Disaster Resilient Strategy

In Table 20-2 through Table 20-12, we summarize the prioritized recommended actions and policies of the Disaster Resilient Strategy for the State of Hawai‘i, in the key areas of:

1. Hurricanes, High Winds, and Floods
2. Tsunami and Earthquakes
3. Droughts and Wildfires
4. Other hazards: Volcanic Hazards; Landslide/Rockfall; Coastal Erosion/High Surf / Dam Failures; Hazardous Material
5. Health Vulnerability and Risk
6. Climate Change Adaptation
7. Multi-Hazard Actions
8. Land Use and Building Requirements
9. Infrastructure Resilience
10. Recovery and Macro-Economic Effects
11. Threat Identification and Risk Analysis (THIRA) Implementation

Note: Projects listed in **bold** text are the most highly rated; projects at the bottom of each list are of low priority.

Table 20.2 Prioritized Components of the Strategy for Hurricanes, High Winds, and Floods

Hurricane and High Winds	Also in County Plans/THIRA	Floods / Coastal Erosion / Dam Failures	Also in County Plans/THIRA
By 2018, update the design standards for new high-occupancy public buildings that can provide enhanced hurricane protective areas, and consider SCD Mass Care Council recommendations	X	**Evaluate vulnerability of critical infrastructure systems and supply chain in the inundation zone and implement protective measures or back-up resources**	X
Evaluate vulnerability of critical infrastructure systems in the inundation zone (power, water, fuel, communications, ports, airports) and implement protective measures or back-up resources to the most practical extent	X	**All county flood managers to contribute to the State General Flood Plan**	X
Replace weathered wood poles with NESC-conforming poles.	X	**Adopt 2012 IBC and related codes per HRS 107 Part II**	X
By 2014, adopt wind design standards for the installation of photovoltaic panels on residential rooftops. Adopt 2012 IBC and related codes per HRS 107 Part II.	X	**Additional rain gauges to fill in radar data gaps in area coverage for real-time flooding identification. Doppler radar coverage is blocked by mountains. More sensors in those areas to be installed by the State.**	X
Incorporate Hawai‘i-specific building types into the geodatabase of the HAZUS MH Hurricane loss estimation module, and make model adjustments to enable reasonable hurricane scenario loss estimates.	X		
Develop hurricane shelter capacity estimates based on 15 sf / person and utilize the Mass Management System with Hurrevac, and identify alternative hurricane evacuation/sheltering policies prioritizing the most vulnerable population areas.	X	Establish 500-year coastal inundation zone requirements for Critical Infrastructure	
Identify the types of buildings that can function as temporary refuges and create a voluntary program for certifying “storm-ready” private facilities by using a standardized procedure. Determine the number of low vulnerability buildings available for refuge in the private sector	X	City and County of Honolulu, County of Kaua‘i, and County of Hawai‘i to participate in the Community Rating System, to reduce premiums for homeowners for NFIP flood insurance.	X
Update design and construction standards for utility lifelines per American Lifelines Association approved standards	X	City and County of Honolulu to adopt coastal erosion setbacks per historical rates; disclosure of erosion rate during real estate transactions. (Mandatory Seller Disclosures in Real Estate Transactions Act)	X
HHRF standards for hurricane retrofits and debris protection, to enable insurance premium credits; Develop a post & pier/single wall hurricane retrofit Expert Tool GUI, similar to earthquake retrofits.	X		

Table 20.3 Prioritized Components of the Strategy for Tsunami and Earthquakes

Tsunami	Also in County Plans/THIRA	Earthquakes	Also in County Plans/THIRA
By 2015, Develop a coordinated warning and evacuation plan that includes the contingency for a Great Aleutian Tsunami that exceeds the current evacuation zones; Prepare coordinated public outreach.	X	**Conduct all hazard evaluations (part of multi-hazard effort) and develop cost-effective seismic retrofits for priority facilities in Hawai‘i and Maui Counties**	X
Evaluate existing policies for use of buildings for vertical evacuation and update as necessary.	X	**Provide public outreach on how to retrofit and establish anchorage of post & pier foundations of Hawai‘i light-frame housing**	X
Implement emergency evacuation signage within the tsunami evacuation zones, prioritizing those areas where the optimal routes may not be apparent or unclear at key junctures.		**Require implementation of seismic bracing requirements for equipment and ceiling systems in renovation and post-disaster repairs of schools and hospitals, and assisted living facilities**	
By 2018, Adopt tsunami-resistant design provisions for new critical and essential buildings and taller multi-story buildings as required by Hawai‘i Revised Statutes Chapter 107	X	**Enhance new seismic code implementation by providing Design Professionals with training in the use of modern codes and retrofit guidelines.**	X
By 2018, Develop maps of probabilistic tsunami inundation and runup for use in designing critical infrastructure facilities, major multi-story buildings and vertical evacuation refuge buildings (required ASCE7 implementation)	X	**Compile detailed Hawai‘i and Maui County bridge seismic retrofit performance objective information from DOT for 50-60 bridges, and update HAZUS inventory to reflect more accurate expected bridge loss estimates in SCD data products.**	X
		Evaluation of critical dams and water supply networks in Hawai‘i and Maui counties for future seismic performance.	X
State Department of Transportation to develop and/or adopt design procedures for tsunami resistance of new coastal bridges that are critical transportation.		Develop Seismic Rating Criteria for Shelters in Hawai‘i and Maui Counties	X
Develop a standard procedure for evaluating existing multi-story buildings as tsunami (and hurricane) refuge structures	X	Provide Local Training to support post-disaster building safety inspections.	X
		Extend database of essential building inventory. Implement in HAZUS.	X
		Conduct Testing of the Performance of Single Wall Construction when subjected to major earthquakes and hurricanes. Develop more reliable retrofit procedures. Improve modeling of this building type in HAZUS MH.	X
		Track and evaluate current development of Earthquake Early Warning systems	
		Generation of shake maps incorporating soil conditions	

Table 20.4 Prioritized Components of the Strategy for Droughts and Wildfires

Droughts	Also in County Plans/THIRA	Wildfires	Also in County Plans/THIRA
Installation of rain gauges to monitor rainfall levels. Include operation and maintenance of instruments.	X	**Fire Break Maintenance by DOFAW. These roads need to be maintained with heavy equipment to stop advancing fire.**	X
Update Drought Monitor website	X	**Reduce and/or convert fuel load along roadsides and community open areas**	X
Water conservation education that involve both the public and the private sectors.	X	**Reduce and/or convert fuel load around individual homes and lots**	X
Development and implementation of a water efficient toilet rebate program and/or a water leak equipment rebate program on the neighbor islands.		**Installation, operation, and maintenance of two remote automatic weather stations to capture microclimate data.**	X
		Construction, improvement, and/or maintenance of thoroughfares for vehicular access to remote areas with high risk of wildfires	X
		Increase wildland fire preparedness capabilities and training in order to improve resilience.	X
		Fire Prevention Education that involves public and the private sectors.	X
Update Drought Mitigation Plan (All Islands)	X	Agricultural Practices to Mitigate Wildland Fires: Agricultural practices to mitigate wildfire impacts on communities and subdivisions.	X
Develop, promote, and implement high-efficient irrigation practices and sustainable water management policies.		Development and maintenance of a GIS map and database of the Wildland Fire Mitigation Resource Mapping and Inventory Program:	
Develop a program to improve drought resilience of communities relying on rainwater catchment systems.		Forest Management Plan with a Wildfire Mitigation Component	
Improve monitoring capability to collect and share hydrologic, groundwater, and stream flow data as drought indicators.	X	Installation of pre-staged water and helicopter pads for us in wildfire suppression.	
Develop additional potable water sources, storage facilities, and upgrade the transmission and distribution systems	X	Installation of fire hydrants and development of static water sources.	X
Renovation, replacement, and/or addition of water storage and conveyance systems to improve the reliability of drinking and irrigation water supply	X	Use of prescribed burns to reduce fuel loads in fire prone areas	X
Extension of public water transmission systems to areas currently served primarily by private water catchment systems.			

Table 20.5 Prioritized Components of the Strategy for Other hazards: Volcanic Hazards; Landslide/Rockfall

Volcanic	Also in County Plans/THIRA	Landslide / Rockfall	Also in County Plans/THIRA
Model to forecast SO_2 hourly based on meteorological conditions and emission rates of the Halemaʻumaʻu and Puʻu ʻŌʻo sources. Based on wind modeling of dispersion over the course of each day.	X	Zones of Required Special Investigations of rockfall are needed near hillsides; it would also be used to define as a duty to notify during real estate transactions. Jurisdictionally, this suggests that the State Legislature could instruct the counties to create the maps of Zones of Required Special Investigations	
		This requires implementation into planning policy documentation and further planning projects to create mapping to identify the hazard areas for regulatory purposes. Necessary geotechnical studies that would be sponsored by the State for consistency of approach.	

Table 20.6 Prioritized Components of the Strategy for Health Vulnerability and Risk / Hazardous Material

Medical Services	**Also in County Plans/THIRA**	**Public Health Services**	**Also in County Plans/THIRA**
Enhance medical surge capacity	X	**Coordinate medical supply chain and points of distribution (PODs)**	X
Essential capabilities of statewide healthcare emergency services	X	**Develop public health messaging.**	X
Information sharing across organizational boundaries	X	**Determine adequate food security, quality of water, sewage and sanitation system infrastructure.**	X
Rapid restoration of essential medical & surgical services	X	**Investigate potential disease and other conditions, exposures, and events that could adversely impact the public's health**	X
Immediate Bed Availability (IBA) surge to 20% within 4 hours of an incident	X	**Collect, analyze, and interpret data from multiple sources to inform actions**	X
Develop and implement Crises Standards of Care (CSC)		**Assure and enhance behavioral health capacity to address increased needs in crises**	X
Create and Integrate MOU's: Public and Private Services and Resources to help support relevant stakeholders. Clarify distinctive roles and responsibilities.	X	**Alternate care capacity for all segments of the population**	X
		Coordinate and accredit Medical Reserve Corps volunteers	X
		Increase public awareness and public information about the individual's role In disaster preparedness, including social media and public education programs	X
Mass Care Services		**Environmental Response/Health Services**	
Food Warehousing to accommodate supply chain disruption		**Greater emergency management and exercise participation is needed with the counties and with the State Department of Health and related supporting organizations.**	X
Integrated shelter list to include private, county, and state facilities	X	**Government should develop Continuity of Operations Plans that is horizontally redundant in essential expertise as well as vertically successional in chain of command, in order to accommodate absenteeism. Also, maintain lists of first responders and essential workers during a disaster.**	X
Continue to retrofit public shelter buildings to increase capacity to decrease the sheltering deficit. Achieve EHPA rated hurricane shelters or alternative types of refuge buildings	X	Prepare response and recovery plans for the management of waste and contamination of food and water resources, wastewater, hazmat, and other conditions that would support the spread of disease	X

Table 20.7 Prioritized Components of the Strategy for Climate Change Adaptation

Climate Change	Also in County Plans/THIRA
Develop a post-disaster recovery and reconstruction plan integrating green technology and building code compliance to Build Back Better disaster resilience	X
Develop maps of probabilistic sea level rise maps for Hawai‘i. These should be used in the estimation of tsunami inundation and runup that are needed for use in designing critical infrastructure facilities, major multi-story buildings and vertical evacuation refuge buildings, taking into account coastal morphological changes due to sea level rise.	
Develop risk reduction policies for siting and design criteria for critical facilities in the more susceptible coastal hazard zones based on Climate Change Priority Guidelines in HRS Chapter 206. Include the consideration of the function of the facility and the long-term resilience of the community it serves.	X
Establish 500-year coastal inundation zone maps that can be used in land use regulation decisions for all construction	
Encourage counties to establish SMA Zones of Required Special Investigations for areas susceptible to coastal storm surge and water table effects due to sea level rise. This would include implementation into planning policy and mapping to identify the hazard areas for regulatory purposes.	
Make use of sea level rise tools currently under development. City and County of Honolulu to consider hazard-based setbacks based in part on coastal historical erosion rates and sea level rise projections.	X
Adopt legislation to require that erosion rates are disclosed in real estate transactions. (Disclosure of flood inundation zone risks falls under the Mandatory Seller Disclosures in Real Estate Transactions Act, but the statue doesn't cover coastal erosion and sea level rise.)	X

Table 20.8 Prioritized Components of the Strategy for Multi-Hazard Actions

Multi-Hazard Mitigation Actions	Also in County Plans/THIRA
Phase I: Identify current status of risk assessments of public and private critical infrastructure. Identify facility ownership and review any past risk assessment studies. Identify gaps in assessment coverage.	X
Phase II: Conduct hazard and risk assessments and Evaluate vulnerability of public and private critical infrastructure systems	X
Phase III: Implement cost-effective retrofits, protective, and/or Policy/Regulatory measures for public and private critical infrastructure systems to the extent practical.	X
Augment and Expand newly developed HHARP, Hawaiian Hazard Awareness and Resilience Program.	
Develop and adopt multi-hazard assessment, design and construction standards for critical utility lifelines and distribution systems, including but not limited to power, water, gas, communication, etc.	X
Develop a standard procedure for mobilizing in-state and out-of-state engineers to assist in post-disaster building safety inspections, including procedures to update, maintain and test local engineer list.	X
Develop and distribute multi-hazard information brochures for residents and visitors on all islands.	
Develop and Provide Local Training to support post-disaster building safety inspections.	X

Table 20.9 Prioritized Components of the Strategy for Land Use and Building Requirements

Land Use and Building Requirements	Also in County Plans/THIRA
By 2014, adopt wind design standards for the installation of solar and photovoltaic panels on residential rooftops. Adopt 2012 IBC and related codes for ASCE 7-10 wind updates per HRS 107 Part II.	X
By 2018, develop maps of probabilistic tsunami inundation and runup for use in designing critical infrastructure facilities, major multi-story buildings and Risk Category III and IV buildings	X
Develop and/or adopt a procedure for a Hazard Assessment for Coastal Hazards that need to be identified, or addressed, at the early stages of the development process.	
Establish a PUC policy to replace weathered wood poles with NESC-conforming poles meeting wind resistive criteria.	X
Develop standards – (i) Asphalt shingle installation for high winds; (ii) PV installation for high winds; (iii) Drought conditions and preparing a fire break perimeter for wildfire mitigation	
By 2018, adopt tsunami-resistant design provisions for new critical infrastructure facilities, major multi-story buildings and Risk Category III and IV buildings as required by Hawai‘i Revised Statutes Chapter 107	X
Develop and adopt multi-hazard design and construction standards for critical utility lifelines and distribution systems	X
City and County of Honolulu to adopt coastal erosion setbacks per historical rates and disclosure of erosion rate during real estate transactions.	X
By 2018, consider SCD Mass Care Council recommendations to update design standards for new high-occupancy public buildings.	
By 2018, enable tsunami resistant provisions to evaluate Risk Category III and IV structures, and taller Risk Category II structures for “tsunami-ready” status	X
By 2018, Implement requirements for post-disaster repairs of Risk Category III and IV buildings and for substantial improvements and alterations thereof.	
By 2018, Implement seismic bracing requirements for nonstructural building elements in post-disaster repairs of Risk Category III and IV buildings and for substantial improvements and alterations thereof.	
Develop a multi-hazard post-disaster recovery and reconstruction plan integrating green technology and the latest building code compliance to Build Back Better disaster resilience	
Integrate hazard assessment policies into the sustainable community development plans	X
Establish Zones of Required Special Investigations of rockfall near hillsides; also use to define as a duty to notify during real estate transactions.	

Table 20.10 Prioritized Components of the Strategy for Infrastructure Resilience

Infrastructure Resilience	Also in County Plans/THIRA
Provide detailed probabilistic tsunami inundation and coastal flooding maps to critical infrastructure owners and operators for use in design of site-specific mitigation	X
Emergency Operations Plans need to be developed for adequacy of critical marine/ground transportation elements and supply chain disruption and comprehensive alternate port operations/offloading plan	X
Support long-term infrastructure recovery and overall coordination processes for infrastructure recovery, particularly power.	X
Multi-hazard risk assessments of critical infrastructure to include harbors and fuel storage facilities, power plants, water systems, communications sites, sewage treatment plants, water storage tanks and other facilities providing critical services.	X
Compile detailed Statewide bridge information from DOT bridges, and update inventory to enable more accurate bridge vulnerability estimates (HAZUS, etc.)	X
State Department of Transportation to develop and/or adopt design guidelines for tsunami, hurricane and severe storm resistance of coastal bridges and roadways that are critical transportation links.	
Harbor maps to define regimes of currents and timeframes for several scenarios of tsunami to estimate necessary period of ship evacuation	
Evaluate vulnerability of critical infrastructure systems in the inundation zone and implement protective measures or back-up resources.	X
By 2020, Identify tsunami and earthquake protective measures and procedures necessary to prevent failures of any LNG facilities	
Establish electrical transmission and distribution design standards to incorporate Hawai‘i effective wind speed maps.	X
Replace weathered wood poles with NESC-conforming poles.	X
Update design and construction standards for utility lifelines per American Lifelines Association standards.	X
Install an Earthquake Early Warning system (for critical power plants on Maui)	

Table 20.11 Prioritized Components of the Strategy for Recovery and Macro-Economic Effects

Recovery and Macro-Economic Effects	Also in County Plans/THIRA
Risk and Disaster Resilience and Assessment: Conduct multi-hazard and risk assessments of critical infrastructure to include harbors, and fuel storage facilities, power plants, water systems, communications sites, sewage treatment plants, water storage tanks, and all CI/KR facilities providing critical services.	X
Critical Transportation: Emergency Operations Plans need to be reviewed for adequacy of critical transportation elements and supply chain disruption, to include county debris clearance and disposal	X
Risk and Disaster Resilience and Assessment: Adopt tsunami design code as required by law per Hawai‘i Revised Statutes Chapter 107 Part II	X
Community Resilience and Threat and Hazard Identification: Increase public awareness and public information about their role In disaster preparedness, including social media and public education programs.	X
Long-Term Vulnerability Reduction: Establish electrical transmission and distribution design standards to incorporate Hawai‘i utility structures using effective wind speed maps consistent with the State Building Code	X
Long-Term Vulnerability Reduction: Update design and construction standards for utility lifelines per American Lifelines Association approved standards. Develop and adopt multi-hazard design and construction standards for critical utility lifelines and distribution systems	X
Long-Term Vulnerability Reduction and Critical Transportation: State Department of Transportation to develop and/or adopt design procedures for tsunami and hurricane surge resistance of new coastal bridges that are critical transportation links.	X
Review policies to determine if additional policies to mitigate against post-disaster price gouging and fraud due to demand surge are required.	X
State and County Recovery Plans: Develop post-disaster recovery and reconstruction plans that integrate green technology and building code compliance based on guidance provided in the National Disaster Recovery Framework	X

Table 20.12 Prioritized Components of the Strategy for Threat Identification and Risk Analysis (THIRA) Implementation of Core Capability Building

Threat Identification and Risk Analysis (THIRA) Implementation
Public Information: Implement emergency evacuation signs within the tsunami evacuation zones, prioritizing where the optimal routes may not be apparent or unclear. Prepare/disseminate coordinated public information.
Public Information and Operational Coordination: By 2015, develop a coordinated warning and evacuation annex for a Great Aleutian Tsunami. Prepare coordinated public information briefing material. Gain senior elected official agreement on tsunami preparation, response, and recovery strategy and coordination with appropriate senior military leaders.
Community Resilience and Threat and Hazard Identification: Increase public awareness and public information about their role In disaster preparedness, including social media and public education programs.
Planning and Critical Transportation: Plans need to ensure adequacy of critical transportation elements.
Risk and Disaster Resilience and Assessment: Conduct multi-hazard and risk assessments of critical infrastructure to include harbors and fuel storage facilities, power plants, water systems, communications sites, sewage treatment plants, water storage tanks and other facilities/buildings providing critical services.
Risk and Disaster Resilience and Assessment: Adopt tsunami design code as required by law per Hawai‘i Revised Statutes Chapter 107 Part II
Mass Care Services: Continue to retrofit public shelter buildings to increase capacity to decrease the sheltering deficit. Achieve Type A or EHPA rated hurricane shelters or alternative types of refuge buildings.
Operational Coordination: Emergency management exercise participation with the counties, state departments, non-profit organizations, and the private sector.
Long-Term Vulnerability Reduction and Critical Transportation: State Department of Transportation to adopt design procedures for tsunami and hurricane surge resistance of new coastal bridges that are critical transportation links.
Long-Term Vulnerability Reduction: Update design and construction standards for utility lifelines per American Lifelines Association approved standards. Adopt multi-hazard design and construction standards.
Critical Transportation: Develop harbor tsunami current maps to define regimes of currents to estimate the necessary period and standoff of ship evacuations.
Community Resilience and Threat and Hazard Identification and Infrastructure: By 2018, develop maps of probabilistic tsunami inundation and run-up that are needed for use in designing and evaluating critical infrastructure facilities, major multi-story buildings and vertical evacuation refuge buildings.
Long-Term Vulnerability Reduction: Establish electrical transmission and distribution design standards to incorporate Hawai‘i effective wind speed maps consistent with the State Building Code
Planning and Community Resilience: Develop a standard procedure for evaluating existing multi-story buildings as tsunami (and hurricane) refuges. Update policies for vertical evacuation buildings where necessary. Verify integrity of multi-story buildings for tsunami forces including the case of a Great Aleutian Tsunami (GAT).
Operational Coordination: A newer, larger State EOC is needed for managing major and/or complex disaster events
Economic Recovery: Adopt post-disaster reconstruction policies to Build Back Better. Develop policies to mitigate against post-disaster price gouging and fraud due to demand surge. Business to understand that their disaster preparedness would yield the greatest benefit

20.5 State Coordination with County Hazard Mitigation Strategy Priorities

20.5.1 Local County Hazard Mitigation Priorities

Prioritized summaries of the mitigation strategies of the counties are provided below and ranked starting with the highest priority groups of projects and highest priority projects within each group. The counties are listed in order of their resident populations:

20.5.1.1 City and County of Honolulu 2012 Hazard Mitigation Plan priorities regarding hazard mitigation:

1. Property protection in the form of structural retrofits of critical facilities and infrastructure:
   - Hardening of critical facilities, utilities, and port facilities.
   - Hazard Mitigation Retrofits of the County Essential Facility Inventory.
   - Hazard Mitigation Retrofits of the State Essential Facility Inventory.
   - Emergency shelter evaluation: All-Hazard Assessment of Hurricane Shelters.
   - Retrofit public shelter buildings to increase capacity and refine actual evacuation demand.
   - Preliminary engineering of tsunami and coastal flood mitigation retrofit of critical infrastructure.
   - Identify and retrofit critical BWS pumping stations in the tsunami inundation zone.
   - Update the HAZUS MH model to incorporate detailed data on State and County Bridges and determine seismic risk of collapse/outage.
   - Establish a policy for strengthening of critical public facility enclosure integrity.

2. Property protection in the form of structural retrofits of residential buildings or similar buildings:
   - Testing of the Seismic (and Wind Performance) of Single Wall Construction.
   - Incentives for homeowners and businesses to retrofit their structures.
   - Improve assessments of hurricane risks to communities with a Honolulu building inventory database.
   - Develop post & pier/single wall hurricane retrofit guide and Expert Tool.

3. Structural projects with the specific objective to reduce losses during an event:
   - Improve resiliency of fuel supplies during disasters.
   - Increase HECO generator plant capacity.
   - Replace weathered wood poles with NESC-conforming poles.

4. Development of policies and other actions for prevention of losses:
   - Natural hazard policies for the General Plan & Community Development Plans.
   - Establish further upgrades to the electrical transmission and distribution design standards.
   - Develop policy and maps to create buffer zones in new and existing developments between high-hazard rock fall areas and homes.

- Incorporate all-hazard assessments in land development application process.
- Update design and construction standards for utility lifelines per the American Lifelines Association approved standards.
- Adopt 2012 IBC and related codes per HRS 107 Part II.
- Develop a Hawai‘i certification program for residential safe room assemblies. [ongoing]
- Develop tsunami hazard maps (runup and depth) for building code design provisions.
- Develop policies for repetitive loss structures.
- Consider adopting coastal erosion setbacks per historical rates or disclosure of erosion rate during real estate transactions.
- 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.
- Delineate potential liquefaction & lateral spreading hazard areas of coastal O‘ahu.

5. Upgrade of infrastructure and systems necessary for emergency services:
- Improve emergency communication reliability during disasters.
- Identify the types of buildings more suitable for self-sheltering.
- 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. [completed]
- Assimilate the USCOE 2009 Hurricane and Tsunami Evacuation Behavioral Study into evacuation and sheltering policies. [ongoing]
- Develop rainfall and stream flow gauging system suitable to flood monitoring.
- Maintain various fuel breaks/fire roads throughout the island of O‘ahu.
- Waianae Mountain Fuel Reduction Bulldozer Equipment purchase.
- Purchase four 1000-gallon water tanks for rainfall catchment and storage for fire suppression in the Wai‘anae Watershed area.
- Establish a Post-Disaster Technical Clearinghouse for all-hazard emergency management.
- Establish additional flood and debris-flow warning systems on the island of O‘ahu.

6. Increase public education and awareness of hazards and mitigation strategies:
- Update tsunami evacuation maps. [ongoing]
- Develop dam evacuation maps. [ongoing]
- Adopt new DFIRM flood maps for O‘ahu that are hurricane-based for south and west shores and understand differences compared to old maps. [completed]
- Update the Hawai‘i Rainfall Atlas and Precipitation Frequency Atlas.
- Conduct public information workshops, especially regarding: Hurricane Awareness, Hurricane Retrofits, Hurricanes, Tsunamis and Flooding and conduct multi-government agency crisis exercise 2-3 times per year.
- Conduct disaster preparedness education for immigrant minority groups on the island of O‘ahu.

7. Natural Resource Protection:
- Waikīkī Beach Sand Restoration to 1985 width. [ongoing]

20.5.1.2 County of Maui 2010 Hazard Mitigation Plan priorities regarding hazard mitigation:

1. Hardening and retrofitting of critical facilities:
- hospitals primarily, then fire, police, ambulance, and airports
- fuel, power, water, and wastewater utility infrastructure, and port facilities
- hurricane shelters
- highways and critical non-redundant roadways
- county baseyards

2. Flood proofing and tsunami mitigation of critical infrastructure and flood monitoring:
- Coastal pump stations and Kahului Harbor
- Near real-time rainfall and streamflow data monitoring system

3. Develop multi-hazard maps for codes and evacuation planning specifically including:
- tsunamis
- floods
- dam breaks
- rockfalls/landslides

4. Update the Building Code in accordance with Hawai‘i Revised Statutes Chapter 107, Part II, State Building Codes and Design Standards, and adopt tsunami design provisions

5. Integrate natural hazard mitigation policies into the General Plan and community development plans

6. Conduct public awareness/education meetings and workshops, especially regarding:
- Hurricanes
- Tsunami
- VOG
- Earthquakes

7. Adapt HAZUS MH Level 3 local data and applications for use in the County of Maui
- Update the Building Inventory for the Hurricane Module using property tax data
- Update the Bridge Inventory using State Department of Transportation data

8. Evaluate and identify the types of buildings more suitable for hurricane refuge
- The number of public shelters will never be enough for the population
- Existing public shelters used for mass occupancy were not specifically designed to provide enhanced hurricane protection
- Other types of more robust construction may be suitable for hurricane refuge

9. Expand water reservoir capacity in Kula for drought and wildfire mitigation

10. Develop additional policies to avoid disproportionate flood losses and improve the County of Maui’s CRS rating

20.5.1.3 County of Hawai'i 2010 Hazard Mitigation Plan priorities regarding hazard mitigation:

1. Hardening and Retrofitting of Critical Facilities
   Conduct all hazard evaluations and develop cost-effective retrofits for priority facilities including:
   - hurricane shelters and schools,
   - hospitals, fire stations, and police stations, airports
   - Hilo and Kawaihae harbors and fuel storage facilities
   - key County bridges and plan alternative transportation routes,
   - power plants, water systems, communications sites, sewage treatment plants, and other facilities/buildings providing critical services

2. Upgrading of County Building Codes in accordance with Hawai'i Revised Statues Chapter 107, State Building Code and Design Standards

3. Mapping/Assessments/Studies
   Analysis of high hazard areas and studies to develop mitigation measures:
   - perform screening evaluations of alternative facilities to augment public shelters to address shelter shortfall
   - investigate and document effectiveness of VOG mitigation techniques and incorporate in public awareness meetings
   - Update the HAZUS MH model to incorporate current bridge status and adapt HAZUS MH with enhanced building information data for hurricane loss estimation and identification of vulnerable structures

   Develop mapping of all major natural hazards:
   - flood map modernization with incorporation of both hurricane flood and tsunami inundation into DFIRM's [completed]
   - updated tsunami evacuation maps [ongoing]
   - earthquake ground failure hazard maps
     - probabilistic lava inundation maps
     - probabilistic tsunami inundation maps
     - dam inundation evacuation maps
     - landslide and slope stability hazard maps
     - LIDAR-based remapping of streams

4. Wildfire Prevention (firebreak establishment and fire mitigation resource inventory)

5. Drought Mitigation by improvements to irrigation aqueduct, reservoirs, and water management

6. Policy for Repetitive Flood Loss Properties

7. Develop natural hazard mitigation criteria policies for county facility site selection and design

8. Public Awareness/Education, with additional focus on implementation of Multi-Hazard Mitigation Techniques and VOG
   - Incentives for Homeowners and Business to retrofit vulnerable structures: To further support this type of outreach, the following actions are still needed:
     - an expedited permit process if the homeowner uses the standard recommended plans;
     - working with insurance companies to get homeowners insurance credits for implementing these retrofits;
     - need to expand the Expert System to add the hurricane mitigation techniques that were previously developed for the Hawai‘i Hurricane Relief Fund’s Loss Mitigation Grant Program.
     - Retrofit training, videos, displays, and demonstration/pilot retrofit projects
   - Multi-hazard public information website consolidating GIS mapping products for hazards & zoning

9. Mitigation of Erosion/Land/Rock Slides in residential areas and highways. (Highways have greater priority)

20.5.1.4 County of Kaua‘i 2009 Hazard Mitigation Plan priorities regarding hazard mitigation:

1. Multi-hazard actions
   - Ensure widespread awareness for reducing disaster risks and mitigating impacts of hazards in policies, planning, and program implementation.
   - Ensure hazard mitigation is incorporated into the County of Kaua‘i General Plan
   - For new construction of public buildings, designate areas to serve as a shelter.
   - Consider options to secure funds to retrofit facilities with hurricane shutters, roof tie-downs, and other improvements, such as emergency power generation equipment.
   - Continue to develop agreements with hotels and resorts to house their own guests and worker families during hurricanes and other major natural disasters.
   - Identify special needs populations and sheltering requirements.
   - Encourage the integration of agricultural planning and coordination into disaster risk management community to improve local food security.
   - Develop a post-disaster recovery plan that incorporates mitigation considerations to better enable mitigation objectives in rehabilitation and reconstruction.

2. Hurricane and High Winds
   - Integrate information about wind risks into mapping, planning, and improvements in local building codes. [completed]
   - Certify hotels and condominium units as official shelters. Set up and hold training and certification programs
   - Emergency Generation for County Facilities to remain operational after a disaster.
   - Distribute Community Education & Hazard Publications
   - Continuity of Operations Planning Training for the County of Kaua‘i’s Visitor and Business Industry; Work with the visitor and business industry to build or update their COOP plans.

3. Floods
- Develop the program for participation in the Community Rating System.

4. Drought and Wildfires
- Compile rain gauges from all sources to ensure spatial rain gauge coverage in a system. Improve data gathering.
- Implement the County drought mitigation strategies. [The County of Kaua‘i has not been in drought conditions]
- Maintain and Upgrade Irrigation networks from reservoirs
- Develop and utilize historical wildfire occurrence maps in planning
- Maintain and Expand Fire Breaks and reduce fuel loads
- Engage in public education programs with schools and communities

5. Climate Variability and Change
- Take into consideration the impacts of climate change in land use, development, and planning.
- Develop Sea Level Rise Inundation Maps.
- Take into consideration potential socioeconomic impacts from climate change for the County of Kaua‘i.
- Educate leaders and the public about sea level rise, increased disaster risks, and ecosystem impacts from climate change

6. Tsunami
- Use tsunami modeling and evacuation planning for the County of Kaua‘i to update evacuation route planning and maps and to inform land use planning and development.

7. Landslides/Debris Flows
- Develop policies for identifying and mitigating landslide hazards and risks to communities subject to isolation. Identify and implement mitigation of landslide hazard risks to State Highways in the County of Kaua‘i.

8. Erosion
- Develop a Shoreline Certification based on the shoreline geology for each shore segment. Develop erosion management and mitigation plans.

9. Dam Safety
- Participate in the inspection of dams and levees.
- Educate and inform public living downstream of dams about potential dam break risks and identify evacuation routes.

10. Hazardous Materials
- Identify areas of hazardous materials that could pose additional risks in hurricanes, tsunami, severe flooding, coastal inundation, and other hazards, and determine ways to mitigate these risks.

11. Public Health Disasters

- Develop plans and protocols to minimize spread of pandemic flu and to ensure continuity of government and health facility operations in an event.
- Develop plans and protocols to address increased public health risks after a disaster.

20.5.2 Local Mitigation Coordination and Prioritization

Over the years, the State has developed and demonstrated mechanisms to implement mitigation plans and projects, including this State of Hawaiʻi Multi-Hazard Mitigation Plan and the processes explained throughout. Local jurisdictions are strongly encouraged to incorporate mitigation actions that are based on established, local, natural hazard risk assessments into proposed projects and as improvements to existing projects. Local hazard mitigation projects developed in the last updates of county plans in 2009 (Kauaʻi) 2010 (Maui and Hawaiʻi) and 2012 (City and County of Honolulu) that were also reviewed by State Civil Defense and State Mitigation Forum. By reference within the State Plan to local county plans, the state incorporates the county projects and their prioritization thereof.

As of 2013 with this update of the State Hazard Mitigation Plan, it is observed in the preceding sections that a large degree of general concurrence and consistency has evolved between the State and County Hazard Mitigation Plans, with respect to Goals and Objectives, and shared mitigation action priorities. The THIRA 2012 process was instrumental towards encouraging this convergence towards disaster resilience because the State THIRA was based on county THIRA workshops of local stakeholders that preceded the workshops of the state stakeholder groups. THIRA is also performance-based to the extent that achieving Core Capability Targets in fact represents attaining multi-hazard resilience for disaster and threat prevention, protection, mitigation, response, and recovery, and required holistic awareness of the total impacts of disasters to the 31 Core Capabilities that communities depend on during all types of disasters.

All of the four counties will receive equal priority for the following natural hazards because all jurisdictions are vulnerable: tsunami, hurricane and high winds, floods, landslides and rockfalls. Priorities (in order) for earthquake projects are: (1) County of Hawaiʻi; (2) County of Maui; (3) City and County of Honolulu; and (4) County of Kauaʻi. The County of Hawaiʻi will receive top priority for projects involving lava flows and VOG. Drought and wildland fires mitigation actions are of greater need for the counties or Honolulu, Maui, and Hawaiʻi while coastal erosion risk is more significant for the counties of Kauaʻi, Honolulu, and Maui.

20.5.3 Local Funding

Local governments receive a significant portion of their funding for mitigation projects from the federal programs discussed above. Sources of local funding include departmental budget allocations, tax-funded investments (predominantly from property and sales tax) in infrastructure improvements and dedicated transportation/capital improvements sales or use taxes, all of which can also serve to mitigate hazards. Many of the mitigation actions require external sources of funding, new equipment, or additional personnel for implementation. Several agencies provide opportunities for additional funding.

20.5.4 Local Mitigation Plan Technical Assistance

The State Civil Defense Mitigation staff provides technical assistance to the applicants in the preparation of the applications, cost-benefit analyses and acquisition of environmental data. Technical assistance includes support in all of these areas. Subject to resources, SCD staff conducts applicant briefings, wherein grant assistance and funding availability, the application process, and grant requirements are explained. This effective practice will be continued.

20.6 Prioritization and Selection of Grant Applications

SCD has established criteria for projects, including multi-hazard considerations. Funded mitigation actions have proven to be effective based on past experience project successes. Loss avoidance is anticipated in locations where mitigation projects have been undertaken, and significant savings are expected to be realized. Effectiveness of specific projects can also be measured using FEMA's benefit-cost software modules, as required prior to applying for FEMA mitigation grant assistance. Benefit-cost analysis is not a prerequisite for qualification as an approved mitigation action, but must be conducted prior to submittal for grant assistance. For example, in the event of another significant seismic or flood event in the area of the Lower Hāmākua Ditch (County of Hawai‘i) on completion of the $3.9 million flood proofing project, it is anticipated that losses avoided will exceed the federal investment of $2.9 million by more than four times. As proffered by FEMA, investment in mitigation will result in a return on investment (ROI) of four to one (4-to-1).

20.6.1 Proposal Submission Evaluations for Specific Funding

Funding will always be an important issue when considering mitigation actions. The state recognizes that proposed state and county mitigation actions are subject to numerous factors, including and not limited to: staff and budget cuts; resource reduction; CIP allocations; reduction of departmental function; departmental consolidation. Generally, federal mitigation funds are mostly limited to the Hazard Mitigation Assistance grants. These programs include the Pre-Disaster Mitigation Program, Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, Repetitive Flood Claims Grant, and Severe Repetitive Loss Program. SCD also uses FEMA‘s Public Assistance Program (Categories C-G) to implement mitigation activities (406 Mitigation). With the exception of the post-disaster HMGP and Public Assistance Program, all these grant programs are non-disaster (annually funded) grant programs. To fairly and efficiently utilize these grant programs to achieve mitigation across the State, a sound process is followed to evaluate and prioritize proposed mitigation actions so that the limited availability of grant funds are used most effectively in Hawai‘i.

SCD has the primary responsibility for reviewing and evaluating mitigation projects submitted by local jurisdictions and state agencies. The State Hazard Mitigation Forum provides its recommendations to SCD, based on its review and assessment of proposed mitigation actions. The Forum, comprised of 19 official voting members from all levels of government and the private sector, develops the criteria. The Director and the Vice Director of Civil Defense have approval authority.

To ensure consistency in submitting mitigation projects for grants, the project form (depicted in Appendix 21B at the end of Chapter 21 – Planning Processes and Update Procedures) is utilized to submit mitigation proposals for consideration by the State Hazard Mitigation Forum. State agencies and institutions, County governments, and SCD hazard specific advisory committees, such as the Hawai‘i State Earthquake Advisory Committee, submit nominations of mitigation actions using the form referenced above. The Forum developed and uses a scoring system that is based on the federal eligibility criteria, the mitigation criteria, mitigation action category, and Hawai‘i Hazard Profile rank, as discussed within this chapter. The criteria in evaluating and ranking the potential projects focus on resolving a significant problem, cost-effectiveness, environmental soundness, long-range solution, and direct relation to the goals/objectives of the State plan. Each criterion is given equal weight. To address the aforementioned criteria, the STAPLEE process is also included in the form to aid the requesting organization in formulating their proposal. The community acceptance criteria are referred to as the STAPLEE criteria (Social, Technical, Administrative, Political, Legal, Economic, and Environmental).[4] The STAPLEE evaluation criteria analyze the appropriateness of alternative mitigation actions by considering the following questions:

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?

[4] Priority-setting methodology from Federal Emergency Management Agency (FEMA), How-To Guide #3: Developing the Mitigation Plan; Identifying Mitigation Actions And Implementing Strategies, FEMA No. 386-3, April 2003.

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?

Typically, the Forum members will have about a month to independently review each project submitted for a particular grant fund opportunity. If necessary, requests may be made for additional information from the applicants. Once this initial review has been accomplished, an official meeting is convened, during which the Forum will numerically rank each high priority project. The Forum will use the information provided on nomination forms as the basis to render the ranking. The Forum developed and uses a scoring system that is based on the federal eligibility criteria, the mitigation criteria, mitigation action category, and Hawai‘i Hazard Profile rank, as discussed within this chapter. (The current project submission, prioritization, and selection process was first developed when Federal and State mitigation funds were made available in 2000. This process is subject to modification if statutory or operational conditions warrant change.) During this meeting, the Forum discusses each project and finalizes the ranking.

To further aid in the selection of projects for funding, SCD and the State Hazard Mitigation Forum use the following checklist as a guide:

- What is the hazard to be mitigated?
- What is the jurisdiction‘s risk for this hazard?
- Does the project have the potential to substantially reduce the risk of future damage, hardship, loss, or suffering that may result from a major disaster?
- Does the project independently (that is, without a second phase project) solve a problem?
- Is the hazard being mitigated a priority hazard in the jurisdiction’s mitigation plan?
- Does the project complement State and local mitigation goals and objectives identified in the mitigation plans?
- Does it fall within the Disaster Resilient Strategy’s key areas of implementation?
- Does the project have the potential to have a larger effect impact within the local and State mitigation strategy than other submitted projects?
- Does the jurisdiction have a FEMA-approved mitigation plan?
- Is the project cost-effective based on FEMA‘s benefit-cost analysis module?
- Does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties?
- In the past, what mitigation efforts were undertaken by the applicant using local funds and initiatives and what were the outcomes?
- Does the applicant have sufficient funds dedicated (or other funds or soft match investments) to meet the local cost-share of the project?
- Does the applicant have the capabilities to complete the project as submitted?
- Does the project reduce impacts in an area experiencing growth and development pressures?
- Does the project have any negative impacts on neighboring communities?

The Forum scores and ranks all project submittals when reviewing projects for grant assistance. As discussed above, numeric scores are assigned all projects after they have been reviewed for minimum grant and federal eligibility requirements. Once project rankings have been compiled and reviewed, the Forum will brief the Director of Civil Defense and Vice Director of Civil Defense on the prioritization of the projects and rationale for the ranking. Final project selection and submission of mitigation measures to the funding agency is determined by both aforementioned State officials. This secondary review of ranked projects is conducted by measuring overall hazard risk and state mitigation priorities against the final ranked list. Also, EPA standards and State Historical Preservation Guidelines will supplement the cost-effectiveness review of each project. Any mitigation project locally endorsed for funding will be submitted on the basis that it will benefit the community at large and, therefore, the State.

20.6.2 Hazard Mitigation Benefits and Cost for the Community

OMB 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.*

The purpose of the benefit-cost analysis (BCA) is to evaluate the tradeoffs about reaching goals concerned with protection of the built and natural environments. The State uses FEMA's cost benefit models to include HAZUS-MH.

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

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. Losses avoided include but are not limited to: reduced loss of life, injury, and damage to property (including historic properties); reduced impacts on environmental, social, and recreational values; reduced community disruption and business interruption; and future expenditures on disaster relief. Most benefits of mitigation are

costs and losses avoided through the reduction in loss probabilities and a reduction in loss amounts/value. Such as reduced:

- Loss of life, injury and pain
- Property destruction and damage
- Community disruption, personal and local infrastructure.
- Business interruption, including closures, shutdowns, un- (and under-) employment.
- Loss of culturally and historically important items.
- Expenditure on disaster relief by both governments and private organizations.

But benefits may also include increased awareness by communities of hazards, their impacts and avoidance, leading to better decisions and future actions. In addition, hazard mitigation may also reduce insurance costs for communities, such as the 10% NFIP Community Rating System program cost reduction for the County of Maui. In some areas, it may make the difference in having access to home insurance in high risk areas.

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

21. Planning Processes and Update Procedures

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CHAPTER 21

Planning Processes and Update Procedures

PLANNING PROCESS: *§201.4(b): An effective planning process is essential in developing and maintaining a good plan.*

Documentation of the Planning Process: ***Requirement §201.4(c)(1):*** *[The State plan must include a] description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.*

Coordination amongst Agencies: ***Requirement §201.4(b):*** *The [State] mitigation planning process should include coordination with other State agencies, appropriate Federal agencies, interested groups, and …*

Program Integration: ***Requirement §201.4(b):*** *[The State mitigation planning process should] be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.*

2010 Plan	Reasons for Updates / Revisions in this 2013 Plan
The 2010 planning plan maintenance and implementation process was described.	• The plan will be updated as mitigation projects and actions are implemented, new benefit/cost analysis is 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 twelve (12) 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. • The start-up of new proposed projects is monitored. Projects will continue to be nominated for funding with the involvement of State Civil Defense. • 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. • Guidelines for grant eligible types of projects are given in Chapter 20.

21.1 Introduction to the Planning Process

The State of Hawai‘i Multi-Hazard Mitigation Plan was first approved in 2004 and previously updated in 2007 and 2010. The plan serves as a guide for State decision-makers as resources are committed to reducing the effects of natural hazards. The process for the plan update is predicated on the Disaster Mitigation Act of 2000 planning and update requirements and FEMA guidance for standard state mitigation plan development and update. The planning process included:

1) Assessment of natural hazard risks and vulnerabilities
2) Review, assessment, and characterization of local (county), state, and federal core capabilities by incorporation of the 2012 Threat Identification and Risk Assessment (THIRA) for the State of Hawaii and its State Preparedness Report
3) Review of state mitigation goals and objectives to reduce hazard vulnerabilities and risks
4) Identification and review of mitigation actions and prioritization of mitigation and disaster resilience strategies

State Civil Defense formally established the Hawai‘i State Hazard Mitigation Forum in 1998. Bylaws (see Appendix 21A at the end of this chapter) for the Forum were adopted, and the Forum serves in an advisory capacity relative to the incorporation of hazard mitigation in policy in Hawai‘i. In the development of the plan update, Hawai‘i State Civil Defense (SCD) engaged its State Hazard Mitigation Forum (SHMF) and state and county agencies, private sector, nongovernmental organizations (NGO) and Hawaii representatives of federal agency stakeholders in providing input and review of the 2013 update of the Plan. This participation and coordination with the public, county agencies, and state agency stakeholders was integrated into the update.

21.2 Documentation of the Planning Process

21.2.1 State Hazard Mitigation Forum Oversight

Within the bylaws, SHMF purpose and activities are to:

- Develop a unified management strategy for state, federal, or county mitigation responsibilities and programs
- Identify vulnerabilities to various hazards and evaluate and prioritize measures to mitigate the risks
- Identify vulnerabilities to various natural hazards and evaluate and prioritize measures to mitigate the risks associated with the hazards; assist State Civil Defense (SCD) to solicit, review and prioritize nominations for mitigation projects to be included in the State of Hawai‘i Multi-Hazard Mitigation Plan and which may be submitted by applicants for Hazard Mitigation Grant Program and Pre Disaster Mitigation grant funding.
- Assist state and county governments in obtaining funds to implement mitigation projects
- Develop specific goals on a biennial basis and provide status reports to state departments, county governments, and private organizations represented on this forum
- Recommend policy and program changes to federal, state, and county agencies involved in mitigation activities

- Develop comprehensive public awareness program on the activities of the forum
- Provide reports as appropriate to the governor and legislature on special mitigation activities addressed by the forum

21.2.2 Evaluation of the 2010 Process for the 2013 Update

In order to determine changes that should be made in the 2010 plan, the Forum considered the FEMA Crosswalk recommendations.

During the development of the 2013 plan, SCD directed the Hawai‘i State Hazard Mitigation Forum (SHMF) to take its principal task to be support of the planning process and review of the plan update. SHMF members provided informational input and independent review of the plan and made recommendations for the plan update. SHMF members assisted with networking of other members of the hazards community for additional contributions to the development of the plan. The Forum can assist in identifying mitigation priorities and strategies for new projects, and assisted as group discussion moderators during the State Disaster Resiliency Strategy Workshop.

November 9, 2012 reconvening of the State Hazard Mitigation Forum in a Joint Meeting with the HSEAC: Review of requirements and desired improvements to the State Hazard Mitigation Plan. This meeting provided some overarching ideas:

- Consider prioritizing hazard chapters by severity of risks
- Discuss hazard mitigation benefits and payoffs
- Emphasize the economic costs and disruptive effects of disaster
    - Business interruption losses and Small Business impacts
    - Protection of island supply chain and critical infrastructure
    - Food Security is addressed in 2012 DEBEDT Plan
- Add Climate Change sea level rise considerations to Coastal Erosion Chapter
- Overall State perspective should be a resilience strategy and not just more or less a compilation of county project proposals

January 3, 2013 Technical Consultant Martin & Chock, Inc. is given Notice to Proceed.

January 22, 2013 State Hazard Mitigation Forum: Phase 1 Briefing and discussion on the proposed scope of changes and organization of the updated plan. Recent relevant mitigation planning efforts were discussed (per below, with the most comprehensive and overarching broad-based stakeholder effort being the THIRA).

February 15, 2013 HSEAC Meeting Briefing on Hazard Mitigation Plan

May 7, 2013 State Hazard Mitigation Forum Meeting: Phase 2 Briefing on Risk Assessment, Hazard Ranking, and THIRA Core Capability Gaps

June 27, 2013 State Hazard Mitigation Forum; Phase 3 Planning for State Disaster Resiliency Strategy Workshop of stakeholders with Forum members as leaders of focus groups:

Purpose of Workshop:

- Developing a Proposed Disaster Resilience Strategy for Hawai‘i
- Strategy Workshop Draft Agenda
- Participants and Profile of representative groups
- List of possible state actions and near-term policy decisions to be posed to Stakeholders

July 9-10, 2013 State Disaster Resilience Strategy Workshop

21.2.3 Recent State Hazard Mitigation Planning Efforts

- State of Hawai‘i **Threat and Hazard Identification and Risk Assessment** (THIRA) and State Preparedness Report (SPR) (2012)
- State Civil Defense Strategic Plan (2011-2015)
- Hawai‘i State Mass Care Council (2012-2013)
- Tsunami Inundation and Evacuation Maps (2010+ and 2013)
- Structural Risk and Vulnerability Assessment of State of Hawai‘i Critical Buildings (2010)
- State of Hawai‘i Energy Assurance Program (2011) DBEDT
- DLNR Dam Break Inundation Maps (2012)

21.2.4 THIRA and SPR 2012

Threat and Hazard Identification and Risk Assessment (THIRA) is an all-hazards capability-based assessment that establishes a foundation to justify and guide preparedness activities and investments, in compliance with Department of Homeland Security Comprehensive Preparedness Guide 201, *Threat and Hazard Identification and Risk Assessment Guide*, April 2012. The THIRA for Hawai‘i was based on county by county THIRA impact studies and workshops with government, private sector, and NGO stakeholders convened in a series of three workshops for each of the four counties and two workshops for State and Federal stakeholders, followed by advisory review meetings of the final THIRA inputs with each county’s emergency managers. Additional meetings were held with subject matter experts in earthquake, flood, tsunami, hurricanes, and security issues. It provided a common approach to maintain a baseline understanding of the risks, facilitating efforts to identify capability and resource gaps, focus capability improvements. THIRA 2012 became the state’s major –re-assessment of preparedness and capabilities, and served as a risk and vulnerability planning process for multiple hazards that was seamless with the update of the state hazard mitigation plan.

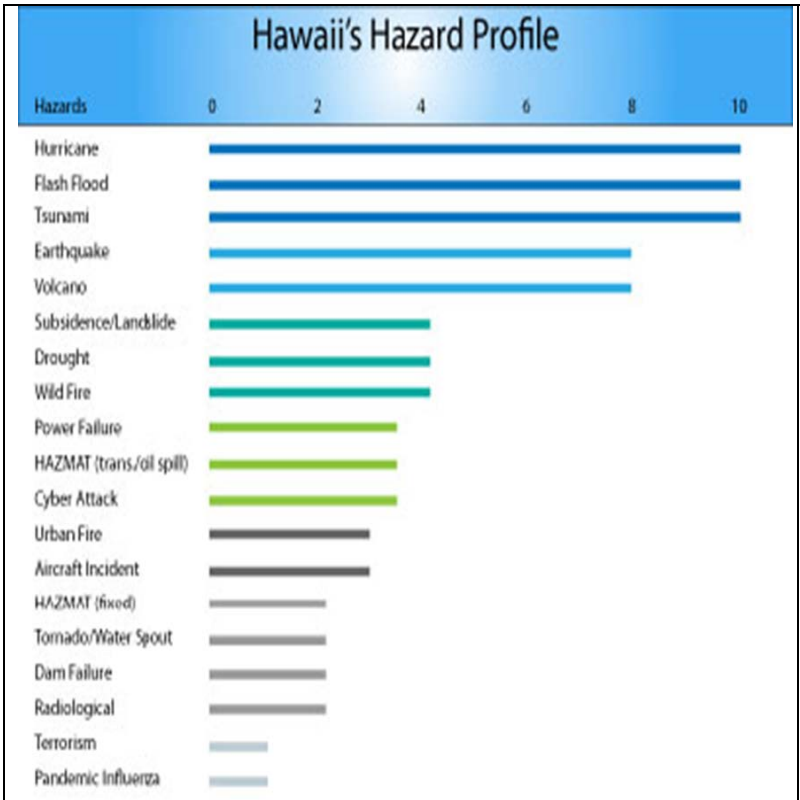
This THIRA, as submitted by the State of Hawai‘i in December 2012, addressed the Desired Outcomes, threat and hazard impacts, and Targets for 31 Core Capabilities relating to the THIRA Missions of Prevention, Protection, Mitigation, Response, and Recovery.

- Prevention: The capabilities necessary to avoid, prevent, or stop an act of terrorism.
- Protection: The capabilities necessary to secure the community against acts of terrorism and manmade or natural disasters.

- Response: The post-event capabilities necessary to save lives, protect property and the environment, and meet basic human needs.
- Recovery: The capabilities necessary to assist communities to recover effectively.
- Mitigation: The capabilities necessary to lessen the impact of disasters.

During the THIRA process, the State Civil Defense Strategic Plan was further evaluated per the interpretation of the threats and hazards in Table 21.1.

Table 21.1 Hawai‘i’s Threats and Hazards Profile



Hazard	THIRA 2012 Comments
Hurricane	High risk
Flash Flood	Frequent seasonal risk
Tsunami	High risk
Earthquake	High risk
Volcano	Limited extent; not pyroclastic
Landslide/Rockfall	Historical moderate risk
Drought	Not an “event”
Wildfire	Frequent but limited
Power / Com Failures	Infrastructure and response risk
HAZMAT incidents	Limited extent
Cyber Attack	Potential widespread collateral Impacts
Urban Fire	Limited extent
Aircraft Incident	High International traffic but not within SCD control
Tornado	Low probability; limited
Dam Failure	Latent risks due to construction; fatalities; dam inundation maps
Radiological Accident	Low probability & limited extent
WMD Terrorism	Low probability; however Hawaii is a key military hub
Pandemic influenza	High consequence International event; addressed in DOH plan

The THIRA process consisted of:

1. Identifying the Threats and Hazards of Greatest Concern to Hawai‘i
2. Giving the Threats and Hazards Context for how they might impact Hawai‘i
3. Examine the Core Capabilities using the Threats and Hazards
   Step 3 (a) of the THIRA process involves identifying impacts on the core capabilities and developing desired outcomes for each hazard
   Step 3 (b) of the THIRA process also involves estimating the impacts of threats and hazards on a community, spanning the core capabilities.
4. Set Capability Targets, looking across the estimated impacts to each core capability and coupling that with the desired outcomes to set the 31 capability targets

5. Applying the Results (including the State Preparedness Report, and integrating mitigation-related conclusions of the THIRA in this update of the State Hazard Mitigation Plan.

The State Preparedness Report, mandated by the Post-Katrina Emergency Management Reform Act of 2006, is a broad self-assessment of preparedness that addresses Core Capability Targets, state and local capability levels, and resource needs to fill any gaps.

Table 21.2 State of Hawai‘i Overall Schedule
Threat and Hazard Identification and Risk Assessment (THIRA)

Task Deliverable	2012						2013
	Jul	Aug	Sep	Oct	Nov	Dec	Jan
1	THIRA Planning						
2		Assessment & county THIRA’s					
3				THIRA Validation –State THIRA			
4							Review by FEMA R IX

21.2.5 THIRA Workshop Events

July 11, 2012 THIRA Scope Discussion Meeting with Department of Emergency Management

July 19, 2012 Overview of Hazard Assessment from 2010 State Hazard Mitigation Plan for THIRA context of most significant hazards, with County Civil Defense administrators and State Civil Defense Vice Director and Executive Officer (SCD Executive Administrators Meeting)

August 14, 2012 THIRA Planning SCD Executive Administrators Meeting

August 16, 2012 FEMA RIX THIRA/SPR teleconference

August 24, 2012 Honolulu THIRA Workshop #1 Hazard Impacts

August 20, 2012 Hawai‘i County THIRA Workshop #1 Hazard Impacts

August 27, 2012 Kaua‘i County THIRA Workshop #1 Hazard Impacts

August 28, 2012 Maui County THIRA Workshop #1 Hazard Impacts

August 30-31 FEMA Region IX Risk Management Workshop

September 13, 2012 FEMA RIX THIRA/SPR teleconference

September 13-14, 2012 Honolulu THIRA Workshop #2 Desired Outcomes

September 14, 2013 Hawai‘i County THIRA Workshop #2 Desired Outcomes

September 17, 2012 Kaua‘i County THIRA Workshop #2 Desired Outcomes

September 18, 2012 Maui County THIRA Workshop #2 Desired Outcomes

September 19, 2012 Pacific Preparedness Partnership Conference (DHS FEMA and SCD)

October 2, 2012 State THIRA Planning Meeting at SCD

October 5, 2012 State Level THIRA Working Group Meeting #1 Hazard Impacts and Desired Outcomes

October 9-10 Honolulu THIRA Workshop #3 Capability Targets

October 11, 2012 FEMA RIX THIRA/SPR teleconference

October 11, 2012 Maui County THIRA Workshop #3 Capability Targets

October 12, 2012 noon Hawai‘i County Workshop #3 Capability Targets

October 16, 2012 THIRA Planning SCD Executive Administrators Meeting

October 16, 2012 Kaua‘i County Workshop #3 Capability Targets

October 30, 2012 State Level THIRA Working Group Meeting #2 Capability Targets and Gaps

November 11, 2012 State THIRA Planning Meeting at SCD

November 14, 2012 State Preparedness Report Workshop for Honolulu

November 15, 2012 FEMA RIX THIRA/SPR teleconference

November 26, 2012 State Preparedness Report Workshop for Maui

November 27, 2012 State Preparedness Report Workshop for Kaua‘i

December 4, 2012 Pre-final THIRA/State Preparedness Report Meeting at SCD

December 7, 2012 Long-Term Disaster Recovery and Resiliency Conference (organized by Honolulu Department of Emergency Management)

December 8, 2012 Final THIRA and State Preparedness Report Completed

December 13, 2013 FEMA RIX THIRA/SPR teleconference

From the THIRA process, the Mitigation Mission related impacts and capability targets for the Core Capabilities of Community Resilience, Long-Term Vulnerability Reduction, Risk and Disaster Resilience Assessment, and Threats and Hazard Identification are summarized in Table 21.3.

Table 21.3 Summary of Mitigation Mission Related Impacts and Capability Targets

MITIGATION	**Core Capability: Community Resilience**	**Desired Outcome:** Applicable After Action Report (AAR) and lessons learned implemented into Emergency Operations and Hazard Mitigation Plans. A risk-informed mitigation process designed to improve resilience at every level through community leadership, collaboration, partnership building, education, and skill building implemented. Interagency coordination in the public and private sector in place to maximize resources prior to disasters. All segments of the population are properly educated on disaster preparedness and prepared to survive any emergency or disaster.
	Greatest Estimated Impacts: Hurricanes and Tsunamis: There will be lessons learned from gaps in emergency preparedness and exposure of past missed opportunities for hazard mitigation. Reception of the mitigation message is difficult in the short term.	
	Capability Target: Complete and distribute updated EOP within six months of AAR that is issued within 30-45 days. Increase community participation in Community Emergency Response Team (CERT) and Citizen's Corps. Provide community preparedness info & training. Support 100% of the population in the State, in the short-term after the disaster, with a risk-informed mitigation message and process designed to improve resilience at every level through community leadership, collaboration, partnership building, education, and skill building. Engage with the whole community and all stakeholders when developing/updating State and County mitigation plans within 6 months of disaster AAR and when possible the business continuity plans of large private sector organizations and nongovernmental organizations (NGO's).	
	Core Capability: Long-term Vulnerability Reduction	**Desired Outcome:** Hardening requirements and project scopes that implement hazard mitigation are identified and prioritized. Approved mitigation initiatives and investments to achieve measurable reductions in response and recovery resource requirements of future disasters or incidents are implemented.
	Greatest Estimated Impacts: *Hurricanes*: Critical facilities and other key resources such as power, port operations, and supply chain, acute health care surge capacity would become functionally impaired for months. *Pandemic Influenza*: Outbreak duration with greater than 25% attack rates lasting approximately 8 weeks with multiple waves over 3 or more months, creating about 40% absenteeism.	
	Capability Target: Identify and determine the scope of necessary corrective measures within six months of AAR. Provide staff and support for implementation of approved mitigation initiatives and investments to achieve a measurable reduction in the response and recovery resource requirements of future disasters or incidents. Upgrade / maintain building codes and establish tsunami design code and policies for CIKR and vertical evacuation refuge structures. Train sufficient proportion of responders in enhanced skills / capabilities to attain horizontal redundancy for Continuity of Operations (COOP) during pandemic. Critical agencies and businesses to have appropriate COOP plans. Include community education and outreach preparedness messages. Include community education and outreach preparedness messages, mitigation and initiatives.	

MITIGATION	**Core Capability: Risk and Disaster Resilience Assessment**	**Desired Outcome**: Programs that incorporate and combine lessons learned, from actual disasters, with state-of-the-art information on hazards and risk analyses to produce commensurate planning and policy measures are in place. Emergency managers and responders have a comprehensive understanding and assessments of worst case, most likely hazards and threat events on all counties, populations, infrastructures, etc.
	Greatest Estimated Impacts: Hurricane / Tsunami: Re-evaluate prevention and protective policies and vulnerability assessments. There are assessments of damaged structures and systems that need real-time perishable data collection for analysis and documentation of lessons learned.	
	Capability Target: Identify and determine the scope of necessary corrective measures within six months of AAR of any disaster. Update hurricane loss estimates using HAZUS MH with appropriate inventory of structures. Develop and adopt codes and standards for life safety and hazard mitigation of damage to the built environment and infrastructure. Community education and outreach to be included in other preparedness messages utilizing improvements in policies. Train HAZMAT and SAR responders. Develop training and utilize full-scale exercises.	
	Core Capability: Threats and Hazard Identification	**Desired Outcome**: General planning, risk assessment, hazard mitigation plans, up-to-date design codes and construction project policies, emergency operations plans, and recovery plans are all utilizing modern scientific quantitative evaluation of hazards. Threat information is vetted and used to advise the above efforts.
	Greatest Estimated Impacts: All Hazards and Threats: Incomplete assessments of hazards can result in underestimation of risk or overestimation, leading to either inadequate or inappropriate lack of preparation, or conversely, disproportionate allocation of resources within the spectrum of threats and hazards that are significant.	
	Capability Target: Annually updated THIRA and Training / Exercise Plans for hazard-specific collateral damage threats. Have trained 100% of public sector engineers/inspectors on damage assessment and building collapse by end of 2013. State and County Hazard Mitigation Plans current and applicable stakeholder forums (State of Hawai‘i Hazard Mitigation Forum) and committees active in updating threats and hazards, initiating mitigation projects, and providing oversight over State Hazard Mitigation plan update by October 2013.	

21.3 Planning Approach

The methods and approaches used in the planning process have evolved with guidance from SCD to the SHMF and meeting participants. The initial focus was on the development of county input during the THIRA process, because the local areas experience the greatest impacts of disasters, and it was important to build the state's hazard mitigation strategy from the "ground-up" while securing support from the highest levels of state government. The counties participate actively in the State Hazard Mitigation Forum, helping to guide hazard mitigation planning and activities of the State.

The State of Hawai‘i followed this basic planning approach:

1) Increased efforts to engage a broadened range of participant stakeholders.
2) Briefed County Emergency Managers on all islands with scientific and policy advisors, and invited participation from public and private agencies, organizations, and groups. Discussed process and gained agreement on approach. Throughout the process, briefed officials and advisory committees and sought input and comments. Revised process and products accordingly.
3) Gathered available county asset data; used focus groups, and meetings to collect data. Assessed data availability and condition of data. Gathered and reviewed available hazard studies and assessments.
4) Developed a GIS system using asset data and hazard layers. The State Hazard Mitigation GIS System builds on information gained from the counties, merged with state information and data.
5) Conducted a Risk and Vulnerability Analysis using the information developed in the GIS, and began to update the information with HAZUS risk assessment programs.
6) Held meetings with the Earthquake Advisory Committee and concurrent mitigation planning project teams to gain input into the most up-to-date hazard risk information.
7) Convened planning meetings with stakeholder groups to incorporate strategic ideas in mitigation and disaster recovery.
8) Promoted planning and mitigation projects statewide.
9) Met with SHMF to review risk and vulnerability assessment and strategy development.
10) Established criteria for prioritizing projects and programs with stakeholders.
11) Set up maintenance plan to update strategy with new input, data, and accomplishments.
12) Adopted the plan formally.
13) Implement strategy. Begin projects. Review goals and objectives, revise appropriately, conduct formal evaluation of plan content and implementation, and continue iterative process.

21.4 Coordination Amongst Agencies

Hazard mitigation planning and plan implementation involve a very complex, comprehensive network of participation from the federal, state, and county levels and including non-governmental and private organizations. Some of the participation includes assistance in project development to conducting research projects that enhance our understanding of hazard risks as they pertain to the State of Hawai‘i. Local, county plans and agencies are an essential part of the State's hazard mitigation planning process and have been thoughtfully incorporated into the entire planning process from risk and vulnerability assessment development, strategy preparation, project identification, implementation, monitoring, and planning updates.

For the 2013 State of Hawai‘i Multi-Hazard Mitigation Plan Update, the process utilized the disaster management structures in place, the experts on the committees, and the networks that developed and extended from the original mitigation planning process that the State established. The list of contributors in the acknowledgments reflects the widespread commitment throughout the state for disaster risk reduction.

For the mitigation plan update in 2013 and at the direction of SCD, the hazard advisory committees and regional organizations have been consulted regularly, and agendas in the quarterly meetings include discussions of mitigation actions that should be pursued. Many of the State agencies reviewed sections of the plan related to their expertise area to advice on new methods, additional data, and overall updates to the plan. Numerous individuals from these advisory committees, agencies, and organizations spent their time reviewing the plan and they provided detailed information for revisions based on their expertise. The Office of Planning conducted a coordinated review through its programs and associations, with the Director verifying the updated information before authorizing release of the updated information. The State Drought Coordinator in the Department of Land and Natural Resources Commission on Water Resource Management worked with experts in another DLNR division (Forestry & Wildlife), at the Honolulu Board of Water Supply, and the Hawai‘i Wildlife Management Organization to provide a detailed and coordinated document recommending revisions. Because the leadership and structure of agencies and organizations vary, the formality with which information was provided varied; yet, there was significant input in the plan based on extensive knowledge.

The contributors to the Plan Update have been listed in the Acknowledgements section. Individuals who provided detailed information for the Update have been listed by name. Contributors include: Hawai‘i State Civil Defense; Hawai‘i County Civil Defense: Kaua‘i County Civil Defense; Maui County Civil Defense: City & County of Honolulu Department of Emergency Management: the Hawai‘i State Hazard Mitigation Forum; the Hawai‘i State Earthquake Advisory Committee (HSEAC); the State of Hawai‘i Drought Council; the State of Hawai‘i Building Code Council; Hawai‘i State Land Use Commission; the Hawai‘i State Department of Business, Economic Development & Tourism, Office of Planning; Hawai‘i State Land Use Commission; Hawai‘i State Department of Land & Natural Resources; Hawai‘i State Department of Education; Hawai‘i State Department of Transportation; Hawai‘i State Department of Accounting & General Services; Hawai‘i State Department of Defense; Hawai‘i

State Department of Health; University of Hawai‘i (Center for the Study of Active Volcanoes, School of Ocean, Earth Sciences & Technology, Hawai‘i Coastal Geology Group, UH Sea Grant, UH Social Science Research Institute); Martin & Chock, Inc.; US Army Corps of Engineers; US Geological Survey (USGS): NOAA Integrated Data for Environmental Applications (IDEA) Center: NOAA National Weather Service; the Pacific ENSO Applications Center; the International Tsunami Information Centre: NOAA Pacific Services Center; FEMA Region IX Pacific Area Office; the Pacific Disaster Center; and, the Pacific Regional Integrated Science and Assessment (Pacific RISA).

21.4.1 Hawai‘i State Mass Care Council (Ongoing)

The Hawai‘i State Mass Care Council supports the development, promulgation and implementation of the State Mass Care Strategy. The Council provides leadership, advocacy, and interagency coordination to address statewide mass care-related issues after a major landfalling hurricane. Through the use of workgroups to explore state-wide issues, the Mass Care Council provides the Counties with information for use in developing their mass care plans. It is expected that each county will establish a mass care council and relevant workgroups to develop county mass care plans. Stakeholders include over 100 from non-profit agencies, the private sector, and local, state and federal government.

The Hawai‘i State Mass Care Council is co-led by Hawai‘i State Civil Defense, American Red Cross and County Civil Defense.

Organization	Tri-Chairs
1. Hawai‘i State Civil Defense	Individual, Vice Director
2. American Red Cross	Disaster Emergency Services
3. One County representative	Designated Representative

Scope of Mass Care Strategy

The State Mass Care Strategy will provide a unified and collaborative approach to mass care planning by exploring issues that are common to each county. By bringing organizations and people together in workgroups to explore known deficiencies and address specific issues, the State Mass Care Council will provide strategies for each county to incorporate into their mass care plans. By exploring options and solutions at the state level, the State Mass Care Council will be in a position to pursue state-wide solutions that can be implemented in each county.

Implementation of the State Mass Care Council

The work of the council is performed by **workgroups** organized to address specific issues:

1. *Underlying Assumptions Work Group*. This work group focuses on determining whether the underlying assumptions made in the State of Hawai‘i Catastrophic Hurricane Plan are valid. Questions such as: what data were used to determine the number of people who will need shelter pre and post-hurricane? And: how did we determine the number of homes destroyed? Will be reviewed, as well as looking at behavioral data and anything else that can help us determine numbers of people that will need support from the mass care system.

2. *Shelter Standards Work Group*. This work group reviews the shelter standards we are using across the state for hurricane evacuation shelters and make recommendations on whether to adopt new standards (both structural and social standards).

3. *Shelter Staffing Work Group*. This group explores ways of achieving the required numbers of shelter teams for emergency evacuation shelters and congregate care shelters. This work group will also explore access and functional needs requirements and pet shelters.

4. *Feeding Work Group*. This work group explores ways to conduct mass feeding.

5. Temporary Housing Work Group. This work group explores temporary housing options and makes recommendations on solutions for short-term housing.

6. *Community Distribution of Emergency Supplies Work Group*. This work group develops models for distributing emergency supplies, focusing on private and non-profit networks already established in the communities.

February 13, 2013 Hawai‘i Mass Care Council 1st Meeting

March 8, 2013 Hawai‘i Mass Care Council Meeting re: scenario estimation review

April 18, 2013 Workshop preparation meeting of Working Group leaders, Hawai‘i Mass Care Council

April 25, 2013 Hawai‘i Mass Care Council 2nd Meeting

21.4.2 Coordination of County (Local) Planning

As chartered by the 44 CFR, SCD actively assisted the four counties of Hawai‘i in hazard mitigation planning efforts. The State Hazard Mitigation Officer, State Mitigation Planning Staff, and the Planning Sub-Committee of the Forum provided technical assistance to the County Multi-Hazard Mitigation Planning Steering Committees. Support was provided on hazard analysis, risk and vulnerability assessment, public out-reach programs, GIS data acquisition, and project development. The State will continue to provide assistance as the counties implement their recently updated plans.

At the time of this fourth State planning cycle in 2013, all of the county local mitigation plans have been updated and approved. SCD had conducted an evaluation and assessment of county plans prior to submittal to FEMA for review and approval, and the local mitigation plans were incorporated into the overall planning process. Relevant local hazard mitigation resources included:

- O‘ahu Coastal Community Evacuation Planning Study (ongoing)
- Honolulu Essential Facilities Risk Assessment (2010)
- Multi-Hazard Pre-Disaster Mitigation Plan for the City & County of Honolulu (2012) and plan maintenance targeted item list
- Maui County All-Hazard Assessment of Critical Facilities (2011)
- Multi-Hazard Pre-Disaster Mitigation Plan Update for the County of Maui (2010) and plan maintenance target item list
- Hawai‘i County All-Hazard Assessment of Critical Facilities (2009)
- Multi-Hazard Pre-Disaster Mitigation Plan Update for the County of Hawai‘i (2010) and plan maintenance target item list
- Hawai‘i Building Database Integration for Maui and Hawai‘i Counties (2008)
- Multi-Hazard Pre-Disaster Mitigation Plan Update for the County of Kaua‘i (2009)
- University of Hawai‘i System-wide Multi-Hazard Mitigation Plan (2008) (including system-wide building inventory database)
- August 15-16, 2012 Floodplain Manager’s Conference:
    - State Building Code and Design Standards
    - Community Rating System
    - Homeowner’s Handbook to Prepare for Natural Hazards
- State General Flood Control Plan update
    - September 20, 2012 General Flood Control Plan Update Forum, DLNR
- February 5, 2013 Meeting with Office of State Planning Program leaders
- April 19, 2013 Department of Health Risk and Vulnerability Assessment Stakeholders Meeting

To ensure mitigation planning integrity at the county level, SCD will reference county documents within this 2013 plan update. Currently, the most critical county data is already incorporated into the State Plan. The Governor has adopted these plans by reference in adopting the State Plan.

21.4.3 O‘ahu Coastal Community Evacuation Planning Study (Ongoing)

This project sponsored by the Department of Emergency Management and O‘ahu Metropolitan Planning Organization is developing specific emergency evacuation route plans, with identifying refuge areas and shelter facilities, as appropriate, that will integrate and align with preparedness, response, and recovery actions to be implemented by the City and County of Honolulu Department of Emergency Management in the event of a Tsunami Warning notification.

O‘ahu Emergency Evacuation Plan will then include travel routes for the coastal areas of O‘ahu outside of the urban core (Pearl Harbor to Hawai‘i Kai). The plan will include identifying refuge areas and shelter facilities as appropriate. If private road access will be required, coordination/collaboration requirements are identified. Additionally, the plan will also have a geographical information system (GIS) evacuation route/tsunami boundary signage plan for O‘ahu. Public outreach - Public coordination/collaboration will include meetings with governmental and NGO partners including SCD, DOT, DOH, HAH, JTFHD, Outdoor Circle, neighborhood boards, community associations, and City departments.
Timeline:

August 14, 2012 O‘ahu Evacuation Planning Study
October 15, 2012 O‘ahu Evacuation Planning Study Meeting with Stakeholder Leaders
November 30, 2012 O‘ahu Evacuation Planning Study Meeting with Community Groups
January 7, 2013 O‘ahu Evacuation Planning Study Meeting
February 5, 2013 Online teleconference of O‘ahu Evacuation Planning Study
February 11, 2013 O‘ahu Evacuation Planning Study Coordination Meeting
February 15, 2013 HSEAC Meeting Briefing
April 3, 2013 Department of Emergency Management Briefing on O‘ahu Coastal Communities Evacuation Planning Project
April 17, 2013 Briefing on vertical tsunami evacuation in Waikiki for State Civil Defense
May 8, 2013 SCD Tsunami Advisory Committee Meeting on Great Aleutian Tsunami Scenario
June 28, 2013 HSEAC Meeting Briefing
July 18, 2013 O‘ahu Coastal Evacuation Planning Study Meeting

21.5 Integration of Resilience

The primary goal for the State Civil Defense has been to incorporate hazard mitigation planning into the operations of government within their designated administrative responsibilities and to encourage the public to be responsible for mitigating the impacts of hazards in their communities and homes. As further identified in the THIRA 2012 process, the appropriate goal of hazard mitigation in Hawai‘i should embody the target of achieving greater community resilience.

> **“Resilience is *the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events.* Enhanced resilience allows better anticipation of disasters and better planning to reduce disaster losses—rather than waiting for an event to occur and paying for it afterward.”**
>
> [Disaster Resilience: A National Imperative, 2012. Committee on Increasing National Resilience to Hazards and Disasters; Committee on Science, Engineering, and Public Policy; The National Academies]

21.5.1 Multi-Agency, Multi-Disciplinary, and Multi-Sectoral Participation

While focused on the final goal of hazard mitigation becoming part of “business-as-usual” in the State of Hawai‘i, SCD has developed several mechanisms to encourage interaction and collaboration in hazard mitigation planning among experts and among the general public. Appendix 21C at the end of this chapter lists the rosters and participants in statewide mitigation. The committee meetings provided a forum for discovering opportunities for collaboration. It further enabled partnership efforts in finding resources. One example is the January 24, 2013 ATC-20 Post-Earthquake Building Safety Evaluation Training, that was initiated in discussions at the HSEAC quarterly meetings and enabled FEMA, Hawai‘i Coastal Zone Management Program, State Civil Defense, the Structural Engineers Association of Hawai‘i, and HSEAC to provide funding, space, and experts to conduct building inspection training sessions in Honolulu.

21.5.2 State Disaster Resilience Strategy Workshop 2013

State Civil Defense hosted workshops on July 9, 9 am to noon and July 10, 9 am to noon. The State of Hawai‘i Multi-Hazard Mitigation Plan is a comprehensive plan that encompasses the development of a Hawai‘i strategy for mitigating future disasters to enable improved response and quicker recovery. The purpose of this workshop was to gather the consensus recommendations and priorities for strategic strategies and policies that could have effective and sustainable results within the next five years and beyond. The State Disaster Resilience Strategy Workshop 2013 included over 60 principal stakeholders invited from groups with broad perspectives, including:

- Climate Change Adaptation
- Tsunami and Earthquakes
- Hurricanes and Floods
- Droughts and Wildfires
- Infrastructure Resilience
- Health Vulnerability and Risk
- Recovery and Macro-Economic Effects
- Threat Identification and Risk Analysis (THIRA) Implementation
- Land Use and Building Requirements

Day One Discussions:

Assessment of State Risk to Natural Disasters
State Preparedness and Economic Impacts
Imperative Goals for Disaster Recovery and Disaster Resilience
Breakout Discussions within Groups

Day Two Discussions:

Disaster Mitigation Opportunities and Requirements
Breakout Group Discussions: Disaster Resilience Objectives and Strategy
Results: Determining the Likely or Necessary Key Actions and Near to Intermediate-Term Policy Recommendations for Disaster Resilience

Results of this multi-agency, public and private sector workshop are presented in Chapter 20.

21.5.3 Public Participation in Mitigation Planning

The general public has participated in the planning process primarily through statewide public awareness campaign coordinating mechanisms and surveys. The internet through the public awareness campaign has also been used to provide draft plans for review and comment. The overall mitigation planning process has both informed and been informed by experts and the general public throughout the state and counties. Additionally, each county undertook extensive public survey and outreach campaigns to support mitigation planning updates at the local and state levels.

Even though funding for the initial public education process waned, the members of the Forum and of the advisory committees used their influence and assignments in their agencies and

organizations to extend the hazard mitigation information. For example, the Hawai‘i Coastal Zone Management Program produced hazard wheels and other materials to distribute at community fairs and public events. in addition to producing materials to educate the general public, the UH Center for the Study of Active Volcanoes developed educational materials and curriculum for summer science courses to train teachers, which further extended the reach of mitigation work to youth in Hawai‘i. NOAA National Weather Service and other federal agencies participated in an array of activities to educate the general public and engaged in training exercises to improve capacity for disaster response and mitigation. NOAA also developed an assessment tool for tsunami risks available on the web for use by the general public. The importance of mitigation was promoted through agency activities and further collaborated in public opportunities for hazard mitigation through public awareness and education.

Hawai‘i State Civil Defense has helped to fund programs that build a broader understanding of hazard mitigation throughout Hawai‘i. One significant project has been developed through the Center for the Study of Active Volcanoes (CSAV) whereby natural hazard science courses are taught each summer for science teachers. The application of science to hazard mitigation planning has been taught in conjunction with this course in order to build awareness in Hawai‘i’s public schools.

21.5.4 Building Resilience

The initial framework focused on developing hazard mitigation plans by developing risk and vulnerability assessments. The State of Hawai‘i Multi-Hazard Mitigation Plan is multi-hazard in scope. The first mitigation plan addressed hurricanes and strong winds, floods, earthquakes, tsunamis, volcanoes, landslides, coastal erosion, droughts and wildfires. Although not detailed extensively, the technological, environmental, and human-induced hazards were considered in conjunction with the hazards. In this update, a review of climate variability and change was added because there will be significant changes and increased hazard risks that need to be considered in planning phases and risk reduction efforts now. More information about dam failures and risk assessments has been included. Discussion related health-related hazards have been added.

As the emphasis on understanding risks from various hazard increased, there has been a shift to developing a broader, more comprehensive view of mitigation to one of disaster risk management. Ultimately, the conception of mitigation has broadened in this iteration of the State of Hawai‘i Multi-Hazard Mitigation Plan with a shift to building resilience to hazards.

The plan includes an updated and comprehensive list of hazards, assets, and the socioeconomic factors contributing to risk. The recent disasters have resulted in new understanding of disaster risks in Hawai‘i. Mitigation actions have been developed to address these risks, and to increase knowledge and learning, which can further inform mitigation. The improved building codes should have a significant impact on reducing structural risks. The focus is to target programs and projects that can be implemented in the next five years, before the 2018 mitigation plan update.

21.6 Maintaining the Mitigation Plan

Monitoring, Evaluating, and Updating the Plan ***Requirement §201.4(c)(5)(i):*** *[The Standard State Plan Maintenance Process must include an] established method and schedule for monitoring, evaluating, and updating the plan.*

Monitoring Progress of Mitigation Activities ***Requirement §201.4(c)(5)(ii):*** *[The Standard State Plan Maintenance Process must include a] system for monitoring implementation of mitigation measures and project closeouts. Requirement* ***§201.4(c)(5)(iii):*** *[The Standard State Plan Maintenance Process must include a] system for reviewing progress on achieving goals as well as activities and projects in the Mitigation Strategy.*

21.7 Monitoring, Evaluating, and Updating the Plan

The State's Multi-Hazard Mitigation Plan provides a guideline for addressing risks. It considers vulnerability from multiple perspectives, including local socioeconomic factors that contribute to vulnerability related to a number of hazards. The plan tracks progress and attention to risk reduction efforts.

The State of Hawai‘i will continue to comply with all applicable Federal statutes and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c), and will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d)

FEMA requirements for the Pre-Disaster Mitigation Plan after adoption by the state include monitoring, evaluating, and updating the plan at least every 5 years. The plan update process is intended to result in actively engaging in the hazard mitigation strategy through future milestones. The development of a process ensures that there will be long-term focus on hazard mitigation. Maintaining momentum in process implementation can lead to significant long-term changes and overall risk reduction. The Multi-Hazard Mitigation Plan was developed as a "living" document and will be updated and revised as new information becomes available. In recognition of the need for establishing a formal process for hazard mitigation planning and preparedness, the state will initiate an approach to ensure that this plan is kept updated and pertinent actions are incorporated in other plans as applicable. The updates may be necessary following the actions or events listed below:

- Ongoing mitigation actions within the state and counties.
- Development of new mitigation recommendations.
- Updates on the benefit-cost performance of current mitigation options.
- Changes necessary because of Federal, State, or County legislative acts, appropriations, mandates and recommendations.
- Public involvement in mitigation and other existing planning activities.
- Scientific and other technical data update recommendations based on new data, analysis, or scientific and Geographic Information System modeling capabilities.
- Events or new information on environmental conditions that indicate new mitigation

needs or requirements.

- Incorporation of hazard identification in other plans that have impact on land use, zoning, etc.

21.7.1 Monitoring the Plan Implementation

The State Hazard Mitigation Forum (SHMF) was developed to aid State Civil Defense to provide input on the hazard mitigation to the state, assist in the development and implementation of state and local mitigation plans, and monitoring the implementation of hazard mitigation plans. The SHMF includes several key stakeholders that have their own agency interest in maintaining the planning schedule and in ensuring communication and coordination of mitigation efforts. During the next three years of this plan, several of the counties will begin their next updates for the local mitigation plans due every five years (County of Kaua‘i – 2014; County of Maui – 2015; County of Hawai‘i – 2015; and City and County of Honolulu – 2017). The work in mitigation for the next three years will involve attention to ensuring that the mitigation process outlined in this plan is followed and that mitigation actions become implemented.

21.7.2 Evaluating the Plan and Implementation

In order to develop the mitigation plan update for 2013, the planning team first evaluated the 2010 mitigation plan. The evaluation considered distribution and usefulness of the plan, content, and recommendations to improve the plan. The plan was found to be most useful for identifying and prioritizing mitigation actions. The THIRA 2012 identified several capability gaps in mitigation-related concerns to be used in reviewing the plan update process and identifying key areas for implementation during the years prior to the next update in 2017. The State Disaster Resiliency Strategy Workshop developed the key actions and policies of the highest priorities to address target capabilities for enhancing mitigation for disaster resilience, as detailed in Chapter 20.

THIRA Target Capability Gaps (2012):

Mitigation Mission

- Core Capability 13. Community Resilience:
  - Policy for vertical evacuation refuge in existing buildings
  - Community group engagement in planning varies
  - Public apathy and unawareness of limitations of response
  - Insufficient capacity for sheltering
  - Ability to support persons with special needs
- Core Capability 14. Long-Term Vulnerability Reduction:
  - Except for bridge retrofits, no coordinated approach for hardening critical facilities
  - Enhanced codes could be most effective;
- Core 15. Risk and Disaster Assessment:
  - State lacks tsunami design code as required by law per Hawai‘i Revised Statutes Chapter 107 Part II.

- Need to consistently integrate both natural hazards and other threats into all risk assessments conducted in the state.
- State lacks a consistent disaster training/education program in schools
- Update hurricane loss estimation with HAZUS MH

- Core Capability16. Hazard Identification:
  - Public information outreach needed for society to internalize hurricane and tsunami threat
  - Need probabilistic tsunami hazard maps for planning and risk analysis and design of coastal construction;
  - .Need for post-disaster building safety inspection capacity and analysis of deficiencies and conducting fire and collapse investigations.
  - Integrity of especially older vintage construction that was under-zoned for hazards is not addressed for hurricane, earthquake, and tsunami. exercise

Response Mission:

- Core Capability 17. Critical Transportation:
  - Evaluation of vulnerability of coastal critical infrastructure to tsunami loads and effects has not been conducted.
  - Tsunami evacuation plans need to be reviewed for adequacy of critical transportation elements,
- Core Capability 18. Environmental Response:
  - Assessment and data on potential hazmat releases during disasters
  - Temporary Debris Storage and Recovery Facilities not fully planned or selected
  - Response Mission:
- Core Capability 20. Mass Care Services:
  - Inadequate number of sufficiently robust designated public shelters
  - Need an alternate supply of refuge buildings
- Core Capability 27. Infrastructure Systems:
  - Need probabilistic tsunami hazard maps for planning and risk analysis and design of coastal construction
  - Evaluation of vulnerability of coastal critical infrastructure needs to be performed by experts in bridge and building safety.

21.7.3 Strategic Priority Actions to Achieve Improvements in Mitigation and Resilience (per Chapter 20)

State Civil Defense and the State Hazard Mitigation Forum should focus on the following priorities established by stakeholder consensus:

1. Update and adopt codes and design standards for tsunami, hurricane, and severe storms
2. Produce needed probabilistic design maps for tsunami for application towards mitigation for critical facilities, major buildings, bridges, and key infrastructure such as power plants and ports.

3. Develop coordinated evacuation and public information products to account for Great Aleutian Tsunami scenarios when no more than 3-1/2 hours of warning time is possible.
4. Provide greater public education on their role in disaster preparedness in the context of the limitations of what can be provided in the aftermath of a major disaster (such as a hurricane or tsunami), given Hawai‘i’s geographic isolation and dependence on an oversea supply chain.
5. Invest in additional and improved capabilities for more reliable monitoring / warning of hazards and improve the modeling of hazard impacts by taking into account Hawai‘i-specific data (particularly for incorporating Hawai‘i-specific conditions and building and bridge types into hurricane and earthquake models).
6. Adopt more preventive community impact-based mitigation policies using more advanced hazard maps developed for use earlier in the land use and development process. Incorporate longer-term environmental trends, particularly in the coastal zone.
7. Conduct multi-hazard assessments and vulnerability evaluations of critical infrastructure to include fuel storage facilities, power plants, water systems, communications sites, sewage treatment plants, water storage tanks and other facilities providing critical services and supply chain critical facilities, then implement protection and mitigation to provide greater resiliency against disasters.
8. Conduct multi-hazard assessments and vulnerability evaluations needed to ensure post-disaster adequacy of critical transportation components and systems, such as highways, bridges, ports and harbors, and airports, then implement policies and mitigation to provide greater resiliency against disasters.
9. Develop policies for using alternative types of buildings (in addition to public sector school buildings) for greater capacity for sheltering and evacuation from coastal communities.
10. Increase emergency operational plan and logistical coordination amongst agencies and responders, NGO’s, and private sector service providers and key economic sectors.
11. Improve response and recovery capabilities and arrange the availability of key resources as necessary to accommodate demand surge in critical services after a disaster.
12. Develop a post-disaster recovery and reconstruction plan integrating green technology and building code compliance to Build Back Better disaster resilience. Develop Hawai‘i-specific mitigation and retrofit techniques.

21.7.4 Updating the Plan

21.7.4.1 Evaluating Issues in Process and Coordination

In the process of updating the earlier plans and the plan in 2010, it became apparent that mitigation processes, although well-intentioned, can be interrupted by disaster occurrences. The frequency and attention to disaster response and recovery diverted attention from the outlined mitigation process. Without consistent application of the process, there were increased challenges in coordination.

One of the most important areas of the mitigation process is the coordination among agencies and organizations in the hazard community. Plan update efforts in the next five years are to include the incorporation of expertise and coordination among state agencies and organizations with disaster management responsibilities.

In a strategic planning effort, the issue of the incorporation of hazard information (or lack thereof) into prior SHMF meetings was addressed in the 2012 reconvening of the State Hazard Mitigation Forum. Previous to 2012, the Forum did not explicitly get briefings on activities of hazard-specific committees and agencies, with the exception of project proposals for funding review purposes. As a result, the Forum was somewhat semi-autonomous in viewpoint with respect to the significant work engaged by other committees and agencies. The Forum did not meet in 2011-2012. The new Forum now includes members from the Hawai‘i State Earthquake Advisory Committee (HSEAC), Hawai‘i Drought Council, Office of State Planning Coastal Zone Management Program, Department of Land and Natural Resources (DLNR) Flood Control and Dam Safety Branches, and National Weather Service/Central Pacific Hurricane Center, and International Tsunami Information Center. These organizations have a more active continuous involvement in the key hazards affecting Hawai‘i’s risk to natural disasters, whereas the Forum meets on a quarterly basis to take up tasks from State Civil Defense. By having more direct involvement of these groups, the Forum should become more self-informed and involved itself in ongoing work efforts relating to the state and county hazard mitigation plans.

21.8 Monitoring and Evaluating the Plan

The mitigation plan was developed as an organic document. The State of Hawai‘i recognizes that this document was based on use of the best available information by the targeted deadlines to meet requirements. The plan will be revised and updated as new information becomes available. This plan has tried to summarize and build on a number of important hazard documents. The hazard mitigation planning process has given momentum to the advisory committees for hazards and for information technology and GIS development, and will evolve as information becomes updated through other committees linked to the State. The risk and vulnerability assessment and hazard mitigation strategy will be reviewed and updated in accordance with ongoing efforts such as THIRA 2013 and the Hawai‘i Mass Care Council, and the O‘ahu Coastal Community Evacuation Planning Study, as well as earthquake and tsunami work efforts of the Hawai‘i State Earthquake Advisory Committee that has operated continuously for 23 years, and UH Sea Grant College and the Office of State Planning that annually undertake significant training programs for natural hazard mitigation practices.

The process has also demonstrated the need for improved coordination of the geographic information systems and critical data. With the development of web-based tools and advances in Google Earth imagery, it is possible to improve map layers and models. Detailed hazard layers and parcel layers have been developed in the counties as part of mitigation planning. Better coordination and data sharing protocol would enable richer analyses for use in risk and vulnerability assessments. Some of this data has been used in HAZUS-MH analyses to better understand structural risk and vulnerability to hazards. Improvement in hurricane loss estimation having the capability to include Hawai‘i-specific residential construction is a major gap.

The format of the document was considered when preparing the plan to make it easy for review and update. With this update of the State Hazard Mitigation Plan, the plans of the state and the counties of Hawai‘i, Maui, and Honolulu have a common organizational structure, which will make it easier to make coordinated plan updates. The primary distribution of the document will be by CD-ROM and digital format on the public awareness website.

21.8.1 Monitoring Project Implementation and Closeouts

The State Hazard Mitigation Officer monitors the implementation and closeouts of mitigation projects and oversees these activities with assistance from the State Hazard Mitigation Forum. For Federal disasters, close consultation and coordination with FEMA’s Pacific Area Office will occur. Post Disaster Review (Federal and State Disasters): Implemented projects will be evaluated by the State Hazard Mitigation Forum and appropriate Federal, State, county, and private agencies for performance effectiveness. Documentation will be prepared to highlight effectiveness, short-comings, and future recommendations for improvement. This review may supplant the annual review contingent on the magnitude and timing of the disaster.

21.8.2 Local Plan Review and Updates

Each of the Counties has completed a multi-hazard mitigation plan with guidance and oversight from State Civil Defense. These local plans were originally approved, and the five year updates have been submitted for review to FEMA. These local mitigation plans must be updated every five years, however, mitigation actions are updated annually for mitigation funding cycles.

State Civil Defense provided initial briefings on the planning processes and update briefings on changing pre-disaster mitigation grant program and local plan requirements. The State has been directly involved in the local mitigation plans and has provided assistance to the local hazard mitigation planning committees and technical consulting teams in each county. The intent in the State Hazard Mitigation Plan is to annex the approved county plans, in addition to annexing the hazard-specific plans developed by state agencies.

By developing a collaborative, integrated disaster risk management process, the State has intended to ensure integration of local needs and projects in mitigation. Aspects of these local plans have already been considered in the development of mitigation actions. The state is also assisting the counties in identifying resources to implement plans. Integration of state, local and federal mitigation planning represents an ongoing commitment of the State of Hawai‘i to comprehensive, integrated multi-hazard mitigation plans.

21.8.3 State of Hawai‘i Executive Order Provisions for Supporting Mitigation

The Executive Order to Establish the State of Hawai‘i as a Disaster Resilient Community (EO) provides a framework for implementing the policies and actions identified in this document. The Hawai‘i State Civil Defense will continue to oversee and ensure implementation of the state’s hazard mitigation efforts, mitigation actions and measures. Maintaining the State Hazard Mitigation Forum and encouraging government agency and the private sector support of the committee enables hazard mitigation policies to be supported at all levels in the state.

The EO supports the hazard mitigation planning process outlined throughout this document, including periodic updates. Even though the communities in the island of Kaua'i were consulted during the risk and vulnerability assessment and mitigation planning process, they have not developed mitigation plans for each community. The EO will provide assistance for communities to further engage in mitigation planning.

The EO encourages the continued development of partnerships. At the direction of State Civil Defense, the State Hazard Mitigation Forum initiated a process for partnerships to mitigate impacts from natural hazards throughout the State. These collaborations (discussed in Chapter 2) have demonstrated that partnerships help to maximize limited resources and build awareness throughout all sectors of the community-at-large. The EO establishes a process that enables the sustainability of these partnerships.

To address hazards that cause greatest risk to the State of Hawaiʻi, the EO supports enforcement and improvement of building codes and standards and promotion of hazard considerations in land use decisions.

The EO supports the maintenance of all emergency response, recovery, and mitigation plans, including technical assistance in towns and communities to develop local plans.

The mitigation projects and actions identified in each hazard chapter demonstrate the ongoing support of the State in securing critical facilities and infrastructure, including governmental facilities and privately owned lifelines. This includes improving shelters and hardening facilities where vulnerable populations exist.

State Civil Defense, with advise from its Hawaiʻi State Hazard Mitigation Forum, has supported the development of public awareness and reduction programs, both at the county level through Project Impact and in the State through the public awareness campaign. The EO further supports training opportunities in hazard mitigation for planners, developers, architects, and county personnel, including those involved with information systems and mapping technologies. The State of Hawaiʻi Office of Planning also promotes continuing education for building officials and design professionals in the application and enforcement of modern building codes and standards.

21.8.4 System for Reviewing Progress on Achieving Goals

Hawaiʻi State Civil Defense is responsible for overseeing implementation of this hazard mitigation strategy. The first activity will involve a review of this plan to determine priorities for the Pre-Disaster Mitigation grant program and HMGP and FMA project funding. SCD will consider its needs for ensuring implementation of the plan, including the development of subcommittees. Full updates of the risk and vulnerability assessment and mitigation strategy should occur every five years, with constant updates to the GIS databases as new data and information become available and as actions are completed. State Civil Defense conducts regular quarterly meetings with the administrators of the county civil defense agencies to review the status of hazard mitigation and to coordinate further updates of hazard mitigation initiatives.

The SHMF was re-organized during the 2013 plan update process to ensure that the process was followed for implementing the plan and to review progress on achieving goals set forth in the

plan. The Forum met with the plan update team and State Civil Defense to ensure that public and private sector Prevention, Protection, Mitigation, Response, and Recovery stakeholders were aware of the mitigation plan and provided input into planning process. The Forum has further overseen the development of a coordinating mechanism. The Pacific Disaster Center created a secure server portal to assist the SHMF and other hazard committees with coordination their activities. This is being used to coordinate reviews of the plan, reviews of mitigation actions, and suggestions for updates.

The Forum tracks progress in relation to the plan updates, including sharing information related to the local mitigation plans. It is the responsibility of the Forum to report to SCD on the status of the planning process and target dates for implementation and updates. In the period of 2013-2018, it will be important to assess the functions and needs of the Forum to make improvements to the system for implementing the plan.

21.8.5 Schedule for Mitigation Implementation and Reviewing Progress

In recognition of the need for establishing a formal process for hazard mitigation planning and preparedness within the State and County's operational structures, and in accordance with supporting the local hazard mitigation update process of the current county plans, the State and county will initiate a joint approach to ensure that this plan and the county plans are kept updated and pertinent actions are incorporated in other plans as applicable.

Rather than just describe the need for plan maintenance and general tasks, this chapter was revised to provide specific actions and summary of specific hazard mitigation prioritized initiatives that will impact the next adoption of the mitigation plan. Thus, this provides a checklist of the improvements expected for the plan maintenance tasks. This should ensure continuity and connectivity with ongoing and future work that should improve the next plan. This chapter now includes a checklist of presently ongoing or future strategic hazard mitigation actions which should be explicitly monitored for future implementation into the plan: The plan will be monitored and updated according to the following procedures to maintain a reliable compendium of the latest information and a compass to keep the state and counties pointed toward the disaster-resilient goals of this plan:

1. **Continuing Role of the Hazard Mitigation Planning Committees:** Within the County government itself, the County will continue to convene the civil defense agency planning committees that will be responsible for monitoring, evaluating and updating the county plan. The planning committee will include representatives from each County agency or department having hazard mitigation responsibilities. The civil defense agencies will meet on a quarterly basis with State Civil Defense to ensure that the monitoring, evaluation and updating tasks are being carried out. This enhanced communication will enable the various agencies to gain a comprehensive view of the County's hazard mitigation activities and a better understanding of the interrelationship of their actions. The county planning committee to participate in an annual workshop which will serve as an evaluation tool measuring the progress that has been made toward achieving the objectives of the plan.

2. **The department and agency representatives will also prepare an annual briefing with the Mayor's office, possibly timed in conjunction with a subsequent joint county workshop / meeting with State Civil Defense.** The planning committee will prepare an annual report every year and present it to the Mayor. The annual report will: 1) evaluate progress on meeting the mitigation objectives set forth in the plan; 2) indicate the status of the projects; 3) identify priority projects for the upcoming year by potential funding source; 4)propose a work-plan for advancing new priority projects during the year assigning responsibilities and identifying target deadlines; 5) identify and list future revisions to the mitigation plan; and 6) highlight other plans that should incorporate hazard mitigation measures. The committee will finalize the report by the end of the calendar year, to provide timely input to the County's capital improvement and operational budget process. Information from this annual report of hazard mitigation activities will be incorporated into civil defense section of the County Annual Report.
3. **By March of the year preceding the deadline for the update of a county hazard mitigation plan, the county's civil defense agency will prepare a list of necessary revisions to the mitigation plan** based on the annual reports and input from the planning committee. The civil defense agency will prepare final revisions by June, in time for any last minute changes to the County's budget necessitated by a plan revision.

4. **SCD plans to team to conduct regular annual briefings with county civil defense agencies**, **and the State Hazard Mitigation Forum**, in order to stay updated on funding opportunities and requirements and hazard mitigation activities. Table 21.4 outlines the schedule for implementation of the mitigation plan:

Table 21.4 Schedule for Implementation of the Mitigation Plan

October 2013	*1) Obtain approval from FEMA for State of Hawai'i Multi-Hazard Mitigation Plan, 2013update.*
November 2013- January 2014	1) Review current mitigation strategy and ensure that the implementation schedule is followed. 2) Discuss protocols for information and data sharing as part of an ongoing project to improve geographic information systems, data management, and decision support tools development. 3) Prepare assistance strategy for implementing Local Mitigation Plans. 4) As projects receive funding, set up project timeline and monitoring process. Work with regional hazard mitigation organizations to collaborate and leverage tools and resources, such as the work with the Pacific Risk Management 'Ohana (PRiMO), a hazard mitigation network coordinated by the NOAA Pacific Services Center.
February 2014– September 2014	1) Convene the quarterly meeting of the Forum. 2) Convene advisory committees and task forces to develop partnerships, projects, standards, and recommendations. Set up additional committees as necessary to implement policies identified in the State Hazard Mitigation Plan. 3) Review Risk and Vulnerability Assessment and Mitigation Plan to assess for any gaps or new information that should be incorporated. 4) Look at proposal funding schedules and deadlines, and develop grants. Begin writing proposals for funding. Review proposals through email. 5) Formally develop information sharing protocols within the county, state agencies, federal agencies, and private interests
September– October 2014	1) Convene the fourth quarterly meeting of the committee. 2) Discuss findings. 3) Determine process for addressing gaps in hazard mitigation strategy. 4) Review new guidance criteria and requirements by FEMA. 5) Review project status, successes, and update project lists. Update cost-benefit analyses in preparation for grant program requirements. 6) Summarize any necessary risk and vulnerability assessments
November 2014	1) Convene the Annual Progress Review by the Hawai'i State Hazard Mitigation Forum. 2) Prepare annual report to the Director and Vice Director of Hawai'i State Civil Defense on progress. 3) Prepare one page updates on progress to insert into the strategy. 4) Prepare detailed schedule and actions for year two.

Years 2 - 4:

- Continue with Quarterly meetings, Committee meetings, and additional meetings as needed to ensure implementation of mitigation efforts.
- Continue to update sections of the plan and ensure implementation.
- Review new FEMA requirements.
- Prepare schedule for plan evaluation.

Year 5:

- Continue with Quarterly meetings.
- Continue to update plan and ensure implementation.
- At the beginning of the third year, a thorough review will be undertaken and an evaluation will be conducted.
- Prepare updated plan for **October 27, 2018** requirement.

Schedule Contingency: State Civil Defense will pursue the previous schedule as outlined;, in the event of a disaster during the planning cycle, the schedule is subject to change. The Forum will be directed to meet as needed to guide in response and recovery efforts and respond to Hazard Mitigation Grant Program and Pre-Disaster Mitigation program requirements. The schedule may also be adjusted to accommodate changes in federal, state, and local administrations during this cycle.

The outlined schedule will be reviewed, revised, and updated periodically to best serve Hawai‘i State’s needs in implementing hazard mitigation practices and actions. The schedule will be shared in the secure server to ensure that the state hazard committees are coordinated and organized.

21.8.6 Modifications to the System for Tracking Progress

21.8.6.1 Improved Communications and Coordination for Tracking Progress

There are a series of projects identified in the plan addressing community resilience emphasizing critical facilities and infrastructure. These have been prioritized. As appropriate funding sources become available, these projects will be implemented. New projects will need to be developed and prioritized. These will need to be included in future plan updates.

The mitigation actions included in the plan need further development and assessment before submission to potential sponsors. For the Pre-Disaster Mitigation Grant Program, a further engineering analysis and a cost-benefit analysis may be required if it includes a construction project. Other potential funding agencies will have specific information needs, which will be identified and met. State Civil Defense with assistance from the State Hazard Mitigation Forum will develop identified projects and work with experts in the government and private sector to gather information required in proposals.

21.8.6.2 Digital Formats of State Forms

In previous years, the SCD developed a standard form for mitigation project submittal. The form included questions about the lead agency and contact, description of the project, cost, source of matching funds, environmental impact considerations, and hazards that are mitigated. In addition, the form included an assessment referred to as “STAPLEE” where submission required consideration of impacts or consequences of the project related to areas of social, technical, administrative, political, legal, economic, and environmental concern. In 2009, the Pacific Disaster Center developed a standardized form in fillable Adobe Reader “.pdf” format. The digital format aids in organization. It further enables the projects to be easily distributed and reviewed by SCD and its SHMF members before funding submission. The digital format also benefits the State Hazard Mitigation Officer by saving time in organizing and coordinating project submissions. A sample form is included in Appendix 21B at the end of this Chapter.

21.8.7 Reviewing Progress for Implementing Activities

The State Hazard Mitigation Officer reviews the progress for implementing activities. For projects funded by FEMA, the State Hazard Mitigation Officer submits quarterly reports and

reviews project progress. For hazard mitigation action that are implemented without FEMA funding, SHMF members submit agenda items for quarterly meetings or provide project overviews during "New Business" sections of the agenda.

21.9 Implementation through Existing Programs

The State of Hawai‘i has established a number of mechanisms within its day-to-day operations that will ensure implementation of the hazard mitigation plan, regardless of funding and additional resources. The land use system, building codes and standards, and permitting process already consider hazard risks. Improvements have been identified for these areas that will enhance the system.

The State of Hawai‘i works with the counties for comprehensive land use planning and zoning, capital improvements planning, and building codes and standards to guide and control development in each county. The permit process will integrate the risk and vulnerability assessment and maps in the geographic information system to improve decision making for allowing future development. The State will continue to assist the counties in identifying and establishing improved building code standards.

Another method that will be pursued is seeking comment specifically from non-profit organizations, community planning groups, and watershed management councils. Because these groups have already engaged in mitigation activities separately, it will be important to maintain communication and develop a network of these organizations for future planning efforts.

Upon final approval of the plan by FEMA, the Hawai‘i State Hazard Mitigation Plan will be made available to the public through the website. State Civil Defense will distribute the copies of the plan to relevant agencies and organizations in the state. SCD will also collect comments and suggestions for review and consideration.

21.10 Potential Funding Sources

Requirement §201.4(c)(3)(iv): *[The State mitigation strategy **shall** include an] identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities*

The State of Hawai‘i uses a variety of sources to fund state and local mitigation activities. While most of the funding is from the federal government, additional funding comes from state and local government.

21.10.1 Primary Federal and State Funding

The State, through SCD, has instituted an effective and comprehensive all-hazard mitigation program. Through a variety of programs, and the wise use of available federal and state funds, the State has maximized its use and award of federal mitigation assistance to mitigate future and devastating effects of disasters.

FEMA's hazard mitigation assistance programs are the primary sources of current funding for Hawai'i's mitigation activities. These programs include the Pre-Disaster Mitigation Program and the Hazard Mitigation Grant Program. Mitigation projects that meet eligibility for the Hazard Mitigation Assistance flood programs, including the Flood Mitigation Assistance Program, Repetitive Flood Claims Grant, and Severe Repetitive Loss Program are being reviewed for FY2011 HMA consideration. SCD also uses FEMA's Public Assistance Program (Categories C-G) to implement mitigation activities. With the exception of the post-disaster HMGP and Public Assistance Program, these grant programs are non-disaster (annually funded) grant programs. A project listing on how this assistance was used since 2006 can be found in Chapter 6, Current Mitigation Actions and Capability in the State of Hawai'i. All of these programs are discussed further in the following pages.

21.10.2 Pre-Disaster Mitigation Program

Program Summary: The Pre-Disaster Mitigation (PDM) program is a FEMA grant program. In 2009, Congress amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act to reauthorize the pre-disaster mitigation program of FEMA. The purpose of PDM program is to provide funds to states, territories, Indian tribal governments, and communities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding of these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations.

Project grants are available for voluntary acquisition of real property (i.e., structures and land, where necessary) for open space conversion; relocation of public or private structures; elevation of existing public or private structures to avoid flooding; structural and nonstructural retrofitting of existing public or private structures to meet/exceed applicable building codes; construction of safe rooms for public and private structures; vegetation management (e.g., for wildfire); protective measures for utilities, water and sanitary sewer systems, and infrastructure; storm water management projects; and localized flood control projects that are designed specifically to protect critical facilities and that do not constitute a section of a larger flood control system.

Planning grants are available for new plan development, plan upgrades, and comprehensive plan reviews and updates.

Amount: Under the amendment in 2009, Congress appropriated $25 million for this program covering the fiscal years of 2010, 2011, and 2012. Each State can receive at least $575,000 or the amount that is equal to one percent of the total funds appropriated to carry out this section for the fiscal year.

Eligibility: In Hawai'i, SCD serves as the grantee for all PDM grants. State level agencies, including state institutions (e.g., state hospital or university); federally recognized Indian tribal governments; local governments (including state recognized Indian tribes and authorized Indian tribal organizations); public colleges and universities; and Indian Tribal colleges and universities are eligible to apply to SCD for assistance as sub-applicants. Private nonprofit organizations and private colleges and universities are not eligible to apply to the State, but an eligible, relevant state agency or local government may apply on their behalf. SCD reviews and prioritizes sub-

applications and submits the grant application with sub-applications to FEMA for review and approval.

All sub-applicants that have been identified through the NFIP as having a Special Flood Hazard Area and that have a Flood Hazard Boundary Map or a Flood Insurance Rate Map must be participating and in good standing in the NFIP.

For project grants, sub-applicants must have a FEMA-approved local mitigation plan. All activities submitted for consideration must be consistent with the local mitigation plan as well as the State of Hawai‘i Multi-Hazard Mitigation Plan.

Cost-Share Requirements: PDM grants are provided on a 75 percent federal/25 percent nonfederal cost share basis. Small and impoverished communities may be eligible for up to a 90 percent federal cost-share.

Requirements: Recipients of PDM and L-PDM planning grants must produce FEMA-approved hazard mitigation plans.

More Information:

Pre-Disaster Mitigation Program - www.fema.gov/government/grant/pdm/index.shtm

SCD - (808) 733-4300, http://www.scd.hawaii.gov

FEMA Region IX - (816) 283-7061, http://www.fema.gov/about/regions/regionix/index.shtm

21.10.3 Flood Mitigation Assistance Program

Program Summary: The Flood Mitigation Assistance Program (FMA) is a program under FEMA’s NFIP. Its purpose is to implement cost-effective measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the NFIP. The FMA provides planning grants for communities to assess their flood risk and identify actions to reduce it. Planning grants may be used to develop a new or update an existing flood mitigation plan (this also applies to the flood hazard portion of multi-hazard mitigation plans).

Project grants are available for acquisition, structure demolition, or structure relocation with the property deed restricted for open space uses in perpetuity; elevation of structures; dry flood-proofing of nonresidential structures; and minor structural flood control activities.

Planning grants are available for flood mitigation planning activities.

Amount: For fiscal year 2009 (October 1, 2008-September 30, 2009), Congress appropriated $35.7million for the FMA.

Eligibility: State-level agencies, federally recognized Indian tribal governments, and local governments (including state recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SCD for assistance as sub-applicants. Individuals and private nonprofit

organizations are not eligible to apply to the State, but a relevant state agency or local community may apply on their behalf. SCD reviews and prioritizes sub-applications by the applications that include mitigating repetitive loss properties. SCD then submits the grant application with sub-applications to FEMA for review and approval.

All sub-applicants must be participating and in good standing in the NFIP.

For project grants, sub-applicants must have a FEMA-approved flood mitigation plan or multi-hazard mitigation plan that meets FMA planning requirements. All activities submitted for consideration must be consistent with the local mitigation plan as well as the State of Hawai‘i Multi-Hazard Mitigation Plan.

Cost-Share Requirements: FMA funds are provided on a 75 percent federal/25 percent nonfederal cost share basis. The recipient must provide the 25 percent match, only half of which may be in-kind contributions. For severe repetitive loss properties, FEMA will contribute up to 90 percent of the total eligible costs if the State has taken actions to reduce the number of severe repetitive loss properties and has an approved state mitigation plan that specifies how it intends to reduce the number of severe repetitive loss properties.

Requirements: Recipients of FMA planning grants must produce FEMA-approved flood mitigation plans.

More Information:

Flood Mitigation Assistance (FMA) Program, www.fema.gov/government/grant/fma/index.shtm

SCD - (808) 733-4300, http://www.scd.hawaii.gov

FEMA Region IX - (816) 283-7061, http://www.fema.gov/about/regions/regionix/index.shtm

21.10.4 Hazard Mitigation Grant Program

Program Summary: The Hazard Mitigation Grant Program (HMGP) is a FEMA program to provide funds to states, territories, Indian tribal governments, and communities to significantly reduce or permanently eliminate future risk to lives and property from natural hazards. HMGP funds projects in accordance with priorities identified in state, tribal, or local hazard mitigation plans, and enables mitigation measures to be implemented during the recovery from a disaster.

HMGP funds can be used for projects to protect either public or private property, as long as the project fits within state and local government mitigation strategies to address areas of risk and complies with program guidelines. Examples of projects include acquiring and relocating structures from hazard-prone areas; retrofitting structures to protect them from floods, high winds, earthquakes, or other natural hazards; constructing certain types of minor and localized flood control projects; and constructing safe rooms inside schools or other buildings in tornado prone areas.

The State may set aside up to 7% of the HMGP funds received following a presidential disaster declaration to develop FEMA-approved mitigation plans. The State may also set aside up to 5 percent of the HMGP monies to fund the State 5% Initiative Projects.

Amount: Federal funding under the HMGP is available following a major disaster declaration if requested by the governor. The amount of an HMGP grant will depend on the costs associated with each individual disaster. The State of Hawai‘i Multi-Hazard Mitigation Plan is an enhanced plan, and therefore the State is eligible for up to 15 percent of the total estimated federal assistance provided after a major disaster declaration. States with standard hazard mitigation plans are eligible for 15 percent for amounts not more than $2 billion, 10 percent for amounts of more than $2 billion and not more than $10 billion, and 7.5 percent on amounts more than $10 billion and not more than $35.3 billion.

Eligibility: HMGP funds are administered by SCD. Local governments, eligible private on profit organizations or institutions, and Indian tribes or authorized tribal organizations are eligible to apply to SCD for assistance as sub-applicants. Individuals and businesses are not eligible to apply to the State, but eligible local governments or private non-profit organizations may apply on their behalf.

SCD’s administrative plan for federal disasters, the most recent being FEMA-1814-DR-HI in January 2009, states that SCD is the agency responsible for administering the Hazard Mitigation Grant Program.

For project grants, sub-applicants must have a FEMA-approved local mitigation plan. All activities submitted for consideration must be consistent with the local mitigation plan as well as the State of Hawai‘i Multi-Hazard Mitigation Plan.

Cost-Share Requirements: HMGP funds are provided on a 75 percent federal/25 percent non-federal cost share basis. The non-federal match does not does not need to be cash; in-kind services and/or materials may be used.

More Information:

Hazard Mitigation Grant Program, www.fema.gov/government/grant/hmgp/index.shtm

SCD - (808) 733-4300, http://www.scd.hawaii.gov

FEMA Region IX - (816) 283-7061, http://www.fema.gov/about/regions/regionix/index.shtm

21.10.5 Repetitive Flood Claims Program

Program Summary: The Repetitive Flood Claims (RFC) Program is a FEMA program designed to reduce or eliminate the long-term risk of flood damage to structures insured under the NFIP that have had one or more claim payment(s) for flood damage.

Project grants are available for acquisition, structure demolition, or structure relocation. Once the structure is removed the property is deeded to the community and restricted only to open-space use. The property can never be developed again.

Planning grants are not available.

Amount: For fiscal year 2009 (October 1, 2008-September 30, 2009), Congress appropriated $10 million for the RFC program. RFC grants are awarded nationally without reference to state allocations, quotas, or other formula-based allocation(s) of funds.

Eligibility: RFC funds can only be used mitigate structures that are located within a state or community that cannot meet the requirements of the FMA for either cost share or capacity to manage the activities.

State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SCD for assistance as sub-applicants. Individuals and private nonprofit organizations are not eligible to apply to the State, but a relevant state agency or local community may apply on their behalf. SCD reviews and prioritizes sub-applications and submits the grant application with sub-applications to FEMA for review and approval.

All sub-applicants must be participating and in good standing in the NFIP.

Cost-Share Requirements: All RFC grants are eligible for up to 100 percent federal assistance.

More Information:
Repetitive Flood Claims Program, www.fema.gov/government/grant/rfc/index.shtm

SCD - (808) 733-4300, http://www.scd.hawaii.gov

FEMA Region IX - (816) 283-7061, http://www.fema.gov/about/regions/regionix/index.shtm

21.10.6 Severe Repetitive Loss Program

Program Summary: The Severe Repetitive Loss (SRL) program is a FEMA program with a purpose to reduce or eliminate the long-term risk of flood damage to severe repetitive loss residential properties and the associated drain on the National Flood Insurance Fund (NFIF) from such properties. FEMA defines SRL properties as residential properties that have at least four NFIP claim payments over $5,000 each, at least two of which occurred within any ten-year period, and the cumulative amount of such claims payments exceeds $20,000; or that have at least two separate claims payments (building payments only) where the total of the payments exceeds the value of the property, when two such claims have occurred within any ten-year period.

Project grants are available for flood mitigation activities such as acquisition, structure demolition, or structure relocation with the property deed restricted for open-space uses in perpetuity; elevation of structures; flood-proofing of structures; minor physical localized flood control projects; and demolition and rebuilding of structures. SCD gives the highest priority to the sub-applicant projects that demonstrate the greatest savings to the NFIF based on a benefit cost ratio. Planning grants are not available.

Amount: The SRL program is authorized for up to $40 million for each fiscal year 2005 through 2009. The SRL program is subject to the availability of appropriation funding, as well as any directive or restriction made with respect to such funds.

Eligibility: State-level agencies, federally recognized Indian tribal governments, and local governments (including state recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SCD for assistance as sub-applicants. Individuals and private nonprofit organizations are not eligible to apply to the State, but a relevant state agency or local community may apply on their behalf. SCD reviews and prioritizes sub-applications and submits the grant application with sub-applications to FEMA for review and approval.

All sub-applicants must be participating and in good standing in the NFIP and an approved local mitigation plan is required.

Cost-Share Requirements: SRL grants are provided on a 75 percent federal / 25 percent nonfederal cost share basis. Up to 90 percent federal cost-share funding may be available for projects approved in states, territories, and federally recognized Indian Tribes with FEMA approved standard or enhanced mitigation plans or Indian tribal plans that include a strategy for mitigating existing and future SRL properties.

More Information:
Severe Repetitive Loss Program, www.fema.gov/government/grant/srl/index.shtm

SCD - (808) 733-4300, http://www.scd.hawaii.gov

FEMA Region IX - (816) 283-7061, http://www.fema.gov/about/regions/regionix/index.shtm

21.10.7 FEMA's Public Assistance—Mitigation

Program Summary: Section 406 (Public Assistance) of the Stafford Act establishes the program for the repair, restoration, and replacement of facilities damaged as a result of a presidentially declared disaster. These funds can also be used for hazard mitigation measures a state or local government determines to be necessary to meet a need for governmental services and functions in the area affected by the major disaster. Section 406 mitigation funds can only be used in the declared disaster areas (usually counties) and only in conjunction with identified, eligible disaster projects that will strengthen existing infrastructure and facilities to more effectively withstand the next disaster. One example would be replacing a blown out culvert with one designed to convey higher flows, instead of one that will be easily damaged in a flood again.

Eligibility: State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SCD for assistance.

Cost-Share Requirements: Public Assistance grants are provided at not less than 75 percent federal/25 percent nonfederal cost share basis for emergency measures and permanent restoration. All projects approved under State disaster assistance grants will be subject to the cost sharing provisions established in the FEMA-State Agreement and the Stafford Act.

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:

- For HMGP and PDM generators and/or related equipment purchases (e.g., generator hook-ups) when the generator directly relates to the hazards being mitigated and is part of a project (the 5% initiative allows for the stand-alone purchase of generators)
- 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 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
- 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

More Information:

FEMA's Public Assistance Program, http://www.fema.gov/plan/ehp/noma/projects2.shtm

SCD - (808) 733-4300, http://www.scd.hawaii.gov

FEMA Region IX - (816) 283-7061, http://www.fema.gov/about/regions/regionix/index.shtm

21.11 Other Sources of Federal and State Funding and Technical Assistance

Additional sources of federal and state funding and technical assistance are included in Table 21.5, and are separated into the following categories:

- General emergency management grants, loans, and assistance;
- Floods/flood control grants, loans, and technical assistance;
- Earthquake grants, loans, and technical assistance;
- All-hazard mapping grants, loans, and technical assistance;
- Ancillary flood and natural resource projects grants, loans, and technical assistance;
- Basic and applied research/development grants; and
- Other planning resources: Demographics, societal data, and transportation, agricultural, industrial, and economic statistics.

Table 21.5 Other Sources of Funding

Program/Activity	Type of Assistance	Agency and Contact
General Emergency Management Grants, Loans, and Technical Assistance		
Mitigation Project Funding	State Capital Improvement Program funds	State Civil Defense (808) 733-4301
Emergency Management/Mitigation Training	Training in disaster mitigation, preparedness, and planning.	FEMA Region IX NFIP and Mitigation http://training.fema.gov/
Post-disaster Economic Recovery Grants and Assistance	Grant funding to assist with the long-term economic recovery of communities, industries, and firms adversely impacted by disasters.	Economic Development Administration (800) 345-1222 (202) 482-6225 www.eda.gov/

Program/Activity	Type of Assistance	Agency and Contact
General Emergency Management Grants, Loans, and Technical Assistance		
Physical Disaster Loans and Economic Injury Disaster Loans	Disaster loans to nonfarm, private sector owners of disaster damaged property for uninsured losses. Loans can be increased by up to 20 percent for mitigation purposes.	Small Business Administration (202) 205-6734 www.sba.gov/services/disasterassistance
Disaster Grants—Public Assistance	Grants for the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain private nonprofit organizations. Mitigation funding is available for work related to damaged components of eligible buildings/structures.	FEMA Region IX www.fema.gov/government/grant/pa/index.shtm
Community Development Block Grants State's Program	Grants to states to develop viable communities (e.g., housing, a suitable living environment, expanded economic opportunities) in non-entitled areas, for low- and moderate-income persons.	U.S. Department of Housing and Urban Development Community Planning and Development (202) 708-3587 x4538 www.hud.gov/offices/cpd/index.cfm
Community Development Block Grants/Entitlement Grants	Grants to entitled cities and urban counties to develop viable communities (e.g., decent housing, suitable living environments, expanded economic opportunities), principally for low- and moderate-income persons.	U.S. Department of Housing and Urban Development (HUD) Community Planning and Development (202) 708-3587 x4538 www.hud.gov/offices/cpd/index.cfm
Disaster Recovery Assistance	Critical housing and community development resources to aid disaster recovery (including mitigation).	U.S. Department of Housing and Urban Development (HUD) Community Planning and Development (202) 708-2605 www.hud.gov/offices/cpd/index.cfm
Public Housing Capital Fund Emergency/Natural Disaster Funding	Funding to public housing agencies that confront an emergency situation or a natural disaster.	U.S. Department of Housing and Urban Development Office of Capital Improvements (202) 708-0950 www.hud.gov/offices/pih/programs/ph/capfund/index.cfm
Single Family Housing Repair Loans and Grants (Section 504 Rural Housing Loans and Grants)	Repair loans, grants, and technical assistance for very low-income homeowners living in rural areas to repair their homes and remove health and safety hazards.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-1474 www.rurdev.usda.gov/rhs/
Guaranteed Single Family Housing Loans (Section 502 Rural Housing Loans)	Loans, loan guarantees, and technical assistance to help very low, low-income, and moderate-income households in rural areas buy, build, or improve permanent residences.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-1474 (direct loans) (202) 720-1452 (guaranteed loans) www.rurdev.usda.gov/rhs/
Farm Ownership Loans	Direct loans, guaranteed/insured loans, and technical assistance to farmers to develop, construct, improve, or repair farm homes, farms, and service buildings and to make other necessary improvements.	U.S. Department of Agriculture Farm Service Agency (202) 720-1632 www.fsa.usda.gov/

Program/Activity	Type of Assistance	Agency and Contact
General Emergency Management Grants, Loans, and Technical Assistance		
HOME Investment Partnerships Program	Grants to states, local government, and consortia for permanent and transitional housing (including support for property acquisition, improvements, demolition, and relocation) for very low and low-income persons.	U.S. Department of Housing and Urban Development (HUD) Community Planning and Development Affordable Housing Programs HOME Investment Partnership Programs (202) 708-2470 www.hud.gov/offices/cpd/affordablehousing/index.cfm
Rural Development Assistance—Housing	Grants, loans, and technical assistance for addressing rehabilitation and health and safety needs in primarily low-income rural areas. Declaration of major disaster necessary.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-4323 www.rurdev.usda.gov/rhs/
Rural Development Assistance—Utilities	Direct and guaranteed rural economic loans and business enterprise grants to address utility issues and development needs.	U.S. Department of Agriculture (USDA) Rural Development Utilities Program (202) 720-9540 www.rurdev.usda.gov/rhs/
Assistance—Community Facility Direct Loans/Grants	Grants, direct and guaranteed loans, and technical assistance to construct, enlarge, or improve community facilities for healthcare, public safety, and public services in primarily low-income rural areas.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-4323 www.rurdev.usda.gov/rhs/cf/cp.htm
Community Development Block Grant—Section 108 Loan Guarantees	Loan guarantees to public entities for economic development, housing rehabilitation, public facilities, and large-scale physical development projects (including mitigation measures).	U.S. Department of Housing and Urban Development Community Planning and Development/Section 108 (202) 708-1871 www.hud.gov/offices/cpd/communitydevelopment/programs/
Homeland Security Grant Program	Grants to enhance the ability of states, territories, and urban areas to prepare for, prevent, and respond to terrorist attacks and other major disasters. Includes State Homeland Security Program, Urban Areas Security Initiative, Law Enforcement Terrorism Prevention Program, Metropolitan Medical Response System, and Citizen Corps Program grant programs.	FEMA Grants Management (800) 368-6498 askcsid@dhs.gov www.ojp.usdoj.gov/odp/grants_hsgp.htm
Infrastructure Protection Program	Grants to strengthen the nation's ability to protect critical infrastructure facilities and systems. Includes Transit Security Grant Program, Port Security Grant Program, Intercity Bus Security Grant Program, Trucking Security Program, and Buffer Zone Protection Program grant programs.	FEMA Grants Management (800) 368-6498 askcsid@dhs.gov www.ojp.usdoj.gov/odp/grants_ipp2007.htm

Program/Activity	Type of Assistance	Agency and Contact
General Emergency Management Grants, Loans, and Technical Assistance		
Assistance to Firefighters Grant Program	Grants to local fire departments to protect citizens and firefighters against the effects of fire and fire-related incidents.	FEMA Grants Management (866) 274-0960 firegrants@dhs.gov www.firegrantsupport.com/afg/ FEMA Region IX
Fire Prevention and Safety Grant Program	Grants for projects that enhance the safety of the public and firefighters from fire and related hazards. The primary goal is to target high-risk populations and mitigate high incidences of death and injury.	FEMA Grants Management (866) 274-0960 firegrants@dhs.gov www.firegrantsupport.com/afg/ FEMA Region IX www.fema.gov/about/contact/regionix.shtm
Fire Management Assistance Grant Program	Grants for the mitigation, management, and control of fires on publicly or privately owned forests or grasslands, which threaten such destruction as would constitute a major disaster.	FEMA Region IX www.fema.gov/government/grant/fmagp/index.shtm
Hazardous Materials Emergency Preparedness Program	Project grants and technical assistance to enhance hazardous materials emergency planning and training.	U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration Office of Hazardous Materials Safety (202) 366-0001 http://hazmat.dot.gov/training/state/hmep/hmep.htm
Floods/Flood Control Grants, Loan, and Technical Assistance		
National Flood Insurance Program	Flood insurance to residents of communities that adopt and enforce minimum floodplain management requirements.	FEMA Region IX NFIP and Mitigation www.fema.gov/about/programs/nfip/index.shtm www.floodsmart.gov/floodsmart/pages/index.jsp
Flood Control Planning Assistance	Technical and planning assistance for the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/
Nonstructural Alternatives to Structural Rehabilitation of Damaged Flood Control Works	Direct planning and construction grants for nonstructural alternatives to the structural rehabilitation of flood control works damaged in floods or coastal storms.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/
Floodplain Management Services	Technical and planning assistance at the local, regional, or national level needed to support effective floodplain management.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/
Land Protection	Technical assistance for run-off retardation and soil erosion prevention to reduce hazards to life and property.	U.S. Department of Agriculture Natural Resources Conservation Service (202) 720-4527 www.usda.gov/

Program/Activity	Type of Assistance	Agency and Contact
Earthquake Grants, Loans, and Technical Assistance		
National Earthquake Hazards Reduction Program and Other Earthquake Hazards Reduction Programs	Technical and planning assistance for activities associated with earthquake hazards mitigation.	FEMA Region IX NFIP and Mitigation www.nehrp.gov/
All-Hazard Mapping Grants, Loans, and Technical Assistance		
National Digital Orthophoto Programs	Develops topographic quadrangles for use in mapping of flood and other hazards.	U.S. Geological Survey National Mapping Division (573) 308-3802 ortho@ndop.gov www.ndop.gov/
National Streamflow Information Program	Operation of a network of over 7,000 stream gaging stations that provide data on river flood characteristics.	U.S. Geological Survey Office of Surface Water (703) 648-5303 http://water.usgs.gov/nsip/
Mapping Standards Support	Expertise in mapping and digital data standards to support the National Flood Insurance Program.	U.S. Geological Survey National Mapping Division (573) 308-3802 www.ndop.gov/
Earthquake Hazards Program	Seismic hazard maps.	U.S. Geological Survey (703) 648-6785 http://earthquake.usgs.gov/
Cooperating Technical Partners	Technical assistance, training, and data to support flood hazard data development activities.	FEMA Region IX www.fema.gov/plan/prevent/fhm/ctp_main.shtm
Map Modernization Management Support	Provides funding to supplement, not supplant, ongoing flood hazard mapping management efforts by local, regional, and State agencies.	FEMA Region IX NFIP and Mitigation www.fema.gov/plan/prevent/fhm/mm_main.shtm
Community Assistance Program State Support Services Element (CAP-SSSE)	Provides funding to states to provide technical assistance to communities in the National Flood Insurance Program (NFIP) and to evaluate community performance in implementing NFIP floodplain management activities.	FEMA Region IX NFIP and Mitigation
Geospatial One-Stop (geodata.gov)	GIS portal that contains metadata records and links to live maps, features, and catalog services, downloadable data sets, images, clearinghouses, map files, and more.	Geospatial One-Stop geodata@usgs.gov http://gos2.geodata.gov/
Ancillary Flood and Natural Resource Projects Grants, Loans, and Assistance		
Environmental Quality Incentives Program	Technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) (202) 720-1845 www.nrcs.usda.gov/programs/eqip/
Nonpoint Source Implementation Grants (Clean Water Act Section 319 Grants)	Grants to states to implement nonpoint source programs, including support for nonstructural watershed resource restoration activities.	U.S. Environmental Protection Agency Office of Water Non-Point Source Control Branch (202) 566-1203 www.epa.gov/owow/nps/cwact.html

Program/Activity	Type of Assistance	Agency and Contact
Capitalization Grants for Clean Water State Revolving Funds	Loans to fund water quality protection projects for wastewater treatment, nonpoint source pollution control, and watershed and estuary management.	U.S. Environmental Protection Agency Office of Wastewater Management www.epa.gov/owm/cwfinance/index.htm
National Wetland Program Development Grants	Grants to build capacity to protect, manage, and restore wetlands.	U.S. Environmental Protection Agency Office of Wetlands, Oceans, and Watersheds Wetlands Division www.epa.gov/owow/wetlands/
Watershed Protection and Flood Prevention Program	Technical assistance for designing and installing watershed works of improvement and financial assistance for cost-sharing of measures for watershed protection, flood prevention, agricultural water management, and sedimentation control, etc., in small watersheds less than 250,000 acres.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division www.nrcs.usda.gov/programs/watershed/
Soil and Water Conservation Program	Technical assistance to the general public in planning and applying natural resource conservation practices, systems, and treatment; and furnishing technical natural resource conservation information to State and local governments.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) (202) 720-4527 www.nrcs.usda.gov/programs/swca/
Watershed Surveys and Planning	Technical assistance planning activities to help solve water and related land resources problems.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division www.nrcs.usda.gov/programs/watershed/
Emergency Watershed Protection Program	Provides technical and financial assistance for relief from imminent hazards in small watersheds and to reduce vulnerability of life and property in small watershed areas damaged by natural hazard events.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division www.nrcs.usda.gov/programs/ewp/
Wetlands Reserve Program	Financial and technical assistance to protect and restore wetlands through easements and restoration agreements.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division www.nrcs.usda.gov/programs/wrp/
Project Modifications for Improvement of the Environment	Provides for ecosystem restoration by modifying structures and/or operations or water resources projects constructed by the U.S. Army Corps of Engineers or restoring areas where a Corps project contributed to the degradation of an area.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/
Aquatic Ecosystem Restoration	Direct support for carrying out aquatic ecosystem restoration projects that will improve the quality of the environment.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/
Planning Assistance to States (Water Resources Development Act)	Financial and technical assistance to prepare comprehensive plans for the development, use, and conservation of water and related land resources.	U.S. Army Corps of Engineers (USACE) (202) 272-0169 www.usace.army.mil/cw/cecw-cp/

Program/Activity	Type of Assistance	Agency and Contact
Beneficial Uses of Dredged Materials	Direct assistance for projects that protect, restore, and create aquatic and ecologically-related habitats, including wetlands, in connection with dredging an authorized federal navigation project.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/
Soil Survey	Maintains soil surveys of counties or other areas to assist with farming, conservation, mitigation or related purposes.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Soil Science and Resource Assessment (202) 690- 4616 http://soils.usda.gov/survey/
Land Acquisition	Acquires or purchases easements on high-quality lands and waters for inclusion into the National Wildlife Refuge System.	U.S. Fish and Wildlife Service Division of Realty (703) 358-1713 realty@fws.gov www.fws.gov/realty/lap.html
Transfers of Inventory Farm Properties to Federal and State Agencies for Conservation Purposes	Transfers title of certain inventory farm properties owned by the Farm Service Agency to federal and state agencies for conservation purposes (including the restoration of wetlands and floodplain areas to reduce future flood potential).	U.S. Department of Agriculture Farm Service Agency Farm Loan Programs (202) 720-3467, 1632
Disposal of Federal Surplus Real Property for Parks, Recreation, and Historic Monuments	Identifies, assesses, and transfers available federal real property for acquisition for state and local parks and recreation, such as open space.	National Park Service (NPS) (202) 354-6915 nps_flpnational@nps.gov www.ncrc.nps.gov/programs/flp/ NPS—Northeast/Midwest Regions (617) 223-5190 nps_flpnorth@nps.gov
Partners for Fish and Wildlife	Financial and technical assistance to private landowners interested in restoring or otherwise improving native habitats for fish and wildlife on their lands.	U.S. Fish and Wildlife Service Branch of Habitat Restoration (703) 358-2201 www.fws.gov/partners/
Conservation Contracts	Debt reduction for delinquent and non-delinquent borrowers in exchange for conservation contracts placed on environmentally sensitive real property that secures Farm Service Agency loans.	U.S. Department of Agriculture Farm Service Agency (202) 720-3467, 1632
Federal Assistance Monitor	Published by CD Publications. Semi-monthly report on federal and private grants. Available for a fee.	CD Publications (301) 588-6380, (800) 666-6380 info@cdpublications.com www.cdpublications.com/
Catalog of Federal Domestic Assistance	Database of all federal programs available to State and local governments; federally recognized Indian tribal governments; domestic public, quasi-public, and private profit and nonprofit organizations and institutions; specialized groups; and individuals.	Catalog of Federal Domestic Assistance http://12.46.245.173/cfda/cfda.html
Basic and Applied Research/Development		

Program/Activity	Type of Assistance	Agency and Contact
Decision, Risk, and Management Sciences	Funding for research directed at increasing the understanding and effectiveness of decision making by individuals, groups, organizations, and society.	National Science Foundation Directorate for Social, Behavioral, and Economic Sciences (703) 292-8700 www.nsf.gov/dir/index.jsp?org=SBE
Science and Society	Funding for research that examines questions that arise in the interactions of engineering, science, technology, and society.	National Science Foundation Directorate for Social, Behavioral, and Economic Sciences 703) 292-8700 www.nsf.gov/dir/index.jsp?org=SBE
National Earthquake Hazards Reduction Program	Funding for research to mitigate earthquake losses by providing earth science data and assessments essential for land use planning, engineering design, and emergency preparedness decisions.	U.S. Geological Survey External Research Support (703) 648-6716 gd-erp-coordinator@usgs.gov http://erp-web.er.usgs.gov
Structural Systems and Hazards Mitigation of Structures	Funding for research on new technologies for improving the behavior and response of structural systems subject to natural hazards.	National Science Foundation Directorate for Engineering Division of Civil, Mechanical, and Manufacturing Innovation (703) 292-8360 www.nsf.gov/div/index.jsp?org=CMMI
Environmental Technology	Funding for research to develop and test new technologies in the field of environmental engineering emphasizing principles underlying pollution avoidance as well as pollution treatment and remediation.	National Science Foundation Directorate for Engineering Division of Chemical, Bioengineering, Environmental, and Transport Systems (703) 292-8320 www.nsf.gov/div/index.jsp?org=CBET
Infrastructure Management and Hazard Response	Funding for research on multidisciplinary issues concerning the impact of natural, technological, and manmade hazards upon critical infrastructure systems and society.	National Science Foundation Directorate for Engineering Division of Civil, Mechanical, and Manufacturing Innovation (703) 292-8360 www.nsf.gov/div/index.jsp?org=CMMI
Environmental Sustainability	Funding for research with the goal of promoting sustainable engineered systems that support human well-being and that also are compatible with sustaining natural (environmental) systems, which provide ecological services vital for human survival.	National Science Foundation Directorate for Engineering Division of Chemical, Bioengineering, Environmental, and Transport Systems (703) 292-8320 www.nsf.gov/div/index.jsp?org=CBET
Behavioral and Social Research on Disasters and Health	Funding for research in the behavioral and social sciences on the consequences of natural and man-made disasters for the health of children, the elderly and vulnerable groups, with an ultimate goal of preventing or mitigating harmful consequences.	National Institutes of Health (301) 496-4000, TTY (301) 402-9612 NIHinfo@od.nih.gov http://grants.nih.gov/
Other Planning Resources: Demographics, Societal Data, and Transportation, Agricultural, Industrial, and Economic Statistics		

Program/Activity	Type of Assistance	Agency and Contact
Demographics, Societal Statistics and Economic Statistics	Free planning information concerning jobs, business and economic statistics, population and housing statistics, and help with census products (i.e., statistics, maps, reports, etc.). Note: For statistics regarding clean water, wetlands, conservation, disasters, natural resources, rivers, and other subjects covered in this document, use the contact information provided in the subject matter areas.	U.S. Census Bureau (301) 457-4608 www.census.gov/ Bureau of Economic Analysis Public Information Office (202) 606-9900 CustomerService@bea.gov www.bea.gov/ Bureau of Labor Statistics (BLS) Division of Information Services (202) 691-5200, (800) 877-8339 blsdata_staff@bls.gov www.bls.gov/

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

Appendix 21A

Bylaws of the State of Hawai‘i Hazard Mitigation Forum

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BYLAWS

HAWAII STATE HAZARD MITIGATION FORUM

ARTICLE I - NAME

I-1. The name of this organization is the Hawaii State Hazard Mitigation Forum (HSHMF).

ARTICLE II - PURPOSE

II-1. The HSHMF shall:

a. Develop a unified management strategy with recommendations concerning State, federal, or county mitigation responsibilities and programs, and mitigation plans.

b. Identify vulnerabilities to various natural hazards and evaluate and prioritize measures to mitigate risks associated with the hazards; assist State Civil Defense (SCD) to solicit, review, and prioritize nominations for mitigation projects to be included in the State of Hawaii Multi-Hazard Mitigation Plan and which may be submitted by applicants for Hazard Mitigation Grant Program and Pre Disaster Mitigation grant funding.

c. Assist State and county governments in obtaining funds to implement mitigation projects.

d. Develop specific goals on a biennial basis and provide status reports to State departments, county governments, and private organizations represented on this Forum.

e. Recommend policy and program changes to federal, State, and county agencies which are involved in mitigation activities.

f. Develop a comprehensive public awareness program on the activities of the Forum, highlighting successful mitigation projects.

g. Provide reports, as appropriate, to the Governor and Legislature on special mitigation activities addressed or completed by the Forum.

h. Coordinate activities and mitigation planning among other committees.

ARTICLE III - DEFINITIONS

III-1. For the purpose of these Bylaws, the following definitions are derived from statutory documents which have been accepted as functional by all levels of government involved in emergency management activities or operations:

a. Hazard Mitigation: Any action taken to reduce or permanently eliminate the long-term risk to human life and property loss or damage from natural hazards.

b. Hazard Mitigation Grant Program (HMGP): An ongoing program involving a coordinated effort of State and county agencies and private organizations to reduce risks to people and property from natural hazards. During and after periods of Presidential declared disasters, the Stafford Act makes available federal funds up to

15 percent of the estimated aggregate amount of grants for emergencies and permanent repairs with respect to a federally declared disaster. The federal government may contribute up to 75 percent of any cost-effective measure to be implemented while State and county governments and private nonprofit organizations must contribute the remaining 25 percent in this cost-sharing relationship.

c. Major Disaster: Any natural catastrophe (including hurricane, tornado, storm, high water, wind-driven water, tsunami, earthquake, volcanic eruption, landslide, mud slide, flood, or drought), or, regardless of cause, any fire or explosion which, in the determination of the President, causes damage of sufficient severity and magnitude to warrant major disaster assistance under the Stafford Act to supplement the efforts and available resources of State and county governments and disaster relief organizations in alleviating the damage, loss, hardship, or suffering caused thereby.

d. Measure/Project: Any activity proposed to reduce risk of future damage, hardship, loss, or suffering from major disasters. The terms (measure and project) are used interchangeably in federal regulations.

e. Stafford Act: Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended, signed into law on November 23, 1988, amended the Disaster Relief Act of 1974, PL 93-288.

f. State Hazard Mitigation Officer: The officer coordinates and monitors all State hazard mitigation programs. For the State of Hawaii, this responsibility has been placed in the State Civil Defense Division of the Department of Defense.

g. Pre-Disaster Mitigation (PDM) grant program: a Federal Emergency Management Agency (FEMA) grant program that provides funding 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 plans and projects reduce overall risks to the population and structures while also reducing reliance on funding from actual disaster declarations. PDM grants are awarded on a competitive basis; the program is subject to annual reauthorization.

ARTICLE IV - MEMBERSHIP

IV-1. The Forum shall be composed of a minimum of 11 members and a maximum of 19 members. Each county shall be entitled to at least one member. If the county seat is filled by other than the county civil defense administrator (CDA), the CDA shall be entitled to non-voting ex-officio Forum membership. A FEMA representative shall be entitled to non-voting ex-officio Forum membership.

IV-2. Members of the Mitigation Forum shall serve three-year terms, subject to reappointment.

a. At the last meeting of each calendar year, Forum members shall reaffirm willingness to be considered for Forum membership.

b. A member who has more than two absences from scheduled meetings per year without valid cause may be requested by the Forum to forfeit membership.

c. Voting shall be done by secret ballot only. Each Forum member shall vote for each of the available vacancies; multiple votes for a single nominee shall not be made.

d. Nominees receiving a majority of votes shall be declared recommended, except, if the number of nominees receiving a majority of votes exceeds the established number, those nominees with the highest number of votes shall be declared recommended. Absentee ballots will be accepted.

e. If a vacancy should occur, the remaining members may recommend a replacement to fill the vacancy. The appointment shall be made as soon as possible but not more than three months from the vacancy. The appointee shall complete the term of the individual whose position was vacated.

IV-3. A Forum member shall be a person with experience and interest in mitigation activities such as, but not limited to, the following areas of expertise: Environmental Studies/Protection, Risk Analysis, Hazard Analysis, Public Awareness, Education, Emergency Management, Structural Engineering, Seismology, Geology, Public Works, Public Utilities, Insurance, Planning, Flood Control, Land Utilization, Waste Management, Sheltering, Energy, Construction, Communications, Building Codes, Architecture, and Coastal Zone Management. A member may be selected from governmental agencies, the private sector, and the public at large, if one of the above qualifications is met. Each county government will be insured of having at least one member.

IV-4. The opinions of Forum members need not represent the views of other organizations in which they have membership.

ARTICLE V - OFFICERS

V-1. The Forum shall elect a Chairperson and Vice Chairperson from among its members. The Executive Assistant(s) will be appointed from the State Civil Defense Division (SCD).

V-2. The duties of the Chairperson shall be:

a. Preside at all meetings of the Forum;

b. Call for approval of the minutes of the preceding meeting when a quorum shall be present;

c. Announce the business before the Forum;

d. Receive and submit all matters properly brought before the Forum to call for votes upon the same and to announce the results;

e. Appoint members to all committees, subject to appeal by a majority of Forum members;

f. Authenticate, by signature, all acts of the Forum as may be required;

g. Make known all rules of orders when so requested and to decide all questions of order, subject to appeal to the Forum;

h. Act as spokesperson for the Forum;

i. Perform other duties as may be required of such office.

V-3. The duties of the Vice Chairperson shall be:

a. Act as the presiding officer in the absence or disability of the Chairperson;

b. Perform any special duties assigned by the Chairperson;

c. In case of resignation or incapacitation of the Chairperson, the Vice Chairperson shall become Chairperson for the unexpired part of the term.

V-4. The duties of the Executive Assistant shall be:

a. Keep accurate and current records of each meeting of the Forum, noting all actions taken, whether carried or lost;

b. Call the meeting to order in the absence of the Chairperson and Vice Chairperson and proceed with the election of a temporary Chairperson;

c. Prepare and disseminate correspondence as directed;

d. Send out all notices of meetings;

e. Keep an account of receipts and expenditures.

ARTICLE VI - MEETINGS

VI-1. A majority of the entire voting Forum membership shall constitute a quorum.

VI-2. The affirmative vote of the majority of the entire voting Forum membership shall be necessary to take any action. Proxy votes shall not be allowed. However, a Forum member may submit his or her vote for membership and projects in writing (hard or electronic copy).

VI-3. Regular meetings of the Forum shall be held three times per year. The Forum may also convene special meetings at any other times deemed appropriate.

VI-4. Special meetings may be called by the officers of the Forum.

VI-5. Any Forum member may request that a matter be placed on the agenda by notifying the Executive Assistant 15 days before the date of a meeting.

VI-6. The Forum requests prior notification of dissenting opinions when such opinions are made public. The Forum shall not prohibit the expression of dissenting opinions.

VI-7. The Forum shall be notified of any solicitation of outside party review of Forum work. The reviewer shall be notified.

VI-8. Minutes of all meetings will be prepared by the Executive Assistant and disseminated to all members prior to the next scheduled meeting.

ARTICLE VII - COMMITTEES

VII-1. The Forum should utilize the work of established committees, boards, councils, etc., which are involved in mitigation affairs such as the Hawaii State Earthquake Advisory Committee to facilitate its own actions and to maximize available resources and expertise.

VII-2. The Forum may establish special committees whose members are appointed by the Chairperson.

ARTICLE VIII

PETITION FOR ADOPTION, AMENDMENT, OR REPEAL OF BYLAWS

VIII-1. Any voting Forum member may petition the Forum requesting adoption, amendment, or repeal of any articles of the Bylaws. Subject to Article XI, amendment of the Bylaws shall become effective at the next regularly scheduled meeting.

VIII-2. Bylaws may be adopted, amended, or repealed by the vote in person of a majority of the voting membership of the Forum.

ARTICLE IX - PARLIAMENTARY AUTHORITY

IX-1. Robert's Rules of Order, revised, shall govern the Forum where the same are not inconsistent with these Bylaws.

ARTICLE X - VALIDITY

X-1. If any section or part of the Bylaws is held to be invalid for any reason whatsoever, such invalidity shall not affect the validity of the remaining sections of the Bylaws.

ARTICLE XI - EFFECTIVE DATE OF THESE RULES

XI-1. These Bylaws shall become effective upon approval of the Director of Civil Defense and filing with the State Civil Defense Division.

CIVIL DEFENSE DIVISION
DEPARTMENT OF DEFENSE
STATE OF HAWAII

APPROVED AS TO FORM:

BY: _____
DARRYLL D. M. WONG
MAJOR GENERAL
HAWAII NATIONAL GUARD
DIRECTOR OF CIVIL DEFENSE

26 Apr. 13
DATE

BY: _____
DOUG MAYNE
Vice Director of Civil Defense

Apr 25th, 2013
DATE

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STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

Appendix 21B

Sample Form for State of Hawai‘i Hazard Mitigation Project Proposal

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State of Hawaii
Hazard Mitigation Project Proposal

Instructions: All fields are required. Email completed form to Mitigation-Proposal@scd.hawaii.gov

Applying For Grant Assistance Program (check all that apply):

☐ HMGP ☐ PDM ☐ NTHMP ☐ NEHRP

☐ State Mitigation Plan Project List ☐ Other (specify):

Today's Date:

Jurisdiction:

Agency / Organization:

Project Title:

Contact Person:

Phone:

Email:

Project Physical Address:

Project TMK:

Natural Hazard(s) to be Mitigated (check hazard(s) that apply):

☐ Drought ☐ Erosion ☐ Flood ☐ Hurricane, High Winds ☐ Landslide ☐ Seismic

☐ Tsunami ☐ Volcano / Lava Flow ☐ Wildfire ☐ Other (specify):

Meets Criteria for Environmental / Historical Preservation Soundness: No

If "Yes" please attach letter from the SHPO; if "No" please explain (applicants are required to **provide information to support the FEMA EHP compliance review**):

Long Range Solution (+15 years): No If Yes, # of years:

Is the Proposed Project consistent with a Mitigation Goal(s) and Objective(s) listed in the County or State Mitigation Plan? If YES, please specify the Goal(s) and Objective(s), and include the page number(s):

Goal(s):

Objective(s):

Page Number(s):

Plan Title (enter complete title) and Plan Approval Date:

Is the Proposed Project Currently Listed in the State Multi Hazard Mitigation Plan and/or Applicable County Multi Hazard Mitigation Plan?

State Plan: No County Plan: No Other (specify):

Estimated **Federal** Cost of Project:

Project Period (duration in ***months***):

Estimated **Non-Federal** Cost of Project:

Estimated **TOTAL** Project Cost:

Source(s) of Non-Federal Cost Match:
(Minimum 25% PDM & HMGP)

Estimated Value of Structure or Facility to be Mitigated:

Estimated Value of Structure's Contents:

Project Description:

The project description must include the following: 1) comprehensive summary of the Scope of Work; 2) description of how the applicant will meet the minimum 25% cost-match requirement; 3) time line for project activities, not to exceed 36 months; 4) proposed budget estimate (lump sum budget is not allowed). Attach additional pages as necessary.

Instructions: Enter your comments in the following STAPLEE table as they apply to this project proposal.

Evaluation Category	Considerations	Comments
S = Social	Community Acceptance	
	Adversely Affects Segments of the Population	
T = Technical	Technical Feasibility	
	Long-Term Solution	
	Secondary Impacts	
A = Administrative	Staffing	
	Funding Allocated	
	Maintenance/Operations	
P = Political	Political Support	
	Plan Proponent	
	Public Support	
L = Legal	Authority	
	Action Subject to Legal Challenge	
E = Economic	Benefit	
	Cost of Action	
	Contributes to Economic Goals	
	Outside Funding Required	
E = Environmental	Affects Land/Water Bodies	
	Affects Endangered Species	
	Affects Hazardous Materials and Waste Sites	
	Consistent with Community Environmental Goals	
	Consistent with Federal Laws	

Version 3, May 2011

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Appendix 21C

Statewide Partners in Hazard Mitigation Planning

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This appendix shows the varied types of councils and committees that form the disaster management sector for the State of Hawai‘i. Participants range in representation from geographic communities to government agencies. The following councils and committees are shown:

1) The State Civil Defense Advisory Council
2) The Hawai‘i Emergency Preparedness Executive Committee
3) The State Hazard Mitigation Forum
4) Hawai‘i State Earthquake Advisory Committee
5) State Emergency Communications Committee
6) Joint Armed Services/State of Hawai‘i Civil Defense Coordinating Committee
7) Hawai‘i State Hurricane Advisory Committee
8) State Law Enforcement Coalition
9) Urban Search & Rescue Task Force
10) State of Hawai‘i Energy Council

These councils and committees do not represent the entire extent of participation in statewide disaster management activities, but rather those coordinated by State Civil Defense. Different agencies, such as the National Weather Service, hold public awareness campaigns and joint readiness activities. The Red Cross is involved locally in training communities to deal with hazards and in providing operational staff for the state shelter system. Each county has a civil defense agency linked to the mayor’s office that provides information, records to disaster threats, and coordinates mitigation activities on a daily basis. The extensive partnering infrastructure ensures the connection and interaction that helps to minimize overall risk from hazards in the State of Hawai‘i.

STATE CIVIL DEFENSE ADVISORY COUNCIL

The Civil Defense Advisory Council, established and organized under Hawai‘i Revised Statute, Chapter 26 and 126, was founded in 1951. The Governor and the Director of Civil Defense may consult with the seven-member Advisory Council on matters pertaining to emergency management.

While the Advisory Council members, appointed by the Governor, serve without compensation, they provide an invaluable service to the State and to the counties they represent by strengthening and promoting a vital civil defense system in the State of Hawai‘i. The Council meets on a quarterly basis each year.

STATE HAZARD MITIGATION FORUM

The State Hazard Mitigation Forum (SHMF) is comprised of a broad spectrum of agencies to include representatives from all four Counties, FEMA, various State agencies, and members of the private sector. One of the most important duties of the Forum is to assist in the development of the State Hazard Mitigation Plan. Additionally, the Forum makes recommendations to the Director of Civil Defense with regard to grant awards for statewide mitigation projects.

Buika, James	Maui - Planning
Chock, Gary	Martin & Chock, Inc.
Fujii, Neal	DLNR – Drought/Water Cons Coordinator
Haigh, Doug	Kaua‘i - DPW
Hamnett, Mike Dr.	RCUH
Hiu, Timothy	DPP – Honolulu
Kawata, Erwin	Board of Water Supply – Program Administrator
Keolanui, Stan	U. S. Army Corps of Engineers – Emergency Management
Kong, Laura Dr.*	NWS/International Tsunami Info Center
Matsuda, Edwin	DLNR – Flood Control/Dam Safety
Ogata-Deal, Ann*	State Office of Planning – Coastal Zone Management
Cantin, Michael	NWS/Honolulu Forecast Office
Thomas, Don Dr.*	Center for Study – Active Volcanoes – UH
Kaanoi Clemente	HECO
Thomas Payne	Chaminade University
Jody Galinato	Kaua‘i County

Ex Officio Participants (non-voting):

Mayne, Doug	State Civil Defense (SCD) – Vice Director
Miyagi, Vern	SCD – Executive Officer
Kanda, Larry	SCD-HAZMAT Advisor (Prior HAZMAT Officer)
Duncan, Ian	SCD-HAZMAT Officer
Okamura, Havinne	SCD-Mitigation Planner
Kaku, Mel	CC of Honolulu Department of Emergency Management

HAWAII STATE EARTHQUAKE ADVISORY COMMITTEE

The Hawai‘i State Earthquake Advisory Committee (HSEAC) is a valuable resource to emergency managers, who utilize the members’ knowledge and expertise to better manage Hawai‘i’s risks and vulnerabilities with regard to earthquakes, tsunami, and lava flows.

Cheryl Anderson	University of Hawai‘i
Andrea Chatman	Pacific Disaster Center
Gary Chock	Martin & Chock, Inc.
George Curtis	University of Hawai‘i
Gerard Fryer	Pacific Tsunami Warning Center
Troy Kindred	USPACOM
Dr. Laura Kong	International Tsunami Information Center
Quince Mento	Hawai‘i Civil Defense Agency
Dr. Peter Nicholson	University of Hawai‘i
Ann Ogata-Deal	Dept. of Business, Economic Development, & Tourism
Dr. Paul Okubo	United States Geological Survey
Dr. Ian Robertson	University of Hawai‘i
Afaq Sarwar	Sarwar Structural Engineering
Jiro Sumada	Department of Transportation
Dr. Donald Thomas	University of Hawai‘i
Cecily Wolfe	University of Hawai‘i
Brian Yanagi	ITIC/NWS

HAWAII DROUGHT COUNCIL

Members of the Hawai‘i Drought Council represent the various sectors of the community impacted by drought – water supply, agriculture and commerce, and environment, public health and safety. They have expertise in various technical, scientific, and social disciplines and lend their support in drought mitigation planning and monitoring as well as advising State and County governments on situational awareness and status of water supply.

Jeffrey Eng	Maui Department of Water Supply
Wayne Hashiro	Honolulu Board of Water Supply
Garret Hew	East Maui Irrigation
Dawn Johnson	Hawai‘i State Civil Defense
Sandra Kunimoto	Department of Agriculture
Mark Marshall	Kaua‘i Civil Defense Agency
Milton Pavao	Hawai‘i Department of Water Supply
Laura Thielen	Department of Land & Natural Resources
Pono Von Holt	Hawai‘i Cattlemen’s Council
Warren Watanabe	Hawai‘i Farm Bureau
Vacant	Governor’s Representative.

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22. References

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CHAPTER 22
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STATE OF HAWAII

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23. List of Acronyms

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Acronyms

BWS	Board of Water Supply (City & County of Honolulu)
CSAV	Center for the Study of Active Volcanoes (University of Hawai‘i at Hilo)
DAGS	Department of Accounting and General Services
DEM	City & County of Honolulu Department of Emergency Management
CWRM	Commission on Water Resource Management (Department of Land & Natural Resources)
CZM	Coastal Zone Management (State of Hawai‘i)
DBEDT	Department of Business, Economic Development, & Tourism (State of Hawai‘i)
DCCA	Department of Commerce and Consumer Affairs
DEM	Department of Emergency Management (City & County of Honolulu)
DHHL	Department of Hawaiian Home Lands
DHS	Department of Human Services (State of Hawai‘i)
DLIR	Department of Labor and Industrial Relations (State of Hawai‘i)
DLNR	Department of Land and Natural Resources (State of Hawai‘i)
DOH	Department of Health (State of Hawai‘i)
DOT	Department of Transportation (State of Hawai‘i)
HBWS	Honolulu Board of Water Supply
HCDA	Hawai‘i Civil Defense Agency (County of Hawai‘i)
HSEAC	Hawai‘i State Earthquake Advisory Committee
ITIC	International Tsunami Information Centre
KCDA	Kaua‘i Civil Defense Agency (County of Kaua‘i)
MCDA	Maui Civil Defense Agency (County of Maui)
OP	Office of Planning (State of Hawai‘i)
PDC	Pacific Disaster Center
PRiMO	Pacific Risk Management ‘Ohana
RCUH	Research Corporation of the University of Hawai‘i
SCD	State Civil Defense (State of Hawai‘i)
SHMF	Hawai‘i State Hazard Mitigation Forum
SOEST	School of Ocean, Earth Science, & Technology
SSRI	Social Science Research Institute
UH	University of Hawai‘i
UHM	University of Hawai‘i at Mānoa

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24. Glossary

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Glossary

Adverse Consequences - Negative impacts that may result from failure. The primary concerns are loss of human life, economic loss (including property damage), lifeline disruption, and environmental impact.

Annualized Benefits and Costs - The value of benefits and costs based on the probability the benefit or cost will be realized in a given year.

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. Generally it is not the same as price, which bounds cost from above.

Cost Effective - The least cost alternative means for achieving the same stream of benefits or a given objective. Cost-effectiveness analysis is less comprehensive than benefit/cost analysis, but can be appropriate when the benefits from competing alternatives are the same or where a policy decision has been made that the benefits must be provided. It can be used to compare programs with identical costs but differing benefits. FEMA guidance has defined cost-effective as the benefits equal to or exceeding the costs. (From OMB A-94)

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 establishing geographically where certain phenomena are likely to pose a threat to human settlements.

Hazard Potential - Possible adverse consequences.

Hazard Potential Classification - A system that categorizes dams according to the degree of adverse incremental consequences of a failure or miss-operation of a dam. The hazard potential classification does not reflect in any way on the current condition of the dam (e.g., safety, structural integrity, flood routing capacity.)

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.

Maximum Foreseeable Loss - An estimate of losses assuming the worst combination damage and disruption to a business. This estimate allows consideration of the worst possible consequences.

Mitigation - All 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.

Multiplier - The ratio between the direct effect on output or employment and the full effect including the effects of second order rounds or spending. (From OMB A-94)

Natural Hazard - The probability of occurrence of a potentially damaging natural phenomenon within a specific period of time. Some of these include tropical cyclones, hurricanes, drought, earthquakes, floods, landslides, tsunamis, and volcanic eruptions.

Net Present Value - The discounted monetized value of expected net benefits (i.e., benefits minus costs). This is the standard criterion for deciding whether a government program can be justified on economic principles. Net present value is compute by assigning monetary values to benefits and costs, discounting future benefits and costs using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits. (From OMB A-94)

Opportunity Cost - The value of alternatives foregone to achieve the mitigation activity. It can be thought of as the value of the good or service in its best alternative use.

Present Value - The value of a stream of benefits or costs when discounted back to the present time.

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.

Process Mitigation - Indirect mitigation activities that lead to policies, practices, and projects that reduce risk. They include efforts to assess hazards, vulnerability and risk; conduct planning to identify projects, policies and practices and set priorities; educate decision-makers and build constituencies and political will; and to facilitate the selection, design, funding and construction of projects.

Project Mitigation - Project mitigation includes measures to avoid or reduce damage resulting from hazard events. They include projects to elevate, acquire and/or relocate buildings, lifelines and structures threatened by floods, strengthen buildings to resist earthquake or wind forces, and to improve drainage and land conditions.

Rehabilitation - Action undertaken in the weeks or months following a disaster to restore basic services which enable life in the region to return to normality. However, it should be recognized that normality also gave rise to a disaster. Therefore, the term can be equated with vulnerability, and there is thus a need to advance from the status quo towards post-disaster improvements.

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.

STATE OF HAWAII

DEPARTMENT OF DEFENSE

CIVIL DEFENSE DIVISION

OFFICE OF THE DIRECTOR OF CIVIL DEFENSE

25. Plan Review Crosswalk

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Instructions for Using the Plan Review Crosswalk for Review of Standard State Hazard Mitigation Plans

Attached is a Plan Review Crosswalk based on the ***Multi-Hazard Mitigation Planning Guidance Under the Disaster Mitigation Act of 2000***, published by FEMA, with revisions dated November 2006. This Plan Review Crosswalk is consistent with the *Disaster Mitigation Act of 2000* (P.L. 106-390), enacted October 30, 2000 and *44 CFR Part 201 – Mitigation Planning, Interim Final Rule* (the Rule), published February 26, 2002.

SCORING SYSTEM

N – Needs Improvement: The plan does not meet the minimum for the requirement. Reviewer's comments must be provided.

S – Satisfactory: The plan meets the minimum for the requirement. Reviewer's comments are encouraged, but not required.

Each requirement includes separate elements. All elements of a requirement must be rated "Satisfactory" in order for the requirement to be fulfilled and receive a summary score of "Satisfactory." A "Needs Improvement" score on elements shaded in gray (recommended but not required) will not preclude the plan from passing.

Optional matrices for assisting in the review of sections on profiling hazards and assessing vulnerability are found at the end of the Plan Review Crosswalk.

The example below illustrates how to fill in the Plan Review Crosswalk.

Example

Assessing Vulnerability by Jurisdiction

Requirement §201.4(c)(2)(ii): *[The State risk assessment **shall** include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments … . The State **shall** describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard event.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the plan describe the State's vulnerability based on information from the local risk assessments?	Section III, pp. 12-28	The plan includes a description of local vulnerable structures. The plan presented a vulnerability summary by regions in the state. This information was collected from the approved plans on file.		✓
B. Does the plan present information on those jurisdictions that face the most risk?	Section III, pp. 30-36	The vulnerability description did not indicate which jurisdictions were the most vulnerable. **Required Revisions:** • Use the information provided in the summaries to determine which jurisdictions are most threatened by the identified hazards. • Identify which jurisdictions have suffered or are likely to suffer the most losses. • If data are not readily available, note these data limitations in the plan. Include actions in the mitigation strategy to obtain these data for the plan update.	✓	
		SUMMARY SCORE	✓	

Standard State Hazard Mitigation Plan Review and Approval Status

State Point of Contact: **Ian Duncan**	**Address:** 3949 Diamond Head Road Honolulu, Hawaii 96816-4495
Title: **Hawaii State Hazard Mitigation Officer**	
Agency: State Civil Defense, Department of Defense	
Phone Number: (808) 733-4300	**E-Mail:iduncan@scd.hawaii.gov**

FEMA Reviewer: Juliette Hayes	**Title:** Community Planners	**Date:** August 23, 2013
Date Received in FEMA Region [Insert #]	August 26, 2012	
Plan Not Approved		
Plan Approvable Pending Adoption		
Date Plan Approved		

STANDARD STATE HAZARD MITIGATION PLAN SUMMARY CROSSWALK

The plan cannot be approved if the plan has not been formally adopted.

Each requirement includes separate elements. All elements of the requirement must be rated "Satisfactory" in order for the requirement to be fulfilled and receive a score of "Satisfactory." Elements of each requirement are listed on the following pages of the Plan Review Crosswalk. A "Needs Improvement" score on elements shaded in gray (recommended but not required) will not preclude the plan from passing. Reviewer's comments must be provided for requirements receiving a **"Needs Improvement"** score.

SCORING SYSTEM

Please check one of the following for each requirement.

N – Needs Improvement: The plan does not meet the minimum for the requirement. Reviewer's comments must be provided.

S – Satisfactory: The plan meets the minimum for the requirement. Reviewer's comments are encouraged, but not required.

Prerequisite	NOT MET	MET
Adoption by the State: §201.4(c)(6) and §201.4(c)(7)	X	

Planning Process	N	S
Documentation of the Planning Process: §201.4(c)(1)		
Coordination Among Agencies: §201.4(b)		
Program Integration: §201.4(b)		

Risk Assessment	N	S
Identifying Hazards: §201.4(c)(2)(i)		
Profiling Hazards: §201.4(c)(2)(i)		
Assessing Vulnerability by Jurisdiction: §201.4(c)(2)(ii)		
Assessing Vulnerability of State Facilities: §201.4(c)(2)(ii)		
Estimating Potential Losses by Jurisdiction: §201.4(c)(2)(iii)		
Estimating Potential Losses of State Facilities: §201.4(c)(2)(iii)		

Mitigation Strategy	N	S
Hazard Mitigation Goals: §201.4(c)(3)(i)		
State Capability Assessment: §201.4(c)(3)(ii)		
Local Capability Assessment: §201.4(c)(3)(ii)		
Mitigation Actions: §201.4(c)(3)(iii)		
Funding Sources: §201.4(c)(3)(iv)		

Coordination of Local Mitigation Planning	N	S
Local Funding and Technical Assistance: §201.4(c)(4)(i)		
Local Plan Integration: §201.4(c)(4)(ii)		
Prioritizing Local Assistance: §201.4(c)(4)(iii)		

Severe Repetitive Loss Mitigation Strategy
(only required for 90/10 under FMA & SRL)

	N	S
Repetitive Loss Mitigation Strategy: §201.4(c)(3)(v)		
Coordination with Repetitive Loss Jurisdictions §201.4(c)(3)(v)		

Plan Maintenance Process	N	S
Monitoring, Evaluating, and Updating the Plan: §201.4(c)(5)(i)		
Monitoring Progress of Mitigation Activities: §201.4(c)(5)(ii) and (iii)		

STANDARD STATE HAZARD MITIGATION PLAN APPROVAL STATUS

PLAN NOT APPROVED	
PLAN APPROVED	

See Reviewer's Comments

1. PREREQUISITE

Adoption by the State

Requirement §201.4(c)(6): *The plan **must** be formally adopted by the State prior to submittal to [FEMA] for final review and approval.*

Requirement §201.4(c)(7): *The plan **must** include assurances that the State will comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c). The State will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d).*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE NOT MET	SCORE MET
A. Has the State formally adopted the **new or updated** plan?		**State Civil Defense Comment:** The submitted plan is in concurrent review by the executive branch and is not yet adopted; anticipated to occur once FEMA comments are received for second submittal with adoption for FEMA approval. **Required Revision:** Adopt State Hazard Mitigation Plan	X	
B. Does the plan provide assurances that the State will **continue to** comply with all applicable Federal statutes and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c), and will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d)?	Section 1.1 page 1-1 and Section 21.7 page 21-18			
		SUMMARY SCORE	X	

2. PLANNING PROCESS: *§201.4(b): An effective planning process is essential in developing and maintaining a good plan.*

Documentation of the Planning Process

Requirement §201.4(c)(1): *[The State plan **must** include a] description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the plan provide a narrative description of how the **new or updated** plan was prepared?	Chapter 1, Sections 1.2 and 1.3, pages 1-3 through 1-17 Chapter 20,			

	Section 20.3 and Pages 20-8 through 20-29 Chapter 21, Sections 21.1 through 21.4, pages 21-2 through 21-12; Section 21.5 pages 21-15 to 21- 17			
B. Does the **new or updated** plan indicate who was involved in the **current** planning process?	See Acknowledgements Section			
C. Does the **new or updated** plan indicate how other agencies participated in the **current** planning process?	Acknowledgements Section, Chapter 20, Section 20.3 and Pages 20-8 through 20-29; Chapter 21, Sections 21.2 to Section 21.5 pages 21-2 through 21-16			
D. Does the updated plan document how the planning team reviewed and analyzed each section of the plan?	Chapter 1, Sections 1.2 and 1.3, pages 1-3 through 1-17			
E. Does the updated plan indicate for each section whether or not it was revised as part of the update process?	Chapters 1 & 2, 20 & 21 and the individual chapters have this summarized. *Note that the plan was substantially re-organized and the subject matter on individual hazards was re-written rather than edited.*			
		SUMMARY SCORE		

3. Coordination Among Agencies

Requirement §201.4(b): *The [State] mitigation planning process* ***should*** *include coordination with other State agencies, appropriate Federal agencies, interested groups, and … .*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe how Federal and State agencies were involved in the **current** planning process?	Chapter 2, Section 2.3, pages 2-12 through 2-20 Chapter 21, Section 21.4, pages 21-11 to 21-12	***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
B. Does the **new or updated** plan describe how interested groups (e.g., businesses, non-profit organizations, and other interested parties) were involved in the **current** planning process?	Chapter 2, Section 2.2.1.4 Chapter 20 Chapter 21	***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
C. Does the updated plan discuss how coordination among Federal and State agencies changed since approval of the previous plan?	Chapter 2, Section 2-3 and 2.4 pages 2-12 to 2-36; and Chapter 20 Sections 20.1 and 20.2 Pages 20-2 to 20-7; Section 20.3 pages 20-11 to 20-18; and Chapter 21, Sections 21.2 to Section 21.5 pages 21-2 through 21-16			
		SUMMARY SCORE		

4. Program Integration

Requirement §201.4(b): *[The State mitigation planning process **should**] be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe how the State mitigation planning process is integrated with other ongoing State planning efforts?	Chapter 2, Section 2.3 to Section 2.4 and pages 2-12 to 2-36	***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
B. Does the **new or updated** plan describe how the State mitigation planning process is integrated with FEMA mitigation programs and initiatives?	Chapter 2, Sections 2.2 to 2.5 and pages 2-3 to 2-38 Chapter 21 Section 21.2 pages 21-6 to 21-9; Sections 21.9 to 21.10 and pages 21-29 to 21-39	***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
		SUMMARY SCORE		

RISK ASSESSMENT: *§201.4(c)(2): [The State plan must include a risk assessment] that provides the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments.*

5. Identifying Hazards

Requirement §201.4(c)(2)(i): *[The State risk assessment **shall** include an] overview of the type … of all natural hazards that can affect the State … .*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of the type of **all natural hazards** that can affect the State? If the hazard identification omits (without explanation) any hazards commonly recognized as threats to the State, this part of the plan cannot receive a Satisfactory score.	Chapter 1 Introduction Section 1.1 and Chapters 4 to 19. *Note that Chapter 16, 17, and 18 are optional chapters on effects that State Civil Defense has decided to include although not requirements of FEMA*	11 hazards have been identified: Hurricane and Strong		
		SUMMARY SCORE		

6. Profiling Hazards

Requirement §201.4(c)(2)(i): *[The State risk assessment **shall** include an overview of the] location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate … .*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the risk assessment identify the **location** (i.e., geographic area affected) of each natural hazards addressed in the **new or updated** plan?	Chapter 4 through 15 have sections that include hazard differentiation (example, earthquake hazards) by counties and geographic context (example, topographic wind effects and coastal tsunami mapping) where significant			
B. Does the **new or updated** plan provide information on **previous occurrences** of each hazard addressed in the plan?	Chapter 4 through 15 have sections on historic events or physical process trends			
C. Does the **new or updated** plan include the **probability of future events** (i.e., chance of occurrence) for each hazard addressed in the plan?	Chapter 4 through 15 have probability of occurrence sections that summarize what is expected for the hazards			
		SUMMARY SCORE		

Assessing Vulnerability

Requirement §201.4(c)(2)(ii): *[The State risk assessment **shall** include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned critical or operated facilities located in the identified hazard areas shall also be addressed … .*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

7. Assessing Vulnerability by Jurisdiction

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe the State's vulnerability based on estimates provided in local risk assessments as well as the State risk assessment?	Chapter 19; Chapter 20 Section 20.5 and pages 20-30 to 20-36;			
B. Does the **new or updated** plan describe the State's vulnerability in terms of the jurisdictions most threatened and most vulnerable to damage and loss associated with hazard event(s)?	Chapter 19 compiles this information and provides the hazard differentiation by jurisdiction			
C. Does the updated plan explain the process used to analyze the information from the local risk assessments, as necessary?	Chapter 20 Section 20.5 and pages 20-30 to 20-36; Chapter 21 Section 21.2 Section 21-4 to 21-9; Section 21.4 pages 21-13 to 21-14			
D. Does the updated plan reflect changes in development for jurisdictions in hazard prone areas?	Chapter 2 Section 2.4.1 Land Use and Chapter 3 Land Use and Development			
		SUMMARY SCORE		

8. Assessing Vulnerability of State Facilities

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe the types of State owned or operated critical facilities located in the identified hazard areas?	Chapters 5, 7 , 8 , 10, and 19			
		SUMMARY SCORE		

Estimating Potential Losses

Requirement §201.4(c)(2)(iii): *[The State risk assessment **shall** include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

9. Estimating Potential Losses by Jurisdiction

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan present an overview and analysis of the potential losses to the identified vulnerable structures?	Chapters 5, 7 , 8 , 10, and 19			
B. Are the potential losses based on estimates provided in local risk assessments as well as the State risk assessment?	See hazard chapters and Chapter 19 summary			
C. Does the updated plan reflect the effects of changes in development on loss estimates?	See Chapters 2 and 3 and 18			
		SUMMARY SCORE		

10. Estimating Potential Losses of State Facilities

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan present an estimate of the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities in the identified hazard areas?	Chapters 5, 7 , 8 , 10, and 18 and 19			
		SUMMARY SCORE		

MITIGATION STRATEGY: *§201.4(c)(3) [To be effective the plan must include a] Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment.*

11. Hazard Mitigation Goals

Requirement §201.4(c)(3)(i): *[The State mitigation strategy **shall** include a] description of State goals to guide the selection of activities to mitigate and reduce potential losses.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of State mitigation **goals** that guide the selection of mitigation activities?	Chapter 20 Section 20.2 and Section 20.3 and pages 20-2 to 20-17			
B. Does the updated plan demonstrate that the goals were assessed and either remain valid or have been revised?	Chapter 2 Chapter 20 Section 20.1and pages 20-2 to 20-7; Chapter 21 Section 21.2 and Section 21.3 and pages 21-2 to 21-11			
		SUMMARY SCORE		

12. State Capability Assessment ***Requirement §201.4(c)(3)(ii):*** *[The State mitigation strategy **shall** include a] discussion of the State's pre-and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas [and] a discussion of State funding capabilities for hazard mitigation projects … .*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan include an evaluation of the State's **pre-disaster** hazard management policies,	Chapter 2 Section 2.3			

programs, and capabilities?	pages 2-13 to 2-33 and the Mitigation Strategy Sections in Hazard Chapter 4 to 16; Chapter 20 Section 20.3 and pages 20-14 to 20-17			
B. Does the **new or updated** plan include an evaluation of the State's **post-disaster** hazard management policies, programs, and capabilities?	Chapter 20 Section 20.4 and pages 20-12 to 20-29			
C. Does the **new or updated** plan include an evaluation of the State's policies related to **development in hazard prone areas**?	Chapter 2 Section 2.3 pages 2-13 to 2-33 and Section 2.4 ; Chapter 3 Section 3.4; Chapter 9 Section 9.4 and pages 9-40 to 9-46; Chapter 12 Section 12.4 and Section 12.5 and pages 12-13 to 12-28; Chapter 20 Section 20.4 and pages 20-12 to 20-26			

D. Does the **new or updated** plan include a discussion of State **funding capabilities** for hazard mitigation projects?	Chapter 2 Section 2.3 and pages 2-12 to 2-20;			
E. Does the updated plan address any hazard management capabilities of the State that have changed since approval of the previous plan?	See Chapter 2 Section 2.3 and Page 2-12 to 2-13and 2-28 Most significantly from an overall hazard mitigation perspective of comprehensive effectiveness, the State created a State Building Code Council to develop a statewide building code. This is probably the greatest single step taken in modern times to establish a major implementation of hazard mitigation to reduce the vulnerability of infrastructure to natural hazards.			
		SUMMARY SCORE		

13. Local Capability Assessment

Requirement §201.4(c)(3)(ii): *[The State mitigation strategy **shall** include] a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan present a general description of the local mitigation policies, programs, and capabilities?	See hazard specific chapters and Chapter 20 Section 20.5 and pages 20-30 to 20-37			
B. Does the **new or updated** plan provide a general analysis of the effectiveness of local mitigation policies, programs, and capabilities?	See Chapter 20 Section 20.5 and Chapter 21 Section 21.7.2			
		SUMMARY SCORE		

14. Mitigation Actions

Requirement §201.4(c)(3)(iii): *[State plans **shall** include an] identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section **should** be linked to local plans, where specific local actions and projects are identified.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan identify cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering?	Chapter 20 Section 20.3 and 20.4 and pages 20-12 to 20-29	1.		
B. Does the **new or updated** plan evaluate these actions and activities?	Chapter 20 Section 20.3 and 20.4 and pages 20-12 to 20-29			
C. Does the **new or updated** plan prioritize these actions and activities?	Chapter 20 Section 20.3 and 20.4 and pages 20-12 to 20-29			
D. Does the **new or updated** plan explain how each activity contributes to the overall State mitigation strategy?	Chapter 20 Section 20.3 and 20.4 and pages 20-12 to 20-29			
E. Does the mitigation strategy **in the new or updated** section reflect actions and projects identified in local plans?	Chapter 20 Section 20.3 and pages 20-14 to 20-18 and Section 20.5 and pages 20-30 to 20-36	*Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.*		
		SUMMARY SCORE		

15. Funding Sources

Requirement §201.4(c)(3)(iv): *[The State mitigation strategy **shall** include an] identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan identify **current** sources of Federal, State, local, or private funding to implement mitigation activities?	Chapter 2 Section 2.2 Chapter 21 Section 21.10 and pages 21-29 to 21-47			
B. Does the **new or updated** plan identify **potential** sources of Federal, State, local, or private funding to implement mitigation activities?	Chapter 20 Section 20.6; Chapter 21 Section 21.10 and pages 21-29 to 21-47			
C. Does the updated plan identify the sources of mitigation funding used to implement activities in the mitigation strategy since approval of the previous plan?	Chapter 2 Sections 2.3, 2.4, and 2.5			
		SUMMARY SCORE		

COORDINATION OF LOCAL MITIGATION PLANNING

16. Local Funding and Technical Assistance

Requirement §201.4(c)(4)(i): *[The section on the Coordination of Local Mitigation Planning **must** include a] description of the State process to support, through funding and technical assistance, the development of local mitigation plans.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of the State process to support, through funding and technical assistance, the development of local mitigation plans?	Chapter 20 Section 20.5 and pages 20-30 to 20-41			
B. Does the updated plan describe the funding and technical assistance the State has provided in the past three years to assist local jurisdictions in completing approvable mitigation plans?	Chapter 2 Section 2.5 and Chapter 20 Section 20.3 and pages 20-14 to 20-18			
		SUMMARY SCORE		

17. Local Plan Integration

Requirement §201.4(c)(4)(ii): *[The section on the Coordination of Local Mitigation Planning **must** include a] description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the State Mitigation Plan.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of the **process and timeframe** the State established to **review** local plans?	Chapter 20 Section 20.6 and Chapter 21 Section 21.4.2 and pages 21-13 to 21-14; Section 21.7 to 21.9 and pages 21-18 to 21-29			
B. Does the **new or updated** plan provide a description of the **process and timeframe** the State established to **coordinate and link** local plans to the State Mitigation Plan?	Chapter 20 Section 20.5 and Chapter 21 Section 21.7 to 21.9 and pages 21-18 to 21-29			
		SUMMARY SCORE		

18. Prioritizing Local Assistance

Requirement §201.4(c)(4)(iii): *[The section on the Coordination of Local Mitigation Planning **must** include] criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which **should** include consideration for communities with the highest risks, repetitive loss properties, and most intense development pressures.*

*Further, that for non-planning grants, a principal criterion for prioritizing grants **shall** be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities… Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of the criteria for prioritizing those communities and local jurisdictions that would receive planning and project grants under available mitigation funding programs?	Chapter 20 Section 20.5and pages 20-36-20-37; Chapter 21 Section 21.7 to 21.9 and pages 21-18 to 21-29			

B. **For the new or updated plan, do** the prioritization criteria include, for non-planning grants, the consideration of the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated cost?	Chapter 20 Section 20.3 and Pages 20-11 to 20-13; Section 20.6 and pages 20-37 to 20-41			
C. **For the new or updated plan, do** the criteria include considerations for communities with the highest risk?	Chapter 19 and Chapter 20 Section 20.3 and pages 20-10 to 20-12	*Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.*		
D. **For the new or updated plan, do** the criteria include considerations for repetitive loss properties?	Chapter 9	*Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.*		
E. **For the new or updated plan, do** the criteria include considerations for communities with the most intense development pressures?	Chapter 2 Section 2.4 and Chapter 20 page 20-26	*Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.*		
		SUMMARY SCORE		

19. PLAN MAINTENANCE PROCESS

Monitoring, Evaluating, and Updating the Plan ***Requirement §201.4(c)(5)(i):*** *[The Standard State Plan Maintenance Process **must** include an] established method and schedule for monitoring, evaluating, and updating the plan.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe the method and schedule for monitoring the plan? (e.g., identifies the party responsible for **monitoring**, includes schedule for reports, site visits, phone calls, and/or meetings)	Chapter 21 Section 21.7 and Section 21.8 and Pages 21-18 to 21-28			
B. Does the **new or updated** plan describe the method and schedule for **evaluating** the plan? (e.g., identifies the party responsible for evaluating the plan, includes the criteria used to evaluate the plan)	Chapter 21 Section 21.7 and Section 21.8 and Pages 21-18 to 21-28			
C. Does the **new or updated** plan describe the method and schedule for **updating** the plan?	Chapter 21 Section 21.7 and Section 21.8 and Pages			

	21-18 to 21-28			
D. Does the updated plan include an analysis of whether the previously approved plan's method and schedule worked, and what elements or processes, if any, were changed?	Chapter 1 Section 1.2 and Chapter 21 Section 21.7 and Section 21.8 and Pages 21-18 to 21-28			
		SUMMARY SCORE		

20. Monitoring Progress of Mitigation Activities ***Requirement §201.4(c)(5)(ii):*** *[The Standard State Plan Maintenance Process **must** include a] system for monitoring implementation of mitigation measures and project closeouts. Requirement **§201.4(c)(5)(iii):** [The Standard State Plan Maintenance Process **must** include a] system for reviewing progress on achieving goals as well as activities and projects in the Mitigation Strategy.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe how mitigation measures and project closeouts will be monitored?	Chapter 21 Section 21.8.1			
B. Does the **new or updated** plan identify a system for reviewing progress on achieving goals in the Mitigation Strategy?	Chapter 21 Section 21.8.4			
C. Does the updated plan describe any modifications, if any, to the system identified in the previously approved plan to track the initiation, status, and completion of mitigation activities?	Chapter 21 Sections 21.8.6 and 21.8.7			
D. Does the **new or updated** plan identify a system for reviewing progress on implementing activities and projects of the Mitigation Strategy?	Chapter 21 Section 21.8.5			
E. Does the updated plan discuss if mitigation actions were implemented as planned?	Chapter 1 Section 1.2 and Chapter 2 section 2.3 and pages 2-12 to 2-20; Chapter 21 Section 21.2.2 and pages 21-2 to 21-4 and Section 21.7.4	1.		
		SUMMARY SCORE		

SEVERE REPETITIVE LOSS STRATEGY *(only required for 90/10 under FMA & SRL)*

21. Repetitive Loss Mitigation Strategy

Requirement §201.4(c)(3)(v): *A State may request the reduced cost share authorized under §79.4(c)(2) of this chapter for the FMA and SRL programs, if it has an approved State Mitigation Plan … that also identifies specific actions the State has taken to reduce the number of repetitive loss properties (which* ***must*** *include severe repetitive loss properties), and specifies how the State intends to reduce the number of such repetitive loss properties.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE NOT MET	SCORE MET
A. Does the new or updated plan describe State mitigation goals that support the selection of mitigation activities for repetitive loss properties (see also Part 201.4(c)(3)(i))?	Chapter 9 & each county plan.	***[Note: Only required for SRL 90/10 under FMA & SRL]***		
B. Does the new or updated plan consider repetitive loss properties in its evaluation of the State's hazard management policies, programs, and capabilities and its general description of the local mitigation capabilities (see also Part 201.4(c)(3)(ii))?	Chapter 9 & each county plan.	***[Note: Only required for SRL 90/10 under FMA & SRL]***		
C. Does the new or updated plan address repetitive loss properties in its risk assessment (see also Part 201.4(c)(2))?	Chapter 9 & each county plan.	***[Note: Only required for SRL 90/10 under FMA & SRL]***		
D. Does the new or updated plan identify, evaluate and prioritize cost-effective, environmentally sound, and technically feasible mitigation actions for repetitive loss properties (see also Part 201.4(c)(3)(iii))?	Chapter 9 & each county plan.	***[Note: Only required for SRL 90/10 under FMA & SRL]***		
E. Does the new or updated plan describe specific actions that have been implemented to mitigate repetitive loss properties, including actions taken to reduce the number of severe repetitive loss properties?	Chapter 9 & each county plan.	***[Note: Only required for SRL 90/10 under FMA & SRL]***		
F. Does the new or updated plan identify current and potential sources of Federal, State, local, or private funding to implement mitigation activities for repetitive loss properties (see also Part 201.4(c)(3)(iv))?	Chapter 9 & each county plan.	***[Note: Only required for SRL 90/10 under FMA & SRL]***		
		SUMMARY SCORE		

22. Coordination with Repetitive Loss Jurisdictions

Requirement §201.4(c)(3(v): *In addition, the plan* ***must*** *describe the strategy the State has to ensure that local jurisdictions with severe repetitive loss properties take actions to reduce the number of these properties, including the development of local mitigation plans.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the new or updated plan provide a description of the State process to support, through funding and technical assistance, the development of local mitigation plans in communities with severe repetitive loss properties (see also Part 201.4(c)(4)(i))?	Chapter 2 Section 2.2 and Chapter 9 & each county plan.	***[Note: Only required for SRL 90/10 under FMA & SRL]***		
B. Does the new or updated plan include considerations for repetitive loss properties in its criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available mitigation funding programs (see also Part 201.4(c)(3)(iii))?	Chapter 2 Section 2.2 and Chapter 9 & each county plan.	***[Note: Only required for SRL 90/10 under FMA & SRL]***		
		SUMMARY SCORE		

Matrix A: Profiling Hazards

This matrix can assist FEMA in scoring each hazard. States may find the matrix useful to ensure that their plan addresses each natural hazard that can affect the State. **Completing the matrix is not required.**

Note: First, check which hazards are identified in requirement §201.4(c)(2)(i). Then, place a checkmark in either the N or S box for each ***applicable*** *hazard. An "N" for any element of any identified hazard will result in a "Needs Improvement" score for this requirement. List the hazard and its related shortcoming in the comments section of the Plan Review Crosswalk.*

Hazard Type	Hazards Identified Per Requirement §201.4(c)(2)(i)	A. Location		B. Previous Occurrences		C. Probability of Future Events	
	Yes	N	S	N	S	N	S
Dam Failures	☒	☐	☒	☐	☒	☐	☒
Droughts	☒	☐	☒	☐	☒	☐	☒
Earthquake	☒	☐	☒	☐	☒	☐	☒
Erosion	☒	☐	☒	☐	☒	☐	☒
Floods	☒	☐	☒	☐	☒	☐	☒
Health Risks and Vulnerability	☒	☐	☒	☐	☒	☐	☒
High Surf	☒	☐	☒	☐	☒	☐	☒
Hurricane/Strong Wind	☒	☐	☒	☐	☒	☐	☒
Landslide/Rockfalls	☒	☐	☒	☐	☒	☐	☒
Tsunami	☒	☐	☒	☐	☒	☐	☒
Volcanic Hazards	☒	☐	☒	☐	☒	☐	☒
Wildfires	☒	☐	☒	☐	☒	☐	☒

To check boxes, double click on the box and change the default value to "checked."

Legend:
§201.4(c)(2)(i) Profiling Hazards
A. Does the risk assessment identify the location (i.e., geographic area affected) of each natural hazard addressed in the **new or updated** plan?
B. Does the plan provide information on previous occurrences of each hazard addressed in the **new or updated** plan?
C. Does the plan include the probability of future events (i.e., chance of occurrence) for each hazard addressed in the **new or updated** plan?

Matrix B: Assessing Vulnerability

This matrix can assist FEMA in scoring each hazard. States may find the matrix useful to ensure that their plan addresses each requirement. Note that this matrix only includes items for Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii) that are related to specific natural hazards that can affect the State. **Completing the matrix is not required**.

Note: First, check which hazards are identified in requirement §201.4(c)(2)(i). Then, place a checkmark in either the N or S box for each ***applicable*** *hazard. An "N" for any element of any identified hazard will result in a "Needs Improvement" score for this requirement. List the hazard and its related shortcoming in the comments section of the Plan Review Crosswalk.*

Hazard Type	Hazards Identified Per Requirement §201.4(c)(2)(i)	§201.4(c)(2)(ii) Assessing Vulnerability					§201.4(c)(2)(iii) Estimating Potential Losses				
		1. Vulnerability by Jurisdiction		2. Vulnerability to State Facilities			3. Loss Estimate by Jurisdiction		4. Loss Estimate of State Facilities		
	Yes	N	S	N	S		N	S	N	S	
Dam Failures	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Droughts	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Earthquake	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Erosion	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Floods	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Health Risks and Vulnerability											
High Surf	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Hurricane/Strong Wind	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Landslide/Rockfalls	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Tsunami	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Volcanic Hazards	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Wildfires	☒	☐	☒	☐	☒		☐	☒	☐	☒	
Climate Change	☒	☐	☒	☐	☒		☐	☒	☐	☒	

To check boxes, double click on the box and change the default value to "checked."

Legend

§201.4(c)(2)(ii) Assessing Vulnerability by Jurisdiction (see element B)

1. Does the **new or updated** plan describe the State's vulnerability in terms of the jurisdictions most threatened and most vulnerable to damage and loss associated with hazard event(s)?

§201.4(c)(2)(ii) Assessing Vulnerability to State Facilities (see element A)

2. Does the **new or updated** plan describe the types of State owned or operated critical facilities located in the identified hazard areas?

§201.4(c)(2)(iii) Estimating Potential Losses by Jurisdiction (see element A)

3. Does the **new or updated** plan present an overview and analysis of the potential losses to the identified vulnerable structures?

§201.4(c)(2)(iii) Estimating Potential Losses of State Facilities (see element A)

4. Does the **new or updated** plan present an estimate of the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities in the identified hazard areas?

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