

CHAPTER 10a: NATURAL HAZARDS (Updated 2005)



Maintained by the PRiMO Observations and Data Management Hui

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Theme Description:

Natural hazards of concern in Hawaii include: hurricane/windstorm/storm surge, coastal erosion/sea level rise, tsunamis, inland erosion/landslide/rockslide, wildfire/drought, flood, earthquake, and volcanic eruption/lava flow/emissions.

Some, but not all, changes in the natural environment are treated as hazards, which could potentially result in catastrophic events. Even a gradual change may be considered a natural hazard. Taking the example of coastal erosion, the result can be extensive long-term property loss as well as an increased risk of future catastrophic events (e.g. tsunami run up).

Natural hazard mapping can be broken into two categories: delineated areas susceptible to a hazard in the either the likeliest or the worst-case scenario, and detailed maps showing the degree of sensitivity of areas to the hazard.

Risks from natural hazards may be amplified when there is a concurrence of different natural processes (e.g. tsunami coinciding with strong winds and heavy rain). So, this chapter does not exclude natural processes in the hydrosphere or the biosphere. For example, wildfire risk is measured by the organic fire fuel levels, drought and wind conditions and, especially on the Island of Hawaii, the location of current lava flows.

Mapping the risks from natural hazards uses a combination of empirical data, historical data, and modeling. There are advantages to having multiple analyses of a hazard risk, based on different mixes of historical data, empirical data, and modeling assumptions. Whereas an epidemiologist studying a mosquito-born disease might be interested in total quarterly rainfall, a natural hazards planner might want data on the frequency and severity of the largest storms.

Natural hazards as envisioned in the Hawaii I-Plan is primarily a scientific rather than a policy theme. However, the intended use and even the choice of map name of some of these scientific layers may suggest policy implications (e.g. Flood Insurance Rate Maps and Tsunami Evacuation Zones).

The Physical Environment, Terrestrial Layers, Marine Layers, Hydrography, Elevation/Bathymetry, Imagery, Structures, and Cultural/Demographic chapters of the Hawaii I-Plan provide additional data layers of use for natural hazard preparation and mitigation planning. Other planning data layers used by natural hazard preparedness are not covered in the Hawaii I-Plan, such as fire response maps showing areas where each agency has primary wildfire responsibility.

A final clarification is to note that this chapter covers natural but not manmade hazards, which are often included among “environmental hazards”.

Status:

Natural Hazards Forums

The Pacific Risk Management Ohana (PRiMO, <http://www.csc.noaa.gov/psc/FHMPPI/>) is the network of partners and stakeholders involved in the development and delivery of risk management–related information, products, and services in the Pacific. PRiMO was established at the 2004 Roundtable of Federal Hazard Mitigation Partners in the Pacific Islands (FHMPPI), held in Honolulu, Hawaii in March 2004. PRiMO is based on a mutual recognition of the benefits of collective action, and acknowledges the need for local, national, and regional participation to achieve effective hazard mitigation and dissemination of information. PRiMO members include representatives from government agencies, institutions, and private and non-profit organizations in the Pacific. PRiMO working groups, or Hui O Hana, are: Observations and Data Management; Data Analysis and Decision Support Tools; Risk Reduction and Post Disaster Evaluation; Communications; Education and Outreach; Training; and Traditional Knowledge and Practices.

The Pacific Islands Regional Integrated Science and Assessment (Pacific RISA, <http://research.eastwestcenter.org/climate/risa>) program - supports the emergence of an integrated program of climate risk management in the Pacific region. With an emphasis on reducing Pacific Island vulnerability to climate-related extreme events such as drought, floods and tropical cyclones, this emerging RISA builds substantially on existing regional efforts in climate science and services, including over a decade of regional experience in the development and use of ENSO-based forecasts. Led by researchers at the East-West Center (EWC) in Hawaii, Pacific RISA works in close collaboration with scientific, educational institutions and regional organizations throughout the Pacific. The program emphasizes the effective engagement of Pacific Island communities, governments and businesses in developing effective policies to build resilience in key sectors such as water resource management, coastal resources, agriculture, tourism, disaster management and public health.

The Hawaii Statewide Hazard Mitigation Forum (<http://www.mothernature-hawaii.com/aboutus.html>) was established to raise public awareness on reducing losses due to natural hazards. Within the Forum, the Multihazard Science Advisory Committee (MSAC) brings together physical science and engineering expertise. This technical group is intended to represent access to an evolving comprehensive base of knowledge on natural hazard phenomena. Other entities within the Forum include: the State of Hawaii Earthquake Board, Tsunami Board, and Hurricane Board, which allow members to discuss data and modeling issues. The Hawaii State Hazard Mitigation Plan was adopted by the State and formally approved by the Federal Emergency Management Agency (FEMA) in 2004. This plan serves as the fundamental document to promote hazard mitigation activities within the State of Hawaii (http://www.mothernature-hawaii.com/hazmit_planning_0.htm).

The Hawaii State Civil Defense (SCD, <http://www.scd.state.hi.us/>) sponsored Tsunami Technical Review Committee (TTRC) meets to review tsunami hazard mapping, warning, preparedness, response and recovery issues.

The SCD, University of Hawaii (UH), Pacific Disaster Center (PDC), Hawaii State Department of Land and Natural Resources (DLNR), and Department of Defense (DoD) participate in the National Oceanic and Atmospheric Administration's (NOAA) National Tsunami Hazard Mitigation Program (NTHMP, <http://www.pmel.noaa.gov/tsunami-hazard/>). Tsunami hazard maps have been prepared in the past based primarily on assumed maximum elevation of wave run up, or in some cases, on historic tsunami impacts. In this new program, inundation maps will be based on complex computer modeling of tsunami waves as they move across the ocean and interact with the sea floor and shoreline configuration in shallower near shore water. The inundation maps will undergo review by the State Geologist or other geologist accepted by the State. The accepted inundation maps will provide the basis for county tsunami hazard planning and construction of evacuation route maps. Evacuation zones must be established, or re-established as the case may be, by the counties (<http://www.pmel.noaa.gov/tsunami/time/hi/index.shtml>).

The Hawaii State Earthquake Advisory Committee (HSEAC), also sponsored by the SCD, provides emergency managers with expertise and knowledge to better manage Hawaii's risks and vulnerabilities with regard to earthquakes, tsunami and lava flows. HSEAC has provided technical expertise to the County of Hawaii to adopt the 2000 International Building Code seismic provisions for the latest design of earthquake resistant structures and wrote seismic structural specifications for the county's simplified design procedure ordinance. HSEAC along with the PDC developed a HAZUS Earthquake Loss Estimation Atlas of earthquake damage scenarios in Hawaii and Maui Counties for use in community preparedness planning prior to a future destructive earthquake. HSEAC also coordinated FEMA and NOAA projects to gather data on unique volcanic based soil profiles for the islands of Hawaii and Maui.

Natural Hazards Geospatial Information Services

The Asia Pacific Natural Hazards Information Network (APNHIN), hosted by the Pacific Disaster Center, directly supports disaster and resource managers, planners, governments, and nongovernmental organizations with a suite of applications and information services designed to search for, evaluate, and access high-quality geospatial data for natural hazard applications within the Asia Pacific region. APNHIN comprises a community of organizations who create and share disaster and hazards-related information (<http://apnhin.pdc.org>). At the March 2005 PRiMO Annual meeting, APNHIN was identified as a hazards-related information network that could fulfill PRiMO's data catalog, search, access, and sharing needs. Accordingly, the PRiMO Observations and Data Management Hui drafted a proposal that recommended endorsing the use of, and encourage the participation in APNHIN by its member organizations. In December 2005, the PRiMO Coordinating Council formally endorsed APNHIN.

The Pacific Disaster Center has developed the Asia Pacific Natural Hazards and Vulnerabilities Atlas. This Atlas provides a dynamic geospatial framework through which information may be accessed and viewed over the Internet by the disaster management and humanitarian assistance communities. The Atlas combines baseline geographic and infrastructure data layers with historical and near-real time data on natural hazard events including: earthquakes, tsunamis, volcanoes, wildfires, and tropical storms (<http://atlas.pdc.org>). In April 2005, the PDC deployed Version 2 of the Atlas featuring increased functionality and analytical capabilities, additional data, as well as a new companion Hawaii edition.

GEODE (GEO-Data Explorer) is the data delivery system of the USGS Geologic Discipline and provides unbiased scientific and energy related data to the public via a fully functional, web accessed GIS map server (http://geode.usgs.gov/geode_frame.htm). GEODE displays all types of geologic data including data sets from each of the Geologic Discipline's programs including: Coastal and Marine Geology; Earth Surface Dynamics; Earthquake Hazards; Integrated Natural Resource Sciences; Mineral Resources; National Cooperative Geologic Mapping; and Volcano Hazards.

The Federal Emergency Management Agency has launched a national web site for hazards data, the MultiHazard Mapping Initiative (MMI). The goals of this initiative are to foster the exchange and collection of geospatial hazards data, increase hazard awareness by providing a multihazard mapping capability on the Internet for advisory purposes, and encourage data providers to establish standards based services that facilitate access and distribution of their data for the creating of these maps (<http://www.hazardmaps.gov/atlas.php>).

The Hawaii Resource Information System for Coastal Hazards (HI RISC) is a collaborative effort between the NOAA Pacific Services Center (PSC) and the Pacific Disaster Center. HIRISC will integrate observational data and model-based decision support tool outputs with analytic functionality in a web-based mapping environment to support development of multi-hazard vulnerability maps and their use by decision makers in the State of Hawaii for disaster risk reduction. HI RISC is a Pacific Region Integrated

Data Enterprise (PRIDE, <http://apdrc.soest.hawaii.edu/PRIDE>) project that meets PRIDE's objective of producing integrated data products to enhance the capacity to provide timely oceanographic and environmental data and services to Hawaii and the US Flag Pacific Islands.

The establishment of a Hawaii Post-Disaster Technical Clearinghouse (PDTC) is an initiative of the Hawaii State Civil Defense Tsunami Technical Review Committee (TTRC) and Hawaii State Earthquake Advisory Committee (HSEAC), and the Pacific Disaster Center, to develop a web-based, electronic technical clearinghouse for archiving and displaying information in a Geographical Information System (GIS) database. The PDTC web site, activated immediately following a damaging earthquake or tsunami, will provide users with a central shared repository for efficiently accessing, managing, and viewing all data, surveys, and reports, and provide a single resource point for widespread information exchange among researchers, emergency managers, and practitioners, and for sharing with the media and public. The PDTC implementation strategy highlights a four-phase approach in which user requirements are identified, system design architecture developed, system implementation and maintenance resources and costs identified, and finally a prototype PDTC created for user evaluation (http://www.mothenature-hawaii.com/files/shmp_ch6_mitstrategy.pdf#search='Hawaii%20PostDisaster%20Technical%20Clearinghouse%20%28PDTC%29').

Ongoing Natural Hazards Data Activities

One of the PRiMO Observations and Data Management Hui's principal goals is to provide data framework support for the development and delivery of risk management-related information products and services in the Pacific Basin region (<http://csc.noaa.gov/mailman/listinfo/primo-obsdatahui>). This initiative was defined at the PRiMO Hazard and Risk Data Providers and Brokers workshop held in November 2004. As a result of this workshop, several natural hazards data framework initiatives including a proposed theme structure, data structure documentation files, and data dictionaries involving natural hazards related data and services were developed. The draft regional hazards data structure, theme categorization, and related documentation was presented for review at the March 2005 PRiMO Annual meeting. The natural hazards data framework was subsequently endorsed by PRiMO. The PRiMO Wave and Water Level Data Framework Development workshop was held in December 2005 to engage subject matter experts to develop this initial focus area of the natural hazards framework. Additionally, in January 2005, the PRiMO Observations and Data Management Hui assumed the responsibility of maintaining the Natural Hazards chapter of the Hawaii I-Plan.

The U.S. Integrated Ocean Observing System (IOOS, <http://www.oceanservice.noaa.gov/topics/coasts/monitoring/ioos/ioos.html>) includes efforts to develop and provide systems and applications relevant to mitigating natural hazards, detecting and forecasting oceanic components of climate variability, preserving and restoring healthy marine ecosystems, managing resources for sustainable use, and ensuring public health. Near term goals include establishing Data Management and

Communication (DMAC, <http://dmac.ocean.us>) coordination at the national level and establishing of processes to ensure DMAC coordination at regional levels. The Pacific Islands Integrated Ocean Observing System (PacIOOS, <http://research.eastwestcenter.org/PacIOOS>) is one of eleven regional observing programs around the country that are supporting the emergence of IOOS. The NOAA Integrated Data and Environmental Applications Center (NOAA IDEA Center, <http://research.eastwestcenter.org/PacIOOS/noaaideta.html>) supports PacIOOS and develops new integrated data products and environmental applications on hazards risk management, climate vulnerability and adaptation, and coastal and marine ecosystems.

The Hawaii State Earthquake Advisory Committee (HSEAC), comprised of Hawaii's scientific, engineering and emergency management professions, advises the State and Building Seismic Safety Council (BSSC) of the National Institute of Building Sciences on seismic hazard and related policy issues. The HSEAC and Hawaii State Civil Defense are developing project priorities and seeking funding on mapping the seismic qualities of soils and the risks of liquefaction, which is of greatest concern to coastal alluvial areas.

Maui County and Prescott College are working on a cooperative modeling project through the USGS Science Impact Program (http://www.usgs.gov/science_impact/). Prescott College is one of the universities that the Science Impact Program has external partnerships with to further research activities. The project participants include Blueline Consulting Group LLC, Pacific Disaster Center, Maui County Planning Department, Maui County GIS, Maui County Transportation Department, and others. This project involves the development of several models including a Spatial Growth Model, Water Impact Model, Transportation Impact Model, Risk & Vulnerability Assessment Model, and Fire Fuels Model.

The Pacific Disaster Center and the USGS initiated discussions in April 2005 in regard to the potential synergies that may be realized through the designation of the PDC as a USGS Science Impact Center. A Memorandum of Agreement is being drafted that will establish a collaborative relationship for the PDC under the USGS Science Impact Program to support the development and application of science and information products and services to disaster management activities and organizations within the Asia Pacific region.

The Pacific Disaster Center has been closely collaborating with organizations including the South Pacific Applied Geoscience Commission (SOPAC), the International Tsunami Information Centre (ITIC), and the Intergovernmental Oceanographic Commission's International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) to develop a "Tsunami Awareness Kit" - a tailored collection of resources to help Pacific Island countries prepare for the deadly and destructive potential of tsunamis. Composed of a wide variety of resources including maps, booklets, checklists, brochures, reference materials, visualization products, and movie clips, the Kit's contents are packaged in several formats. Target audiences include Pacific Island disaster managers, as well as government and community leaders, business owners, and educators (<http://www.pdc.org/PDCNewsWebArticles/2005TAK/index.html>).

The Pacific Disaster Center has several models being analyzed or under development including the MIKE11 model (<http://www.dhisoftware.com/mike11>), which adds capabilities in the prediction and mapping of inland and coastal flooding, a real-time storm surge simulation package to model and predict coastal flooding, and a predictive physical model of lava flows. The PDC also funded and developed the Fire Fuels Model component of the Maui County cooperative modeling project.

The Federal Emergency Management Agency has initiated a Flood Map Modernization Program that calls for acquiring LIDAR (Light Detection and Ranging) data as described in the elevation and bathymetry chapter (http://www.fema.gov/fhm/mm_main.shtm). Once the imagery is collected and elevations derived, FEMA will derive new flood map products using historical/empirical information combined with modeling.

The NOAA Pacific Services Center (PSC) has overseen the development of three projects for decision-support tools: 1) the Risk Management Measure Assessment Tool (RMMAT), 2) the Storm Damage Assessment and Reporting Tool (SDART), and 3) the Slope Movement Assessment and Reporting Tool (SMART). PSC also assisted in creating draft Environmental Sensitivity Index (ESI) maps for American Samoa and plans for updating these maps for Guam and the Commonwealth of the Northern Mariana Islands (CNMI). The ESI maps will be used during responses to oil and chemical spills and for response planning (<http://www.csc.noaa.gov/psc/riskmgmt.html>).

Natural Hazards-related Data Layers

The following table lists significant data layers for each natural hazard sub-theme, identifies the data source, provides a link to the data, and describes the data. The information was derived from the Hawaii Natural Hazards Data Dictionary, v February 2005. This Data Dictionary was created by and is maintained by the PRiMO Observations and Data Management Hui (<http://csc.noaa.gov/mailman/listinfo/primobsdatahui>). The complete version of the Data Dictionary also includes the following information: Data Type, Scale/Resolution, Spatial Extent, Projection/Datum, Last Update, Metadata Status, Licensing Status, and Additional Notes.

Data Sources

Data source information and links to the data are documented in the following Significant Natural Hazards-related Data Layers table:

Data Layer	Data Source/Link	Data Description
<i>I. Hurricane/Windstorm/Storm Surge</i>		
Active Watches and Warnings	NOAA/NWS/Honolulu Forecast Office http://www.prh.noaa.gov/hnl/pages/watchwarn.php	Watches/warnings/advisories/statements that have been issued for Hawaii, and the surrounding waters.

Active Tropical Cyclones	PDC/Asia Pacific Natural Hazards and Vulnerabilities Atlas http://atlas.pdc.org/	Current tropical cyclones - previous, current, and forecast positions. Information is based on message traffic received from JTWC and NWS/NCEP/TPC.
Active Storm Winds	PDC/Asia Pacific Natural Hazards and Vulnerabilities Atlas http://atlas.pdc.org/	Previous, current, and predicted storm winds reported for current tropical cyclones. Information is based on message traffic received from JTWC and NWS/NCEP/TPC.
Wind Summary	NOAA/NWS/Honolulu Forecast Office http://www.prh.noaa.gov/hnl/Products/hiwinds.php	Hourly wind summary for Hawaii.
Historical Tropical Cyclone Storm Tracks	PDC/Asia Pacific Natural Hazards Information Network http://apnhin.pdc.org/	Historical storm tracks from 1945-2002. Only storms that were classified above a tropical depression in strength are included. Information includes charts on the track of the storm, tracking position in latitude and longitude, maximum sustained winds in knots, and central pressure in millibars.
Tropical Storm Intensity Zones	PDC/Asia Pacific Natural Hazards Information Network http://apnhin.pdc.org/	Tropical storm intensity zones based on the 5 different wind speeds of the Saffir-Simpson Hurricane Scale. Indicates probable property damage.
Tropical Cyclone Wind Damage Assessment	PDC/Asia Pacific Natural Hazards and Vulnerabilities Atlas http://atlas.pdc.org/ , http://www.pdc.org/pdf/Modeling_webformat.pdf	The CATS model uses NWS tropical storm advisories to map predicted storm paths and predicted wind speeds.
Regional Spectral Model for 10 Meter Winds	NOAA/NWS/Honolulu Forecast Office http://www.prh.noaa.gov/hnl/pages/rsm_page.php	Forecast plots display the ten-meter wind directions in degrees and speeds in knots.
Orographically Amplified Wind Loss Models	Martin & Chock Inc. and Cermak Peterka Petersen Inc. http://www.martinchock.com/Orographicshort1.htm	Risk and consequence assessments of windstorm damage to structures, including the impact of wind amplification caused by topography.
Overwash from Hurricane Iniki	State of Hawaii/CZM http://www.state.hi.us/dbedt/gis/tsunhts.htm	Overwash resulting from storm surge during Hurricane Iniki determined from aerial photography flown after the hurricane.
Storm-Induced Coastal Flooding	UH/SOEST/Dept of Ocean and Resources Engineering http://oe.soest.hawaii.edu/OE/research.html	Model outputs surge, waves, and run up as a function of time and could be used to develop additional overwash zones on other islands based on specified storm scenarios. Validated using Hurricane Iniki data.
Storm Surge Heights Resulting from Tropical Cyclones	PDC http://www.pdc.org/pdf/Modeling_webformat.pdf	TAOS is a numerical model that estimates peak winds and storm surge heights resulting from tropical cyclones.
Storm Surge Modeling	PDC http://www.pdc.org/pdf/Modeling_webformat.pdf	Real-time simulation package to model and predict coastal flooding - currently under development.

II. Coastal Erosion/Sea Level Rise		
Beach Monitoring	USGS/CMG & UH/SOEST/CGG http://geopubs.wr.usgs.gov/open-file/of01-308/	The overall goals of this study are to document the coastal erosion history in Hawaii, determine the causal factors of that erosion, provide high-quality data for other end-users in applied studies, and increase general understanding of low-latitude coastal geologic development.
Coastal Lands Program	State of Hawaii/DLNR/OCCL http://www.state.hi.us/dlnr/occl/coastal.php	Project initiatives include developing pilot programs for beach nourishment, streamlining the beach nourishment regulatory process, restoration of beaches, and funding sediment and coastal engineering studies to better understand complex coastal areas.
Atlas of Natural Hazards in the Hawaiian Coastal Zone	USGS http://pubs.usgs.gov/imap/i2761/	The history and relative intensity of coastal hazards in Hawaii.
Atlas of Natural Hazards in the Hawaiian Coastal Zone – Vector Data	PDC/Asia Pacific Natural Hazards Information Network http://apnhin.pdc.org/	Shapefile versions of the technical hazard maps published in the Atlas: Geologic Attributes; Erosion Hazard Intensity; High Wave Intensity; Sea Level Hazard Intensity; Stream Flooding Hazard Intensity; Tsunami Hazard Intensity; Volcanic and Seismic Hazard Intensity; Slope; and Overall Hazard Assessment.
Maui County Shoreline Atlas	County of Maui http://www.co.maui.hi.us/departments/Planning/erosion.htm	Maps of coastal erosion hazards along Maui's shoreline depicting the average annual erosion rate calculated by linear regression of historical shoreline positions.
Sea Level Data	UH/SLC http://ilikai.soest.hawaii.edu/uhslc/datai.html	The University of Hawaii Sea Level Center provides 3 online databases; the research quality data, the GLOSS/CLIVAR "fast delivery" data, and the JCOMM Sea Level Program in the Pacific map data.
Buoy Reports	NOAA/NWS/Honolulu Forecast Office http://www.prh.noaa.gov/hnl/pages/obs.php	Wave height, swell height, wind direction, and wind speed.
CO-OPS Water Level Observation Network	NOAA/NOS http://tidesonline.nos.noaa.gov/geographic.html	Water level station data by State.
CO-OPS Mean Sea Level Trends	NOAA/NOS http://www.co-ops.nos.noaa.gov/sltrends/sltrends_states.shtml?region=hi	Water level records are a combination of the fluctuations of the ocean and the vertical land motion at the location of the station. The sea level variations determined are the linear trend, the average seasonal cycle, and the interannual variability at each station.
Coastlines	USGS/Hawaii Data Clearinghouse http://www.hinhp.org/website/hawaii/data.html	Coastlines for the main Hawaiian Islands. Extracted from 1:24,000 USGS Digital Line Graphs. Datasets are island-based.

National Coastal Data Development Center	NOAA/NCDDC http://www.ncddc.noaa.gov/	The NCDDC provides for the archive of, and access to, the long-term coastal data record.
National Oceanographic Data Center	NOAA/NODC http://www.nodc.noaa.gov/	The NODC manages the acquisition, ingest processing, quality control and long-term preservation of physical, chemical, and biological oceanographic data.
III. Tsunami		
Tsunami Bulletins	NOAA/PTWC http://www.prh.noaa.gov/ptwc/bulletins.htm	Pacific Basin and Indian Ocean tsunami bulletins, warnings, watches or advisories.
Tsunami Inundation Maps	NOAA/PMEL/NTHMP http://www.pmel.noaa.gov/tsunami/time/hi/index.shtml	New tsunami inundation maps for Hawaii's coastal regions are being created by Hawaii Civil Defense working in conjunction with tsunami inundation models.
Tsunami At-risk Population	NOAA/PMEL/NTHMP http://www.pmel.noaa.gov/tsunami/time/hi/population/index.shtml	Tsunami at-risk population for the communities of Hawaii within one kilometer of the coast.
Tsunami Evacuation Zones	PDC/Asia Pacific Natural Hazards Information Network http://apnhin.pdc.org/	Tsunami evacuation zones for the major Hawaiian Islands.
Locally-generated Tsunamis in Hawaii	UH/SOEST http://www.soest.hawaii.edu/tsunami/	Estimations of the inundation hazard in Hawaii from locally generated tsunamis.
Tsunami Wave Heights	State of Hawaii/DBEDT/OP http://www.state.hi.us/dbedt/gis/tsunhts.htm	Readings of tsunami wave heights at various locations from the 1946, 1952, 1957, 1960 and 1964 Hawaii tsunamis.
Tsunami Event and Runup Databases	NOAA/NGDC http://www.ngdc.noaa.gov/seghazard/tsu.shtml	Event db contains information such as the cause of the tsunami, the source location, the magnitude and intensity of the tsunami, etc. The Runup db contains information on locations where tsunami effects occurred.
Tsunami Time and Inundation Model and Visualization	PDC http://www.pdc.org/pdf/Modeling_webformat.pdf	The Tsunami Time Travel Model estimates the time it would take a tsunami wave to cross the Pacific Basin and generates a contour map showing tsunami travel times for the entire region.
IV. Inland Erosion/Landslide/Rockslide		
Hawaii Soil Survey Geographic (SSURGO) Database	USDA/NRCS http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/dta/hi.html	This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey.
Debris-flow Hazard in the Honolulu District of Oahu, Hawaii	USGS http://geopubs.wr.usgs.gov/open-file/of93-213/	Map depicting debris-flow hazard in the Honolulu District of Oahu, Hawaii.
Debris-flow Hazards in the United States	USGS http://pubs.usgs.gov/fs/fs-176-97/fs-176-97.html	Information on debris flow hazards, sometimes referred to as fast-moving landslides, including mudslides, mudflows, lahars, or debris avalanches.

National Landslide Hazards Mitigation Strategy	USGS http://pubs.usgs.gov/circ/c1244/	A comprehensive national strategy for reducing losses from landslides, including activities at the national, State, and local levels, in both the public and private sectors.
V. Wildfire/Drought		
Fire Weather Planning Forecast	NOAA/NWS/Honolulu Forecast Office http://www.prh.noaa.gov/hnl/pages/firewx.php	Sky/weather, max temperature, min humidity, 20-foot winds, mixing height, transport winds.
Hawaii Wildfire Data	State of Hawaii/DLNR/DOFAW http://www.hawaii.gov/dlnr/dofaw/fmp/firedata.htm	Fire report data records since 1975 maintained by DOFAW. Data includes lat/long, acres burned, general cause, fuel model, ignition component spread component, and damage.
Maui County Fire Fuels Mapping	PDC	High-resolution, up-to-date fire fuels map that is periodically updated to reflect land use/landcover changes. Utilized for wildfire planning activities within Maui County.
Asia Pacific Historical Large Wildfires	PDC/Asia Pacific Natural Hazards Information Network http://apnhin.pdc.org/	Large wildfires (>2000 acres in size) from March 2000-October 2004 in the Asia Pacific region. Includes information on the date, location, size, and intensity of each wildfire.
Asia Pacific Recent MODIS Hotspots	PDC/Asia Pacific Natural Hazards and Vulnerabilities Atlas http://atlas.pdc.org/	Location, size, and intensity of thermal anomalies in the Asia Pacific region for the past week. Derived from MODIS (Moderate Resolution Imaging Spectroradiometer) satellite data.
Wildfire Interactive Maps	NOAA/NGDC http://www.ngdc.noaa.gov/se/hazard/wildfire.shtml	Real time environmental satellite data and derived products including the Hazard Mapping System Fire and Smoke Product (HMS) and the WF-ABBA product. Derived from GOES satellite data.
OSEI Fire Products	NOAA/NESDIS http://www.osei.noaa.gov/Events/Fires/	Fire products include multichannel color composite imagery and single-channel grayscale imagery of major wildfire and controlled burn events. Products in this event group show smoke, hotspots or both.
Drought Announcements	State of Hawaii/CWRM http://www.hawaii.gov/dlnr/cwr/drought/index.htm	Drought announcements - current and archived.
U.S. Drought Monitor	NDMC http://www.drought.unl.edu/dm/monitor.html	Summary map based on a multi-index drought classification scheme.
Solar radiation (sunshine maps)	State of Hawaii/DLNR http://www.state.hi.us/dbedt/gis/solrad.htm	Estimated daily solar insolation contours, in calories/sq.cm/day.
Climate Information	NOAA/NWS/Honolulu Forecast Office http://www.prh.noaa.gov/hnl/pages/hiclimat.php	Daily and monthly temperature and precipitation summaries.
VI. Flood		

Active Watches and Warnings	NOAA/NWS/Honolulu Forecast Office http://www.prh.noaa.gov/hnl/pages/watchwarn.php	Watches/warnings/advisories/statements that have been issued for Hawaii, and the surrounding waters.
Real-Time Stream Flow Data	USGS/WRD http://waterdata.usgs.gov/hi/nwis/rt	Real-time data typically are recorded at 15-60 minute intervals, stored onsite, and transmitted every 1-4 hours, depending on the data relay technique used.
Real-Time Rain Gauge Data	NWS and PDC/Asia Pacific Natural Hazards Information Network http://apnhin.pdc.org/	Rainfall totals for approved NWS rain gauge stations for Hawaii. Data is downloaded several times daily from the National Weather Service, Honolulu Forecast Office.
Climate Information	NOAA /NWS/Honolulu Forecast Office http://www.prh.noaa.gov/hnl/pages/hiclimat.php	Daily and monthly temperature and precipitation summaries.
Digital Flood Insurance Rate Maps	FEMA http://www.state.hi.us/dbedt/gis/dfirm.htm , http://store.msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1&userType=G	Digital flood map data for the islands of Kauai, Oahu, Kahoolawe, Maui, Molokai, Lanai and Hawaii.
Regional Spectral Model - Precipitation 3 Hour Totals	NOAA/NWS/Honolulu Forecast Office http://www.prh.noaa.gov/hnl/pages/rsm_page.php	Forecast plots display the total precipitation in inches for the three hours preceding the valid forecast time.
Flood and Erosion Forecasting Modeling	PDC http://www.pdc.org/pdf/Modeling_webformat.pdf	The MIKE11 model forecasts flood and erosion scenarios.
Dam Failure Flood Inundation Modeling	PDC http://www.pdc.org/pdf/Modeling_webformat.pdf	The M2M model converts FLDWAV model values into an inundation map that shows which downstream areas will be flooded. Three types of analysis can be made from the model output: Quick Assessment; Vulnerability Assessment; and Economic Damage Assessment.
VII. Earthquake		
Recent Earthquakes in Hawaii	USGS/HVO http://elsei.wr.usgs.gov/results/seismic/recenteqs/	Index maps for each County depicting recent earthquakes. Updated within 5 minutes of an earthquake or once an hour.
Destructive Earthquakes in Hawaii County since 1868	USGS/HVO http://hvo.wr.usgs.gov/earthquakes/destruct/	Date, epicenter location, max intensity, magnitude, deaths, and damage.
Seismicity for the Island of Hawaii	USGS/HVO http://hvo.wr.usgs.gov/earthquakes/seismicity/	Annual seismicity of the Island of Hawaii for the years 1992-2000. In particular the tectonic and volcanic earthquakes as they relate to major fault zones and to the eruptions and intrusions of magma.
Seismic-Hazard Maps for Hawaii	USGS http://pubs.usgs.gov/imap/i-2724/	Probabilistic seismic hazard maps portraying peak horizontal ground acceleration and horizontal spectral response.

Earthquake Hazards in Hawaii	USGS/HVO http://hvo.wr.usgs.gov/earthquakes/hazards/	Report on seismic hazards in Hawaii related to ground shaking.
Significant Earthquakes and Earthquake Intensity Databases	NOAA/NGDC http://www.ngdc.noaa.gov/seis/hazard/earthqk.shtml	Information on destructive earthquakes from 2150 B.C. to present and damage/felt reports for U.S. earthquakes from 1638 to 1985.
Global Earthquake Catalog	ANSS http://quake.geo.berkeley.edu/cnss/catalog-search.html	Earthquake hypocenters (epicenters and depths) with date, time and magnitude.
Earthquake Damage Model	PDC http://www.pdc.org/pdf/Modeling_webformat.pdf	FEMA's loss estimation model, HAZUS, estimates structural and economic impacts that can result from an earthquake. GIS-based maps that depict damage to various structure types are created. Direct and induced physical damage to essential facilities are identified. Potential direct and economic social loss is calculated.
Hawaii HAZUS Atlas	PDC/Hawaii HAZUS Atlas http://www.pdc.org/hha/html/hzshome.jsp	In collaboration with HSCD and HSEAC, PDC has developed the Hawaii HAZUS Atlas (HHA). HHA is designed to provide a better understanding of potential future earthquake scenarios and expected damage loss estimates for Hawaii and Maui Counties. Using FEMA's loss estimation model, HAZUS, HHA contains damage loss calculations for each scenario. HHA assists communities in disaster planning before, during, and after a destructive earthquake.
<i>VIII. Volcanic Eruption/Lava Flow/Emissions</i>		
Kilauea Volcano Eruption Update and Image Archive	USGS/HVO http://hvo.wr.usgs.gov/kilauea/update/	Eruption update, image archive, deformation information, and maps of current lava flows for Kilauea Volcano.
Lava Flow Boundaries	USGS/HVO http://www.hawaii.gov/dbedt/gis/data/lavaflow_ohd.txt	1961, 1977, 1983, 1984, 1986, 1989 and 1990 East Rift Zone lava flow boundaries of Kilauea Volcano.
Lava Flow Hazard Zones on the Island of Hawaii	USGS/HVO http://pubs.usgs.gov/gip/hazards/maps.html	Maps showing volcanic hazard zones on the Island of Hawaii. Zones are ranked from 1 through 9 based on the probability of coverage by lava flows.
Lava Inundation Zones for Mauna Loa, Hawaii	USGS/HVO http://geopubs.wr.usgs.gov/map-mf/mf2401/	Maps estimating the areas most likely to be affected by eruptions originating on various parts of Mauna Loa Volcano based on known source vents and areas affected by past eruptions.
Volcanic and Seismic Hazards on the Island of Hawaii	USGS/HVO http://pubs.usgs.gov/gip/hazards/hazards.html	Fact sheet describing volcanic hazards including lava flows, airborne lava fragments, volcanic gases, explosive eruptions, ground cracks, and settling.
Geologic Map of the Island of Hawaii	USGS http://volcanoes.usgs.gov/About/Highlights/HawaiiMap/HawaiiMap.html	This map is a compilation of geologic mapping from 1975-1995 and shows the age and distribution of lavas that form the surfaces of the five volcanoes on the Island of Hawaii.

OSEI Volcano Products	NOAA/NESDIS http://www.osei.noaa.gov/Events/Volcano/	Volcano products include multi-channel color composite imagery showing major ash clouds, hotspots from lava flow or both.
Asia Pacific Recent MODIS Hotspots	PDC/Asia Pacific Natural Hazards and Vulnerabilities Atlas http://atlas.pdc.org/	Location, size, and intensity of thermal anomalies in the Asia Pacific region for the past week. Derived from MODIS (Moderate Resolution Imaging Spectroradiometer) satellite data.
Volcanic Air Pollution	USGS/HVO http://pubs.usgs.gov/fs/fs169-97/	Fact sheet describing volcanic air pollution from Kilauea Volcano on the Island of Hawaii.
Volcano and Volcanic Ash Advisory Databases	NOAA/NGDC http://www.ngdc.noaa.gov/se/g/hazard/volcano.shtml	Latitude, longitude, elevation, type of volcano, and last known eruption.

Standards:

One of the few existing natural hazards geospatial data layer standards is FEMA's guidelines and specifications for its Digital Flood Insurance Rate Map (DFIRM) product (http://www.fema.gov/fhm/frm_bsmpt.shtml).

Inconsistencies in natural hazards data from various sources can limit the ability of hazard and emergency management organizations to assess risk, determine vulnerability, and appropriately mitigate disasters. The development and application of standards for natural hazard data content will help to improve the ability to identify, access, analyze, and share information and will provide a consistent data schema for subsequent data collection and map production.

Existing geospatial information services with a broad-based natural hazards focus such as the PDC's Asia Pacific Natural Hazard Information Network (APHNIN, <http://apnhin.pdc.org>) and FEMA's MultiHazard Mapping Initiative (MMI, <http://www.hazardmaps.gov/atlas.php>) have applied Federal Geographic Data Committee (FGDC) standards (<http://www.fgdc.gov/standards/standards.html>) to the fullest extent possible. However, it should be noted that a natural hazards data theme in the FGDC and International Organization for Standardization (ISO) geospatial data standards does not currently exist.

The absence of a natural hazards data theme prompted PRiMO to assign their Observations and Data Management Hui (<http://csc.noaa.gov/mailman/listinfo/primobsdatahui>) the task of developing a regional natural hazards data framework. This initiative was defined at the PRiMO Hazard and Risk Data Providers and Brokers workshop held in November 2004. As a result of this workshop, several natural hazards data framework initiatives including a proposed theme structure, data structure documentation files, and data dictionaries involving natural hazards related data and services were developed. The draft regional hazards data structure, theme categorization, and related documentation were presented for review at the March 2005 PRiMO Annual meeting. The natural hazards data framework was subsequently endorsed by PRiMO. The PRiMO Wave and Water Level Data Framework Development workshop was held

in December 2005 to engage subject matter experts to develop this initial focus area of the natural hazards framework.

Priority:

Natural hazards mapping for the purposes of mitigation and disaster planning have high priority given Hawaii's setting. Analysis of annualized economic losses indicates that the highest threats in Hawaii are: 1) hurricanes, 2) seismic hazards, 3) volcanic hazards, and 4) tsunamis. The economic fallout from hurricane Iniki on the island of Kauai lasted for a decade. Kilauea Volcano is the most active volcano in the world, and Mauna Loa Volcano is showing signs of possible renewed activity. The city of Hilo and other coastal locales on the Big Island have a past history of tsunami events.

The priority is high enough that funding for natural hazards-related mapping has benefited core FGDC themes. The OrthoImagery theme has benefited where USDA has funded the Emerge CIR DOQQ collection, the State of Hawaii has funded the QuickBird DOQQ collection, the USGS has funded the IDP DOQ collection, and the NGA has funded the Honolulu EarthData orthoimagery collection. The Elevation/Bathymetry theme has also benefited where FEMA, USACE, NOAA and local partners are funding the acquisition of LIDAR data collections.

Estimated total investment in this theme:

Investment in natural hazards data development and mapping is not easily broken out from other activities performed by organizations. A narrow view would include the labor and equipment of dedicated mapping professionals. A broad view would include:

- the cost of baseline imagery, elevation, topologic and infrastructure data,
- the cost of purchasing, supporting and maintaining monitoring equipment,
- the cost of developing and updating models and run-time costs, and
- the cost of developing and maintaining a primary information network.

Natural hazards mapping is usually budgeted in combination with disaster preparation mapping such as evacuation zones, primary transportation routes, and critical infrastructure. Natural hazards mapping of specific data layers are usually ad hoc projects (unlike the FEMA Flood Map Modernization project). In addition to government agencies, the PDC, which is a non-profit organization, has a large investment in natural hazards data, models, and information services.

Estimates of annual investment is \$1,000,000 - \$2,500,000. This estimate is a range to indicate both views. Baseline data acquisition costs incorporated in other chapters of the Hawaii I-Plan is not included in this section.

Estimated current state and local contributions:

The State and Counties have contributed towards individual natural hazard projects on an ad hoc basis. Over the last decade, the State Office of Planning has often created digital

versions of layers mapped by other organizations. Maui County funded its coastal erosion mapping. There is County participation in hurricane wind speed-up mapping. FEMA has been partnering with the State and Counties to fund LIDAR acquisition for flood map modernization.

What is needed:

At present, some of the primary needs for natural hazards mapping include:

- the continued collection of imagery, bathymetry and LIDAR for elevation models,
- the completion of the High Wind modeling using the Speed-up Methodology,
- the porting the Storm-Induced Coastal Flooding model to be available to be run for hypothetical storm scenarios as well as in real-time for actual storms on the supercomputer at the Maui High Performance Computer Center (MHPCC, <http://www.mhpcc.edu>),
- the continued funding of tsunami inundation and evacuation route mapping, and
- the funding of engineering assessments of the seismic qualities of soils and the risks of liquefaction, which is of greatest concern to areas built on coastal alluvial areas, due to local ground motion amplification.

The primary needs listed are not in prioritized order.

What is the likely source:

Likely sources include NOAA (hurricane, tsunami, coastal erosion hazards, LIDAR, information services), USACE (LIDAR), FEMA (flood hazards, LIDAR), USGS (earthquake, volcanic hazards), and PDC (hazard modeling, information services).

Estimated current allocation of funding:

Estimated current allocation of funding, mostly in ad hoc projects is \$400,000.

Estimated budget shortfall:

Completion of the High Wind Speed-up mapping is an identified shortfall with estimated costs of \$450,000.

Coastal erosion mapping is covered in the Marine Layers chapter of the Hawaii I-Plan.

Possible ways to overcome this gap:

The Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA) administers the majority of funding and grant programs related to hazard mitigation (<http://www.fema.gov/fima/>).

A number of other agencies and organizations including USGS, NOAA, USACE, EPA, DOT, NASA, and PDC may provide funding and support for hazard mitigation projects

and planning, natural hazards-related data collection and revision, and modeling development activities.

Bill S.50, the Tsunami Preparedness Act of 2005 was passed in the Senate by unanimous consent on July 1, 2005 and moved on to the House to be voted on (<http://www.govtrack.us/congress/bill.xpd?bill=s109-50>). The Coastal Community Vulnerability and Adaptation Program (S.50, Section 8) specifies the establishment of a "NOAA coastal vulnerability and adaptation program focused on improving the resilience of coastal communities to natural hazards and disasters. The program shall be regional in nature, build upon and integrate existing Federal and State programs, and provide usable products to improve the preparedness of communities, businesses and government entities. The program may include the following activities: 1) Development of multi-hazard vulnerability maps; 2) Multi-disciplinary vulnerability assessment, research and education; 3) Risk management and leadership training; 4) Risk assessment technology development; 5) Risk management data and information services; and 6) Risk communication systems. Within 1 year after the date of enactment of this Act, the Administrator shall establish 3 pilot projects to conduct regional vulnerability assessment and priority shall be given to collaborative partnership proposals from regionally-based multi-organizational coalitions. There are authorized to be appropriated to the Administrator of NOAA \$5,000,000 for each of fiscal years 2006 through 2012 to carry out section 8, of which at least \$3,000,000 for each fiscal year shall be used to carry out the pilot projects authorized by section 8 (b)."

Most appropriate data steward:

Existing geospatial information services with a broad-based natural hazards focus are the PDC's Asia Pacific Natural Hazard Information Network (APHNIN, <http://apnhin.pdc.org>) and FEMA's MultiHazard Mapping Initiative (MMI, <http://www.hazardmaps.gov/atlas.php>).

Other natural hazards-related data providers and services such as USGS/HVO, USGS/GEODE, NOAA/PTWC, NOAA/NGDC, NOAA/NWS, UH/SOEST, and the proposed Hawaii Post-Disaster Technical Clearinghouse have their focus on specific natural hazard sub-theme(s) and/or may not have the appropriate level of geospatial information services capabilities in place to support a broad-based natural hazards data steward role.

Maintenance Process:

Updating data for natural hazards is likely to be required as new natural hazard models are developed, improved instrumentation or scientific advances lead to better data, or a major natural disaster occurs (such as large magnitude earthquake, volcanic eruption, hurricane, or tsunami). Recent examples of major natural disasters that have led to improved collection instrumentation, data updates and model development are the Indian Ocean Tsunami and Hurricane Katrina.

Estimated Maintenance cost:

Mostly where data maintenance is needed, it is already included in the budgets, with the exceptions of natural hazards mentioned above. The annual costs of maintaining natural hazards data is likely to vary greatly from one year to the next.

List of Acronyms

ANSS – Advanced National Seismic System
APHNIN - Asia Pacific Natural Hazard Information Network
BSSC - Building Seismic Safety Council
CATS – Consequences Assessment Tool Set
CLIVAR – Climate Variability and Predictability Programme
CNMI - Commonwealth of the Northern Mariana Islands
CO-OPS – Center for Operational Oceanographic Products and Services
CWRM – State of Hawaii Commission on Water Resource Management
CZM – State of Hawaii Coastal Zone Management Program
DBEDT – State of Hawaii Department of Business, Economic Development. & Tourism
DFIRM - Digital Flood Insurance Rate Map
DHS – U.S. Department of Homeland Security
DLNR - State of Hawaii Department of Land and Natural Resources
DMAC - Data Management and Communication
DoD – U.S. Department of Defense
DOFAW – State of Hawaii Division of Forestry and Wildlife
DOQ - Digital Orthophoto Quadrangle
DOQQ - Digital Orthophoto Quarter Quadrangle
DOT – U.S. Department of Transportation
EPA – Environmental Protection Agency
ESI - Environmental Sensitivity Index
EWC - East-West Center
FGDC – Federal Geographic Data Committee
FEMA - Federal Emergency Management Agency
FHMPPPI - Federal Hazard Mitigation Partners in the Pacific Islands
GEODE - GEO-Data Explorer
GIS - Geographic Information System
GLOSS - Global Sea Level Observing System
GOES – NOAA Geostationary Operational Environmental Satellites
HAZUS – Hazard U.S.
HHA - Hawaii HAZUS Atlas
HI RISC - Hawaii Resource Information System for Coastal Hazards
HMS - Hazard Mapping System
HSEAC - Hawaii State Earthquake Advisory Committee
HVO - Hawaiian Volcano Observatory
IDP – Imagery Derived Products
IOG - Intergovernmental Oceanographic Commission
IOOS - Integrated Ocean Observing System

ISO – International Organization for Standardization
ITIC – International Tsunami Information Centre
ITSU - International Coordination Group for the Tsunami Warning System in the Pacific
JCOMM - Joint WMO/IOC Commission for Oceanography and Marine Meteorology
JTWC – Joint Typhoon Warning Center
LIDAR - Light Detection and Ranging
MHPCC - Maui High Performance Computer Center
MMI - MultiHazard Mapping Initiative
MODIS - Moderate Resolution Imaging Spectroradiometer
MSAC - Multihazard Science Advisory Committee
NASA – National Aeronautics and Space Administration
NCDDC – National Coastal Data Development Center
NCEP - National Centers for Environmental Prediction
NDMC - National Drought Mitigation Center
NESDIS – National Environmental Satellite, Data, and Information Service
NGA – National Geospatial-Intelligence Agency
NGDC – National Geophysical Data Center
NOAA - National Oceanic and Atmospheric Administration
NOAA IDEA Center – NOAA Integrated Data and Environmental Applications Center
NODC - National Oceanographic Data Center
NOS – National Ocean Service
NRCS – Natural Resources Conservation Service
NTHMP - National Tsunami Hazard Mitigation Program
NWS – National Weather Service
OCCL - State of Hawaii Office of Conservation and Coastal Lands
OP – State of Hawaii Office of Planning
OSEI - Operational Significant Event Imagery
Pacific RISA – Pacific Islands Regional Integrated Science and Assessment
PacIOOS - Pacific Islands Integrated Ocean Observing System
PDTC - Hawaii Post-Disaster Technical Clearinghouse
PRIDE - Pacific Region Integrated Data Enterprise
PRiMO - Pacific Risk Management Ohana
PDC - Pacific Disaster Center
PMEL – Pacific Marine Environmental Laboratory
PSC - Pacific Services Center
PTWC – Pacific Tsunami Warning Center
RMMAT - Risk Management Measure Assessment Tool
SCD - Hawaii State Civil Defense
SDART - Storm Damage Assessment and Reporting Tool
SMART - Slope Movement Assessment and Reporting Tool
SOEST – UH School of Ocean and Earth Science and Technology
SOPAC - South Pacific Applied Geoscience Commission
SSURGO - Soil Survey Geographic Database
TAOS - The Arbiter of Storms
TPC - Tropical Prediction Center
TTRC - Tsunami Technical Review Committee

UH - University of Hawaii
UHSLC – University of Hawaii Sea Level Center
USDA – U.S. Department of Agriculture
USACE – U.S. Army Corps of Engineers
USGS - U.S. Geological Survey
WMO - World Meteorological Organization
WRD – USGS Water Resources Division