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COASTAL ENGINEERING EVALUATION AND ENVIRONMENTAL ASSESSMENT FOR A REVETMENT STRUCTURE AT LANIKAI, OAHU, HAWAII (TMK: 4-3-04:77)

MARCH 1991

1.0 LOCATION AND PROBLEM DEFINITION

The project site is located at Lanikai, at the southeast end towards Wailea Point (TMK: 4-3-04:77). Figure 1 shows the general site location and Figure 2 is a copy of the shoreline and topographic survey of the parcel prepared by R.M. Towill Corporation.

The parcel shorefront is presently protected with a rock riprap slope which was constructed without obtaining a variance from the Shoreline Setback Rules and Regulations and is therefore in violation of the regulations. The owner has been directed by the City and County Department of Land Utilization to remove the existing shore protection structure pending approval of a setback variance for a replacement structure.

This coastal engineering evaluation and environmental assessment is prepared in support of an application for a Shoreline Setback Variance for a shore protection structure, and in accordance with Ordinance No. 4631 Shoreline Setback Rules and Regulations.

2.0 COASTAL SETTING

2.1 Shoreline Characteristics

The coastal reach southeastward of the project site to Wailea Point is presently devoid of dry beach. Various types of seawalls and revetments protect the entire +2,000 foot stretch of shoreline south of the project site. A narrow dry beach fronts the project site and extends northwestward for approximately 3,000 feet along the central portion of the Lanikai coast. Few shore protection structures presently exist along this reach. Further northwestward towards Alala Point, approximately 1,000

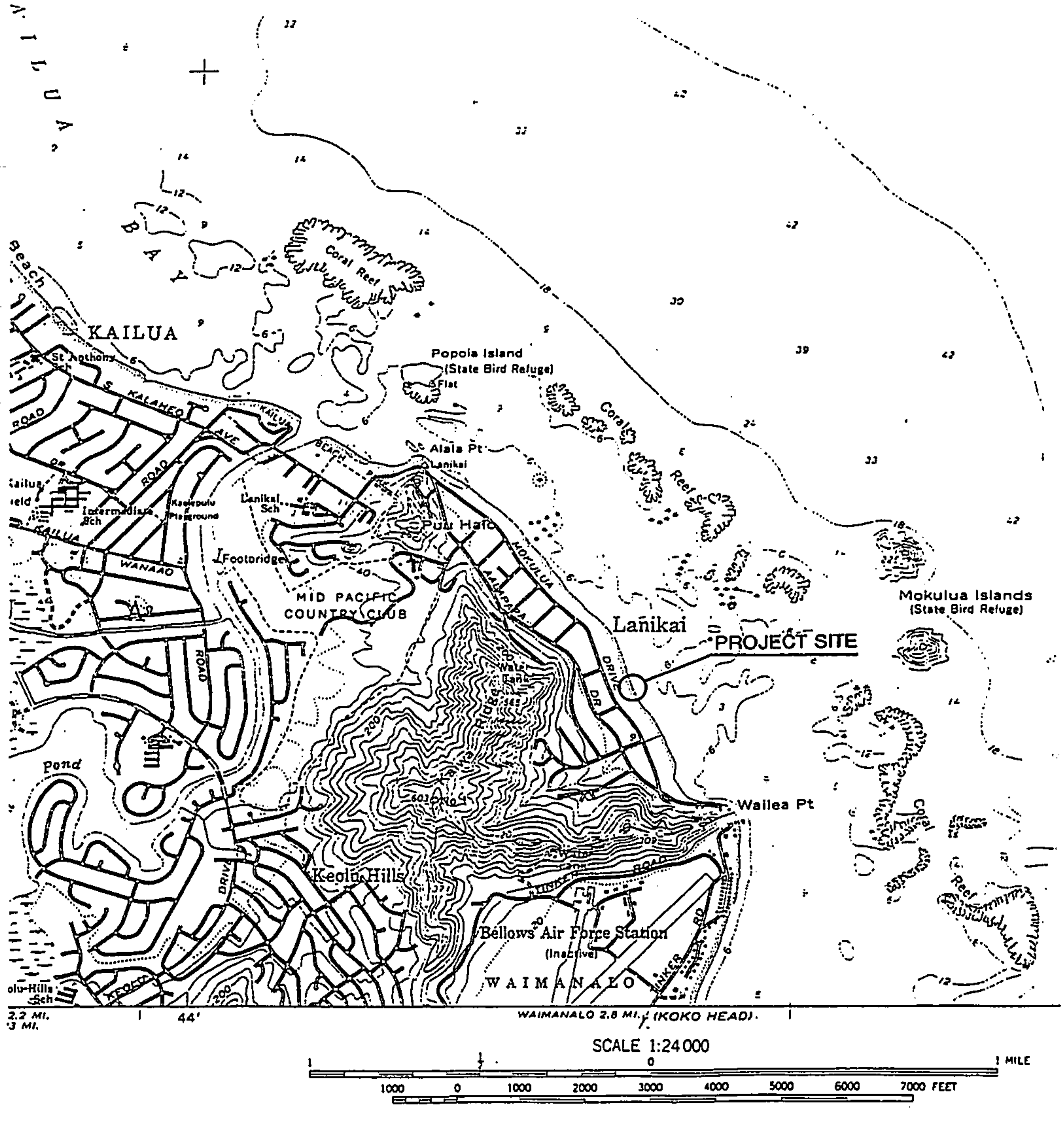


FIGURE 1. LOCATION MAP

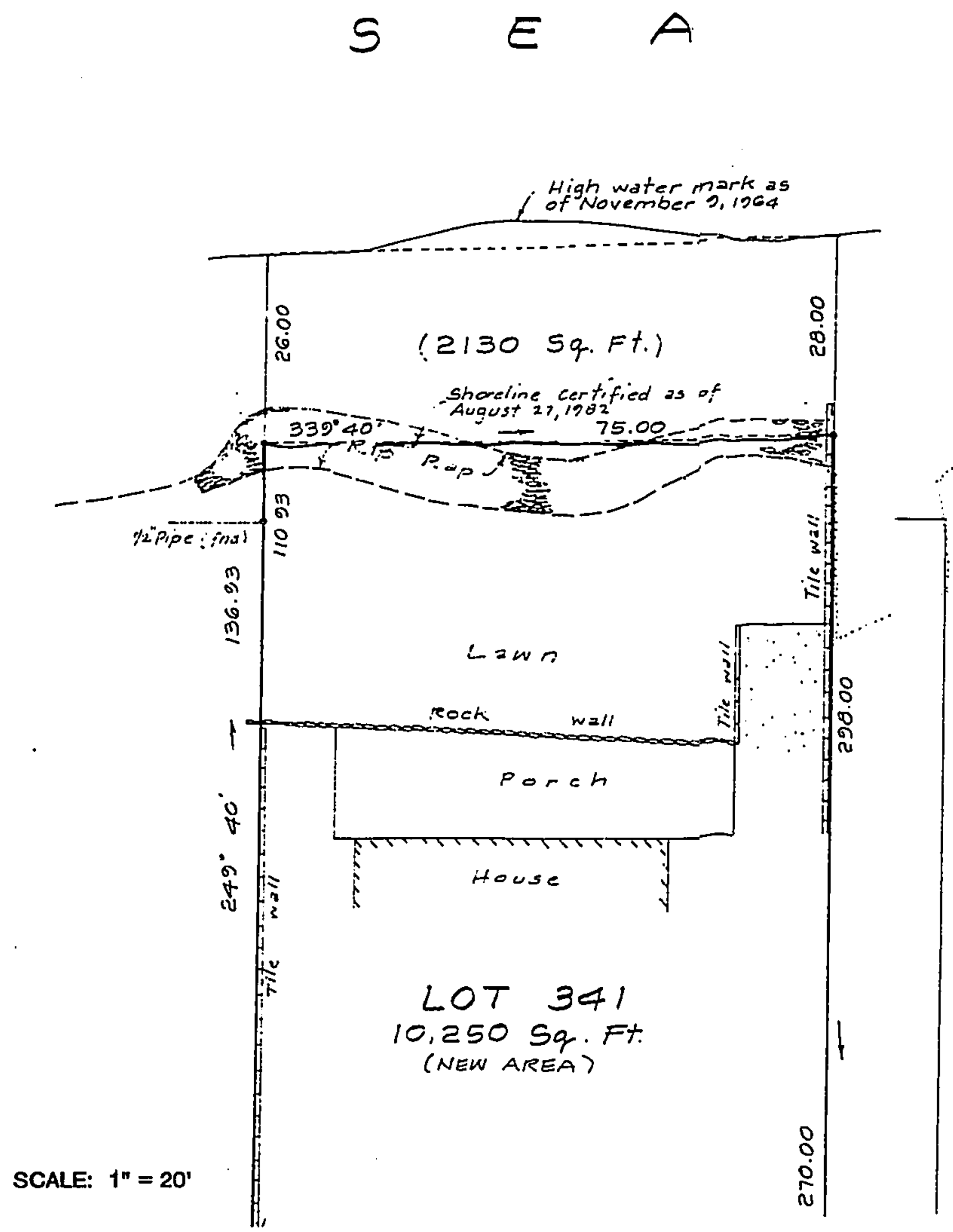


FIGURE 2. PORTION OF SHORELINE SURVEY

feet of shoreline is devoid of dry beach and protected with various types of seawalls and revetments.

The wave climate along the Lanikai shoreline is relatively mild because of the protection afforded by the shallow offshore fringing reefs and islands. Large deepwater waves initially break on the shallow reefs and what energy remains propagates to the shoreline as reformed waves which break at the shore. Typical nearshore wave heights are 1 foot or less, with typical maximum wave heights less than 2 feet. Maximum storm waves which can attack the shoreline are limited by the nearshore water depth. Maximum breaking wave height at the shoreline during an extreme storm is estimated to be less than 4.8 feet at the project site.

The nearshore wave approach patterns are complex due to interactions between the wave trains and the irregular offshore reefs and islands. For the project site, longshore transport is estimated to be northwestward during typical northeasterly tradewind wave conditions due to refraction and diffraction effects caused by the Mokulua Islands and the offshore reef flat. Because there is a deficit of sand at the southeast end of Lanikai, there is little sand transport towards the project site. During the winter months when northerly swell can occur, southeastward longshore transport of sand from the beach areas north of the project site can result in some buildup of sand along the project reach. However, with the return of the predominant tradewind waves, much of this sand will return to the beachfront north of the project site.

2.2 Coastal Processes

The project site is at the southeast end of Lanikai, within about 1,000 feet northwest of the Lanipo Drive drainage channel.

This southeast end of Lanikai had experienced considerable accretion and subsequent erosion over a long-term period from 1950 to the 1980s. Figure 3a shows the average cumulative movement of the shoreline over a 2,500 feet length along the southern third of the Lanikai coastline.[1] Between 1950 and 1970, this shoreline reach accreted substantially, a maximum of about 200 feet near the drainage channel. Many of the property owners legally extended their property boundaries seaward by claiming these accreted fastlands. From 1970 to the early 1980s, the shoreline eroded back to the approximate 1950s position. Most of the seawalls were constructed in response to this erosion cycle. Presently, the entire +2,000-foot reach at the southeast end of Lanikai is armored with shore protection structures.

The long-term accretion and erosion cycle was a natural process, possibly caused by shifts in wind and wave patterns. The southern Lanikai shore displayed similar historical accretion-erosion trends as the Kailua Beach Park shoreline (which was and still is unprotected). Figure 3b shows the historical shoreline movement at Kailua Beach Park. The Lanikai seawalls were constructed in response to the erosion cycle to protect existing residential improvements, and were not the cause of the erosion trend. Their influence now, however, is to discourage sand buildup if there is a return to an accretionary phase of the cycle. With the increase in reflectivity due to the seawalls, there is little chance for sediment to be re-deposited and for the beach to build back naturally in the near future.

[1]Based on analysis of historical aerial photos as described in the study report, "HAWAII SHORELINE EROSION MANAGEMENT STUDY, Overview and Case Study Sites (Makaha, Oahu; Kailua-Lanikai, Oahu; Kukuiula-Poipu, Kauai)", prepared by Edward K. Noda and Associates, Inc. and DHM Inc., for the Hawaii Coastal Zone Management Program, Office of State Planning, June 1989. Refer to this study for a detailed discussion of the littoral processes and long-term changes along the entire Lanikai shoreline.

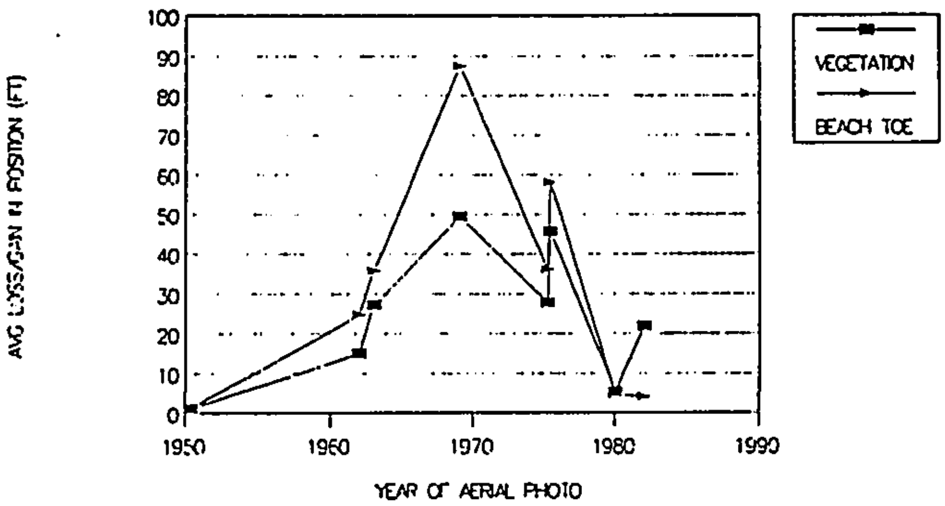


FIGURE 3a. Average cumulative movement for a 2,500-foot stretch of shoreline from Wailea Point northward past the project site.

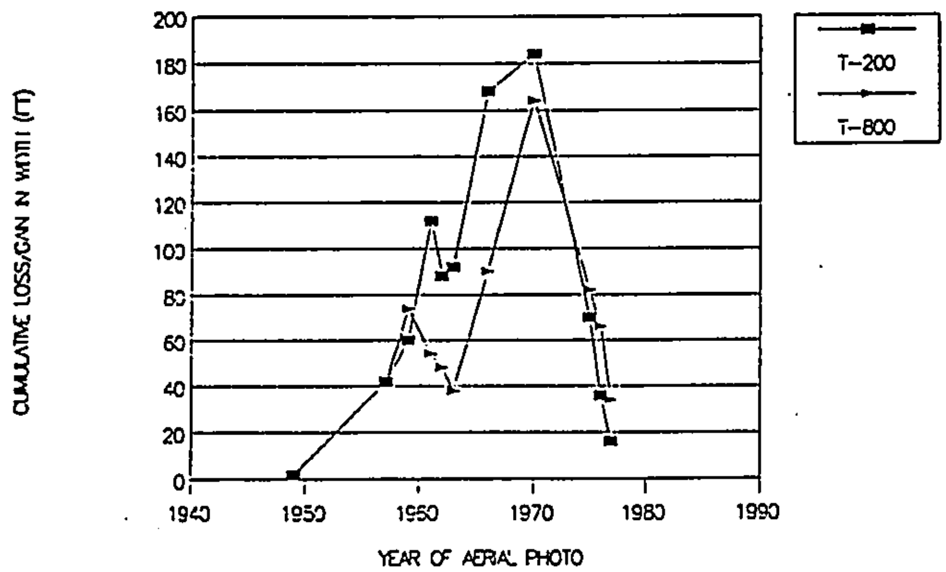


FIGURE 3b. Cumulative movement of the shoreline at Kailua Beach Park at locations 200' and 800' from the boat ramp.

(From "HAWAII SHORELINE EROSION MANAGEMENT STUDY, Overview and Case Study Sites - Makaha, Oahu; Kailua-Lanikai, Oahu; Kukuiula-Poipu, Kauai", by Edward K. Noda and Associates, Inc. and DHM Inc., for the Hawaii Coastal Zone Management Program, June 1989.)

There is an ample beach width over the middle segment of the Lanikai coastline. Because the shoreline has been relatively stable along this central reach throughout the +30 year period from 1950 to the early 1980s, there is a relative absence of shore protection structures.

The project site is in the transition zone between the southeastern end of Lanikai that historically has undergone a dramatic accretion-erosion cycle, and the middle segment of Lanikai that historically has been relatively stable. The extreme southeast Lanikai shoreline has experienced net long-term erosion since 1970, and deficit of sand along this southeastern shoreline reach may be causing a gradual shift of the erosion trend towards the shoreline reach north of the project site. Photo 1 shows a view of the shoreline reach southward from the project site, and Photo 2 shows a view northward of the project site.

There is generally a narrow dry beach fronting the subject parcel towards the beginning of the summer season after winter northerly swell activity transports sand from beach areas north of the project site (Photo 3). By the end of the summer season however, tradewind waves transport much of this sand back to the beaches north of the project site (Photo 4).

3.0 CONSIDERATION OF ALTERNATIVES

Removal of the existing rock slope without constructing replacement shore protection is not a viable alternative, since the unprotected shoreline will likely experience further erosion damage. During periods of minimal beach width, high waves and water levels can cause substantial erosion and overtopping damage to the backshore area. The existing rock slope was constructed

Photo 1. View of shoreline southward of project site. Photo date 6-17-90, tide +1.6' MLLW.

Photo 2. View of shoreline northward of project site. Photo date 6-17-90, tide +1.6' MLLW.

Photo 3. Typical maximum beach width. Photo date 6-17-90, tide +1.6' MLLW.

Photo 4. Typical minimum beach width. Photo date 8-8-90, tide +1.9' MLLW.

during one such period to prevent loss of the coconut trees as well as further loss of fastlands due to the erosion. The receded and escarped condition of the adjacent unprotected parcel is evidence of the continued erosion trend affecting this site. Beach nourishment and stabilization with structural measures to protect the beach fill would be the preferred alternative for the entire southeast end of Lanikai. Beach nourishment would be required for a long stretch of shoreline reach extending beyond the applicant's parcel, since wave energy will quickly redistribute small quantities of beach material unless beach containment structures such as groins are built to confine the beach fill fronting the individual parcel. Periodic nourishment would likely be required if the present erosion trend continues and if no structural measures are built to stabilize the beach fill. This alternative is costly and not realistic to implement for the individual residential landowner since large quantities of natural beach sand are presently not commercially available.

An offshore breakwater structure would be a suitable alternative to mitigate continued erosion damage. The breakwater would dissipate the incoming wave energy, thereby forming a protective area in the lee of the structure. Since littoral sediment transport processes require breaking wave energy to transport the littoral materials at the shoreline, a reduction of the incident wave energy will directly reduce erosion in the lee of the breakwater. However, offshore breakwater construction is costly and carries a higher risk than onshore construction. Repair or maintenance of the structure, if damaged due to an extreme storm event, is also very costly due to difficulty in accessing the structure with conventional land equipment.

For individual residential landowners, seawalls and revetments are the most viable methods of protecting a shoreline from wave attack. Seawalls are vertical structures, typically concrete or grouted rock masonry walls. Revetments are sloping structures typically constructed using rock of sufficient size to remain stable under design wave attack. Seawalls are generally less costly to construct than revetments since they can be constructed using smaller building materials than rock revetments and require much less total quantity of building material. Near-vertical seawalls also occupy less space along the shore, thus maximizing use of the backshore areas as well as preserving the open space public shorefront seaward of the structure.

For sandy shorelines, vertical impermeable seawalls are generally not appropriate because of their high reflectivity, which causes scouring of the sand in front of the structure. This can lead to undermining at the base of the wall if the seawall is not founded on hard material. For beach environments, sloping rock revetments are more effective in dissipating wave energy and are therefore more conducive to beach accretion. However, it must be emphasized that long-term accretion and erosion patterns are caused by environmental factors such as winds, waves, and offshore sand supply. Revetments and seawalls do not alter these environmental factors. Their purpose is to protect an already eroding shoreline. Therefore, while a revetment is more likely to allow sand to build up on the beach than seawalls, a revetment cannot reverse erosion processes.

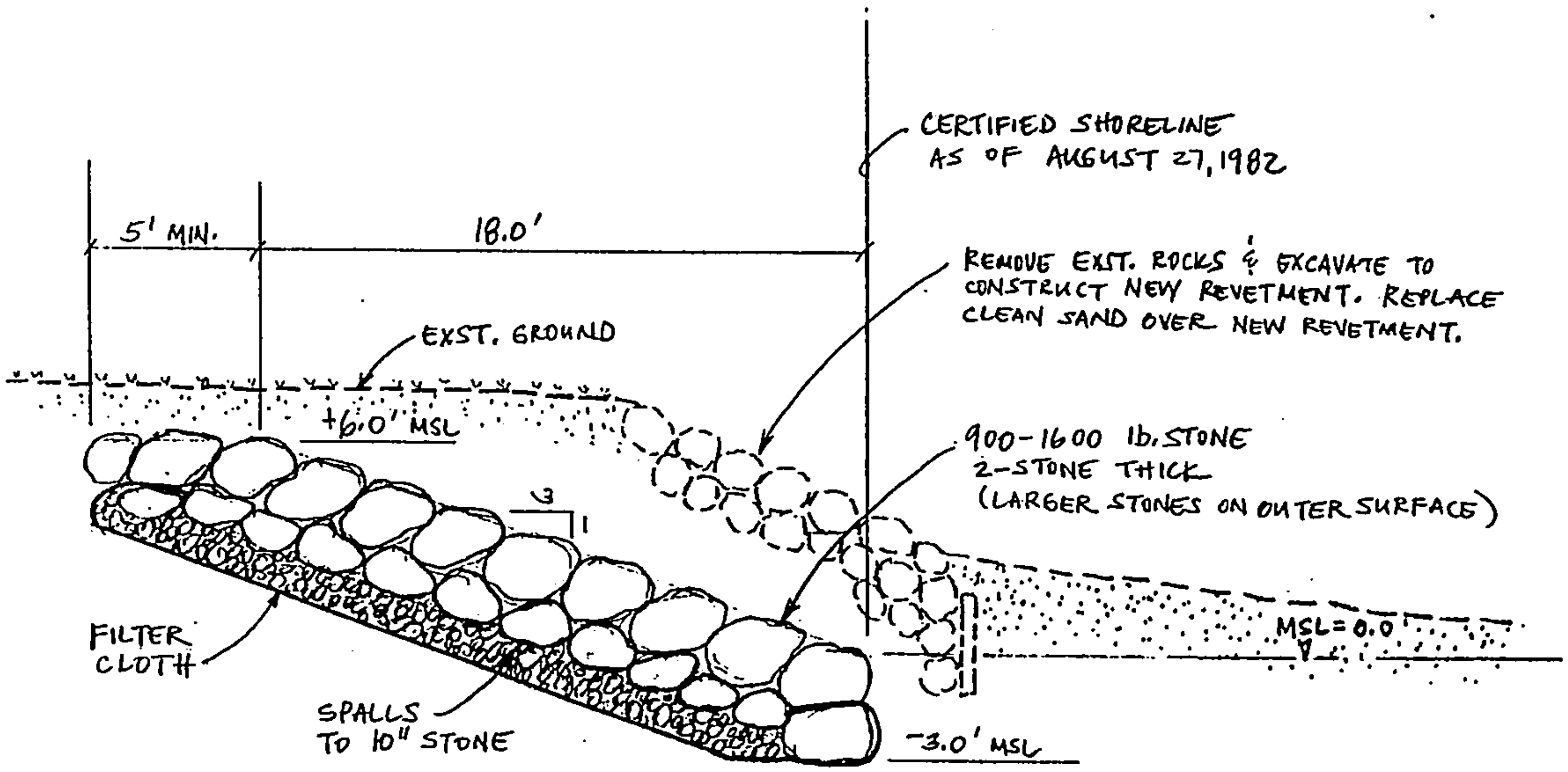
If properly designed and constructed, revetment structures are durable and not prone to catastrophic damage due to its flexibility. The disadvantages are the requirement for heavy equipment and special skills to place the large stones used for the armor layer, in addition to the cost to quarry and haul the large stones to the site. Another disadvantage of revetments is that they occupy substantial space on the shoreline due to their sloping face and multiple rock layers. For many property owners, the substantial erosion of shorefront property may leave insufficient space between the certified shoreline and the dwelling to construct a revetment.

4.0 DESCRIPTION OF PROPOSED ACTION

The existing rock slope has sustained damage due to unraveling of the small rocks on the slope. According to the contractor, the toe of the slope was stabilized by jetting plastic pipe into the sand to a depth of about 3 feet where a discontinuous layer of hard material was encountered. The line of pipes can be seen along the toe of the rock slope where the tops of the pipes have become exposed. Rocks were also jetted into the sand along the line of pipes to minimize the potential for scouring and settling of the rocks at the toe of the slope. Rocks were then placed on the shoreline embankment at a slope of 1V:1.5H to 1V:2H. While the central reach appears to be in good condition, the end segments are unraveling due to the small rock sizes and inadequate layer thickness, and are subject to slope failure.

The existing rock slope is proposed to be replaced with a new revetment structure that will be constructed landward of the shoreline and buried. Figure 4 shows a typical section for the replacement revetment and Figure 5 shows the proposed layout of the structure on the property.

The revetment will be placed on a 1V:3H slope, with the toe excavated to elevation -3' MSL (or to hard foundation material, if encountered). The rock slope will consist of 900-1600 pound armor stone (two-stone thick layer), underlain with a bedding of smaller stones over filter cloth material. The crest elevation will be +6' MSL, which is about 1-2 feet below the existing ground elevation.



TYPICAL SECTION - PARCEL 17

1" = 5'-0"

FIGURE 4. REPLACEMENT REVETMENT TYPICAL SECTION

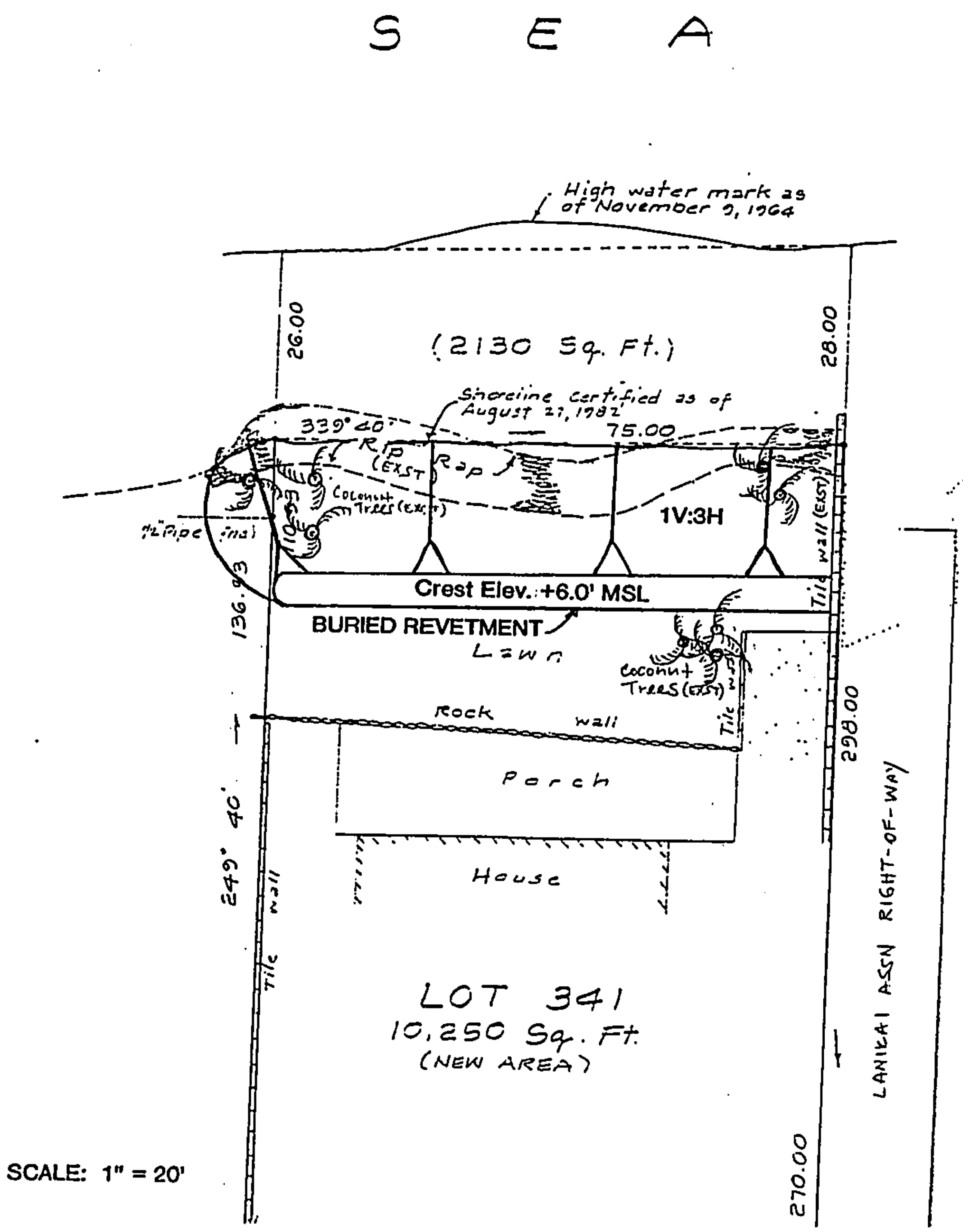


FIGURE 5. PROPOSED REVETMENT LAYOUT PLAN

The City & County DLU mandated that the revetment be constructed landward of the existing shoreline and buried. The existing rock slope will be removed and approximately 15-20 feet of lawn area landward of the existing rock slope will have to be excavated in order to construct the new revetment. The stones from the existing rock slope may be reused in the new revetment, as appropriate. Clean sand from the excavation will be replaced over the new revetment to approximately existing grade. Existing coconut trees will be replanted and new vegetation will be established over the buried revetment to help stabilize the shoreline.

The revetment is intended as a "last line of defense" in case of continued erosion due to normal seasonal trends or catastrophic storm events which may result in loss of the vegetation and sand covering the revetment and subsequent exposure of the armor slope. If exposed, the armor stones (nominal diameter 2 feet) are large enough to remain stable under storm wave attack. The voids in the armor slope will also serve to dissipate wave energy and be more conducive to subsequent beach accretion. However, wave overtopping may still occur during high wave conditions because of the low elevation of the revetment crest.

5.0 <u>POTENTIAL IMPACTS</u>

The proposed replacement revetment will have no adverse effect on existing coastal processes or on the surrounding environment. The revetment construction would not impact the adjacent Lanikai Association right-of-way nor the proposed overflow swale through the right-of-way planned for construction by the City and County. An existing tile wall on the applicant's property alongside the right-of-way forms the boundary between the right-of-way and the revetment. Because of concern that the drainage flows through the right-of-way will undermine the existing tile wall, the applicant proposes to reconstruct a portion of the sidewall in conjunction with the shore protection work to prevent flanking damage due to the runoff flows through the right-of-way.

The construction activities will result in short-term noise and traffic impacts to the residential community due to trucks and equipment working on site. These impacts will be similar to the impacts resulting from previous shore protection construction in the vicinity.

There will be minor water quality impacts during construction since the revetment would be situated predominantly landward of the mean high water line. The large armor stones can be placed on the beach as a temporary berm to protect the work area from wave action. This will minimize wave erosion and turbidity during excavation of the shoreline for the new structure, and will facilitate construction. However, this will result in short-term impacts to beach access and use.

The project site is located within a coastal flood hazard zone designated Zone AE (base flood elevation 6 feet) on the federal Flood Insurance Rate Map (FIRM), as indicated in Figure 6. The new construction will have little, if any, effect on the flood characteristics.

There are no known rare, threatened, or endangered species nor their habitats located in or near the project site.

This report has been prepared by:

Elaine E. Tamaye
Coastal Engineer

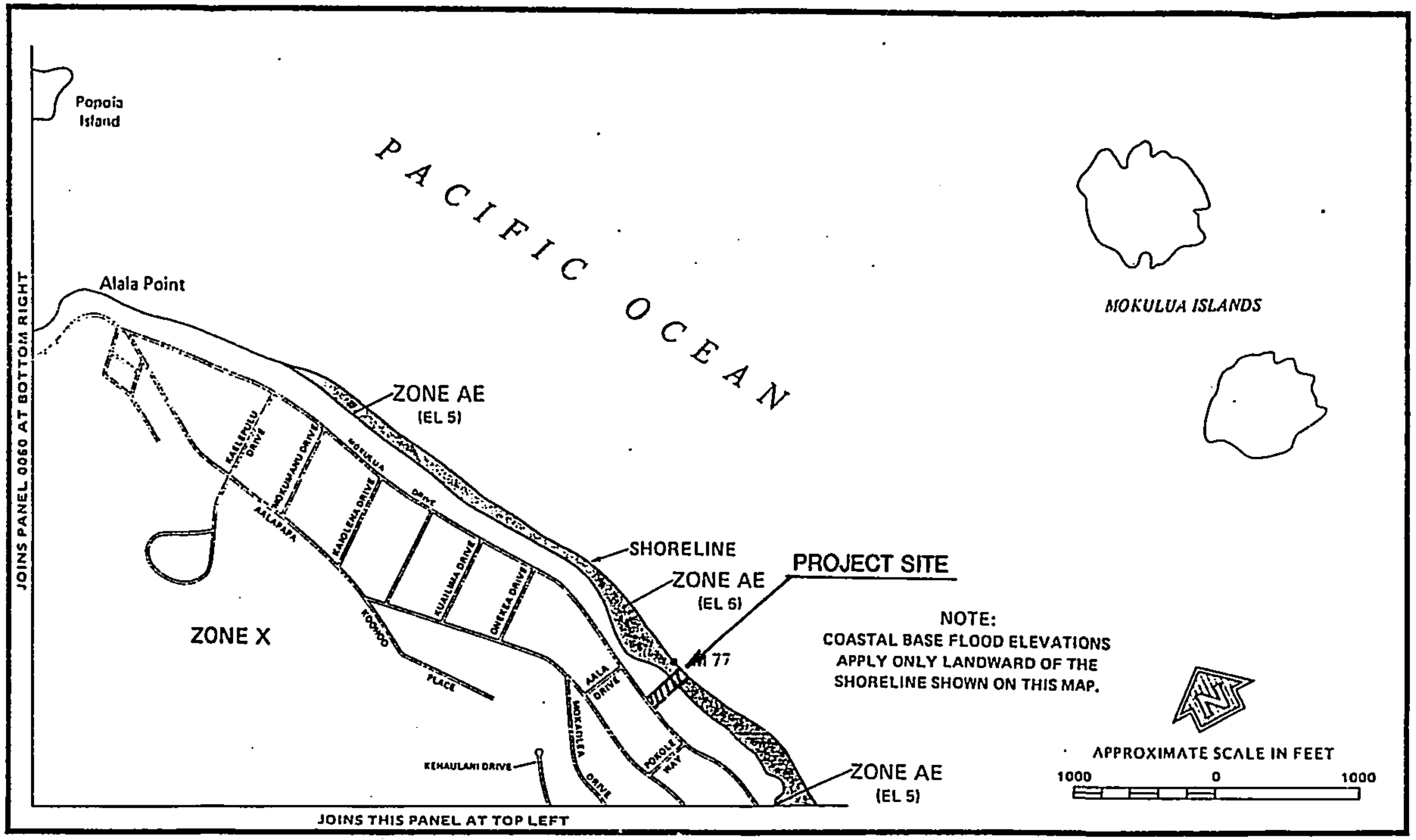


FIGURE 6. PORTION OF FEMA FLOOD INSURANCE RATE MAP (FIRM), PANEL NO. 150001 0095B, REVISED SEPTEMBER 4, 1987

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ELAINE E. TAMAYE OCEAN ENGINEER

EDUCATION

University of Hawaii, M.S. Ocean Engineering, 1977
Specializing in Coastal Engineering
University of Hawaii, B.S. General Engineering, 1974
Specializing in Marine Environmental Engineering

EXPERIENCE

- Ocean Engineer
  Edward K. Noda and Associates
  1983 to present

Ms. Tamaye is the senior coastal engineer responsible for coastal design analysis and oceanographic criteria evaluations. Her major programs and studies have included:

- OTEC 40-MW Pilot Plant Program: The OTEC Pilot Plant Program was funded by the U.S. Department of Energy. As part of the program, oceanographic design criteria were established for the preliminary design of the Land Based Containment System (LBCS), including evaluation of the typical and extreme wave and current conditions, hydrodynamic loads on the LBCS, and potential impacts on littoral processes.
- Hurricane Vulnerability Study for Honolulu, Hawaii and Vicinity: The Hurricane Vulnerability Study for Honolulu was prepared for the U.S. Army Corps of Engineers. As part of the study, inundation limits due to hurricane wave exposure were determined for the south shore of Oahu. A unique computer model was developed which determines the overland flooding effects due to hurricane waves. The model incorporates wave refraction, wave breaking, wave setup, wave runup/overtopping effects, and determines the overland flooding limits.
- Hawaii Ocean Science and Technology (HOST) Park: As part of the planning and design for the HOST Park project, oceanographic criteria were developed for the cold water intake pipeline, including design waves and currents in the nearshore zone.
- Leone Harbor Study for the American Samoa Government: This study evaluated the feasibility of constructing a harbor facility at Leone Bay, based on estimated costs of construction versus anticipated economic benefits to be derived from the harbor. Following the feasibility study, a comprehensive Environmental Assessment was prepared for the proposed harbor.
- Hawaii Shoreline Erosion Management Study: This study was prepared for the State Coastal Zone Management Office, to provide an overview of the erosion processes, discussion of shoreline protection measures and existing regulatory measures for controlling and managing erosion problems, and recommendations for improving erosion management in Hawaii. Three case study sites were evaluated: Makaha and Kailua-Lanikai on Oahu, and Kukuiula-Poipu on Kauai.
- Ke'ehi Lagoon Recreation Plan: This program for the State Harbors Division included initial conceptual planning and design for boating improvements in Ke'ehi Lagoon related to the America's Cup Race. Subsequent efforts included updating the entire recreation master plan for Ke'ehi Lagoon and preparation of an Environmental Impact Statement for the proposed development of the lagoon.

- Civil/Hydraulic Engineer
  U.S. Army Corps of Engineers, Pacific Ocean Division
  1977 to 1983

  Served as hydraulic engineer performing coastal engineering planning and design studies, 1977-1982. Responsible project manager for design of navigation and shore protection projects, preparation of planning/project reports, and plans and specifications for construction. Involved in numerous coastal projects throughout the Pacific Basin, including Hawaii, Guam, Commonwealth of the Northern Mariana Islands, and American Samoa. Her numerous projects included:

  - Hawaii: Planning/design for beach restoration at Kualoa Regional Park (Oahu), planning/design for Barbers Point Deep Draft Harbor (Oahu), design/construction of revetments at Kekaha (Kauai) and Kahului Wastewater Treatment Facility (Maui), planning study for shoreline protection at Iroquois Point Naval Housing Area (Oahu).
  - American Samoa: Planning/design/construction of shore protection for the Pago Pago International Airport Runway, planning/design of shore protection of Matafao School and Masefau Village, design inspection during construction of small boat harbors at Tau and Aunuu-Auasi, and Coastal Zone Management (CZM) coordination activities.

  Served as civil engineer with the Tripler Resident Office, performing a full range of contract administration functions for the Tripler Army Medical Center construction project, 1982-1983. Responsible for preparing change orders, negotiating and processing contract modifications, and evaluating contractor claims.

- Graduate Student
  Department of Ocean Engineering, University of Hawaii
  1975 to 1977

  Assisted on a bathymetric survey off Keahole Point, Hawaii, in conjunction with OTEC program, 1977. Served as marine apprentice technician on a 3-month oceanographic cruise to obtain geological/geophysical data in the Western Pacific, 1977. Co-authored two technical papers, 1976.

AFFILIATIONS

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