Hawaii Coastal Hazard Mitigation Guidebook

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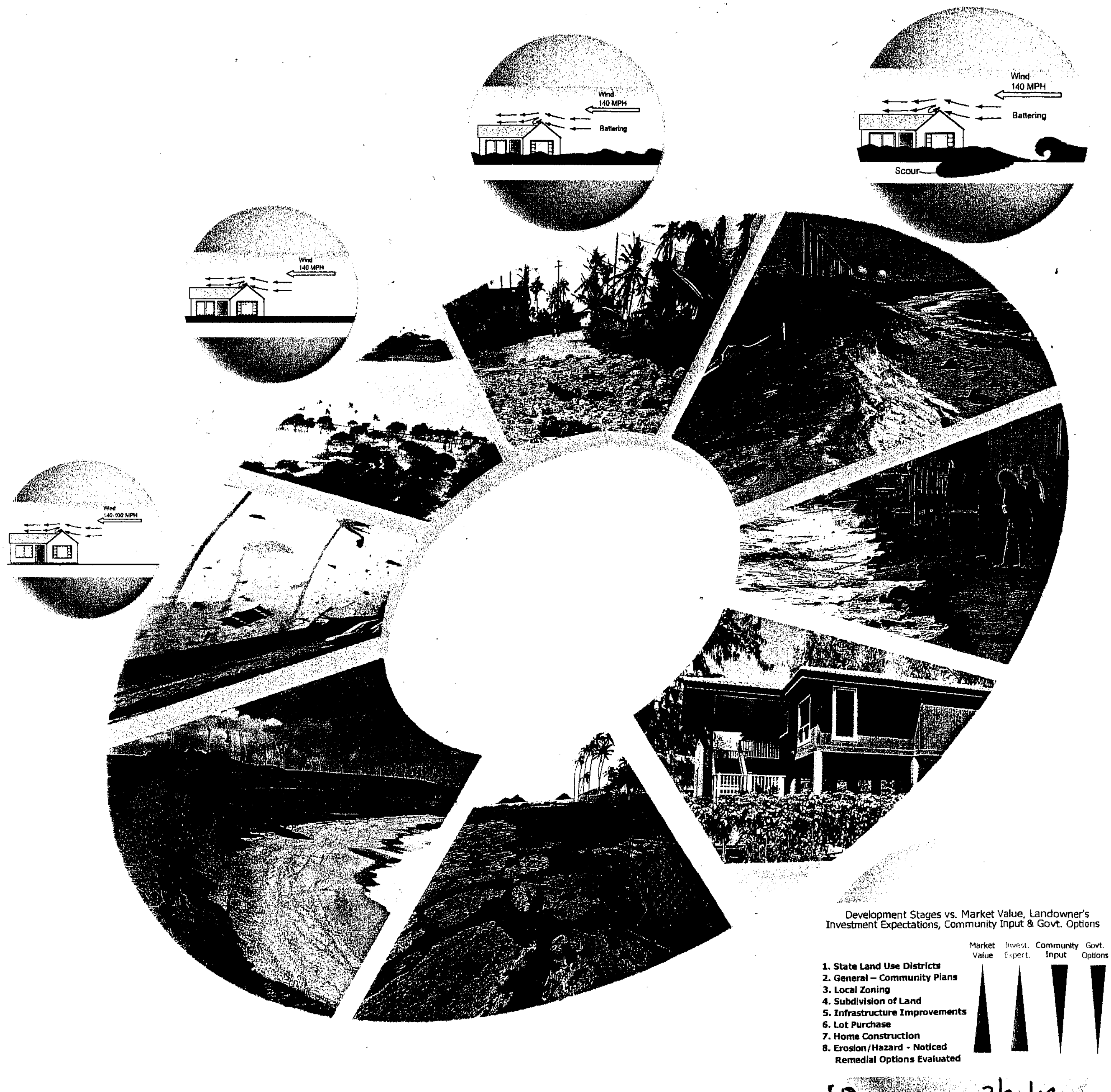

National Oceanic and Atmospheric Administration · NOAA · U.S. Department of Commerce
Sea Grant University of Hawaii
Department of Land and Natural Resources · State of Hawaii
CZM Hawaii Coastal Zone Management
NOAA Pacific Services Center
KO KĀKOU KAPAKAI, KO KĀKOU MUA

Standard to Determine the Erosion Rate

- At minimum, aerial photographs should be selected for the period from the late 1940's-early 1950's to the present. Periods of coverage should be every five years, but may vary depending on availability of coverage. See Appendix C for Sources of Photographs.

- The photographs should be corrected for tilt and distortion using ground reference points or orthophoto coverage. The correction should be in three dimensions so that all photos used are orthophotos.

- The vegetation line and beach toe or water line can be continuously digitized. An average rate of shoreline change can be determined for specific reaches. Transects can be established at the center of the lot and taken, at a minimum, every 50-100 feet in both directions. Erosion rates should be averaged in the alongshore direction to reduce variability.

- An erosion rate should be calculated for the vegetation line and the beach toe or water line. The consultant should discuss differences between the rates or erosion and the influence of manmade or seasonal changes. Discussion should be based on field observations over a period of a year. The greater of the erosion rates should be utilized.

- In identifying the position of the vegetation line in the field or on photographs, the consultant should reject: (i) artificial alterations such as human induced plantings or watering, or (ii) sparse vegetation (e.g., beach morning glory sending streamers to the water). A consistent threshold, such as 75% or greater coverage of vegetation should be utilized to identify the vegetation line on the aerial photographs and in the field. An analysis should determine if vegetation line change is less than the rate of beach width change or beach toe change.

- Linear regression should be the method used to calculate the erosion rate. Storm shorelines or statistical outlier points should be treated in accordance with linear regression methodology. Temporal bias should be avoided (e.g., selecting many photographs over a short time period to influence the linear regression erosion rate).

- The report should contain photographs of the beach and back shore, taken at different seasons of the year, and examples of the earliest and most recent aerial photograph with the locations of the selected shoreline change reference feature (vegetation line and beach toe or water line).

- The consultant should plot the position of the vegetation line and beach toe or water line versus time for all observation periods. Erosion and accretion rates for each observation period should be provided and discussed (Figure 4-3). Alternating multi-yearly periods of accretion and erosion that may result in a low erosion rate and wrongly indicate shoreline stability should be compensated for (e.g., use the most landward position of the vegetation line as a base to measure the erosion zone).

- Calculate a standard deviation, or use some other method to assess the variability of the erosion rate (See Jones et al., 2002).

- Certify that the erosion study was conducted by an experienced qualified professional using best professional judgment. A statement should be made that risks to future residents from coastal erosion, wave inundation and flooding have been minimized. Sufficient information should be included on erosion and flooding that will allow the approving county agency to certify that the site is suitable for its intended use, for structures with inhabitants that may be on site for 70 to 100 years (Chapter 8).

Figure 4-4 – Erosion Rate Standard - Where there is no suitable data, a qualified, professional consultant can be retained to determine the erosion rate utilizing the above guidelines.

4.1.7 Safety/Design Buffer

A design buffer should be added to the setback, even if there are no errors or risk from sea-level rise. For example, if the life expectancy of a structure is 70 years and the erosion rate is 1 ft/yr, placing the house 70 feet from an eroding shoreline with no margin of safety is risky. Assuming linear erosion and no errors, after 60 years, the structure would be ten feet from the shoreline with ten years of useful life left.

Experience in dealing with homeowners in Hawaii indicates that when a house is closer than 20 feet from the vegetation line, the homeowner is likely to panic. On Maui, when structures are within 20 feet of the shoreline, they are considered threatened and variances to the setback for erosion control measures may be considered. In North Carolina, the 20 foot threshold determines when emergency measures are allowed.[17] It is recommended that at no time during the useful life of a structure, should a residence be within 20 feet of the shoreline. Thus, a margin of safety of at least 20 feet should be added to the setback calculation so at the end of the useful life of a building, the structure is not at the shoreline, but at least 20 feet away.

By utilizing a margin of safety in the design, situations such as shown in Figure 1-11 can be avoided. Furthermore, margins of safety are recommended for other coastal hazards, such as flooding, where FEMA recommends a freeboard of 1-2 feet above the Base Flood Elevation.

The 20 foot safety/design buffer along with the default storm event estimate of 20 feet (Section 4.1.6) combine for a setback of 40 feet. This is comparable to the current State shoreline setback and would be sufficient if there was no risk of long-term shoreline erosion.

4.1.8 Summary of Parameters to Determine the Erosion Zone

With all of the parameters defined, it is now possible to determine the erosion zone. In Table 4-1, the erosion zone is calculated utilizing various erosion rates, and life expectancy of structures. In Hawaii, typical erosion rates are on the order of 0.5 to 1 ft/yr. (Hwang, 1981, Sea Engineering, Inc., 1988, Makai Ocean Engineering, Inc., et al., 1991, and Fletcher et al., 2002).

[17] Interview with Spencer Rogers, North Carolina, Sea Grant

Erosion Rate ft./yr.	Adjusted Rate for Errors (20%)	Adjusted Rate for Errors and Accel. Sea Level Rise (20%) X (10%)	Storm Event	Safety/Design Buffer	Erosion Zone 70-year Life of Structure	Erosion Zone 100-year Life of Structure
0	0.12*	0.13*	20	20	49*	53*
.1	0.12	0.13	20	20	49	53
.2	0.24	0.26	20	20	58	66
.3	0.36	0.39	20	20	67	79
.4	0.48	0.52	20	20	76	92
.5	0.60	0.66	20	20	86	106
1.0	1.20	1.32	20	20	132	172
1.5	1.80	1.98	20	20	179	238
2.0	2.40	2,64	20	20	225	304

Table 4-1 – Extent of Erosion Zone Given the Erosion Rate and Life Expectancy - For areas that are accreting, the erosion rate should be treated as zero, since HRS Section 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 ft./yr.* 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. If no analysis is done, the default value should be utilized. This analysis assumes no adjustments for erosion rate variability (See section 4.1.5).

It is instructive to compare how the setback for this manual compares with established setbacks in Hawaii and elsewhere.

For Oahu, there is a 60 foot setback for new subdivisions. This would be comparable to the setback for structures with a 70-year life and an erosion rate of 0.2 ft/yr (Table 4.1). However, the fixed 60 foot setback would be too small if the measured erosion rate increases. For example, if the erosion rate is .5 ft/yr, the setback should be about 86 feet.

On October 28, 2003, the Maui Planning Commission passed new shoreline setback rules, which were approved by the Mayor on November 14, 2003. The new rules have a setback of 20 feet plus 50 years multiplied by the erosion rate. This is felt to be an improvement over pre-existing rules, but still, may not be sufficiently protective. For instance, a shoreline with an erosion rate of .5 ft/yr would lead to a setback of 45 feet, which is only slightly larger than the current State setback of 40 feet. Assuming linear erosion, after 50 years, the homeowner would be 20 feet from the shoreline with an estimated 20 years of useful life left in the structure. Thus, the homeowner would be in a threatened situation (See section 4.1.7). Furthermore, this setback would not account for errors, storm erosion events or accelerated sea level rise. This guidebook would create a setback of 86 feet under similar circumstances. Various land use tools or strategies can then be utilized to minimize the impact on the landowner (see Chapter 11 for further discussion).

Originally Maui proposed a setback of 40 feet plus 70 years times the erosion rate for new subdivisions. This would have been comparable to the setback formula in this manual, except the original Maui formula did not include adjustments to the erosion rate for errors and potential acceleration in sea-level rise. Furthermore, for large structures, district reclassifications at the State level (Stage 1) or zoning changes at the county level (Stage 3), a 100 year time frame is recommended instead of 70 years.

North Carolina has established a setback of 30 years times the average annual erosion rate, with a minimum setback of 60 feet. This is similar to the setback in this manual, where an erosion rate of 0 leads to a setback of 49 feet. However, for an erosion rate of 1 ft/yr, the setback would be 60 feet in North Carolina and about 132 feet using this manual. North Carolina is evaluating the suitability of their coastal setback.[18]

Finally, the FEMA CCM calls for a setback around a minimum planning period of 50 years and a minimum erosion rate of 1 foot per year. For an erosion rate of zero, the FEMA CCM would lead to a setback of 50 feet and is close to the 49 feet for this manual. At an erosion rate of 0.5 ft/yr, the FEMA CCM would also lead to a setback of 50 feet, while this manual calculates the appropriate setback at 86 feet.

Generally, when compared to other jurisdictions, the formula in this manual leads to comparable setbacks for no or low erosion rates. For higher erosion rates, the setback is greater due to a longer planning period, which more accurately reflects the expected life of a building and the actual risk on the coastline. From a political point of view, the greater setbacks are made more feasible when they are determined and implemented in the early stages of development (Stages 1-4 in Figures 2-5 and 2-6). This is a significant departure from past practices, in which setbacks are traditionally implemented at Stage 7 in the development process. To further illustrate the ability to implement a large setback in the early stages of development, it should be noted that in the Maui County Zoning Ordinance (Stage 2), there is a requirement for a 300 foot setback for any beach area at Manele.[19]

To make scientifically based setbacks more acceptable, this manual recommends adjustments to the implementation strategy, depending on the specific stage of development to consider legal rights, political realities, fairness and practicality. For example, various permutations of a minimum buildable area for existing residential lots are discussed in Chapter 11 to specifically address the issue with regard to small lots. The use of regulatory incentives is also introduced to deal with the issue of nonconforming structures that later become damaged by coastal hazards. These

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[18] Interview with Spencer Rogers, North Carolina Sea Grant

[19] Maui Comprehensive Zoning Ordinance § 19.70.100(A) and (B)(10)

strategies are covered in later sections of the guidebook and summarized in Chapter 13.

4.2 Determining the Wave, Flood and Inland Zones

One advantage of utilizing the wave, flood and inland zones (Figure 3-1) in the overall hazard mitigation strategy is that FEMA has already mapped V, VE, A, AE and X zones on Federal Insurance Rate Maps ("FIRMs"). These flood zones can be used to determine the inland extent of the zones used in this manual. For example, the wave zone in this manual coincides with the V and VE zones on the FIRM. The flood zone would coincide with A, AE and X zones.[20] The inland zone is the area away from the coast that is not in the V, VE, A, AE, or X zones.

Another advantage of using FEMA's designation is that the FIRMs incorporate tsunami and hurricane inundation data into the mapping of the inland extent of the V and A zones. For the islands of Oahu, Maui, Molokai and Hawaii, tsunami inundation boundaries are computed for most of the shoreline. The VE zone boundary is determined where the depth of water from the 100-year tsunami is 4 feet or greater.[21] Water levels that are less than 4 feet identify the A zone on the FIRM.

For the island of Kauai, again, the 4 foot inundation level from the tsunami serves to identify the VE zone. In addition, the southwest coastline of Kauai was restudied to account for severe coastal inundation caused by Hurricanes Iwa (1982) and Iniki (1992). Before these hurricanes, coastal inundation by hurricanes was not considered to be significant.

FIRMs are based on flood insurance studies that are conducted by FEMA. For Oahu, the flood insurance study was updated on November 20, 2000. Kauai's flood insurance was updated on September 30, 1995, Maui and Molokai's on May 15, 2002 and the island of Hawaii on June 2, 1995. These studies are updated on a periodic basis as new data and/or methodologies become available.

There is one shortcoming in relying on the FIRMs to plan for tsunami or hurricane inundation. Inundation from these hazards is mapped only where a section of the coastline has experienced a particular hazard event. As an example, the south coast of Kauai experienced inundation from Hurricanes Iwa in 1982 and Iniki in 1992. The south coast of Oahu has not experienced similar hurricane inundation, although scientists have

[20] The reader should check the building departments at each county for construction standards related to each of the FEMA flood zones.
[21] In most coastal states, the V-A zone boundary is determined where the wave height is greater than 3 feet over the 100-year stillwater elevation. In Hawaii, the V zone is determined where the depth of water from the 100-year flood is greater than 4 feet (See Section 4.4). The 4 foot water depth sustains a 3 foot wave, since wave height is depth limited according to the formula .78 (depth) = height of the breaking wave (August 17, 1977 letter from the Federal Insurance Administration – Flood Insurance Office – Department of Housing and Urban Development).

indicated that a hurricane impact for any of the islands is likely (Schroeder, 1993; Oahu Civil Defense Agency, 2003). Because there is no experience with severe inundation from hurricanes on Oahu, this hazard is not incorporated into the FIRM for Oahu using rigorous technical analysis. Due to this shortcoming, the assessment of tsunami and hurricane risk should rely not only on the FIRMs but on resources such as the FEMA CCM, Atlas of Natural Hazards in the Hawaiian Coastal Zone, or other published reports and field observations. These issues may be resolved by future modernization of FIRMs (see Section 4.4).

V-zone, hurricane and tsunami inundation is likely to be significantly further inland than the erosion zone. At Kahuku Point on Oahu, the V-zone is about 900 feet and the A-zone over 5,500 feet inland. Runup heights of up to 27 feet were recorded for the 1946 tsunami in this area (Lande and Lockridge, 1989; Fletcher et al., 2002). Aerial photographs taken in 1949 show that the sand and debris field believed to be caused by the 1946 tsunami was about 1,200 feet inland (Hwang, 1981). Compare the inland extent of these V and A zones with the erosion zones calculated in Table 4-1.

4.3 The Hazard Assessment

Before major development decisions are made along the coast, it is recommended that a hazard assessment be conducted, with the heart of the assessment being the erosion study (Section 4.1). The erosion study would help to identify the erosion zone. The hazard assessment would also help to determine the wave, flood and inland zone, which would be derived primarily from the FIRMs.

Ideally, local planning agencies could determine the erosion and hazard zones for the entire county at one time. This would ensure that the methodology is uniform, while minimizing the costs to obtain the planning data. The data could then be used for private, State or county projects. However, if such comprehensive studies are not conducted, it is recommended that a retained consultant determine the erosion and hazard zone for each project following set guidelines. This would be preferable to making siting decisions along the coast without information needed for planning on the magnitude of erosion or hazard risks.

A standard for a hazard assessment is described in Figure 4-5. This standard could be followed, or the applicable county agency may choose to refine or develop their own standard.

Standards for the Hazard Assessment

- Determine an erosion rate using existing data, or calculate a rate utilizing standards such as those found in this manual (Figure 4-4).
- Consultants, including those identified in Appendix B and Aerial Photographs identified in Appendix C can be utilized if there are no current studies on the erosion rate.
- Determine the erosion zone with the formula outlined in this manual. The consultant should discuss the applicability of the sea-level rise factor and the storm erosion factor and apply any adjustments if needed.
- Determine the wave (V-VE), flood (A-AE-X) and inland zones through the examination of existing FIRMs. The location of these zones should be adjusted for the potential of erosion (Figures 1-9 and 4-6)
- Superimpose the property boundaries and project footprint on a map along with the erosion, wave (V-VE), flood (A-AE-X) and inland zones.
- Examine relevant reports, such as the Atlas of Natural Hazards in the Hawaiian Coastal Zone (Fletcher, et. al., 2002) to further evaluate all hazard risks at the project site (Chapter 3). Review updated reports or assessments in progress for the State or counties such as those related to wind strength mapping, remapping of flood inundation zones, or refinement of lava flow risk areas.
- Through the review of relevant reports and field observations, determine if hazards other then erosion, bluff erosion and lava should be addressed during the early stages of development (Stages 1-4). In particular, hurricane and tsunami inundation should be assessed to determine if local conditions require these hazards to be avoided through proper siting. Unusual siting issues may also arise next to steep slopes (e.g., wind speed up or landslide/debris flows).
- If critical facilities and infrastructure are proposed in the flood zone, discuss why these facilities are needed there and any mitigation measures to reduce the risk of damage. Critical facilities should not be in the erosion or wave zone.
- Certify that the assessment was conducted by an experienced qualified professional using best professional judgment. A statement should be made that risks to future residents from coastal erosion, wave inundation and flooding have been minimized. Sufficient information should be included on erosion and flooding that will allow the approving county agency to certify that the site is suitable for its intended use, for structures with inhabitants that may be on site for 70 to 100 years (Chapter 8).

Figure 4-5 – Hazard Assessment Standard - Standards for a hazard assessment can be followed for major projects that are up for district reclassification, zoning change or subdivision approval.

4.4 Adjusting the Wave, Flood and Inland Zone Based on Erosion

The erosion study in Section 4.1 may reveal that an adjustment to the position of the wave (V-VE), flood (A-AE-X), and inland zone is warranted (see Figures 1-9, 3-1 and 4-5). This is an evaluation that can be done in the hazard assessment.

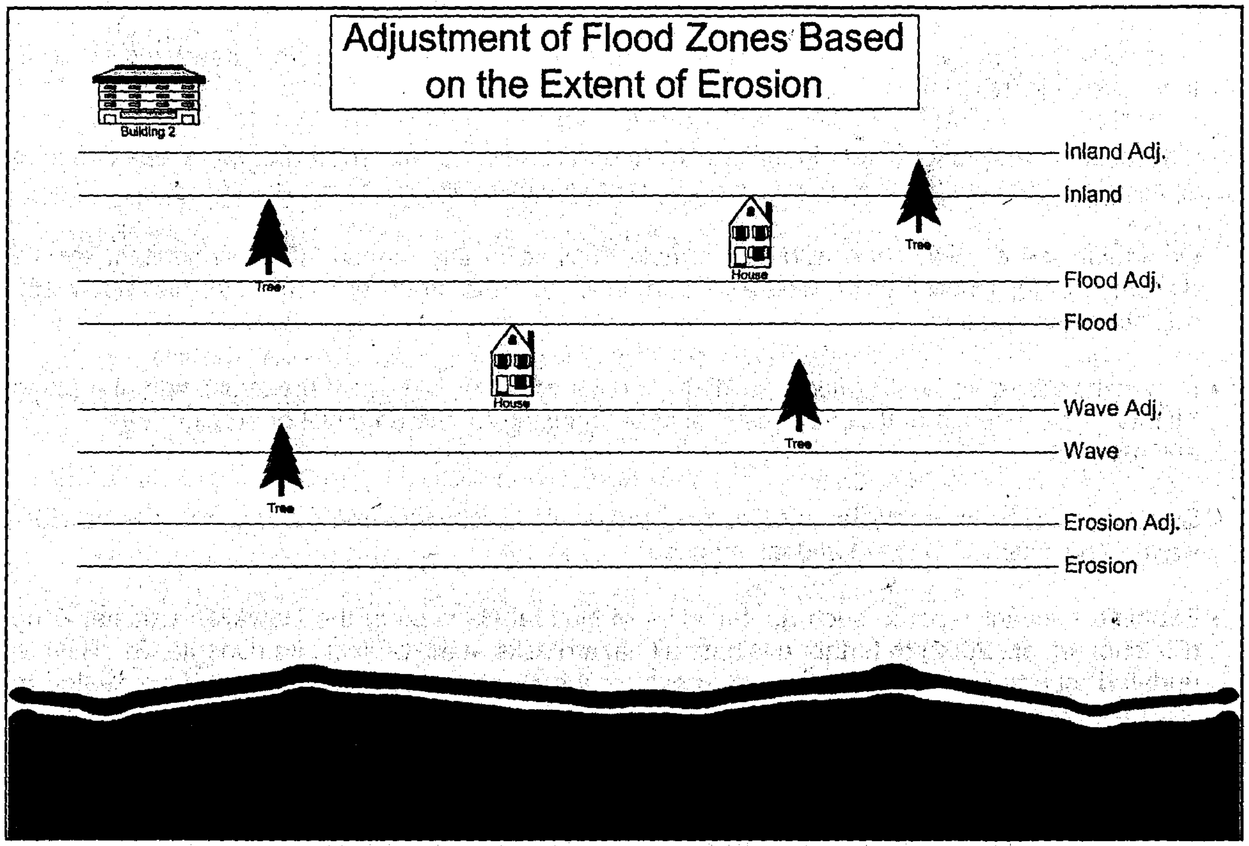

Figure 4-6 – Migration of Flood Zones with Erosion – Over time, erosion may cause the wave, flood and inland zones to migrate inland (see Figure 1-9). The migration of these zones should be accounted for in the hazard assessment. The significance of erosion on location of the flood zones is site specific and depends on factors such as the tsunami height, coastal slope, and surface roughness, among other factors.

The relationship between the horizontal extent of erosion and the migration of the flood zone is complex and requires an explanation of how V zones are determined in Hawaii. For background information on this topic, the reader is referred to the Flood Insurance Studies for each county, and the report "Manual for Determining Tsunami Runup Profiles on Coastal Areas of Hawaii" (M&E Pacific, Inc., 1978).

Many measurements on historical tsunami runup heights were made by investigators at various coastal locations. Based on historical data, a relationship between tsunami elevation and frequency of occurrence was developed for a distance that is 200 feet inland from the shoreline. Thus, for the hundred year event that defines the special flood hazard zone, a tsunami elevation at 200 feet inland from the shoreline can be estimated for any section of the coastline in Hawaii.

With the tsunami elevation at 200 feet from the shoreline ("H"), runup inland of that point can be predicted using equations that relate the inland extent of flooding with

H, the slope of the coastal segment, the roughness of the coastal surface and whether the tsunami wave is a bore or non-bore type (Bretschneider & Wybro, 1976). For example, given a specific tsunami depth of 6 feet at the 200 foot focal point from the shoreline,[22] a coastal slope of 1%, a nonbore tsunami and an average surface roughness number of .045 (typical of rough surface areas with thick grass, trees or brush), it would require about 110 feet from the focal point, or 310 feet from the shoreline, before the tsunami depth decreased to 4 feet. This reflects the fact that the tsunami depth will diminish inland due to the rising ground elevation and friction or decay from roughness of the coastal surface.

Note that the 4 foot water depth for the 100-year event defines the V zone in Hawaii (Section 4.2). Depths that are greater than 4 feet are in the V zone. Depths less than 4 feet to the inland extent of the 100-year flood are in the A zone. The X zone is from the runup limit of the 100-year flood to the runup limit of the 500-year flood.

While the flood zones for most of the coastline in Hawaii are based on tsunami elevation, the south coast of Kauai, from Poipu to Kekaha is based on a combination of tsunami and hurricane data. Flood elevations at the 200 foot focal point for Hurricane Iwa and Iniki were estimated using the Bretshcneider-Wybro wave runup equations and data on inundation limits as indicated by debris lines (U.S. Army Corps of Engineers, 1994). Combining the hurricane and tsunami flood elevation data and using frequency analysis, the flood elevation at 200 feet could be determined for the 100 and 500-year events.[23] The Bretshcneider-Wybro equations are then again used to determine the inland location of the 100 and 500-year events, thus determining the locations of the V, A and X zones.

Erosion may change the location of the flood zones by moving the 200 foot focal point inland a distance equal to the erosion zone. This could move the flood zones inland a significant amount, particularly for coastal areas with very gentle slopes. In the hazard assessment, a qualified professional consultant should determine if there is an impact to the wave and flood zones using the "Manual for Determining Tsunami Runup Profiles on Coastal Areas of Hawaii," or other generally accepted coastal engineering methods.

Each area is different and needs to be evaluated on a case by case basis. Situations of potential concern may be where: (i) there is a very gentle, or no coastal slope, (ii) the erosion zone is relatively large compared to the wave or V zone, (iii) after erosion, relative surface roughness decreases in the space between the 200 foot focal point and the flood zones, (iv) after erosion, relative surface slope decreases in the space between the 200 foot focal point and the flood zones, or (v) a structure in the A zone is in close proximity to the V zone. Situations that may not be of concern would be for structures

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[22] The tsunami depth would be the 100 year tsunami elevation minus the ground elevation.
[23] In essence, Hurricanes Iwa and Iniki elevations were treated as tsunami elevations due to the lack of reliable hurricane models to estimate storm frequency elevations from hurricanes in Hawaii. Interview with Steven Yamamoto, Army Corps of Engineers.

that are significantly above the 100-year tsunami elevation. It is up to the consultant performing the hazard assessment to determine the relative importance of each factor for the specific characteristics of the site in question.

The flood zones in Hawaii are based on slightly different methods and data sets depending on the particular section of the coast. While most of Hawaii is based on tsunami elevation and runup, the south coast of Kauai is based on tsunami and hurricane data, and the south shore of Oahu is based, in part, on a 1985 study prepared by Edward K. Noda and Associates for the U.S. Army Corps of Engineers. The Noda study was prepared to support State Civil Defense hurricane evacuation planning and not for establishing 100-year coastal flood elevations. Nevertheless, because the study provided the most current and relevant analysis of the potential coastal flooding due to hurricane wave attack, and the probable inundation was greater than that previously determined for tsunami runup, the FIRM was revised by FEMA to reflect the 100 year zone due to hurricane storm surge/runup.[24]

Discussion with FEMA officials indicate that the FIRM maps for the south shores of the islands may someday be modernized based on hurricane modeling and the generation of a hypothetical 100-year hurricane. Whatever method is used to determine the flood zones in Hawaii, consideration by the consultant should be given to the methodology used to determine the flood zone at the particular site, and the impact of erosion on the location of the flood zones based on the utilized methodology.

The adjustment of flood zones for erosion is not a regulatory requirement of the national or State flood insurance program. It is a proactive measure that the counties, or the proponents of a development should consider in order to reduce the risks of flooding to future occupants. Such an analysis seems appropriate for new or large subdivisions along the coast. If the adjustment is conducted on a consistent basis in the absence of a regulatory requirement, the procedure could become an industry standard.

4.5 Adjusting the Hazard Assessment for Selected Coastal Areas

The agencies can use local knowledge to streamline the hazard mitigation analysis based on the characteristics of the particular coastal site. For example, the County of Kauai could develop policy that in the hazard assessment, earthquake and lava risks do not need to be addressed because the risk of lava on Kauai is nonexistent and earthquake risk is adequately addressed in the building code during the construction stage of development. Conversely, a hazard assessment for a project in the County of Hawaii may require analysis for the risk from lava, earthquakes and subsidence.

Another example of using local knowledge is that the risks from hurricane

[24] Comments from Elaine Tamaye, Edward K. Noda and Associates, Inc.

inundation are greater along the south coasts of the islands. This is one reason that FEMA may modernize the flood mapping for the south coasts of the islands. Tsunami elevation and inundation data continue to be the main determinant for the flood zones on east, west and north facing coastlines.

Given the particular section of the coastline, the counties should be able to provide further guidance as to what are appropriate issues to address in the hazard assessment.

4.6 Adjusting the Hazard Assessment for the Stage of Development

Depending on the stage of development, the hazard assessment should be adjusted so that it is appropriate for a particular project. A 40 acre subdivision with hundreds of potential residents may require one level of analysis (Stage 4), while the building of a single house on an infill lot may require another (Stage 7).

In cases where a full blown assessment may be inappropriate (e.g., the infill of a single house on an existing improved lot) an abbreviated analysis may be in order. Since an infill lot is likely to have many existing residences nearby, hazard mitigation issues and solutions may already have been identified by the agencies. This knowledge may negate the need to analyze all hazards.

For small structures proposed on an infill lot (Stage 7), it may be appropriate to streamline the erosion study. For example, the erosion study may utilize aerial photographs every ten years, instead of every five. In addition, an erosion rate can be calculated using the very earliest quality aerial photo, and the most recent aerial photo (end-point calculation versus linear regression).

In Table 4-2, an example is provided of how the level of hazard assessment can be modified, given the particular stage of development. Three levels of analysis are proposed that consider the usefulness of the hazard information, the resources of the parties and the practicality of the assessment request, given the particular stage of development. This scheme can serve as a guide on the appropriate level of assessment for projects in various stages of development.

It is up to the individual counties to decide if the assessment scheme in Table 4-2 should be more or less stringent. A more strict provision would require a full erosion study (Level 2 Assessment) for even small structures on infill lots (Stage 7). A less strict provision may require no hazard assessment for a change to the general or community plan (Stage 2), provided language in the plan states that one must be conducted for any zone change, subdivision or infrastructure approval.

Appendix A - Existing Reports

In this Appendix is a summary of key coastal zone management reports taken directly from the State of Hawaii Coastal Erosion Management Plan (COEMAP), Technical Supplement, Part A, State of Hawaii, Department of Land and Natural Resources, Coastal Lands Program; School of Ocean and Earth Science and Technology, University of Hawaii, Technical Report 98-04, Updated 2001). The summary has been adapted and updated to include significant works completed by the University of Hawaii in 2001 & 2002. These recent reports provide an additional source of information that can be used for the planning of coastal hazards.

INTRODUCTION

Beaches are one of Hawaii's most important resources. They are precious natural features that provide recreational opportunities and scenic beauty. Hawaii's beaches are critical for tourism, the primary industry of the State, and are culturally important to the residents of Hawaii. Furthermore, beaches, dunes, and offshore sandbars help minimize risks from coastal hazards by dissipating wave energy which may otherwise damage inland property. Beaches are also important as habitats for seabirds, turtles, seals and other animals and plants.

One of themes heard most often at coastal zone management public meetings is a concern about the "loss of beaches." Clearly, "loss of beaches" means different things to different individuals and communities. Some are talking about the literal loss of beaches by means of erosion that in many cases has already reduced recreational areas and threatened property. In this context, erosion, and legal and illegal erosion control structures, such as seawalls, are a concern. Others are referring to continuing loss of coastal open space that they associate with particular beaches or the construction of homes and hotels that block views along the shorelines. Loss of beaches also connotes reduced access to popular beaches because of new construction, leasehold conversion, reduced parking or other impediments. It also means increased competition among residents and visitors for limited beach space and competition among different types of recreational activities.

Some of these problems are addressed by the shoreline setback and special management area provisions of the Coastal Zone Management (CZM) Program. However, to increase our understanding of the problems and issues and to develop mechanisms to improve beach management, a number of beach management studies have been conducted.

Hawaii CZM Program Beach Management Projects

<u>Beach Changes on Oahu as Revealed By Aerial Photographs</u>, **prepared by Dennis Hwang for the Department of Planning and Economic Development by the Urban and Regional Planning Program and the Hawaii Institute of Geophysics, University of Hawaii, 1981.**

This report analyzes aerial photographs of the beaches of Oahu taken over a period of up to 50 years. To determine whether accretion or erosion had taken place, changes in the beach vegetation line at designated transects are recorded. Transects are conducted at approximately 1,000-foot intervals. The vegetation lines of sequential photographs are then compared to determine the net movement of sand.

To characterize the sandy shore of Oahu, the report develops 5 classifications: hazard area, chronic erosion area, unstable beach area, stable beach area, and accreting beach areas. It notes that areas classified as hazard, chronic erosion, and unstable should be areas of greatest concern to coastal managers. Also, the report indicates that many buildings have been placed in areas extremely vulnerable to large wave inundation.

Recommendations

Hazard areas

1. Establish a minimum 80-foot setback from the vegetation line for all new subdivisions.
2. Prohibit new houses within the new 80-foot zone.
3. Carefully analyze reconstruction after destruction of previous structures and buildings.
4. Discourage the reduction of dunes or berms for vista creation because of their role in protecting backshore areas from large waves.

Chronic erosion areas

1. To determine rate of retreat, conduct periodic field or aerial surveys.
2. Prohibit new subdivisions that require building in these erosion areas.
3. Determine the extent of setback using local erosion rates and the life expectancy of proposed structure.

Unstable beach areas

1. Avoid development in accretion areas to avoid destruction during the erosional phase of the cycle characteristic of these areas.

2. Obtain appropriate setback for unstable beach areas by adding the historic range of the vegetation line position and a buffer of 40 ft.

Accreting beach areas

1. Generally, in accreting beach areas, there are no major problems. However, ownership of accreted land may be a concern.

Stable beach areas

1. No major problems exist in these areas, except for tsunami and storm damage possibilities.

Hawaii Erosion Management Study, prepared by Edward K. Noda and Associates, Inc., and DHM Inc., for Hawaii Coastal Zone Management Program, 1989.

The study provides a comprehensive overview of erosion and erosion management in Hawaii as an initial step towards the development of a uniform method or regulatory process for the implementation of non-structural and structural measures.

Numerous factors affecting shoreline erosion control are discussed, including coastal processes, probable long-term erosion trends, methods for estimating long-term shoreline change, shoreline protection/stabilization, and erosion management and regulation. Specific case study sites apply these factors. In addition, reviews of states with more advanced erosion management systems (i.e. Florida and North Carolina) are included.

Alternative shoreline stabilization mechanisms, fitting of shoreline stabilization alternatives to various geological, land use and development scenarios, and benefit/cost analyses are discussed. A proposed system to improve erosion management in Hawaii is developed.

Recommendations

1. Develop a statewide approach to funding, planning, and designing appropriate shoreline erosion counter-measures in Hawaii (CZM Office - preliminary role)

2. Coordinate the counties in the development of an on-going system for beach erosion monitoring. This includes routine data collection, aerial photography, computer mapping, and erosion rate projections. (CZM Office - lead role)

3. Monitor and enforce erosion management regulations. (Counties lead role)

4. Classify littoral cells as stable or unstable through a program of data collection and analysis and then determine appropriate shoreline setbacks, considering land use and erosion rates.

5. First, develop long-term erosion plans for critical, unstable, and erosion-prone areas involving combinations of structural and non-structural remedies. Second, develop site-specific management plans for these areas.

6. Littoral cell erosion management plans should include policies and programs for alternative management and financing of physical structures that benefit private property owners.

7. Streamline the permit process and clarify erosion policy objectives in federal, state, and local permits.

8. Develop in-house expertise and knowledge of coastal processes and engineering principles in government agencies with management and regulatory responsibilities.

Oahu Shoreline Study, Part 1. Data on Beach Changes, prepared by Sea Engineering, Inc., for the City and County of Honolulu, 1988.

The study produced two products. The first is a collection of 1988 aerial shoreline photographs and computer-generated images from these photographs which depict recent shoreline changes. The second product is an update of the study, Beach Changes on Oahu as Revealed by Aerial Photographs (1981). The 1988 changes are measured and summarized in tables that include the results of the 1981 report.

Oahu Shoreline Study, Part 2. Management Strategies, prepared by Sea Engineering, Inc., for the City and County of Honolulu, 1989.

Shoreline setback and management recommendations are provided for each beach sector studied on Oahu. The management strategies are developed by integrating the beach change data with existing land use data, the extent and conditions of existing shore protection, existing beach conditions, and qualitative and quantitative knowledge of continuing beach processes.

Beach-specific setback recommendations

1. Extend shoreline setbacks to comply with recommendations of this report (primary recommendation).

2. Review zoning along Oahu's shoreline within the context of existing and recommended setback provisions.

3. Investigate the establishment of "beach improvement districts."

4. Review the provisions of the Shoreline Setback Rules.

5. Focus shoreline setback provisions prohibiting development in the shoreline sectors on habitable, protective, and other structures that might impede natural shoreline processes.

6. Monitor the shoreline more closely for illegal shoreline construction. Amend the Shoreline Setback Rules to establish fines for setback violations. Institute a program for monitoring setback violations by conducting shoreline aerial photography every two to four years.

7. Implement the shoreline setback provisions with close coordination between the DLU and the State Department of Land and Natural Resource (DLNR).

Beach-specific management policies

1. Set examples of shoreline preservation with City and County beach parks.

2. Establish public rights-of-way to all beaches to ensure public access.

3. Update the data in this report every eight to ten years.

Erosion Management Program Recommendations for Hawaii, prepared by Oceanit Laboratories, Inc., for Hawaii Coastal Zone Management Program, 1990.

The report proposes the development of a comprehensive database on erosion, based on the analysis of aerial photography using computerized methods for calculating historic rates of beach recession. Guidelines for evaluating and recommending solutions to erosion problems are also proposed. A list of information requirements and a set of questions that should to be raised in dealing with site-specific erosion problems is included. Other recommendations are to develop a comprehensive erosion plan and create an Office of Beaches. In addition, a proposed mission statement, guidelines, goals, and objectives for the erosion management program are discussed.

Recommendations

Informational Recommendations

1. Establish a database for the coastal zone of Hawaii, including oceanographic, topographic, land and water uses.

2. Use aerial surveys and a computer-aided digitizing method for monitoring the total coastline of Hawaii, supplemented with shoreline surveys at selected high-risk locations.

3. Coordinate federal, state, and county erosion management funding to develop a comprehensive database for coastal areas.

Planning Recommendations

1. Define the certified shoreline and tie it into survey monuments. Revise the line continuously to account for erosion.

2. Simplify the permit process and inform coastal land users of permit requirements in their areas.

3. Create a master plan for state erosion management addressing the nature and cause of erosion problems, problem assessment, and immediate, medium, and long-term mitigative activities.

4. Develop a comprehensive State coastal erosion plan as part of a shoreline plan.

5. Consolidate jurisdiction and regulatory powers of the shoreline area into one agency. Establish a separate division within an existing agency responsible for handling these matters. The division would be responsible for:

   a) periodic updates of coastal database;

   b) regulating shoreline uses in accordance with the coastal erosion plan;

   c) conducting enforcement matters relative to illegal uses or structures; and

   d) implementing beach renourishment or shore protection measures when necessary.

Resource Management Recommendations

1. Clarify and strengthen enforcement power over the actions and results of coastal area construction.

2. Delineate areas susceptible to erosion damage from storm waves, surge and inundation.

3. Create maps of the hazard areas and inform public of restrictions on protecting properties in these areas.

<u>Kauai Shoreline Erosion Management Study</u>, prepared by DHM Inc., Edward K. Noda & Associates, Inc., and Moon, O'Connor, Tam & Yuen for Hawaii Coastal Zone Management Program, 1990.

The study develops appropriate management recommendations for Kauai shoreline areas, analyzes the impacts of these recommendations, and develops specific shoreline erosion management plans for selected areas of Kauai. Aerial photographs were used to evaluate historic shoreline movements. Beach vegetation lines, waterlines, and selected features in Hanalei Bay and the Haena-Wainiha area were digitized into a computer- aided drafting (CAD) system. The long-term shoreline change data are used to develop shoreline management recommendations.

Legal, social, and economic impacts of both the recommended regulatory changes to shoreline setbacks and the adoption of Shore Districts as an erosion management tool are discussed. Shore Districts allow the Kauai County Planning Department discretion in establishing shoreline setbacks in these areas. Possible implementation mechanisms for the recommendations are included.

Recommendations

1. Give non-structural remedies preference over structural remedies for shoreline management on Kauai.

2. Remove illegal shoreline structures.

3. Enforce more strictly all regulations affecting coastal development and beach preservation.

4. Establish setbacks of no less than 60 feet for Haena area and 75 feet for Hanalei Bay.

5. Develop and update a shoreline structure inventory.

6. Create overlay Shoreline Special Districts as specified in the Kauai Comprehensive Zoning Ordinance for the Hanalei, Haena-Wainiha, and Poipu areas.

7. Develop a Shoreline Special Treatment Zone Plan for adoption by the Kauai Planning Commission.

8. Establish an 80-foot shoreline setback for the Poipu Beach Park area.

<u>Aerial Photograph Analysis of Coastal Erosion on the Islands of Kauai, Molokai Lanai, Maui and Hawaii</u>, prepared by Makai Ocean Engineering, Inc., and Sea Engineering, Inc., for the State of Hawaii Office of State Planning Coastal Zone Management Program, 1991.

Approximately 66.2 miles of sandy shoreline are included in the study. Aerial photographs from different years are analyzed for each area selected to determine historical changes in shoreline positioning. To determine erosion and accretion rates, photographs were digitized, corrected, and compared. This report is in atlas form with a description of the coastal characteristics, beach history, backshore development, shoreline processes, and beach usage; graphs depicting erosion and accretion rates between photographic dates; and a diagram of each shoreline area. The diagram of each shoreline area includes shoreline protection structures, 1988 water and vegetation lines, roads and buildings, and the transect lines used for the analysis.

Recommendations

1. For future monitoring efforts, focus on areas that are not already committed to shoreline protection structures.

2. Develop and implement a program to select beaches needing more frequent and/or detailed monitoring.

3. For the monitoring program, select beaches that are eroding, slated for future development, or already have shoreline protection that might affect the beach.

4. For every monitored beach, take a complete set of overlapping vertical and low-level oblique color aerial photographs every five years. The low-level oblique photographs will help interpret the vertical photographs and document further beach dynamics.

5. Add new data on shoreline change to the existing digital database.

1991 Oahu Shoreline Management Plan, prepared by Sea Engineering, Inc., and Barbara Moon for The City and County of Honolulu Department of Land Utilization, 1991.

The report focuses on 31 miles of sandy beaches on Oahu that 1) are being developed primarily for residential *use,* 2) are high-quality recreational beaches that should be preserved for public use, and 3) were recommended in Part 2 of the Oahu Shoreline Study for increased shoreline setbacks. The study:

1. identifies natural beach sectors that are high-qualify public recreational resources;

2. develops alternative strategies to preserve beaches;

3. examines potential impacts of alternative strategies on existing residences and other private land abutting the shoreline; and

4. recommends government regulations and other actions to implement a plan encompassing the most promising strategies.

Digitized maps showing all major features were created for the 13 miles of residential shoreline properties were created. This study predicts future shoreline positions and provides information on the statistical variability of the prediction.

Recommendations

Short-term, cost-effective, low impact strategies

1. Eliminate the 20-foot shoreline setback permitted under certain condition.

2. Require a minimum area of 3,000 square feet buildable lot area for residential beachfront properties.

3. Prohibit shoreline setback credit for property owners who acquire, through land court and/or consolidation and resubdivision, accreted shorefront land.

4. Require a minimum setback of 60 feet for new developments on vacant land, or redevelopments resulting in a higher unit count.

5. Create a mechanism to grandfather illegal shoreline protection structures that meet criteria established by technical engineering and design standards.

6. Prohibit the use of vertical seawall structures in areas where this form of protection is not wide-spread and where future seawall requests are likely. Require buried

revetments or similar form of private property protection, if necessary, without complex permitting requirements.

7. Strengthen criteria for granting shoreline setback variances by stricter standards for proving "hardship"

8. Apply established administrative enforcement procedures to violations within the shoreline setback area.

Long Term Strategies

1. Amend the City and County of Honolulu Land Use Ordinance (Article 7) or the Special Management Ordinance to create a Beach Preservation District to manage beach sectors subject to chronic long-term erosion or episodic and severe erosion.

2. Establish objectives for each District sector and develop specific regulatory requirements for problems specific to the sector.

3. Adapt the existing Improvement District approach to vulnerable beach sectors necessitating public/private cost-sharing.

4. Establish and fund a recruitment and training program for professional monitoring and enforcement staff.

The Hawaii Ocean Resources Management Plan, prepared by Hawaii Ocean and Marine Resources Council, 1991.

The Office of State Planning, as a member of the Hawaii Ocean and Marine Resources Council, was involved in the development of the Hawaii Ocean Resources Management Plan. This Plan addresses broad ocean management issues as well as specific ocean management sectors, including beaches and coastal erosion. The stated objective for beaches and coastal erosion is to develop an integrated State erosion management system that ensures: 1) the preservation of sandy beaches and public access to and along the shoreline; and 2) the protection of private and public property from flood hazards and wave damage. Policies and implementing actions are also included. The policies are listed below:

1. Establish and maintain a comprehensive coastal shoreline survey, database, and other research.

2. Coordinate County, State and Federal erosion and beach-management efforts.

3. Exercise greater enforcement of laws and regulations.

4. Ensure the continued natural production of sand and assess the potential for using beach replenishment.

5. Promote an erosion-control structure limitation strategy.

6. Develop an active public participation and education program to preserve and protect beaches.

7. Maintain and develop access to beaches and along the shoreline.

8. Assure adequate funding resources and personnel.

9. Plan for climate change, sea-level rise, and emerging issues.

<u>Beach Management Plan with Beach Management Districts</u>, prepared by Dennis Hwang and Charles Fletcher for Hawaii's Coastal Zone Management Program, 1992.

The purposes of the study were to develop a comprehensive and coordinated management plan to preserve pristine beaches while allowing for "intelligent and safe" development along with shore and to address the erosion problems of currently-developed sections of the coast. The report found that, since 1928, approximately 8 to 9 miles (or close to 15%) of the sandy shorelines studied on Oahu have disappeared or been negatively impacted by shoreline stabilization structures. The loss of beaches is also occurring on Hawaii's other islands. Beach loss has accelerated due to a combination of factors such as sea-level rise and hardening of the shoreline. The report notes that beach loss is likely to accelerate unless there is a fundamental change in beach resource management.

Beach Management Districts (BMDs) are recommended as an alternative to hard control structures. The three general forms of BMDs finance the study and implementation of possible erosion control alternatives. Other states, such as Florida and Maryland, have successfully implemented BMDs.

Recommendations:

1. Establish an agency responsible for the administration and management of beaches.

2. Establish improvement and overlay districts to help in the management of Hawaii's beaches.

3. Promote erosion control devices other than traditional hard control structures through Beach Management Districts.

4. Distribute the cost of preventive erosion measures between the State, counties, and coastal landowners.

5. Develop an education program to convey the problems of beach loss, erosion, and sea-level rise to the public.

6. Enable the modification of shoreline setback regulations through new legislation.

7. Concentrate further research on the monitoring of beaches with aerial photographs and beach profile surveys to facilitate proper beach management decisions.

8. Investigate the prospect of using offshore sand deposits as a cheap source for renourishment projects.

Beach Nourishment Viability Study, conducted by Sea Engineering, Inc. and Lacayo Planning for the Hawaii Coastal Zone Management Program, 1993.

This study explores the viability of beach nourishment from offshore sand sources. Hawaii's, and other states,' procedures, permits, and environmental assessment requirements associated with offshore sand mining and beach nourishment are reviewed. Options are presented to adjust Hawaii's management framework to facilitate rather than discourage beach nourishment by casting regulatory requirements in a more supporting role. In addition, the report reviews previous investigations of Oahu's offshore sand resources, synthesizes and presents the useful data, describes an unsuccessful effort to profile an offshore sand deposit, and outlines a future work plan for sub-bottom profiling

Recommendations:

1. Establish an office of beaches within the Division of Boating and Ocean Recreation, DLNR.

2. Establish a Department of Environmental Protection to facilitate more effective administration of water quality regulations relative to beach nourishment projects.

3. Repeal the section of Chapter 205A, HRS that enables the counties to prepare beach management plans and extend their jurisdiction makai to the high water line, providing instead that the new state office of beaches be the lead agency for beach management.

4. Amend Chapter 183, HRS, and Title 13, Chapter 2, HAR, to create a new subzone in the conservation district for all submerged lands and beaches. Include a distinct set of objectives for the conservation of ocean and beach resources, and regulations to facilitate non-structural approaches to shoreline protection.

5. Implement the "master CDUA" concept for beach nourishment activities. Also, delegate the BLNR's decision-making authority to the DLNR's Office of Conservation and Environmental Affairs.

6. Continue the research in shoreline erosion and beach management issues through the CZM Program, but transfer the lead role for research to the proposed office of beaches.

7. Request the State Legislature to establish a dedicated fund for shoreline research and beach management activities, into which revenues from fines, licenses, damage awards, and permit application fees for shoreline-related activities shall be deposited.

8. Charge the proposed office on beaches with responsibility for preparing beach management plans.

9. Charge counties with responsibility for establishing and administering assessment districts for private shoreline properties that benefit from shore protection projects.

Recent University of Hawaii – School of Ocean & Earth Science Technology Projects

<u>Hawaii Beach Monitoring Program: Beach Profile Data</u>, by Anne E. Gibbs, Bruce M. Richmond, Charles H. Fletcher, and Kindra Hilman for the U.S. Department of the Interior, U.S. Geological Survey, School of Ocean & Earth Science Technology, 2001.

Between August 1994 and July 1999, biannual beach profiles were collected at 42 Oahu and 36 Maui locations. Surveys were conducted at approximately summer-winter intervals. The profiles were conducted to establish baseline beach conditions, monitor seasonal beach fluctuations, and understand the dynamics of beach change in Hawaii. This would help to document the coastal history in Hawaii, determine the causal factors of erosion, provide high-quality data for other "end-users" and increase the general understanding of the impact of coastal development.

Maui Erosion Study, by Charles H. Fletcher III for the Maui County Planning Department and School of Ocean & Earth Science Technology, 2002.

The Maui Erosion Study provides long-term shoreline erosion data for the North Shore, West Coast and Kihei Coast of Maui. An average annual erosion rate is determined using aerial photographs and National Oceanic & Atmospheric Administration T sheets. The data covers the period from 1900 to the late 1997. The erosion rate is from linear regression and end point analysis. Shore normal transects are established and the movements of the beach toe are monitored. Once an erosion rate is calculated, it is projected 30 years into the future.

Atlas of Natural Hazards in the Hawaiian Coastal Zone, by Charles H. Fletcher III, Eric E. Grossman, Bruce M. Richmond, and Ann E Gibbs for the U.S. Department of the Interior, U.S. Geological Survey, School of Ocean & Earth Science Technology, 2002.

The Atlas communicates to citizens and regulatory authorities the history and relative intensity of coastal hazards in Hawaii. This information is key to the proper management of coastal resources. The information can improve the ability of Hawaiian citizens and visitors to safely enjoy the coast and provides a strong data base for planners and managers to guide the future of coastal resources.

The work is largely based on previous investigations by scientific and engineering researchers and county, state and federal offices and agencies. The Atlas assimilates efforts in documenting Hawaiian Coastal Hazards and combines existing knowledge into a single comprehensive coastal hazard data set.

Both small scale and large scale maps are provided that summarize the risks from tsunamis, stream flooding, high waves, storms, erosion, sea level rise, and volcanic-seismic activity for various sections of the Hawaiian coastline.