SOUTHEAST OAHU
REGIONAL SEDIMENT MANAGEMENT
DEMONSTRATION PROJECT

REGIONAL SEDIMENT MANAGEMENT PLAN

Prepared for:
U.S. Army Corps of Engineers
Honolulu District
and
State of Hawaii
Department of Land and Natural Resources
Office of Conservation and Coastal Lands

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EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE) began a National Regional Sediment Management (RSM) Demonstration Program in 1999. RSM refers to the effective use of littoral, estuarine, and riverine sediment resources in an environmentally effective and economical manner. Several U.S. Army Engineer Districts are conducting RSM programs in cooperation with state or local partners.

The Honolulu District of the U.S. Army Corps of Engineers (POH) is performing a RSM Demonstration Project on the southeast shores of Oahu. The project is co-sponsored by the State of Hawaii Department of Land and Natural Resources (DLNR) Office of Conservation and Coastal Lands (OCCL).

The overall objective of a Regional Sediment Management Plan is to provide guidance on solving sediment problems in the region using a systems approach that considers the entire region from the mountains to the sea. A series of objectives are identified and discussed.

The Southeast Oahu Regional Sediment Management (SEO/RSM) demonstration project's tasks are to: (1) document long-term trends in wave climate for the windward side of Oahu, Hawaii, (2) model nearshore circulation, (3) develop a regional sediment budget, (4) develop a geographic information system (GIS) along the southeast Oahu coast, (5) identify suitable sand sources, and (6) map shoreline change for the region. Each task with results and status is discussed herein.

The SEO Regional Sediment Management demonstration project includes tasks for modeling coastal processes. The Coastal and Hydraulics Laboratory used STWAVE model and ADCIRC model to characterize the region.

The University of Hawaii (UH) Department of Geology and Geophysics is conducting an historical shoreline analysis for the SEO region. The analysis consists of determining the rate of shoreline change at 20 m intervals over the period from the early 20th century to 2005. UH also identified, mapped, and estimated volumes for reef top sediment bodies in the study area.

POH developed a sediment budget for each part of the SEO/RSM study area, Kaiona and Kaupo Beaches, Bellows Air Force Station, Lanikai Beach, and Kailua Beach. The budgets are based on erosion rate maps produced by the University of Hawaii and on the results of the STWAVE model study. The USACE's Geotechnical and Structures Laboratory made geotechnical investigations on coral sand from the region.

A web-based GIS platform was deployed for the SEO Region. The GIS contains georeferenced maps, attributes and metadata corresponding to SEO/RSM requirements. Aerial photography, digital elevation models, geotechnical information, survey data, wave parameters and other pertinent georeferenced information have been automated via the GIS.

To make the public aware of the project, three workshops were held to inform community stakeholders and coastal experts on the goals, progress, and results of the demonstration project and to solicit feedback from attendees.

Four potential demonstration projects (PDPs) were selected and discussed by participants in the workshops. At the north end of the region, a PDP at the Ka`elepulu Stream mouth focuses on better use of sediments periodically removed from the mouth. The PDP for Lanikai Beach is to determine methods of controlling beach erosion along a shoreline armored by seawalls. The third PDP is at Bellows Air Force Station beach where a revetment protects recreation cottages, but traps sand that otherwise might go into the littoral system. Kaupo and Kaiona beaches at the south end of the region suffer from shoreline and embankment erosion and are evaluated in the fourth PDP.

The Regional Sediment Management Plan presented herein compiles the program's completed work, presents objectives, and offers solution alternatives for the four potential demonstration projects (PDP).

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AEHR	Annual Erosion Hazard Rate
ADCIRC	ADvanced CIRCulation long-wave hydrodynamic model
CHL	Coastal and Hydraulics Laboratory
DLNR	Department of Land and Natural Resources
DPP	Department of Planning and Permitting
ERDC	U.S. Army Engineer Research and Development Center
GIS	Geographic Information System
GSL	Geotechnical and Structures Laboratory
OCCL	Office of Conservation and Coastal Lands
PDP	Potential Demonstration Project
POH	Honolulu District U.S. Army Corps of Engineers
RSM	Regional Sediment Management
RSMP	Regional Sediment Management Plan
SEO	Southeast Oahu
STWAVE	STeady-state spectral WAVE model
UH	University of Hawaii
USACE	U.S. Army Corps of Engineers

I. Introduction

The islands of Hawaii are the most remote islands in the world. Located in the vast expanses of the Pacific Ocean, the U.S. Army Corps of Engineers has a division and district office located on the island of Oahu. The Honolulu District (POH) is performing a Regional Sediment Management (RSM) Demonstration Project on the southeast shores of Oahu. In the future, additional demonstration projects could take place on the other Hawaiian Islands. The project is co-sponsored by the State of Hawaii Department of Land and Natural Resources (DLNR) Office of Conservation and Coastal Lands (OCCL).

The project consists of a series of studies to characterize the coastal processes as described below. The Regional Sediment Management Plan presented herein compiles the program's completed work, presents objectives, and offers solutions to four potential demonstration projects (PDP).

The project is a combined effort of POH, the Coastal Hydraulics Laboratory, the Geotechnical and Structures Laboratory, the University of Hawaii Department of Geology and Geophysics, and Oceanit Laboratories, Inc. OCCL provides advisory assistance.

II. Regional Sediment Management Program

The U.S. Army Corps of Engineers began a National RSM Demonstration Program in 1999. RSM refers to the effective use of littoral, estuarine, and riverine sediment resources in an environmentally effective and economical manner. RSM strives to maintain or enhance the natural exchange of sediment within the boundaries of the physical system.

Managing sediment to benefit a region potentially saves money, allows use of natural processes to solve engineering problems, and improves the environment. As a management method, RSM

- Includes the entire environment, from the mountains to the sea
- Accounts for the effect of human activities on sediment movement as well as its transport in streams, lakes, bays, and oceans
- Protects and enhances the nation's natural resources while balancing economic needs

The U.S. Army Corps of Engineers (USACE) holds in trust and manages lands and waterways across the U.S. Using regional sediment management concepts will significantly improve the USACE's mission accomplishment. The USACE's engineers and scientists develop new technologies through research to make management decisions more accurate and efficient. Simultaneously, they evaluate RSM concepts through demonstration projects that highlight and improve sediment management activities.

Regional sediment management encompasses the following characteristics:

- RSM is a “system-based approach” that seeks to solve sediment-related problems by designing solutions that fit within the context of a regional strategy.

- RSM is the integrated management of littoral, estuarine, and riverine sediments to achieve balanced and sustainable solutions to sediment-related needs. This approach provides opportunities to achieve greater effectiveness and efficiency.

- RSM involves making local project decisions in the context of the sediment system and forecasting the long-range implications of management actions.

- RSM recognizes sediment as a resource – sand and sediment processes are important components of coastal and riverine systems that are integral to economic and environmental vitality.

- RSM engages many stakeholders. Many federal and non-federal sediment management activities may potentially have system-wide effects.

- RSM recognizes that sediment management actions have potential economic and ecological implications beyond a given site, beyond originally intended effects, and over long time scales (decades or more).

- RSM is a Corps-wide approach that is being implemented through coordinated activities using several Corps authorities.

- RSM is implemented by establishing an RSM team, seeking management support, engaging and involving other agencies that have a stake in managing sediment, and informing and engaging other key stakeholders, including the public (US Army Corps of Engineers, 2004).

III. Southeast Oahu Regional Sediment Management Demonstration Project

The Southeast Oahu Regional Sediment Management (SEO/RSM) demonstration project’s purpose is to: (1) document long-term trends in wave climate for the windward side of Oahu, Hawaii, (2) model nearshore circulation, (3) develop a regional sediment budget, (4) develop a geographic information system (GIS) along the southeast Oahu coast, (5) identify suitable sand sources, and (6) map shoreline change for the region.

The SEO region is located on the southeast shoreline of the island of Oahu, Hawaii (see Figures 1 and 2). It extends along approximately 12 miles of

shoreline from Mokapu Point in the north to Makapu`u at the south end. There are three littoral cells, Kailua in the north, Lanikai in the middle, and Waimanalo in the south part of the study area. Both sub-aerial and offshore geologic controls affect sediment transports within these cells. The offshore region is a 2,000 foot long sloping reef along which waves break. Wave heights are limited by the 4-foot reef depth as they approach the shoreline.

SEO/RSM investigations will determine if there is sediment transport between the cells. Long-term (decadal or more) shifts in wind, wave direction, and wave period may shift sediment transport patterns and magnitudes. As a result, sediment transport processes of these beaches are difficult to understand, and RSM solutions are not readily apparent. The final products from this study will be wave and current model results, a sand source inventory, web-enabled GIS platform, a sediment budget, regional shoreline change maps, and this regional sediment management plan for the study area. The SEO/RSM Regional Sediment Management Plan (RSMP) documents all of the activities that have been conducted since the beginning of the SEO/RSM investigations in fiscal year 2005. Work performed by the Honolulu District, Coastal & Hydraulics Laboratory, Geotechnical and Structures Laboratory and the University of Hawaii (UH) is summarized herein along with the results of the study workshops. Descriptions of the various tasks that are in progress or have been completed are provided as appendices to this document. Many of the SEO/RSM products can be found online at the following web site.

http://gis.poh.usace.army.mil/rsm/pages/

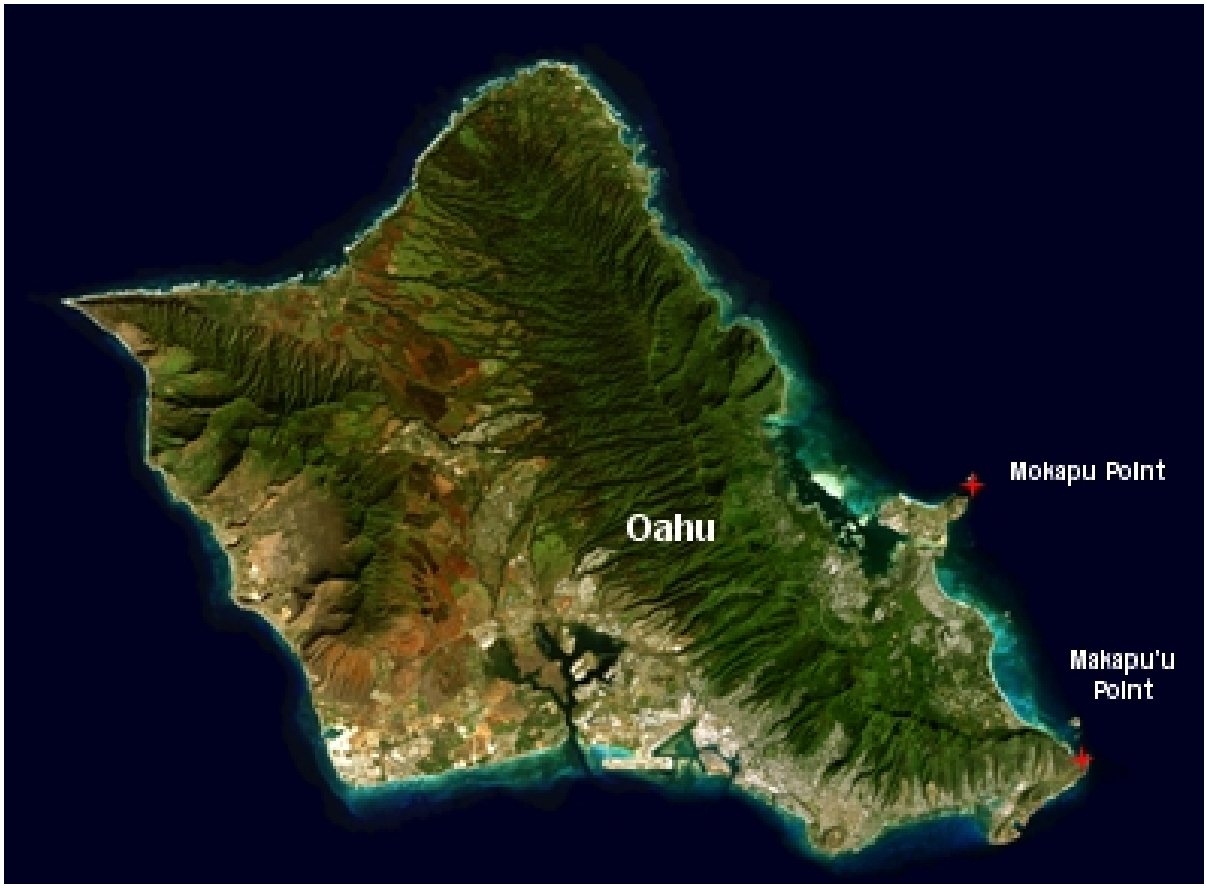

Figure 1. Southeast Oahu Region

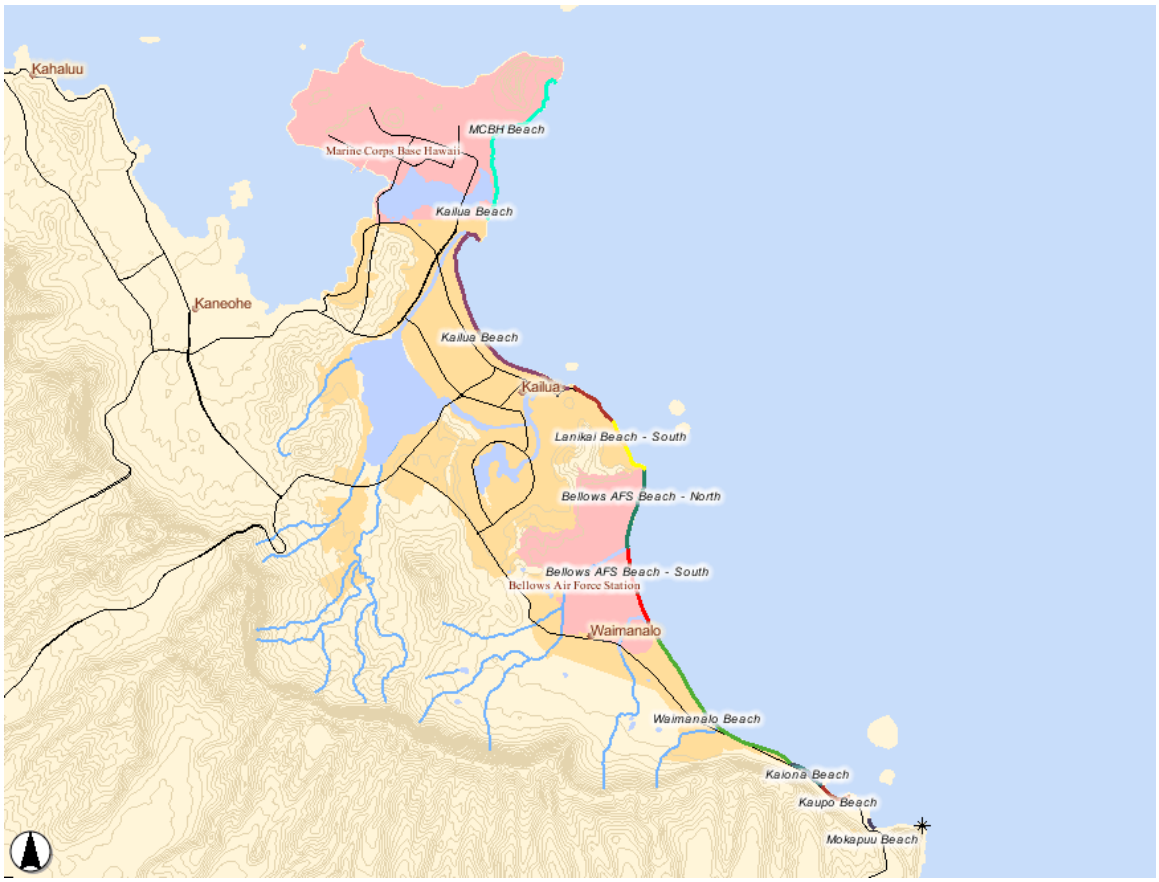

Figure 2. Southeast Oahu RSM Map

IV. Coastal Ecosystem

The primary focus of the project is on the physical factors that influence regional sediment processes. Much of the sediment is biologically derived, e.g., calcium carbonate sand is produced by coral and algae, but the study seeks to understand the best tools, either physical or environmental, to manage the sediment.

The typical coastal ecosystem in southeast Oahu consists of coral sand beaches sometimes backed by coastal dunes; a nearshore flat shallow area of sand, rubble, and hard substrate; and a fringing coral reef that drops off into deeper water.

The beach is dynamic. It changes continually with waves, currents, tides and wind. Seasonal changes are normal. A beach may change quickly in response to storms and high waves. When a beach is eroding, upland areas, such as houses or highways, can be threatened and damaged.

Dunes are typically built by wind-blown sand and serve as a reserve sand source that replaces sand lost to storm waves. A stable dune will often have vegetation, which tends to collect and hold the blown sand.

The fringing reef and reef flat are sources for beach sand. They are also the habitat for much of the marine life found in Hawaii. A healthy reef helps maintain a healthy beach. Reefs are sensitive to water quality that often depends on inland conditions. Rainfall runoff can carry silt and other pollutants that will damage or kill a coral reef. Nutrients in runoff will encourage the growth of algae that will displace live coral polyps and take over a coral area.

V. Coastal Erosion, Beach Loss and Coral Reef Degradation

The primary cause of coastal erosion is waves; however, there are a number of other factors that affect the work of the waves. These include sea level rise, variability in sediment supply, storms, deflation by wind, longshore and offshore sediment transport, reduction of sediment supply, removal of sediment by man, interruption of material in transport, and change in natural protection by man or nature.

Erosion is a natural response to the water and wind processes at the shore, but erosion is only a problem when human development is at risk. Sometimes, man-made alterations to the littoral system, including modifications to sediment sources or sinks, may contribute to the eroded condition. (Coastal Engineering Manual, Section 1-2-4)

Much of the beach sand in Hawaii is carbonate based. It is made by coral and algae growing on nearshore reefs. If reef growth is slowed by poor water quality, sediment from runoff, or if the reef is otherwise unhealthy, sand production is reduced and erosion may remove sand faster than it can be replaced. Since the beach size depends on sand supply, a beach can shrink in response to reef degradation.

VI. Objectives

The overall objective of a Regional Sediment Management Plan is to provide guidance on solving sediment problems in the region using a systems approach that considers the entire region from the mountains to the sea. A series of objectives are identified and discussed in the paragraphs below.

A. Identification of Erosion Hotspots and Erosion Watchspots

Erosion hotspots are areas where coastal erosion has threatened shoreline development or infrastructure. They are existing management challenges. In most cases, the shoreline has been armored to protect property and development, and there has been a noticeable environmental impact and/or a

decrease in recreational use. Erosion hotspots can be restored, but restoration will require substantial economic resources. **Erosion watchspots** are areas where the coastal environment will soon be threatened if shoreline erosion trends continue. (Mullane and Suzuki, 1977)

Shorelines where erosion exists or threatens to be a problem must be thoroughly evaluated before deciding on shoreline use. Planning includes identifying eroding shorelines in the SEO Region.

B. Guidelines for Shore Protection Measures

A plan objective is to identify shore protection methods appropriate for erosion control in the region. These methods include both soft methods such as beach nourishment and hard methods such as seawalls. The choice must be based on engineering, economic, environmental, and regulatory considerations. A set of selection guidelines should be developed based on the SEO/RSM study results.

C. Beach Nourishment

1. Sand Sources for Beach Nourishment

For beach nourishment to be a viable form of shore protection, sand sources must be identified and mapped. Sources need not be in the region, but the cost of hauling sand from long distances is a major factor in deciding to use nourishment. Nearby offshore sources might be easier and more economical to use. The University of Hawaii, as part of the SEO/RSM project, is writing a report titled, “Reef Top Sediment Bodies in Windward Oahu,” a draft of which is attached in the appendix. When finished, this report will be the primary reference for locating potential offshore beach nourishment sand sources in the study area.

2. Pilot Beach Nourishment Project

A pilot beach nourishment project is recommended as one of the potential demonstration projects discussed later in the plan.

D. Dune Preservation and Restoration

An objective is to preserve and restore beach dunes, since they are one of the primary natural shore protection systems. Sections of the regional shoreline such as Lanikai and Kailua have dune systems that can be stabilized or enhanced for better protection. Some dune areas, such as Lanikai and Kailua Beaches, have been identified during the SEO/RSM studies. Dune evaluation is recommended as an objective for the PDPs discussed later in this plan.

E. Coral Reef Ecosystems, Water Quality, and Upland Activities

The primary source for coral sand is Hawaii's reefs. If reefs suffer in a coastal region because of runoff or pollutants entering nearshore waters, they will produce less sand. Environmental control and clean water are therefore necessary for healthy reefs and consequently healthy beaches. This objective includes keeping the reef healthy by controlling water quality and upland activities that could pollute nearshore waters. These upland activities are as diverse as construction, agricultural and urban runoff, streams, sewage production, and industrial pollution. Water activities including recreation such as boating, fishing, snorkeling, or SCUBA can also affect reef ecosystems.

F. Shoreline Setbacks and Coastal Erosion Hazard Data

The City and County of Honolulu (County) regulates shoreline setbacks and has started a program to study coastal erosion rates and quantify erosion hazards. The program is being done by the University of Hawaii Department of Geology and Geophysics under contract with the County. Shoreline setbacks are already established in the county, but variable setbacks based on local or regional erosion rates could be used to regulate coastal development.

G. Proactive Development of Coastal Lands

Development of coastal lands, especially along shorelines with beaches, requires advanced planning by owners, developers, and regulatory agencies. Many, if not most, landowners, developers, and real estate agents do not understand coastal dynamics and the potential problems they might encounter.

The "Beach Management Plan for Maui" states the following:

> *Proactive management occurs in the planning stages of new developments or redevelopments along the shoreline, well before project layout is finalized. This type of planning is beneficial to coastal landowners and developers who are not always aware of shoreline processes, coastal hazards, and the potential impacts of development on the beach and other nearshore areas. The permitting agency should apprise the applicant of the recommendations listed below during project layout. Incorporating the advice of the Planning Department would streamline the permitting process and decrease the risk of coastal hazards.*
>
> *Developers and landowners should be encouraged to pre-consult with various experts and governmental agencies familiar with coastal erosion in order to get appropriate recommendations on project design. Developers and landowners should also acknowledge that developments along the shoreline are subject to the risk of coastal erosion and high wave events and that any*

request to protect structures and property with shoreline armoring is currently discretionary based on grounds of hardship and impacts on the environment.

These ideas can be applied to the County Department of Planning and Permitting (DPP) on Oahu as well as to various state regulatory agencies.

H. Inter-Agency Coordination

An objective of the RSMP is to use inter-agency coordination and cooperation whenever possible to make sediment management projects simpler and faster with minimal regulatory processing.

The “Beach Management Plan for Maui” states the following:

> *Much of the coastline of Maui consists of parks, highways, and other public works projects, which are threatened or will soon be threatened by erosion and other coastal hazards. Inter-agency communication and education is necessary to more effectively plan for or mitigate coastal hazards and implement more environmentally sound projects. Better inter-agency coordination would also reduce delays, duplications, paperwork, and resource demands in permit processing, resulting in cost-savings to both permit applicants and governmental agencies.*

In Hawaii, the state has responsibility for regulating coastal development seaward from the certified shoreline. The county has responsibility for areas landward from the certified shoreline. The Corps of Engineers, representing the federal government, regulates development in “waters of the United States,” which include all waters subject to the ebb and flow of the tide and inland waters such as streams, lakes, and wetlands. These three areas of governmental jurisdiction may overlap, and permits from more than one agency are sometimes necessary when coastal development is planned.

An example of inter-agency coordination is the Small-Scale Beach Nourishment (SSBN) Project permit. The State Department of Land and Natural Resources processes this permit that includes the state Conservation District Use Permit, the Department of the Army Permit, the State Programmatic General Permit, the State of Hawaii Department of Health Section 401 Water Quality Certification, and the Hawaii Coastal Zone Management Federal Consistency Review.

However, the City and County of Honolulu Department of Planning and Permitting does not fully participate in the SSBN permit process. Currently, if a land owner plans to place beach nourishment and the placement extends above the certified shoreline, the County requires a permit and an environmental assessment for placing the sand and for any temporary sandbag retaining or protection structures. This objective includes convincing DPP to cooperate more

fully with the State DLNR's SSBN Permit processing and to not require a separate permit.

I. Structures and Activities within the Shoreline Area

1. Minor Structures

For the County, minor structures are defined in the Department of Planning and Permitting Rules, Part 2, Rules Relating to Shoreline Setbacks and Special Management Areas, Chapter 15, Minor Structures and Activities. Typically, minor structures are those that have little or no effect on shoreline processes. This objective supports continued use of a simplified process for approving minor structures.

2. Major Structures

For major structures, the objective is to convince Honolulu to cooperate more fully with the State DLNR's SSBN Permit processing. Currently, if a land owner plans to place beach nourishment and the placement extends above the certified shoreline, the County requires a permit for placing the sand and for any temporary sandbag retaining or protection structures.

J. Beach Management Districts

The SEO/RSM project does not include beach management districts as a primary task; however, this is a secondary objective for longer-term consideration. Maui County lists beach management districts as one of their objectives (Mullane and Suzuki, 1997). The SEO Regional Sediment Management Demonstration Project area is probably somewhat larger than Maui's beach management districts but contains shoreline areas such as Lanikai or Kailua that would qualify as management districts. A summary of Maui's objectives is as follows:

> ***Beach management districts*** *should be established on a neighborhood scale to help maintain or restore nearby beaches and other shoreline areas. A beach management district (BMD) is a special designation for a group of neighboring coastal properties that provides a mechanism for implementing erosion mitigation projects at multi-property scales. BMDs streamline the permitting requirements for beach preservation and restoration projects and facilitate cost sharing between the group of neighborhood owners and county, state, and federal agencies. Further details about establishing beach management districts and the advantages and challenges of establishing them are thoroughly discussed in a 1992 report entitled Beach Management Plan with Beach Management Districts by Hwang and Fletcher. Certain beach management projects (e.g., large beach restorations) affect several*

beachfront properties. The formation of a beach management district allows a group of adjacent landowners to address shoreline issues as a unit rather than as individual property holders (HWANG AND FLETCHER, 1992). As a beach management district, the group can pool its resources and streamline the permitting process for such projects. Often, county, state, and federal agencies will participate in cost sharing for a particular project, if it benefits the public. Some condominium associations and neighborhood boards already act as de facto beach management districts.

Although beach management districts have been recommended for Maui County, they have not yet been defined for Oahu. However, DPP has considered neighborhood beach areas when evaluating neighborhood problems.

Oahu has a Development/Sustainable Community Plan for the shoreline area of Ko`olaupoko on the windward side along the same area as the SEO/RSMP (Department of Planning and Permitting, July 2000). Excerpts from the plan are given below. If implemented on Oahu, beach management plans would be the next lower level of planning. The Ko`olaupoko plan states the following:

Land Use Policies, Principles, and Guidelines

3.1.3.2 Shoreline Areas

Ko`olaupoko's shoreline characteristics are quite varied, from the rocky headlands of Makapu`u at the south end of the district, to wide sandy beaches fronting Waimanalo Bay and Kailua Bay, to mud flats along Kaneohe Bay. The shoreline provides residents and visitors with significant active and passive recreational value. Thus, public access, both mauka-makai and lateral, should be maintained and improved. In addition, Ko`olaupoko's shoreline areas offer spectacular scenery. As such, views from public roads to the shoreline should be maintained or created. Particular segments of the shoreline are discussed below.

***Mokapu Peninsula**. Sandy beach dunes facing the ocean are situated between large remnants of volcanic craters. On one side of Nuupia Ponds, at the neck of the peninsula, is a narrow, sandy beach facing Kailua Bay, and on the other side is a siltier beach fronting Kaneohe Bay. Except at certain times for special events, the general public is denied physical access to the peninsula, which is under military jurisdiction.*

***Kailua Bay, from Kapoho Point to Alala Point**. Kailua Beach is wide and sandy, but dynamic and subject to significant erosion and accretion cycles. It is famed for its high quality as a recreation area. Kailua Bay is attractive for a variety of ocean recreation activities, notably swimming, body surfing, windsurfing, kayaking and canoe racing. Public access to the beach and coastal waters is provided primarily at Kailua Beach Park, on either side of the Ka`elepulu Stream outlet, and at the smaller Kalama*

Beach Park. At both locations, vehicular parking spaces are in great demand on weekends and holidays. There are five public rights-of-way for pedestrians at dispersed points along Kalaheo Avenue, the street that runs parallel to the beach, but no off-street parking, public restrooms or showers are available at these locations. Visual access to the shoreline from the adjacent street is available only at Alala Point and the Ka`elepulu Stream crossing.

***Kailua Bay, from Alala Point to Wailea Point (Lanikai)**. Severe erosion is occurring at either end of Lanikai Beach, where adjacent residential property owners have built seawalls and revetments along most of the shoreline. The remaining sandy beach in the central portion is popular for recreation. Public access for pedestrians is provided at eleven points along the parallel public street, Mokulua Drive, but no offstreet vehicular parking, public restrooms or showers are available for beach-goers. Visual access to the shoreline from the street is very limited.*

***Waimanalo Bay, from Wailea Point to Makapu`u Point**. Wide sandy beaches front almost the entire length of Waimanalo Bay. There is a narrower beach and emerging reef rock in the vicinity of Pahonu Pond in the mid-section of the Bay shoreline. While Kalanianaole Highway is relatively distant from the shoreline at the northern portion of the beach, physical access is readily available during peak recreation periods at Bellows Air Force Station and Waimanalo Bay State Recreation Area. In the beachfront residential area of Waimanalo, there are three pedestrian rights-of-way to the shoreline along Laumilo Street. Further south, at Waimanalo Beach Park and Kaiona Beach Park, the highway is close enough to the shoreline to afford both visual and physical access. In the southernmost stretch, along Kaupo Beach Park and Makapu`u Beach Park, visual and physical access to the shoreline is virtually unimpeded. The highway offers dramatic vistas of coastal headlands and cliffs, ocean waters and off-shore islands, and a direct link to the proposed 354-acre scenic shoreline area extending from Makapu`u Point to Koko Head in East Honolulu.*

Guidelines pertaining to shoreline areas are listed below:

Maintain existing makai view channels along Kalanianaole Highway between Makapu`u Point and Waimanalo Beach Park; along Kawailoa Road and North Kalaheo Avenue in Kailua; along Lilipuna Road in Kaneohe; and along Kamehameha Highway north of Kaneohe. Avoid visual obstructions, such as walls and dense landscaping.

Create and maintain new makai view channels along Kamehameha Highway and Kahekili Highway north of Kaneohe through selective clearing of dense vegetation and the removal of structures. Such view

channels should be created by public acquisition of shoreline properties along the highway or by obtaining easements and maintenance agreements with private landowners. Priority should be given to the areas where clearing would open up vistas of perennial streams, wetlands, fishponds and off-shore islands.

Place high priority on maintaining the untamed landscape quality of the Makapu`u view shed. Any modification to this shoreline area should be done in a manner that continues the landscape character of the proposed scenic shoreline corridor on the East Honolulu side of Makapu`u Point.

Consideration should be given to the establishment of buffer zones for the protection of rare coastal resources and recognition that such resources should be defined and identified.

Increase opportunities for physical access to the shoreline areas of Kaneohe and Kailua by acquiring additional shorefront areas. The top priority for such acquisition is in Kaneohe. In Kaneohe, access is being designed at the site of the Kaneohe Wastewater Pre-Treatment Facility, to be named Waikalua Bayside Park. The park is adjacent to Kaneohe Stream, which will be dredged to a depth of nine feet. Future expansion may be possible by either acquiring the adjacent Kokokahi YWCA facility or entering into a cooperative agreement with this organization for the joint use of both properties. Other sites in Kaneohe are at King Intermediate School and at a spot north of Heeia Kea Landing. The latter may require realignment of a portion of Kamehameha Highway to create adequate land area makai of the roadway. In Kailua, an additional park site should be sought in either the Oneawa Beach area, near the surf spot known as "Castles" or in the frontage along Kalaheo Avenue between Kailua Beach Park and Kalama Beach Park. The latter beach park could also be expanded if there is an opportunity to acquire an adjoining property.

Existing pedestrian rights-of-way to the shoreline should be improved by providing onstreet or off-street parking nearby; secured bicycle racks where the access point adjoins an existing or planned bikeway, such as along Mokulua Drive in Lanikai and Kaneohe Bay Drive in Kaneohe; and provisions for emergency vehicle access and lateral access along the shoreline.

To maintain lateral access along popular beaches that are subject to long-term and seasonal erosion, particularly at Lanikai and Kualoa, beach management plans should be developed and implemented, with an emphasis on non-structural approaches and prevention of adverse effects on adjacent coral reef ecosystems. Greater shoreline setbacks should be established for new structures along these and other unstable shoreline areas, using criteria developed in various shoreline studies.2 Plans and

activities should be consistent with the objectives and policies of the State Coastal Zone Management Program.

The placement and design of exterior lighting in areas adjacent to the shoreline may contribute to disorientation, injury or death of seabirds. Therefore, lighting should be designed and constructed to avoid such effects, using DLNR guidelines.

The Alala Point to Wailea shoreline should be designated as an erosion-prone area and a beach management plan prepared and implemented. Periodic beach restoration activities should also focus on the Bellows Air Force Station beach and Kaupo beach.

The shoreline along Kamehameha highway adjacent to Kualoa Ranch to Kualoa Point should be designated as an erosion-prone area and be subject to a beach management plan.

To preserve public ownership and use of shoreline resources, legislation should be pursued to render all shoreline accretion as public (State) property in perpetuity.

Discourage the use of shore armoring structures.

2 See City and County of Honolulu Department of Land Utilization, Oahu Shoreline Study, Parts 1 and 2, (prepared by Sea Engineering, Inc.), 1988 and 1989.

K. Public Awareness and Education

The SEO Regional Sediment Management Demonstration Project has already hosted three public workshops that are discussed further in Section XIII. The Project should continue holding workshops or public meetings as the work progresses.

VII. Geomorphology

Historical shoreline position, beach profile, aerial photography, bathymetric, and geologic information for the study area were evaluated to identify (a) long-term trends in shoreline position; (b) long-term trends in bathymetric change; (c) locations with possible sources of beach nourishment material, and (d) geologic controls on littoral processes. Historical shoreline position data were available from the University of Hawaii. Sand samples were taken both onshore and offshore, and jet probes were conducted and analyzed to identify possible offshore sources of beach quality material. Because of the low hardness value of the sediment, it is possible that abrasion or mechanical disintegration is a significant process in shoreline retreat. The abrasive characteristics of beach

sediments were quantified. This task provided data for development of the regional sediment budget.

VIII. Coastal Process Modeling

A. Modeling Tasks

The SEO Regional Sediment Management demonstration project includes tasks for modeling coastal processes. The scope of these tasks are summarized in the following paragraphs

B. Wave Climate

From observations of shoreline position on the northeast side of Oahu, it appears that there is a long-term trend (15 or more years) of alternating episodes of erosion and accretion. These cycles of beach change may be caused by shifts in wave climate, including multi-decadal shifts in storm activity associated with the Pacific Decadal Oscillation. The long-term wave climate was developed by using the updated Wave Information Study hindcast for the project area. Directional wave buoy data were also available for the years 2000-2006, and non-direction wave buoy data were available for more than 20 years. This task provided a regional wave climate for regional shoreline change analysis.

The STWAVE model was adapted for the SEO/RSM and validated using field data. STWAVE is a spectral wave transformation model that incorporates many of the factors that change wave characteristics as they proceed toward the shoreline. The model was applied using 1234 selected nearshore conditions that were saved at 10 points to create nearshore time series lookup tables. The results of the model study, “Coastal Processes Modeling Utilizing Numerical Models: ADCIRC and STWAVE,” is included in Appendix C.

C. Water Circulation

Because waves are depth-limited as they approach the study area, it is believed that nearshore circulation (wave-, tide- and wind-induced) may be a significant process controlling sediment transport. This task involved setting up and running the Advanced Circulation model, ADCIRC, for the study area. The modeling effort was a cooperative effort of the Pacific Ocean Division, Honolulu District of the U.S. Army Corps of Engineers and the Coastal Hydraulics Laboratory. There were no nearshore circulation data available for model validation/calibration; thus, wave, current and drogue studies were conducted for a one-month period in August 2005. A report from this study titled, “Coastal Processes Modeling Utilizing Numerical Models: ADCIRC and STWAVE,” is included in Appendix C.

D. Regional Sediment Budget

POH developed a sediment budget for each part of the SEO/RSM study area, Kaupo and Kaiona Beaches, Bellows AFS, Lanikai Beach, and Kailua Beach. The budgets are based on erosion rate maps produced by the University of Hawaii and on the results of the STWAVE model study.

Volumetric change for historical and present-day time periods was developed for the active littoral region. These data, together with knowledge of the long-term wave and wind climate and regional shoreline change analysis were used to develop sediment budgets for the region. Sediment sources and sinks were identified and quantified. A regional sediment budget was developed, including an assessment of whether long-term sand sharing between littoral cells occurs. The regional sediment budget is used to develop this RSM Plan.

The following steps were conducted in the development of a regional sediment budget for Southeast Oahu (Mokapu Point to Makapu'u Point). As indicated in Figure 3, National Data Buoy Center Station 51201 is located approximately 5 miles northwest of Waimea Bay in a water depth of about 650 feet. The station consists of a Datawell directional wave buoy that acquires wave energy spectra, wave direction and sea water temperature. Data is collected by the gage at 30 minute intervals and information available for the years 2001 through 2004 was utilized for the regional sediment budget analysis (RSBA). The numerical wave propagation model STWAVE transformed incident wave conditions from the gage located to ten nearshore save points (see Figure 4). To characterize the incident wave climate at the gage, 1,234 unique combinations of wave height, wave period and wave direction were modeled in STWAVE to develop look-up tables at the ten save point locations. The look-up tables enabled rapid determination of resultant wave conditions at the ten save points for each wave gage time step utilized in the RSBA.

Once the nearshore wave climate was determined for each save point, a modified CERC formula provided estimates of potential sediment transport for each time step considered. The CERC formula has been widely used for prediction of annual sediment transport rates and its strengths and weaknesses are well documented. For the SEO/RSBA, annual left and right directed sediment transport rates at each save point were calculated. The ratio of the annual left directed transport divided by the annual right directed transport at each save point facilitated evaluation of gross transport quantities identified by littoral cell via the shoreline change analysis conducted by the University of Hawaii, School of Ocean and Earth Science and Technology (SOEST).

As described elsewhere in this report, SOEST calculated shoreline change rates for the SEO/RSM study area based on historical aerial photography, USGS T-sheets and other available map/survey products. Based on shoreline change rates calculate by SOEST at each transect, the corresponding sediment volume

change rates were determined using a correlation factor of 0.7 cubic yards of beach fill required to extend one foot of shoreline a distance of one foot in the offshore direction. Littoral cells were then identified by contiguous reaches of accretion and erosion. Net transport was inferred at each cell boundary and the STWAVE analysis of left versus right directed transport was applied. Figures 5 through 9 display shoreline change rates, littoral transport cells, net sediment transport rates, and cell boundary sediment transport vectors by sub-regions of the study area.

- Current status: **operational**
- Most recent location: **21 40.36 N 158 6.95 W (21.6727 -158.1158)**
- Instrument description: **Datawell directional buoy**
- Most recent water depth (MLLW): **200 m (656 ft, 109 fm)**
- Measured parameters: **wave energy,wave direction,sea temperature**
- NDBC identifier: **51201**

- **Photo Gallery**

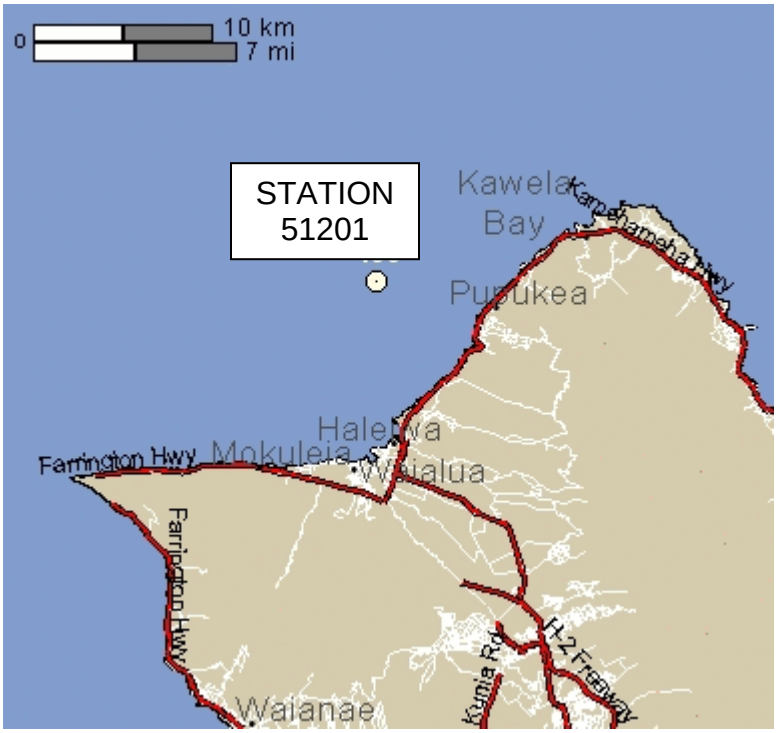

Figure 3: Station 51201 Map
"located approximately 5 miles NW of Waimea Bay "

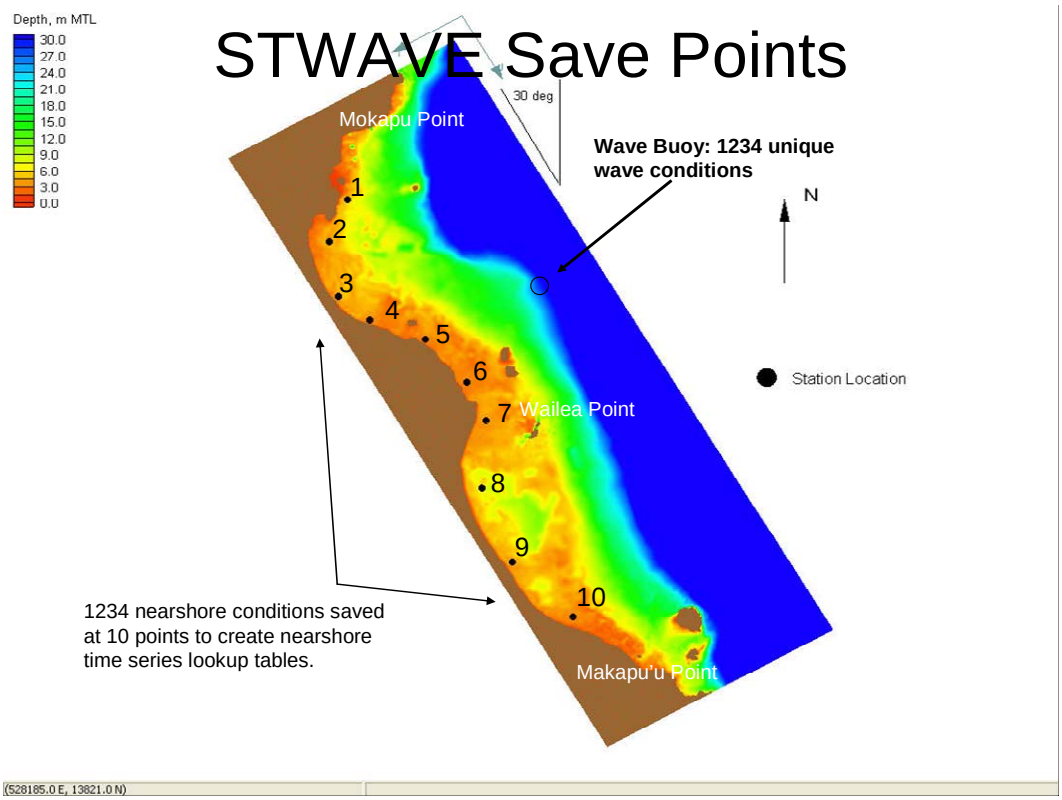

Figure 4: Location of the STWAVE nearshore save point locations.

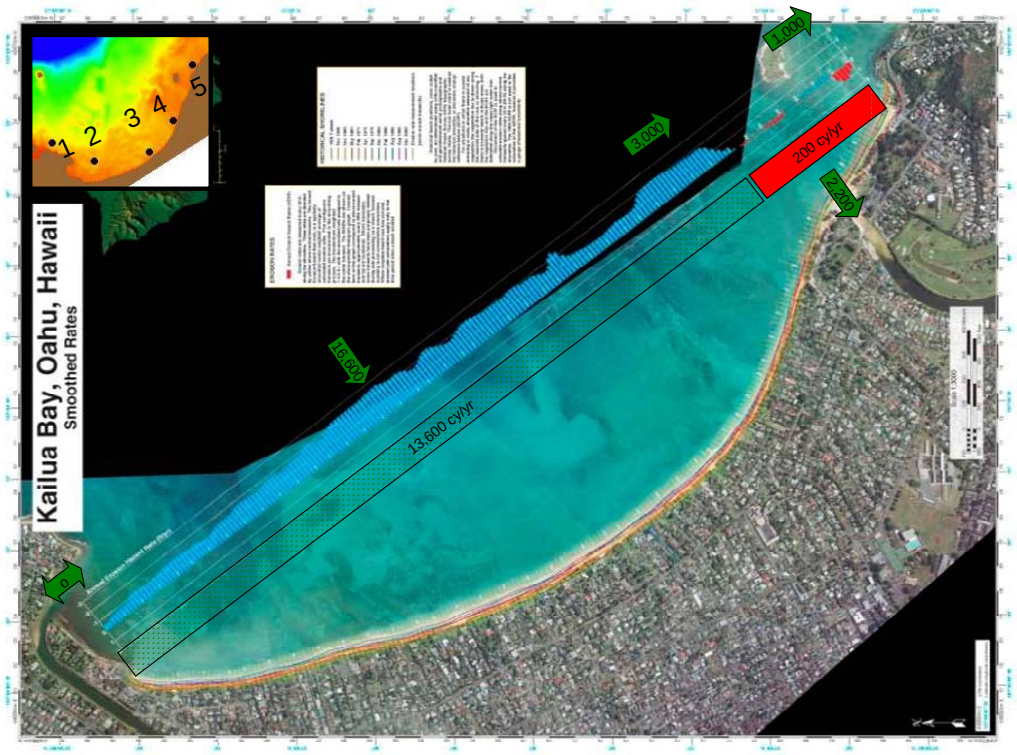

Figure 5: Kailua Bay shoreline change rates, littoral transport cells, net sediment transport rates and cell boundary sediment transport vectors.

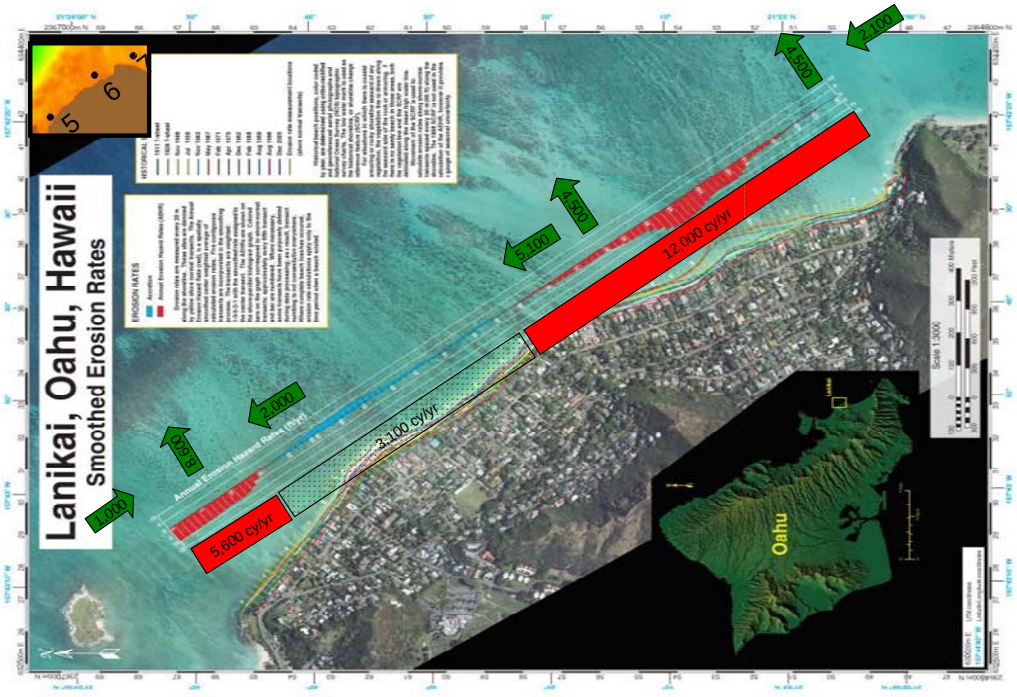

Figure 6: Lanikai shoreline change rates, littoral transport cells, net sediment transport rates and cell boundary sediment transport vectors.

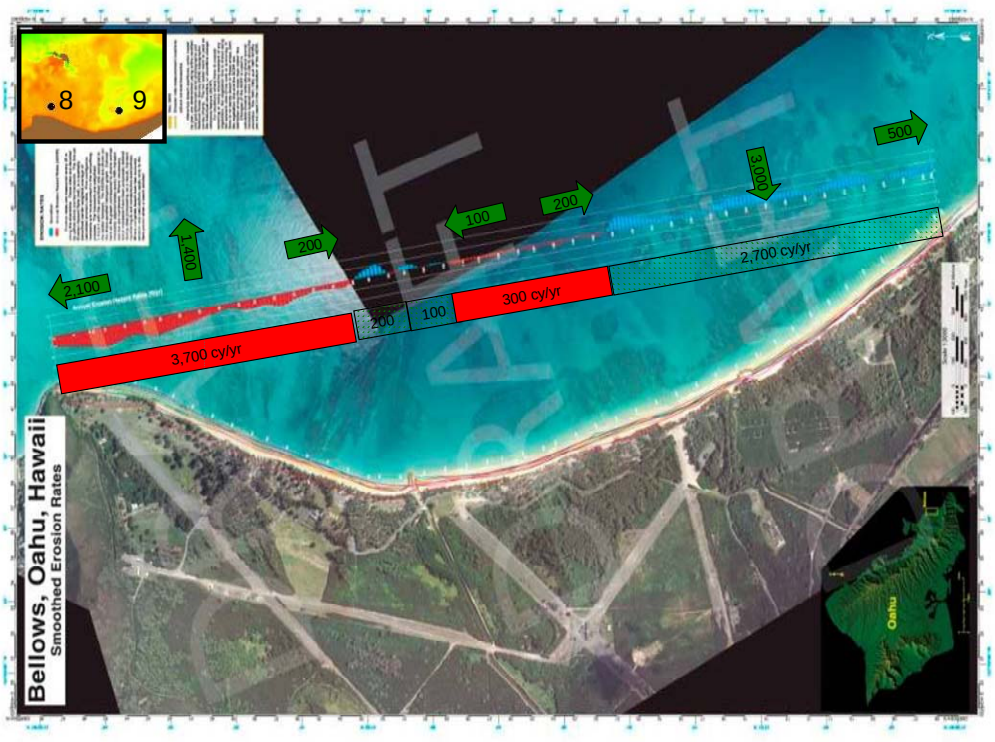

Figure 7: Bellow Air Force Station shoreline change rates, littoral transport cells, net sediment transport rates and cell boundary sediment transport vectors.

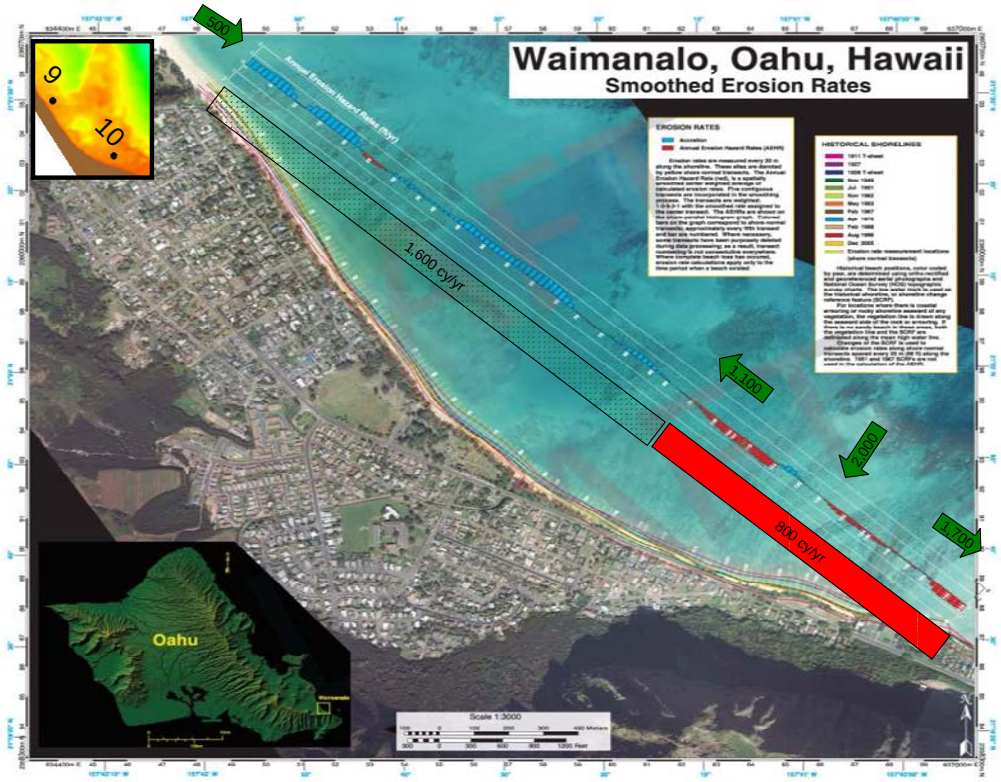

Figure 8: Waimanalo Bay shoreline change rates, littoral transport cells, net sediment transport rates and cell boundary sediment transport vectors.

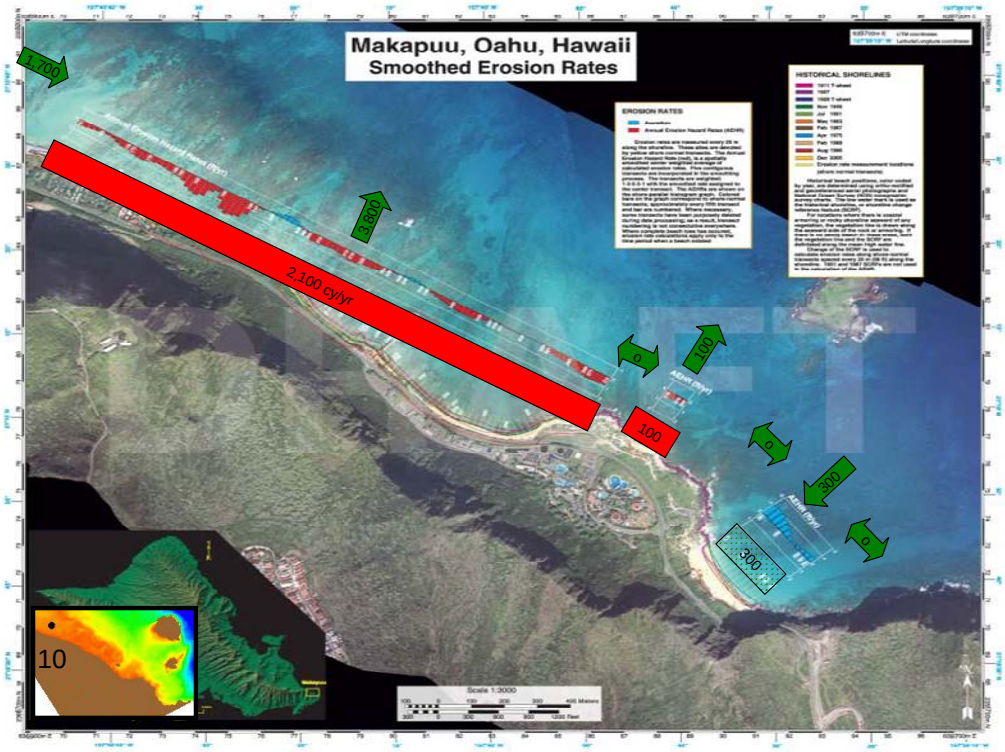

Figure 9: Makapu'u shoreline change rates, littoral transport cells, net sediment transport rates and cell boundary sediment transport vectors.

IX. Shoreline Change

The University of Hawaii (UH) SOEST Department of Geology and Geophysics is conducting an historical shoreline analysis for the SEO region. The analysis consists of determining the rate of shoreline change at 20 m intervals over the period from the early 20th century to 2005. NOAA "T" sheets dating from the early 20th century will be orthorectified using modern GPS ground control and used in comparison with 4 to 8 orthorectified aerial photographs from the post WWII era to determine a long-term rate of shoreline change. UH is using the re-weighted least median of squares linear regression technique to determine the long-term trend of historical change. This technique eliminates outlier points from the linear regression and combines measurement and positional uncertainties with regression uncertainties in calculating the standard deviation of the trend (Fletcher et al, 2003; Genz et al, in review).

New aerial photographs ca. 2005 at a scale of 1:8400 digitally scanned at 10 microns were be acquired for the study. These cover a coastal strip approximately 800 to 1000 m wide centered on the shoreline. Stereo-photogrammetry using orthorectified pairs of photos, with GPS ground control, will be used to create coastal DEM's. These are digitally combined with offshore SHOALS Lidar data (where such data exist) to create a seamless topographic/bathymetric DEM for the study area.

Historical photography and "T" sheets will be orthorectified using the 2005 DEM so that all derived shoreline data are based on orthorectified positions, thus minimizing positional errors. RMS positional error of final orthorectified-photos is typically ~1-2 m. Using topographic field profiles to measure beach and dune volume shoreline change rates can be converted to rates of sand volume change over time. A final budget of beach sand volume shifts over the period of study (approximately 80 years) will be produced. This approach was documented in Norcross et al, (1998).

The UH study is in progress. Draft erosion rate maps are shown in the following figures.

X. Sediment Trend Analysis

A sediment trend analysis is being done at the US Army Engineer Research and Development Center. The analysis results will be included when received.

Sediment grain size trend analysis is being done by the UH, but results have not yet been received.

XI. Sand Source Investigations

Sand bodies have been mapped by UH in areas offshore from the region. The maps are given in the report, "Reef Top Sediment Bodies in Windward Oahu, Hawaii," which can be found in Appendix C. Research and development of sand manufacturing techniques has been done by the Corps' Geotechnical Structures Laboratory. The final report is not yet received, but a briefing is contained in the Appendix.

XII. Web-based GIS

A web-based GIS platform was deployed for the SEO Region. The GIS contains georeferenced maps, attributes and metadata corresponding to SEO/RSM requirements. Aerial photography, digital elevation models, geotechnical information, survey data, wave parameters and other pertinent georeferenced information have been automated via the GIS. The GIS uses state-of-the-art web enabling software to provide real-time access of products to the public through the internet. The GIS site can be accessed at: http://gis.poh.usace.army.mil/rsm/pages/index.htm .

XIII. Workshops

Three Workshops were held to inform community stakeholders and coastal experts on the goals, progress, and results of the demonstration project and to solicit feedback from attendees. Summaries of the workshops are found in the following web site.

http://gis.poh.usace.army.mil/rsm/pages/

1. Workshop #1
    a. June 2004 at Waimanalo Library
    b. Twenty-five attendees
    c. Breakout session identified data needs, environmental concerns, environmental permits, potential funding sources, and potential demonstration projects
2. Workshop #2
    a. June 2005 at Ko`olau Golf club
    b. Twenty-four attendees

c. Breakout sessions on Potential Demonstration Projects identified problems specific to each site, opportunities/issues at each location, alternatives possible in each PDP area, and potential funding sources

3. Workshop #2
   a. August 2006 as a field trip to PDP sites
   b. Twenty-six attendees
   c. Included an overview of Southeast Oahu RSM, update of SEO/RSM activities, site visits, and a summary on follow up discussions

XIV. Potential Demonstration Project Description

Four PDPs were selected by participants in Workshop #1 and discussed further in Workshop #2. A summary of the discussion on each PDP with suggested alternative solutions follows:

A. Ka`elepulu Stream

Proposed Demonstration Project Location:

The proposed demonstration project is located at the mouth of Ka`elepulu Stream in Kailua Bay. Beach sand from either side of the stream along with terrestrial sediments deposits at the mouth of the stream and impedes navigation, stops flow and degrades water quality. To the south, the beach narrows at the boat ramp and terminates at the adjacent headland (Alala Point). North of the stream, the beach is relatively wide and advancing seaward as evidenced by the vegetated backshore and by historical shoreline mapping (Figure 10).

Problem Statement:

Sand is removed from the Ka`elepulu Stream mouth during stream maintenance and is then stockpiled on the stream banks. Some sand is blown inland by trade winds and lost to the system. Some returns to the beach. The scope of the stream management project is limited by permits. A better plan would consider the sand budget on all of Kailua Beach and put the sand where it is most needed. Kailua Beach remains a natural beach system. One problem raised is that the sand removed from the stream mouth acts as a natural filter for upland water quality. Removing the sand allows unfiltered water to enter the ocean.

Opportunities:

The University of Hawaii did a shoreline erosion study for Kailua in 2000 and is currently updating it. The SEO/RSM study should take advantage of the updated information.

Since Kailua Beach is natural, study of the beach provides an opportunity to see if what is learned can be applied to other areas. It would be beneficial to learn why Kailua Beach and its dunes remain stable and if there is any interaction between Kailua and Lanikai Beaches.

A workshop participant suggested that the Corps of Engineers might be a source of funding for problems resulting from Kawainui Marsh.

If there is a surplus of sand at the stream mouth, it might be used as a sand source for beach nourishment activities. About 10 – 12,000 cy of sand was bypassed to Lanikai in 2000. No effect on Kailua Beach Park was seen. A temporary beach 500-600 feet long lasted for 6 months.

The State Department of Health is doing a TMDL water quality study for the watershed. The data that applies to Ka`elepulu Stream should be obtained.

Issues:

The primary issue raised was on water quality from Ka`elepulu Stream. Storm events can cause the sand berm to be removed resulting in dirty water flowing into the ocean. Should a sand buffer be left in the mouth? There can be a difference between natural and urban river systems. Is Ka`elepulu natural or urban and should it be dirty after heavy rainfall? Enchanted Lakes, located upstream, has not been dredged because there is contamination in the lakes. How is beach management at the stream mouth related to the watershed study and management of Ka`elepulu?

Alternatives:

There are several alternatives to handling the sand removed from Ka`elepulu Stream. A start is to develop and implement a Dune Management Plan. Part of the plan could be to backpass material to updrift locations such as the boat ramp or Lanikai, or to put it back into the north transport channel during the right conditions. Another alternative is to stockpile the sand and use it for individual erosion events as needed.

Alternatives related to the stream include restoring the natural stream flows so that the channel flushes itself, restoring the Kawainui Marsh natural drainage patterns and developing and implementing a watershed study.

B. Lanikai Beach

Proposed Demonstration Project Location:

The proposed demonstration project is located along the entire shoreline of the Lanikai community.

Problem Statement:

Shoreline erosion has resulted in the loss of dry beach along the southern portions of the Lanikai shoreline. To the north, the beach tends to widen therefore providing a buffer to wave induced impacts to upland development. Almost the entire length of the Lanikai shoreline has been hardened through construction of various types of coastal structure.

During the workshops, participants raised many questions on what should be done at Lanikai. Participants discussed goals for restoration; loss of recreation; seawalls; characteristics, trends, and patterns of erosion; and sediment budgets and beach stability.

Opportunities:

Some of the opportunities listed include developing a sediment budget, mapping biological zones and structures, modeling waves and currents, and developing a Special Management Area Plan. Other potential opportunities were conducting an economic study, use as a fisheries management area, and planning for recreational use.

Issues:

There are many issues that might potentially affect finding a solution for Lanikai's erosion problems. The causes are complex and more than one type of solution will probably be necessary. Use of beach nourishment could damage marine life including coral, algae, and fish. Nourishment will affect water quality. Since shore-front homes extend the entire length of Lanikai Beach and most of these homes are protected by seawalls or revetments, new shore protection schemes will have to use the area seaward of the walls. It will be difficult to receive approval to add additional shore protection structures, because both the community and the regulatory agencies may object.

Other issues discussed at the workshops include the need for an historical study of the shoreline, the possibility of considering the sand dune areas of the beach as ecosystems rather than just recreational areas, and the need to protect lateral access.

Alternatives:

Alternatives suggested by workshop attendees included using a combination of beach fill and hardened structures, creating designs that would replace existing seawalls, and considering the beach as an ecosystem. To get sufficient knowledge to design any new solution, attendees listed developing a master plan and focusing on science such as sediment budget analysis.

C. Bellows Air Force Station

Proposed Demonstration Project Location:

The proposed demonstration project is located at the northern end of Bellows Air Force Station in front of recreational beach cottages. The project extends approximately 3,000 linear feet along the shoreline.

Problem Statement:

Erosion is threatening the recreational beach cottages. To stop the erosion, a rock revetment has been constructed along the shoreline. This revetment is seen by some in the community as tying up the sand supply for down-drift beaches in Lanikai. The beach to the south is used for amphibious training by the Marines and must also be preserved. The training beach will likely be affected if beach dynamics change by the cottages. Marine training is going to be an important factor in the solution for Bellows. Another important factor is that Bellows is a rest and recreation area for military members and their families.

Opportunities:

There is an opportunity to build partnerships with the Marine Corps Base, Air Force Station, City & County of Honolulu, and others that would facilitate solving coastal problems in overlapping areas of interest. Another opportunity is to receive information from the AFS pier dump site “installation restoration study” and coincidently for the RSM team to help educate the Air Force staff.

There are other opportunities to coordinate with the EPA/DOH on priority pollutant cleanup of the Ko`olaupoko watershed, perform pilot projects on selected areas of Bellows Beach, and to model the original coastal system.

Issues:

Workshop attendees presented a number of issues that should be considered during the search for solutions to Bellows’ erosion. These are the need to protect lateral access, the need to add reefs into the models, and the need to consider endangered species such as sea turtles in proposed studies.

A participant asked what effect the revetment has on other shorelines nearby. Another asked about conflicts with military training.

Alternatives:

A number of alternatives were suggested at the SEO/RSM workshops. These include moving cottages back, removing the revetment and allow a natural shoreline, moving the revetment inland, removing the jetty at Waimanalo Stream to release trapped sand, recycle or back-pass sand in front of the revetment, and investigate sand that might be trapped in the streams. The selected solution will likely include more than one method.

D. Kaupo and Kaiona Beaches

Proposed Demonstration Project Location:

Kaupo Beach is located south of the Makai Research pier. The length of the potential demonstration project area is approximately 1,500 feet. Kaiona Beach is located north of the pier and the problem area is also approximately 1,500 feet in length. These two narrow beaches front Kalanianaole Highway and provide only minimal protection against wave induced impacts to the road and adjacent upland development. To the south of Kaupo Beach, a rocky headland extends out into Waimanalo Bay and provides coastal storm damage protection to the highway. North of Kaiona Beach, the highway turns mauka of the shoreline and out of harms way. Between the two problem areas, the shoreline is sheltered from wave energy by Manana Island and a wide shallow reef system.

Problem Statement:

Erosion is threatening approximately 500 to 800 feet of Kalanianaole Highway. The Beaches are narrow and unstable and offer little protection to the highway. The embankment is steep. Erosion is undermining the highway and the state Department of Transportation is placing pilings to stabilize the embankment.

There are a number of issues that reduce the options for a solution to the problem. The area sees high recreational use for surfing, wind surfing, and fishing. The nearby beaches are heavily used. Sea Life Park is very close to the damaged road. The road provides the sole access around Makapu`u Point from Waimanalo to Hawaii Kai. There is not sufficient space to move the road inland because of the cliffs or because of Hawaiian homelands between the road and the cliffs. Also rock fall hazard is high beneath the cliffs. Drainage under the road might contribute to the erosion.

The Makai Pier and its breakwater are located just offshore near the highway erosion area. These structures plus nearshore bathymetry will affect coastal waves, currents, and consequently beach erosion. Manana Island and

Kaohikaipu Island are located offshore from the site and do have an effect on coastal processes.

Opportunities:

Workshop attendees listed several opportunities presented by the problem.

The State of Hawaii Department of Transportation has a plan for coastal work along windward Oahu highways that was completed by Ed Noda & Associates. The report has good background information and should be acquired. The plan was to widen the road. Coordination with DOT is advisable since the problem is erosion below the highway.

Detailed wave models can be used to determine changes in wave patterns with different versions of structural solutions.

There is an opportunity to develop a site-specific sediment budget

The State Department of Health (DOH) designated this area for priority pollution control. There is an opportunity to work with DOH prior to selecting a solution.

Alternatives:

A number of alternative solutions were listed during the SEO/RSM project workshops. These include a groin, offshore breakwater, bank stabilization, beach nourishment, elevating the road on pilings over the beach, and moving or abandoning the road.

XV. Potential Demonstration Project Conceptual Alternatives

A. Ka`elepulu Stream Mouth

The south end of Kailua Beach and the Ka`elepulu Stream mouth are shown in Figure 15. Based on POH research, the recommended alternative for Ka`elepulu Stream is fairly obvious. The sand removed from the stream mouth should be placed at other locations on Kailua Beach where it is most needed (see Figure 16). Kailua Beach is accreting except at the south end between Alala Point and the stream.

Based on informal communications with City and County of Honolulu maintenance personnel, approximately 3,000 cubic yards of sand is removed from the stream mouth monthly (36,000 cubic yards per year). The material is currently being pushed up onto the banks of the stream and spread north and/or south of the stream mouth as deemed appropriate. The portion of sand relegated to the stream bank can be considered as lost to the littoral zone unless physically reintroduced back into the active beach profile.

Alternatives for effective utilization of the beach quality sand that is periodically extracted from the Ka`elepulu stream mouth include bypassing and back passing the material to various reaches along Kailua Beach. Construction of rubble mound groins on either side of the stream, designed to intercept the material before it enters the stream mouth, is another sediment management option. As the holding capacity of the groin fillets begin to reach capacity, the sand would be redistributed along appropriate reaches of Kailua Beach. Redistribution of the sand currently locked up along the banks of the stream, back into the littoral zone, should also be considered in the development of best management practices for Ka`elepulu stream mouth clearing activities.

Kailua Beach is currently accreting except at its southern end between Alala Point and the Ka`elepulu stream. As previously discussed, sand removed from the stream mouth should be placed along reaches of Kailua Beach where it is most needed (Figure 16). The City and County of Honolulu has a Department of the Army (DA) permit that allows placement of the sand excavated from the stream along designated reaches of shoreline. The DA permit should be reviewed and revised if necessary to allow sand placement within the entire Kailua Bay littoral cell.

Low flows through Ka`elepulu stream may be the cause of excess sedimentation at its seaward extent. Historically, the stream may have had sufficient flow velocities to periodically flush sediment from its mouth and into the receiving waters of Kailua Bay. Impacts of the Kawainui Marsh Federal flood control project on the flows through Ka`elepulu stream may be responsible for the lack of sediment flushing at the mouth of the stream. Section 1135 of the 1986 Water

Resource and Development Act provides authority for the U.S. Army Corps of Engineers to restore degraded ecosystems through modifications and operations of Federal structures. The maximum Federal cost for project development and construction of any one project is $5,000,000 and each project must be economically justified, environmentally sound, and technically feasible. At the request of an appropriate non-Federal sponsor, a Section 1135 study might be initiated to investigate the impacts of the Kawainui Marsh flood control project on Ka`elepulu stream ecosystem.

Figure 15. Ka`elepulu Stream and Kailua Beach (UH photo)

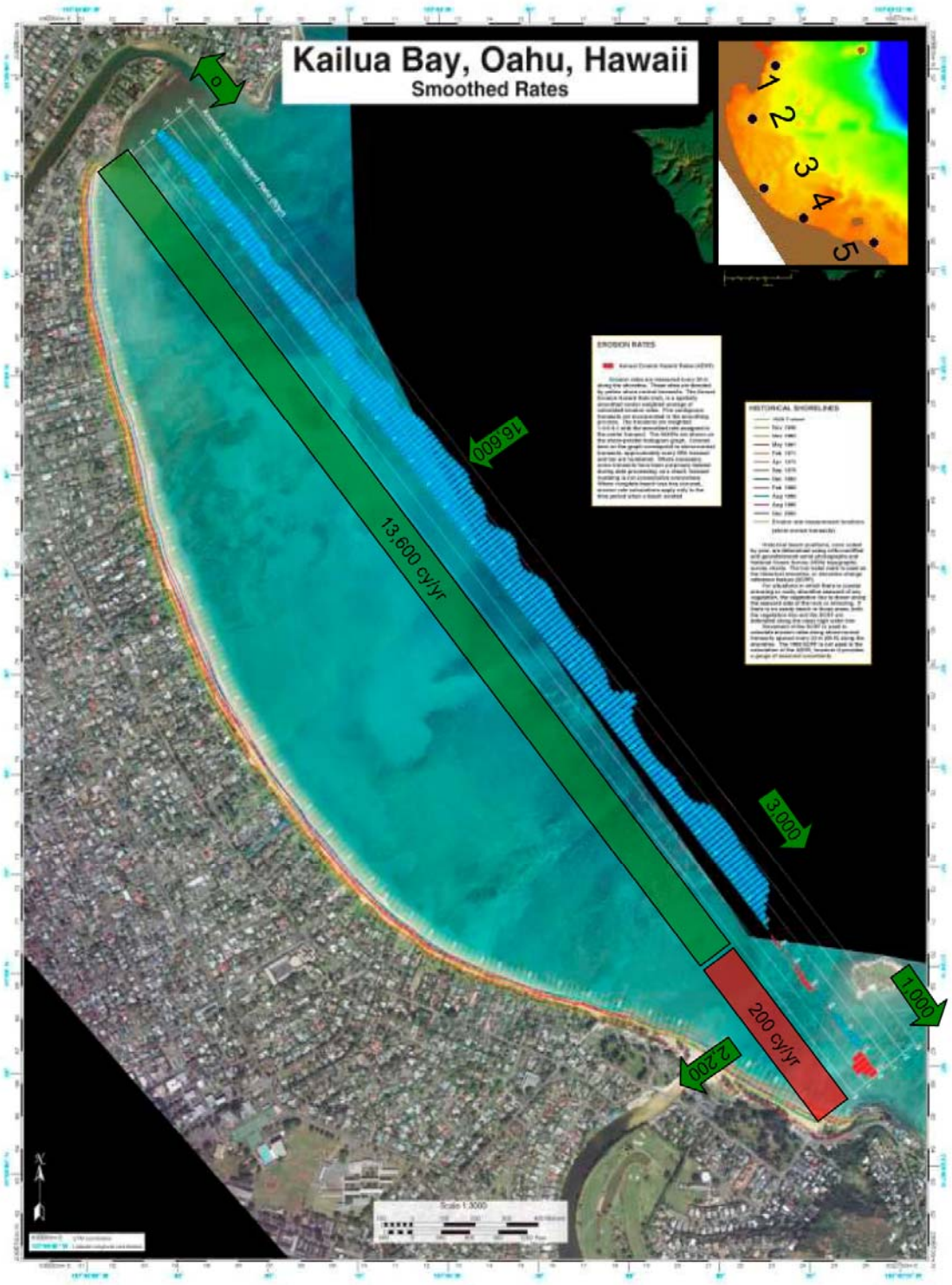

Figure 16. Kailua Sand Budget

B. Lanikai Beach

The proposed demonstration project is located along the entire shoreline of the Lanikai community (Figure 17). Shoreline erosion has resulted in the loss of dry beach along the southern portions of the Lanikai shoreline and at the north end near Alala Point. To the north, the beach tends to widen therefore providing a buffer to wave induced impacts to upland development. Almost the entire length of the Lanikai shoreline has been hardened through construction of various types of coastal structure.

The erosion has been studied, but the process and causes are not completely understood. There is a reef offshore from Lanikai where most waves break. The area between the reef and the shoreline is complex and not easily characterized. The bottom is a mix of sand, hard substrate, and coral heads. The nearshore area has changed in the lifetime of some residents.

POH calculated a sand budget for Lanikai shown in Figure 18. The graph shows that the southern half of Lanikai Beach is eroding, the north central portion is accreting, and the north end approaching Alala Point is eroding. The graph also shows that a large part of the sand is probably moving offshore. Offshore sand body locations as determined by UH are shown in Figure 19.

The following is a hypothesis of what could be happening in Lanikai. More data are necessary to prove, disprove, or refine the hypothesis. The nearshore configuration at Lanikai appears to influence the erosion and accretion at the beach. At the north end offshore from Alala Point, there appears to be a gap or deeper area in the reef south of Flat Island. More wave energy can reach the beach than at locations farther south. Waves passing through the gap are diffracted resulting in a dispersion area or node at the beach. That is, sand is pushed in both directions leaving a narrow beach.

To the south, in the center section of Lanikai, the beach becomes wider, and photos show waves breaking on the outer reef thereby reducing their energy. Also the bottom inside the reef looks to have more reef material, rocks, or hard bottom that may also reduce wave energy. It appears possible that the sand is pushed into an area of lower energy and remains there to form the wider beach.

The southern part of the beach, noted for erosion problems, has two large sand patches reaching from the shoreline to the outer reef. The lack of breaking waves suggests deeper water again. And the Mokulua Islands are just outside the reef break. The islands block and diffract waves causing mixed wave patterns as they propagate to the beach. The beach will typically conform to these mixed patterns.

The shoreline change map (Figure 11) shows that the southern part of Lanikai Beach went through an accretion/erosion cycle that may have started in the

1940s or 1950s, reached maximum accretion between 1967 and 1971, and returned to its starting point by about 1989. The cycle appears to have been more than 40 years. Of interest is that the center section of the beach that has recently been accreting was much narrower in 1967 when the southern part was widest. If the reason for the cycle can be determined, then solutions for current erosion might be more apparent.

There is probably no one solution for erosion at Lanikai. Community and regulatory agency restrictions may limit the use of more coastal structures for shore protection. Moving homes inland is not likely to be acceptable to property owners and there is no inland space. Beach nourishment is probably acceptable to both residents and regulatory agencies, but available and economic sand sources will have to be identified.

At the north end of Lanikai, the sediment budget (Figure 18) shows that sand moves into the eroding area and then offshore on the south side of Alala Point. The north central portion of the beach is accreting and probably needs no protection now. However, it may be accreting with sand carried from the eroding southern half of the beach. Since much of the sand loss on the southern beach is offshore, this part of the beach could benefit from beach nourishment. The nearby sand deposits, especially one off Wailea Point, have enough sand for partial nourishment but not enough to replace annual losses. So either more sand is needed or a method to reduce sand loss must be designed.

Additional sand plus breakwaters should be considered for the eroding section on the north end of Lanikai Beach. The eroding north section is about 1,100 feet long. To increase the beach width by 30 feet (an arbitrary number), approximately 7,500 cy of sand would be required. This quantity is based on measured beach profiles at Lanikai. The beach width will likely change after placement as waves shape the profile. The estimated cost to pump the required sand from an offshore source at $45/cy is about $337,500. Sand from land-based sources would likely cost much more, on the order of $70/cy. The UH calculated an annual hazard erosion rate (AEHR) of about 10 feet/year along the north end of Lanikai Beach. At that rate, the beach would have to be re-nourished in 3 years or less. A series of groins or offshore breakwaters could reduce the erosion rate, but the number and configuration of these structures would have to be designed after more detailed study.

The eroding southern portion of Lanikai Beach requires about 30,800 cy of sand to fill a 30-ft width. Cost would be $1,386,000 at $45/cy. The AEHR at south Lanikai is as much as 14 feet/year, so the nourishment might last only 2 years. Again groins or offshore breakwaters could potentially slow the erosion rate. There are already several groins at the south end of Lanikai that appear to be trapping sand from moving north. Without more detailed study; however, it would not be safe to conclude that other groins would perform similarly.

UH studies (Appendix F) show that there is sufficient sand in offshore deposits to nourish Lanikai Beach; however, the deposits may not be thick enough to dredge efficiently. Many sand areas are much less than 1 meter thick. Beach nourishment, then, would require additional sand from other sources either offshore or land-based.

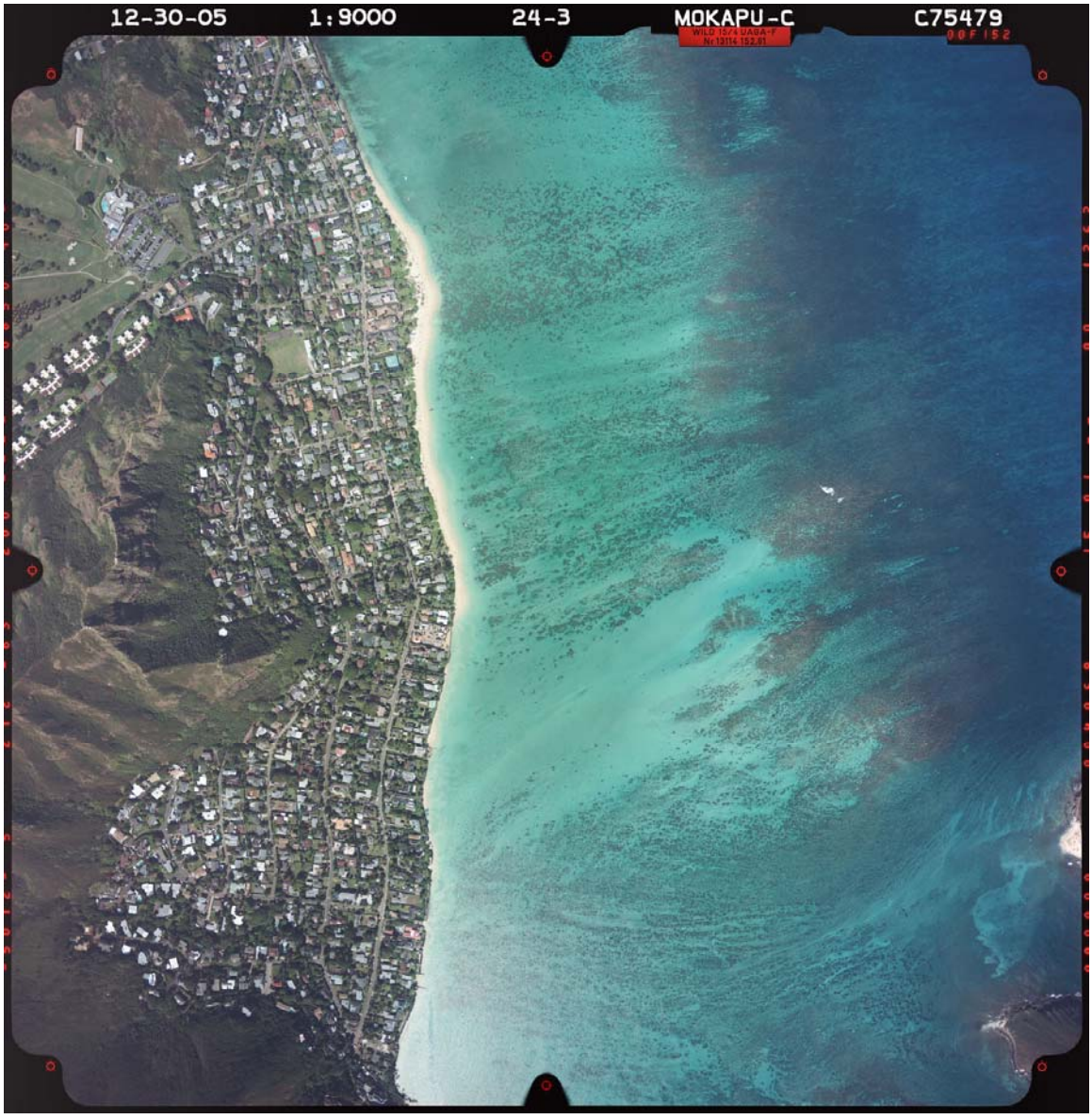

Figure 17. Lanikai Aerial Photo

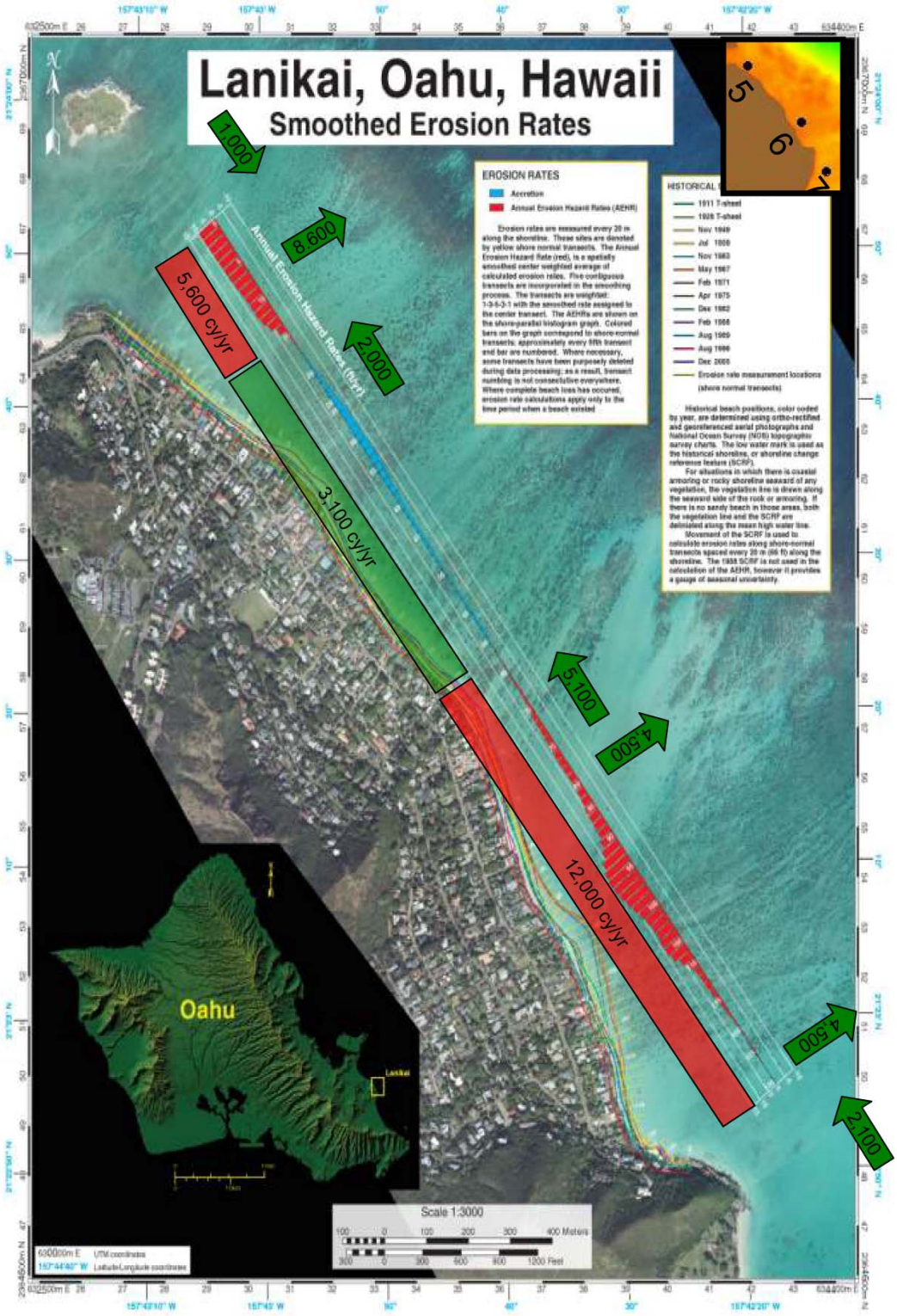

Figure 18. Lanikai Sediment Budget

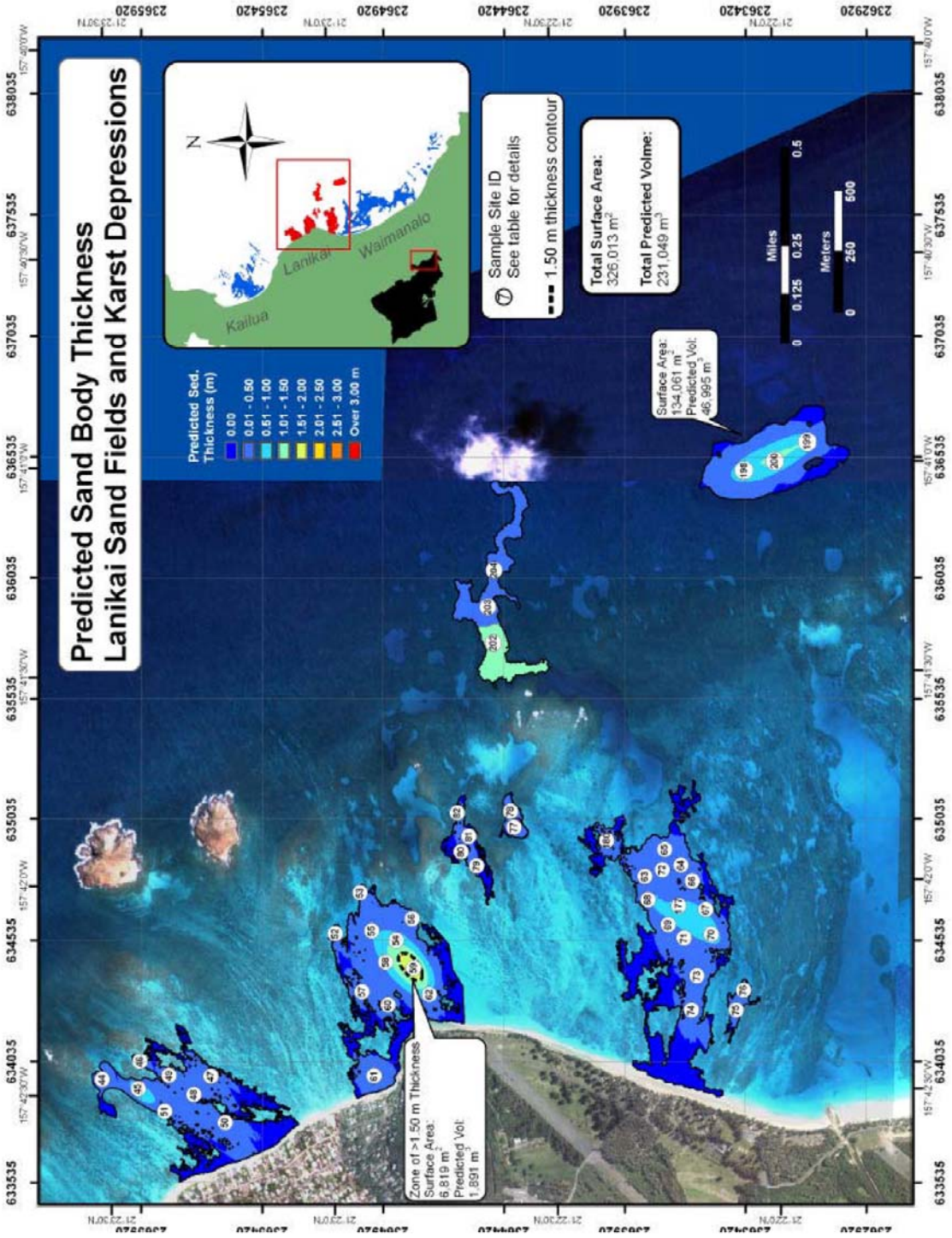

Figure 19. Lanikai Sand Bodies (University of Hawaii)

C. Bellows Air Force Station

A rock revetment protects only part of the north end of Bellows Beach adjacent to vacation cottages. Some residents to the north in Lanikai believe that the revetment is preventing sand from migrating to Lanikai Beach, which results in a net loss of Lanikai sand. This belief is not proved, although estimates show sand transport to the north. Aerial photos of Bellows are shown in Figures 20-22.

There are several factors that restrict the solutions that might be applied to Bellows. This is a military recreation area where families come to enjoy the beach. Sacrificing any of the beach or backshore area would be counter to the intended use. The beach is also used for amphibious training by the Marines, so any solution that interfered with that training would likely face opposition. It is obviously critical to receive support and cooperation from the Air Force and Marine Corps to make any proposed solution work. If Bellows removes the revetment, the resulting erosion will take valuable land and eventually make the cottages unusable. A solution that helps Lanikai at the expense of Bellows is highly unlikely to be acceptable. With that in mind, it does not appear likely that the Air Force would readily agree to remove the revetment.

An obvious partial solution is to move the threatened cottages inland. Many are built close enough to the water that, even without erosion, they could be subject to storm wave damage, especially if the revetment was to fail.

Based on SEO/RSM study data and the beach and nearshore configuration shown in aerial photographs, the north beach needs a continuing supply of sand. POH sand budget calculations show that the north end of the beach has net erosion, while the south end is accreting (Figure 23). About 3,700 cy would replace the estimated annual loss. Therefore, beach nourishment should be considered a partial solution. UH studies show that there are offshore sand bodies along Bellows Beach. These are typically thin layers with only small areas being over 1.5 m thick. UH estimates sufficient quantities in the bodies to make up the annual loss. Inland sand might be an additional source at Bellows. The base is located on a sandy plain, but the availability of inland sand must be studied before a decision can be made on its use.

POH calculations also show that sand from the north beach moves onshore/offshore and alongshore toward Lanikai (Figure 23). To slow down nourished sand movement out of the local system, groins or offshore breakwaters might be necessary. State and county agencies typically discourage the use of shore protection structures, so groins and breakwaters will probably be opposed.

Beach nourishment of 3,700 cy per year could cost as much as $200,000 - $300,000 without including the cost of sand placement. Pumping the sand from offshore might be less expensive – roughly $150,000. Groins and offshore breakwaters can cost in the neighborhood of $2,000 per linear foot.

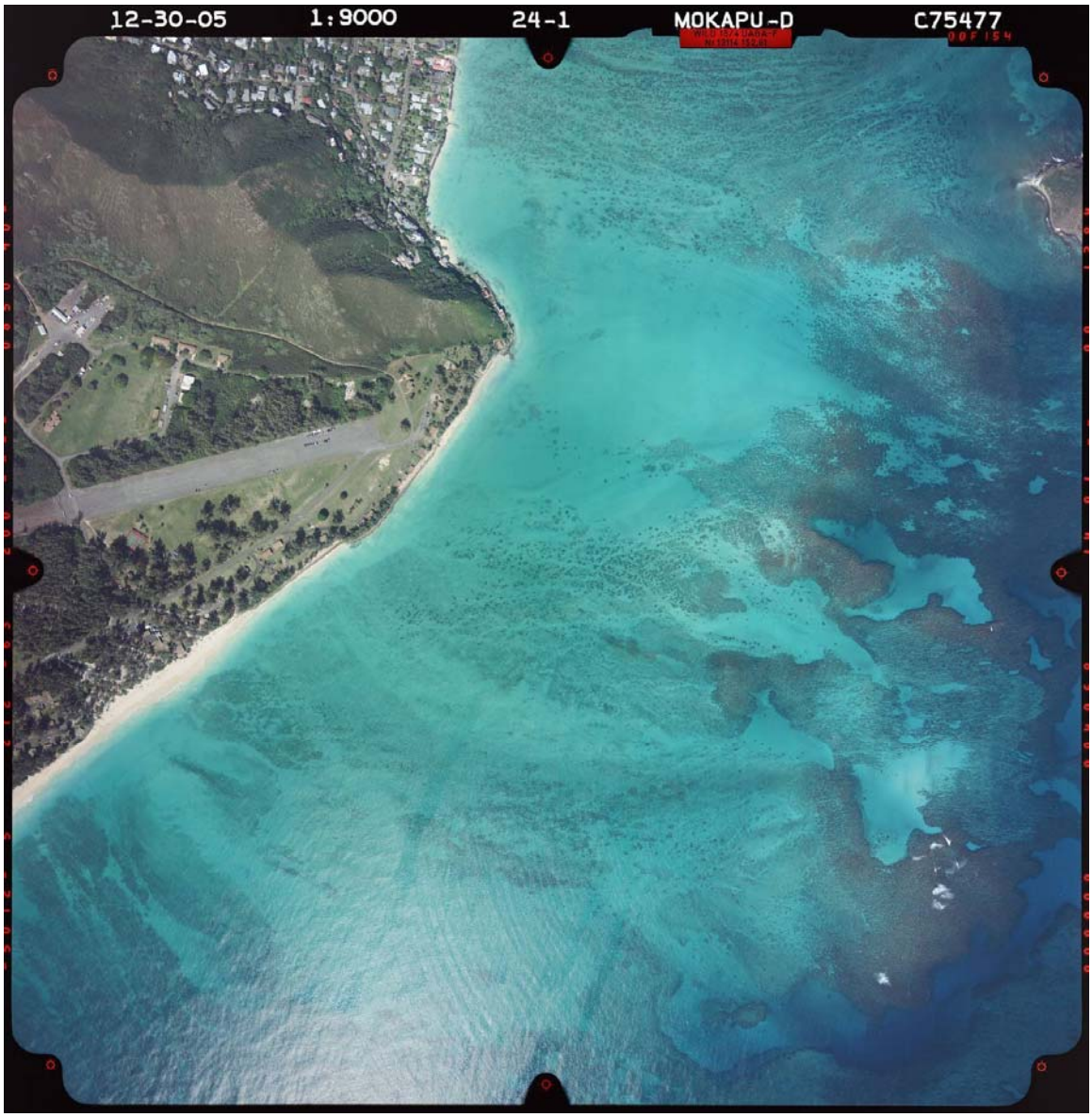

Figure 20. Bellows North End

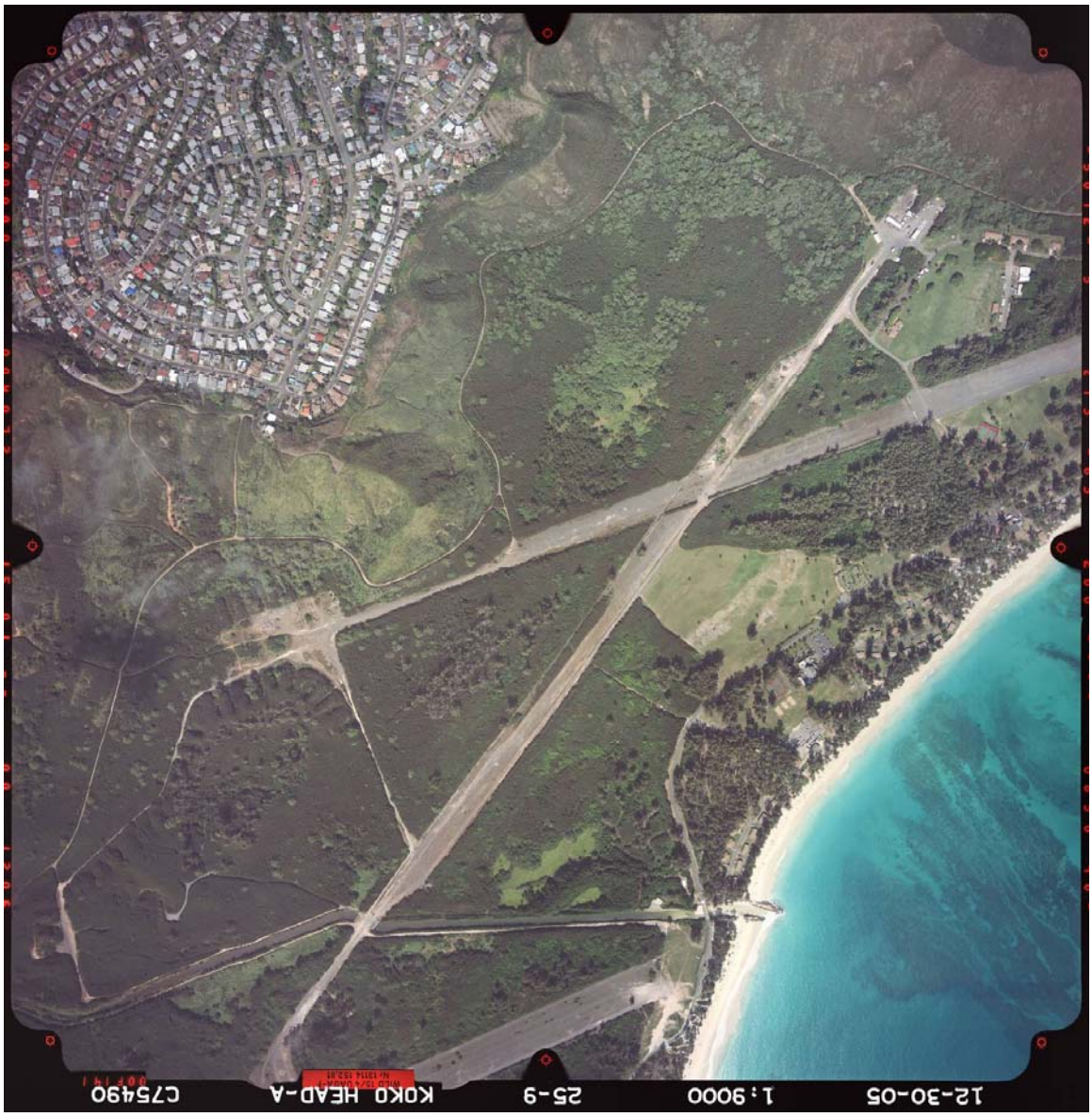

Figure 21. Bellows Central

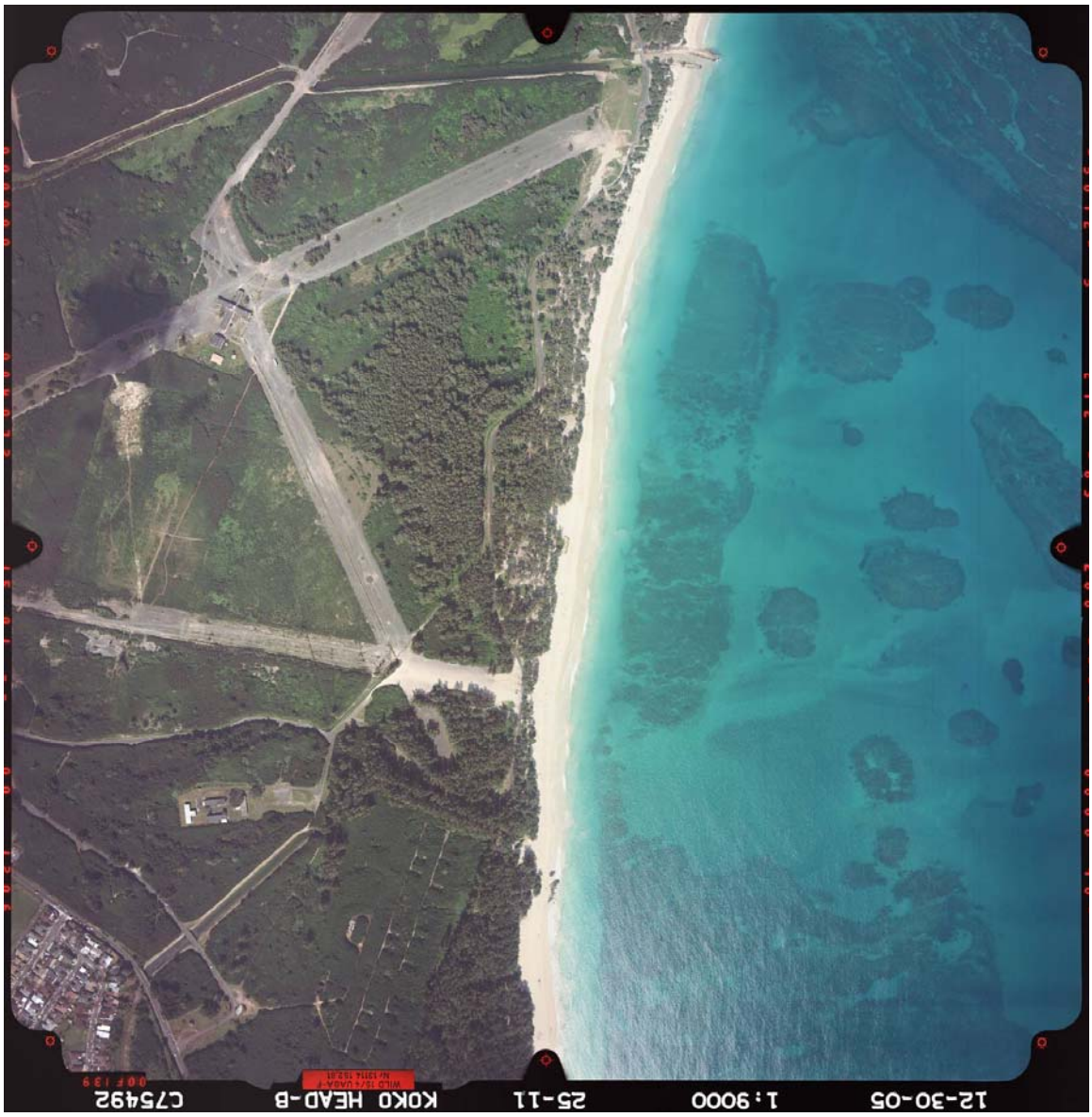

Figure 22. Bellows South

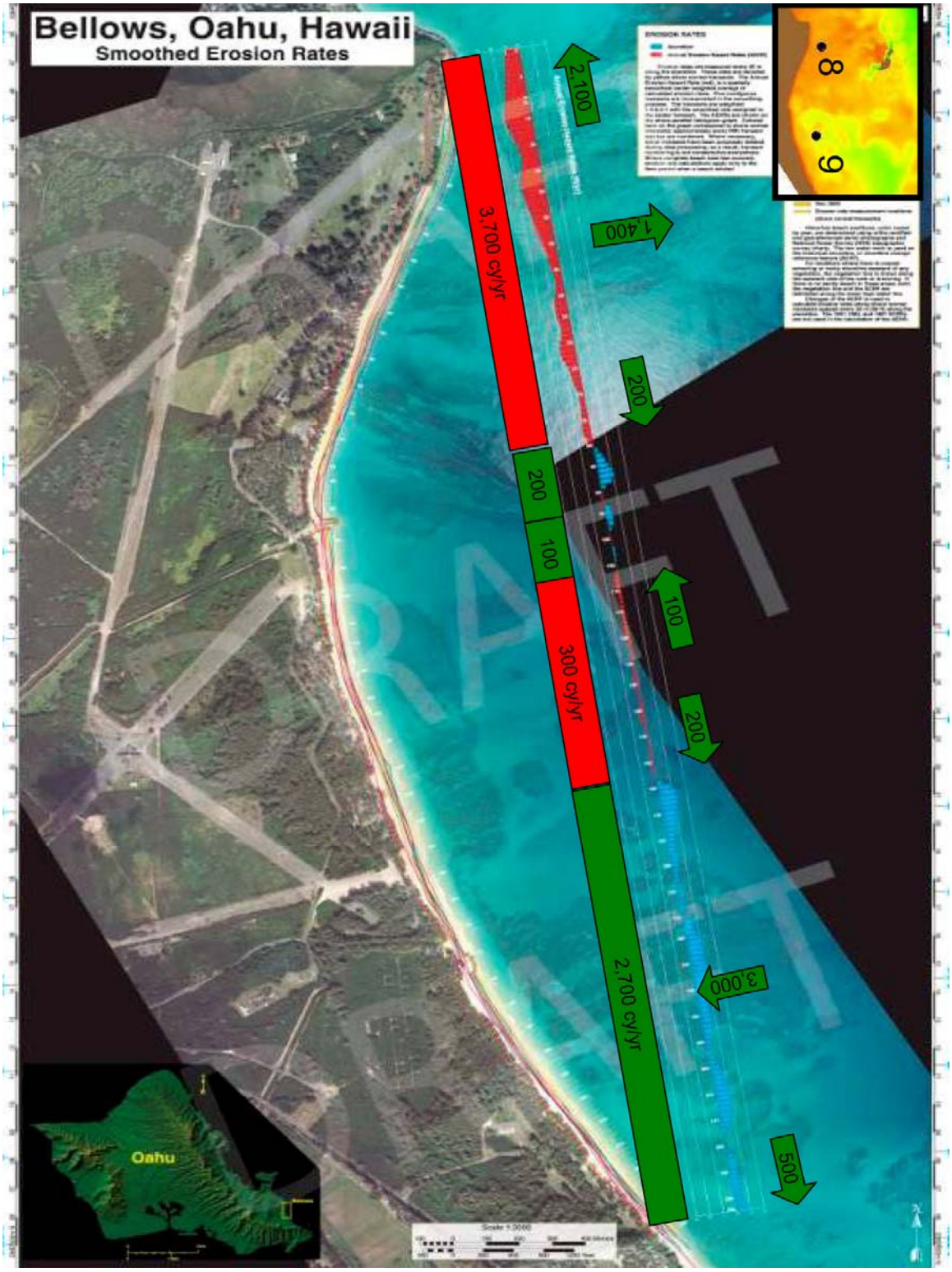

Figure 23. Bellows Sand Budget

D. Kaupo and Kaiona Beaches

Kaupo Beach and road embankment south of Makai Pier are eroding. The erosion appears to be a combination of beach erosion caused by waves and currents and embankment erosion caused by rainfall runoff from the highway and upland areas. The state Department of Transportation (DOT) is shoring up the road embankment with piles.

Based on the UH shoreline studies, the beach north of Makai Pier has been historically eroding (Figure 14). Stretches of the eroding shoreline are armored. Aerial photographs of Kaupo Beach (Figure 24) show a beach at the eroded shoreline below the road damage. They also show what appear to be large sand patches in nearshore area. The University of Hawaii has mapped sand bodies seaward from the pier and breakwater (Figure 25).

A sand channel (Pukakukui Channel) is on the south side of Makai Pier offshore from the eroding area (Figure 26). This channel was periodically dredged years ago when an underwater habitat and submersibles were deployed from Makai Pier. Water is deeper in the channel than in the surrounding area. It is probable that, under some conditions, waves pass over the channel without breaking before they hit the eroding shoreline. The unbroken waves carry more energy to the beach. The photos show waves breaking over the reef to the north but none breaking over the channel. The two conditions, the offshore sand deposits and the fact that higher wave energy might reach the eroding beach, suggest that beach nourishment and offshore breakwaters should be considered as possible solutions. The breakwaters would reduce wave energy reaching the eroded area. Nourishment would replace some of the lost sand. However, the source of nourishment sand must be carefully considered since dredging in the wrong location could make the erosion worse.

According to calculations made by POH, onshore/offshore sand transport, rather than longshore transport, dominates along Kaupo Beach (Figure 27). Therefore, a groin or series of groins might not help stabilize the beach. With the data available from the SEO/RSM studies, an offshore breakwater system can be modeled to determine shoreline response. Sufficient sand can be added to the design to minimize several years' erosion. These actions should move the shoreline seaward.

That still leaves the problem of an unstable embankment under the highway. The DOT has been stabilizing the road with piles, but stabilizing the bank between the road and the beach probably should be a joint project between DOT and DLNR. There are various bank-stabilization best management practice (BMP) methods that should be considered including terraces, gabions, redirection of runoff flow, and vegetation.

Kaiona Beach also suffers from net erosion that threatens the highway and private homes. Both onshore/offshore and longshore transport are probable at Kaiona Beach (Figure 28). The eroded sand appears to move both north towards Waimanalo and south towards Makapu`u. Parts of the eroded area near the highway are protected by seawalls or revetments. Just to the south are two shore-connected breakwaters that probably affect sediment transport.

Beach nourishment, groins, and offshore breakwaters are all possible solutions for the Kaiona erosion. There are sand deposits off Waimanalo Beach Park to the north that could possibly be used for beach nourishment. Waimanalo Beach is accreting, so any proposed solution must consider the effect of shore protection on this beach.

Figure 24. Aerial Photo Kaupo Beach and Makai Pier (University of Hawaii)

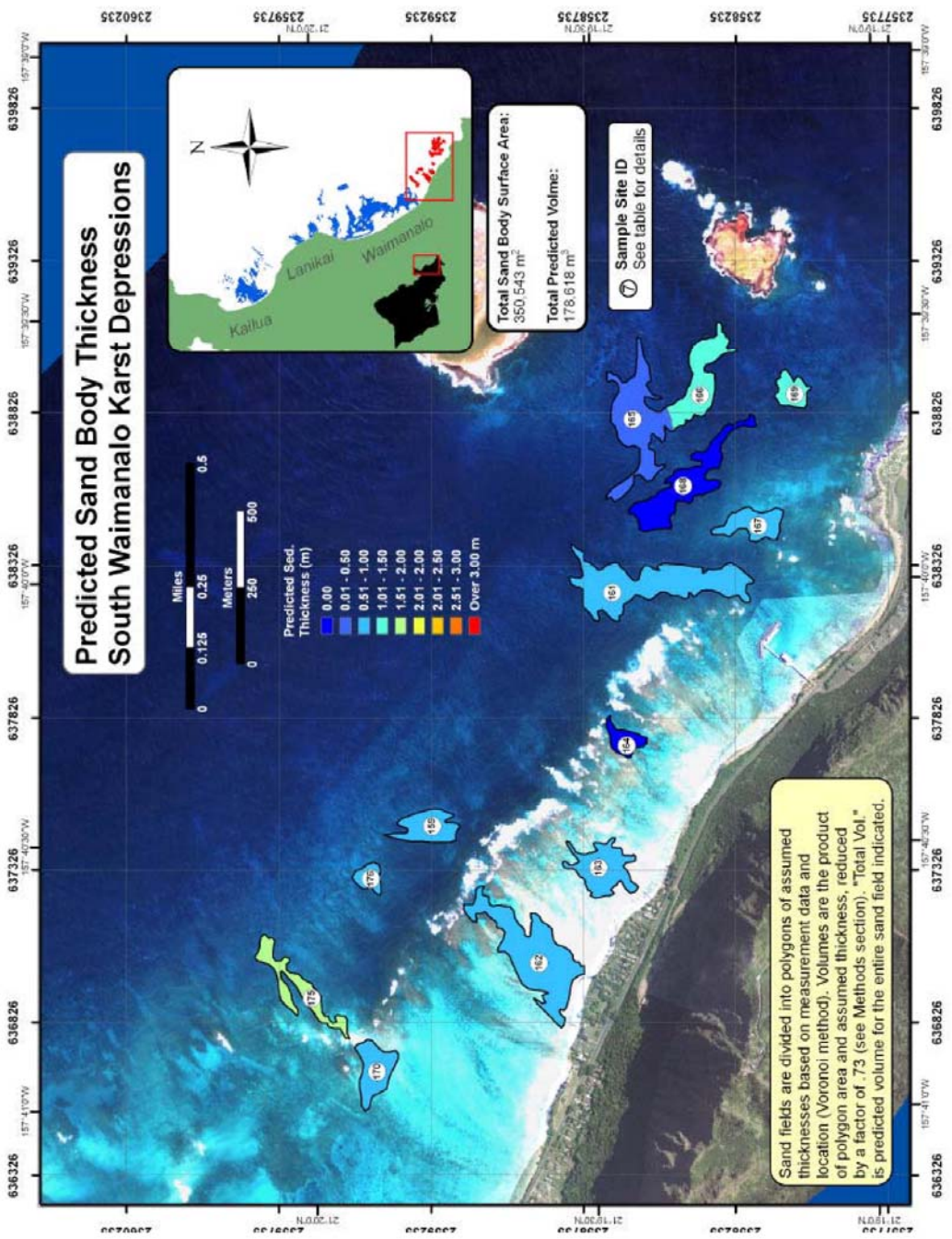

Figure 25. South Waimanalo Sand Bodies (University of Hawaii)

Figure 26. Oblique Aerial Photo Showing Channel Area and Breaking Waves (University of Hawaii Photo)

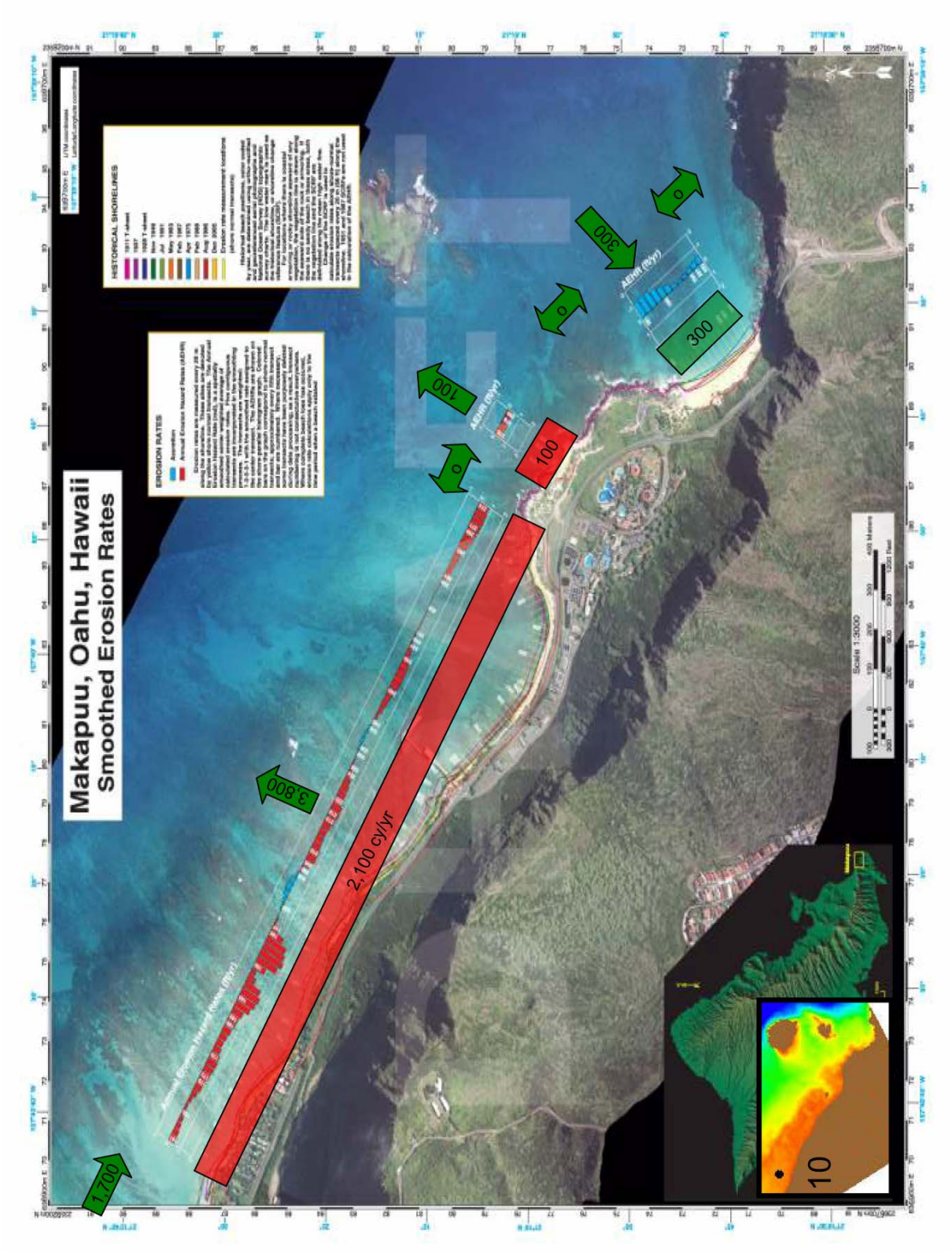

Figure 27. Kaupo Beach Sand Budget

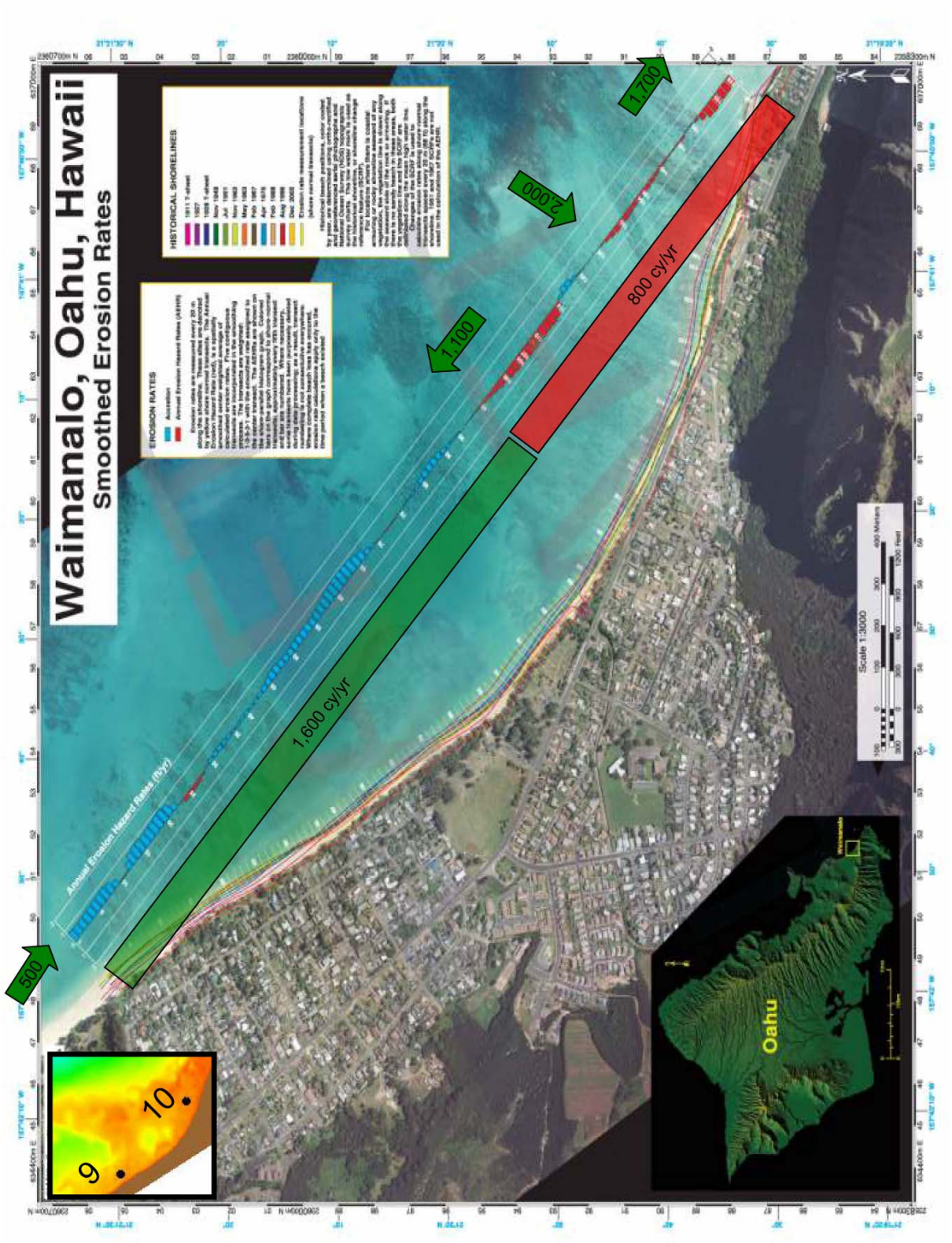

Figure 28. Kaiona Beach Sand Budget

VII. Conclusions and Recommendations

A. Conclusions

The SEO/RSM project shoreline consists primarily of coral sand beaches, some of which are eroding causing damage to private and public property. Several studies conducted by the U.S. Army Corps of Engineers and the University of Hawaii have helped characterize the littoral processes and nearshore configuration of the study area. The results of these studies provide a basis for designing solutions to regional erosion problems. This RSM Plan provides guidance for additional planning and research necessary to further develop alternative concepts for the four PDPs. Active sediment management will result in less shoreline erosion, lower threat to private and public property, and more available recreational space.

Beach nourishment was found to be a common element in the PDP evaluations; however, more sand sources must be identified. The problem with sand placement at the Ka`elepulu stream mouth can probably be fixed by re-issuing the County's Department of the Army Permit. The erosion a Lanikai might be mitigated by beach nourishment and use of groins or offshore breakwaters. At Bellows Air Force Station, threatened cottages could be moved inland and inland sand sources might be used for beach nourishment. Kaiona Beach would probably benefit from nourishment controlled by structures. The eroding embankment at Kaupo Beach could use shoreline stabilization with sand and drainage best management practice methods.

B. Recommendations

Ka'elepulu Stream: The Department of the Army permit for steam cleaning at Ka'elepulu Stream should be reviewed and revised if appropriate to allow for additional maintenance material disposal options. Currently, material removed from the stream mouth is placed along the banks of the stream and/or along the shorelines adjacent to the stream. Optimally, the material should be placed wherever it is needed at the time of stream cleaning within the limits of Kailua Beach.

Lanikai: State and local interests should utilize the information provided in this RSM Plan to develop a long-term strategy to manage shoreline recession in this portion of the SEO region. Beach nourishment (possibly in conjunction with properly designed coastal structures) could be implemented to stabilize the Lanikai shoreline. Offshore sand bodies have been preliminarily identified for use as a source of beach quality material. Suitable beach fill material may also be available within the upland limits of Bellow Air Force Station.

Bellows Air Force Station (AFS): RSM options for Bellow AFS station include removal of the existing rock revetment and Waimanalo Stream groins to restore

the natural sediment transport regime along this portion of shoreline. Given the case where these structures are left in place, the Air Force should consider placement of an equivalent volume of sand to offset the sediment budget deficit that the structures have caused since their construction.

Kaiona/Kaupo Beaches: Since Kaiona Beach has been partially armored and it would be unrealistic to try to maintain a beach along its reach, no action is recommended for that portion of shoreline at this time. On the other hand, bank stabilization, storm water runoff control and beach nourishment in combination would stabilize the Kaupo Beach shoreline and provide needed protection to Kalanianaole Highway.

The Southeast Oahu Regional Sediment Management demonstration project has produced a regional sediment budget for use in the development of sediment management strategies within the region. Coastal processes modeling and geotechnical investigations have been conducted as part of the SEO/RSM effort to facilitate future beach nourishment and other shore protection alternative investigations. This Regional Sediment Management Plan provides documentation on the tasks undertaken and the products resulting from the SEO/RSM demonstration project. Additional products and information can be found at http://gis.poh.usace.army.mil/rsm/pages/index.htm.