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FINAL
SECTION 103 FACT SHEET FOR KAHANA BAY MAUI, HAWAII STORM DAMAGE REDUCTION

U.S. Army Corps
of Engineers
Honolulu District

16 March 2016

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Dep. Planning Dir.

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1. Project. Kahana Bay, Maui, Hawaii - Continuing Authorities Program (CAP), Section 103 (Storm Damage Reduction Project).

2. Location of Project/Congressional District. Kahana Bay is located along the West Maui coast north of Honokowai and south of Napili (Figure 1). It is in the State of Hawaii Congressional District 2, which is currently represented in the U.S. Senate by Senators Brian Schatz and Mazie Hirono and in the U.S. House of Representatives by Representative Tulsi Gabbard. The study area extends along approximately 4,000 feet of the West Maui shoreline (Figure 2).

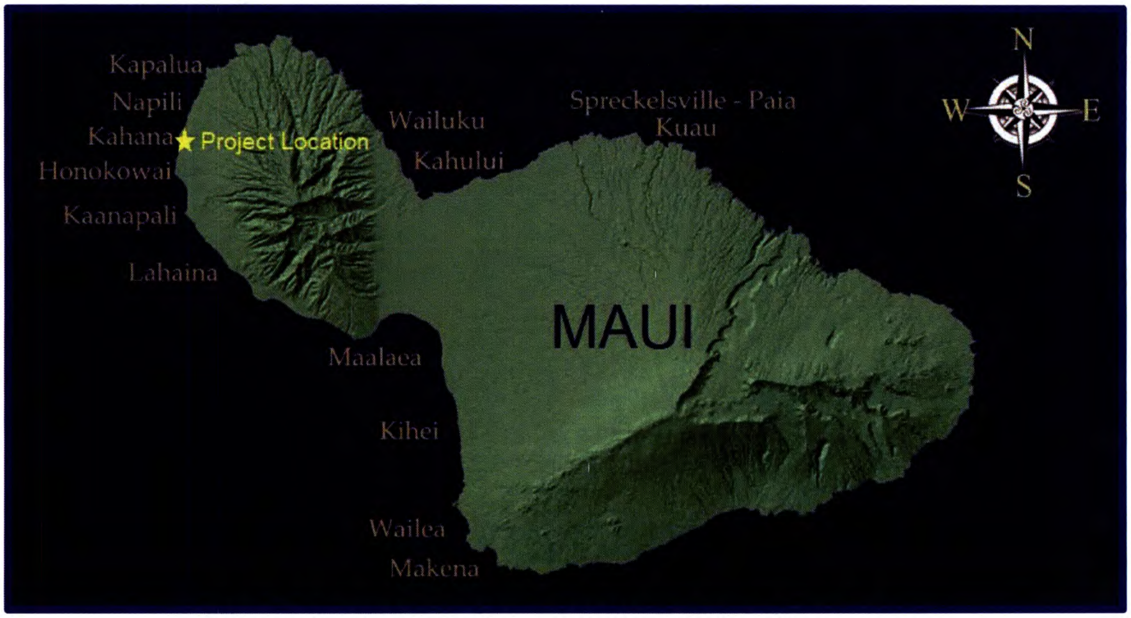

Figure 1: Kahana Bay vicinity and location maps

3. Study Authority. The study is authorized under Section 103 of the River and Harbor Act of 1962, as amended. The Section 103 authority addresses beach erosion and hurricane and storm damage reduction with a statutory federal expenditure limit of $5,000,000 per project.

4. Study Purpose. The purpose of this reconnaissance level study is to determine whether a federal interest exists in continuing into a cost-shared feasibility phase study. The County of Maui, Hawaii is the non-federal sponsor for this study.

5. Discussion of Prior Studies, Reports and Existing Water Projects.

a. Prior Reports.

1) *Draft Hawaii Regional Sediment Management (RSM): Regional Sediment Budget for the West Maui Region, Technical Report, U.S. Army Corps of Engineers*

(USACE), Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL), J. H. Podoski et.al, in press. This technical report provides a description of the RSM investigations performed by the USACE, Honolulu District, along the West Maui coastal region of the Island of Maui, Hawaii. To develop a regional sediment budget for the West Maui coast, the report discusses the methodology for determining volume change rates. To identify sediment pathways, numerical modeling is also presented, including particle tracking modeling.

Figure 2: Kahana Bay study area

2) *Hawaii Regional Sediment Management: Potential RSM Project; West Maui Region, Maui, Hawaii, Coastal and Hydraulics Engineering Technical Note (CHETN), USACE, ERDC, CHL, T. Smith, February 2016.* The CHETN identifies conceptual alternatives that could be refined and implemented through acquisition of appropriate federal authorizations; by other federal, state, and/or county agencies; by partnerships; or by the private sector.

3) *National Assessment of Shoreline Change: Historical Shoreline Change in the Hawaiian Islands,* Charles H. Fletcher, Bradley M. Romine, Ayesha S. Genz, Matthew M. Barbee, Matthew Dyer, Tiffany R. Anderson, S. Chyn Lim, Sean Vitousek, Christopher Bochicchio, and Bruce M. Richmond, U.S. Department of the Interior, U.S. Geological Survey, Open-File Report 2011-1051, (http://pubs.usgs.gov/of/2011/1051). This report on shoreline change on three of the eight main Hawaii islands (Kauai, Oahu, and Maui) is one in a series of reports on shoreline change in coastal regions of the United States that currently include California, the Gulf of Mexico region, the Southeast Atlantic Coast, and the Northeast Atlantic Coast. The report summarizes the methods of analysis, documents and interprets the results, explains historical trends and rates of change, and describes the response of various communities to coastal erosion.

b. Existing Projects.

There are no existing federally authorized projects within the Kahana Bay Section 103 study area.

c. Proposed Projects.

This fact sheet (reconnaissance report) considers construction of shore protection measures along approximately 4,000 feet of shoreline to protect upland development and property in Kahana Bay, Maui, Hawaii and to address wave action and coastal inundation caused by storms.

6. Plan Formulation.

a. Identified Problems.

The passage of large wave events, severe tropical storms and hurricanes are accompanied by a significant rise in the mean sea level nearshore. The rise in sea level, referred to as storm surge, is caused by wind stress on the water surface, atmospheric pressure reduction, and wave setup on the reef flat due to the mass transport of water by breaking waves. The much higher than usual wave heights reaching the shoreline during severe events increase the flooding problem, damage shoreline structures, and cause shoreline erosion.

b. Existing Conditions.

Existing Without-Project Conditions. The primary study area is about 4,000 feet of eroding beach fronting development in Kahana Bay and a beachfront road, Lower Honoapiilani Road, on the northwest coast of Maui. This highly developed, condominium neighborhood consists of a minimum of 8 different oceanfront complexes. Four of the oceanfront condominium complexes in the immediate study area have existing seawalls. These individual, noncontiguous seawalls vary in design, construction materials, top elevations, condition and effectiveness. In lieu of seawalls, the other half of these condominium complexes either have no protection or have employed less hardened shoreline protection methods such as berms. These individual berms primarily consist of large sandbags covered with sand and plantings.

These communities are concerned about losing their beach and possibly their homes due to both long-term erosion and storm induced erosion. Over the past several decades, they have witnessed their once pristine sandy beach degraded to the point of being impassable and somewhat dangerous to walk along. During the winter months, much of the sand that accumulates during the summer months is swept away, and the highly desirable sandy beach narrows to the point where it is practically unusable. This is especially true for sections of the shoreline where seawalls exist and it is no longer possible to walk along the water's edge. Each year, residents of the complexes with existing seawalls see their walls go from 5 or 6 feet high to 12 feet or higher as the beach erodes away. In addition, several of these seawalls experience flanking and piping problems and their long-term effectiveness is in question.

For several of the condominium complexes with no existing sea walls, the risk of loss of life and property are bigger problems. Over the last decade or so, it has become routine for these more threatened condominiums to experience at least one event annually where the ocean washes over their limited protection and spills into their pools and parking areas. Multiple such occurrences in recent years have become more commonplace for a few of the complexes. Residents are worried about the risk to their property and even their lives.

Shoreline and Volume Change Analyses: Due to the presence of extensive reef and hard bottom nearshore, this region has a limited sediment supply from the ocean side. Freshwater and terrestrial sediments are brought into this region by streams. Shoreline change for the study area was quantified by the USGS and the University of Hawaii School of Ocean and Earth Science and Technology (UH/SOEST) (Fletcher et al. 2012) in a report: "National Assessment of Shoreline Change: Historical Shoreline Change in the Hawaiian Islands".

The Honolulu District estimated shoreline change between 1997 and 2014 based on comparison of the USGS/SOEST data and shoreline positions obtained from use of Global Positioning System (GPS) along the shoreline. These two analyses are described in the following, along with the associated volume change estimates.

USGS/SOEST Shoreline Change Estimates: Shoreline change rates were calculated by the USGS/SOEST from "short-term" and "long-term" shoreline data. All available shorelines were used for long-term rate calculations. Post World War II shorelines were used for short-term rate calculations. A minimum of three historical shoreline positions were required when calculating a shoreline change rate with the technique employed by the USGS (Fletcher et al. 2012).

All littoral cells (sub-regions) in West Maui are erosional based on the short- and long-term average shoreline change rates. The average erosion rate is slightly lower in the short-term than in the long-term. The average short-term rate is -0.43 ± 0.03 feet/year [ft/year] (-0.13 ± 0.01 meter/year [m/year]), with 77% of the region's shoreline being erosional. The average of all long-term rates for West Maui is -0.49 ± 0.03 ft/year (-0.15 ± 0.01 m/year), with 85% of the shoreline being erosional in the long-term.

The maximum short-term erosion rate was found at Mokuleia Beach at -2.30 ± 5.58 ft/year (-0.70 ± 1.70 m/year). The Napili-Kapalua sub-region has the highest average erosion rates at -0.62 ± 0.10 ft/year (-0.19 ± 0.03 m/year) in the short-term and -0.72 ± 0.07 ft/year (-0.22 ± 0.02 m/year) in the long-term. Other areas with significant long-term erosion include Honokowai (-1.64 ± 1.31 ft/year or -0.5 ± 0.4 m/year), Kahana (-1.31 ± 0.33 ft/year or -0.40 ± 0.10 m/year), and Napili Bay (-1.31 ± 0.64 ft/year or -0.40 ± 0.20 m/year).

Honolulu District Shoreline Change Estimates: Within the region's littoral cells, the 2014 shoreline position was acquired by POH through the use of GPS equipment. The USGS/SOEST study tracked the movement of the beach toe (intersection of the beach profile and reef flat). POH adjusted the 2014 shoreline positions to account for the offset between the surveyed shoreline and the beach toe. Figure 3 displays shoreline positions (from south to north) for 1997 (from USGS/SOEST) and 2014 in the Kahana Bay littoral cell. In the southern portion of the littoral cell (mile [M] 0 to M 0.25 in Figure 3), the shoreline advanced seaward on the order of 25 feet during the time period. In contrast, the shoreline receded approximately 25 feet from M 0.32 to M 0.42 on Figure 3 during that same period. This is the area in which shoreline erosion is currently threating a number of condominiums. A seawall stabilizes the shoreline form M 0.42 to M 0.49 and the unarmored shoreline from M 0.49 to M 0.56 was relatively stable as well. The remainder of the littoral cell shoreline (M 0.56 to M 0.74) has advanced seaward 30 feet on average due in part to private beach nourishment efforts.

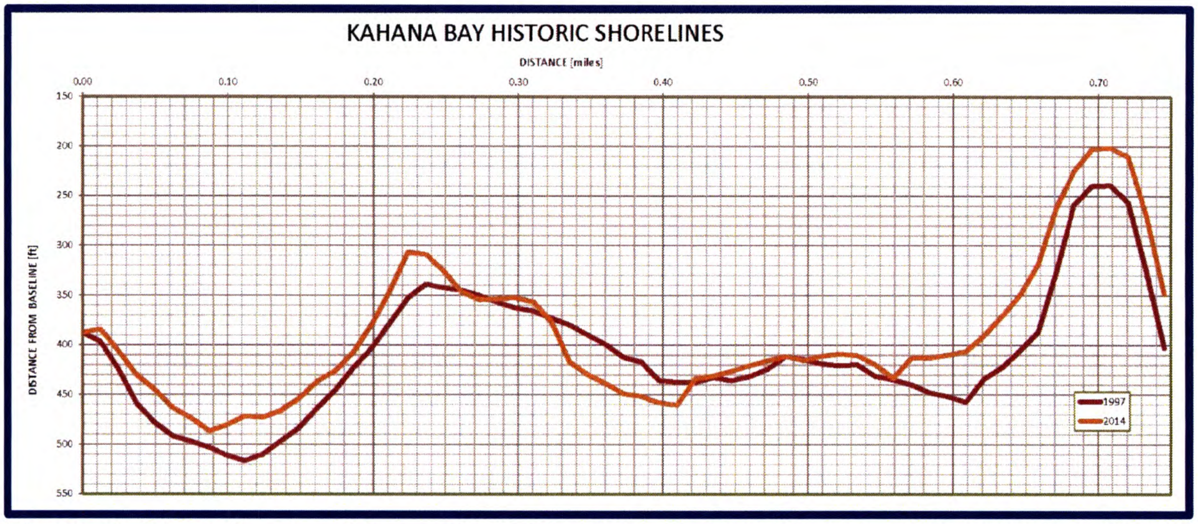

Figure 3. Shoreline positions within the Kahana Bay littoral cell for 1997 and 2014.

Volume Change Rates: For the study area, the active beach profile has a typical vertical extent of 10.8 ft (3.3 m), which included 3.0 ft (0.9 m) depth to the reef flat and 7.8 ft (2.4 m) elevation to the upper limit of the profile. This translates to 0.4 cy/ft/ft when the 10.8 ft vertical extent is converted to volume per foot of shoreline change over each foot of shoreline length, then divided by 27 ft^3/cy. Thus, a conversion factor of 0.4 cubic yards (cy) of sand per foot of shoreline change over each foot of shoreline length was used to estimate the volume change corresponding to the shoreline changes from 1997 to 2014. This conversion factor is based on the Bruun Rule (Bruun, 1962) and experience with other Hawaii shorelines.

Figure 4 shows sediment volume change rates for the Kahana littoral cell. These volume change rates are in cubic yards per year (cy/year). The volume change rates are provided over various time periods available in the shoreline change data. A positive value indicates shoreline advance and negative value for shoreline recession.

Results for this littoral cell indicate the volume change rates are typically small for all time periods, remaining within ± 5,000 cy/year. Largest rates of erosion occurred in the littoral cell during the periods of 1949-1960 (-5,000 cy/year) and 1988-1992 (-4,000 cy/year). For the present time period (1997-2014), the volume change rates in the littoral cell was +1,500 cy/year.

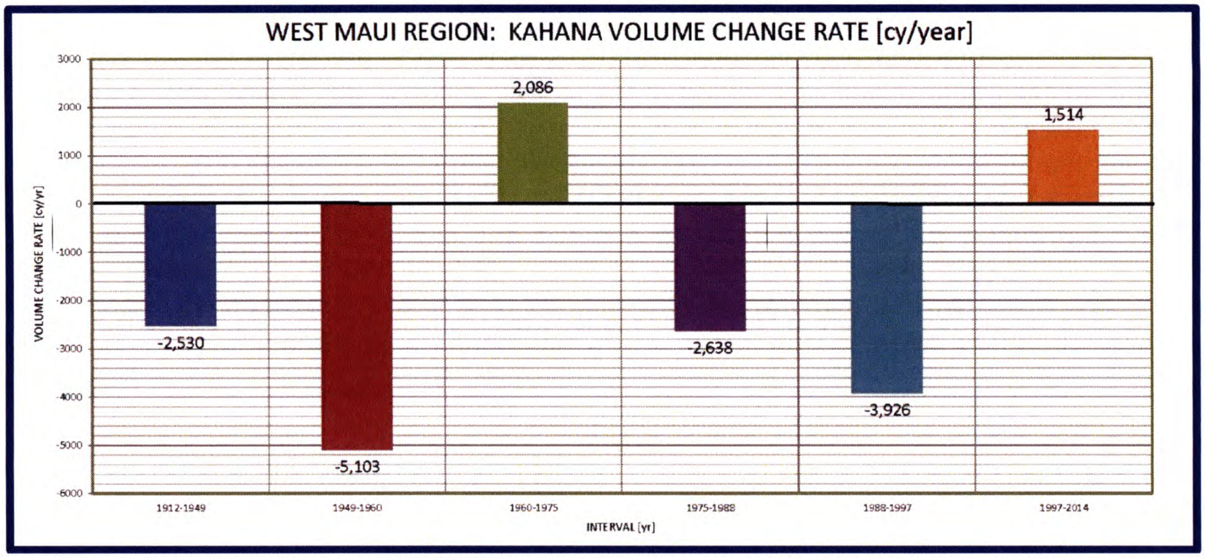

Figure 4. Volume change rates through time (cy/year) for the Kahana littoral cell.

Wave Information Study (WIS). For open ocean wind and wave forcing, the USACE ERDC Wave Information Study (WIS) long-term hindcast data (http://wis.usace.army.mil/hindcasts.shtml) are available for the Central Pacific for the years 1980 through 2011. Since there are no WIS stations located directly offshore of the study area, data from one station located north (Station 82517) of Maui and one located to the south (Station 82546) were utilized. Figure 5 shows the location map for Station 82517 and 82546.

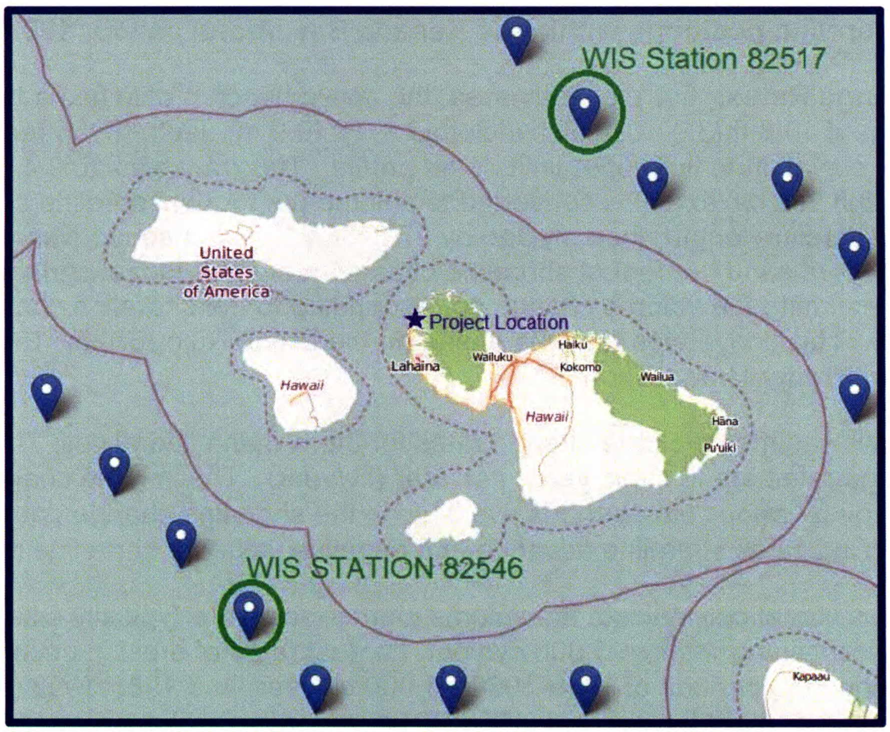

Figure 5: Wave Information Study hindcast station locations

Winds. The wind roses for Station 82517 and Station 82546 all years in the WIS database (1980 through 2011) are shown in Figure 6. Even though the two stations are located approximately 70 miles apart, the occurrence percentages and wind speeds contained in each band of the two wind roses are nearly equal. In general, the majority of the winds come from east northeast through east (a total of over 60% of the time). Other directional bands contain a maximum of 10% of the occurrences and are associated with light winds. Note that these stations are located in the open ocean and do not encounter West Maui's mountainous terrain. Orographic tuning of winds from the northeast redirects the winds more northerly while winds from the southeast are redirected more southerly in the study area.

Waves. The wave roses for Station 82517 and Station 82546 covering all years in the WIS database (1980 through 2011) are shown in Figure 7. The wave climate to the north of Maui, shown on the left (Station 82517), is dominated by 1-3m waves coming from the northwest through the east. Approximately 30% of the time the waves come from the east northeast. Waves come from each the other directional bands about 10-15% of the time. The significant wave height of the majority of the waves are 1-2m (about 45%) and 2-3m (about 40%). However, a significant percentage, about 15%, have wave heights greater than 3m. Although Station 82546 is to the south of Maui, the waves primarily come from the east rather than from the south or west. Approximately 25% of the time waves come directly from the east. Wave heights are overall smaller at this station, with heights from 0-1m occurring about 30% of the time and heights from 1-2m about 65% of the time. Less than 5% of the time wave heights are greater than 2m.

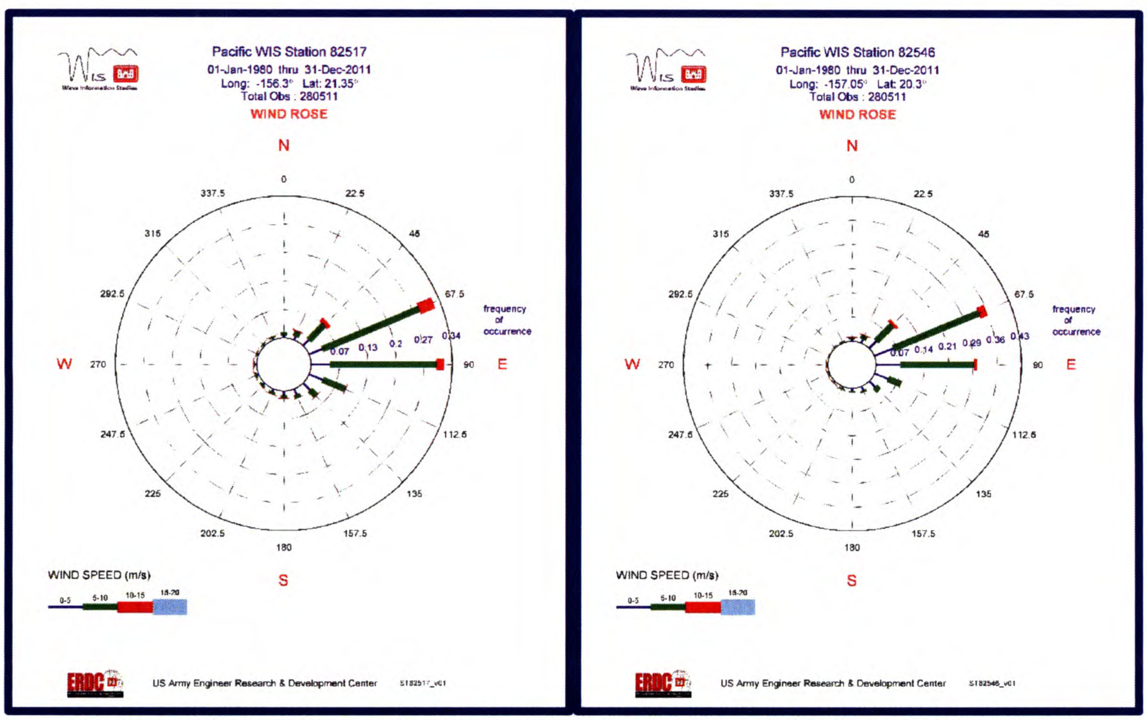

Figure 6: Wind roses for Station 82517 (left) and Station 82546 (right)

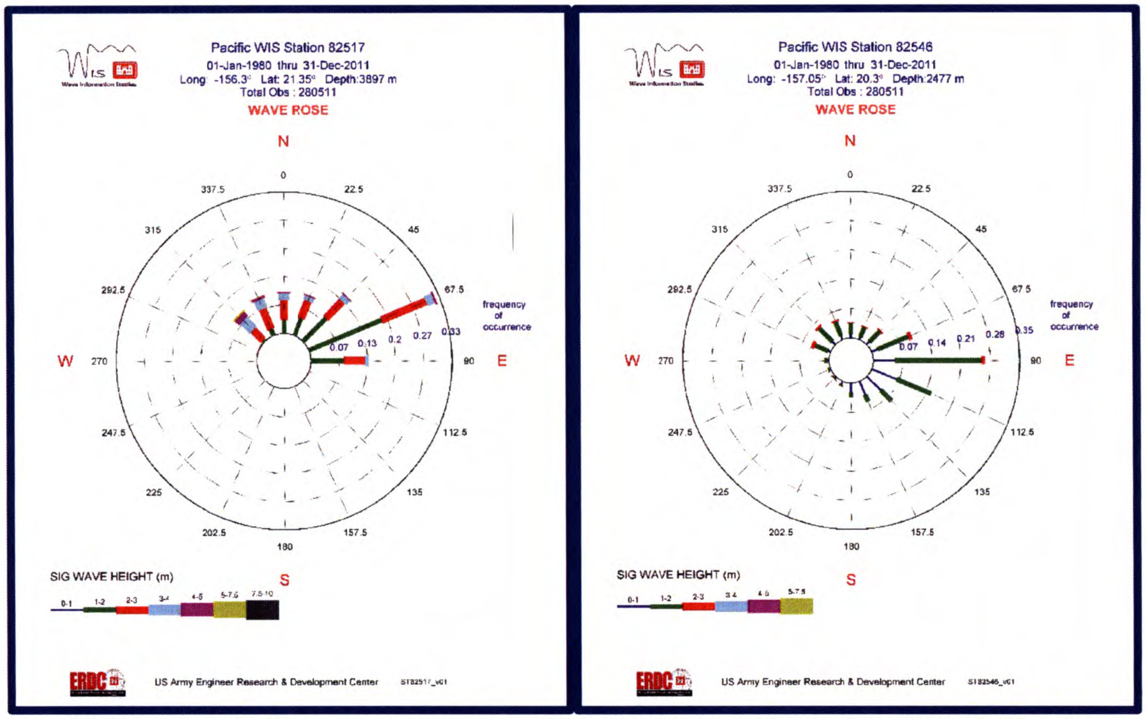

Figure 7: Wave roses for Station 82517 (left) and Station 82546 (right)

Tides. Tidal effects in the Hawaiian Islands are relatively small because the tidal range is less than 3.3 ft (1 m). The nearest National Oceanographic and Atmospheric Administration (NOAA) tide gauge, Station 1615680 at Kahului Harbor, had water level data were available. Table 1 provides the NOAA tide datums for Kahului Harbor, Maui, as determined for the tidal epoch from 1983 through 2001. The following are definitions of the tidal characteristics and information used to quantify the tidal datums.

Mean Higher High Water (MHHW): The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch.

Mean High Water (MHW): The average of all the high water heights observed over the National Tidal Datum Epoch.

Mean Sea Level (MSL): The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch.

Mean Low Water (MLW): The average of all the low water heights observed over the National Tidal Datum Epoch.

Mean Lower Low Water (MLLW): The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.

National Tidal Datum Epoch: The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean lower low water, etc.) for tidal datums. It is necessary for standardization because of periodic and apparent secular trends in sea level. The present NTDE is 1983 through 2001 and is actively considered for revision every 20-25 years.

Table 1. Kahului Harbor Tidal Datums
(NOAA Tide Station 1615680, Tidal Epoch 01/01/1983 - 12/31/2001)

	Elevation [feet]
Highest Observed Water Level	2.37
Mean Higher High Water (MHHW)	1.13
Mean High Water (MHW)	0.78
Mean Sea Level (MSL)	0.00
Mean Low Water (MLW)	-0.79
Mean Lower Low Water (MLLW)	-1.12
Lowest Observed Water Level	-2.73

Sea Level Change. Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) has documented global warming during the 20th century that is anticipated to either continue or accelerate for the 21st Century. Global mean sea level change varies in response to global climate change and it was determined that global mean sea level rose at an average rate of 0.07 inches per year (in/yr) (1.7 ± 0.5 millimeters per year [mm/year]) during the 20th century.

Recent USACE guidance (EC 1165-2-211) requires incorporating the effects of future sea-level changes in all managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects or systems of projects in tidally influenced areas. The guidance recommends assessing sea-level change based upon "low", "intermediate", and "high" rates of sea-level change developed by the National Research Council (NRC). Sea level change will be incorporated into project planning and design during the feasibility phase of study in accordance with USACE guidance, policy and regulations.

c. Expected Future Without Project Conditions. This area of the Kahana Bay shoreline will continue to be vulnerable to inundation and wave damages from elevated water levels during storm events. Larger storms will erode significant portions of shoreline where no seawall exists to attenuate it. Where sea walls currently exist, and possibly where more will be added between today and the would-be project base year, the shoreline may likely hold. However, where seawalls end, shoreline erosion is likely to be accelerated, and more oceanfront land will be lost at the flanking point of the walls. The same is true with long-term erosion. Under future without-project conditions over the next several decades, given sea level rise and the stopgap measures presently employed to lessen erosion, this stretch of Kahana Bay may become an inaccessible, rocky beach with little to no sand. The possibility also exists that in the not too distant future the beach could be lined with abandoned shells of deteriorating condominium towers and townhouses.

d. Planning Objectives and Constraints.

Objectives. The objective of this project is to identify a plan that will provide an increased level of coastal flood risk reduction in a manner that is acceptable to the federal government and non-federal sponsor, and reduces damages to upland development in the area.

Constraints. No planning constraints have been identified for this project.

e. Problems and Opportunities.

The main problems in the study area include reoccurring inundation and wave damages to upland development.

Opportunities exist for structural and non-structural solutions for improving coastal flood risk management.

f. Alternative Plans.

The following alternative plans were considered 1) rock revetment (Figure 8), 2) sheet pile seawall (Figure 9), and 3) beach fill (Figure 10). The no action plan was also considered but was found unresponsive to the problems currently being experienced and the anticipated future conditions within the study area.

The rock revetment shown in Figure 8 consists of one layer of armor stone and two layers of underlayer stone placed onto geotextile filter fabric. The armor layer would be comprised of stones designed to be stable under the impact of elevated water levels and associated storm waves. The underlayer stone would be sized to resist displacement through the armor layer and provide a relatively even surface for placement of armor stone. The geotextile filter fabric would confine the foundation material under the revetment which could include hard substrate and/or unconsolidated sediment. The revetment toe would either be notched into hard substrate (if existent) or have a sacrificial design in which toe scour would be anticipated as is the case for the design shown in Figure 8. The revetment crest elevation would be determined through performance criteria required for the project along with the elevation of the existing backshore and upland development.

The sheet pile seawall (Figure 9) would consist of sheet pile either driven to refusal into hard substrate or to a depth of penetration that would provide the necessary earth pressures for it to remain stable under design conditions. A concrete cap would be formed and poured in-place in the upper portion of the sheet pile wall to provide added strength and resistance to corrosion. The concrete cap would extend from the crest of the sheet pile seawall to below existing ground on the oceanside of the structure. Similar to the revetment, the crest elevation of the seawall would be determined through performance criteria required for the project along with the elevation of the existing backshore and upland development.

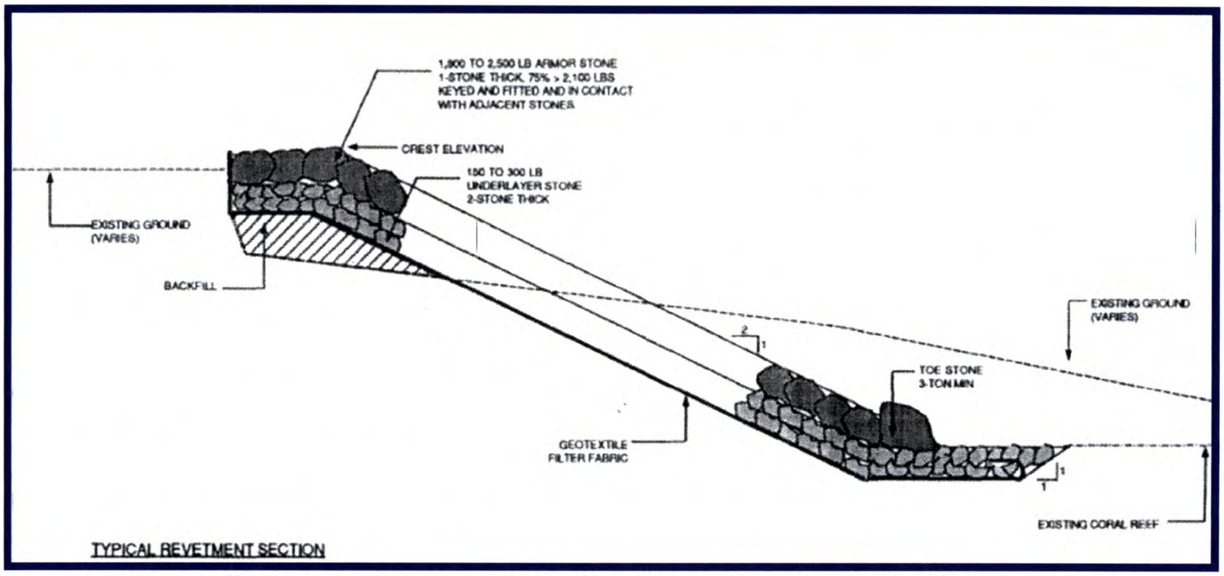

Figure 8. Section view of rock revetment alternative

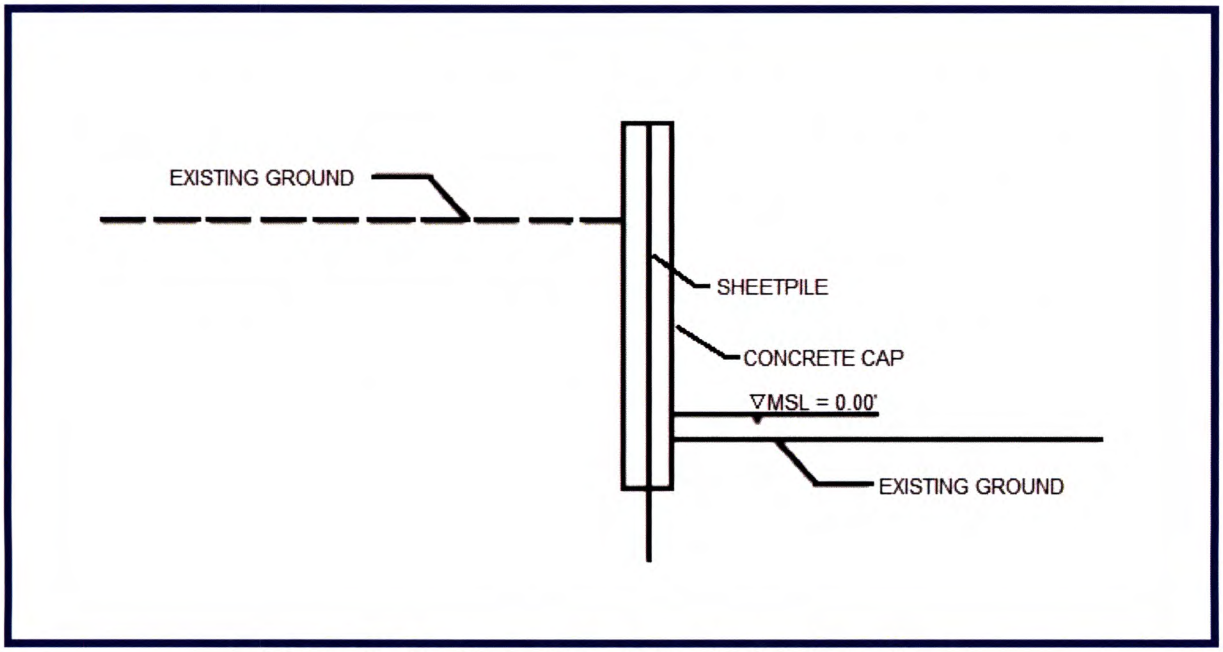

Figure 9. Section view of sheet pile alternative

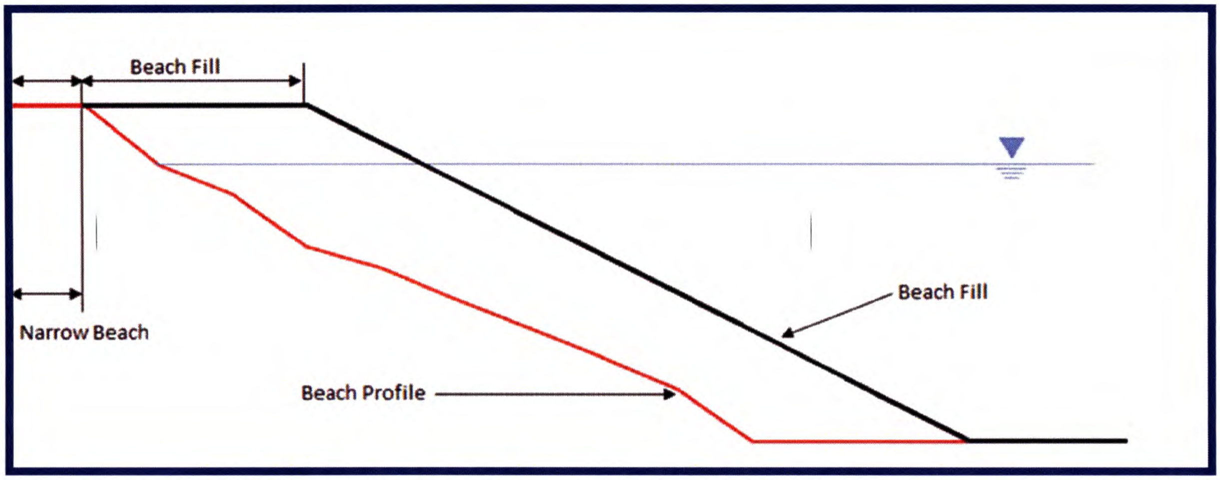

Figure 10. Section view of beach fill alternative

The beach fill alternative is a "soft" solution that would provide the same types of benefits as the "hardened" coastal flood risk management alternatives previously discussed. A generic cross section for the beach fill alternative is shown in Figure 10. The pre-project beach profile is shown in red while the mean seal level waterline is the blue horizontal line. Beach fill is represented by area between the red and black lines. The beach fill extension is the horizontal distance between the pre-project and beach fill lines. The beach toe in the study area is where the beach profile intersects the nearshore reef. The berm elevation is determined by its vertical location on the pre-project beach profile. In the study area, the vertical distance from the beach berm to the beach toe is on the order of 11 feet. This equates to a volume of 0.4 cubic yards of sand required to extend the beach 1 foot seaward and 1 foot longshore. Therefore it is estimate that it will take 16,000 cubic yards of sand to extend the 4,000 feet of shoreline in the study area by 10 feet.

Figure 11 demonstrates how the beach fill alternative would protect upland development. The top 2 panels of Figure 11 show the pre-project condition, where the beach fronting the upland development is narrow. The red line highlights the pre-project beach profile. The top left panel is the pre-project condition during a typical day. The narrow beach is sufficient to protect the development. However, during a storm event as illustrated in the top right panel, the narrow beach is incapable of protecting the development. The buildings are in danger of undermining and flood damage from wave attack propagating landward due to the presence of the storm surge.

The bottom two panels in Figure 11 show how the beach fill alternative can protect a development from storm damages. The red line indicates the pre-project beach profile. Sand placed on the beach spreads over the entire profile, extending the profile seaward and widening the beach. Even during a storm, shown on the bottom right, the wider beach prevents the storm surge and waves from reaching the development. A standalone nonstructural plan will also be evaluated as required by USACE regulations and WRDA 1996.

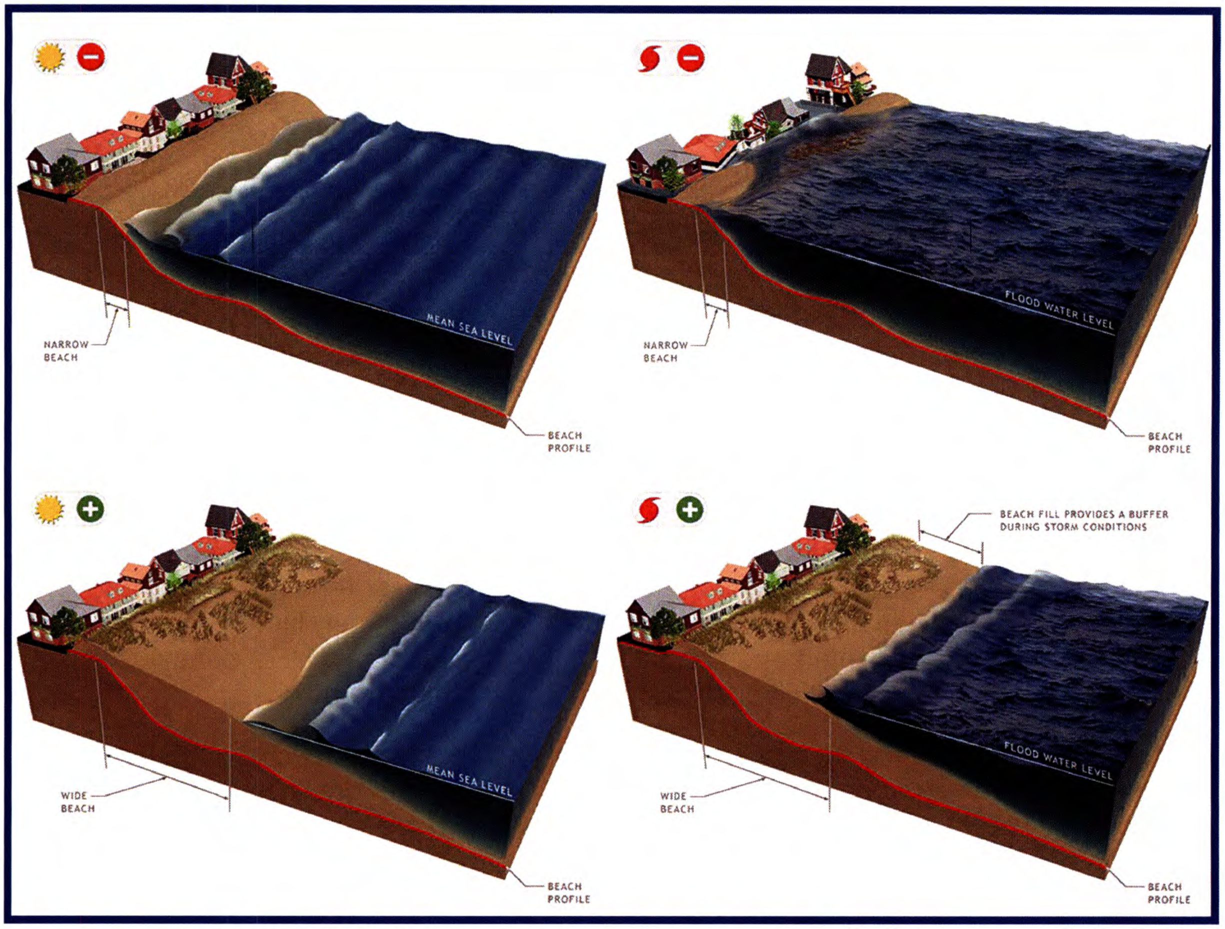

Figure 11. Storm impacts with and without beach fill

g. Preliminary Evaluation of Alternatives.

If the return period still water level is below the existing ground elevation, coastal flooding will be caused by wave runup causes by waves breaking at the shoreline which will also contribute to continued shoreline erosion. If the return period still water level is higher than the existing ground, study area will be submerged and the existing infrastructure will also be vulnerable to both flooding and wave impact damages from wave propagation.

1) Likely Benefits of Project. Benefits are defined as the difference between conditions with- and without- a project in place. National economic development (NED) benefits would accrue from reductions in damages to lands, structures and contents prone to inundation, costs to the Count of Maui for additional emergency shoreline protection and/or restoration measures, emergency highway repair costs, utility damages, and travel delays. Regional economic development (RED) benefits, such as reducing the number of interruptions in business operations and sales caused by storms, is another category of benefits likely to be investigated. Other intangible, but important benefits of the different alternatives include reducing the threat to human safety, as well as trauma and stress of the area's residents and business owners.

2) National Economic Development (NED) Benefits. The NED benefit for reducing storm damages is anticipated to be the largest benefit category. This not only includes reducing damages to structures, contents, automobiles, utilities and landscaping, but also includes an important subcategory called land loss prevented. As explained above, these oceanfront condominium complexes are losing land each year. This translates into a significant annual benefit if it can be stopped. USACE regulations require land loss benefits be determined using "near shore" land values, not the inflated market value that people must pay for highly desirable oceanfront property. If an alternative could prevent future land loss from long-term erosion, this annual benefit could easily eclipse $100,000.

In addition to storm damage reduction, there are two other important benefit categories expected to contribute to the NED benefit totals. One is based on savings stemming from averting expenses that would otherwise be incurred for temporary measures to combat erosion. The other is a general recreation benefit. Currently, condominium owner associations are making hard choices on whether to spend their money constructing new individual seawalls or sandbagged berms, or repairing such beach stabilization investments already in place. These collective expenditures on stopgap measures can be documented and annualized, then claimed as a NED benefit to offset the cost of a more comprehensive, cost-shared project to halt erosion.

Some increase in general recreation value is likely to be experienced as a beach in a continuous degrading state is potentially restored to its former pristine condition. People prefer to go to the beach nearest their homes and are theoretically willing to pay more for that privilege. The difference in the experience value, under with and without each alternative improvement conditions, can be captured through the unit day value method and claimed as a NED benefit.

3) Regional Economic Development (RED) Benefits. Under a separate benefit account, the feasibility study will also disclose RED benefits attributable to the TSP and NED Plan. These benefit categories will capture such economic impacts of a cost-shared shoreline protection project on Maui County's tax base, rental incomes and taxes paid from the leasing of these units, maintaining the estimated 200 jobs dependent on these condominiums, and the temporary economic impacts of an injection of Federally cost-shared money in the project.

4) Structure Inventory and Content Damage. The neighborhood in the primary study area consists of a minimum of 8 different oceanfront complexes. Five of these 8 condominium complexes consist of a total of eleven 8- to 12-story towers. One of these tower complexes consists of two 8-story towers, another has four towers (2 eight and 2 nine stories), and a couple complexes have 2- to 3-story townhouses and quadruplexes. All the towers are constructed of concrete and steel, while the townhouses and quadruplexes are predominantly masonry and wood frame construction.

There are about 1,000 residential units within these oceanfront condominium complexes. Altogether, they contribute about $400 million to the Maui County tax base in structure value and nearly another $100 million in land value. Of course, most of these are above the first finished floor. However, there are an estimated 75 units worth about $30 million that could be flooded by a large storm event. This could put 100 to 200 people's lives in danger as well. When content value and automobile values are included, in addition to lobbies, swimming pools, cabanas, utilities and landscaping, the total value in harm's way of a 1 percent annual chance exceedance (100-year) storm could be in the $65-$75 million range. That assumes that entire structures would not be lost to the storm event. If that were the case, then the upper floor values would also be included.

5) Project Cost. The cost of a rock revetment is estimated at $400 to $600 per foot of shoreline to be protected. Maintenance of the revetment is estimated at 10% of the initial construction cost every 10 years. Therefore, initial construction costs for the rock revetment would range from $1,600,000 to $2,400,000. Maintenance costs would be between $160,000 and $240,000 every 10 years.

The cost of a steel sheet pile seawall is estimated at $300 to $400 per foot of shoreline to be protected. Maintenance of the seawall is estimated at 10% of the initial construction cost every 10 years. Therefore, initial construction costs for the steel sheet pile seawall would range from $1,200,000 to $1,600,000. Maintenance costs would be between $120,000 and $160,000 every 10 years.

The unit cost (per cubic yard cost for sand placed on the beach) is estimated at $150 to $200 per cubic yard for the beach fill alternative. It is anticipated that the project would have to be renourished every 15 years over its 50 year project life. This would result in renourishments at years 15, 30 and 45. Therefore, the initial construction cost for a 20-foot beach fill would take about 32,000 cubic yards at an approximate cost between $4,800,000 and $6,400,000. Renourishment costs for placement of 16,000 cubic yards of sand would range from $2,400,000 to $3,200,000.

6) Summary of Economic Review. For the purpose of this study, with a limited analysis of the total economic benefits, the likelihood of a successful project capable of achieving a benefit cost ratio (BCR) of at least 1.0 must be based on past experience using a sensitivity test. If the Tentatively Selected Plan (TSP) were to cost $5 million (with no operation and maintenance (O&M) costs), it would require a total annual benefit of about $200,000 to match the annual cost and yield a BCR of 1.0 at the Federally prescribed interest rate for FY2016 of 3-1/8 percent. If construction costs were $6 million with $60,000 in annual O&M costs, it would take $300,000 in annual benefits to reach a BCR of 1.0. Finally, with a $2.5 million construction cost with an annual O&M cost of $50,000, it would require an annual benefit of $150,000 to achieve a 1.0 BCR. It can be confidently stated that in the case of this 4,000 linear foot reach of Kahana Bay, there are potentially sufficient benefits to cover any of these scenarios.

7) Real Estate Considerations. Within the project study area the beach shoreline is owned by the State of Hawaii. Adjoining the shoreline is privately owned lands, the majority of which are owned by nine various condo associations. The private land owners are supportive of the project, therefore real estate considerations pose no issues or concern. If any issues arise, the non-federal sponsor has authority to use

eminent domain in the benefit of the general public. No real estate issues or concerns surfaced during this analysis.

8) Environmental Considerations. There is no known National Environmental Policy Act (NEPA) documentation that exists for the project site, and the proposed activity is not covered by a categorical exclusion. Because the potential environmental impacts of the proposed project are anticipated to be less than significant, an Environmental Assessment is recommended to meet NEPA requirements. The environmental coordination and permit requirements for the proposed project may ultimately include, but not be limited to the following:

- Coordination with County of Maui Planning Commission of Commerce who administers the Coastal Zone Management Program.

- National Historic Preservation Act Section 106 evaluation of historical and cultural resources in the project area and coordination with the State of Hawaii Historic Preservation Officer.

- Additional Requirements: Additional requirements may include, but may not be limited to, compliance with Clean Water Act (CWA) Section 401 (Water Quality Certification), CWA Section 402 (National Pollutant Discharge Elimination System), CWA Section 404, Endangered Species Act (ESA), Fish & Wildlife Coordination Act (FWCA), and Magnuson-Stevens Fishery Conservation and Management Act (Essential Fish Habitat), Marine Mammal Protection Act (MMPA).

The need for consultation under the ESA, FWCA, Essential Fish Habitat, and MMPA will be determined during the development of the Environmental Assessment.

7. Findings and Federal Interest.

An implementable solution that warrants further Federal involvement has been identified amongst alternative plans considered in this reconnaissance level investigation. A Federal interest exists for continuing into the cost shared feasibility phase for storm damage reduction at Kahana Bay, Maui, Hawaii, under Section 103 of the CAP. There is a reasonable chance that an economically justified project (i.e., benefit-cost ratio greater than 1.0) can be identified.

8. Study Phase Schedule.

Table 2. Preliminary Schedule

Description	Duration (months)	Cumulative (months)	Month/Year
Execute Feasibility Cost Share Agreement/Initiate Study*			September 2016 (Est)
Develop Array of Alternatives	3	3	December 2016
Identify Tentatively Selected Plan	12	15	December 2017
Agency Endorsement of Plan	12	27	December 2018
Submit Decision Document	3	30	March 2019
Prepare Plans and Specifications	18	48	September 2020
Award Construction Contract	6	54	March 2021

* Subject to availability of federal and local funds.

9. Recommendations.

A preliminary analysis has determined that an economically feasible alternative in the federal interest can likely be identified to protect the coastal infrastructure, upland development and private property at Kahana Bay, Maui. Further study under the Section 103 authority to determine the feasibility of providing coastal storm damage reduction for Kahana Bay is recommended. A full range of alternatives providing protection along the Kahana Bay shoreline will be examined in the feasibility phase of study.

The recommendations contained herein reflect the policies governing formulation of individual projects and the information available at this time. They do not necessarily reflect program and budget priorities inherent in the County of Maui programs, or the formulation of a national civil works water resources program. Consequently, recommendations may be modified at higher levels within the executive branch before they are used to support funding. However, prior to initiating the feasibility study, the non-federal sponsor will be advised of any modifications and will be afforded an opportunity to comment further.

10. Views of the Sponsor.

The non-federal sponsor, County of Maui, Hawaii, understands local cost-share obligations and supports federal assistance in proving flood damage reduction for Kahana Bay, Maui, Hawaii, and will provide a letter in support of continuing with a cost-shared feasibility study.

11. Views of Other Resource Agencies.

Coordination with federal and local resource agencies will occur in the feasibility phase study.

12. Supplemental Information.

None

13. Feasibility Phase Cost Estimate and Scope.

Feasibility phase costs for a study of this scope are estimated at $1,450,000. A Project Management Plan will be developed prior to initiation of the feasibility phase study and will include a detailed study cost estimate and schedule.

14. Project Delivery Team Activities.

Major activities that will be accomplished during the feasibility phase (listed by discipline) include:

- Study Initiation
- Review Existing Studies and Gather Information
- Attend Team Meetings
- Coordination
- Site Visit
- Technical Analysis (see Hydrology and Hydraulics below)
- Identify Tentatively Selected Plan (see Economics below)
- ATR Review
- Independent External Peer Review
- Incorporate Comments

- **Engineering:**
    a. Analyze Updated Wave Hindcast Database
    b. Wind and Wave Analysis
    c. Hydraulic Analysis and Design
    d. Survey
    e. Geotechnical Investigations

- **Economics:**
    a. Inventory Flood Damages
    b. Develop Without- and With-Project Conditions
    c. Quantify All Benefit Categories
    d. Identify Tentatively Selected Plan and National Economic Development Plan

- **Environmental Resources:**
    a. Initial Regulatory Coordination
    b. Prepare Environmental Assessment

- **Cost Estimating:**
    a. Feasibility Cost Estimate
    b. Total Project Cost Estimate

- **Value Engineering:**
    a. Value engineering of the feasibility alternatives (if required)

- **Contracting:**
    a. Acquisition plan for project construction and engineering services

- **Real Estate:**
    a. Real estate appraisal report

15. Study Assumptions.

- Sheet pile of appropriate length can be provided by the contractor.
- Sheet pile will be able to be driven to the necessary depth.
- Access is available at the site for construction activities during daylight hours.