HILO AREA
COMPREHENSIVE STUDY
VOLUME 4 OF 4

Kumukahi Small Craft Harbor

DRAFT
SURVEY REPORT AND
DRAFT ENVIRONMENTAL
IMPACT STATEMENT

US Army Corps
of Engineers
Pacific Ocean Division

APRIL 1983

DEPARTMENT OF THE ARMY
US ARMY ENGINEER DISTRICT, HONOLULU
FT SHAFTER, HAWAII 96858

VOLUME IV
CAPE KUMUKAHI, HAWAII

A DRAFT SURVEY REPORT AND ENVIRONMENTAL IMPACT STATEMENT FOR SMALL-CRAFT NAVIGATION IMPROVEMENTS

APRIL 1983

HONOLULU ENGINEER DISTRICT

SYLLABUS

This is a survey report for the feasibility of constructing a small-craft boat harbor at Cape Kumukahi, Hawaii. This report was prepared as part of the Hilo Area Comprehensive Study. The initial requests for this study were Resolutions 144 (1973) and 480 (1975) by the Hawaii County Council. In 1976, the US Congress authorized the study. The Honolulu Engineer District initiated the Hilo Area Comprehensive Study that year.

This report addresses the Small-Craft (Commercial) Navigation component of the Comprehensive Study. The proposed project would be constructed on the south side of Cape Kumukahi which is located about 25 miles southeast of Hilo and situated on State and Federal lands. This plan would provide berthing for 165 vessels up to 35 feet in length. The inland harbor would be excavated from rock using wave absorbers to line the entrance channel and a wave stilling basin. There would be sufficient backup space on land to serve as an industrial park to support commercial fishing.

The total investment cost is estimated to be $21.4 million with an average annual cost of $1.7 million. The average annual net benefits are $1,026,000 with a benefit to cost ratio of 1.6.

VOLUME V. KUMUKAHI SMALL-CRAFT HARBOR

A DRAFT SURVEY REPORT AND ENVIRONMENTAL IMPACT STATEMENT
FOR
SMALL-CRAFT NAVIGATION IMPROVEMENTS

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AUTHORITY

The authority for this report is Section 144 of the Water Resources Development Act of 1976 (Public Law 94-587). Section 144 states:

> The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the State of Hawaii and appropriate units of local government, shall make a study of methods to develop, utilize, and conserve water and land resources in the Hilo Bay Area, Hawaii, and Kailua-Kona, Hawaii. Such study shall include, but not be limited to, consideration of the need for flood protection, appropriate use of flood plain lands, navigation facilities, hydroelectric power generation, regional water supply and wastewater management facilities systems, recreational facilities, enhancement and conservation of water quality, enhancement and conservation of fish and wildlife, other measures for environmental enhancement, and economic and human resources development. Based upon the findings of such study, the Secretary of the Army, acting through the Chief of Engineers, shall prepare a plan for the implementation of such findings which shall be compatible with other comprehensive development plans prepared by local planning agencies and other interested Federal agencies.

PURPOSE AND SCOPE

This report presents a plan for the implementation of the study findings to develop small-craft (commercial fishing) navigation facilities on the island of Hawaii (Figure 1). The investigations described in this report encompass the eastern coast of Hawaii (Figure 2). Investigations were made of the immediate and future regional needs for expansion of small-craft (commercial fishing) navigation facilities; measures or combinations thereof capable of satisfying such needs; the accompanying economic, environmental, and social considerations; and coordination with concerned agencies and the public. These studies provide the depth and detail required to determine plan feasibility.

After review and approval by the Board of Engineers for Rivers and Harbors, the final report of the Chief of Engineers will be forwarded to the Secretary of the Army who will obtain the views of the Office of Management and Budget .

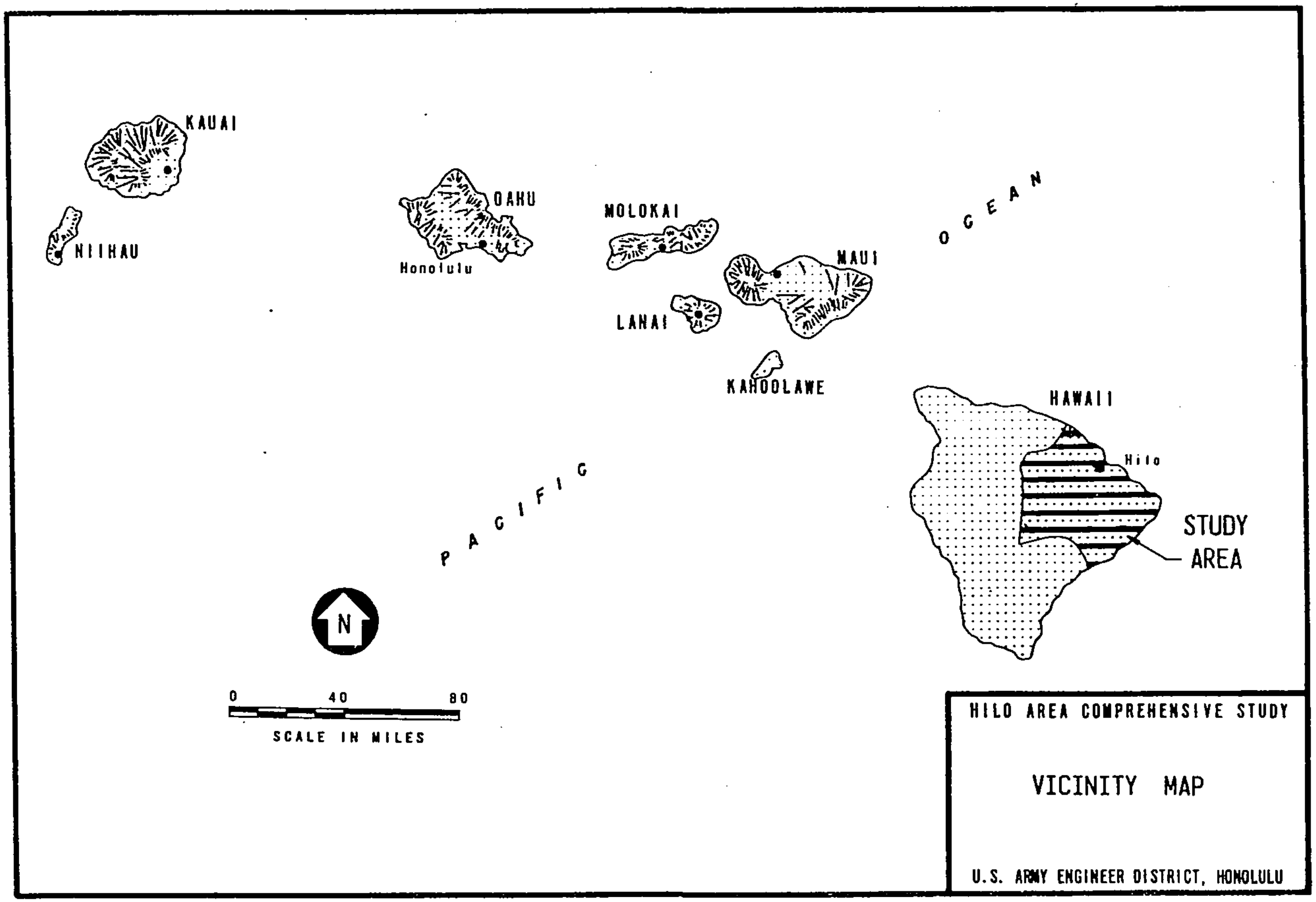
KAUAI
NIIHAU
OAHU
Honolulu
MOLOKAI
LANAI
MAUI
KAHOOLAWE
HAWAII
Hilo
STUDY AREA
PACIFIC OCEAN
N
0
40
80
SCALE IN MILES
HILO AREA COMPREHENSIVE STUDY
VICINITY MAP
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 1

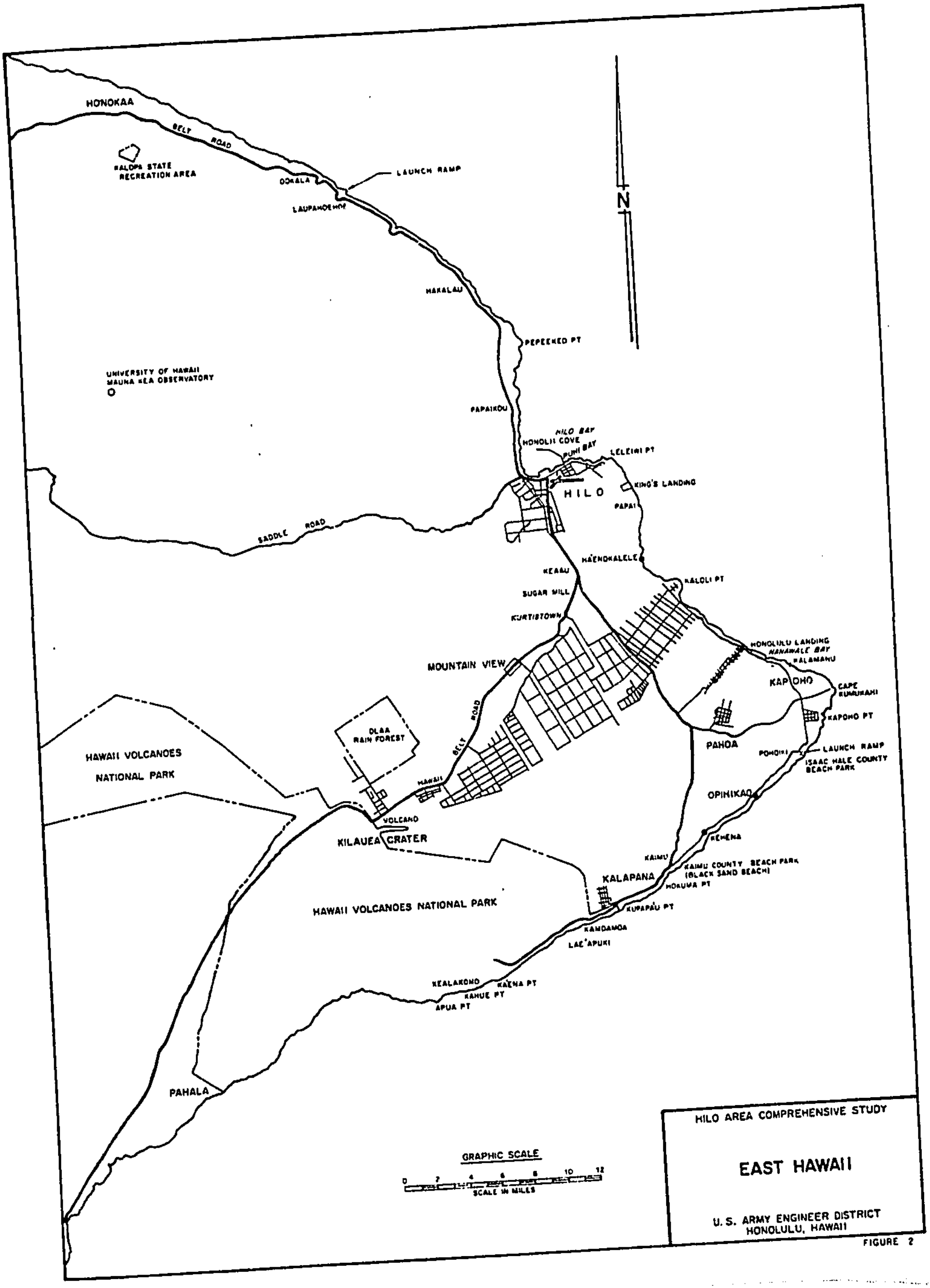
HONOKAA
BELT ROAD
KALOPA STATE RECREATION AREA
LAUNCH RAMP
OOKALA
LAUPAHOEHOE
HAKALAU
PEPEEKEO PT
UNIVERSITY OF HAWAII MAUNA KEA OBSERVATORY
PAPAIKOU
HILO BAY
HONOLII COVE
PUHI BAY
LELEIWI PT
KING'S LANDING
HILO
PAPAI
SADDLE ROAD
HAENOKALELE
KEAAU
SUGAR MILL
KURTISTOWN
KALOLI PT
HONOLULU LANDING
HANAWALE BAY
KALAMANU
MOUNTAIN VIEW
KAPOHO
CAPE KUMUKAHI
KAPOHO PT
OLAA RAIN FOREST
BELT ROAD
HAWAII VOLCANOES NATIONAL PARK
PAHOA
POHOIKI
LAUNCH RAMP
ISAAC HALE COUNTY BEACH PARK
OPIHIKAO
VOLCANO
KILAUEA CRATER
KEHENA
KAIMU
KAIMU COUNTY BEACH PARK (BLACK SAND BEACH)
KALAPANA
HAWAII VOLCANOES NATIONAL PARK
KUPAPAU PT
KAMOAMOA
LAE'APUKI
KEALAKOMO
KAENA PT
KAHUE PT
APUA PT
PAHALA
GRAPHIC SCALE
0 2 4 6 8 10 12
SCALE IN MILES
N
HILO AREA COMPREHENSIVE STUDY
EAST HAWAII
U. S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII

FIGURE 2

and transmit the report to the Congress. If the Congress concurs with the report's findings and authorizes the project, funds will be requested to perform advanced engineering and design work. Construction would be initiated after assurances of local cooperation are furnished.

This report is a decisionmaking document containing an Environmental Impact Statement and supporting documentation including engineering, design and cost; geology; and economics.

PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

A draft Survey Report and Environmental Impact Statement which was circulated for public review in August 1981 tentatively recommended construction of a harbor at King's Landing. This report included alternative sites at Leleiwi Point and at Kalapana. At a public meeting in September 1981, members of the public and commercial fishermen opposed these sites. A workshop was held in February 1982 where commercial fishermen and County of Hawaii and State officials attended. They came to a mutual agreement which recommended that a site at Kumukahi be investigated for feasibility. The results of that investigation are reported here as well as the alternatives previously investigated at Leleiwi and King's Landing. Kalapana has been dropped from further consideration due to its great historic significance and the lack of adjacent land suitable for use to support a commercial fishing industry.

PLAN FORMULATION

EXISTING CONDITIONS

Hilo is the urban, commercial and government center for Hawaii County located on an island of more than 4,000 square miles with a population of some 92,000. Forty-six percent of the population resides in Hilo. It contains one of the County's two major airports and the primary commercial harbor (the third largest in the State).

The basic elements of the economy of Hawaii County are tourism, agriculture, fishing, manufacturing and scientific research, with tourism being the number one industry. Hilo's unemployment rate has remained somewhat higher than the overall unemployment rate for the State. Recently there has been significant growth in commercial fishing which is expected to continue in the foreseeable future.

In east Hawaii, access to the ocean for boaters is especially difficult due to trade wind exposure and the rugged coastline. The needs expressed by the boating public indicate a need for more small-craft berths, harbors of refuge, protected mooring areas for fish offloading and vessel resupplying, and launch ramps for trailered boats. The significant increase in commercial fishing is making the need for facilities to serve those boaters particularly acute. Hilo Bay contains the only all-weather small-craft harbors in east Hawaii. However, depending on the locations of the fish runs, it is often far from the best fishing grounds. Further, due to the lack of land area for major backup facilities, Hilo Bay has limited small-craft facilities and the possibilities for commercial operations expansion are constrained.

FUTURE CONDITIONS (WITHOUT A PROJECT)

Even without additional small-craft facilities, the number of small craft and the demand for wet storage will continue to grow with increased trailering compensating for lack of berths. The commercial fish catch and associated incomes will increase, but the rate of growth will be depressed with the shortage of berths which constrain the boat sizes in the fishing fleet. Rising fuel costs will increase the costs of trailering, further constraining the fleet. There will be losses to the national economy because of an inefficient industry.

PROBLEMS AND OPPORTUNITIES

The Hilo coast has three main problems: (1) a rugged coastline; (2) a trade wind exposure; and (3) an excess demand for harbor facilities due to the rapidly growing commercial fishing industry.

The rugged coastline in east Hawaii affords few natural embayments for small craft facilities or harbors of refuge. Trade wind exposure compounds the problem of locating a safe small-craft harbor in east Hawaii. Hilo Bay and a launch ramp at Ponoiki Bay (located about 30 miles south of Hilo Bay) are currently the only protected facilities in east Hawaii. This situation poses a serious problem should mechanical problems occur. The unexpected increase in commercial fishing has caused a shortage in berthing, refueling, and other related facilities to accommodate present and future needs.

OBJECTIVES

The following objectives were established for the study:

a. Support the needs of commercial and sport fishing along the coastal zone of east Hawaii by providing new and expanded small-craft harbor facilities.

b. Contribute to the overall safety of commercial and recreational boating in east Hawaii by providing refuge facilities for shelter from storms or other emergencies.

CONSTRAINTS

Several constraints were identified prior to formulating alternative plans:

a. The rough coastline of east Hawaii poses a severe constraint as to possible locations for a small-craft harbor.

b. The exposure to the trade winds cause the ocean to be particularly rough on east Hawaii, north of Kumukahi, where the coastline is exposed to north swells.

ALTERNATIVES

AVAILABLE MEASURES

The following measures are available to meet the planning objectives:

Nonstructural

There are no nonstructural measures available to meet the existing and future small-craft harbor facilities requirements for east Hawaii.

Structural

Structural measures applicable to small-craft (commercial fishing) navigation improvements are construction of a new small-boat harbor and new launch ramps with adequate dry storage areas for boats.

a. Small Boat Harbors. The existing small boat harbors in Hilo Bay cannot be expanded due to physical limitations. There are no new sites available in the bay. A suitable site exists at Reed's Bay where a recreational small craft harbor was authorized in 1965. This is the subject of a reevaluation report recommending construction of a 100 berth harbor for recreational boats. In order to accommodate the increasing number and size of the commercial fishing boats, a new small craft harbor, preferably closer to the best fishing grounds, should be constructed.

b. Launch Ramps. Additional launch ramps in lieu of a new small craft harbor were considered in each planning stage. They were not carried forward for final evaluation because of the following reasons:

1. There are no naturally protected sites available where ramps can be inexpensively built.

2. If ramps with special protective works were provided, boats which are too large for trailering (i.e., ±35 feet) could not be accommodated.

3. The need for a calm basin suitable for commercial fishing operations such as loading of fuel, ice, and equipment or unloading of fish would not be met.

DEVELOPMENT OF ALTERNATIVE PLANS

Ultimately, the choice in small-craft plan formulation was limited to the construction of an entire harbor facility. Seventeen sites were identified as having the potential for development of a small-craft facility and are shown on Figure 3.

Table 1 summarizes the 17 sites examined. Fourteen of these were dropped during preliminary evaluation because of various factors. This left only the King's Landing, Leleiwi Point, and Cape Kumukahi sites as viable alternatives for detailed planning and analysis. The Leleiwi Point site is located within a county park; the King's Landing site is on private land; and the Cape Kumukahi site is on State lands. A sensitivity analysis was performed to assist in determining the number of berths (Table 2). This analysis shows that the highest net benefits are achieved with a harbor which provides for the highest anticipated demand (161 berths).

TABLE 2. SENSITIVITY ANALYSIS FOR SIZE OF HARBOR

	NUMBER OF BERTHS		
	67	117	161
FEDERAL	14,000,000	14,000,000	14,000,000
NON-FEDERAL	2,570,000	4,380,000	6,000,000
	16,520,000	18,380,000	20,000,000
AVERAGE ANNUAL COST	1,331,000	1,481,000	1,611,000
AVERAGE ANNUAL BENEFITS	1,200,000	2,100,000	2,800,000
NET BENEFITS	-	619,000	1,189,000

Description of Plans

All three plans are for an inland harbor, requiring blasting and excavation for the entrance channel and basin(s). They are described as follows:

a. Plan A at Leleiwi Point (Figure 4). This plan consists of a total 1,310 feet of wave absorber and dredging entrance and access channels totaling 1,565 feet in length and a 14,000-square-foot turning basin.

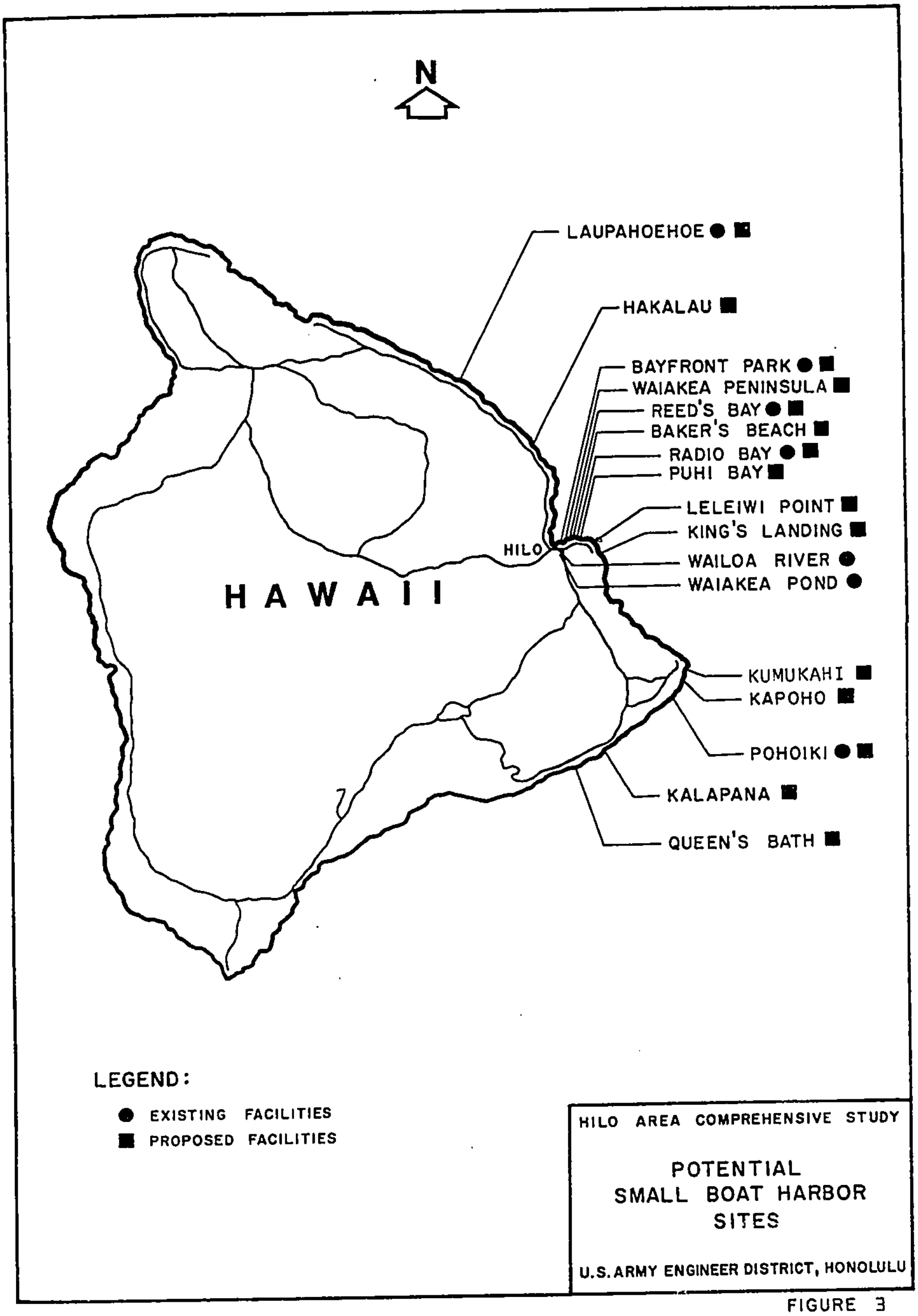
N
HAWAII
HILO
LAUPAHOEHOE
HAKALAU
BAYFRONT PARK
WAIAKEA PENINSULA
REED'S BAY
BAKER'S BEACH
RADIO BAY
PUHI BAY
LELEIWI POINT
KING'S LANDING
WAILOA RIVER
WAIAKEA POND
KUMUKAHI
KAPOHO
POHOIKI
KALAPANA
QUEEN'S BATH
LEGEND:
EXISTING FACILITIES
PROPOSED FACILITIES
HILO AREA COMPREHENSIVE STUDY
POTENTIAL
SMALL BOAT HARBOR
SITES
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 3

TABLE 1. SUMMARY OF NAVIGATION IMPROVEMENT ALTERNATIVES

Site	Existing Facility	Proposed Improvement	Status
Laupahoehoe	1-lane ramp, loading dock.	Protectie breakwater, improved launch ramp.	Detailed Project Report under Small Project Authority in Fiscal Year 1983.
Hakalau	None.	Launching facilities, refuge harbor.	Proposed by Statewide Boat Launching Facilities Master Plan as alternative to Laupahoehoe. No further plans being developed.
Bayfront Park	50-foot wharf at mouth of Wailoa River.	150 berths, 2-lane launch ramp, protective breakwater.	Hawaii County plans to develop a Bayfront Park. Plans for small-craft facilities not continuing.
Waiakea Peninsula	None.	Launching facilities.	The State has constructed a senior citizens park. Plans for launch ramp not continuing.
Reeds Bay	26 sailboat anchor moorings.	Launch ramp, increase berthing spaces to 100, protective breakwater.	Authorized Federal project. Reevaluation Report completed in Fiscal Year 1983.
Baker's Beach	None.	Small-boat harbor.	Dropped from HACS plans. Insufficient backup space.
Radio Bay	11 berths with mooring by anchor in the middle of the bay for 10 crafts.	Launch ramp and more berthing.	Insufficient backup space. State has plan to fill in Radio Bay to provide for more container storage.
Puhi Bay	None.	Launch ramp.	State DOT has dropped plans for construction.
Leleiwi Point	None.	Small-boat harbor, launching facilities.	One of three alternatives presented in this report.
King's Landing	None.	Small-boat harbor, launching facilities.	One of three alternatives presented in this report.
Wailoa River	36 berthing spaces, 2-lane launch ramp, loading ramp.	Increased car and trailer parking, dredge mouth, raise Wailoa Bridge to accommodate vessels with high profiles.	District has recommended emergency dredging of the mouth. State DOT Plans to replace existing bridge with one with same vertical clearance leaving little potential for expansion. No further Corps planning.
Kumukahi	None.	Small-boat harbor, launching facilities.	One of three alternatives presented in this report.
Kapoho	None.	Launch ramp, small-boat harbor.	Local residents oppose any development, alternative has been dropped from HACS plans.
Pohoiki	Federal breakwater, 1-lane launch ramp.	Small-boat harbor.	Potentially severe impacts on archaeological sites. Dropped from further study.
Kalapana	None.	Small-boat harbor.	Dropped from further consideration because of potentially severe impacts on historical sites.
Queens' Bath	None.	Small-boat harbor.	Located adjacent to National Park. Potentially severe impacts on historical sites. Dropped from HACS plans.

b. Plan B at King's Landing (Figure 5). Plan B involves construction of a total 1,755 feet of wave absorber, dredging entrance and access channels totaling 1,430 feet in length and a 14,000-square-foot turning basin.

c. Plan C at Cape Kumukahi (Figure 6). Plan C includes the construction of a wave absorber-turning basin 500 feet long and 600 feet wide (includes 1,750 feet of wave absorber), dredging entrance and access channels totaling 1,100 feet.

SCREENING OF ALTERNATIVES

The three small-craft harbor plans formulated in preliminary planning were carried forward for screening. The plans are identified as follows:

Plan A - Leleiwi Point
Plan B - King's Landing
Plan C - Cape Kumukahi

The cost apportionment for each plan is based on current law and regulations. Revisions in cost apportionment policy are discussed in the section "PLAN IMPLEMENTATION."

Economic benefits at King's Landing and Leleiwi were adjusted as follows to take into account actions differing between the three alternative sites.

Wave Conditions. When waves exceed 6 feet in the ocean near the entrance channels, it is assumed that small craft would not operate. The frequency of wave heights above 6 feet at leleiwi Point and King's Landing exceeds that at Kumukahi. This occurs because Kumukahi, due to its orientation, receives waves directly from the south and southeast while Leleiwi Point and King's Landing receive waves directly from the northwest, north, northeast and east. Waves above 6 feet will affect Leleiwi Point and King's Landing 16 percent and Kumukahi one percent of the year. Since fishing days are affected by wave conditions, the computed benefits must be reduced accordingly. Average annual benefits of $2,800,000, reduced by 16 percent equals $2,352,000 for Leleiwi and King's Landing; they equal $2,772,000 when reduced by one percent for Kumukahi. These adjustments are directly related to the annual average of 285 vessel trips which reflects time off for rest, repairs, or poor fishing conditions.

Recreational Losses at Leleiwi Point. Conversion from park to commercial fishing use at Leleiwi Park would result in a loss of recreation benefits. Presently, there is an average of 8,950 recreational visits per month or 107,400 per year. Classed as general recreation and camping, each visit is valued at $3.50. The average annual value of recreational use (107,400 x $3.50) equals $375,900. Benefits at Leleiwi must be reduced by this amount ($2,352,000 - $375,900) and equal $1,976,100 annually.

PLAN A - LELEIWI POINT

Description. This plan (Figure 4) requires construction of dredging entrance and access channels totaling 1,565 feet, a 1,310-foot wave absorber, a 14,000-square-foot turning basin and a launch ramp. Table 3 shows the summary of project costs of this plan. Table 4 shows the investment cost summary and Table 5 summarizes the costs, charges and benefits.

TABLE 3. PLAN A COSTS ($)

	Project Total	Federal Share	Non-Federal Share
Project First Cost			
Project Construction Cost	$11,197,000	$ 7,342,000 2/	$3,855,000
Engineering, Design, Supervision & Administration (E&D, S&A)	2,091,000	1,324,000	767,000
Total Project First Cost	$13,288,000	$ 8,666,000	$ 4,622,000
Annual Maintenance Cost	$ 17,000 3/	$ 17,000	$ 0

1/ Includes 20% contingencies.

2/ Includes $20,000 for Aids to Navigation by USCG.

3/ Based on 1% armor stone cost; no future dredging required.

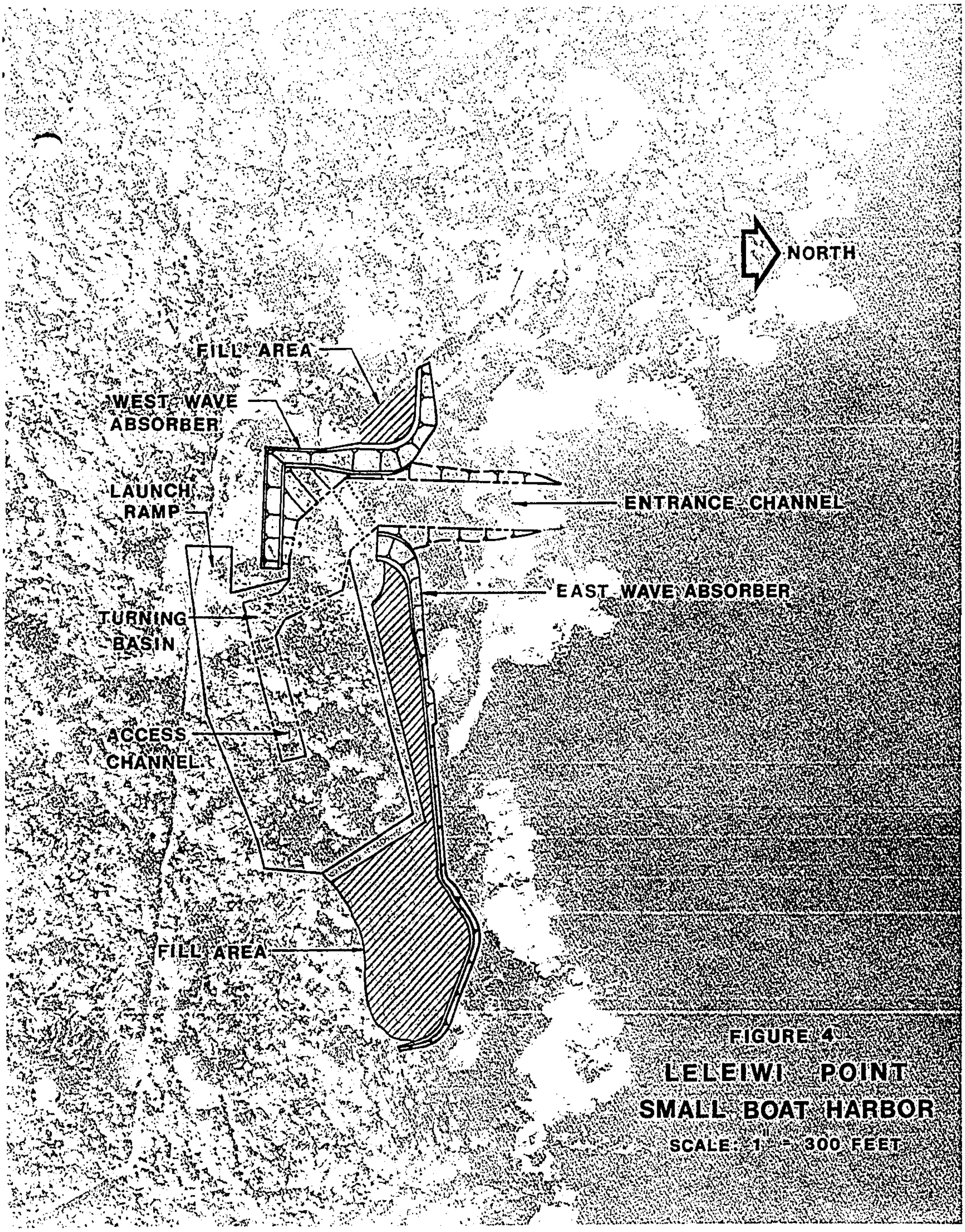

FIGURE 4
LELEIWI POINT
SMALL BOAT HARBOR
SCALE: 1" = 300 FEET

TABLE 4. PLAN A - INVESTMENT COST SUMMARY

Total First Cost	$13,288,000
Interest During Construction	1,057,000[1]
Total Investment Cost	$14,345,000

1/ Based on 7-7/8% interest rate and a 24 month construction period.

TABLE 5. PLAN A - SUMMARY OF COSTS, CHANGES AND BENEFITS

Project Investment	$14,345,000
Annual Charges	
Interest and Amortization on Investment	$ 1,156,000
Operation and Maintenance	17,000
Total Annual Charges	$ 1,173,000
Annual Benefits	$ 1,976,100
Benefit-Cost Ratio	1.7
Net NED Benefits	$ 803,000

Impact Assessment. The project eliminates 43 acres of park land and fills several tidepools which provide protected swimming areas within park lands. The tidepools provide unique local aquatic habitats. A condominium is adjacent to the site and construction noise and traffic will create a significant social nuisance. Harbor operations will induce a traffic increase on Kalanianaole Avenue. The harbor site is located in a tsunami hazard inundation zone with a high volcanic hazard risk area. No endangered or threatened species will be affected.

Mitigation Requirements. The harbor channel and basin will be excavated inland prior to opening the harbor to the sea. Intensive archaeological surveys could be performed prior to project implementation, if necessary.

Implementation Responsibilities. The Corps would provide overall management for implementation and the State and/or County would be responsible for all local requirements.

Cost Allocation. None.

Public Views.

Federal Agencies: The US Fish and Wildlife Service recommended preservation of some of the tidepools because they serve a valuable recreational resource and provide habitat for juvenile reef fish.

Interested Persons: Particularly strong objections have come from residents who do not want added traffic along the access road. Commercial fishermen found this site unacceptable because of its closeness to Hilo and the severe wave conditions.

PLAN B - KING'S LANDING

Description. This plan (Figure 5) requires dredging of entrance and access channels totaling 1,430 feet in length, a 1,755-foot-wide wave absorber, a 14,000-square-foot turning basin and a launch ramp. Table 6 displays the project costs. The investment costs are shown in Table 7 and the project costs, charges and benefits are summarized in Table 8.

TABLE 6. PLAN B
SUMMARY OF PROJECT COSTS

	Project Total	Federal Share	Non-Federal Share
Project First Cost			
Project Construction Cost	$14,089,000 1/	$10,016,000 2/	$ 4,073,000
Engineering, Design, Supervision & Administration (E&D, S&A)	2,081,000	1,479,000	602,000
Total Project First Cost	$16,170,000	$11,495,000	$ 4,675,000
Average Maintenance Cost	$ 27,000 3/	$ 27,000	0

1/ Includes 20% contingencies.

2/ Includes $20,000 for Aids to Navigation by USCG.

3/ Based on 1% Armor Stone cost; no future dredging required.

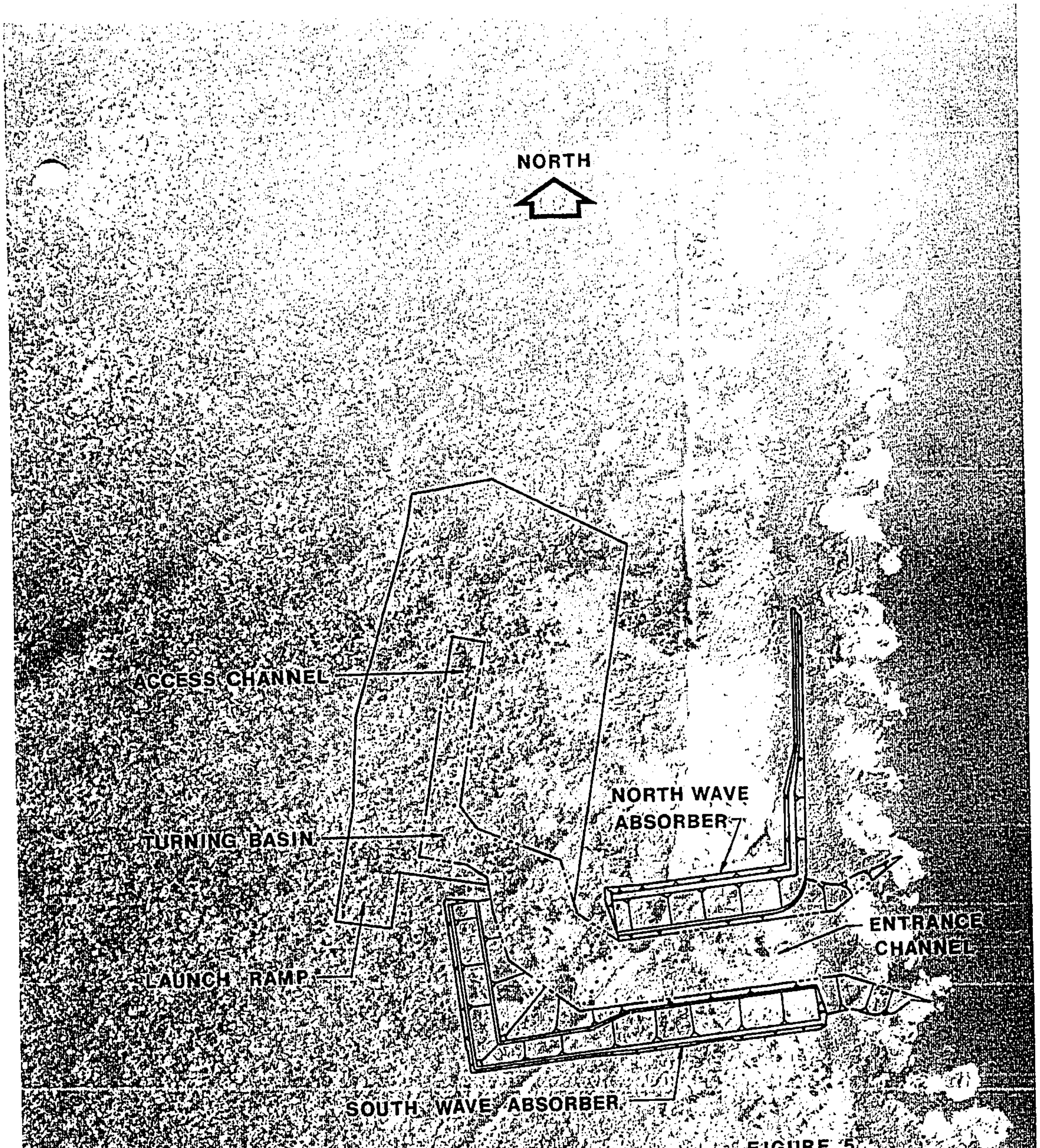

FIGURE 5
KING'S LANDING
SMALL BOAT HARBOR
SCALE: 1" = 300 FEET

TABLE 7. PLAN B - INVESTMENT COST SUMMARY

Total First Cost	$16,170,000
Interest During Construction	1,286,000 1/
Total Investment Cost	$17,456,000

1/ Based on 7-7/8% interest rate and a 24 month construction period.

TABLE 8. PLAN B - SUMMARY OF COSTS, CHANGES AND BENEFITS

Project Investment	$17,456,000
Annual Charges	
Interest and Amortization on Investment	$ 1,406,000 1/
Operation and Maintenance	27,000
Total Annual Charges	$ 1,433,000
Annual Benefits	$ 2,352,000
Benefit-Cost Ratio	1.6
Net NED Benefits	$ 919,000

1/ Interest and Amortization at the rate of 7-7/8% and based on an economic life of 50 years.

Impact Assessment. This plan creates 11 acres of marine habitat at the loss of 11 acres of open, ohia scrub forest, general habitat. An unknown number of anchialine ponds will be filled and destroyed. The harbor would destroy several archaeological sites, including a heiau and midden site which have potential for inclusion to the National Register of Historic Places. And could enhance community development plans in the surrounding areas. No direct effect on human residences is anticipated with construction due to the undeveloped nature of the location. No endangered or threatened species will be affected. The project site is located within a tsunami inundation hazard area and an area of high volcanic hazard risks.

Mitigation Requirements. The channel and basin will be excavated inland before opening the harbor to the ocean. Intensive archaeological surveys would be performed, if necessary, before project implementation.

Implementation Responsibilities. The Corps would provide overall management for implementation and the State and/or County would be responsible for all local requirements.

Cost Allocation. None.

Public Views.

Federal Agencies: No objections.

Non-Federal Agencies: No objections.

Interested Persons: Objections (see text).

PLAN C - CAPE KUMUKAHI

Description. Plan C (Figure 6) includes the construction of an entrance channel 15 feet deep and 150 feet wide, a wave absorber turning basin 14 feet deep and 500 feet long by 600 feet wide, an access channel 12 feet deep and 100 feet wide, a berthing basin 12 feet deep and 700 feet long by 800 feet wide and a launch ramp. Tables 9, 10 and 11 summarize the project costs; investment cost; and the costs, charges and benefits, respectively.

TABLE 9. PLAN C
SUMMARY OF PROJECT COSTS

	Project Total	Federal Share	Non-Federal Share
Project First Cost			
Project Construction Cost	$17,786,000 1/	$11,554,000 2/	$ 6,232,000
Engineering, Design, Supervision & Administration (E&D, S&A)	2,080,000	1,351,000	729,000
Total Project First Cost	$19,866,000	$12,905,000	$ 6,961,000
Average Maintenance Cost	$ 18,000 3/	$ 18,000	$ 0

1/ Includes 20% contingencies.
2/ Includes $20,000 for Aids to Navigation by USCG.
3/ Based on 1% Armor Stone cost; no future dredging required.

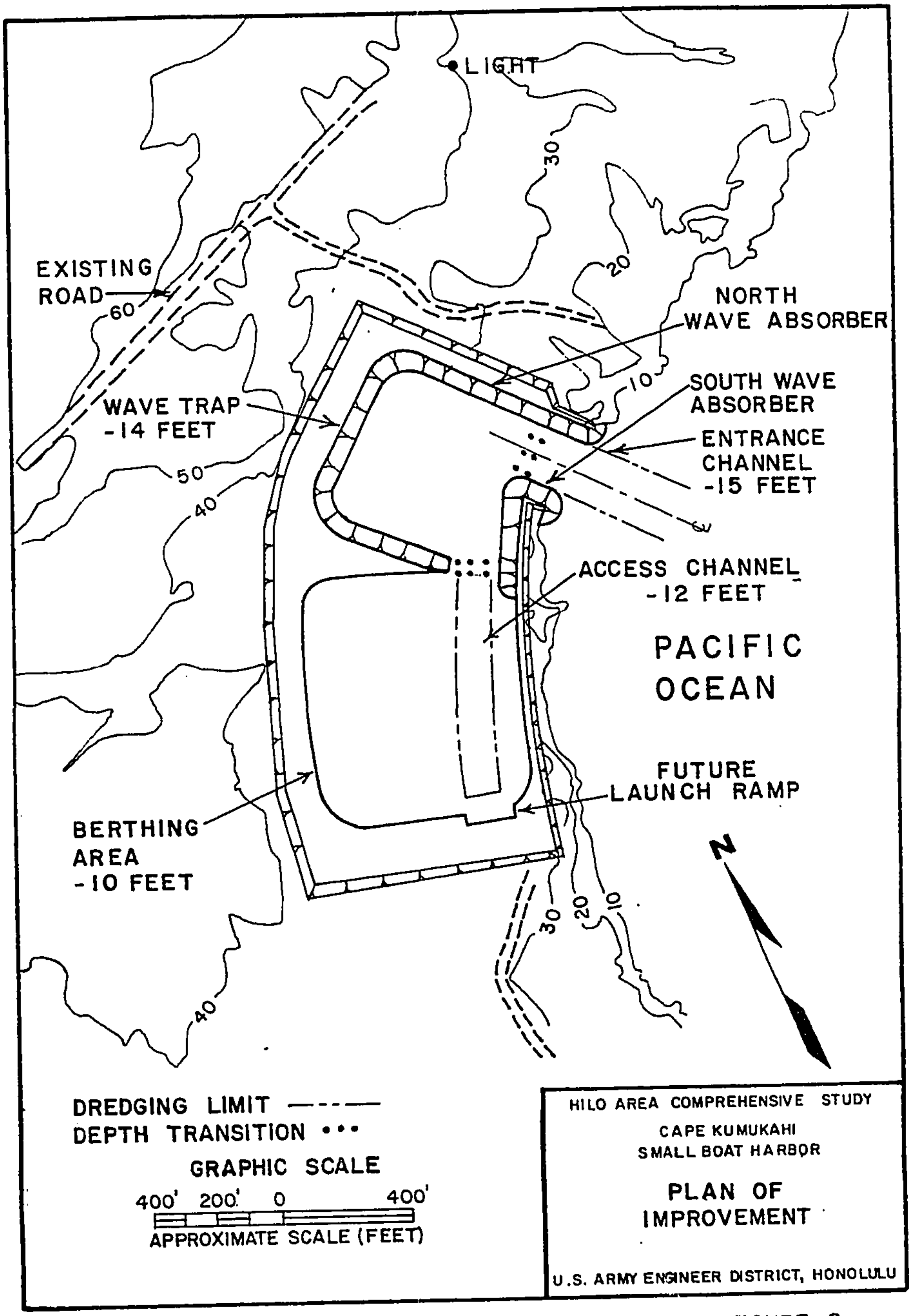
LIGHT
30
20
10
60
50
40
EXISTING ROAD
NORTH WAVE ABSORBER
SOUTH WAVE ABSORBER
WAVE TRAP -14 FEET
ENTRANCE CHANNEL -15 FEET
ACCESS CHANNEL -12 FEET
PACIFIC OCEAN
FUTURE LAUNCH RAMP
BERTHING AREA -10 FEET
N
DREDGING LIMIT
DEPTH TRANSITION
GRAPHIC SCALE
400' 200' 0 400'
APPROXIMATE SCALE (FEET)
HILO AREA COMPREHENSIVE STUDY
CAPE KUMUKAHI SMALL BOAT HARBOR
PLAN OF IMPROVEMENT
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 6

TABLE 10. PLAN C - INVESTMENT COST SUMMARY

Total First Cost	$19,866,000
Interest During Construction	1,580,000 1/
Total Investment Cost	$21,446,000

1/ Based on 7-7/8% interest rate and a 24 month construction period.

TABLE 11. PLAN C - SUMMARY OF COSTS, CHANGES AND BENEFITS

Project Investment	$21,446,000
Annual Charges	
Interest and Amortization on Investment	$ 1,728,000 1/
Operation and Maintenance	18,000
Total Annual Charges	$ 1,746,000
Annual Benefits	$ 2,772,500
Benefit-Cost Ratio	1.6
Net NED Benefits	$ 1,026,000

1/ Interest and Amortization at the rate of 7-7/8% and based on an economic life of 50 years.

Impact Assessment. Construction will have no direct impact on potential historic sites located close to the proposed harbor. The site is located in a tsunami and volcanic hazard area, which encompasses most of the shoreline in this area. Temporary turbidity would occur during construction of the entrance channel.

Mitigation Requirements. None.

Implementation Responsibilities. The Corps would provide overall management for implementation and the State would be responsible for all local requirements.

Cost Allocation. None.

Public Views.

Federal Agencies: No objections.

Non-Federal Agencies: Supported by County and State agencies.

Interested Persons: Supported by commercial fishermen.

EVALUATION OF FINAL PLANS

PLAN A - LELEIWI POINT. This plan would have significant adverse impacts on Keaukaha residents because of increases in traffic on Kalanianaole Avenue. The County's Leleiwi Park would change from a peaceful beach camping area to a busy commercial fishing complex. The northern exposure of this site would make for more frequent rough sea conditions for boats entering or leaving the harbor.

PLAN B - KING'S LANDING. This plan would not adversely affect the Keaukaha residents since a separate access road would be provided from the Volcano Highway. The land is presently unused so that no existing human activities would be disrupted. This site has a northeast exposure which would make for more frequent rough sea condition for boats entering and leaving the harbor.

PLAN C - CAPE KUMUKAHI. There is an existing access road through an unpopulated area. There are no existing uses of the site which would be disrupted by the harbor's construction. The entrance channel is in the lee of Cape Kumukahi and the southeast exposure provides protection under most conditions for boats entering and leaving the harbor.

Costs for construction were estimated at September 1983 price levels. Table 12 shows the summary of costs and benefits for the three plans.

TABLE 12. SUMMARY OF COSTS AND BENEFITS ($)

	Leleiwi Point Plan A	King's Landing Plan B	Cape Kumukahi Plan C
Total First Cost	13,288,000	16,170,000	19,866,000
Federal Share	8,666,000	11,495,000	12,905,000
Non-Federal Share	4,622,000	4,675,000	6,961,000
Investment Cost (TFC + IDC)	14,345,000	17,456,000	21,446,000
Average Annual Cost (Incl O&M)	1,173,000	1,433,000	1,746,000
Average Annual Benefits	1,976,000	2,352,000	2,772,000
Net Annual NED Benefits	803,000	919,000	1,026,000
Benefit-Cost Ratio	1.7	1.6	1.6

RATIONALE FOR DESIGNATION OF THE NED PLAN

Plan C would be the NED plan since it has the highest annual net benefits.

TRADE-OFF ANALYSIS

Plan A (Leleiwi Point) and Plan B (King's Landing) have less net benefits than Plan C (Cape Kumukahi); both Plans A & B were questioned by the public and commercial fishermen at the September 1981 public meeting. A key problem was the wave climate. Plan C evolved from that experience and the site was suggested by commercial fishermen.

At the Cape Kumukahi site (Plan C) backup facilities and commercial fishing support industries would be located above tsunami inundation levels. This is because the harbor would be excavated from approximately +40.0 feet above mean lower low water.

Tables 13 thru 16 display the effects of the with and without project conditions.

PLAN SELECTION

Plan C (Cape Kumukahi) is tentatively selected as the final plan because it fulfills all of the project objectives and is acceptable to the public, government agencies and to commercial fishermen. It has the highest net benefits.

SELECTED PLAN DESCRIPTION

COMPONENTS

The selected plan includes the following components:

a. Entrance channel: 400 feet long, 150 feet wide, and 15 feet deep.
b. Wave absorber turning basin: 500 feet by 600 feet, and 14 feet deep.
c. Access channel: 700 feet long, 100 feet wide and 12 feet deep.
d. Berthing basin: Sufficient area to accommodate 165 berths.
e. Launch ramp: Sufficient area to provide up to a 10 lane launch ramp with adequate backup space.
f. Local interest will:
   (1) provide berths and launch ramps; and
   (2) operate and maintain the small-boat harbor.

KUMUKAHI SMALL CRAFT HARBOR

TABLE 13

EXISTING AND FUTURE CONDITIONS
WITHOUT THE
ALTERNATIVE PLANS

	Existing	Future
DESCRIPTION	East Hawaii has 82 berths or moorages, all in Hilo Bay. These include 54 berths at Wailoa River, 11 berths for transient craft at Radio Bay and unprotected moorages for 16 sailboats at Reeds Bay.	The member of berths would remain the same.
PROBLEMS	The rapid growth of the commercial fishing industry in Hawaii has out-paced existing facilities.	The situation will persist. The potential catch and economic benefits will not be realized.
OPPORTUNITIES	Locate a new facility outside Hilo Bay to serve a dual function for berthing and as a harbor of refuge. Include sufficient back-up space on land for development of supporting industries.	Without the project, local industry will not develop nor will the employment opportunities increase.

KUMUKAHI SMALL CRAFT HARBOR

TABLE 14

ALTERNATIVES WHICH WERE CONSIDERED BUT NOT DEVELOPED INTO PLANS

Measures	Effects	Reason for Not Proceeding Further
New Launch Ramps	No Requirement for Berthing Areas.	Suitable, protected sites unavailable. Larger, more efficient and safer boats could not be accomodated. Harbor of Refuge needs not met. Need for a calm basin to refuel, load ice or unload fish would not be met.
Other Dry Storage such as lift out facilities	Same as the above.	Same as the above.

KUMUKAHI SMALL CRAFT HARBOR

TABLE 15

ALTERNATIVES AND EFFECTS

Measure	EFFECTS	
	NED	Other
Leleiwi Point. This plan consists of a total 1,310-feet of wave absorber and dredging entrance and access channels totaling 1,565 feet in length and a 14,000-square-foot turning basin.	Average Annual Benefits $803,000	Loss of Recreational Park. BCR 1.7
King's Landing. Plan B involves construction of a total 1,755-feet of wave absorber, dredging entrance and access channels totaling 1,430 feet in length and a 14,000-square-foot turning basin.	Average Annual Benefits $919,000	Increase public Access to the Shoreline. BCR 1.6
Cape Kumukahi. Plan C includes the construciton of a wave absorber-turning basin 500 feet long and 600 feet wide (includes 1,750 feet of wave absorber), dredging entrance and access channels totaling 1,100 feet.	Average Annual Benefits $1,026,000 NED PLAN	BCR 1.6

KUMUKAHI SMALL CRAFT HARBOR

TABLE 16

EXISTING OR EXPECTED
FEDERAL AND NONFEDERAL PROJECTS
WHICH MAY AFFECT THE
RECOMMENDED PLAN

Project	Interactions		
	Economic	Environmental	Physical
FEDERAL			
None	None	None	None
NONFEDERAL			
None	None	None	None

The harbor would include road access (Figure 7) for trucks or semitrailers to bring materials, supplies, boats and fuel down to dockside. There would be road access leading directly to the main piers. However, the major support facilities would be located out of the excavated harbor at elevation equal to or greater than +30.0 feet elevation.

DESIGN AND CONSTRUCTION

Design work can be accomplished in less than one year with construction taking approximately 24 months. Construction will require drilling and blasting. Excavated material will be disposed of on vacant land near the site.

OPERATION AND MAINTENANCE

Federal maintenance of the structures lining the entrance and access channels, and wave absorber - turning basin would have an estimated annual cost of $18,000.

Local interest would maintain the berthing area.

ACCOMPLISHMENTS

The proposed plan provides adequate wet storage facilities to meet existing and future needs. It will support the needs of the expanding commercial fishing industry in east Hawaii and will provide a much needed all-weather harbor in east Hawaii in addition to Hilo Bay.

The proposed small-boat harbor will also reduce the amount of damage now experienced due to lack of adequate and safe facilities.

SUMMARY OF ECONOMIC, ENVIRONMENTAL, AND OTHER SOCIAL EFFECTS

Selected Plan (Plan C)

Economics

Total Investment Cost	$21,446,000
Annual Maintenance	18,000
Benefit-Cost Ratio	1.6

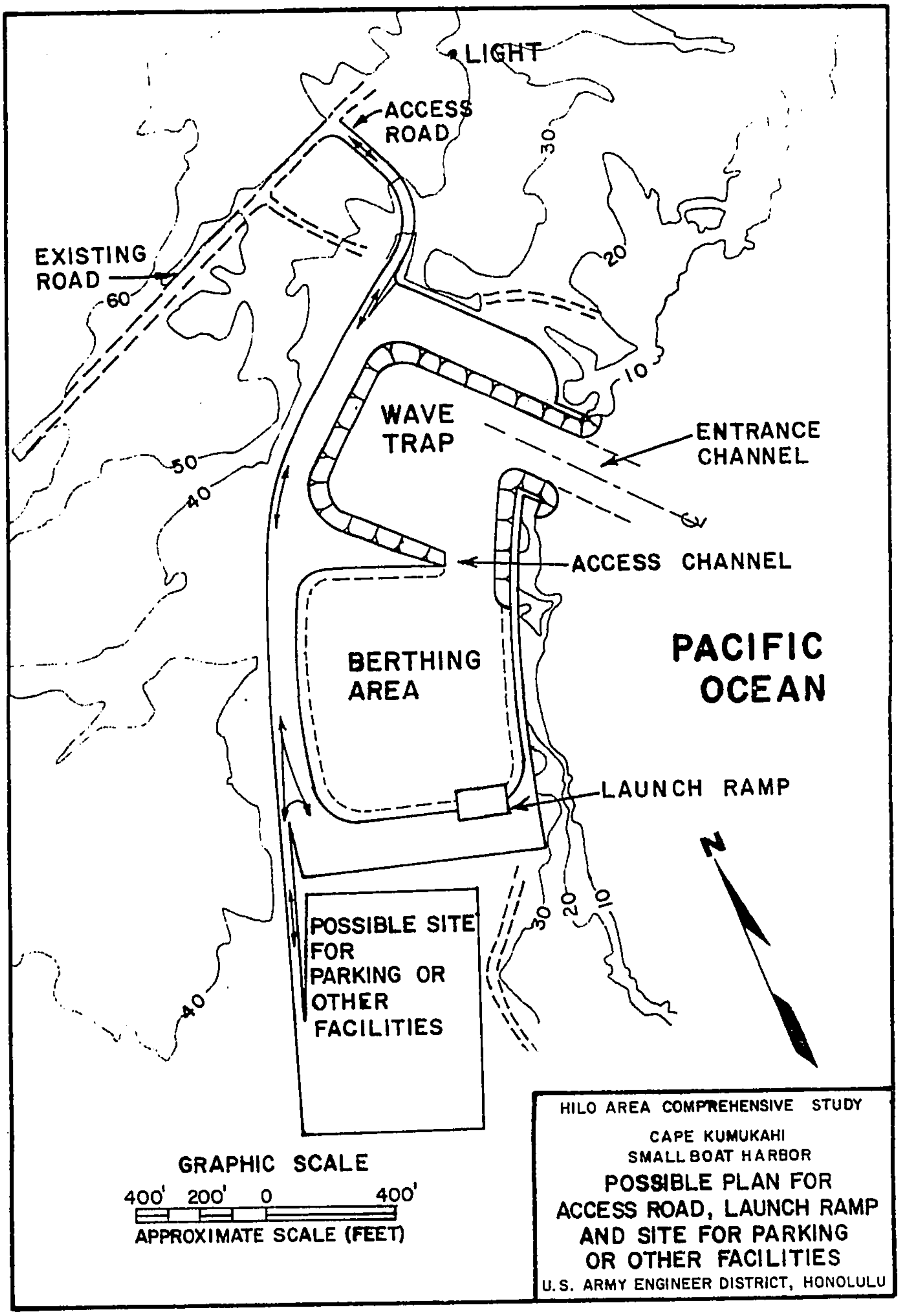
LIGHT
ACCESS ROAD
EXISTING ROAD
60
30
20
10
50
40
WAVE TRAP
ENTRANCE CHANNEL
ACCESS CHANNEL
BERTHING AREA
PACIFIC OCEAN
LAUNCH RAMP
N
POSSIBLE SITE FOR PARKING OR OTHER FACILITIES
30
20
10
40
GRAPHIC SCALE
400' 200' 0 400'
APPROXIMATE SCALE (FEET)
HILO AREA COMPREHENSIVE STUDY
CAPE KUMUKAHI
SMALL BOAT HARBOR
POSSIBLE PLAN FOR
ACCESS ROAD, LAUNCH RAMP
AND SITE FOR PARKING
OR OTHER FACILITIES
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 7

Environment

- Temporary turbidity during construction of the entrance channel.
- No significant long-term effects or changes.

The proposed project at Cape Kumukahi is not expected to have a significant adverse impact on any endangered or threatened species. No terrestrial species are known to inhabit the project area. Although the Green Turtle is known to feed along the Puna coast, no aggregations are known from the project area, nor were turtles seen during surveys of the area by U.S. Fish and Wildlife and Corps biologists. Prior to any blasting in ocean waters, the National Marine Fisheries Services will assist the Corps to ensure that no endangered or threatened species are adversely impacted.

IMPLEMENTATION

INSTITUTIONAL REQUIREMENTS

Following authorization by Congress, the Honolulu Engineer District would perform first preconstruction engineering and design work. The District would administer construction. The Harbors Division, Department of Transportation, State of Hawaii is the local sponsor and responsible administrator for operation of the proposed Kumukahi Small-Boat Harbor.

FEDERAL AND NON-FEDERAL RESPONSIBILITIES

Under current regulations, the local share of the project requires dredging (estimated cost of $6,961,000) of the berthing area. The Federal government would be responsible for construction of the project and providing funds for the entrance and access channels, wave absorber-turning basin and for the wave absorber lining these components. The Federal share of the total investment cost is $14,485,000.

SUMMARY OF COORDINATION, PUBLIC VIEWS AND COMMENTS

A draft report and environmental impact statement were issued for public review in summer 1981 covering Kings Landing, Leleiwi Park and other sites. At a public meeting held in Hilo in September 1981, fishermen felt that a site less exposed to the north would be a better choice. In February 1983, fishermen and government representatives agreed to look at Kumukahi because of it's southern exposure.

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

PROPOSED PLAN FOR SMALL CRAFT NAVIGATION IMPROVEMENTS

HILO AREA COMPREHENSIVE STUDY, HILO, HAWAII

The responsible local cooperating agency is the State of Hawaii, Department of Transportation.

The responsible lead Federal agency is the US Army Engineer District, Honolulu.

The US Fish and Wildlife Service is a cooperating Federal agency.

Information, displays and figures referred to in the Main Report and Appendices are incorporated as a part of this Environmental Impact Statement.

Abstract: The study to provide a small boat harbor to serve commercial fishing interests on the eastern side of the island of Hawaii, focused on siting the harbor at one of three locations, Cape Kumukahi, King's Landing and Leleiwi Point. The Cape Kumukahi site is located on State and Federal land, and is designated for conservation use. It is part of the 1960 lava flow. The King's Landing site was located on private, undeveloped land. The site at King's landing encompassed anchialine pools, archaeological sites and involves construction in a wetland. The Leleiwi Point site is planned for park use and the tide pools at the site provide a unique recreational resource. Cape Kumukahi was designated the tentatively selected plan; however, some archaeological sites are located in the study area, including eight historic grave sites.

SEND YOUR COMMENTS TO THE DISTRICT ENGINEER BY:

If you would like further information on this environmental impact statement please contact:

Dr. James Maragos, Chief
Environmental Resources Section
U.S. Army Engineer District, Honolulu
Building T-1
Fort Shafter, HI 96858
Phone: (808) 438-2263

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1. SUMMARY:

1.1 Major Conclusions and Findings: The Small Craft Navigation Improvements Study found that a potential site could be developed at Cape Kumukahi to provide facilities for commercial fishing vessels. The tentatively recommended plan is Plan C, which would provide a 120-boat harbor. The discharge of rock in wave absorber construction is specified in the Section 404(b)(1) guidelines evaluation (Appendix A). Construction at the Kumukahi site will have no direct impact on historic resources that are listed on or are eligible for inclusion to the National Register of Historic Places. Historic period grave sites have been located within the proposed harbor area. If human burials are still present, they would be relocated in advance of project construction. The site is located in a tsunami and volcanic hazard area. The US Fish and Wildlife Service has indicated a preference for Plan C and has indicated that the impacts from that plan will be minimal. Construction of that plan will not jeopardize the continued existence of the endangered humpback whale or hawksbill turtle, or the threatened green sea turtle. No ocean dumping or prime agricultural lands are involved.

1.2 Areas of Controversy: None.

1.3 Unresolved Issues: Use and historic significance of grave sites and other historic sites.

1.4 Relationship to Environmental Requirements: See Table 1.

1.5 Adoption of an EIS: Not applicable.

TABLE 1. RELATIONSHIP TO ENVIRONMENTAL REQUIREMENTS.

	Cape Kumukahi	King's Landing	Leleiwi Point
Federal Statutes			
Archaeological and Historic Preservation Act (see Section 6)	Partial	Partial	Partial
Clean Air Act	Full	Full	Full
Clean Water Act (see Section 6)	Partial	Partial	Partial
Coastal Zone Management Act (see Section 6)	Partial	Partial	Partial
Endangered Species Act (see Section 6)	Partial	Partial	Partial
Estuaries Protection Act	N/A	N/A	N/A
Federal Water Project Recreation Act (see Section 6)	Partial	Partial	Partial
Fish and Wildlife Coordination Act (see Section 6)	Partial	Partial	Partial
Land and Water Conservation Fund Act	N/A	N/A	N/A
Marine Protection, Research and Sanctuaries Act	N/A	N/A	N/A
National Historic Preservation Act (see Section 6)	Partial	Partial	Partial
National Environment Policy Act Partial (see Section 6)	Partial	Partial	Partial
Rivers and Harbors Act	N/A	N/A	N/A
Watershed Protection and Flood Prevention Act	N/A	N/A	N/A
Wild and Scenic Rivers Act	N/A	N/A	N/A
Executive Orders, Memoranda, Etc.			
Floodplain Management (E.O. 11988)	N/A	N/A	N/A
Protection of Wetlands (E.O. 11990)	N/A	Full	N/A
Environmental Effects Abroad of Major Federal Actions (E.O. 12114)	N/A	N/A	N/A
Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum)	N/A	N/A	N/A

TABLE 1. RELATIONSHIP TO ENVIRONMENTAL REQUIREMENTS (Cont)

State and Local Policies.	Cape Kumukahi	King's Landing	Leleiwi Point
State Land Use Plan	N/A	Full	Full
County General Plan (see Section 5.3)	N/A	Partial	Partial
State Environmental Policy Act (see Section 6)	Partial	Partial	Partial
Special Management Area Permit	Partial	Partial	Partial
Coastal Zone Management Program (see Section 6)	Partial	Partial	Partial
Conservation District Use Area Permit	Partial	Partial	Partial
Federal Coastal Zone Consistency Determination (see Section 6)	Partial	Partial	Partial

Notes:

Full - Full compliance, having met all requirements of the statute, E.O. or other environmental requirements for the current stage of planning (either pre- or post-authorization).

Partial - Partial compliance, not having met some of the requirements that normally are met in the current stage of planning.

NC - Non-Compliance, Violation of a requirement of the statute, E.O. or other environmental requirement.

N/A - Not-Applicable, no requirements for the statute, E.O. or other environmental requirement for the current stage of planning.

2. Need for and Objectives of the Action:

2.1 Study Authority: The study of small craft navigation needs in the Hilo Area was performed under Section 144 of the Water Resources Development Act of 1976, which authorized the Corps of Engineers in cooperation with the State of Hawaii and County of Hawaii to study methods to develop, utilize and conserve water and land resources in the Hilo Bay area including the consideration of the need for navigation facilities, enhancement and conservation of water quality, enhancement and conservation of fish and wildlife, and other measures for environmental enhancement and economic and human resources development. The Corps of Engineers has studied the need for small craft navigation at the request of and in cooperation with the State of Hawaii, Department of Transportation, Harbors Division.

2.2 Public Concerns: The public has expressed the need for: (a) small craft facilities, (b) launch ramps and harbors to increase navigation safety along the Puna Coast, (c) boat haul-out and maintenance facilities, (d) fish processing and marine stores and other support facilities, (e) reducing travel time from Hilo to the Puna fishing grounds, by locating the facility near the fishing grounds. The only opposition to these needs was at a public meeting in Pahoa, where residents of Kapoho objected to the siting of a harbor in their community. Subsequently, the Kapoho Bay site was dropped due principally to the lack of support from the landowners.

2.3 Planning Considerations: The following opportunities for small craft navigation improvements were derived from the consideration of public concerns, and management needs expressed during public and agency coordination of the project.

a. Provide appropriate facilities to meet the needs of commercial fishermen and recreational boaters who use 30- to 40-foot power or sailing craft.

b. Locate new facilities so that small craft have less distance to travel to launch or to take refuge in case of emergency.

c. Improve commercial fishing opportunities.

d. Minimize environmental modifications to terrestrial and marine environments.

e. Minimize potential natural hazard damages or losses.

f. Protect significant archaeological and historic sites.

g. Improve socio-economic opportunities for the people of East Hawaii.

h. Increase or maintain recreational diversity.

3. <u>Alternatives, Including the Proposed Action</u>:

3.1 <u>Plans Eliminated from Further Study</u>:

(1) The study included the districts of South Hilo and Puna within the Hilo Area Comprehensive Study. The search for possible harbor sites covered the entire coastline from Hilo to Kalapana. Sites selected for closer inspection were chosen based upon geological features that offered natural protection along the shoreline, the availability of land at low costs, i.e., public lands or lands where landowners expressed interest in supporting a harbor, and a preliminary estimate on construction costs. Based on this evaluation, Kapoho and Pohoiki sites were eliminated from further study. Kapoho was a sheltered embayment which had a relatively large community along the shoreline. At a public meeting residents and the principal landowner objected to the construction of the harbor at the site. Since the land was privately owned, further investigations of the site were terminated due to lack of landowner support. Pohoiki, the site of the Pohoiki launch ramp, was considered because the area appeared to offer the opportunity of constructing the harbor using breakwaters with a minimum of inland excavation. However, the water depth forced the siting of a breakwater near shore with extensive inland excavation. Since the harbor would also destroy a surfing site, a plan to construct the harbor entirely by excavation from the shoreline was evaluated. Due to the topography, the harbor would have had to be excavated from lava rock raising to a height of 20-35 feet above sea level. The large amount of rock that would have to be removed in order to build the harbor

would have resulted in extremely high construction costs. Thus, the site was eliminated from further consideration. Leleiwi Point and Kings Landing were also considered as possible harbor sites. Commercial fishermen objected to those sites because of the high energy waves at both sites, and because both were quite close to Hilo and would not have a significant location advantage over the existing Suisan harbor. Additionally, both sites would require extensive terrestrial excavation, resulting in high construction costs.

(2) Launching Ramps: The construction of boat launching ramps in the Puna and South and North Hilo Districts is being studied under small project authorities, and is not a part of this draft environmental impact statement. Boat launching ramps are incorporated into the harbor design; however, boat launching ramps as an alternative to the harbor did not meet the projected need for wet storage of 30- to 40-foot craft, for protected anchorage and for the growth of commercial fishing in the project area. The launch ramp would satisfy only part of the project objectives and does not provide for larger ($\pm$35 feet) vessels which cannot be trailered.

(3) Dry Storage: This alternative consisted of providing a large land area to store boats and a shoreside dock crane or launch ramp to place the boats in the water. Operation of dry storage could not handle the 30- to 40-foot design fishing vessels, but could more appropriately accommodate smaller recreational craft.

3.2 Without Conditions:

(1) Presently, only the launch ramps and harbor in Wailoa River, on Hilo Bay and the Pohoiki launch ramp are available to serve commercial fishing interests within the study area. The State of Hawaii has no plans to provide any other launch ramp or harbor facility within the region outside of Hilo Harbor. Approximately 72 miles from Hilo at Kaulana, South Point, a project of the Corps of Engineers has been approved to provide improvements to the ramp and a protective breakwater. A private ramp is also located at Punaluu in the Kau District, approximately 46 miles from Hilo. Although both ramps are located outside the study area, they are available for use to fishermen in

the South Hilo and Puna Districts willing to drive the distance. Navigational safety along the Puna coast will continue to be treacherous due to weather conditions and to the lack of harbors of refuge or other harbor facilities which could offer haven for boats operating in Puna waters.

(2) The potential harbor sites are located within rural areas dependent upon agriculture and upon employment in Hilo. Agriculture is expected to remain the mainstay of the Puna economy supplemented by various employment opportunities in Hilo. Resort development is nonexistent at present, but areas around Kaimu-Kalapana, Pohoiki and King's Landing have long been zoned for urban and resort development. Such development could occur depending upon economic conditions which would favor investment, although resort development in Puna has been opposed by local residents. Resort development and population increases could trigger or be triggered by an increase in development of recreational facilities in the region. In spite of the possible growth in agriculture and increase in population due to recreational, urban and resort expansion, economic and population growth was previously expected to be slow in comparison with the rest of the County (Hawaii Water Resources Regional Study, 1975). However, population growth between 1970 and 1980 showed a remarkable increase of 128% (5,154 to 11,751), the second highest in the county. Most of this growth occurred 15-20 road miles from the Cape Kumukahi area.

Water, power and other utility demands, and traffic flow between Hilo and Kalapana will increase with population growth. The Puna Coast Highway connecting Hilo to Kapoho could be constructed in the long-term future, speeding the flow of traffic in the area and possibly inducing accelerated agricultural and urban development in the region. Water resources are sufficient to support increased demands, and planned development of geothermal power will be able to satisfy future electrical demands. Tsunami and volcanic hazards in the region will continue to be significant factors influencing land use and the coastal environment in the region. Shoreline development in the region will contribute to an increase in potential tsunami and volcanic hazard losses and damages. While natural hazards may be the most significant factors affecting future environmental conditions, urban and agricultural development will also be factors affecting the coastal environment. Urbanization can contribute to increased exploitation of natural resources by improving access to areas previously inaccessible and by increasing the number of persons in the area that can exploit the resources. Hawaii's resources are sensitive to heavy exploitation; however, if the rugged nature of the coastal area remains the same, hazardous shoreline and water conditions will probably discourage many from utilizing the coastal areas.

3.3 Plans Considered in Detail:

(1) Plan A - Leleiwi Point - Requires construction by dredging of entrance and access channels totaling 1,565 feet, a 1,310-foot wave absorber, a 14,000-square-foot turning basin and a launch ramp. Construction of the harbor at this location would require the use of 43 acres of land zoned for park development and will eliminate the use of the tide pools in the park. Water, power, sewer and road utilities are in place. The site is located outside Hilo Harbor and will reduce travel time around the Hilo Breakwater, but the site is the farthest site from the Puna fishing grounds. The site is adjacent to a residential area and the construction noise and dust impacts would create a nuisance. Construction dust and noise controls would have to be implemented to reduce public inconveniences, and the alignment of the harbor and discharge of excavated material will have to be altered to protect the tide pools. An intensive archaeological survey of the Leleiwi Point area may be necessary to determine the significance of the midden site.

(2) Plan B - King's Landing - This plan requires dredging of entrance and access channels totaling 1,430 feet in length, a 1,755-foot-wide wave absorber, a 14,000-square-foot turning basin and a launch ramp. This plan creates 11 acres of marine habitat at the loss of 11 acres of open, ohia scrub forest, general habitat. The site is in a wetland and will essentially destroy the 12-acre wetland; the wetland probably does not provide important beneficial values and is part of the general wildlife habitat in the area. The harbor would destroy several archaeological sites, including a heiau and midden site which have potential for inclusion to the National Register of Historic Places, and would possibly eliminate some anchialine pools in the area. Construction would require action to salvage any archaeological data. This site is also far from the Puna fishing grounds.

(3) Plan C - Cape Kumukahi - Plan 3 includes the construction of an entrance channel 15 feet deep and 150 feet wide, a wave absorber basin 15 feet deep and 400 feet long by 600 feet wide, an access channel 12 feet deep and 150 feet wide, a berthing basin 12 feet deep and 700 feet long by 800 feet wide and a launch ramp. Construction will directly impact a cluster of historical period grave sites located within the wave-trap basin. Relocation of grave sites is needed, depending on whether or not they contain burial remains. Several other archaeological resources may be affected by the project. An archaeological survey and possible salvage will also be undertaken prior to construction. Plan C is the closest to the Puna fishing grounds. Plan C is the tentatively recommended plan, and there is no nonstructural plan available to fulfill the project purpose and needs.

(4) Endangered Species: None of the plans are expected to jeopardize the continued existence of the endangered humpback whale, the endangered hawksbill turtle or the threatened green sea turtle. Coordination with the US Fish Wildlife Service and the National Marine Fisheries Service has been initiated in accordance with the Endangered Species Act of 1973.

3.4 Comparative Impacts of Alternatives: A comparison of alternative impacts is provided on Table 2.

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES

Significant Resources	Leleiwi Point	King's Landing	Cape Kumukahi
Construction			
Federal Cost	8,666,000	11,495,000	12,905,000
Local Cost	4,622,000	4,675,000	6,961,000
Amount of rock excavated	212,000 CY	225,000 CY	1,670,000 CY
Population			
Base Condition	No residents on-site. Condominium adjoining property; area suburb of Hilo. Quiet rural area. No commercial or industrial activity.	No residents present. Quiet rural area. No commercial, industrial or residential activities at either site.	
Effect			
Noise, dust	Construction noise and dust will create a significant nuisance to the residents.	Construction noise and dust judged to be not significant due to lack of residents.	
Traffic	Road present. Commercial traffic volume will increase.	New road to be provided. Commercial traffic volume will increase.	Road present. Commercial traffic volume will increase.
Odors	Long-term effect possible dependent upon type of facilities constructed to support commercial fishing harbor.		
Landownership			
Base Condition	Public lands, unrestricted access.	Private lands, restricted access.	Public lands, unrestricted access.
Effect	No effect	150 acres, private land converted to public; public access improved.	Federal land necessary for the project and associated activities would be transferred to the State of Hawaii.

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Cont)

Significant Resources	Leleiwi Point	King's Landing	Cape Kumukahi
Land Use			
Base Condition	43 acres to be developed as Lehia Park. Zoned conservation; open space	2,000+ acres of private land. Urban & resort zoning. Shoreline zoned for space.	The land is vacant lava flow, except for the Coast Guard lighthouse.
Effect	43 acres of park land dedicated to harbor use. No zoning change.	150 acres of urban conservation and resort land converted to harbor use. No zoning change.	Change lava fields to boat harbor, w/ no effect to lighthouse.
Recreation			
Base Condition	43 acre park with protected tide pools used for swimming. Shorefishing and possibly opihi picking.	Project site represents relatively pristine coastal environment offering picnicking, fishing and opihi gathering. Because of the rough wave action, the area is not often used for other types of recreation.	
Effect	Harbor will fill several tide pools which provide protected swimming. But, it will increase recreational boating & commercial fishing. Shoreline fishing will not be obstructed.	Harbor will increase opportunity for recreational boating, as well as commercial fishing. Shoreline fishing will not be obstructed, and additional marine habitat provided by harbor will provide more easy access for fishermen.	
Water			
Base Condition	Serviced by a 8" water line extending from Hilo City.	No system present at the site.	
Effect	Present system capable of handling harbor use, just extend lines to harbor site.	Increased water demands anticipated for all project sites, however, the quantity is unknown. Resources adequate to meet demands, but will have to be developed.	

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Cont)

Significant Resources	Leleiwi Point	King's Landing	Cape Kumukahi
Power			
Base Condition	Power transmission lines from Shipman Power Plant in Hilo. Is at end of Kalanianaole Ave.	No power distribution system exists.	Transmission line at Coast Guard lighthouse at edge of project area.
Effect	Increased power demands for all sites; quanity unknown.		
	Extend lines to harbor.	Extend lines to harbor site or develop individual power producing capability.	
Sewer			
Base Condition	Sewerline at end of Kalanianaole Highway.	No system present.	No system present.
Effect	Extend sewerline to harbor site.	Sewerline or other method of waste disposal must be provided as well as "pump out" facilities for the vessels.	
Roads			
Base Condition	Kalanianaole Ave.	Private, gravel road.	Cinder road from the Kapoho Highway to the lighthouse.
Effect	Access/Egress provided.	New all weather public access road must be constructed.	
Historic Resources			
Base Condition	Possible midden site.	Midden site, Piko stone both potentially eligible to National Register Historic Places.	A fishing shrine, a small petroglyph field, and 8 historic period grave sites are located in the study area.
Effect	Potential midden site excavated.	Midden site buried. Piko stone relocated.	No specific effect can be determined until the detailed archaeological survey is performed, however, no significant adverse impacts are anticipated.

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Cont)

Significant Resources	Leleiwi Point	King's Landing	Cape Kumukahi
NATURAL HAZARDS			
Tsunami			
Base Condition	Harbor site within 100-year Tsunami Inundation Zone.		The seaward edge of the harbor site is in the 100-year Tsunami Inundation Zone.
Effect	The presence of the harbor increases potential tsunami damages and losses. The harbor is not expected to increase flood elevations inland.		
Volcanic Hazards			
Base Condition	Hazard Zone E, high risk from lava flows; subject to earthquakes possible subsidence.		Hazard Zone F, very high risk from lava flow, earthquakes and subsidence.
Effect	Presence of harbor increases potential damages and losses from volcanic activity.		
Water Quality			
Base Condition	No riverine systems located in the study area. Groundwater leakage probably influences nearshore salinity slightly at all locations. No wastewater discharges.		
Effect Temporary	Water turbidity will increase when dredging entrance channel opening (each location has a different amount of time).		
Long Term	Boating operations and handling of fish will introduce petrochemicals, organic and other pollutants, and common garbage into the harbor and subsequently into the ocean. Groundwater leakage creates estuarine conditions in the harbor and increases nutrient level.		
Groundwater Impacts			
Base Condition	Groundwater fed by rainwater percolating through the volcanic rock. Chlorinity high in the area. No drinking water sources present. Leakage occurs along the shoreline.		
Effect	No effect on drinking water sources at any of the sites. Groundwater leakage into the harbor basin will create an estuary and carry organic nutrients into the harbor.		

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Cont)

Significant Resources	Leleiwi Point	King's Landing	Cape Kumukahi
Air Quality			
Base Condition	No industrial or commercial pollution sources at sites. Volcano, agricultural fires and automotive emissions are primary air pollutants.		
Effect	Increase in automotive type emissions at the harbor location. Potential fish odor and other pollutants with harbor development.		
FISH AND WILDLIFE HABITAT			
Terrestrial			
Base Condition	43 acres Ironwood and Kamani tree.	2,000+ acres Naupaka coastal strand and ohia scrub forest 12-acres; wetland present. No important beneficial values.	5% old lava flow, sparsely vegetated with no important flora or fauna. Remainder new flow (1960) essentially unvegetated.
Effect	43 acres of ironwood and Kamani trees converted to marine habitat.	150 acres Naupaka and ohia scrub forest and 12-acres wetland converted to marine habitat.	Convert 20± acres of terrestrial habitat to estuarine/marine habitat.
Marine			
Base Condition	No coral reef, but 10% coral cover. Tide pools.	No coral reef, but 10% coral cover. Anchialine pools.	Relatively pristine marine coastal environment, with large numbers of fish, healthy coral and other invertebrates.
Effect	Tide pools destroyed.	Some anchialine pools filled.	Little or no dredging required in the ocean.
	Temporary increase in turbidity during dredging of mouth of entrance channel. Boating operations will introduce petrochemicals and other pollutants into the marine environment. Fishing activities will introduce fish blood and other biological pollutants into the harbor and hence into the marine environment.		

TABLE 2. COMPARISON OF IMPACTS OF THE ALTERNATIVES (Cont)

Significant Resources	Leleiwi Point	King's Landing	Cape Kumukahi
Wetland Values			
Base	None	12 acres, general wildlife habitat.	None
Effect	None.	Lost 12 acres of general wildlife habitat.	None.
Endangered Species			
Base Condition	Humpback whales seasonally migrate through waters around Hawaii. None of the sites were identified as a calving, nursing or breeding grounds. Endangered hawksbill and threatened green sea turtles feed along the coastline.		
Effect	Harbors are not expected to jeopardize the continued existence of the endangered and threatened species.		

4. AFFECTED ENVIRONMENT:

4.1 Environmental Conditions:

(1) Plan A - Leleiwi Point: Leleiwi Point is located 6 miles east of Hilo at the end of Kalanianaole Highway within the undeveloped Lehia Park. The area is considered a suburb of Hilo in this report. The project site is located in a low-lying section of the coast fronted by a large, boulder tract and sand pockets vegetated by ironwood trees, kamani trees, hau and beach grass. While no persons live in the park, a condominium is located on private lands adjacent to the park. The park attracts island residents and visitors. The upland areas are also comprised of old pahoehoe flows vegetated by scrub ohia. Utility services along Kalanianaole Avenue are available to service the area when the park is developed. The park area is subject to tsunami and high wave inundation due to its depressed topographic relief. The volcanic hazards in the Leleiwi Point area are similar to those in the King's Landing area.

(2) Plan B - King's Landing: King's Landing is located about 8 miles east of Hilo and one must pass through the Leileiwi Point site to get to King's Landing. The project site is located on private land, and public

access is restricted. The shoreline area is zoned for open space, but the upland area is zoned for mixed urban and resort development. The area is undeveloped except for single lane access road and three beach parks constructed by the landowner. The land consists of pahoehoe lava flows heavily vegetated by scrub ohia, ohelo berry, aalii, ferns and pandanus, and is moderately sloped (0-6% slope) although the ground is very irregular due to collapsed lava tubes and lava ridges and depressions. The old flows create a cliff shoreline and the wave and spray swept rocks are unvegetated. Large wave-tossed boulders form boulder tracts, and isolated pockets of sand and sand dunes are present. The backshore is heavily vegetated by naupaka and pandanus which grade into the scrub ohia uplands. No people live in the area. Occasional campers and fishermen with permission to use the land, and the park ground keepers are usually present in the area. No utilities service the area. The area is subject to tsunami and high wave flooding, but to a smaller degree than Kalapana and Leleiwi Point. Volcanic hazards are greatly reduced in comparison to Kalapana, but still significant in comparison with the island as a whole. The landowner has conceptual plans to develop the area for urban and resort uses, but no plans have been approved or reviewed by the local government agencies. The landowner has ideas of developing hotels around Papai Bay, a golf course along the shoreline and residential areas further inland.

(3) Plan C - Cape Kumukahi: Cape Kumukahi is located approximately 30 miles southeast of Hilo, Hawaii. The general area is largely unpopulated due to the rugged terrain of the recent 1960 lava flow. The closest residential area is Kapoho Bay, consisting largely of summer homes or leisure homes. It is located approximately 1-1/2 miles south of the Cape. The actual project site is located primarily on land owned by the State of Hawaii. It is new land, accreted by the 1960 lava flow. It consists of both aa and pahoehoe lava with mounds, ridges and depressions formed by the cooling lava. The shoreline is jagged and irregular with protrusions, ridges and spurs falling away into deep water. Greenish black basalt sand is found in pockets and cavities on the surface of the rugged terrain. The upper part of the flow consists of porous volcanic slag, underlain with basalt of undetermined hardness and thickness. There is a high risk to life and property from the natural hazards associated with the project site. Located on the Kilauea eastern rift zone, Kumukahi has been the site of lava flows, one of which covered the community of Kapoho in 1960. Submarine eruptions have been

documented offshore near the Cape, and recent significant land subsidence has occurred in the vicinity as a result of earthquakes. The coastal portions of the site are also within the High Coastal Hazard tsunami flood inundation zone outlined in Federal Flood Insurance Rate Maps for the area.

4.2 Significant Resources:

(1) Population: No people reside on the property being considered as a potential harbor site. At Leleiwi Point, a condominium development is adjacent to the potential harbor site. King's Landing and Cape Kumukahi are undeveloped. Unless there is a change in economic conditions that make resort or urban development feasible at these locations, no change in population is anticipated, although district populations will continue to grow.

(2) Landownership: The State of Hawaii owns 43 acres at Leleiwi Point and the upland area is owned by State Department of Hawaiian Home Lands. At Cape Kumukahi, approximately 100 acres of land along the shoreline south of the lighthouse is owned by the State. The Federal Government owns, and the US Coast Guard administers approximately 50 acres which contain the lighthouse. Land ownership patterns are not expected to change significantly in the near future.

(3) Land Use: At Leleiwi Point, the State's 43 acres are zoned for open space to be developed as Lehia Park. At King's Landing, the lands are zoned for resort and urban use with the coastal area zoned for open space. Cape Kumukahi is zoned for conservation. Land use patterns are not expected to change significantly in the near future. The King's Landing landowner wants to develop urban and resort activities at King's Landing, but detailed development plans for the area are not available.

(4) Recreation: Sites under consideration are pristine coastal areas offering a variety of recreational opportunities. Since King's Landing is privately owned, public access and use of the area is restricted and controlled by the landowner. Leleiwi Point is a public park with unrestricted public access. All the sites offer recreational fishing opportunities, principally pole fishing and possibly opihi picking. At King's Landing one opihi picker was swept to his death by the rough waters. Due to rough water

conditions and the rugged coastline, swimming from shore is generally not possible at King's Landing and Cape Kumukahi. Diving & snorkeling are possible from a boat at all 3 sites except during high seas. Waters are also rough at Leleiwi Point, but swimming conditions are judged better than the other two sites. Tide pools at Leleiwi provide protected swimming areas and are located in quiet pleasant surroundings. None of the sites provide boat launch facilities. Leleiwi Point is an undeveloped park area which the Keaukaha Shoreline Plan (County of Hawaii, undated) indicates will be developed as Lehia general park providing swimming, camping and hiking opportunities. No surfing sites at the three locations were identified during the survey.

(5) Natural Hazards: All the sites lie within volcanic and tsunami hazard zones. Cape Kumukahi lies within a volcanic hazard area rated as a very high risk area exposed to lava flows, earthquakes, subsidence and local tsunamis. In comparison the King's Landing and Leleiwi Point sites are located in areas of high risk, but still subject to threat of lava flows. The degree of risk decreases with distance from the summit of the volcanoes and rift zones. All sites lie within the 100-year tsunami flood inundation zone outlined in Federal Flood Insurance Rate Maps for the area. Water elevations at distances 500 to 2,000 feet inland range from 18-34 feet based on the maps.

(6) Utilities:

(a) Water: The Leleiwi Point area is serviced by an 8-inch water line extending out from Hilo City. No water system is available at King's Landing and Cape Kumukahi. Water production in the district is adequate for existing and near future needs and the potential source capability is more than adequate to meet long-term demands, but would have to be developed.

(b) Power. At Kumukahi, powerlines supply the Coast Guard lighthouse, and could provide power for harbor facilities. No power system exists at King's Landing. Power transmission lines from Shipman power plant in Hilo service the Leleiwi Point area.

(c) Sewer: No sewer system is present at King's Landing and Cape Kumukahi. The Hilo wastewater treatment system services the Leleiwi Point area.

(d) Roads: Cape Kumukahi and Leleiwi Point are easily accessible over improved roads. King's Landing is accessible via a private gravel road. Traffic on roads servicing Leleiwi Point will increase with park development. King's Landing will not be improved unless the landowner develops the area.

(7) Water Quality: No riverine or wastewater discharges occur at any of the potential harbor sites. Groundwater leakage from the aquifer possibly creates low salinity conditions nearshore at all sites, but no measurements are available to determine the effect. No long-term changes are anticipated.

(8) Groundwater: The groundwater system in the region is dependent upon rainfall in the high elevations. Water near shore is too saline for drinking purposes, containing 700-900 mg/l of chloride. The rate of groundwater leakage into the ocean was estimated at 100 mgd in the South Hilo-Kumakahi area and 4 mgd from Kapoho to Punaluu (Hawaii Water Resources Regional Study, 1975).

(9) Air Quality: None of the sites have sources of air pollutants. King's Landing and Cape Kumukahi are the the most pristine with only occasional camping and agricultural fires. Leleiwi Point is located within easy driving distance from Hilo, thus automotive emissions are the only source of air pollution at the site. Volcanic emissions are another significant factor affecting air quality in the entire study area.

(10) Historic Properties:

(a) Cape Kumukahi:

1 US Coast Guard Lighthouse: The lighthouse at Cape Kumukahi is a popular tourist attraction, because of the 1960 lava flow which destroyed the town of Kapoho and spared the lighthouse. The lava divided and flowed around the lighthouse to the sea.

2 Early Historic Petroglyphs: In the area seaward of the lighthouse which was not covered by the 1960 lava flow, a small (12 x 25 meters) petroglyph field has been identified. The petroglyphs consist of names, undated, done in the typical "Missionary" style. An additional single petroglyph name was located 50 meters from the field.

3 Fishing Shrine: A probable fishing shrine is located approximately 200 meters southwest of the lighthouse. No determination has yet been made concerning eligibility for inclusion to the National Register of Historic Places.

4 A group of Historic grave sites is located approximately 400 meters south of the lighthouse. It is not known at this time if remains are still actually interred in any of the sites, however, prior to construction a detailed archaeological survey will be performed along with public notification in accordance with the State Department of Health procedures and Federal statutes.

(b) King's Landing Plan 1. The project encompasses a heiau, a sand dune midden site which contains archaeological data, a lava sinkhole enclosure, and possibly a house platform. The heiau and midden site have potential for inclusion to the National Register of Historic Places.

(c) Leleiwi Point. No sites are present. A midden site may possibly exist in the area. The area was devastated by a tsunami which could have destroyed sites in the area covering them with sand and other debris.

(11) Fish and Wildlife:

(a) Anchialine Ponds: At King's Landing many small anchialine ponds formed by lava tubes or depression may be present under the heavy undergrowth. The U.S. Fish and Wildlife Service indicated that the presence of mosquito fish in the ponds surveyed precludes the presence of any unique aquatic species. The geological youthfulness of the area provides an opportunity of finding many more similar habitats along the coast from Hilo to Kalapana. Vegetative litter will eventually fill the ponds removing them from aquatic productivity.

(b) Vegetation: No unique vegetation was found by the US Fish and Wildlife Service in any of the potential harbor sites. The King's Landing area consists of scrub ohia and alaa berries colonizing recent lava flows. Naupaka and pandanus are common along the shoreline. Leleiwi Point is a continuation of the King's Landing vegetative cover, except that the ironwood, hau and kamani trees form a dense cover in the park with the ironwood and beach grass forming the predominate cover around the tide pools. Cape Kumukahi is highly disturbed due to a recent (1960) lava flow. The vegetation is sparse and consists of scrub ohia, Christmas berry, Naupaka, swordfern and other common plants.

(c) Habitat Values: No unique or special habitat values were found by the US Fish and Wildlife Service. The vegetative cover provided general habitat for a variety of common upland species found in the area.

(d) Marine Environment: No coral reefs are present at the sites. Basalt beds and boulders dominate the substrate and corals are judged to cover about 10 percent of the substrate. The varied bathymetric relief and rocky interstices probably provide habitat for a variety of common reef fish and invertebrates. No silty environments are found at any of the project sites.

(e) Tide Pools: The tide pools at Leleiwi Point contained common, juvenile, reef fish, invertebrates and an algal turf. The tide pools are unique aquatic habitats subject to severe salinity and temperature variations, and serve as nursery areas of unknown value.

(12) Wetland Resource: A wetland is located at the King's Landing site. It is formed by a depression in the lava field separated from the ocean by 300-400 feet of lava rock. A park is built on a sand dune which lies on top of the lava rock separating the wetland from the ocean. The wetland has no visible connection to the ocean and is densely overgrown with vegetation. No open water bodies exist in the wetland. The water level in the wetland rises and falls with the tide. During spring high tides the water in the wetland covers the road through the wetland.

(a) Existing Wetland Values:

1 Natural Biological Functions:

a Food Chain Production: The wetland provides food for insects and some avian species, but no important wetland specific organisms are known to occur in the wetland.

b General Habitat: The wetland together with the surrounding ohia scrub habitat provide general habitat for wildlife.

c Nesting, Spawning, Rearing and Resting Areas. None.

2 Refuge or Sanctuary: None. The wetland is not set aside as a refuge, sanctuary or other area for special aquatic studies.

3 Natural Drainage, Sedimentation, Salinity, Flushing, Current Pattern Benefits: None. The wetland is not tributary to any riverine or flood plain system, where the wetland would influence natural drainage, sedimentation, salinity, flushing or current of the water body.

4 Erosion Barrier: None. The wetland is not associated with any barrier beach, island, reef or bars that protect other areas from wave action, erosion or storm damage.

5 Storage Area for Storm and Floodwaters: None. The wetland is not tributary to a riverine or other water body which periodically floods so that the wetland serves as a storage area for storm and floodwaters. The wetland does lie within a tsunami inundation zone and is periodically flooded by storm waves, but the area does not store or protect the surrounding lands from those flood events.

6 Prime Natural Recharge Area: None. The prime groundwater recharge areas in the region lie farther upland in areas of high rainfall.

7 Natural Water Filtration: None. The wetland is not tributary to any riverine or other water body such that the water passes through the wetland and the wetland can filter out sediments and other nutrients prior to discharge into the ocean.

(b) Potential Wetland Values: The wetland resembles an anchialine or tide pool which has filled in and become overgrown with wetland vegetation. As time progresses, natural processes will permit the invasion and establishment of upland species. Without intervention from man the wetland will eventually disappear, but will still provide general habitat for wildlife in the area. The wetland could be cleared, possibly restoring the anchialine pool characteristics and allowing the natural colonization by anchialine pool organisms. Periodic infilling by storm wave, will necessitate continued clearing of sediment from any recreated pool. The open pool would probably attract water birds and shorebirds as would other open water bodies in the region.

(13) Endangered and Threatened Species: Humpback whales seasonally migrate through the waters of the island of Hawaii. The National Marine Fisheries Service indicated that the number of whales seen in the Leleiwi Point area have decreased from 12 in 1976 to 9 in 1979. The whales are not known to calve, mate or nurse their young in waters off the proposed harbor sites. The humpback whales appear to concentrate north of Hilo at Upolu Point during the peak of the season, which begins in November and ends in June. The endangered hawksbill turtle and threatened green sea turtle are said to feed along the coast from Hilo to Kapoho, but are not known to concentrate at any particular site including the three study areas.

5. Environmental Consequences:

5.1 Population: Construction of the harbor at either Kumukahi, King's Landing or Leleiwi Point, will not result in the displacement of any residences because no people are living in the construction areas. Construction noise, including blasting and heavy equipment operation, dust and increased vehicular traffic will be a significant nuisance to condominimum dwellers at Leleiwi Point. With the development of the commercial fishing industry, odors, human traffic and light industrial activities will be continuous long-term nuisances to residents used to relative quiet, rural locations. While park development will increase traffic and noise problems in the Leleiwi Point area, the effects are judged to be less annoying in relation to industrial activities associated with a commercial fishing harbor.

5.2 Landownership: Public access to the shoreline at the Leleiwi Point site will not be changed with the development of a harbor since the lands are public lands. Public access and use of the shoreline at King's Landing will be increased with the donation of 150 acres of private lands for public use by the landowner. Public access to the shoreline at Cape Kumukahi will not be changed with the development of a harbor since the lands are all public lands. The development of a commercial fishing harbor and facilities conflicts with the current Conservation Land Use designation. The harbor will require redesignation of land use and zoning. Adjacent land areas zoned for agricultural uses should not be incompatible with long-term harbor related light industrial activities.

5.3 Land Use: The development of a commercial fishing and recreational boat harbor conflicts with some aspects of residential/resort/park land-use zoning. The harbor may require land rezoning or land use planning to reduce residential exposure to light industrial activities associated with the harbor. Adjacent land areas zoned for urban and resort uses may be incompatible with long-term light industrial activities. At Leleiwi Point, the harbor would eliminate about 43 acres of open space for park use. Since there is no urban development at the King's Landing harbor site, construction and development can proceed without any direct impact on land uses. However, subsequent urban and resort development would have to be planned to reduce industrial nuisances to future urban and resort users. The harbor would enhance the developer's plans to develop King's Landing and possibly induce the developer to start his project in conjunction with harbor construction.

5.4 Recreation: The construction of a commercial fishing harbor at Leleiwi Point may eliminate any future park development in this area. Recreational fishing will still be available, although opihi picking may decline. Swimming, sunbathing, hiking and camping opportunities will be reduced, if not partially eliminated, since the harbor will concentrate on light industrial, fishing activities and will create an unpleasant environment for passive recreational pursuits. Harbor activities would tend to attract sightseers, but the relatively pristine, quiet atmosphere will be lost. At Leleiwi Point, the harbor development will destroy the tide pools. At King's Landing the harbor will increase public use of the private land. Since public access to and use of King's Landing is restricted, the public would enjoy open use of the area, if the harbor was constructed. However, rough waters offshore will prevent swimming and other water contact activities, but fishing will benefit. Recreational craft will be allowed in the harbor, enhancing boating recreation at the selected harbor site. The construction of a commercial fishing harbor at Kumukahi would have no significant effect on recreation, but some improvements will occur.

5.5 Natural Hazards: The construction and development of the harbor at any of the proposed locations will increase potential damages and losses since the harbor will be located within tsunami and volcanic hazard zones. Volcanism is more active in the Kumukahi area than near Leleiwi Point and King's Landing; thus, the hazards at Kumukahi are greater. The problem of long-term subsidence is island-wide; however, rapid subsidence related to local earthquakes is greater at Kumukahi. Tsunami runup elevations at Kumukahi are less than at Leleiwi Point or King's Landing and are not expected to increase due to habor development.

5.7 Water Quality: Construction will temporarily increase water turbidity during the excavation of the harbor entrance channel. The severity of the increase cannot be predicted since the excavation will involve use of explosives and the excavation of solid basalt. The duration of the water turbidity impact is qualitatively estimated in Table 2 by the number of days required to complete the excavation of the entrance channel. Excavating the harbor access and berthing in the inland areas prior to opening the harbor to the ocean reduces the amount of work performed in the water providing some measure of turbidity control and reduction in sedimentation stress.

5.8 Groundwater: Fresh water leakage into the harbor basin is anticipated, based upon surveys of Honokohau Harbor, Kailua-Kona, Hawaii, which was constructed in 1970. The groundwater discharge in the proposed harbor should be brackish, may create a two-layered water body in the harbor, may induce a continuous outflow on the surface and may be a source of nutrients in the harbor. The rate of discharge should vary directly with the amount of rainfall in the upland areas. The surface water should be cooler than the bottom water, should contain a higher level of nutrients and should be less saline than the bottom water. Turbidity may probably range from less than 0.5 FTU to less than 1.50 FTU due to phytoplankton growth. At Honokohau phytoplankton was the principal factor affecting water turbidity, and phytoplankton density was controlled by a combination of high nutrient concentration and water residence time.

TABLE 3. PROBABLE WATER QUALITY IN THE HARBOR BASIN
(RANGE OF MEAN CONCENTRATIONS OVER THREE-YEAR PERIOD)
(Based on experience at Honokohau Harbor)

	Surface	Bottom
Salinity	12-35°/00-	35°/00
Temperature	22-24°C	24-26°C
Nitrate-Nitrogen (g-at N/l)	10.74 - 43.9	0.15 - 1.050
Reactive Phosphate (g-at P/l)	0.45 - 3.375	0.15 - 1.050
Ammonia (g-at N/l)	0 - 1.41	0.14 - 9.60
Amino nitrogen (g-at N/l)	0.133 - 0.566	0.290 - 1.720

5.9 TRASH: Development in support of commercial fishing activities in the harbor has the potential for introducing trash, fish offal and petroleum and other chemical pollutants into the water in greater amounts than a recreational harbor. While sewage pumpout facilities, and the restriction of live aboards in the harbor will help to reduce pollution sources, marine dry dock facilites and day-to-day fishing operations can be a major source of pollution.

5.10 Potable Water: No groundwater drinking sources will be affected.

5.11 Air Quality: During construction, temporary dust nuisances will be created for workers and adjacent residence at Leleiwi Point. The problem will be significant at Leleiwi Point, where the site is adjacent to the condominium. At King's Landing and Kumukahi, only the workers will be exposed to the dust and noise. Automotive emissions will increase with the operational use of the harbor due to boat and automotive engines. Air pollution sources could be present with the development of shoreside facilities, since the harbor will be servicing commercial fishing operations. Odors could occur if fish processing activities, such as smoking and drying facilities, are allowed. The odor problems could be great in areas with adjoining residences, such as Leleiwi Point. King's Landing and Kumukahi are undeveloped and uses of the land could be planned to avoid impact.

5.12 Historic Properties:

(a) Cape Kumukahi: The present alignment of the proposed harbor will impact historic grave sites. It has not yet been determined if remains are still actually interred in any of the sites, or have ever been; therefore, it is not possible to assess the severity of the impact. A detailed archaeological survey of the sites will be conducted prior to construction. Additionally, the increased availability of the petroglyph fields and fishing shrine may lead to vandalism or other damage. No impact is anticipated on the lighthouse.

(b) King's Landing: The harbor would destroy the stone artifact and the sand dune which contains archaeological data. The stone could be relocated. Archaeological data recovery would preserve some data for the scientific community. The unaffected portion of the sand dune would be covered during construction of the harbor preserving any remaining information in the dune for an eternity.

(c) Leleiwi Point: No effect anticipated.

5.13 Utilities: The construction of the harbor at any of the three sites by excavating the entrance channel and berthing basin from the basalt shoreline does not require an increase in utilities demands. However, the development of ancillary backup facilities to support commercial fishing activities will increase demands on water, power and wastewater systems, and will require road improvements. The utility demands created by development of the harbor cannot be predicted at this time due to the uncertainty of the nature of the harbor development and the lack of plans on the types of services to be provided. New water sources will be required, and the Hawaii Water Resources Regional Study indicates that potential water sources are available but must be developed. There are no wastewater treatment facilities at any of the sites. Solid waste processing and treatment would also have to be provided. At Leleiwi Point, water, power, sewer and roads can easily be extended to the harbor site, but may have to be increased to handle the demands created by light industrial activities. The expense of providing utilities at King's Landing would be the greatest since the site is isolated and no systems are presently available. Road access to the site would be a major construction item. Power can be brought in or generated using individual generator. Water can probably be developed on site or brought in from Hilo. Sewer systems could be provided in a similar fashion. At the present time, the State of Hawaii and the landowner have not determined the sharing of costs to provide the utilities if King's Landing is selected. Road access at Kumukahi is easily provided due to the closeness of the site to the Kapoho Highway. Power is available at the Coast Guard lighthouse which can easily be extended to the harbor site, but may have to be increased to handle the demands created by light industrial activities.

5.14 Fish and Wildlife:

The major effect of harbor construction at any of the potential harbor sites is the conversion of general terrestrial habitat into marine habitat. Based on a five-year survey of Honokohau Harbor, which was constructed by excavating the harbor basin from a recent basaltic laval flow, a stratified estuary should be created in the new harbor and colonization by mollusks, sea urchins, algae, coral and fish from adjacent marine areas should proceed rapidly. Within one year of construction both brackish water and marine organisms should colonize the walls and bottom of the new harbor. Investigators hyphothesized that biological succession in Honokahau would probably take 15-20 years before biological communities approach a climax state within the harbor.

TABLE 4. BIOLOGICAL SUCCESSION PATTERN IN HONOKOHAU HARBOR

	1971	1972	1973	1976	1981
Mollusks (# species)	43	48	61	78	133
Sea Urchins (# species)	8	8	9	8	8
Coral					
Density (# per M^2)	0.05	1.43	2.66	3.4	3.6
Growth (Mean diameter of coral)	4 cm	8.5 cm	12.5 cm	19.8	22.7
Fish (# species)	18-28	33-46	25-40	34-54	29-75
(# individuals)	93-225	244-381	142-337	355-629	157-586

At Honokohau, diversity, abundance and density variations of marine life, depended on distance to the open ocean with depth of water and with bottom relief and bottom type (sediment or hard surface). Sea urchin density doubled during the survey period while the number of species remained relatively stable. Coral recruitment rate was estimated at 1.23 colonies per square meter per year. Most fish observed were juvenile and sub-adults; and the data suggest that the number of fish species was generally increasing from year-to-year, until the inner harbor basin (Phase II) was constructed. The rate and nature of succession and colonization in the proposed harbor would be dependent upon man's use of the harbor and the ability of aquatic organisms to withstand stresses and conditions in the harbor. Petro-chemical spills, trash, organic debris and maintenance activities may alter the community health and species composition particularly within the inner harbor reaches. For example, higher nutrient inputs may induce a higher phytoplankton and zooplankton growth that would increase water turbidity reducing light penetration in the harbor stressing photosynthetic organisms, and corals. The piers, wharves and boat bottoms will provide habitat for fouling organisms which will contribute to an increase in benthic species diversity, but hull maintenance will periodically affect the community abundance. Hull cleaning and the plankton population may contribute to sedimentation in the harbor. The size and shape of the basin will affect water circulation or residence time which in turn will affect the abundance, diversity and distribution of marine life.

5.15 Wetland Resources: The plan at King's Landing will destroy the wetland by excavation and filling. Development of a harbor at either Leleiwi Point or Kumukahi avoids the wetland site. King's Landing will eliminate the wetland as general wildlife habitat, preventing any potential uses of the wetland. No measures to minimize unavoidable adverse impacts are available since the plan destroys the wetland. Realignment of the harbor would still require excavation in the wetland and would drain the wetland. The only other form of mitigation available is the replacement of 12 acres of general habitat.

5.16 Anchialine Ponds: Construction at King's Landing has the potential for destroying an undeterminable number of pools in the lava substrate. At the present time, no unique organisms are known to occur in pools surveyed by the Fish and Wildlife Service in the King's Landing area.

5.17 Tide Pools: The tide pools at Leleiwi Point would be filled, if the site is selected, destroying the organisms presently inhabitating the pools and eliminating any future use of the pools by man or aquatic organisms.

5.18 Vegetation: The loss of vegetation at any of the potential harbor sites will result in a localized loss of general habitat. While the loss is not significant in comparison with the remaining vegetated areas surrounding the sites, the loss represents a long-term reduction in vegetation and modification of the island coastal environment.

TABLE 5. VEGETATIVE LOSS AT POTENTIAL HARBOR SITES

Kumukahi	very sparse vegetation
King's Landing	150 acres of naupaka and ohia scrub forest
Leleiwi Point	43 acres of ironwood and kamani trees

5.19 Endangered and Threatened Species:

(1) Humpback Whales: The endangered whales migrate through the waters off the three potential harbor sites. The harbors will not interfere with their migratory movement. Studies at Glacier Bay, Alaska, seem to indicate that fishing boats under the 100-ton class do not bother the whales, unless the boats buzz the whales. The potential harbor sites are not known calving, nursing or mating grounds. Since the whales are usually seen migrating through the area, harbor operations during the migration are not expected to jeopardize the continued existence of the whale.

(2) Sea Turtles: The endangered hawksbill and threatened green sea turtles are reported to feed along the coastal areas from Hilo to Kalapana. The relative isolation of the areas and rough waters protect the turtles from man. Since no concentrated turtle feeding or nursing grounds are known to occur at any of the potential harbor sites, the construction of the harbor is not expected to jeopardize the continued existence of the sea turtles. With an increase in boating activity along the coast, human contact with turtles will probably increase and some fishermen may attempt to illegally harass or catch them. Accidental boat collisions with turtles are also probable, but these collisons with individuals are not expected to jeopardize the continued existence of the species. Blasting, if any, conducted in open coastal waters will be coordinated with the National Marine Fisheries Service to insure that it does not jeopardize the continued existence of threatened or endangered marine species.

5.20 Blasting: Blasting will be required to facilitate removing the rock in the entrance channel and turning basin. Prior to blasting, the Contractor will submit a blasting plan which must be approved by the Corps of Engineers Contracting Officer. This plan shall contain the details of the blasting operations. General blasting related impacts are discussed below.

a. Blasting Noise. Detonation of the blasting agent will generate noise. The sound level will depend on the amount and kind of explosive used, the burden over the charges and the distance of the observer from the blast. If a detonating cord is used to initiate detonation of the blasting agent, an audible air-shock wave will be created. The Contractor will be required to comply with all applicable State or local noise control regulations.

b. Ground Vibration. Ground vibration or seismic motion typically accompanies all detonations. The vibrations may or may not be perceptible depending on several factors, such as the geology of the site; the weight of explosives per delay; and the distance to structures and observers. The seismograph is used universally to measure vibratory motion. According to Corps safety and health requirements, when a blast is planned that would have a scaled distance less than 50, a 3-component seismograph will be required to monitor vibration levels. Scaled distance is a function of the distance from the nearest structure to the blast site and the maximum weight of explosives per delay as follows:

$$S = \frac{D}{W^{1/2}}$$

Where: S = Scaled distance ft/lb$^{1/2}$

D = Distance from nearest structure to blast site, feet.

W = Maximum weight of explosives per delay in pounds.

This formula will be used to determine the maximum explosive weight allowed per delay. If vibration levels are kept below 2 IPS (inches per second), no damage to structures is anticipated. If below 0.2 IPS negative reactions from nearby residents will be minimized.

c. Dust and Flyrock. Dust or flying particles are expected since the blasts will be concentrated on land. Measures must be taken to prevent damage to the lighthouse and neaby Kapoho residents.

d. Smoke and Odors. Smoke and odors from blasting are anticipated, but there will be no significant impact, since there are no residents near the site.

e. Marine Environment. There are no coral reefs at Cape Kumukahi, but basalt beds and boulders dominating the substrate. A variety of reef fish and invertebrates are present in this habitat. Some blasting will be done in the water and a number of fish and invertebrates may be killed, but the amount of biomass destroyed will not be significant because large amounts of blasting are not anticipated.

f. Safety. The Contractor will be required to conduct his blasting operations in accordance with the blasting plan approved by the Corps Contracting Officer, Engineer Manual 385-1-1, Safety and Health Requirements Manual, and State Occupational Safety and Health Standards.

6. Public Involvement:

6.1 Public Involvement Program: The public involvement program has consisted of a series of ten public workshops held on the island of Hawaii from 1976 to 1982. The problems of small craft navigation needs have centered primarily on identifying sites for small craft facilities and safe anchorages to assist local commercial fishermen. However, the need for recreational craft was also stressed by the State of Hawaii. The need for facilities at Laupahoehoe, in Hilo, at Pohoiki and in the Puna area to support fishing interests were defined early in the study. The Pohoiki launch ramp was improved in 1979 as a result of the study. Small craft facilities at Laupahoehoe and in Hilo will be studied under separate project authorities, while the study for a small craft facility in the Puna area continues under the Hilo Area Comprehensive Study. Sites at Leleiwi Point and King's Landing were initially discussed with the public. Sites at Kapoho and Kalapana were later added based on fishermen's desire to have a harbor closer to the Puna fishing grounds. Kapoho was later dropped as a result of a March 1981 public workshop in which resident and landowner objection to the site was great. Leleiwi area residents opposed the Leleiwi Point site, and fishermen indicated that the Leleiwi Point and King's Landing sites were too treacherous for their boats. The most recent meeting with commercial fishermen resulted in their recommendation in support of the Kumukahi site included in this report.

6.2 Required Coordination:

(1) Prime and Unique Agricultural Lands: No prime or unique agricultural lands are located at any of the potential harbor sites. However, the comments from the US Soil Conservation Service and the State of Hawaii, Department of Agriculture concerning the project effects on agricultural lands will be solicited by the circulation of the draft report and environmental impact statement.

(2) Clean Water Act Section 404 - Evaluation: The evaluation of the discharge of dredged or fill material is contained in Appendix A, and will be coordinated with the US Congress during the authorization process. This constitutes compliance with the requirements of the Clean Water Act.

(3) Wetland Evaluation: The wetland evaluation in accordance with Executive Order 11990 is contained in the draft environmental impact statement for agency and public review and comment.

(4) Endangered Species: A biological assessment concerning project impacts on the endangered humpback whale, endangered hawksbill turtle and the threatened green sea turtle, and the determination that the project will not jeopardize the continued existence of the species is being coordinated with the US Fish and Wildlife Service and the US National Marine Fisheries Service in accordance with the Endangered Species Act.

(5) Fish and Wildlife Coordination: Comments concerning project effects from the US Fish and Wildlife Service, National Marine Fisheries Service and the State Division of Fish and Game required under the Fish and Wildlife Coordination Act will be solicited using the draft report and environmental impact statement. The US Fish and Wildlife Service will also provide an independent report under Section 2(b) of the Act for consideration and inclusion in the final report and environmental impact statement.

(6) Coastal Zone Management (CZM) Consistency Determination: The Corps CZM consistency determination is being coordinated with the State CZM Office in order to obtain State concurrence.

(7) Historic Coordination: Consultation on determinations of eligibility for inclusion to the National Register of Historic Places will be completed with the State Historic Preservation Officer and the National Park Service before final determinations of effect under the National Historic Preservation Act.

(8) Recreation: The County of Hawaii, Department of Parks and Recreation, and the State of Hawaii Department of Land and Natural Resources will be contacted for their views concerning project impacts on recreation. The coordination will be done under the Federal Water Project Recreation Act.

(9) Water Quality, Air Quality, and Noise Control: The US Environmental Protection Agency and the State Department of Health will have the opportunity of commenting on project impacts discussed in the environmental impact statement under the Clean Water Act, Clean Air Act and Noise Control Act.

(10) State and Local Policies: The State of Hawaii, Department of Transportation is responsible for obtaining all necessary State and local permits or authorizations for the construction of a harbor at the selected location, including a State certification under Section 401 of the Clean Water Act.

6.3 STATEMENT RECIPIENTS. The following agencies and public-at-large will be sent copies of the draft environmental statement and survey report.

Federal Government

- US Advisory Council on Historic Preservation
  - Washington DC Office
  - Western Project Review Office
- US Environmental Protection Agency
  - Office of Environmental Review
  - Region IX
  - Pacific Islands Office
- US Army Corps of Engineers
  - Coastal Engineering Research Center
- US Department of Agriculture
  - Institute of Pacific Islands Forestry
  - Soil Conservation Service
  - Hawaii District Office
- US Department of Energy
- US Department of Commerce
  - Secretary of Environmental Affairs
  - National Marine Fisheries Service
    - Southwest Region Office
    - Pacific Program Office
  - Office of Coastal Zone Management
  - National Weather Service, Pacific Region
- US Department of the Interior
  - Office of Environmental Review
  - US Geological Survey, Hawaii Volcano Observatory
  - Secretary Field Representative, Pacific Southwest Region
  - US Fish and Wildlife Service
    - Regional Office
    - Pacific Islands Office
    - Endangered Species Coordinator
  - National Park Service
    - Office of Archaeological and Historic Preservation
    - Interagency Archaeological Service

Federal Government (cont.)

Arizona Archaeological Center
Pacific Southwest Region Office
Hawaii State Office
US Department of Housing and Urban Development
US Department of Health and Human Services
US Department of Transportation
Federal Highway Administration
14th Coast Guard District
Cape Small, Hilo
Federal Maritime Commission

State Government

Governor George R. Ariyoshi
Hawaii Congressional Delegation
Department of Planning and Economic Development - Clearinghouse
Department of Health
Office of Environmental Quality Control
International Tsunami Information Center
Department of Land and Natural Resources
State Historic Preservation Officer
Division of State Parks
Division of Fish and Game
Forestry and Wildlife Division
Land Management Division
Water and Land Development Division
Conservation and Resources Enforcement Division
Hawaii District and Agent
Board of Land and Natural Resources
Marine Affairs Coordinator
Department of Transportation
Highways Division
Harbors Division
Department of Accounting and General Services

State Government (cont.)

Attorney General
State Department of Agriculture
Board of Agriculture
Public Utilities Commission
Hawaii State Library
  Hawaii Island Branches
Department of Hawaiian Home Lands
Keaukaha School

County Government

Mayor Herbert T. Matayoshi
Hawaii County Council
Hawaii Legislative Delegation
Department of Parks and Recreation
Department of Planning
Planning Commission
Department of Public Works
Department of Research and Development
Department of Water Supply
County Fire Department
Department of Civil Defense

Organizations

Big Island Resource Conservation and Development Council
Big Island Casting Club
Association of Hawaiian Civic Clubs
Big Island Fish and Game Association
Conservation Council for Hawaii
  Hawaii Island Chapter
Hale Consultants, Inc.
Hawaii Audobon Society
Hawaii Community College Library
Hawaii Electric Light Co.

Organizations (cont.)

Hawaii Island Board of Realtors
Hawaii Island Chamber of Commerce
Hawaii Tribune Herald
Hawaiian Civic Club
Hawaii Leeward Planning Conference
Hilo Transportation and Terminal Co., Inc.
Hilo Trolling Club
Hawaiian Paradise Park Corp.
Hilo Sailing Club
Life of the Land
Kalapana Community Association
Hilo Downtown Improvement Association
Kailua Trolling Club
Kawaihae Trolling Club
Japanese Chamber of Commerce and Industry of Hawaii
Kona Mauka Troller, Inc.
Kona Yacht Club
Mark's Boat Works
North Hilo Community Council
Moku Loa Sierra Club Group
Matson Navigation Co.
Puna Community Council
Suisan Co.
Save Our Surf
University of Hawaii
    Water Resources Research Center
    Library
    Environmental Center
    Hawaii Institute of Marine Biology
    Seagrant/Marine Advisory Program, Kona and Hilo Offices
Young Brothers Inc.
Wester Division Project Review, Lake Plaza South

Individuals

Mr. Alika Cooper
Mr. Dan Pakele
Mr. Dave Soderland
Mr. Edward Bumatay
Mr. Herbert Mann
Ms. Lei Keliipio
Mr. Paul Friesema

6.4 Public Views and Responses (To be completed after review of the draft environmental impact statement)

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8. LIST OF PREPARERS:

The following people were primarily responsible for preparing this Environmental Impact Statement.

Dr. James E. Maragos	Marine Ecology	BS, Zoology; PhD, Oceanography; 2 years postdoctoral research; 8 years environmental consultant; 8 years EIS studies, Corps of Engineers.	Review, overall impact assessment. (NEPA Coordinator)
Mr. William B. Lennan	Biology	BA, Zoology; 2 years postgraduate studies, University of Hawaii; 3 years fishery biologist, USFWS 1 year environmental biologist Corps of Engineers	Overall impact assessment and editing.
Ms. Margie Swafford	Biology	BA, Japanese Language; 2 years research aquaculture; 1 year water quality analysis.	Overall impact assessment.
Mr. David G. Sox	History and Culture	BA, MA Geography; 6 years research; 8 years EIS studies; Corps of Engineers	Cultural and historical impact assessment.
Mr. David W. Cox	Archaeology	BA, Anthropology; 2 years postgraduate studies, w/diploma in cultural resources management, EWC; 1 year EIS studies, Corps of Engineers	Archaeological/historic sites reconnaissance and impact assessment.
Mr. John I. Ford	Limnology	BS, MS Zoology; 4 years EIS studies, Corps of Engineers; 1 year, fishery biologist, USFWS	Fish and Wildlife assessment.

APPENDIX A

404(b) (1) EVALUATION

SECTION I. SMALL CRAFT NAVIGATION IMPROVEMENTS

A. DISCHARGE OF DREDGED OR FILL MATERIAL, SMALL CRAFT NAVIGATION IMPROVEMENTS SECTION 404(b)(1) FACTUAL DETERMINATION:

1. Special Aquatic Areas.

Sanctuaries and Refuges: None.

Wetland: A 12-acre, wetland occurs at the King's Landing site. The area is choked with bulrush, California grass and beach grass. Wetland is isolated, not connected with river or flood plain system and is not openly connected with ocean. The wetland does not provide infiltration, aquifer recharge, recreation, buffer zone, floodwater storage or fisheries values. Effect: The wetlands provides general wildlife habitat, the same as the surrounding ohia scrub forest. The discharge of basalt armor units will occur in the harbor created by excavating the wetland. Excavation in the wetland will essentially drain and destroy the wetland.

Mudflat. None.
Vegetation Shallows: None.
Coral Reefs: None.
Riffle and Pool Complex: None.

Other: Anchialine Pools. Several small depressions and holes in the lava substrate in the King's Landing area contained water and mosquito fish. The pools are referred to as "anchialine pools" which are close to the ocean with no direct connection, and the water levels fluctuate with the tide, but the water remains brackish or fresh. The US Fish and Wildlife Service did not ascertain whether the pools were actually anchialine, but for the purposes of this evaluation they are considered anchialine pools. The number of pools in the area are not known, but the recent geologic age of the area suggests that the pools are common throughout the region. Since no rivers have formed in the recent lava, the underground water surfacing in the lava tubes or depressions allows freshwater organisms, usually found in streams and rivers in Hawaii, to establish themselves in the inhospitable environment creating unique aquatic ecosystems with unique aquatic organisms.

The US Fish and Wildlife Service indicated that the presence of introduced carnivorous fish species in the pools reduces the possibility of finding unique anchialine pool organisms. Effect: During the grading of the surrounding land area for the development of the harbor, material will fill the pools and eliminate them from further biological usefulness. The number of pools both large and small that would be destroyed are not determinable based upon the information provided by the US Fish and Wildlife Service.

2. Human Use Characterization:

Municipal Water Supply: None.

Recreation Fishing: Recreational pole fishing present along entire coastline between Hilo and Kalapana. Opihi picking confined to infrequently used areas. Public access to King's Landing and Kumukahi restricted by rugged coastline and private landowner control of access (to King's Landing). Leleiwi Point is public park lands. Effect: Recreational fishing values improved with the placement of armor units in the water. The wave absorbers and breakwater will provide habitat for common reef fish, possibly providing new fishing sites.

Commercial Fishing: The open ocean near Cape Kumukahi is a popular destination for commercial fishermen. There is no commercial fishing at the project site itself. Effect: Increased access to fishing grounds could possibly result in overfishing. No direct effect from discharge of armor units.

Water-Related Recreation: King's Landing access and public use is restricted. Hiking, camping, sunbathing and swimming available at Leleiwi Point. Tide pools at Leleiwi Point provide unique recreational resource. Effect: The discharge of excavated material will destroy the tide pools at Leleiwi Point.

Aesthetics: Pristine, open coastal area. Effect: Discharge will form a wave absorber structure in the open coastal area.

Parks: Leleiwi Point and Lehia Park. Effect: The discharge of fill does not affect the park use; however, harbor construction will eliminate park lands.

National Monuments: None.

National Park: None.

National Seashore: None.

National Wilderness Areas: None.

Research Sites: None.

National Historic Sites: Present. Effect: Discharge of fill does not affect the sites. Harbor construction excavation will affect the sites, before the discharge occurs.

3. *Physical Substrate Determination.*

Harbors: The harbor discharge sites will have substrates consisting of recently excavated, solid basalt, which would not be subject to erosion or movement. Effect: The placement of basalt armor units to form the wave absorbers and the breakwaters will not alter the physical substrate in the harbor.

Tide Pools, Leleiwi Point: The tide pools are formed by depressions in the lava flow and sand has been deposited in the pools by natural wave action. Effect: The discharge of excavated material into the tide pools will cover the sandy substrate. The fill will be protected and not easily erodible.

Anchialine Pools, King's Landing: The pools have basalt bottoms probably covered with organic debris. Effect: The discharge of basalt material into the pools will cover the organic layer on the bottom of the pool. Since the pools are located inland the fill will not be erodible by wave or riverine action.

4. Water Quality, Circulation, Fluctuation and Salinity Determination:

Harbor: The discharge will occur within a man-made body of water, since the harbor will be excavated out of a volcanic basalt shoreline. Effect: The placement of the basalt armor units to form the wave absorbers will not interfere with water circulation or fluctuation in the harbor. The structures will reduce wave energy in the harbor, thereby reducing mixing energy, allowing the brackish groundwater to form a layer over the more saline ocean water. The structures will not affect water current direction or pattern, normal water fluctuations, potability, color, odor, taste, water chemistry or physical properties, pathogen or biological content, or eutrophication.

Tide Pools, Leleiwi Point: The tide pools are formed by ocean water passing over the lava shore into the pool and by tidal waters seeping through the rock into the pools. Groundwater leakage also provides water to the pools. Effect: The fill will cover the pools eliminating them as aquatic systems. The fill will not affect the leakage of the groundwater or coastal water quality, circulation, fluctuation or salinity.

Anchialine Pools, King's Landing: The pools are not directly connected to the ocean and are located inland outside of the water. The lava tubes or depressions extend below the groundwater level allowing the formation of pools. The groundwater floats on the saline ocean water and the water level in the pool fluctuates with tide and rainfall intensity. Effect: The fill will cover the pools eliminating them as aquatic systems. The fill will not affect the normal fluctuation of groundwater levels or coastal water quality.

5. Suspended Particulate/Turbidity Determination: The placement of armor units into the harbor waters is not expected to affect water turbidity or suspended particulate concentration, or to create a significant turbidity plume. The filling of the anchialine pools will not affect coastal water turbidity since they are located out of the water. The fill in the tide pool will form part of a revetted landfill, and will be contained and protected by a revetment.

6. Contaminant Determination: The armor units and fill material are not contaminated, and the material is classified as Category 5. The initial evaluation does not indicate the presence of contaminants above background levels.

7. Aquatic Ecosystem and Organism Determination:

Harbor: The placement of armor units will occur within a recently excavated harbor basin in which no organisms will be present. Effect: The armor units will form rocky intertidal and submerged interstitial habitat for a variety of common marine and brackish water organisms

Tide Pools: The tide pools are colonized by common algae and juvenile reef fish. While the tide pool provides some nursery habitat, no major food chain productivity is associated with the tide pool. Effect: The fill will eliminate the tide pools within the project limits.

Anchialine Pools: The pools form unique aquatic habitats (see item 1), but are not major food chain contributors. Effect: The fill will eliminate anchialine pools within the project limits.

Ocean: No armor units will be placed in the ocean, therefore there will be no effect on the oceanic aquatic ecosystem.

B. DISCHARGE OF DREDGED OR FILL MATERIAL, SMALL CRAFT NAVIGATION IMPROVEMENTS SECTION 404(b)(1) INITIAL EVALUATION:

The material to be discharged is fill material consisting of basalt rock excavated from the selected project site. Estimated quantities of basalt to be discharged are provided below:

Leleiwi Point	King's Landing Site 1	Kumukahi
32,000 C.Y.	51,800 C.Y.	20,000 C.Y.

Contaminants cannot flow into the project area because no riverine systems pass through or into the areas. The areas consist of recent lava fields which are too geologically young for the development of streams. Rainwater quickly percolates through the rock into the groundwater table.

The material proposed for discharge has not been previously tested under the Section 404(b)(1) test requirements.

Pesticide runoff cannot enter the extraction site by surface flow.

Spills or disposal of contaminants have not been documented at or near the extraction sites. All the sites remain rural without major agricultural, industrial or commercial development. King's Landing and Kumukahi have no human residences. Leleiwi Point is also park land.

No natural deposits of minerals or other substances harmful to man are present at the extraction site.

Findings:

a. The material is not contaminated.

b. The fill material is classified as Category 5.

c. Further testing is not required.

C. <u>DETERMINATION</u>:

a. The discharge of armor units into the harbor does not significantly degrade water quality in the harbor since it does not destroy special aquatic areas, degrade human uses of the water, alter the physical substrate or water quality and water fluctuation in the harbor, cause prolonged water turbidity; contain contaminants, or significantly degrade the aquatic ecosystem.

b. The discharge of fill material into the tide pools eliminates any recreational use of the pools at Leleiwi Point. The fill eliminates the tide pools, but does not significantly degrade coastal water quality, does not affect coastal water turbidity, and does not contain contaminants that can cause a long-term environmental stress or affect human health. The tide pools are a localized recreational and biological resource.

c. The discharge of fill into the anchialine pools destroys the pools eliminating further use as a unique aquatic habitat. The fill does not significantly degrade water quality since the fill destroys only those pools within the project limits, does not affect human uses of water in the area, does not alter physical substrates in coastal areas, does not affect groundwater movement, fluctuation and quality, does not affect water turbidity in coastal waters and does not result in a release or introduction of contaminants into the water. The loss of the pools is localized and does not affect pools outside the harbor area.

d. Contaminants: The initial evaluation of the material indicated that the material has a low likelihood of being contaminated. The extraction site is adjacent to the discharge site and the materials are similar, thus, are not likely to degrade the disposal site. The material placed in the habor is not likely to be eroded and carried to less contaminated areas. The fill used at the tide pools will be revetted and protected from wave erosion. The fill in the anchialine pools are located outside the influence of the ocean and will not be eroded into the water to contaminate other areas.

APPENDIX B

ARCHAEOLOGY

PRELIMINARY ARCHAEOLOGICAL RECONNAISSANCE OF
CULTURAL RESOURCES AT THE PROPOSED SITE OF
THE CAPE KUMUKAHI SMALL CRAFT NAVIGATIONAL IMPROVEMENTS

1. INTRODUCTION. The purpose of this field survey was to identify the presence or absence of any cultural resources in the area of the proposed Commercial Fishing /Small Craft Harbor at Cape Kumukahi, Kula ahupua'a Puna Hawaii. The field investigation for this project was undertaken by David W. Cox, Archaeological Technician for the Corps of Engineers, Pacific Ocean Division, on September 29, 1982. Six sites of archaeological interest, each composed of one or more features were located during the field reconnaissance. Four of these sites are apparently described here for the first time. An additional site has been subsequently identified by another field investigator, geologist Eric Bjorken (26 Oct 82). This site is located further to the west and south of the others. Bjorken's site, as well as another additional one nearby, have been tentatively confirmed through aerial photo analysis by Cox, as probably of the historic period. This gives a total of eight sites to be discussed in this report.

2. METHODS. The field reconnaissance was performed by one person (Cox) walking a series of eight nearly straight (as terrain would allow) transect sweeps through the trianglular study area. The land is an open and almost vegetationless older lava flow field, providing good visability for a 50 to 75 m radius (therefore double that for reliable transect width). Starting from the Light House the first sweep proceeded to the E, and the Cape. The remaining sweeps worked alternately a short leg along the coast, then back toward the Light House, and returning to the shoreline. All cultural features seen were investigated and recorded with notes, sketch maps being made and photos being taken. No material, or artifacts were collected. Copies of field notes, maps and photos are on hand at the Corps POD Planning Branch, Honolulu.

3. BACKGROUND. Alfred Hudson performed the first 'Sites Survey' (which is equivalent to a general archaeological reconnaissance) in the coastal areas of the Puna District, for the Bishop Musuem between 1930 and 1932. This fieldwork was reported in his manuscript of 1932. His characterization of the general area of interest here is still accurate. "...the coastline is irregular, ending in jagged cliffs interspersed in a few places with small beaches of sand and boulders" (p. 304). Even with the massive changes to the surrounding lands wrought by the Kapoho lava flows of 1960, the coastal area of the Cape itself is essentially the same today as Hudson saw it some thirty years before the more recent volcanic activity. The flow(s) split on reaching the Light House enclosure, with the northern section going on to the sea to the north and east of the present study area. The rest of the flow swung from the Light House to the south. This left a roughly triangular section of much older lavas untouched (the study area). The first six sites noted below are all in this quarter circular area. This kipuka (hawaiian for an area of older land surrounded by newer lava) has its apex at the Light House, and a radius of approximately 1,200 feet in length. The resulting quarter circle encompasses in arc of the coastline of about 1,400 feet long (see Figure 1), and is approximately 26 acres in area.

Two of the eight sites have been noted in previous material. One site the "King's Pillars" is located at the Big Island's eastern most point of land. Hudson (1932) describes this site (his site No. 103) as -

> ...stone cairns, built of rough lava from the surrounding flow, which are said to have been built by the various monarchs of the Hawaiian Kingdom upon assuming the throne. At present (1932) there are three complete cairns, from 5 to 8 feet high, the foundations of two others and traces of several more. There are numerous initials and dates, all resent, cut or scratched onthe stones." (1932:325)

Henry Kinney mentions this practice of errecting mounds at this location as well, in his The Island of Hawaii (1913:83). This site as also been given a State Site No. 10-46-4250, but the supporting forms and files were not located in a recent search by State Parks staff. The other site was identified by Virginia Loo and William Bonk, Site 68 (1970), and is now listed as State Site No. 10-46-4251, the Kumukahi Gravesite. Their description (appended here as enclosure 1) indicates two possible gravesites of the Puoa type, and unspecified distance east of the Light House. Their feature descriptions are similar to those of Cox's Site 6, Features A and B; however, the latter is located south of the Light, not east (see Figure 1) and thus it may not be the same.

4. RESULTS. Descriptions of the sites and features that were noted during the reconnaissance are presented in this section. They are numbered starting from the coast, at the northern extreme of the study area.

Site No. 1 - The "Kings Pillars" type of site = rock mounds, or ahu. (Hudson's Site No. 103, and State Site No. 50-10-46-4250) Two ahu were noted at the south end of the area of Hudson's Site No. 103. The two features are 120cm to 180cm high (4 to 8 ft). One is on a prominantly high natural lava outcrop, that is immediately seaward of the present rough bulldozer trail along the coastline. This outcrop is at the southeastern end of the small sandy beach at the Big Island's eastern most point of land.

Site No. 2 Petrogylphs - Early historic period rock carvings of names, initials, words and a few numerals. These were found in two locations, the larger group (Area I) is approximately 80 to 100 feet south and east of the beach, and Site No. 1 mentioned above. The smaller group (Area II) is another 200 feet further S.E. Both features are about 100 feet inland from the shoreline, and just inshore of the bulldozer trail (see Figure 1), at approximately the 20-foot elevation.

Area I is a bowl of rough, slightly weathered pahoehoe lava measuring 12 meters x 25m, and is surrounded by upthrust flow rubble except to seaward. There are at least 65 petroglyphy 'units' here, most are Hawaiian names, with some initials, words and numerals (but no dates), and a single geometric design - a circle. The letters are the typical "Missionary Print" style, that is, with triangular seriphs, mixed caps and lower case, and with an occasional inverted or reversed letter element. Many of the glyphs are rather large in size, but most are shallowly marked, and a few are now weathered and indistinct.

Area II has a much smaller available usable pahoehoe surface, and only three or four units were noted. One glyph however is quite large and distinct - the name Kaleile, in bold seriphic "Missionary Style."

No soil deposits of any size were seen, but numerous scattered opihi shells were noted on the surface at, and around Area I. Small clumps of grass established in isolated soil pockets might yield very limited subsurface midden.

Site No. 3, Old Foot Trail. This foot trail approximately parallels the coastline, but is some 500 feet inshore. It was noted as a faintly worn pathway across the mostly smooth pahoehoe flats some 800 feet east and slightly south of the light, and in line with the petroglyph Area II (above).

Site No. 4, Small Shelter Caves. These are two adjacent low lava blister shelters that are located 200 feet west, or further inland from the trail (Site No. 3, above). Both of the thin roofed lava bubbles have natural blowout openings facing to the west, so are well protected from the otherwise strong prevailing N.E. trade winds coming across the cape from the sea. The small caves have clean lava surface floors, without any soil, or midden deposits. The entrance and inside heights are less than 100 cm, but both caves have sufficient protected space for one or two persons to comfortably stretch out.

Site No. 5, Brackish Water Pond. This small anchaline pool, probably modified, is located immediately inshore of the cobble and boulder beach berm (and bulldozer trail) and is approximately 200 to 250 feet northeast of the southern edge of the study area kipuka and the newer (1960) flow area. The roughly eight figured - shaped pond is about 15 feet long by 5 to 8 feet wide, when the tide is high, at which time the water depth can be 2 to 2-1/2 feet. In September the pond had drinkable fresh water perched at the surface, and numerous small red shrimp - Opae. There are also patches of Lawai fern, and a variety of small peperomia around the inshore pond edges. At the inshore side is a steep tallus slope of loose, rough AA lava boulder blocks. At pond level there are indications that the pond edge may have been modified to provide easier access and open a larger basin area.

Site No. 6, Platforms. These are two modified natual outcrops with well paved, high platforms facing each other across a large pahoehoe lava flow channel. The smaller platform (Feature A) is 100 feet northwest of Site No. 5, or about 160 feet from the nearest shoreline. The other (Feature B) is some 200 feet further to the north, in the direction of the Light House. These sites may be those listed as Loo and Bonks' No. 68, or State Site No. 10-46-4250.

Feature A is a high, level topped platform, 2.8 meters by 1.6m of irregular, but roughly semi circulr plan, built up with a very nearly vertical wall to 2.1m height. The platform is to the northeast side of a small and slightly higher natural outcrop, or lava flow upthrust at the south edge of the flow channel. The vertical wall is well constructed of regularly sized angular natural lava cobbles. The platform core fill is of similar but smaller sized material, as is the resulting fairly course top pavement. The top provides one with a vantage point with an unbroken 360° view that is well above the surrounding lava flows.

The larger platform (Feature B) is inland and at slightly higher elevation than Feature A. The construction here is similar to that noted at Feature A, except that the two vertical walls here meet to form a right angle, forming a roughly rectangular platform that is built up against the southeast side of a high irregular natural hummock. The level course pavement measures 2.2m by 3.6m.

The vertical walls have a construction style very similar to that described for Feature A, and vary in height from 1.7m to 2m, due to the natural base they are built on. There is also a rough, slightly sloping terrace that approximately parallels the foot of the high walls. This terrace extends at least 1m out from the walls, providing a walkway along the edge of the slopeing hummock edge. Two large water worn coral cobble sized fragments were noted at this feature. One is included in the platform pavement, and measures 21cm in maximum dimension. The other is placed on a small ledge of the outcrop hummock, just above the pavement, and measures 23cm in length. A single, elongated, well water worn, dense basalt stone (40cm in length) rests prominently on the pavement at the top of the corner of the two wall faces.

No soil deposits, or midden material were located at either of these features. However, with the large coral cobbles and the small water worn basalt boulder present on the surface of the larger platform (B), the strong possibility exists that this feature is in fact a shrine of some sort, perhaps a Ko'a, or fishing shrine.

5. DISCUSSION. In October 1982, the location of the preferred harbor plan was realigned more to the south and west to avoid the sites identified during this reconnaissance. It is believed that this new configuration will avoid direct impact on the cultural sites attributed to the project.

As a result of the new design Corps of Engineers geologist (Bjorken) was dispatched to recheck the area of the new alignment. During that investigation a cluster of six or seven potential cultural features were identified in the middle of the relocated wave trap basin some 500 feet from the shoreline. This area happens to be a small isolated Kipuka that is surrounded by the 1960 flow. The features have been designated Site No. 7 here (see Table 1 and Figure 1). They are all low (waist high) rectangular platforms, mostly free standing, but with a few common or partially adjoining sides. The construction as described is different from that used at Site 4. Rectangular (in plan) walls slope back and up to the level top, with the walls constructed of cobble and small boulder sized lava fragments, that are immediately available naturally occuring material. Where visible, the core fill seemed to be similar but smaller sized material. A few of the platforms have been opened from the center of the top, and the interior exposed show use of large natural slabs of porous pahoehoe lava utilized for vaulting of small chambers. One was seen to have used corrugated sheet iron roofing for vaulting as well. Plants, ferns and small shrubs were noted growing out of the opened platforms.

A second smaller cluster (two or three features) of essentially identical platforms were later identified (and listed as Site No. 8) during the aerial photo analysis, identification and Location of Site No. 7.

6. PRELIMINARY EVALUATION AND RECOMMENDATIONS. On the basis of the style of construction and the remaining contents noted above it is concluded that sites 7 & 8) are historic period grave sites. A field assessment of the features in these two sites, by a qualified archaeological investigator is recommended, so that a determination of the presence or absence of human burial remains, and the graves possible period of construction and use can be made.

7. REFERENCES.

Hudson, Alfred E., 1932 MS, "Archaeology of East Hawaii." The B. P. Bishop Museum, Honolulu.

Kinney, Henry W., 1913, The Island of Hawaii. __________, Hilo.

Loo, Virginia and William J. Bonk, 1970, A Historical Site Study and Evaluation of North Hawaii. For the County of Hawaii, Hilo.

State of Hawaii (DLNR), 1973, Hawaii Register of Historic Places, Certification Forms. State Parks Div., Honolulu.

TABLE 1

ARCHAEOLOGICAL RESOURCES IDENTIFIED
DURING RECONNAISSANCE

SITE NO.	TYPE OF SITE (or name if known)	PREVIOUS SITE NOS. Hudson	Loo & Bonk	State of Hawaii (#10-46-)	REMARKS
1	'The King's Pillars' (2 rock mounds)	103	-	4250	
2	Petroglyphs (2 features)	?	-	-	Portion(s) may be those mentioned by Hudson (at #103).
	Area I (large group)	-	-	-	
	Area II (small cluster)	-	-	-	
3	Old Foot Trail	-	-	-	
4	Small Shelters (2)	-	-	-	
	Feature A	-	-	-	
	Feature B	-	-	-	
5	Water Source	-	-	-	
6	Platforms	?	68	4251	
	Feature A (near shore)	-			
	Feature B (inland) KOA	-			
7	Burials	-	-	-	
8	Burial	?	-	-	
-		(104)			Hudson's Site 104, "a 'rough shelter,' with an adjoining platform" was not relocated.

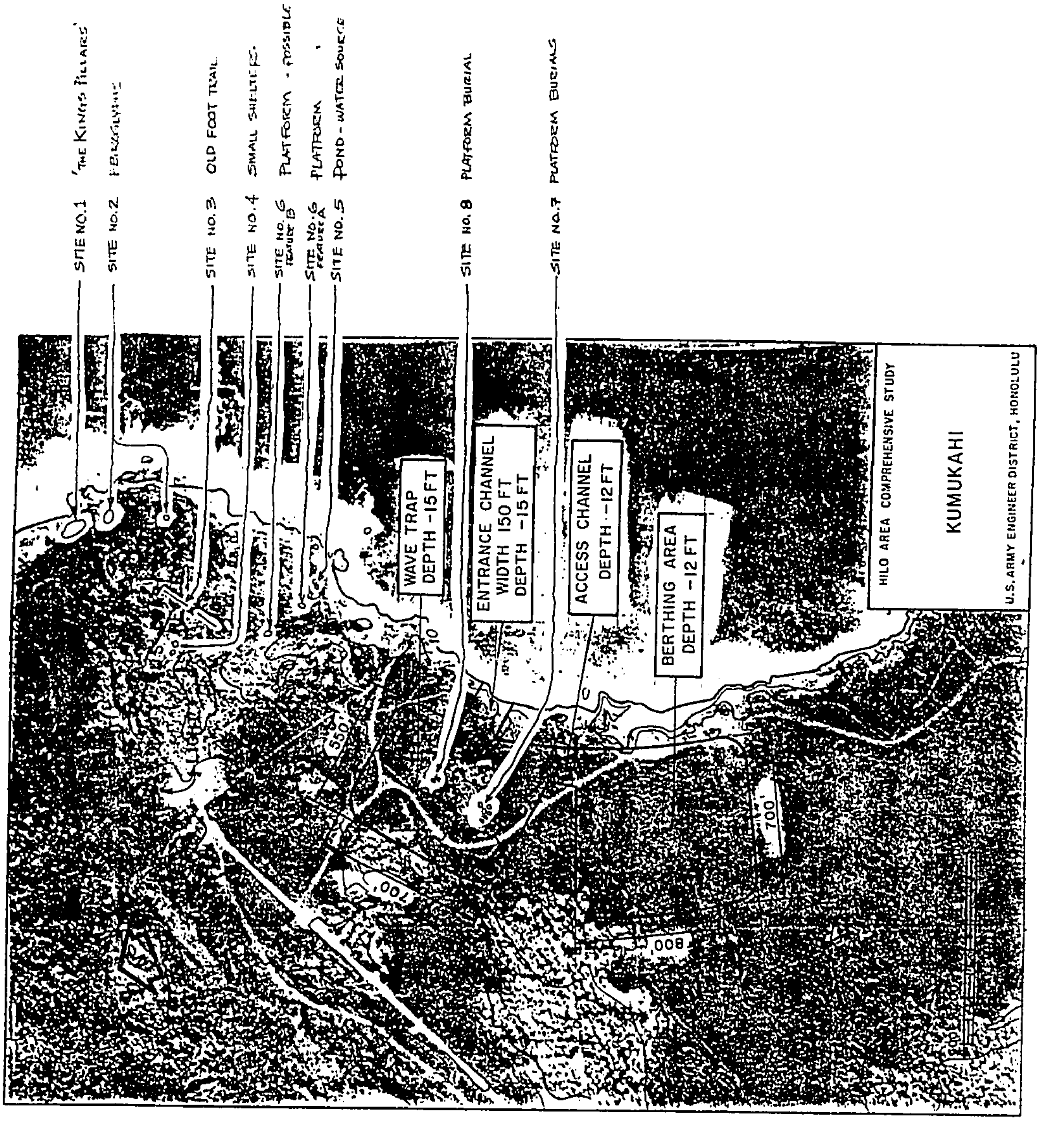

SITE NO.1 'THE KINGS PILLARS'
SITE NO.2
SITE NO.3 OLD FOOT TRAIL
SITE NO.4 SMALL SHELTERS
SITE NO.6 FEATURE B PLATFORM - POSSIBLE KO'A
SITE NO.6 FEATURE A PLATFORM
SITE NO.5 POND - WATER SOURCE
SITE NO.8 PLATFORM BURIAL
SITE NO.7 PLATFORM BURIALS
WAVE TRAP DEPTH -15 FT
ENTRANCE CHANNEL WIDTH 150 FT DEPTH -15 FT
ACCESS CHANNEL DEPTH -12 FT
BERTHING AREA DEPTH -12 FT
HILO AREA COMPREHENSIVE STUDY
KUMUKAHI
U.S. ARMY ENGINEER DISTRICT, HONOLULU
550
100
700
800

Figure 1

DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE PARKS DIVISION

HAWAII REGISTER OF HISTORIC PLACES

ARCHAEOLOGICAL FORMS

FEATURE DESCRIPTION FORM

50 - 1 0 (ISLAND) - 4 6 (QUAD) - 4 2 5 (IDENTIFICATION) 1 (NO.)

VERBAL DESCRIPTION MUST INCLUDE: bearings and sources used to locate feature; size; shape; construction technique; materials used; terrain features; condition; surface artifacts; midden. SIGNIFICANCE STATEMENT MUST INCLUDE: research potential; interpretive potential; unusual or important characteristics; probable function; importance as representative of its class; recommendation of Register status.

KUMAKAHI GRAVE SITE

Description:

Two possible grave sites of the puoa type are located eastward of the Coast Guard lighthouse at Cape Kumakahi. These are constructed of stacked lava rocks atop the older lava flows and have escaped destruction by the 1960 lava flow which surrounds the lighthouse and the graves.

The landscape surrounding the graves is relatively flat, barren, and brown. The kipuka in which the graves are situated is itself an older lava flow with little or no soil cover and the only vegetation here is pockets of fern and wild orchids growing in the crevices and niches of the lava folds.

The facing on the eastern or lower, makai puoa is at least 1 m high. It is semi-circular in shape and merges into the natural lava bedrock. The top or platform area measures approximately 2 m by 1 m wide. Condition of the grave is good.

The western and larger of the two is 2 m high with one square corner on the northeastern end. It has been faced and built up on its north and east sides while the south and west side merge into the natural lava ground level. The platform area measures approximately 1-1/2 meters square. Except for some rock fall in the southeastern section the condition of the structure is good.

No surface midden was noted near either site.

Significance:

We are recommending a reserve or valuable with local category significance for these two structures. They are in good condition and although the function is not certain they have acquired a good amount of significance for the local people who point out the fact that they (the graves, or heiaus as they are sometimes called) have escaped the anger of the volcano goddess Pele in the recent 1960 lava flow (who in her utmost fury destroyed the town of Kapoho just mauka of the lighthouse).

Incl 1

APPENDIX C

FISH AND WILDLIFE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P.O. BOX 50167
HONOLULU, HAWAII 96850

IN REPLY REFER TO:
ES
Room 6307

APR 7 1983

Colonel Alfred J. Thiede
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858

Re: Draft Coordination Act Report for Cape Kumukahi Small Craft Harbor Study

Dear Colonel Thiede:

This is the U.S. Fish and Wildlife Service's Draft Coordination Act Report regarding plans of the Honolulu District to construct small boat harbor facilities at Cape Kumukahi, Hawaii. Cape Kumukahi lies within the Hilo Comprehensive Water Resources Study planning area. This draft report has been prepared under the authority of and in accordance with the provisions of Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and other authorities mandating Department of Interior concern for environmental values. It is also consistent with the intent of the National Environmental Policy Act.

These comments are preliminary in nature and are subject to revision. Additional Service comments and recommendations will be provided in a Final Coordination Act Report. The Service's final report will be published in a revised format.

This report has been prepared by John Ford and Yvonne Ching using the results of previous planning studies conducted in the Hilo area, current scientific literature, results of joint-agency field surveys conducted by John Ford and William Lennan in June 1982, and numerous planning reports and conceptual drawings provided by the Honolulu District. Commercial fishery catch statistics, which were provided to the Honolulu District with our Planning Aid Letter, were made available to us by Ken Yoshida, State Division of Aquatic Resources.

Access to waters off Cape Kumukahi was made possible by rental of a commercial fishing vessel piloted by Mr. Wesley Kailimai.

DESCRIPTION OF THE PLANNING AREAS

The Hilo Comprehensive Water Resources Study area is located on the eastern side of the island of Hawaii (Figure 1), and includes approximately 1300 square miles of land (Reference 14). Alternative small boat harbor sites which have been evaluated by the Corps include Cape Kumukahi, King's Landing and Leleiwi Point The Honolulu District has identified Cape Kumukahi as the preferred site for location of a small craft harbor. Previous studies which present detailed descriptions of the geology, hydrology, oceanography, water quality, and fish and wildlife resources in these areas include References 2, 4, 8, 10-12, and 15-20.

1. Leleiwi Point

The Leleiwi Point site is located approximately 4 miles east of Hilo (Figure 2). The coastline at this site consists of basalt boulders and jagged lava cliffs of varying heights. The proposed alternative site is accessible by a dirt road which adjoins the terminus of Kalanianaole Highway.

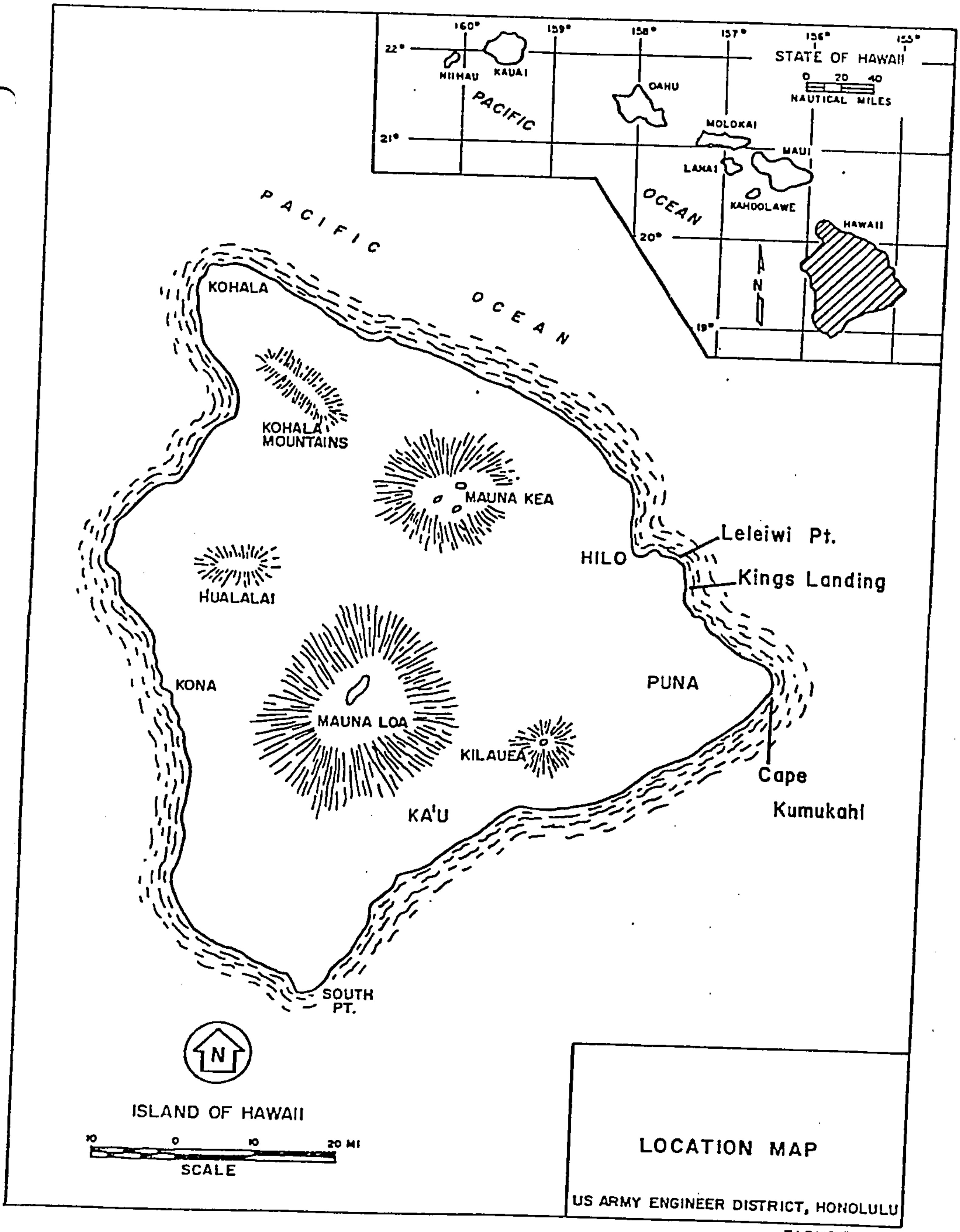
This alternative site has been rejected by the Corps from consideration for a small craft harbor due to the projected increase in vehicular traffic along Kalanianaole Highway, the unacceptable oceanographic conditions at the site (high frequency of storm waves), and the loss of a valuable recreational fishing and picnicking area. The conceptual plan which had been under consideration is shown in Figure 3.

a. Fish and Wildlife Resources

The site is dominated by common, salt resistant, strand plants (Table 1). An extensive tidepool complex lies on the site. The open water areas are permanently flooded. These pools are influenced by daily tidal rhythms. Based upon physicochemical measurements made at the ponds (Reference 20), it is probable that the ponds receive fresh water discharged from springs in the area.

The site supports a relatively diverse assemblage of both aquatic and marine life (Table 2). There are no terrestrial or aquatic species listed or eligible for listing as threatened or endangered within the study area. However, the threatened green sea turtle (Chelonia mydas) and the endangered hawksbill turtle (Eretmochelys imbricata) are known to forage along this coastline. There are no known nesting beaches for these species at Leleiwi Point. Endangered humpback whales (Megaptera novaeangilae) make seasonal migrations into coastal Hawaiian waters and may pass offshore of the site.

Because of its relatively undisturbed nature and its proximity to Hilo, Leleiwi Point is a very popular area for recreational fishing, swimming and family picnicking.



LOCATION MAP

US ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 1

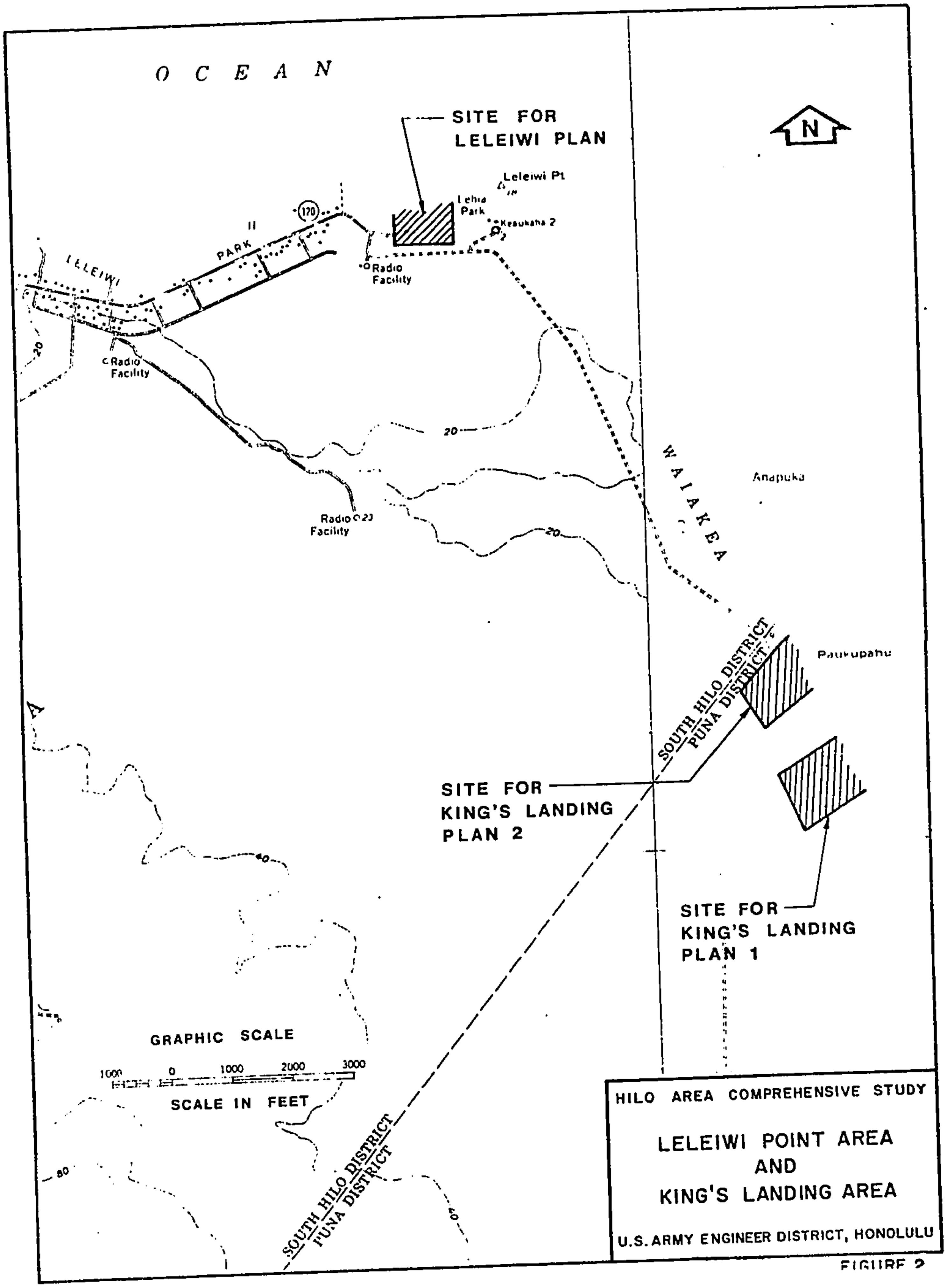

OCEAN
SITE FOR
LELEIWI PLAN
Leleiwi Pt
Lehia
Park
Keaukaha 2
170
LELEIWI
PARK
Radio
Facility
Radio
Facility
Radio
Facility
20
WAIAKEA
Anapuka
Paukupahu
SOUTH HILO DISTRICT
PUNA DISTRICT
SITE FOR
KING'S LANDING
PLAN 2
SITE FOR
KING'S LANDING
PLAN 1
GRAPHIC SCALE
1000 0 1000 2000 3000
SCALE IN FEET
40
80
HILO AREA COMPREHENSIVE STUDY
LELEIWI POINT AREA
AND
KING'S LANDING AREA
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 2

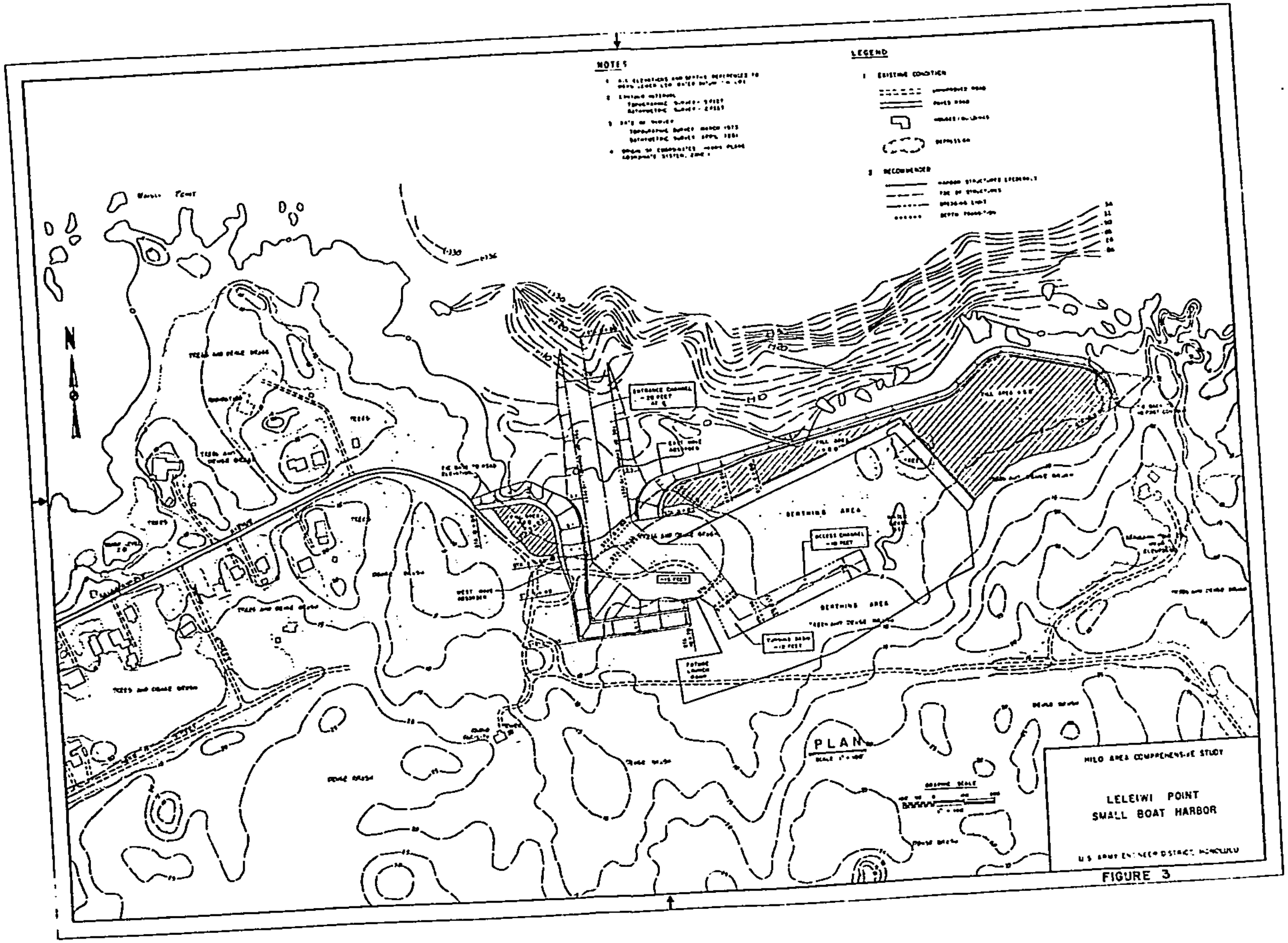

NOTES
LEGEND
EXISTING CONDITION
RECOMMENDED
ENTRANCE CHANNEL
BERTHING AREA
BERTHING AREA
ACCESS CHANNEL
TURNING BASIN
FUTURE LAUNCH RAMP
PLAN
HILO AREA COMPREHENSIVE STUDY
LELEIWI POINT
SMALL BOAT HARBOR
N
FIGURE 3

TABLE 1

Flora Observed at Leleiwi Point and King's Landing Sites During August Survey

Species	Leleiwi Point	King's Landing 1 & 2
Ardisia humilis Vahl	X	X
Brachiaria mutica (Forsk.) Stapf.	X	X
Brassara actinophylla Endl.		X
Casuarina equisetifolia Stickm.	X	X
Cladium leptostachyum Nees & Meyen		X
Cocos nucifera L.		X
Commelina diffusa Burm. f.	X	X
Cordyline terminalis (L.) Kunth		X
Cyperu polystachyus Rottb.		X
Dicranopteris sp.		X
Ficus spp.		X
Hibiscus tiliaceus L.	X	X
Ipomoea brasiliensis (L.) Sweet		X
Lemna minor L.		X
Leucaena leucocephala (Lam.) de Wit	X	X
Metrosideros polymorpha Gaud	X	X
Nephrolepis exaltata (L.) Schott		X
Orchidaceae, 2 species		X
Pandanus odoratissimus L.	X	X
Passiflora foetida L.		X
Psidum cattleranum Sabine		X
Psidium guajava L.	X	X
Scaevola taccada (Gaertn.) Roxb.		X
Scirpus validus Vahl	X	X
Spathoglottis plicata		X
Sporopolus virginicus (L.) Kunth		X
Terminalia spp.	X	X
Tibouchina urvilleana (DC.) Cogn		X
Zingiber zerumbet (L.) Roscoe in Sn.	X	

TABLE 2

Checklist of Fauna Observed During a Survey May 20, 1981 of the Leleiwi Point Site and a Survey August 25, 1981 of the King's Landing Site for the Hilo Bay Navigation Improvement Project

	Leleiwi Point	King's Landing
MAMMALS		
Felis catus	X	
Herpestes auropunctatus	X	X
REPTILES		
Chelonia mydas (Linnaeus)	X	X
BIRDS		
Acridotheres tristis	X	X
Cardinalis cardinalis	X	X
Geopelia striatia	X	X
Lonchura punctulata	X	X
Pluvialis dominica fulva	X	X
Streptopelia tristis	X	X
Zosterops japonica	X	X
FISHES		
ACANTHURIDAE		
Acanthurus achilles Shaw	X	
Acanthurus dussumieri Cuvier & Valenciennes		X
Acanthurus guttatus Bloch & Schneider		X
Acanthurus leucopareius (Jenkins)	X	
Acanthurus nigrofuscus (Forsskal)	X	X
Acanthurus olivaceous (Bloch and Schneider)	X	X
Acanthurus triostegus (Linnaeus)	X	X
Naso literatus (Bloch & Schneider)	X	X
Naso unicornis (Forskal)	X	X
Zebrasoma flavescens (Bennett)	X	X
Zebrasoma veliferum (Bloch)		X
AULOSTOMIDAE		
Aulostoma chinensis (Linnaeus)		X
BALISTIDAE		
Melichthys niger (Bloch)	X	X
Rhinecanthus aculeatus (Linnaeus)	X	

CARANGIDAE		
Caranx melampygus Cuvier and Valenciennses		X
CHAETODONTIDAE		
Chaetodon auriga Forskal	X	X
Chaetodon citrinellus Forskal	X	
Chaetodon fremblii Bennett	X	
Chaetodon lunula (Lacepede)	X	X
Chaetodon miliarus Quoy & Gaimard		X
Chaetodon ornatissimus Cuvier & Valenciennses	X	X
Chaetodon quadrimaculatus Gray	X	X
Chaetodon unimaculatus Block	X	
Forcipiger sp.	X	X
Zanclus cornutus Linnaeus	X	
KYPHOSIDAE		
Kyphosus cinerescens (Forsskal)		X
LABRIDAE		
Halichoeres ornatissimus (Garrett)		X
Thalassoma duperrey (Quoy & Gaimard)		X
MULLIDAE		
Mulloidichthys flavolineatus (Lacepede)	X	X
Parupeneus multifasciatus (Quoy & Gaimard)	X	X
Parupeneus porphyreus (Jenkins)	X	X
POMACENTRIDAE		
Abudefduf abdominalis (Quoy & Gaimard)	X	
Pomacentrus jenkinsi Jordan & Everman	X	
SCARIDAE		
Scarus perspicillatus Steindachner	X	X
INVERTEBRATES		
CNIDARIA		
Montipora flabellata Studer	X	
Montipora verrucosa (Lamark)	X	
Palythoa tuberculosa (Esper)	X	

CORRECTION

THE PRECEDING DOCUMENT(S) HAS
BEEN REPHOTOGRAPHED TO ASSURE
LEGIBILITY
SEE FRAME(S)
IMMEDIATELY FOLLOWING

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Scirpus validus Vahl	X	X
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Tibouchina urvilleana (DC.) Cogn		X
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Geopelia striatia	X	X
Lonchura punctulata	X	X
Pluvialis dominica fulva	X	X
Streptopelia tristis	X	X
Zosterops japonica	X	X
FISHES		
ACANTHURIDAE		
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Acanthurus nigrofuscus (Forsskal)	X	X
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AULOSTOMIDAE		
Aulostoma chinensis (Linnaeus)		X
BALISTIDAE		
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Rhinecanthus aculeatus (Linnaeus)	X	

CARANGIDAE		
Caranx melampygus Cuvier and Valenciennses		X
CHAETODONTIDAE		
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Chaetodon citrinellus Forskal	X	
Chaetodon fremblii Bennett	X	
Chaetodon lunula (Lacepede)	X	X
Chaetodon miliarus Quoy & Gaimard		X
Chaetodon ornatissimus Cuvier & Valenciennses	X	X
Chaetodon quadrimaculatus Gray	X	X
Chaetodon unimaculatus Block	X	
Forcipiger sp.	X	X
Zanclus cornutus Linnaeus	X	
KYPHOSIDAE		
Kyphosus cinerescens (Forsskal)		X
LABRIDAE		
Halichoeres ornatissimus (Garrett)		X
Thalassoma duperrey (Quoy & Gaimard)		X
MULLIDAE		
Mulloidichthys flavolineatus (Lacepede)	X	X
Parupeneus multifasciatus (Quoy & Gaimard)	X	X
Parupeneus porphyreus (Jenkins)	X	X
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Abudefduf abdominalis (Quoy & Gaimard)	X	
Pomacentrus jenkinsi Jordan & Everman	X	
SCARIDAE		
Scarus perspicillatus Steindachner	X	X
INVERTEBRATES		
CNIDARIA		
Montipora flabellata Studer	X	
Montipora verrucosa (Lamark)	X	
Palythoa tuberculosa (Esper)	X	

Pocillapora meandrina Dana	X	X
Porites compressa Dana	X	
Porites lobata Dana	X	
CRUSTACEA		
Grapsus grapsus tenuicrustatus (Herbst)	X	X
MOLLUSCA		
Cellana exarata (Reeve)	X	X
Cellana sandwicensis (Pease)	X	
Littorina pintado (Wood)		X
Theodoxus neglectus (Pease)	X	
ECHINODERMATA		
Colobocentrotus atratus (Linnaeus)	X	X
Echinometra mathaei Blainville	X	
Echinothrix diadema (Linnaeus)	X	
Tripneustes gratilla (Linnaeus)	X	

2. King's Landing

Two alternative sitings for a small craft harbor were evaluated at King's Landing, which is located about seven miles east of Hilo (Figure 2). The area is accessible by a crushed rock road from the vicinity of Leleiwi Point. The geomorphology of the coastline at this site is similar to Leleiwi Point.

The coastline is also visited by recreational fishermen, but not with the same frequency as Leleiwi. It is a more remote area and subject to attack by storm waves. The Corps has concluded that construction of a small boat harbor at this site may not be practicable unless the impact of high waves upon navigation safety can be mitigated. The two alternative plans which were considered are illustrated in Figures 4 and 5.

a. Fish and Wildlife Resources

Environmental resources at this alternate site are similar to those at Leleiwi Point (Table 1 and 2).

3. Cape Kumukahi

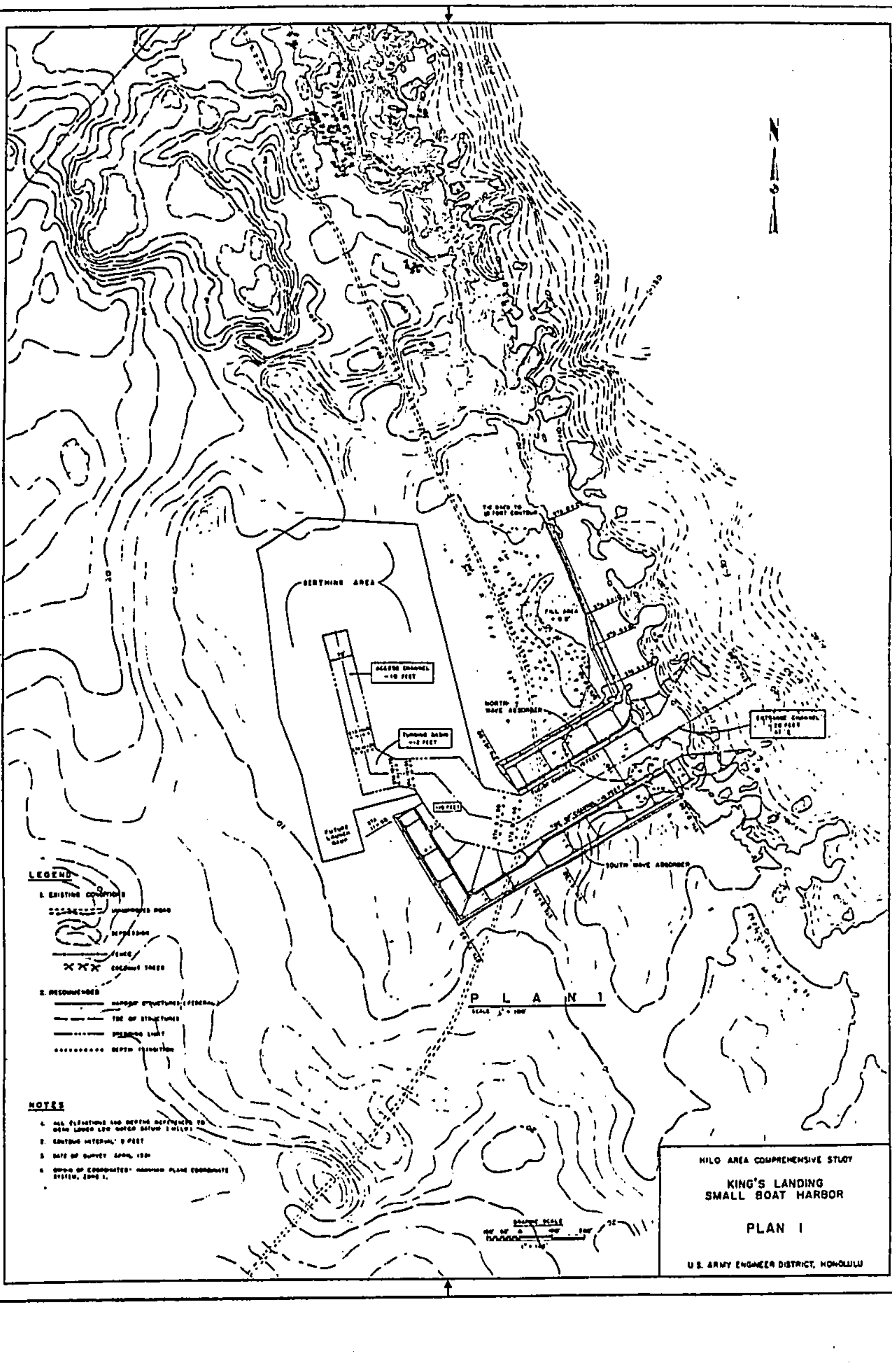
Few previous studies of this area exist (References 3, 5, and 13). The site is situated along the eastern-most tip of Hawaii island and is exposed to trade winds and windward seas. Cape Kumukahi lies on the east rift of the Kilauea volcano. Its shoreline was drastically altered during the 1960 eruption along the east rift (Reference 9).

The coastline at Cape Kumukahi is rugged a'a lava (Figure 6) standing some 20' above sea level. The submerged coastline consists of vertical lava walls fronted by large, lava boulders. This boulder field extends outward to a depth of approximately 25-40 feet. Beyond the boulders, the bottom consists of black sand and occasional massive outcroppings of lava (Figures 7 and 8).

Water clarity along this coastline during the unusually calm conditions experienced in June 1982 was excellent, possibly exceeding 80' in horizontal visibility. Reference 6 suggests that predominant easterly ocean currents here diverge toward the northwest and southwest along the shore. There is no evidence of significant freshwater seepage from basal groundwater aquifers into nearshore waters.

a. Fish and Wildlife Resources

The vegetation within the shoreward portion of the study area at Cape Kumukahi consists of Christmas berry (Schinus terebinthifolius), beach morning glory (Ipomoea pes-caprae), ohia (Metrosideros collina), noni (Morinda citrifolia), naupaka (Scaevola taccada), sourbush (Pluchea symphytifolia), sword fern (Nephrolepis sp.), 'ama'u (Sadleria cyatheoides), hala (Pandanus



BERTHING AREA
NORTH WAVE ABSORBER
SOUTH WAVE ABSORBER
ENTRANCE CHANNEL
TURNING BASIN
FILL AREA
P L A N 1
LEGEND
NOTES
HILO AREA COMPREHENSIVE STUDY
KING'S LANDING
SMALL BOAT HARBOR
PLAN I
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 4

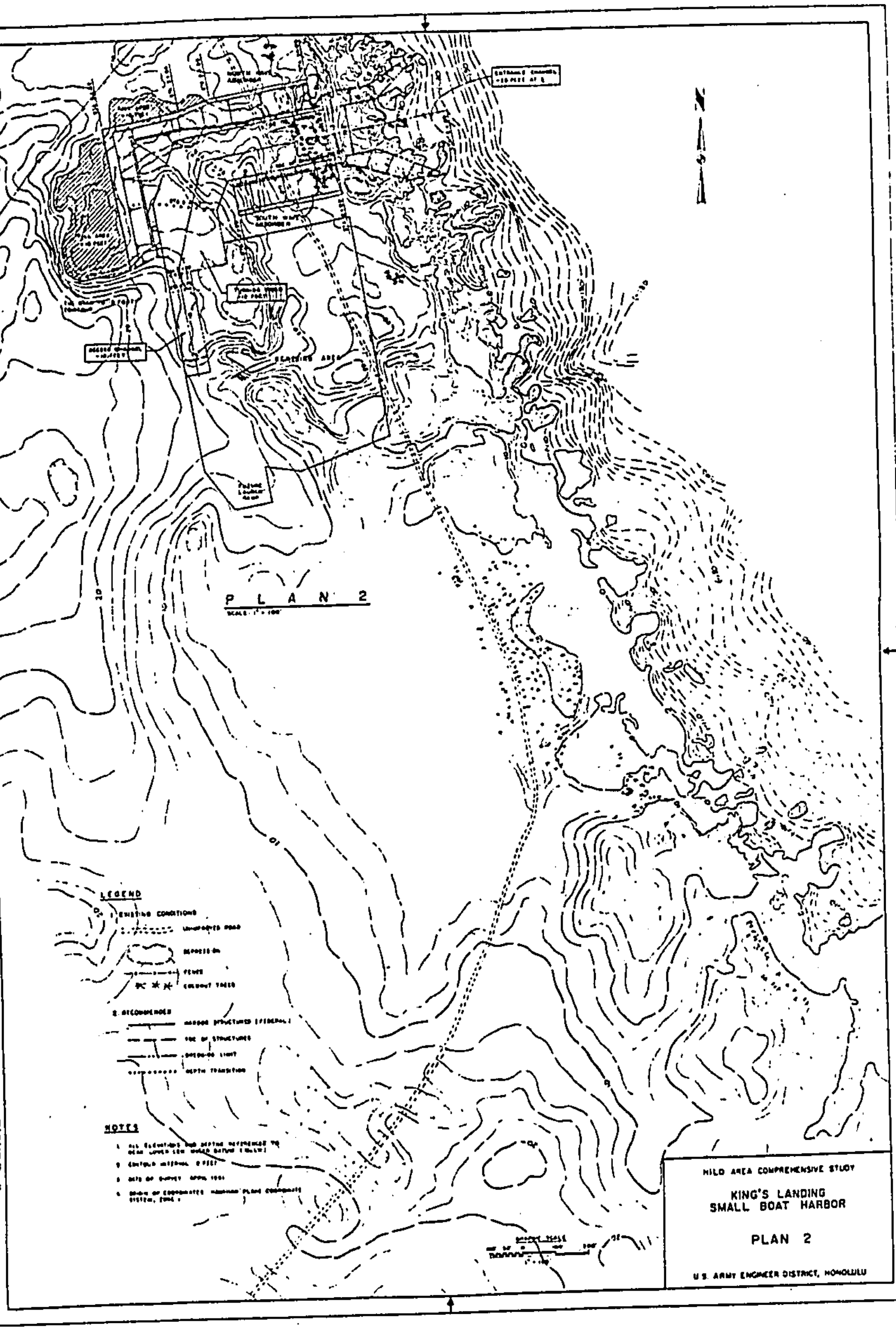

PLAN 2
LEGEND
NOTES
HILO AREA COMPREHENSIVE STUDY
KING'S LANDING
SMALL BOAT HARBOR
PLAN 2
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 5

FIGURE 6. The rugged lava coastline at Cape Kumukahi is exposed to northeasterly trade winds and seas. Portions of this landscape were created by lava flows as recently as 1960. The interidal zone and perched tidal pools along shore support populations of common marine organisms.

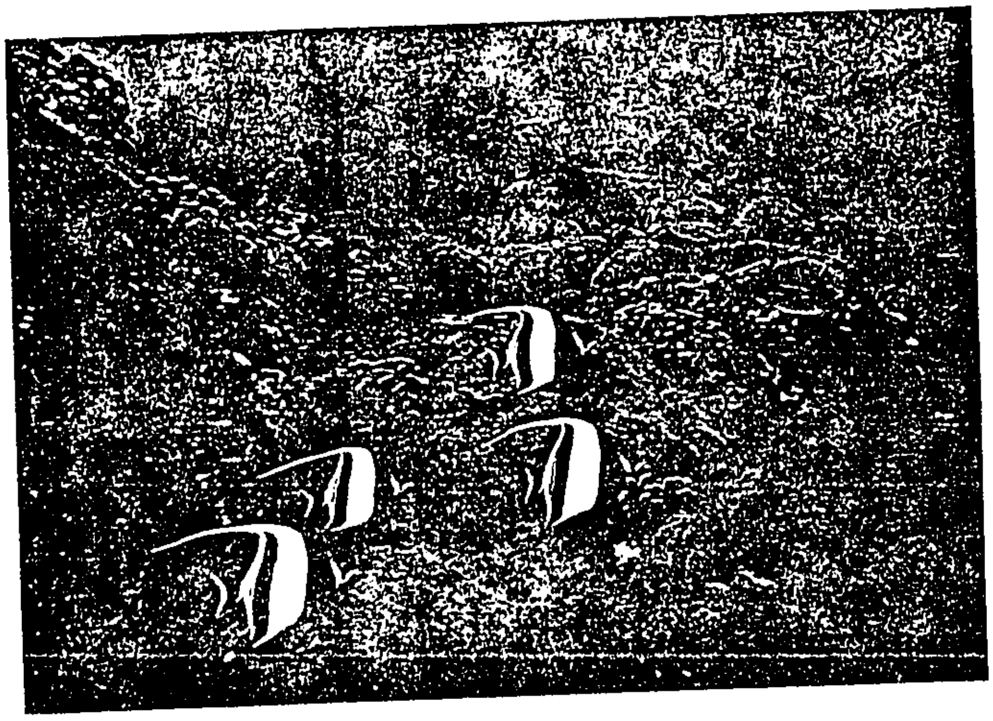


FIGURE 7. Large basalt boulders lie at the base of the sea cliffs at Cape Kumukahi in depths of 15-25'. Stoney coral growth is sparse in this high energy environment.

FIGURE 8. Taape, or blueline snapper (Lutjanus kasmira) are abundant at Cape Kumukahi and seek shelter in rock caves, ledges, and interstices at depths between 15-75'. Despite the fact that the species was introduced from French Polynesia to enhance local fisheries, many commerical fishermen do not fish for taape since it has a relatively low market value. Cape Kumukahi does, however, provide habitat for other species of commercial value.

FIGURE 9. The coastline inland from the shore at Cape Kumukahi is sparsely vegetated with common, native strand plants. Most vegetation is concentrated in small depressiors in the lava terrain.

odoratissimus) and a strand grass (Fimbristylis pycnocephala) (Figure 9).

Table 3 lists intertidal organisms and fishes observed during a reconnaissance survey performed in June 1982. It is apparent that there were large numbers of several reef fishes known to be of commercial fishery value at this site, including menpachi, kumu, weke, kala, uku and taape.

Discussions with commercial fishermen and records of the State Department of Land and Natural Resources suggest that a great deal of commercial trolling, bottom fishing, spearfishing and shore fishing occur along this coastline despite the normally rough seas. Reference 8 (Sub-appendix F) contains commercial fisheries surveys which indicate a substantial amount of fishing effort along this coastline. The economic importance of this fishery is evaluated in References 4, 8, and 15. Commercial fishery statistics for the period 1977 - 1981 demonstrate that aku (skipjack), ahi (yellowfin and bigeye), ono (wahoo) and billfishes from this area yield greater monetary value than other commercially important species.

DESCRIPTION OF THE PROPOSED PROJECT

Two conceptual designs are under consideration for a small craft harbor at Cape Kumukahi: (1), a double basin harbor with 200 berthing spaces; and (2), a single basin harbor with no berthing spaces (Figures 10 and 11). The first alternative is the tentatively selected plan and has been designated as the National Economic Development Plan (NED). Although design is anticipated to take only one year to complete, construction may last as long as 20 years. Total Federal cost for the project, without mitigation, is estimated to be $17.6 million.

Construction would include excavation of an entrance channel 15 feet deep and 150 feet wide, an absorber basin 15 feet deep and 400 feet long by 600 feet wide. The second basin would be connected to the absorber basin by an access channel 12 feet deep and 150 feet wide. The berthing basin would be 12 feet deep and 700 feet long by 800 feet wide. A small craft launching ramp would be provided.

Excavation is expected to involve drilling, blasting and dredging. Excavated basalt sediments will be disposed of on-site; however some material may be used to fill during placement of armor stone units. In order to prevent excessive damage to offshore benthic resources and to protect coastal water quality, excavation of the harbor access and berthing basins will be completed prior to opening the entrance channel to the sea. The channel and basins will be protected by an armor stone revetment. Armor stone will be obtained from existing quarries on the Island of Hawaii.

Table 3. Checklist of fishes and invertebrates observed within the intertidal zone (*) and in nearshore waters at Cape Kumukahi in June 1982. "R" indicates species reported by commercial fishermen, but not observed during this survey.

FISHES

ACANTHURIDAE

Acanthurus achilles Shaw
A. dussumieri Cuvier & Valenciennes
A. leucopareus (Jenkins)
A. triostegus sandvicensis Randall *
Naso literatus (Bloch & Schneider)
N. unicornis (Forskal)

BALISTIDAE

Rhinecanthus rectangulus (Bloch & Schneider) *
Melichthys niger (Lacepede)
M. vidua (Solander)
Sufflamen bursa (Bloch & Schneider)

BLENNIDAE

Istiblennius zebra (Vaillant & Sauvage) *
Plagiotremus ewaensis Randall

CANTHIGASTARIDAE

Canthigastar jactator (Jenkins)

CARANGIDAE

Caranx melampygus Cuvier & Valenciennes
Scomberoides sancti-petri (Cuvier)

CARCHARHINIDAE

Galeocerdo cuvieri (Leseuer) - R

CHAETODONTIDAE

Centropyge potteri (Jordan & Metz)
Chaetodon fremblii Bennett
C. lunula (Lecepede)
C. miliaris Quoy & Gaimard
C. milticinctus Garret
C. quadrimaculatus Gray
Holacanthus arcuatus Gray

Table 3. (Continued)

CIRRHITIDAE

Cirrhitops faciatus
C. pinnulatus
Paracirrhites arcatus (Quoy & Gaimard)

GOBIIDAE

Bathygobius sp. *

HOLOCENTRIDAE

Adiroyx tiere (Cuvier & Valenciennes)
Myripristis berndti Jordan & Evermann

KYPHOSIDAE

Kyphosus cincerascens (Forskal)

LABRIDAE

Coris *ballieui* Vaillant & Sauvage
C. flavovittata (Bennett)
C. gaimardi (Quoy & Gaimard)
Labroides phthirophagus Randall
Thalasomma duperrey (Quoy & Gaimard)

LUTJANIDAE

Aprion virescens
Lutjanus fulvus
L. kasmira

MOBULIDAE

Manta alfredi (Krefft)

MONOCANTHIDAE

Cantherhines dumerili
C. sandwinchensis (Quoy & Gaimard)

MULLIDAE

Mulloidychthys samoensis (Gunther)
Parupeneus cyclostomus
P. multifasciatus (Quoy & Gaimard)
P. porphyreus Jenkins

Table 3. (Continued)

POMACENTRIDAE

Abudefduf abdominalis (Quoy & Gaimard)
A. sordidis (Forskal)*
Chromis sp. *
C. hanui Randall
C. vanderbilti (Fowler)
Stegastes fasciolatus
Forcipiger flavissimus
F. longirostris

SCARIDAE

Scarus rubroviolaceus

SCOMBRIDAE

Thunnus albacares (Bonnaterre)

SPARIDAE

Monotaxis grandoculis (Forskal)

SPHYRNIDAE

Sphyrna lewini (Griffith) - R

ZANCLIDAE

Zanclus cornutus (Linnaeus)

INVERTEBRATES

PORIFERA (1 sp.)

CNIDARIA

Antipathes sp.
Palythoa sp.
Pocillopora damicornis (Linnaeus)
P. meandrina Dana
P. sp. *
Montipora verrili Vaughan

ANNELIDA

Spirobranchus sp.

Table 3. (Continued)

MOLLUSCA

Cellana exarata (Reeve)
Drupa ricina (Linnaeus)
Nerita picea (Recluz)

HOLOTHUROIDEA

Colobocentrotus arcuatus
Echinometra mathei
E. oblonga
Heterocentrotus mammilatus
Linckia multiflora

CRUSTACEA

Grapsus grapsus tenuicrustatus Herbst

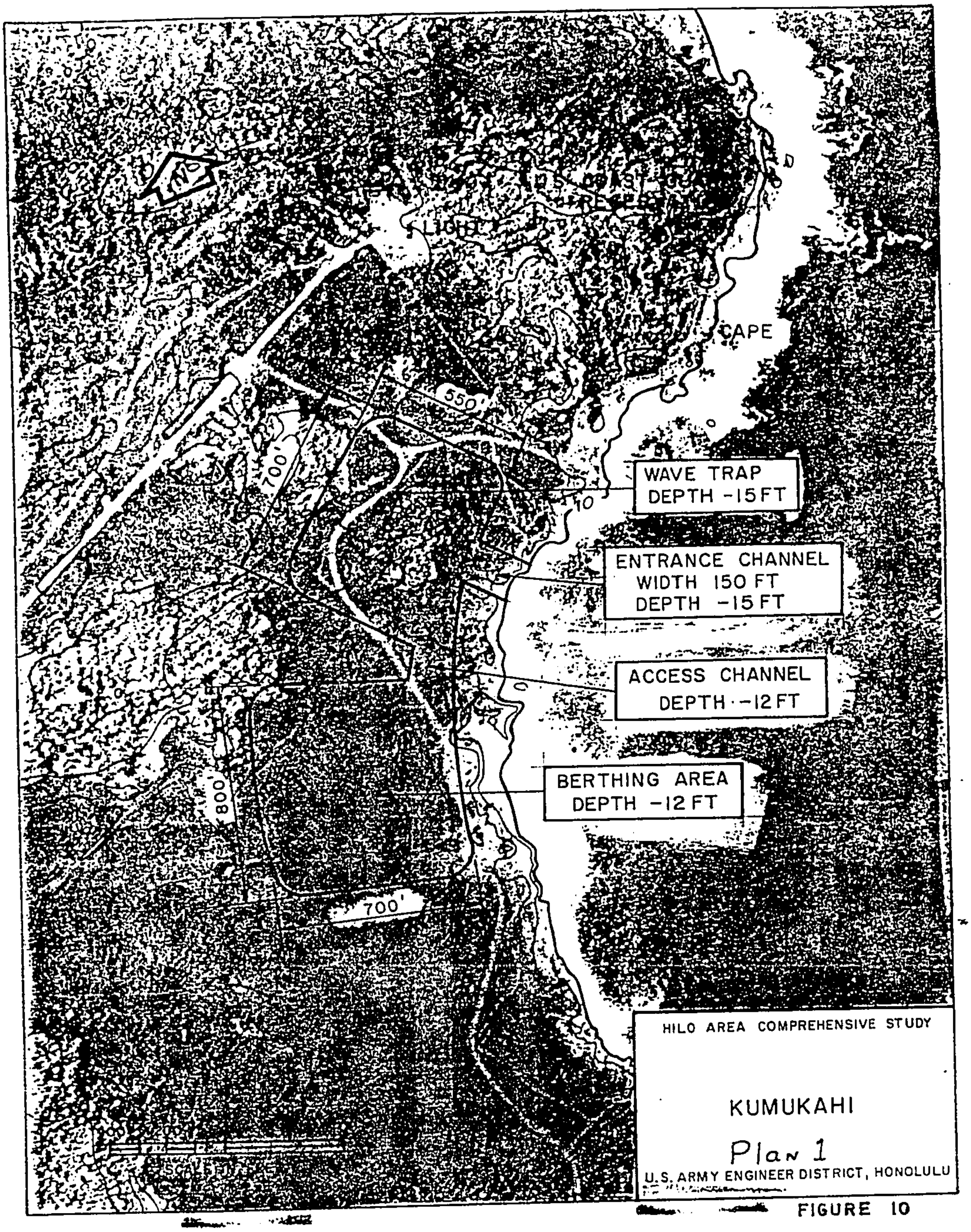

CAPE
LIGHT
550'
700'
800
700'
10
WAVE TRAP
DEPTH -15 FT
ENTRANCE CHANNEL
WIDTH 150 FT
DEPTH -15 FT
ACCESS CHANNEL
DEPTH -12 FT
BERTHING AREA
DEPTH -12 FT
HILO AREA COMPREHENSIVE STUDY
KUMUKAHI
Plan 1
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 10

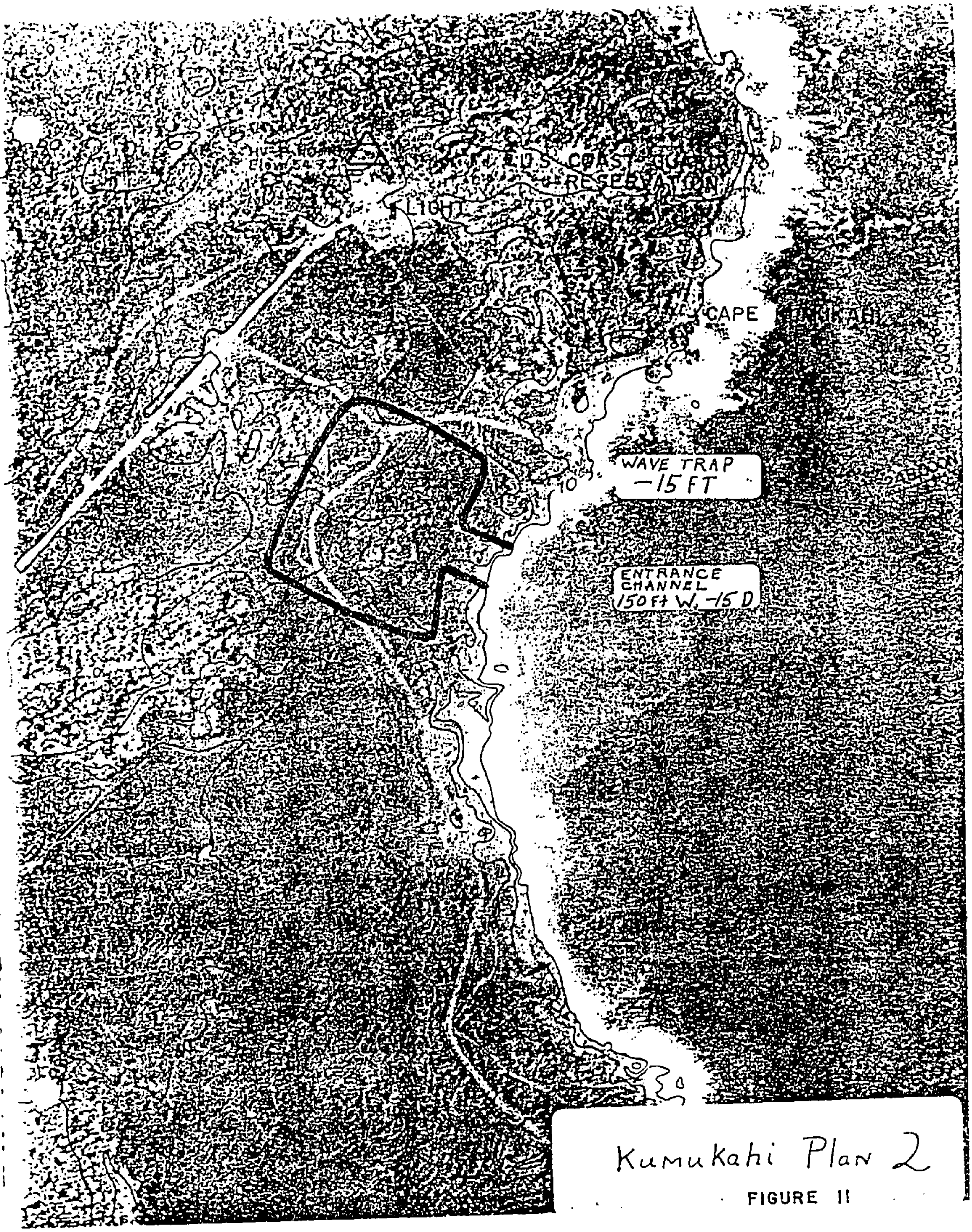

US COAST GUARD
RESERVATION
LIGHT
CAPE
WAVE TRAP
-15 FT
ENTRANCE
CHANNEL
150 Ft W. -15 D
Kumukahi Plan 2

FIGURE II

Additional improvements to the site include an access road, wastewater treatment plant and solid waste processing facilities.

SUMMARY OF ENVIRONMENTAL CONSEQUENCES

Potential impacts common to the construction of all the small craft harbors discussed here include temporary degradation of water quality parameters (specifically, increased turbidity, increased dissolved and suspended nutrients, and biological oxygen demand; and decreased dissolved oxygen concentrations and pH). In some areas, this may lead to loss of benthic resources and habitat in areas adjacent to project sites. These impacts may be minimized by implementation of careful construction methods (refer to Recommendations). Construction of each project may lead to temporary restrictions upon access for shore fishermen, and reduced fishing success. Potential site-specific impacts are reviewed in the following paragraphs.

Leleiwi Point and King's Landing

No significant losses of terrestrial habitat are anticipated at either location. The valuable tidepool habitat at Leleiwi Point and the recreational use of the area would be lost by construction of a small harbor. Recolonization of stoney corals and benthic invertebrates is expected to occur within a period of two to five years.

Cape Kumukahi

No significant losses of terrestrial fish and wildlife resources are expected.

Rich benthic coral communities are not found offshore; therefore, significant resource losses due to construction-generated sedimentation are not anticipated. Blasting and dredging will lead to some mortality of intertidal and fishery resources, and is expected to attract predatory species to the vicinity of construction. No significant changes to dissolved nutrient concentrations are expected due to construction; however, long-term changes from harbor use activities will undoubtedly elevate nutrient levels if adequate flushing is not provided. Runoff and spillage of pollutants such as petroleum products, terrigenous sediments, and sewage are expected to be long-term problems incidental to operations within the proposed small boat harbor. These water quality problems will be exaggerated by poor flushing characteristics.

The completed harbor will provide suitable hard substrata for recolonization of benthic invertebrates. Since the source of propagules for many of these invertebrates will be outside the harbor, recolonization may proceed at a slower rate within the harbor (provided that environmental conditions are appropriate for their growth) (Reference 11). This reference documents the appearance of marine fishes, invertebrates and algae following excavation and construction of a small boat harbor at Honokohau, Kona, Hawaii.

Accumulation of sediments within the harbor basin may also serve to inhibit recolonization of some organisms. The numbers of animals inhabiting the harbor basin is expected to increase with time; however, continual changes in community structure are also expected over time.

The completed harbor would provide a safe access along the perennially rough eastern coastline of Hawaii for recreational and commercial fishing vessels. However, it would also enable a larger number of fishing vessels to operate in this area (some of which may come from other areas of Hawaii). This will lead to an increase in catch effort for certain commercially valuable species. As a consequence of enhanced access to fishery stocks and increased fishing effort, local reduction of some important fish stocks and confrontations between fishermen may occur. Commerical fishing at Cape Kumukahi is expected to decline due to increased boat traffic around the harbor entrance, and reduced fish populations resulting from harbor construction.

Increased boating and fishing activity along the Puna and eastern Hilo coastlines is also expected to increase the frequency of encounters between small craft and endangered or threatened species under the jurisdiction of the National Marine Fisheries Service and the State of Hawaii. This fact, along with the anticipated increase in fishing, may require the commitment of additional State funds to support the appropriate staffing levels for Department of Land and Natural Resources enforcement personnel on Hawaii.

RECOMMENDATIONS

The Service recommends that Leleiwi Point be dropped from further consideration as a site for small craft harbor construction because of the probable adverse impacts on recreational fishing. We sugggest that the Corps adopt the following general measures in project planning to avoid or minimize adverse impacts upon fish and wildlife resources.

1. Offshore blasting should not be conducted during the normal migratory season for endangered humpback whales in Hawaiian waters.

2. Where practicable, harbor facilities should be oriented to take advantage of natural flushing and circulation characteristics of existing current patterns.

3. The use of ungrouted, sloping riprap in lieu of vertical concrete and grouted riprap structures is encouraged to provide additional intertidal and interstitial habitat.

4. Inner boat basins should be dredged to project depth prior to opening the entrance channel.

5. Floating boat slips or pile-supported structures are encouraged in lieu of facilities requiring fill within boat basins.

6. Conscientious water quality monitoring programs should be established to check excessive construction-related degradation to nearshore waters and marine life, and to evaluate the project's possible effect on the occurrence of ciguatera.

7. Public on-shore recreational fishing should be accommodated, and the necessary public conveniences should be provided.

Sincerely,

William R. Kramer
Acting Project Leader,
Office of Environmental Services

Enclosure: Bibliography

cc: Hawaii DAR
NMFS-WPPO
RD, FWS, Portland, OR (AE)

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SUPPORTING DOCUMENTATION

ENGINEERING INVESTIGATIONS AND DESIGN

APPENDIX D

SECTION I. DESIGN ANALYSIS SECTION: SMALL BOAT HARBOR

LIST OF PLATES

LIST OF TABLES

APPENDIX D

DESIGN ANALYSIS SECTION

1. GENERAL CRITERIA

a. FORMULATION AND ANALYSIS. The formulation and analysis of the alternative plans were based on the Waters Resources Council's Principles and Standards, and applicable Corps regulations and guidelines on planning process.

b. TECHNICAL CRITERIA. The following technical criteria were adopted for use in developing alternative plans:

(1) The design of the protective works will allow for minor overtopping by a design wave which could be expected from a theoretical 50-year hurricane and hydrological conditions;

(2) The entrance channel is to be of adequate depth and width to safely accommodate two-way traffic by the design vessel and the turning basin is to provide a safe maneuvering area. The prevailing wind and wave approach directions are to be evaluated to determine safe channel alignments for navigation. To insure navigational safety, the severity of turns (dog legs) of the entrance channel should be minimized and the widening (flaring) of the channel at the turns is to be provided. The protected basin is to have a maximum wave amplitude of 2 feet to insure minimal damage to vessels.

(3) Navigation improvements shall be designed to accommodate a design vessel, whose length is 40 feet, beam is 15 feet, and draft is 6.0 feet, during all weather and sea conditions except severe storms.

(4) The protective harbor basin shall provide a safe maneuvering area for the design vessel, to be compatible with berthing and shoreside facilities.

(5) Harbor plans shall provide for adequate land area for shoreside facilities and adequate access.

c. FEDERAL DESIGN FEATURES. The general navigation features by the Federal Government shall include an entrance channel, turning basin, access channel, and wave absorbers. All berthing and shoreside features necessary for a complete harbor facility would be provided by the State of Hawaii.

d. LEVEL OF DESIGN ANALYSIS. The appendix contains engineering data and analysis to support the Stage 3 formulation and the plan selection process. Each harbor site is situated in an area directly exposed to severe wave attack. The alignment and location of each selected entrance channel is based on theoretical wave analysis and appears to be the most feasible of several possibilities. Considering the hydrographic factors influencing actual wave conditions in the project area and comments by local boaters, a physical model study is necessary as part of the advance engineering and design stage for the selected harbor site in order to develop the most suitable harbor entrance channel alignment and wave absorber plan to insure navigational safety.

2. SITE LOCATION

a. Leleiwi Point (Figure 6 in main report) is located on the northeast coast of the island of Hawaii, about 2.5 road miles east of Hilo Harbor at about 19°44' north latitude and 155°2' west longitude.

b. King's Landing (Figure 6 in main report) is located on the northeast coast of the island of Hawaii, about 5.5 road miles east of Hilo Harbor at about 19°44' north latitude and 155°00' west longitude.

c. Cape Kumukahi (Figure 7 in main report) is located on the southeast coast of the island of Hawaii, about 30 road miles south of Hilo Harbor at about 19°31' north latitude and 154°48' west longitude.

Maps of sites and vicinities are shown on the listed publications:

Description	Prepared By	Chart No.
Island of Hawaii	U.S. Dept of Commerce National Oceanic & Atmospheric Administration	19320
Island of Hawaii	Army Map Service Corps of Engineers	W532XNE515
Hilo, Hawaii	U.S. Geological Survey	N1937.5 - W15500/7.5
Keaau Ranch, Hawaii	U.S. Geological Survey	N1937.5 - W15452.2/7.5
Kalapana, Hawaii	U.S. Geological Survey	N1916.5 - W1547.5/6X10
Kapoho, Hawaii	U.S. Geological Survey	N1926 - W15445/7.5
Kapoho, Hawaii	U.S. Army Corps of Engineers Honolulu District	Flood Insurance Studies Island of Hawaii, sht 4

3. WIND CONDITIONS

a. PREDOMINANT WIND.

Leleiwi Point and King's Landing. The wind velocity and direction records show that winds approach each site primarily from the southwest (SW) and west-southwest (WSW) directions, rather than the typical northeasterly trades that predominate for most of the islands. Winds are predominantly from the SW and WSW during the night and early morning hours, with winds generally shifting to the typical trade direction by midday. A wind diagram for the years 1965-1974 from the gage located at General Lyman Field, Hilo, is shown on Plate D-1.

Cape Kumukahi. There are no wind gages in the immediate vicinity of Cape Kumukahi. Information on wind conditions at this location is extrapolated from statistical data on offshore winds contained in the U.S. Naval Weather Service Command publication, "Summary of Synoptic Meteorological Observation," June 1971. The wind information is for the position 20.9° north latitude and 156.0° west longitude. This information is considered to be representative of conditions at the project site. Plate D-2 is a diagram which shows wind direction, speed, and frequency.

b. TROPICAL STORMS AND HURRICANES. Although extremely rare in the Hawaiian Islands, tropical storms and hurricanes have, from time-to-time, affected the islands. Tropical storms are defined as having sustained wind speeds between 34 and 63 knots, while hurricanes are defined as storms with sustained wind speeds equal to or greater than 64 knots. Based on information from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Weather Service, from 1950 to 1980, at least 14 tropical storms or hurricanes have intruded within 500 miles of the State. Tropical storms and hurricanes which impact on sea and weather conditions in Hawaii generally occur during the summer months. Hurricanes "Dot" in 1959 and "Iwa" in 1982 have caused severe damages, primarily on the islands of Kauai and Oahu. Damages on the island of Hawaii were minimal.

4. WAVE CONDITIONS

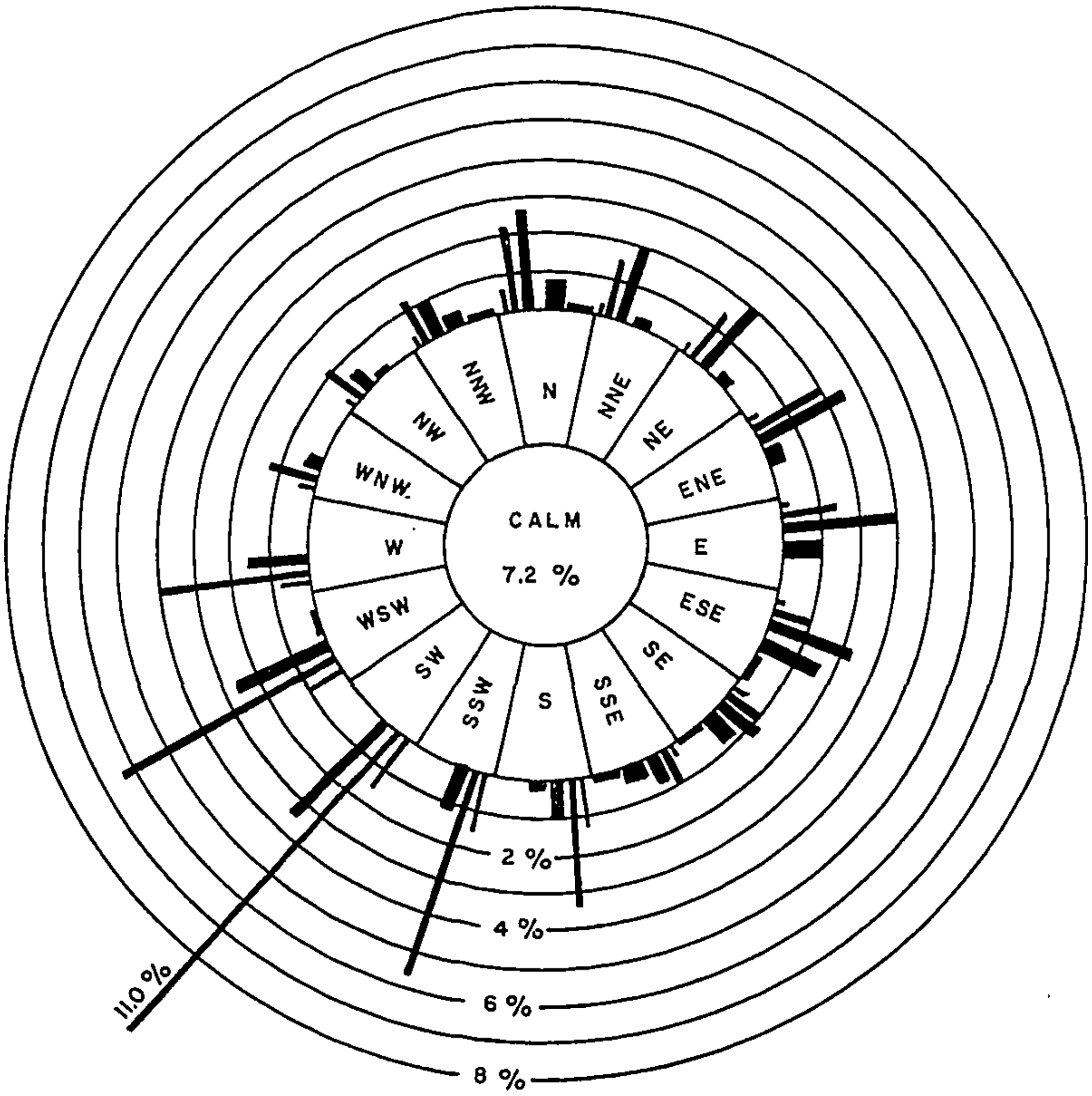
a. WAVE CLIMATE.

Waves arriving at Leleiwi Point, King's Landing and Cape Kumukahi originate from various areas in the Pacific Ocean. These waves have a variety of periods and heights depending on their origin and other factors related to wave building and decay. At each site, several distinct wave types acting simultaneously, produce complex wave climate.

Waves arriving at Leleiwi Point and King's Landing are generated in the northeastern sector of the Pacific Ocean, ranging from the Aleutian Islands in the north to South America. Two primary types affect these sites: (1) the local wind waves and (2) the northern swell. Cape Kumukahi faces roughly southeast and generally is subject to a wave spectrum from the northeast clockwise to the southwest. Four primary wave types affect Cape Kumukahi: (1) the local wind waves, (2) the southern swell, (3) the "Kona" storm waves, and (4) the northern swell.

LOCAL WIND WAVES. There are no wave gage stations in the area. Information on wave conditions is based on statistical data on offshore waves in the "Summary of Synoptic Meteorological Observations" (SSMO), Hawaii and Selected North Pacific Island Coastal Marine Areas, Volume 1, Area 1, Hawaiian Windward,

GENERAL LYMAN FIELD
HILO, HAWAII



NOTE: THE PERCENTAGES AND THE DIRECTIONS ARE AVERAGES DURING THE 10 YEAR PERIOD, 1965 TO 1974 INCLUSIVE.

LEGEND:

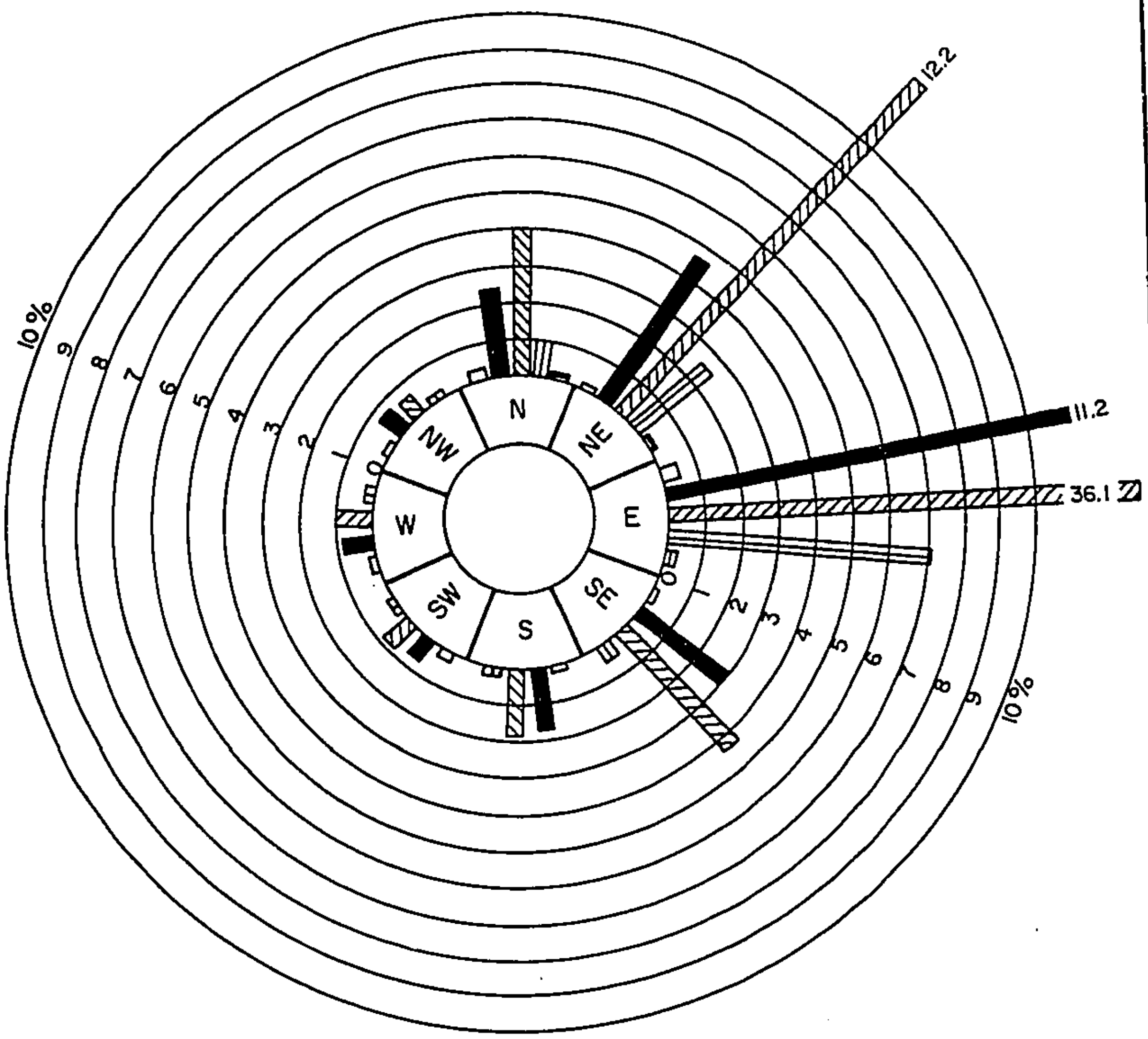
- 0-3 KNOTS
- 4-6 KNOTS
- 7-10 KNOTS
- 11-16 KNOTS
- OVER 16 KNOTS
- —8%— TOTAL % OF YEAR

SOURCE – HONOLULU DLNR, DOWALD

HILO AREA COMPREHENSIVE STUDY

WIND DIAGRAM

U.S. ARMY ENGINEER DISTRICT, HONOLULU



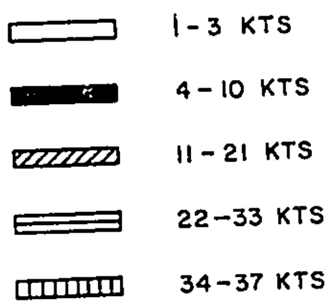
TOTAL % OF THE YEAR
10 %

PERIOD OF RECORD
1963 TO 1970

STATION LOCATION
209 NORTH LATITUDE
156 WEST LONGITUDE

SOURCE
U.S. NAVAL WEATHER SERVICE COMMAND

LEGEND:



HILO AREA COMPREHENSIVE STUDY

OFFSHORE WIND DIAGRAM

US ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-2

prepared by the National Climatic Center for the U.S. Weather Service Command, June 1971. The wave information is for the position 20.9° north latitude and 156.0° west longitude.

This data was obtained through direct synoptic observation by shipboard personnel in the island of Hawaii area and represent data recorded during the 8-year period from 1963 to 1970. These statistics represent average conditions during the period of record. The data also shows that the majority of waves affecting Hawaii are easterly tradewind-generated waves. The tables show that deepwater wind wave heights are generally 2 to 10 feet with periods of 6 to 12 seconds (Table D-1 and D-2).

TABLE D-1

ANNUAL PERCENT OF OCCURRENCE OF WAVE HEIGHTS VERSUS DIRECTION

Wave Ht (Feet)	NW	N	NE	E	SE	S	TOTAL
1	0.1	0.7	0.8	1.4	0.4	0.4	3.8
1-2	0.5	1.8	4.1	10.0	2.1	1.2	19.7
3-4	0.5	2.6	7.0	19.1	3.2	1.3	33.7
5-6	0.2	1.5	4.5	13.9	1.5	0.7	22.3
7	0.1	0.7	2.1	6.2	0.6	0.1	9.8
8-9	0.1	0.3	0.9	3.0	0.1	0.1	4.5
10-11	0.1	0.1	0.2	0.9	0.1	-	1.4
12	-	0.1	0.1	0.4	0.1	-	0.7
13-16	-	-	-	0.2	-	-	0.2
17-19	-	-	-	0.1	-	-	0.1
TOTAL	1.6	7.8	19.7	55.2	8.1	3.8	96.2

TABLE D-2

PERCENT FREQUENCY OF WAVE HEIGHT VERSUS WAVE PERIOD

Period (Sec)	Wave Height (Feet)									TOTAL
	1	1-2	3-4	5-6	7	8-9	10-11	12	13-16	
6	1.0	8.7	17.9	9.4	3.3	1.3	0.3	0.1	0.1	42.1
6-7	-	1.3	6.9	10.8	6.0	2.6	1.1	0.6	0.2	29.5
8-9	-	0.3	1.6	3.8	4.5	2.3	1.1	0.5	0.4	14.5
10-11	0.0	0.1	0.4	0.9	1.5	1.1	0.7	0.4	0.4	5.5
12-13	0.0	-	0.1	0.3	0.4	0.4	0.3	0.2	0.1	1.8
13	0.0	-	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.6
Indet	2.5	0.8	0.8	0.7	0.3	0.2	0.1	-	-	5.4
TOTAL	3.5	11.3	27.6	26.0	16.2	8.1	3.6	1.8	1.3	99.4

NORTHERN SWELL. Northern swell is generated in the north Pacific Ocean by winter storms. Waves may typically have periods of 10 to 15 seconds, and heights of 5 to 15 feet. Some of the largest waves reaching the Hawaiian Islands are of this type. Northern swell usually occurs during the winter season from October to April.

SOUTHERN SWELL. Southern swell is generated during the Antarctic winter months by strong winds blowing over long fetches of the southern Pacific and Indian Oceans. After traveling over thousands of miles of open ocean, these waves arrive at the southern shores of the Hawaiian Islands as long period swell. Periods typically range between 14 and 22 seconds with heights generally 1 to 4 feet. In an average year, southern swell arrives at Cape Kumukahi about 10 percent of the time; usually during the summer months from April to October.

"KONA" STORM WAVES. "Kona" storm waves are generated by local storms and fronts which generally cause winds and waves from the south through the west. These storms are neither frequent nor consistent, however, they can generate large destructive waves which can directly affect Cape Kumukahi. Commonly, periods range from 8 to 10 seconds, with heights of 10 to 15 feet. In any given year, Kona storms may occur several times or not at all. They occur most often in the winter months.

TROPICAL STORM WAVES. In addition to the primary wave types discussed above, there are others which are less frequent, but which are significant. One of these is the large swell generated by tropical storms in the equatorial regions. Wave heights can reach 8 to 15 feet with periods of 10 to 15 seconds. These waves generally approach the Hawaiian Islands from the southeast through the southwest and are most likely to occur in August and September.

HURRICANES. Another infrequent source of large destructive waves is associated with hurricanes. In the last 25 years hurricanes passed through the Hawaiian chain in December 1957, August 1959, and again in July 1978. Theoretical calculations by Dr. C. L. Bretschneider indicate that a significant deep-water wave height of 27 feet can be expected for a typical 50-year hurricane having the following parameters: (a) central pressure reduction of 1 inch of mercury, (b) radius of maximum winds of 20 nautical miles, (c) forward speed of

12 knots. This results in a maximum sustained wind speed of 62 knots (tropical storm speed) and a corresponding maximum deepwater wave height of 46 feet.

b. REFRACTION ANALYSIS. A computer-aided refraction analysis was performed to locate zones of high-energy concentration in the vicinity of proposed harbor entrance channels, and to determine the probable approach alignment of the primary wave types affecting each site. Wave refraction diagrams were drawn for deepwater waves approaching each site. These directions were selected after evaluating the storm exposure regime at each site. The deepwater wave height from the SSMO data for the directions affecting each site were analytically transformed, considering refraction and shoaling, to shallow wave heights at each harbor entrance. Based on Table D-2, percent frequency of wave height versus wave period, 8- and 10-second waves were considered for refraction purposes as being representative of the local wind-wave period. Wave period of 15 seconds were considered characteristic of deep-water swells contributed by a 50-year hurricane.

Preliminary refraction analysis shows that each site is subjected to critical wave attack. Critical wave attack is that which is most likely to produce the largest and most damaging waves. A theoretical 50-year deepwater wave height of 27 feet, refracted towards the shoreline provided greater wave heights than a breaking wave height at the 20-foot depth contour. Depth-controlled design wave criteria was used for selection of design wave height. The proposed entrance channel location is unlikely to be a zone of wave energy convergence. Critical wave direction and wave period at the harbor entrance at each site, to be used in the wave diffraction analysis, is as follows:

	Direction	Period (Sec)
Leleiwi Point --	North	15
King's Landing --	East	15
Cape Kumukahi --	East	15

5. TSUNAMI

All harbors are subject to potential tsunami or seismic sea-wave inundation as are most low-lying coastal areas in the Hawaiian Islands. The nature of tsunami is not fully understood. An occurrence may be nearly imperceptible or may cause catastrophic destruction of coastal areas. A severe tsunami may cause abnormal rising and falling of the sea level, resulting in flooding of low-lying areas, and grounding of boats in the harbor. The 100-year tsunami inundation elevation at Leleiwi Point, King's Landing, and Cape Kumukahi are estimated to be about 18, 17, and 20 feet respectively above the mean lower low water (MLLW) datum. Adverse impacts resulting from locating in the tsunami flood zone include the risks of destruction of property and loss of life. The proposed action will require development in the inundation zone such as harbor backup facilities. There is no alternative location for these facilities, however, utilizing construction practices which meet requirements of the National Flood Insurance Program will minimize tsunami damages. Adverse impacts resulting from increased use of the tsunami flood zone can be minimized by adequate tsunami warning. A State-wide tsunami warning system is presently in existence. The harbor can be evacuated in the event of a tsunami warning. Boats would not reenter the harbor until the tsunami warning has been cancelled.

6. WATER LEVEL AND CURRENTS

a. TIDES. The nearest tidal benchmark to Leleiwi Point and King's Landing is at Hilo Harbor, approximately 2.5 miles from Leleiwi Point and 5.5 miles from King's Landing. The nearest tidal benchmark to Cape Kumukahi is at Honuapo on the south coast of the island, approximately 55 miles from the site. The tidal data shown were obtained from the U.S. Coast and Geodetic Survey and are referenced to Mean Lower Low Water (MLLW). All elevations in this appendix are in feet referenced to MLLW datum.

	Hilo (Feet)	Honuapo (Feet)
Highest tide (observed)	3.80	*4.0
Mean higher high water	2.40	2.50
Mean high water	1.90	2.00
Half tide level	1.10	1.15
Mean low water	0.30	0.30
Mean lower low water	0.00	0.00
Lowest tide (observed)	-1.60	*-1.50

* Estimated.

b. ASTRONOMICAL TIDE (S_a).

The astronomical tide is estimated to be about equivalent to the mean higher high water of 2.4 feet.

c. ATMOSPHERIC PRESSURE DROP (S_p).

The water level rise due to atmospheric pressure is calculated by:

$S_p = 1.14 (P_n - P_o)(1 - e^{-R/r})$ EQ. 3-85, SPM 1/

P_n = 29.92 inches

P_o = 28.92 inches

R = 20 nautical miles

r = 40 nautical miles

S_p = 0.4 feet

1/ U.S. Army Coastal Research Center, Shore Protection Manual, 3d Edition, 1977.

d. STORM SURGE (S_s).

The water level rise due to storm surge is calculated by:

Storm surge = S_i, which is the incremental rise in water level due to wind stress perpendicular to the bottom contour.

$$S = \frac{540K\,U_R^2 \quad X}{\bar{d}} \qquad \text{(TR-4, 1-64)}$$ [2]

X = total distance in N.M.

K = 3.0×10^{-6}

U_R = 62 knots

X = incremental distance in N.M.

$\bar{d}$ = mean depth over increment (FT)

d_i = initial depth

Storm surge in the study area is estimated at 0.6 feet.

e. WAVE SETUP, S_w: Wave setup is estimated from calculated theoretical values, considering that the location of the primary protective structure is not in the zone of maximum wave setup. Under certain wave conditions, the structure may be in a zone of wave setdown, resulting in a relatively lower water level. For engineering calculations, a value of 0.6 feet is selected for S_w.

f. DESIGN STILLWATER LEVEL. The design stillwater level (SWL) is defined as the level of water above the elevation datum plane, when no waves are present. Components of the SWL are astronomical tide level (S_a), atmospheric pressure drop (S_p), storm surge (S_s), and wave setup (S_w). Stillwater level components are calculated as follows; assuming the components are additive functions.

2/ U.S. Army Coastal Research Research Center, Technical Report No. 4, 3d Edition, 1966.

SWL = Design stillwater level

$SWL = S_a + S_p + S_s + S_w$

SWL = 2.4' + 0.4' + 0.6' + 0.6'

SWL = 4.0 feet

g. CURRENTS.

Reports indicate that surface currents in the study area generally follow the northeast trade wind, but occasionally set against it. One current follows the coast northwestward from Cape Kumukahi, the eastern extremity of Hawaii and around the northern extremity. Another current follows the coast southwestward from Cape Kumukahi around the southern extremity of the island. The observations of surface current conditions during the time of the hydrographic surveys were as follows:

Wind and Sea Conditions. Very light northeast tradewinds, 0-5 mph. Moderate north swell, approximately 5-foot wave heights in deepwater with occasional larger sets. Tide ebbing from about 0.8 feet to 0.1 feet and then flooding to about 1.2 feet during the course of the day. At Leleiwi Point, there was a strong seaward setting surface current shoreward of the breaker zone all along the coastline between wave sets. No site specific rip currents were observed, although it is reasonable to presume they exist, particularly during the occurrence of severe north swell. Seaward of the breaker zone a slow easterly setting (toward Leleiwi Point) surface current was present. This current set easterly regardless of the tide stage but was more pronounced during the flooding tide. At King's Landing, the surface current outside the breaker zone was observed to set northwest regardless of the tide stage. Coastal surface currents at both sites were observed to set toward Leleiwi Point, which is in agreement with other surface current information for this area which describes a northwest setting coastal surface current from Cape Kumukahi north to Upolu Point and a possible counterclockwise eddy in Hilo Bay[3].

3/ U.S. Coast Pilot; Laevastu et al, "Coastal Currents and Sewage Disposal in the Hawaiian Islands", HIG Report 64-1.

7. SHORELINE CHANGES

No erosion or sand accretion in the entrance channel is expected as a result of the construction of the harbor. The shoreline in the vicinity of each site is volcanic rock, and there is no evidence of appreciable littoral drift in the area.

8. DESIGN VESSEL

The entrance channel, turning basin, and main access channel are designed to accommodate vessels up to a length of 40 feet, a beam of 15 feet, and a draft of 6.0 feet. These criteria represent the draft of a loaded tuna boat or a large charter fishing boat, which are the largest vessels anticipated to use the harbor. Vessel characteristics are listed in the following tabulation:

VESSEL CHARACTERISTICS

Vessel	Length (Feet)	Beam (Feet)	Draft (Feet)
Tuna boat	40	15	6.0
Charter fishing boat	40	15	6.0
Trailer fishing boat	27	7	2.5

9. ALTERNATIVE HARBOR PLANS

Preliminary analysis indicated that a basin to provide for the projected boat population could not be economically developed through an offshore scheme because of the high cost of required breakwater construction. The inshore harbor concept was determined as being the only reasonable concept based on economics, engineering and environmental standpoint. Plans for all three sites can have the same basic navigation features, including an entrance channel turning basin, access channel and channel wave absorbers (Plates D-3, D-5, D-6, and D-8).

10. CHANNEL AND TURNING BASIN DESIGN

a. ENTRANCE CHANNEL.

Minimum Width. Required channel width is based on concurrent, 2-way passage of the design vessel. Total channel width is the sum of (1) the maneuvering lane, (2) the ship clearance lane, and (3) the bank clearance lane widths all based on the design vessel. Width factors are calculated assuming good vessel operators, presence of strong and gusty winds, and rough sea conditions. Lane widths and total channel width are:

Lane	Factor X Beam (Feet)	Width (Feet)
Bank clearance	2.0 X 15	30.0
Vessel maneuvering lane	2.5 X 15	37.5
Vessel clearance	1.0 X 15	15.0
Vessel maneuvering lane	2.5 X 15	37.5
Bank clearance	2.0 X 15	30.0
Total Channel Width	10.0 X 15	150.0

Channel width is increased to 180 feet at the turn into the harbor basin.

Minimum Depth. Required depth for safe navigation of the design vessel is computed as the sum of the following items at the calculated and estimated values shown:

	Depth (Feet)
Loaded draft of the design vessel	6.0
Vessel squat and trim	1.5
Pitch and roll due to wave action	4.0
Bottom clearance	3.0
Total Channel Depth	14.5 Say 15 feet

b. TURNING BASIN.

Minimum Length and Width. Turning basin dimensions were kept to a minimum to allow for as much berthing space as possible. The length and width of the turning basin is 2.5 times the length of the design vessel.

Minimum Length and Width = 2.5 x design vessel length
= 2.5 x 40 feet
= 100 feet

Minimum Depth. Required depth for safe navigation is computed as the sum of the following items at the values shown:

	Depth (Feet)
Loaded draft of the design vessel	6.0
Vessel squat and trim	1.5
Pitch and roll due to wave action	1.5
Bottom clearance	3.0
Total Basin Depth	12.0

c. ACCESS CHANNEL

Minimum Width. Access channel dimensions were kept to a minimum to allow for as much berthing space as possible. The width of the access channel is 5 times the beam of the design vessel. Extra allowance is used for the Cape Kumukahi harbor due to severe wave action. The access channel width is increased to 7 times the design vessel beam for this site.

Minimum width = 5 x design vessel beam
= 5 x 15 feet
= 75 feet

Minimum Depth. Required depth for safe navigation is computed as the sum of the following items at the values shown:

	Depth (Feet)
Loaded draft of the design vessel	6.0
Vessel squat and trim	1.5
Pitch and roll due to wave action	1.5
Bottom clearance	1.0
Total Channel Depth	10.0

11. WAVE ABSORBER DESIGN

a. WAVE HEIGHTS. During severe tropical storms, waves as high as 20 feet can be expected. Because of depth limitation, 20-feet waves would break offshore. The theoretical wave incident (Hi) to the opening at the channel mouth is assumed to be a broken wave of 17.2 feet, based on an average depth of 22.0 feet and slope of M = 0.000.

b. WAVE ENERGY LOSSES. Based on hydraulic model studies conducted by WES[4/] and existing information[5/] for harbors of similar design in similar physical environments, it is estimated that as much as 70 percent of the incident wave at the harbor entrance will be dissipated by refraction, diffraction, and bottom friction, as the wave propagates up the entrance channel to the location 2 at Leleiwi Point and King's Landing harbors. The rubble sides of the wave absorbers and bottom friction should further reduce the wave height of the wave passing through location 2 at Cape Kumukahi harbor. Based on model test of wave absorbers and wave reducing characteristics of rubble structures, it is estimated that an additional reduction of about 20 percent would occur.

c. DIFFRACTION ANALYSIS. Theoretical wave diffraction analysis were conducted for each plan. The diffraction analysis was performed in accordance with procedures, techniques, and diagrams described in the CERC Shore Protection Manual. Diffraction coefficients were used to compute the theoretical maximum wave height in each plan shown in Plate D-11 to D-14. The diagram is drawn for a 15-second incident wave period. Lines of equal energy and diffraction coefficients are shown for energy entering the harbor basin, incident at location 2 shown on Plates D-11 to D-14.

The theoretical wave incident to the harbor entrance is assumed to be a broken wave (Hi) of 17.2 feet. Based on results from hydraulic model test for harbors of similar design, design wave height (H) at △1 and △2 is determined by multiplying the model test coefficient by the incident wave height, Hi. Wave heights in the harbor basin area is computed by multiplying the wave height (H) at 2 , by the diffraction coefficient, K.

4/ U.S. Army Engineer Waterways Experiment Station:
Technical Report No. 2-740, Investigation of In-Shore Harbor, Site X, 1966.
Contract Report No. 2-122, Wave Absorbers in Harbors 1965.
Technical Report H-74-16, Design of An Interisland Barge Harbor For The Island of Tau, American Samoa, 1974.
Technical Report H-75-15, Wave and Current Conditions For Various Modifications of Kewalo Basin, Honolulu, Oahu, Hawaii, 1975.

5/ U.S. Army Corps of Engineers Honolulu District:
Report of Model Tests, Scheme 9 and 9a, Honokahau Boat Harbor, Hawaii, February 1964.
Technical Report No. 8, Study of Proposed Barbers Point Harbor, Hawaii, April 1970.

Table D-3 shows the design wave heights obtained for the applicable areas at specified locations along the entrance channels.

TABLE D-3. DESIGN WAVE HEIGHTS

Wave Absorber Station of Entrance Channel	Design Wave Height (Feet) Leleiwi Point	King's Landing	Cape Kumukahi
1	10.0	12.5	-
2	6.5	5.5	6.9

d. STRUCTURES. The Coastal Engineering Research Center's Shore Protection Manual (SPM) design formulas were used to determine the weight of the stones and the thickness of the stone layers. The following factors were used in the armor layer design computations:

Unit weight of armor stone: W_r (lb/ft^3)	160-162		
Specific gravity of armor stone: S_r	2.6		
Stability coefficient: K_D			
structure trunk	3.5	3.9	2.4
structure head	2.9	3.7	1.9
Side slope: Cot a	1.5	3	2
Layer thickness: n	2	3	2
Layer coefficient: K	1.15	1.10	1.10
Design wave height: H	See Table D-3		
Armor stone size: $W = \frac{W_r H^3}{K_{D(Sr-1)^3} \text{ Cot } a}$	EQ. 7-11, SPM		

Thickness of armor layers and underlayers:

$$r = nk \left(\frac{W}{W_r}\right)^{\frac{1}{3}} \qquad \text{EQ. 7-113, SPM}$$

The resulting computed armor stone sizes were increased 100 percent in area $\triangle 1$ and 50 percent in area $\triangle 2$ to increase absorption of wave energy at the Kings Landing and Leleiwi Point sites. Stone sizes for the Cape Kumukahi site entrance channel were increased 40 percent over those required for the wave trap. Where cut material is erodable an underlayer of stones is required beneath the armor layer. The underlayer stones were initially computed using a 1/10 factor of the armor stones, adjusted to provide a wide enough range in size to facilitate construction without loss of underlayer material through the armor layers. No underlayer is required for Cape Kumukahi as the land area is near 100 percent basalt rock.

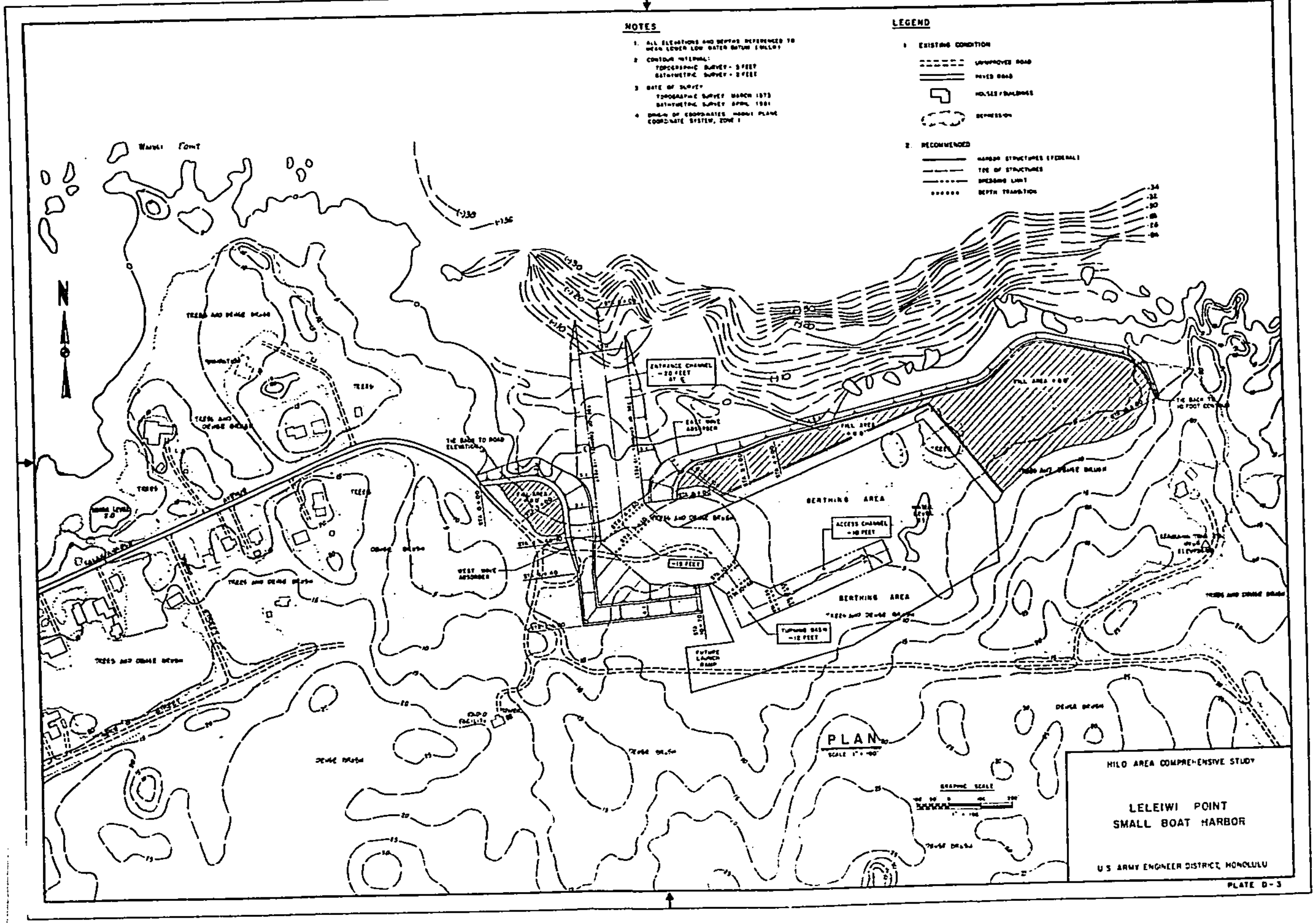
Wave Runup and Crest Elevation. Wave runup (Ru) and resulting crest elevation (CE) for the head 1 , and trunk sections 2 , of the wave absorber were based on criteria contained in the SPM, from existing information[6/] and discussions with personnel at the Waterways Experimental Station (WES). The runup computations were based on a 15-second wave period; 4.0-foot stillwater level; and the structure effective side slopes. The runup and resulting crest elevations for areas 1 and 2 are listed in the following tabulations:

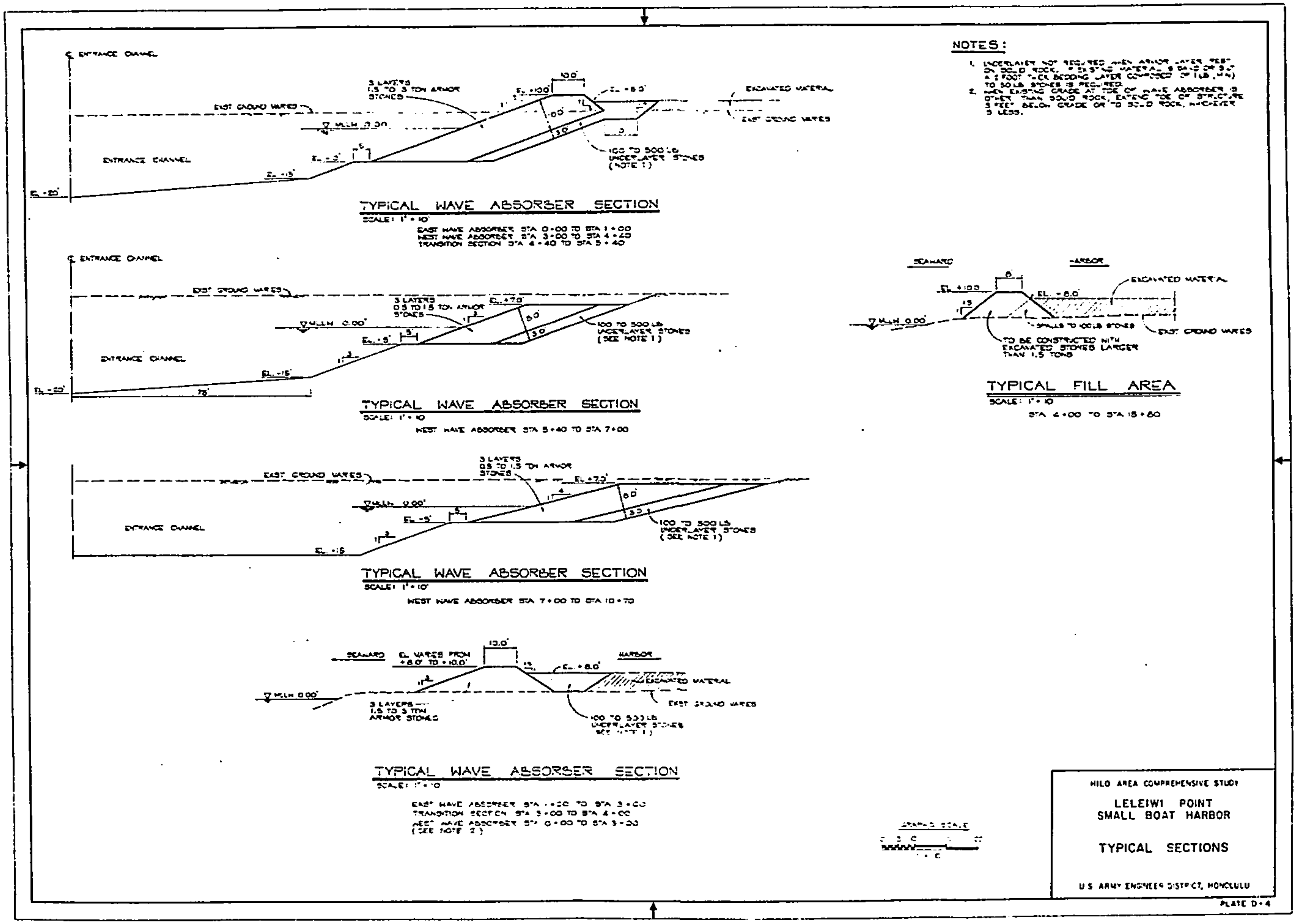
	AREA 1				AREA 2			
	Ru (Feet)	SWL (Feet)	CE (Feet)	CE Set at (Feet)	Ru (Feet)	SWL (Feet)	CE (Feet)	CE Set at (Feet)
Leleiwi Point	6.5	4.0	10.5	10.0	2.6	4.0	6.6	7.0
King's Landing	9.8	4.0	13.8	14.0	3.6	4.0	7.6	8.0
Cape Kumukahi	-	-	-	-	5.9	4.0	10.0	10.0

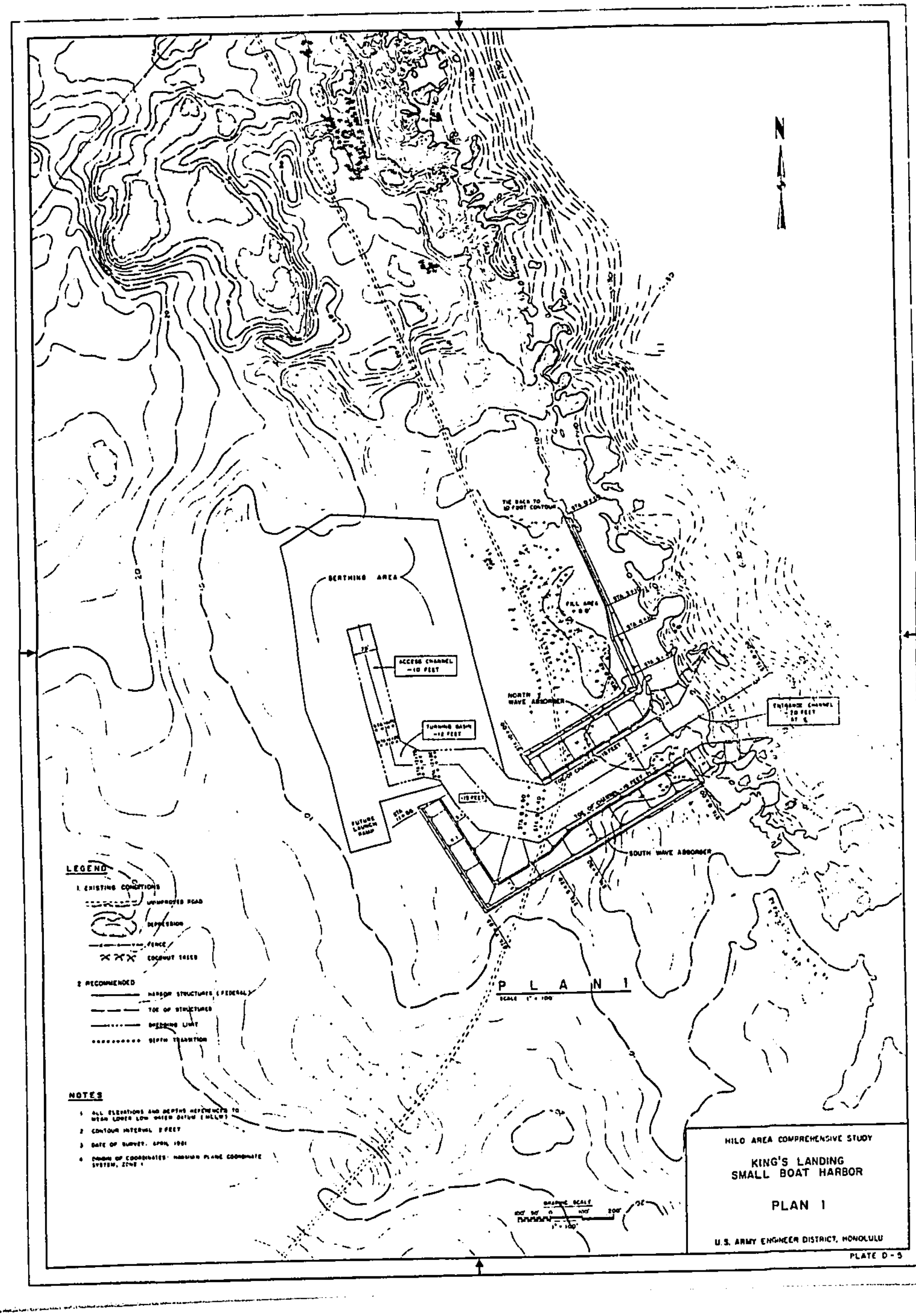
The incident wave approaches the wave absorbers at Leleiwi Point and King's Landing at an angle of 90 degrees, angle between wave crest and wave absorber. The striking wave runs along the structure, increasing the effective surface area for wave energy dissipation and decreasing the wave runup. Computed wave runup results for Cape Kumukahi are similar to Leleiwi and King's Landing harbors.

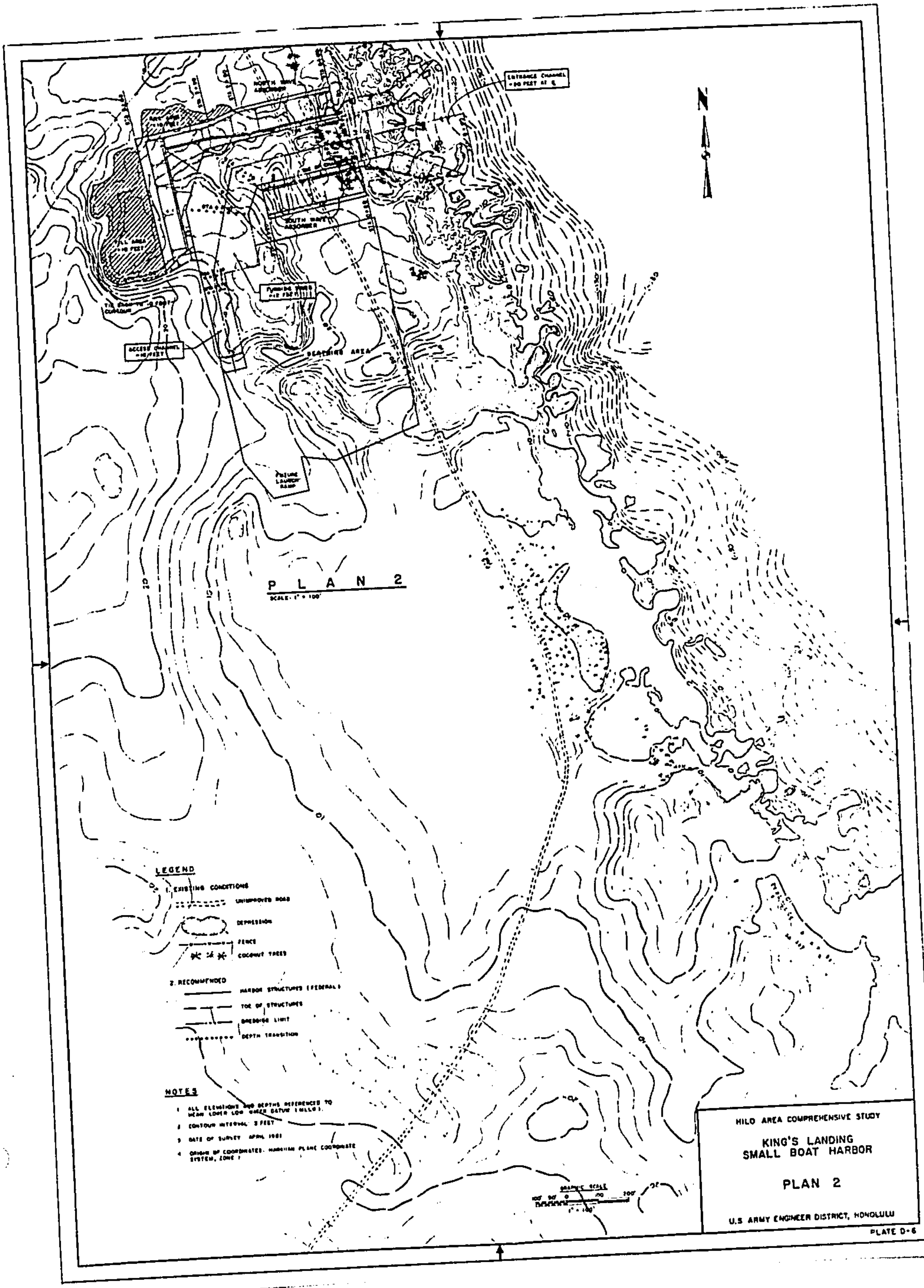
6/ CETA Report No. 79-1, Wave Runup on Rough Slopes, July 1979.

TP Report No. 78-2, Reanalysis of Wave Runup on Structures and Beaches, March 1978.

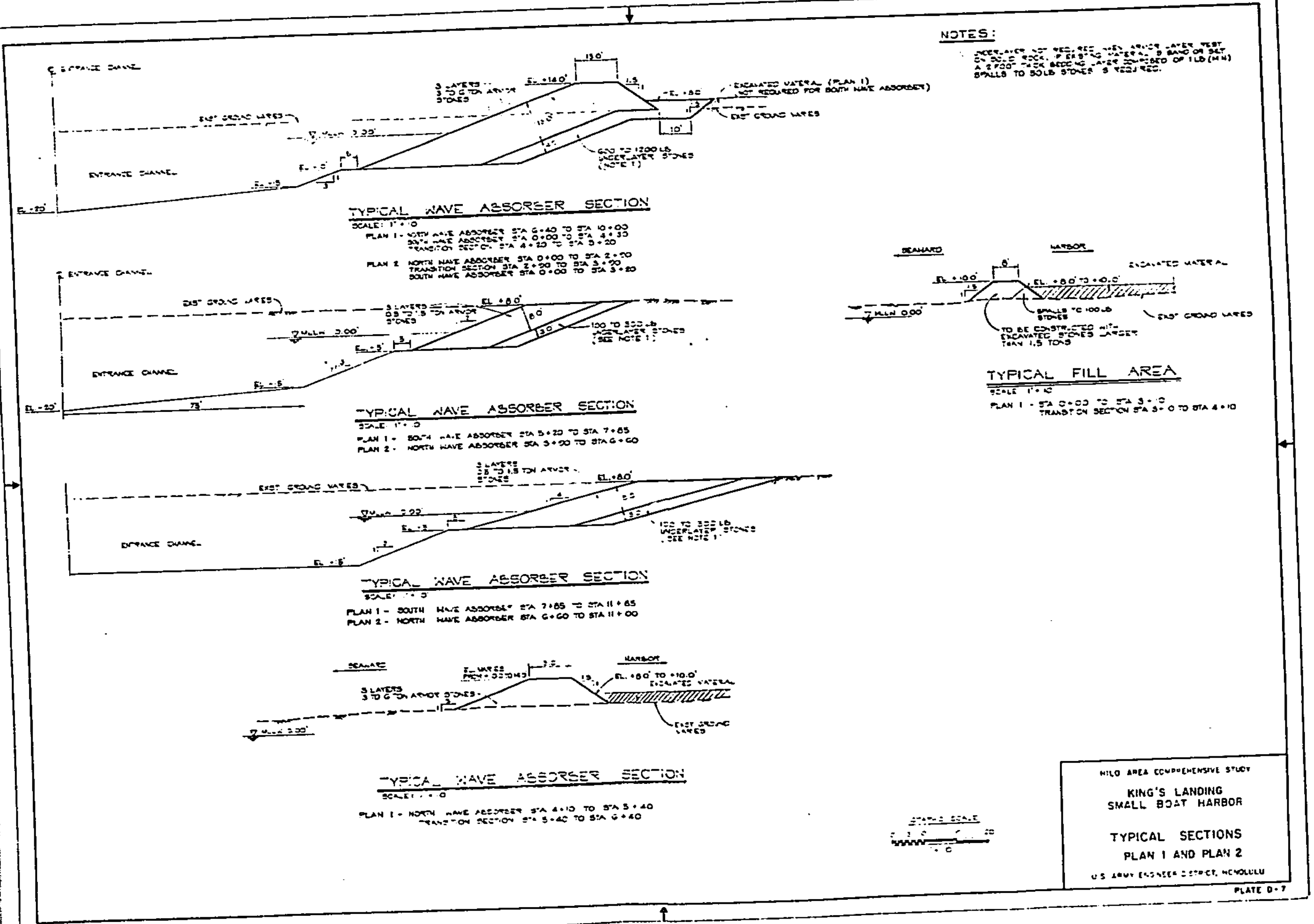

NOTES
LEGEND
1 EXISTING CONDITION
2. RECOMMENDED
BERTHING AREA
BERTHING AREA
PLAN
HILO AREA COMPREHENSIVE STUDY
LELEIWI POINT
SMALL BOAT HARBOR
U S ARMY ENGINEER DISTRICT, HONOLULU
PLATE D-3

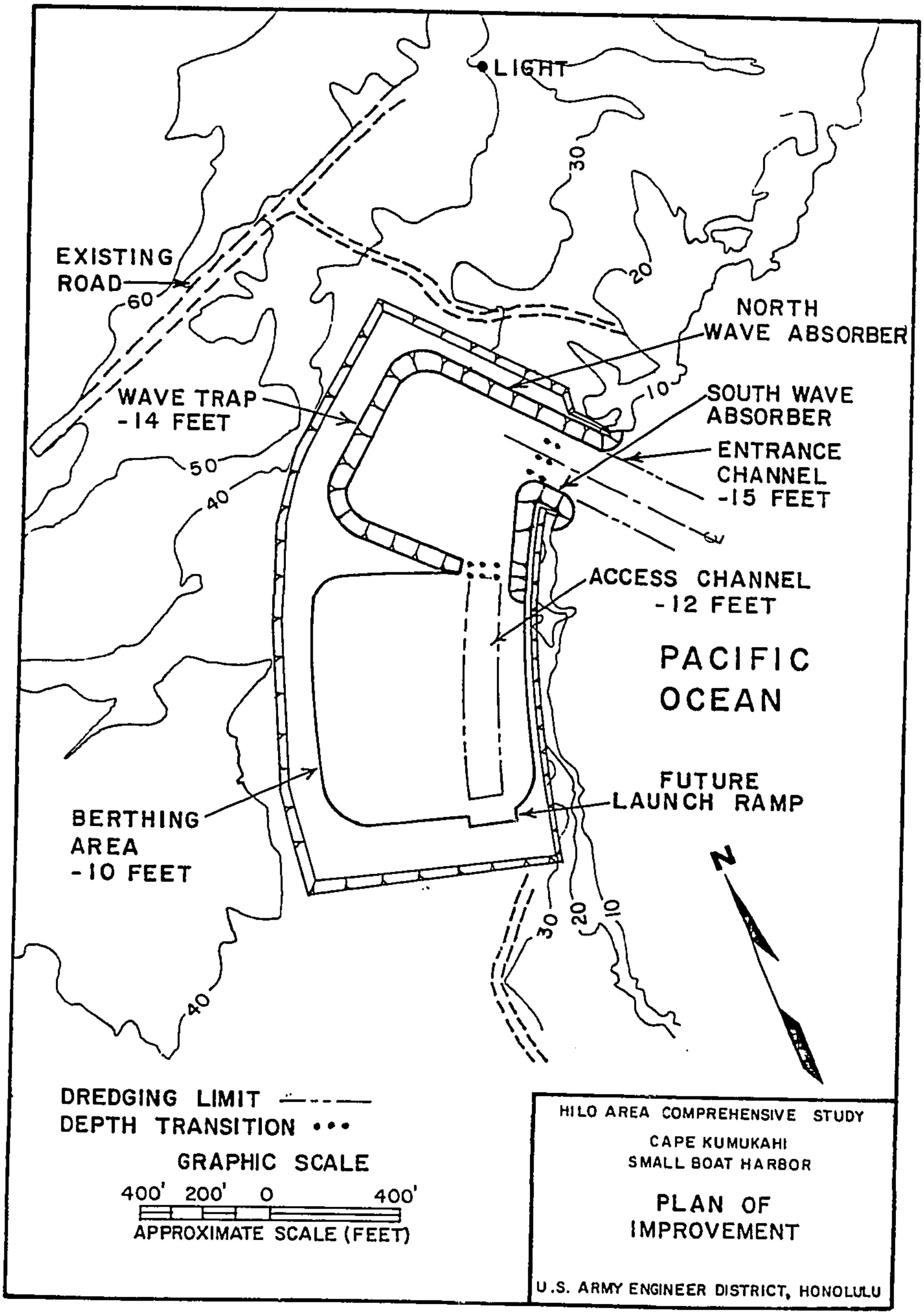

NOTES:
ENTRANCE CHANNEL
EXCAVATED MATERIAL
TYPICAL WAVE ABSORBER SECTION
TYPICAL WAVE ABSORBER SECTION
TYPICAL WAVE ABSORBER SECTION
TYPICAL WAVE ABSORBER SECTION
TYPICAL FILL AREA
SEAWARD
HARBOR
HILO AREA COMPREHENSIVE STUDY
LELEIWI POINT
SMALL BOAT HARBOR
TYPICAL SECTIONS
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE D-4


N
BERTHING AREA
ACCESS CHANNEL -10 FEET
TURNING BASIN -12 FEET
FUTURE LAUNCH RAMP
TIE BACK TO 10 FOOT CONTOUR
FILL AREA
NORTH WAVE ABSORBER
SOUTH WAVE ABSORBER
ENTRANCE CHANNEL -20 FEET AT ℄
PLAN 1
LEGEND
1. EXISTING CONDITIONS
COCONUT TREES
2. RECOMMENDED
HARBOR STRUCTURES (FEDERAL)
TOE OF STRUCTURES
DREDGING LIMIT
DEPTH TRANSITION
NOTES
2 CONTOUR INTERVAL 2 FEET
GRAPHIC SCALE
HILO AREA COMPREHENSIVE STUDY
KING'S LANDING
SMALL BOAT HARBOR
PLAN 1
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE D-5



PLAN 2
LEGEND
1. EXISTING CONDITIONS
UNIMPROVED ROAD
DEPRESSION
FENCE
COCONUT TREES
2. RECOMMENDED
HARBOR STRUCTURES (FEDERAL)
TOE OF STRUCTURES
DREDGING LIMIT
DEPTH TRANSITION
NOTES
SEAPLANE AREA
FUTURE LAUNCH RAMP
HILO AREA COMPREHENSIVE STUDY
KING'S LANDING
SMALL BOAT HARBOR
PLAN 2
U.S ARMY ENGINEER DISTRICT, HONOLULU
PLATE D-6


NOTES:
TYPICAL WAVE ABSORBER SECTION
TYPICAL WAVE ABSORBER SECTION
TYPICAL WAVE ABSORBER SECTION
TYPICAL WAVE ABSORBER SECTION
TYPICAL FILL AREA
ENTRANCE CHANNEL
SEAWARD
HARBOR
HILO AREA COMPREHENSIVE STUDY
KING'S LANDING
SMALL BOAT HARBOR
TYPICAL SECTIONS
PLAN 1 AND PLAN 2
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE D-7



LIGHT
30
20
10
EXISTING ROAD
60
NORTH WAVE ABSORBER
WAVE TRAP -14 FEET
SOUTH WAVE ABSORBER
ENTRANCE CHANNEL -15 FEET
50
40
ACCESS CHANNEL -12 FEET
PACIFIC OCEAN
FUTURE LAUNCH RAMP
BERTHING AREA -10 FEET
N
30
20
10
40
DREDGING LIMIT
DEPTH TRANSITION •••
GRAPHIC SCALE
400' 200' 0 400'
APPROXIMATE SCALE (FEET)
HILO AREA COMPREHENSIVE STUDY
CAPE KUMUKAHI
SMALL BOAT HARBOR
PLAN OF IMPROVEMENT
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE D-8

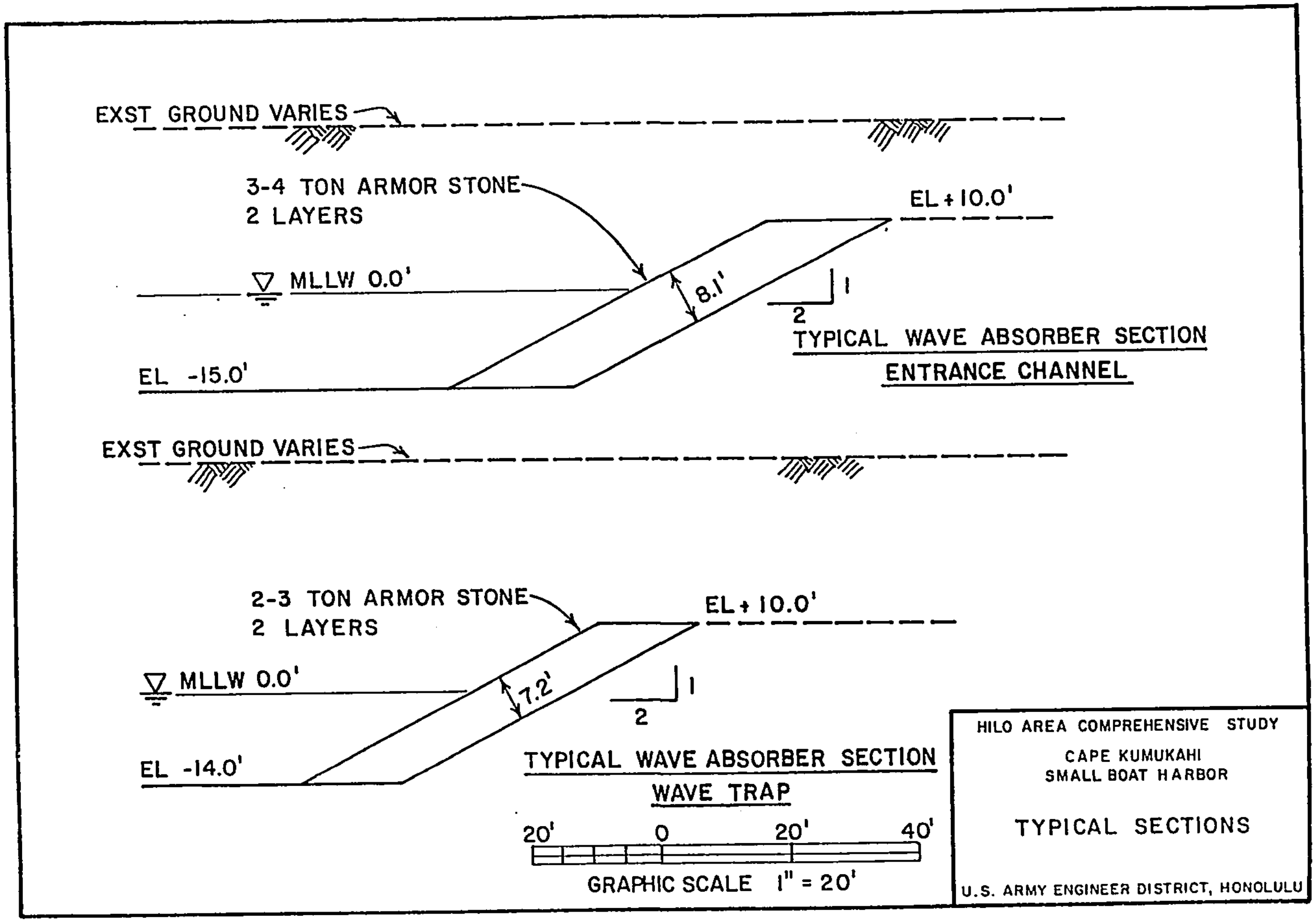
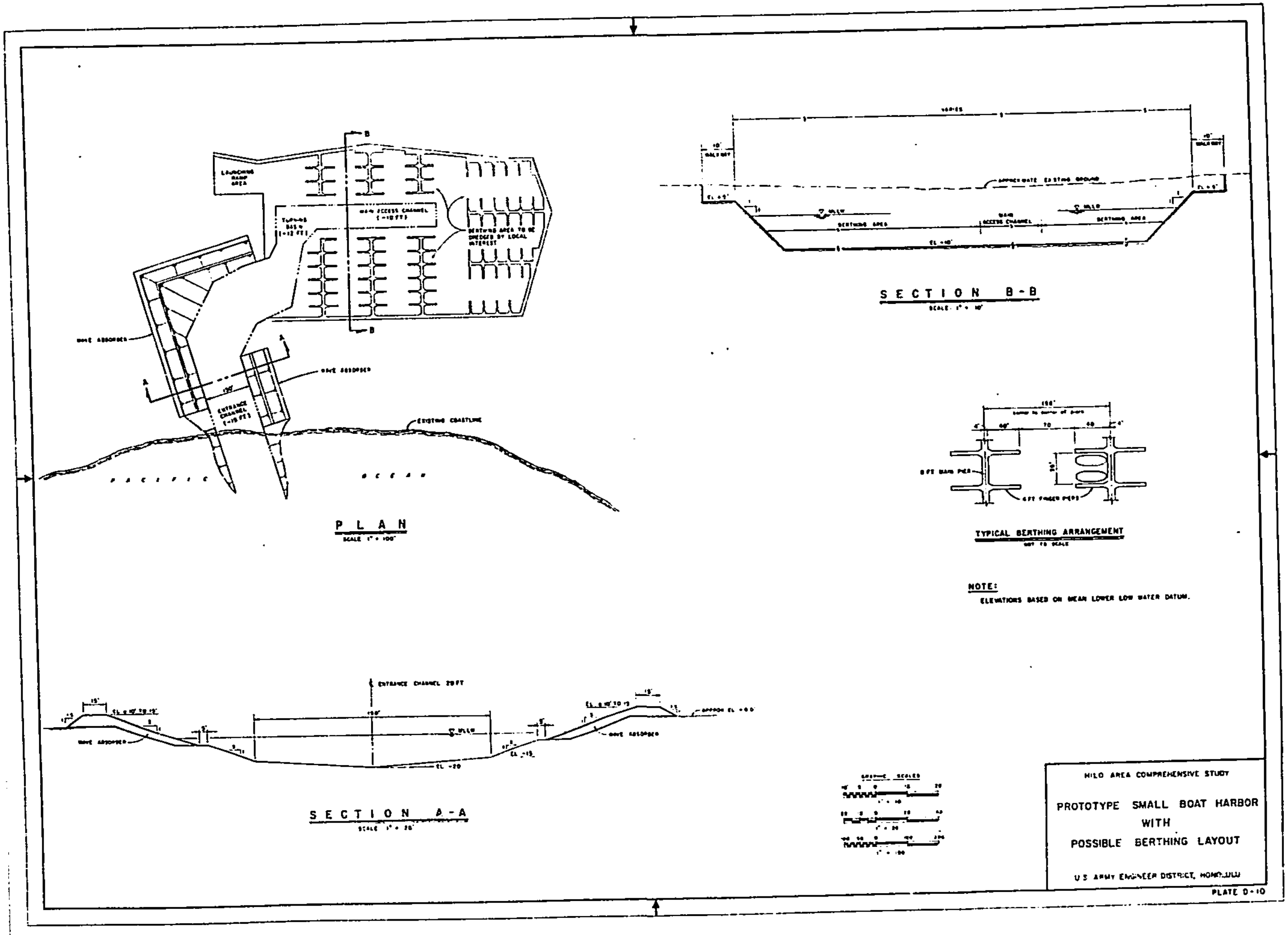

EXST GROUND VARIES
3-4 TON ARMOR STONE
2 LAYERS
EL + 10.0'
MLLW 0.0'
8.1'
1
2
TYPICAL WAVE ABSORBER SECTION
ENTRANCE CHANNEL
EL -15.0'
EXST GROUND VARIES
2-3 TON ARMOR STONE
2 LAYERS
EL + 10.0'
MLLW 0.0'
7.2'
1
2
EL -14.0'
TYPICAL WAVE ABSORBER SECTION
WAVE TRAP
20' 0 20' 40'
GRAPHIC SCALE 1" = 20'
HILO AREA COMPREHENSIVE STUDY
CAPE KUMUKAHI
SMALL BOAT HARBOR
TYPICAL SECTIONS
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE D-9


LAUNCHING RAMP AREA
TURNING BASIN (-12 FT)
MAIN ACCESS CHANNEL (-12 FT)
BERTHING AREA TO BE DREDGED BY LOCAL INTEREST
WAVE ABSORBER
ENTRANCE CHANNEL (-15 FT)
EXISTING COASTLINE
PACIFIC OCEAN
PLAN
SECTION B-B
APPROXIMATE EXISTING GROUND
BERTHING AREA
MAIN ACCESS CHANNEL
TYPICAL BERTHING ARRANGEMENT
NOT TO SCALE
6 FT MAIN PIER
4 FT FINGER PIERS
NOTE:
ELEVATIONS BASED ON MEAN LOWER LOW WATER DATUM.
ENTRANCE CHANNEL 20 FT
EL -20
SECTION A-A
GRAPHIC SCALES
HILO AREA COMPREHENSIVE STUDY
PROTOTYPE SMALL BOAT HARBOR
WITH
POSSIBLE BERTHING LAYOUT
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE D-10

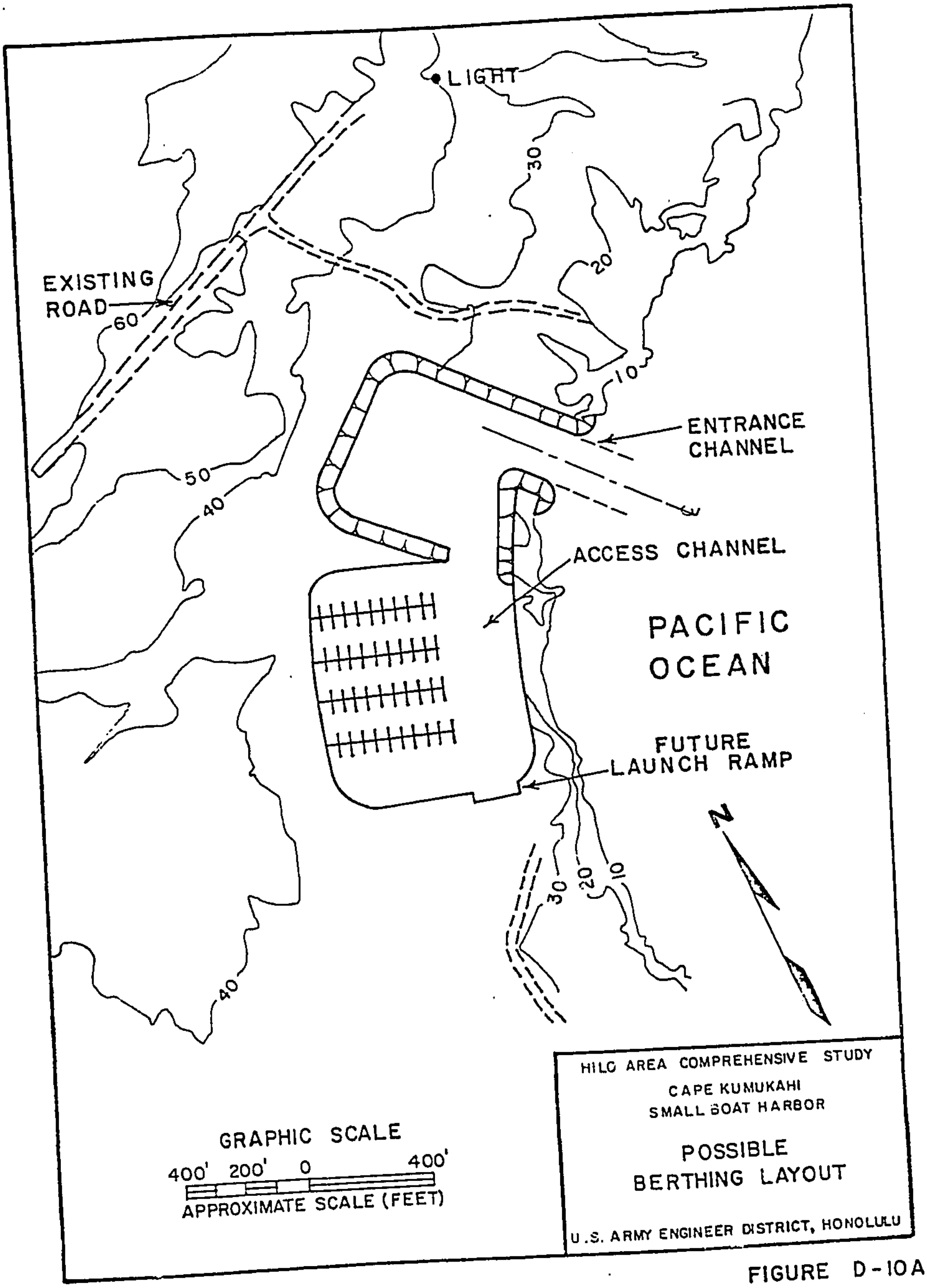
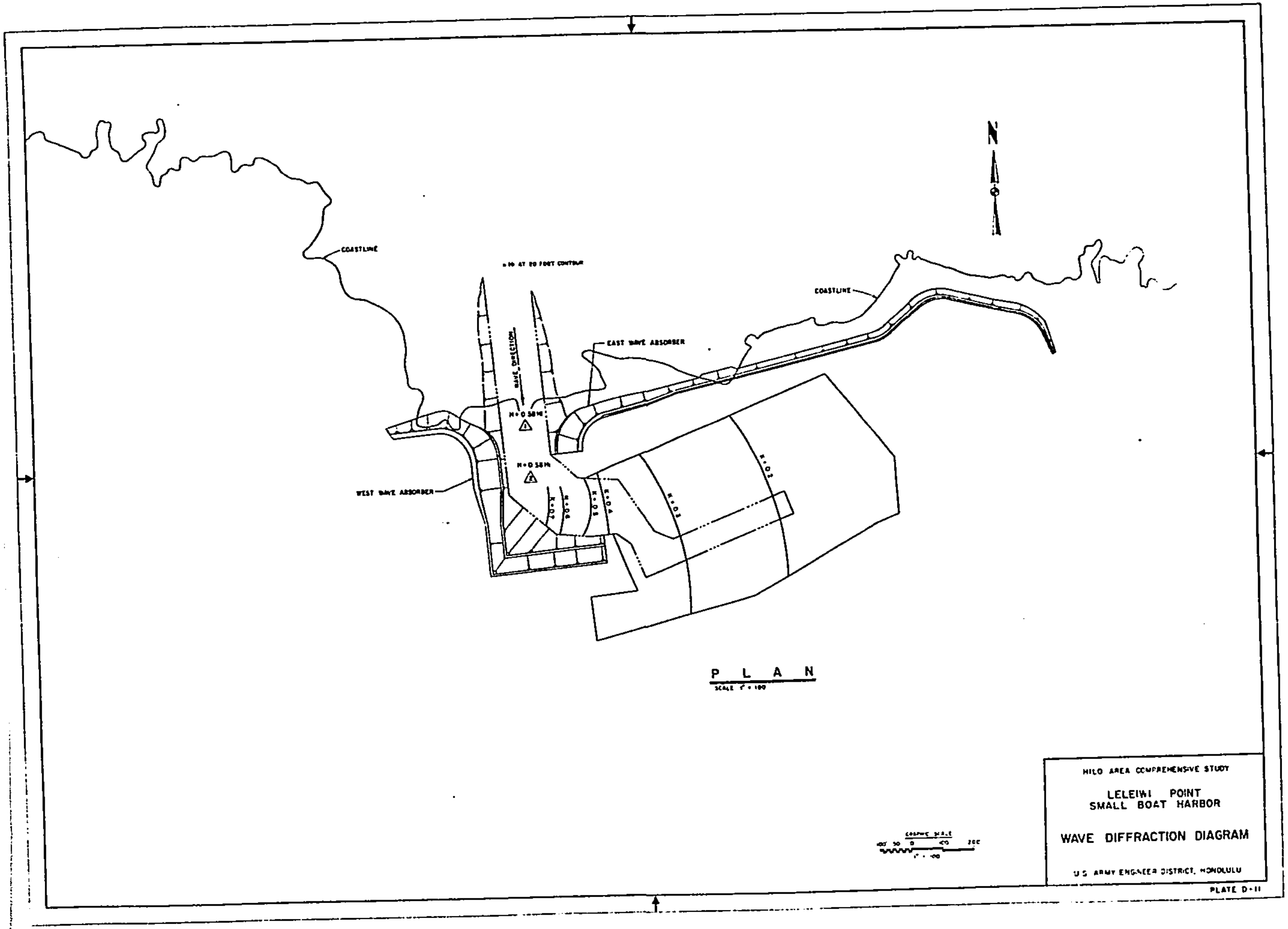
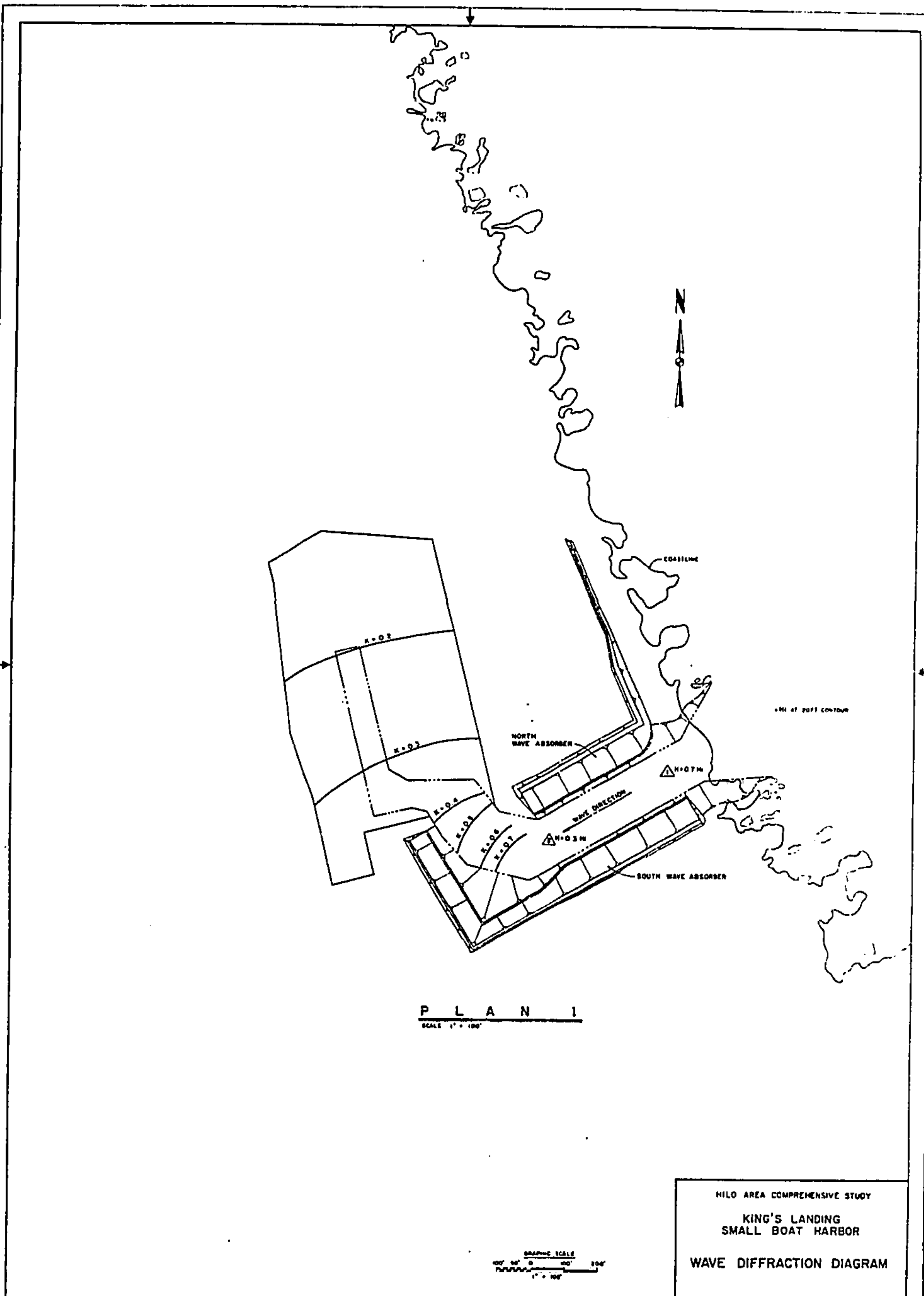

LIGHT
30
20
10
EXISTING ROAD
60
50
40
ENTRANCE CHANNEL
ACCESS CHANNEL
PACIFIC OCEAN
FUTURE LAUNCH RAMP
N
30
20
10
40
GRAPHIC SCALE
400' 200' 0 400'
APPROXIMATE SCALE (FEET)
HILO AREA COMPREHENSIVE STUDY
CAPE KUMUKAHI
SMALL BOAT HARBOR
POSSIBLE
BERTHING LAYOUT
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE D-10A


N
COASTLINE
COASTLINE
EAST WAVE ABSORBER
WEST WAVE ABSORBER
WAVE DIRECTION
PLAN
GRAPHIC SCALE
HILO AREA COMPREHENSIVE STUDY
LELEIWI POINT
SMALL BOAT HARBOR
WAVE DIFFRACTION DIAGRAM
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE D-11



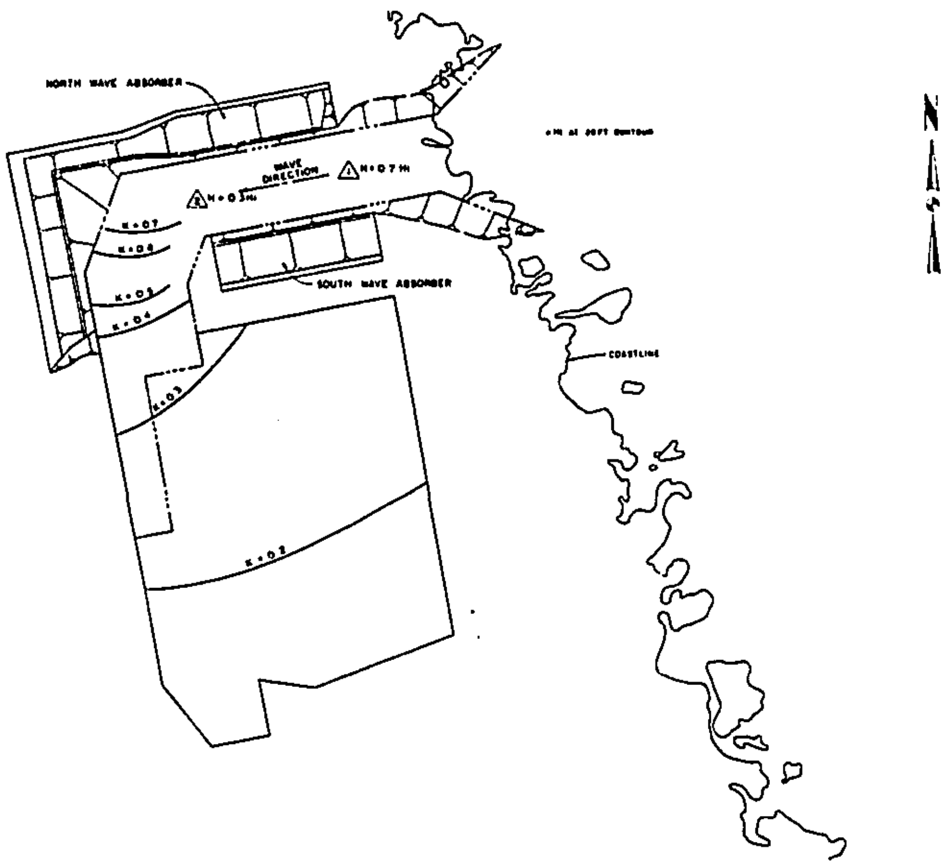
HILO AREA COMPREHENSIVE STUDY

KING'S LANDING
SMALL BOAT HARBOR

WAVE DIFFRACTION DIAGRAM

U S ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-12



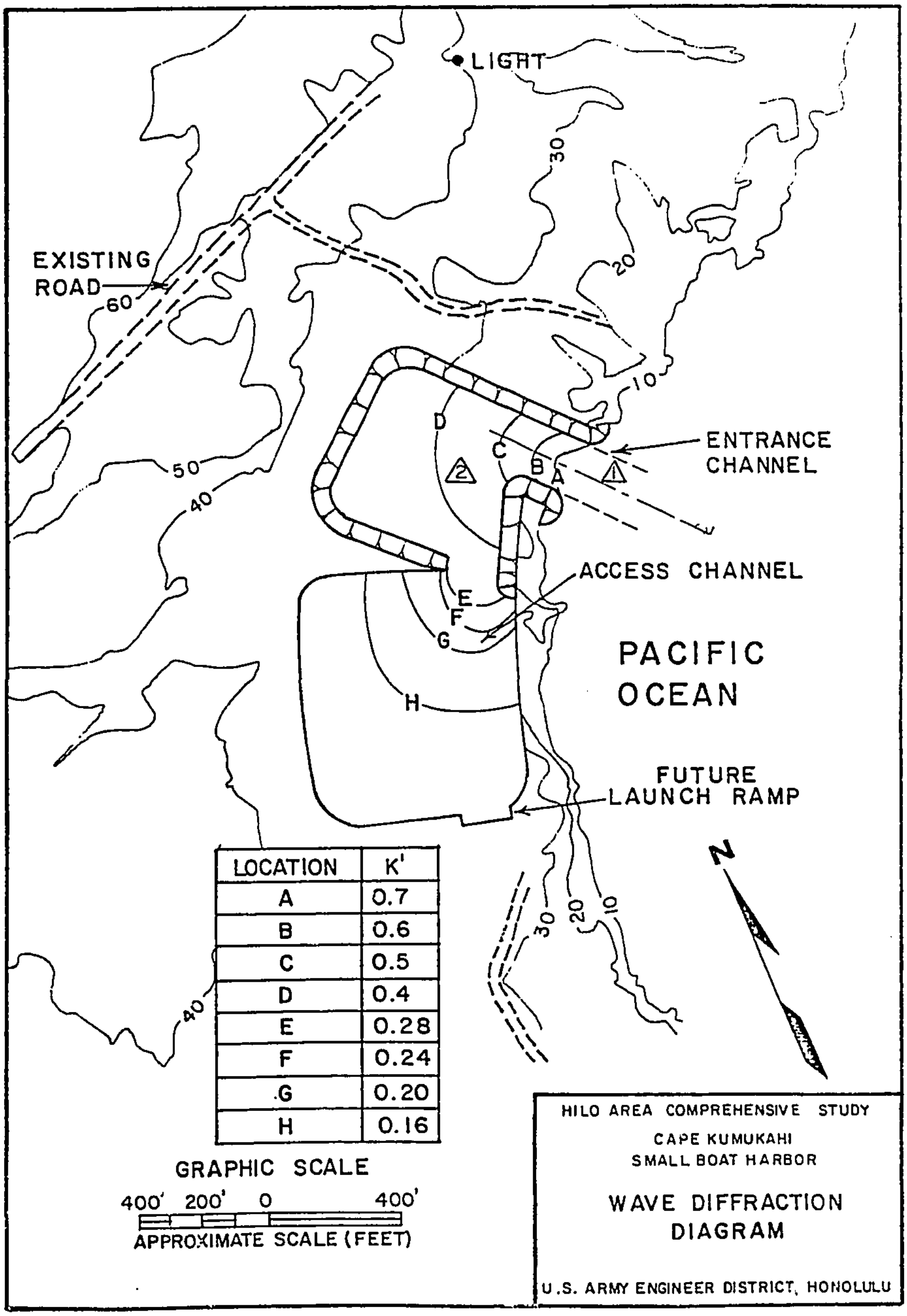
PLAN 2

HILO AREA COMPREHENSIVE STUDY

KING'S LANDING
SMALL BOAT HARBOR

WAVE DIFFRACTION DIAGRAM

U.S. ARMY ENGINEER DISTRICT, HONOLULU



LOCATION	K'
A	0.7
B	0.6
C	0.5
D	0.4
E	0.28
F	0.24
G	0.20
H	0.16

FIGURE D-14

12. BASIN RESPONSE TO INCIDENT WAVE CRESTS.

Theoretical analyses were conducted to determine the wave periods that would increase resonant surging. The fundamental resonance period (T) is the time it takes a wave to travel from one end of a basin to the other end and back. Any multiple of this wave period may induce resonant surging. The fundamental resonance is computed as follows:

$$T = \frac{2b}{\sqrt{gd}}$$

b = basin length, ft

g = acceleration due to gravity, 32.2 ft/sec^2

d = basin depth, ft

Site	b, ft	d, ft	T, sec
Leleiwi Point	900	10	100
Kings Landing			
Plan 1	900	10	100
Plan 2	700	10	78
Cape Kumukahi			
Wave Trap	400	14	38
Berthing Area	800	10	89

APPENDIX D

SECTION II. COST ESTIMATE SECTION: SMALL BOAT HARBOR

Table of Contents

1. BASIS FOR ESTIMATE

a. Estimated quantities were based on existing topograhic and hydrographic maps and surveys and typical plans and section.

b. Materials to be dredged and excavated are hard basalt rock, and will require blasting.

c. The disposal site will be designated within two (2) miles from the site, for Leleiwi and King's Landing, and within one-half mile from the site for Cape Kumukahi.

d. Armor stones and underlayer stones will be obtained from the government quarry at Hilo.

e. Estimated construction period is two (2) years and 12% of cost growth is included in the unit cost.

f. An Oahu contractor will do the construction.

g. September 1983 price levels.

h. A 20% contingency cost allowance.

i. All unit prices includes factors for waste.

2. PROJECT FIRST COST

a. Leleiwi Point

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	315,000	
Clearing	13 AC	3,800.00	49,400	
Drilling and Blasting	235,300 CY	6.50	1,529,500	
Exc. & Disposal - Above Water	86,000 CY	7.05	606,300	
Exc. & Disposal - Below Water	149,300 CY	9.10	1,358,600	
Armor - 1.5 to 3 Ton	10,600 CY	73.65	780,700	
Armor - 0.5 to 15 Ton	7,620 CY	73.65	561,200	
Underlayer 100# - 500#	7,020 CY	60.15	422,300	
Armor from Exc. 1.5 Ton	6,810 CY	57.20	389,500	
Build A Causeway	LS	-	89,000	
				6,102,900
CONTINGENCY 20%				1,220,100
USCG Aids to Navigation				20,000
TOTAL FEDERAL COST				7,342,000
NON-FEDERAL COST				
Clearing	11 AC	3,800.00	41,800	
Drilling and Blasting	211,900 CY	6.50	1,377,400	
Exc. & Disposal - Above Water	65,900 CY	7.05	464,600	
Exc. & Disposal - Below Water	146,000 CY	9.10	1,328,600	
				3,212,400
CONTINGENCY 20%				642,500
TOTAL NON-FEDERAL COST				3,855,000
TOTAL FIRST COST				11,197,000

b. King's Landing - Plan 1

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	315,000	
Clearing	8 AC	3,800.00	30,400	
Drilling and Blasting	307,200 CY	6.50	1,996,800	
Exc. & Disposal - Above Water	112,950 CY	7.05	796,700	
Exc. & Disposal - Below Water	194,250 CY	9.10	1,767,700	
Armor - 3-6 Ton	32,120 CY	63.60	2,042,800	
Armor - 0.5 to 1.5 Ton	8,430 CY	73.65	620,900	
Underlayer 600# - 1200#	6,560 CY	60.15	394,600	
Underlayer 100# - 500#	3,170 CY	60.15	190,700	
Armor from Exc. 1.5 Ton	1,500 CY	57.20	85,800	
Build A Causeway	LS	-	89,000	
				8,330,000
CONTINGENCY 20%				1,666,000
USC Aids to Navigation				20,000
TOTAL FEDERAL COST				10,016,000
NON-FEDERAL COST				
Clearing	10 AC	3,800.00	38,000	
Drilling and Blasting	225,000 CY	6.50	1,462,500	
Exc. & Disposal - Above Water	75,100 CY	7 05	529,500	
Exc. & Disposal - Below Water	149,900 CY	9.10	1,364,100	
				3,394,000
CONTINGENCY 25%				679,000
TOTAL NON-FEDERAL COST				4,073,000
TOTAL FIRST COST				14,089,000

b. King's Landing - Plan 2

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	315,000	
Clearing	11 AC	3,800.00	41,800	
Drilling and Blasting	311,700 CY	6.50	2,026,100	
Exc. & Disposal - Above Water	145,100 CY	7.05	1,023,000	
Exc. & Disposal - Below Water	166,600 CY	9.10	1,516,100	
Armor - 3-6 Ton	24,730 CY	63.60	1,572,800	
Armor - 0.5 to 1.5 Ton	8,850 CY	73.65	651,800	
Underlayer 600# - 1200#	7,730 CY	60.15	465,000	
Underlayer 100# - 500#	3,320 CY	60.15	199,700	
Build A Causeway	LS	-	89,000	
				7,900,000
CONTINGENCY 20%				1,580,000
USCG Aids to Navigation				20,000
TOTAL FEDERAL COST				8,922,000
NON-FEDERAL COST				
Clearing	9 AC	3,800.00	34,200	
Drilling and Blasting	324,700 CY	6.50	2,110,600	
Exc. & Disposal - Above Water	179,900 CY	7.05	1,268,300	
Exc. & Disposal - Below Water	144,800 CY	9.10	1,317,700	
				4,731,000
CONTINGENCY 20%				946,000
TOTAL NON-FEDERAL COST				5,677,000
TOTAL FIRST COST				15,177,000

c. Cape Kumukahi

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
Mob & Demob	Job	-	315,000	315,000
Clearing	7 Acres	3,800	26,600	26,600
Excavate Entrance Channel	9,900 CY	28.00	277,200	
Excavate Wave Trap				
a) Above MLLW	828,000 CY	6.90	5,713,200	
b) Below MLLW	213,900 CY	7.70	1,640,100	7,630,500
Wave Absorber				
a) Placing armor stones	40,000 Tons	41.00	1,640,000	1,640,000
				9,612,100
CONTINGENCY 20%				1,922,400
				11,534,500
USCG Aids to Navigation				20,000
TOTAL FEDERAL COST				$11,554,500
NON-FEDERAL COST				
Clearing	5 Acres	3,800	19,000	19,000
Excavate Berthing Area				
a. Above MLLW	552,000 CY	6.90	3,808,800	
b. Below MLLW	142,000 CY	7.70	1,093,400	4,902,200
Ramp	17,000 SF	16.00	272,000	272,000
				$5,193,200
CONTINGENCY 20%				1,038,600
TOTAL NON-FEDERAL COST				$6,231,800
TOTAL FIRST COST				$17,786,300

SUPPORTING DOCUMENTATION

GEOLOGY

GEOLOGY

LELEIWI POINT, KING'S LANDING AND KUMUKAHI SMALL CRAFT HARBOR

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GEOLOGY

LELEIWI POINT, KING'S LANDING AND KUMUKAHI SMALL CRAFT HARBOR

REGIONAL GEOLOGY

The island of Hawaii, the largest of the Hawaiian Archipelago, covers an area of over 4,000 square miles. The island was formed during the last 800,000 years by the gradual emergence and subsequent coalescence of five volcanoes, Mauna Loa and Kilauea, which are still active, Hualalai, which last erupted in 1801, Mauna Kea, which has been inactive in recent geologic time, and Kohala, which has been extinct for eons. Figure 1 shows the island of Hawaii and the locations of these volcanoes with their respective rift zones (zones of fissures, fractures and faults which have emitted lava).

The volcanic mountains are generally oval and dome-shaped. Mauna Loa rises from a base 15,000 feet below sea level to 13,680 feet above sea level. It is the largest active volcano and is considered the biggest single mountain on earth.

Kilauea volcano is located on the southeastern slope of Mauna Loa and merges so imperceptibly with its giant neighbor that significant dimensions cannot be assigned. Lava from Mauna Loa locally flow over the slopes of Kilauea. The caldera, Halemaumau, is three miles (5 km) and two miles (3 km) wide. The notable topographic features of Kilauea are the high echelon fault escarpments paralelling the south coast.

These five mountains have been formed almost entirely by the accumulation of thousands of thin flows of lava, each separate flow averaging less than ten feet in thickness. The broad, smooth, dome shapes have given rise to the name of "shield" volcanoes. Nowhere are the lower slopes of the mountains steeper than twelve degrees with the average slope around six degrees. The slopes are formed by the cooling of lava and accompanying change in lava gradient. Gentle, flat slopes extend outward beneath the water to the sea floor.

The small boat harbor sites are shown on Figure 1. Kilauea volcano, about 4,090 feet above sea level is the most active volcano on Hawaii within recent history; however, its lava production during this time is only slightly more than Mauna Loa's. Although most of this volcanic activity was associated witn Halemaumau (located within Kilauea's main caldera), much lava has flowed from two rift zones on the flanks of the volcano; the southwest rift zone and the east rift zone. The east rift zone extends from Halemaumau to Cape Kumukahi and consists of a series of small calderas, puus (cindercones), fractures and faults.

LAVA FLOWS - ROCK CLASSES.

Both pahoehoe and aa* basaltic lavas are common on the slopes of Mauna Loa and Kilauea with a preponderance of aa usually found at lower elevations. Because all flows are erupted first in the pahoehoe form the upland parts near the fissure or crater exhibit a larger preponderance of pahoehoe. The level of the ocean at the time the lava flows were deposited controlled to a large extent the quality of the rock that solidified.

The contact of lava flows, one on another is marked by great irregularity occasioned by the broken character of the pre-existing surface and by the chilling and increase in viscosity of the advancing lava. Pahoehoe flows are distinguished by relatively smooth, billowy, ropy or entrail like surfaces. When the viscosity of the molten lava increase and the slope of the terrain decreases, tumuli or pressure domes develop. Transition of pahoehoe to aa goes through a stage called a slabby pahoehoe, a rock form commonly found in the slopes above Kalapana and evidenced in the ridge of rock outcropping in the middle of Kaimu beach.

The upper part of aa consists of clinker and loose scoriaceous basalt pieces which are generally weathered and produce a soil-rock mixture when excavated. The loose clastic surface layer of aa is open and porous and hence decay has created a residual sediment suitable as fill for embankment and levee construction. Dense, hard basalt underlies the clinker-scoriaceous, strippable layer in aa flows. The hard layer varies in thickness and strength, from closely jointed, easily excavatable rock to thick (up to 15 feet), widely jointed (five feet or more) hard rock requiring drilling and

* The terms pahoehoe and aa are Hawaiian and are used to classify the surface appearances and structure of lava flow.

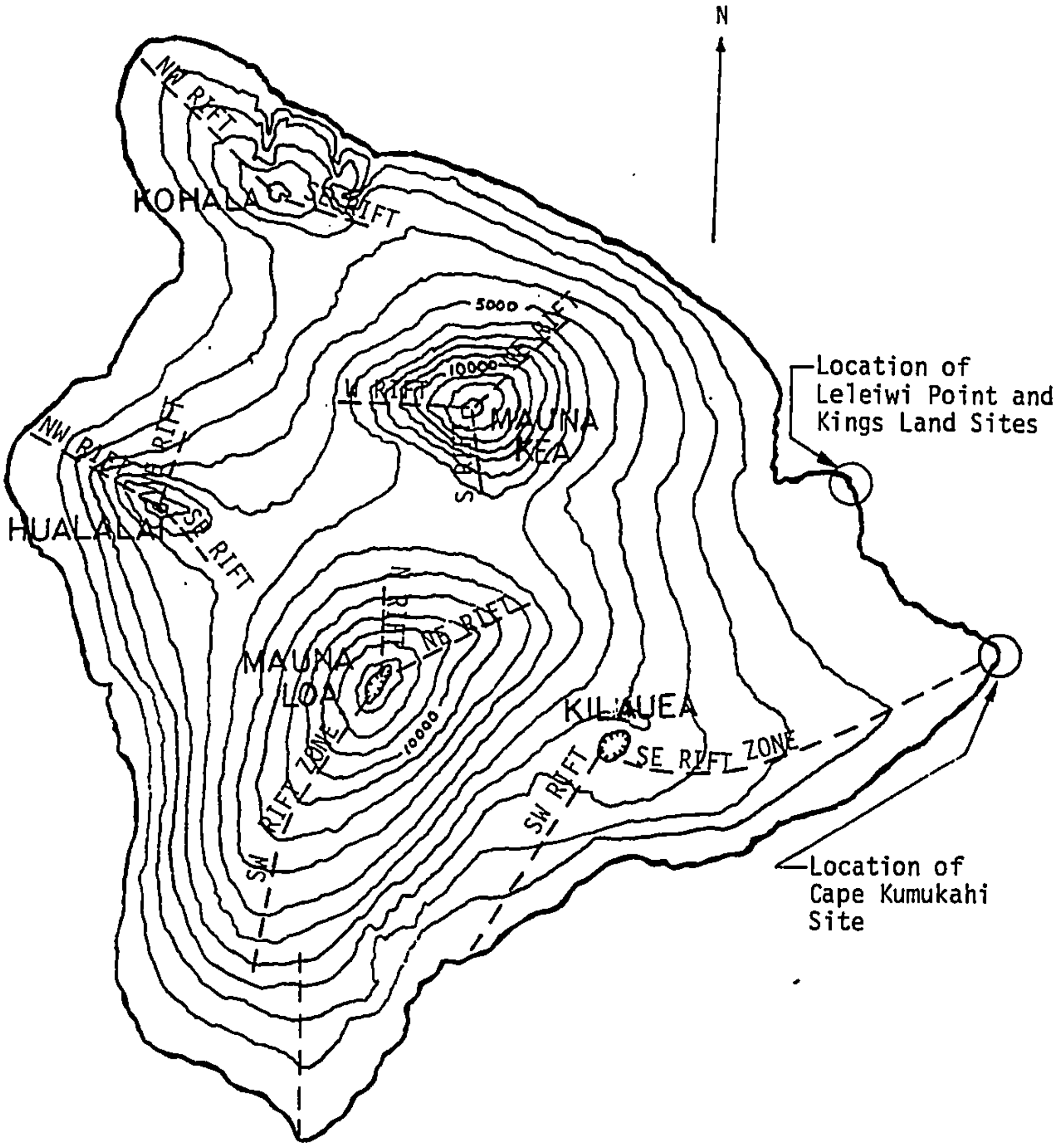

Figure 1. Map of Hawaii Showing Principal Volcanoes with Respective Rift Zones

blasting. The rock at the three proposed sites is expected to be similar to that found at the Honokahau Small Boat Harbor and the construction experiences will be similar.

EARTHQUAKE HISTORY - SEISMIC STABILITY.

Hawaii has a higher density of earthquakes (occurrence rate of magnitude two and greater earthquakes per unit area) than any other state in the United States. During the past 18 years about 48,000 earthquakes in Hawaii have been located and their magnitude determined. Of these 48,000 earthquakes, more than 3,400 events were of magnitude 3.0 to 7.2; magnitude 3.0 is generally the threshold of felt earthquakes in Hawaii.

The strongest earthquake in historic time in the islands occurred April 2, 1868 and was centered along the south coast of the island of Hawaii. This earthquake had a Richter magnitude of about 7.5 on the island of Hawaii and caused serious damage across the entire island even stopping clocks as far away as Honolulu. The last eruption and lava flows affecting the Puna coastline was in September 1977. During the past 15 years, the island of Hawaii has experienced 11 earthquakes with Richter magnitude ratings of 6 or more. The most recent occurred on 19 November 1975. Earthquakes and volcanic activity can be expected to continue in the Puna district. Practically all earthquakes on the island of Hawaii are associated with intermittent volcanic activity.

The Koae and Hilina block fault systems on the south central flank of Kilauea are closely related to intrusion of magma into two rifts, east and southwest. The faults extend the entire south flank and are characterized by gaping cracks and long, sinuous normal fault zones with north-facing scarps. Most fractures are 200 meters or longer and arranged in echelon. Fractures dip vertically, strike N.75°E and have dilated in a N.15°W. Average dilation across the entire fault system is about 25 meters and generally increases eastward.

The Uniform Building Code and Corps of Engineers Manual 1110-2-1902 assign a zone four seismic probability for the portion of the island of Hawaii on which the three sites are located.

SUBSIDENCE.

Depression of the shoreline of the island of Hawaii relative to sea level has been observed in the last 200 years through archaeological and historical investigations. The rise of the sea level has been documented in a paper titled "The Rise of Sea Level in Contemporary Times at Honauanu, Kona, Hawaii" in Pacific Science, Vol XX, No. 1, January 1966 by Russel A. Apple and Gordon A. MacDonald. Increased depth of water over past land routes, comparisons of old and new photographs, increasing storm damage to structures, and newspaper accounts all indicate a relative sinking of the shore. The rate of change of relative level of land and sea over many parts of the island of Hawaii is much greater than that of worldwide change of sea level, and must be the result of actual sinking of the island. The actual sinking indicated by the shoreline evidence is most likely the result of isostatic adjustment resulting from loading of the earth's crust by the great added mass of the volcanoes.

LELEIWI POINT AND KING'S LANDING SITES

SITE GEOLOGY.

No specific geological investigations have been made for these sites. Information was obtained from published and unpublished literature, topographic maps and color aerial photographs. The Leleiwi site is located approximately 3/4 mile from the southeast end of Runway 26 of Hilo Airport, and the King's Landing site is located about 2.6 miles southeastward of the same point. Both harbors would be recessed within the coastal landmass. Excavation at both sites would be into prehistoric aa and pahoehoe lava flows generated from Mauna Loa. Seacliffs of jagged and irregular configuration line the coastline. However, the topographic relief of the subject site is gentle behind the cliff line. Geological hazards at this site, such as lava inundation, pyroclastic inundation, explosive eruptions, land subsidence, ground fractures, and gas, are considerably less probable than at the Kumukahi area since they lie outside the active vent and rift zones of Kilauea and Mauna Loa. Leleiwi and King's Landing sites are, however, still prone to seismic activity generated on the island.

Leleiwi Point and King's Landing are in areas of aa lava flow similar to the terrain south of Hilo in the Waiakea district. The comprehensive quarry investigations made for the Tsunami Protection & Navigation Improvement Project, DM #2 found "the upper part of the aa flows consist of porous, sponge-like rock (volcanic slag)" known as scoria or clinkers. The porous structure is caused by the escape of gases and water vapor resulting from internal mechanical stirring of the lava which leaves voids or vesicles. The upper surface of aa flows are indescribably rough and almost impossible to traverse especially if covered by thick vegetation and the surface is hidden by moss, lichen and ferns. The clinker surface layers normally range from five feet to ten feet and on overly dense, hard basalt.

EXCAVATION.

The basalt layer ranges from two feet to ten feet or more. The near surface layer(s) of basalt, where less than ten feet thick, can be excavated and exposed by ripping. The excavation on the Kaimu-Chain of Craters Road by Yamada and Sons (see PODED-GE report 710 dated 11 Jun 79) was performed using D-9 bulldozers. The rock has a specific gravity of 2.86 S.S.D. and an average unconfined compression strength of 22,500 psi. Pieces are pulled from their interlocked position by using rippers and dozers. Rock below water level will require drilling and blasting or some other similar type excavation to remove.

Lava basalt in the proposed harbor site is variable and unpredictable in physical and chemical properties. Even with detailed investigations, which projects of this magnitude cannot justify or support economically, there will be major sources for changed condition claims. Investigations to map intraflow and clinker layers and lava tubes are necessary. Ragged and irregular surfaces result from drilling and blasting lava basalt even with line drilling and controlled blasting methods, excavation lines are difficult to control and obtain.

Since lava flows in the areas of the harbors are very permeable, it is anticipated that groundwater will flow seaward through the harbors areas.

KUMUKAHI SITE

SITE GEOLOGY.

Geologic studies have not been made specifically for the Kumukahi site and only generalities from published and unpublished literature, topographic maps, personal communications with USGS scientists and visual observations were used in preparing the following paragraphs:

The proposed small boat harbor is located slightly south of the point at Cape Kumukahi as shown on the "Geologic Map," Figure 2. A harbor recessed within the landmass is proposed. The geologic map shows that most of ground surface and shoreline at the proposed site was altered by a recent Kilauea lava flow in 1960. Small Kipukas* within and adjacent to the proposed site offer exposures of the prehistoric Kilauea (older than 1790) lavas underlying the 1960 lavas. Approximately 10% of the surface area of the site consists of the older prehistoric lavas. The prehistoric lavas are identical in physical and chemical composition to the 1960 lava and cannot easily be differentiated in fresh exposures. Only a lighter gray color, slightly smoother rock surfaces and the sparse presence of lichens and other primitive vegetation distinguish the surface of the prehistoric lavas from the 1960 lavas.

Although the topographic relief is not great (on the order of 10 feet), the ground surface at the proposed site consists of small irregular mounds, ridges and depressions formed by the continued movement of cooling, semi-molten aa lava. A very rough terrain has developed which is difficult to traverse because of loose and broken basalt rock. Occasional streams and ponds of solidified pahoehoe lavas can also be observed among the aa lavas. The shoreline is jagged and irregular with protrusions, ridges and spurs falling away into deep water. Wave-cut seacliffs frequently expose massive (10+ feet) sections of basalt and small inlets which represent weaker areas that are more subject to erosion. Greenish black basaltic sand is found in shallow pockets and cavities (less than 2 feet thick) on the surface of the rugged terrain along the shoreline.

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* The term Kipuka is Hawaiian and is used to identify windows or islands of older lavas surrounded by younger.

The surface and a considerable portion of the upper part of the flow layers consists of porous clinker, aa flow rock (volcanic slag) with minor amounts of the smoother pahoehoe lavas. Both have very porous structure which is caused by the escape of gases and water vapor resulting from internal mechanical stirring of the lava which results in vesicles upon solidification. Below the upper clinker zone, the flow layers consist of massive vesicular basalt which are 10 feet in thickness or greater. The wave-cut, massive basalt exposures and small inlets along the shoreline, in addition to the surface conditions mentioned above, suggests that a high degree of variability of rock properties exists both horizontally and vertically at the proposed site. The Kumukahi Site is subject to geologic hazards which are discussed later under heading Geologic Hazards.

SUBSURFACE INVESTIGATIONS.

No subsurface investigations have been performed at the proposed site of the small boat harbor at this stage. Only visual observations as described in the section on site geology are available. It is anticipated that the area consists of recent lava basalt of unknown thickness, underlain by older lava basalt flows of similar physical character. Lenses and/or layers of basalt, clinker zones, and ash may also exist within the subsurface profile.

DESIGN AND CONSTRUCTION CONSIDERATIONS.

(1) Excavation - It is expected that approximately 70% of the excavation for the harbor and entrance channel would require drilling and blasting of lava basalt. The clinker zones can probably be excavated with conventional ripping and/or dredging. A rough estimate of 3 to 4 million cubic yards of material will result from the excavation, most of which will be wasted. Depending upon the quality of the lava basalt, some may be used at the project site, or sold to commercial suppliers for aggregate.

(2) Slopes - Side slopes no steeper than 1 vertical to 1 horizontal are estimated for the harbor entrance channel and turning basin. Future subsurface investigations will be required to determine the final construction slopes for each facility.

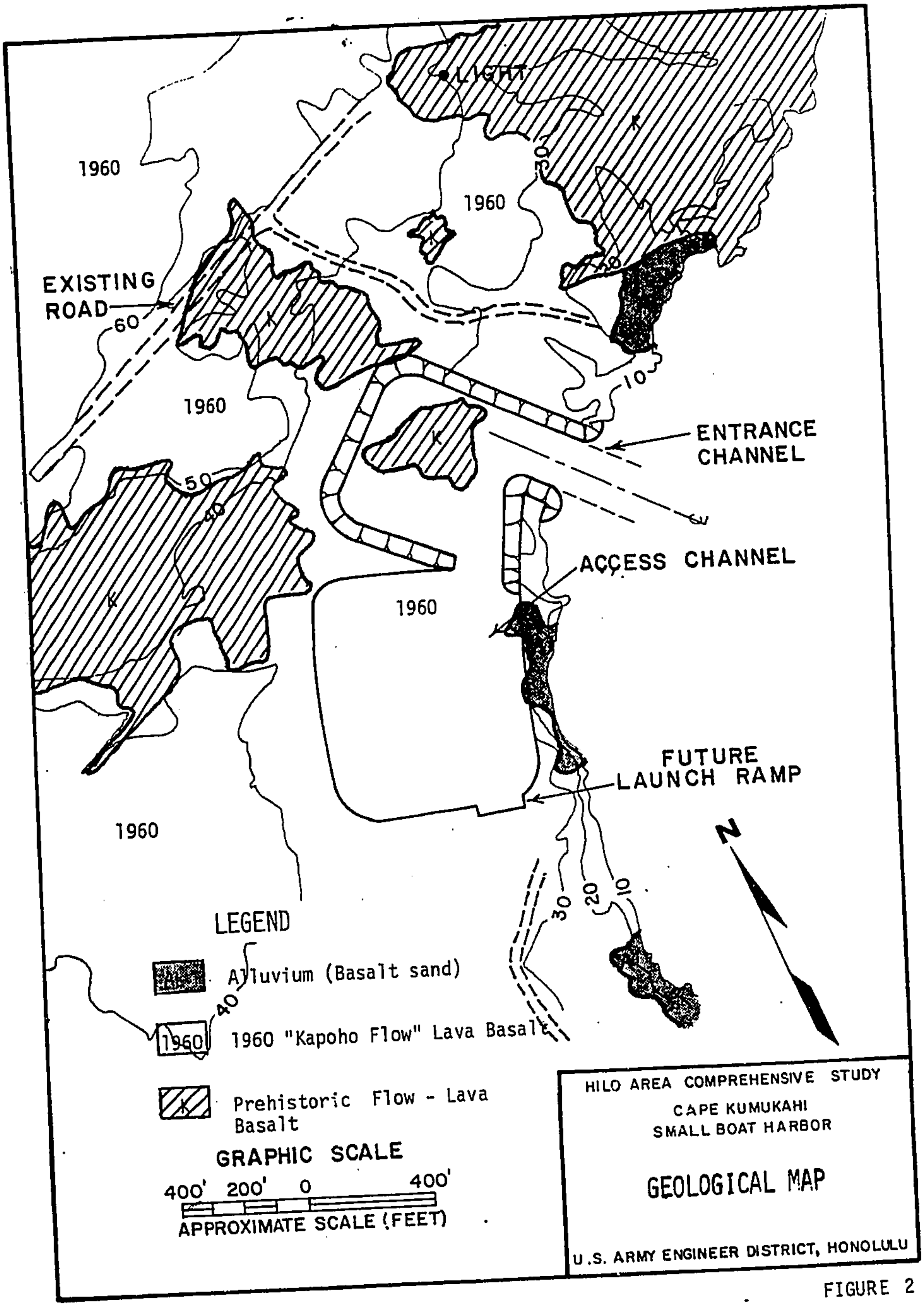
LIGHT
1960
EXISTING ROAD
ENTRANCE CHANNEL
ACCESS CHANNEL
FUTURE LAUNCH RAMP
N
LEGEND
Alluvium (Basalt sand)
1960 "Kapoho Flow" Lava Basalt
Prehistoric Flow - Lava Basalt
GRAPHIC SCALE
400' 200' 0 400'
APPROXIMATE SCALE (FEET)
HILO AREA COMPREHENSIVE STUDY
CAPE KUMUKAHI
SMALL BOAT HARBOR
GEOLOGICAL MAP
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 2

SOURCE OF CONSTRUCTION MATERIALS.

Revetment stone of suitable quality for the entrance channel and inner harbor is not available in the project vicinity. Depending upon the density and hardness of the excavated basalt from the harbor construction, some may be used for revetment stone. The vesicular nature of the basalt may preclude the use of excavated material for armor stone. All other stone will have to be obtained from quarries in Hilo.

Two commercial quarries operate in the Hilo area. They are the Glovers Quarry and the Y and S Quarry. Both are located in the industrial Waiakea District about one mile south of the Terminal Building at the General Lyman Airfield or 30 miles northwest of the project site. The two quarries work the same deposit which was described in detail in Design Memorandum No. 2, Construction of Tsunami Protection and Navigation Improvement Project, Hilo, Hawaii. The rock is a prehistoric member of the Ka'u volcanic series from the Mauna Loa volcano.

Neither quarry operates to produce armor stone sizes and special arrangements have to be made in advance for large quantities of rock for revetments. Small amounts of large stones are stockpiled in both quarries from time to time.

Aggregate for asphaltic and portland cement concrete is available from both quarries.

GEOLOGIC HAZARDS.

The location of Cape Kumukahi, on the east rift zone of the Kilauea volcano, makes the site of the proposed harbor highly susceptible to the geological hazards of, and associated with, volcanic activity. Such hazards include lava and pyroclastic debris inundation, explosive eruptions, seismic activity, land subsidence, tsunamis, ground fracture and volcanic gas.

(1) Lava Inundation - The most common volcanic hazard in Hawaii is burial by lava flows. The proposed site was almost completely inundated by the lava flow in 1960, referred to as "the Kapoho flow" which erupted from the lower

portion of Kilauea's east rift zone. The source of the Kapoho flow was a series of vents located 1/2 mile northwest of the Kapoho Crater and 2-1/2 miles west of the proposed harbor site. The 1960 flow consisted of both pahoehoe and aa type lavas. The general direction of the flow was from southwest to northeast with the main part of the flow entering the ocean just north of Cape Kumukahi. The southern portion of the point at Cape Kumukahi (just north of the proposed site) was not inundated by the Kapoho flow in 1960.

Mullineaux and Peterson (1982) have zoned the entire east rift zone (including Cape Kumukahi) zone f or the highest relative risk zoning possible for lava inundation on the island of Hawaii. Zone f is described by Mullineaux and Peterson as follows:

> "Zone of highest risk; includes summit areas and major rift zones of Kilauea and Mauna Loa Volcanoes. Land within zone f has a historic and recent prehistoric record of active volcanic vents, formation of cones and craters, and of burial by lava flows. Since 1800, about 80 eruptions have originated within zone f, and about half the land area within the zone has been covered by lava. During each period of 20 years, from about 3 to 8 percent of the land within zone f was covered."

Although the proposed harbor site at Cape Kumukahi was inundated by the 1960 Kapoho flow, it escaped inundation during an eruption at Kapoho in 1955. Other historic eruptions in Kilauea's lower east rift zone at Kapoho occurred in 1924, 1840 and 1790, all of which did not reach the location of the proposed harbor site.

(2) Pyroclastic Inundation - The risk of pyroclastic debris inundation for the proposed site is equal to the lava inundation risk. Mullineaux and Peterson have mapped the east rift of Kilauea as Zone III, the highest risk rating for areas susceptible to pyroclastic debris inundation. To corroborate this, cinder cones Puu Kukae and Kapoho Crater, two features of pyroclastic eruptions, are in view of proposed site.

(3) Explosive Eruptions - The hazard of violent, explosive eruptions for this portion of the east rift are not considered as great as they are for the immediate vicinity of Kilauea. Eruptions along the lower east rift are

generally the less violent, lava producing type. The 1960 Kapoho flank eruption lasted 37 days and produced about 160 million cubic yards of lava. Mullineaux and Peterson rate the lower east rift zone, which includes the area of the proposed harbor site, as Zone II. The risk increases from I to III.

(4) Seismic Activity - Hawaii has the highest density of earthquakes (occurrence of magnitude two and greater earthquakes per unit area) in the United States. During the past 18 years, about 48,000 earthquakes in Hawaii have been located and their magnitudes determined. Of these, more than 3,000 events were of magnitude 3.0 to 7.2; magnitude 3.0 is generally the threshold of felt earthquakes.

Possibly the strongest earthquake in historic time in the islands occurred on April 2, 1868 and was centered along the south coast of the island of Hawaii. The earthquake had a Richter magnitude of about 7.5 and caused serious damage across the entire island, even stopping clocks as far away as Honolulu. As a result of earth subsidence, a tsunami was generated. Practically all earthquakes on the islands of Hawaii and Maui are associated with intermittent volcanic activity. However, earthquakes in the islands can also be caused by deep seated tectonic forces not directly associated with volcanic activity. A Richter magnitude 7 earthquake on January 23, 1938 had an epicenter 25 miles north of Pauwela Point on the north shore of Haleakala, Maui. Recent geophysical explorations show that faults and rift zones cut through the major islands and that these faults are branches of a gigantic and deep seated fracture system known as the Molokai Fracture Zone. The largest earthquake since the 1868 event occurred on November 29, 1975. This earthquake registered 7.2 on the Richter scale and was centered about 5 km beneath the Kalapana area. Like the 1868 earthquake, it caused widespread damage and is believed to have resulted from movements of a volcano flank caused by magma intrusion into a rift zone.

The magnitude of Hawaiian earthquakes was not routinely monitored locally until 1958 when the Hawaiian Volcano Observatory (HVO) began monitoring the seismic regime of Hawaii as a part of its "volcanic watching" function. Prior to that, magnitudes of large earthquakes were measured by seismograph stations on the continental United States. Even today, stations such as those at the California Institute of Technology, University of California at Berkeley, and

Columbia University are consulted to determine magnitudes of the larger Hawaiian earthquakes which produces enormous energy and exceeds the measuring capability of HVO's equipment.

The seismic regime of Kilauea's lower east rift has been characterized by episodic swarms of shallow (5 to 10 km), low intensity earthquakes generally associated with magma movements to secondary storage zones and not necessarily with volcanic eruptions. In addition, most of the events or swarms of events occur in the western portion of the lower east rift near Puu Honuaula. Although the specific seismic regime at the subject site is somewhat low-scaled, the intensity of major earthquakes from nearby locations on Hawaii has been pronounced. The 7.2 magnitude earthquake on November 29, 1975 was felt with an intensity between V and VI at Cape Kumukahi (Tilling and other, 1976).

(5) Land Subsidence - The proposed site is located about one-half mile from a fault in the east rift zone (Stearns and MacDonald, 1946). This area of faulting was inundated by lava in 1955 and 1960 and evidence of faulting and land subsidence has been masked. Land subsidence associated with faulting is common along the Puna coast. In 1924 about 12 feet of subsidence occurred at a fault trench (graben) near Kapoho or about 2-1/2 miles from the proposed site.

The mechanics of subsidence and the seismic activity associated with the Kilauea volcano in general can be viewed in simple terms if the buttressing effect of Mauna Loa is considered. Mauna Loa, the larger of the two volcanoes, performs as the stable block against which Kilauea grows. With its continued growth, Kilauea's landmass increasingly obeys gravitational laws and moves downslope and seaward as the downthrown side of this massive fault zone. It is difficult, perhaps impossible, to determine whether the volcanic activity of Kilauea is a result of movement of the volcano or if movements in the landmass trigger volcanic activity. Whatever the case, this cause and effect relationship is very likely to continue into the geologic future. It is noteworthy to point out that some scientists feel the buttressing effect of Mauna Loa north of the rift lessens with increasing distance to the east, (Koyanagi and others, 1981). It seems that subsidence in the lower east would be less; however, these same scientists hypothesize that the changes in landmass stress patterns from west to east resulting from the influence of Mauna Loa is reason enough for instability in the lower east rift and subsequent volcanic activity. In essence, the lower portion of the east rift becomes a secondary storage zone for magma which is supported by recent lava flows at this location as well as submarine eruptions east of Cape Kumukahi.

Regional subsidence of the island of Hawaii was determined by Apple and Macdonald (1966) to be on the order of 30 cm per century. This may be slightly conservative as other estimates of 4 mm per year have been proposed. The importance of the regional subsidence cannot be underestimated because of the long-term (planned) use of coastal facilities and their vulnerability to storm waves and tsunamis. Rapid, block-type land subsidence was demonstrated in the Kapoho area in 1924 and 1960. The collapse of large blocks between faults (called grabens) resulted, in each case, from the withdrawal of magma in the east rift zone. Mullineaux and Peterson point out that the two most susceptible areas in Hawaii to land subsidence are coastlines, specifically the Puna coast, and active rift zones. Hence, the proposed site is a focal point for this hazard. Since the block-type subsidence is related to volcanic activity (whether an eruption occurs or not) the percentage chance of subsidence at the proposed site is at least equal to the percentage chance of lava inundation. Mullineaux and Peterson further suggest that the "settled blocks also become more vulnerable to inundation by lava flows and by the ocean where rift zones cross shorelines." The collapse of lava tubes is another type of subsidence which presents a geologic hazard mainly to structures. The risk of this type of land subsidence, however, is no different for the proposed site than for any location in the volcanic rocks of Hawaii.

(6) Tsunamis - A tsunami, or seismic sea wave, is a series of elastic waves in the water of the ocean, caused by a sudden large displacement of the sea floor. Its importance as a geologic hazard is overshadowed by its hydrologic impacts and will not receive significant treatment in this section. What is important is to note that the geologic processes which create tsunamis are concentrated in and around the proposed site making it a high risk location for tsunami inundation. The 7.2 magnitude earthquake of November 29, 1975 generated tsunamis which measured between 5.9 feet and 11.2 feet at Cape Kumukahi (Tilling and others, 1976).

(7) Ground Fractures and Volcanic Gas - Of less structural significance but high environmental impact on the quality of life are such hazards as ground fractures and volcanic gas. Ground fractures and volcanic gas emissions are a result of the same mechanisms controlling eruptions, earthquakes and land subsidence, therefore, risks assigned for structural designs are the same. The high risk, however, is further enhanced when considering potential injury or loss of life by entrapment and asphyxiation.

(8) Summary of Geological Hazards at Kumukahi Site - The chance of burial from lava flows has been estimated to be 1% over the next 50-year period and 50% over the next 100-year period. These estimates are an educated guess which is based on time cycles of recent (historic) eruptions in this area and areas inundated by the respective eruptions, and personnel communications with USGS scientists at the Hawaiian Volcano Observatory. It is important to note that the estimated percentage chance of recurring lava inundation decreases dramatically for sites north of Cape Kumukahi while only slight improvements can be realized for coastal sites south of the Cape to Punaluu. The potential for burial by pyroclastic debris from lava fountains is equal to the risk for lava inundation. Other geologic hazards contributing to the high risks assigned to the proposed site includes seismic activity, land subsidence, tsunami, ground fracturing and volcanic gas.

The Army Technical Manual 5-809-10 (Feb 1982) assigns a zone four (4) seismic risk rating for the southeast half of the island of Hawaii for design consideration. The impacts of explosive eruptions is the only geologic hazard mentioned which presents only a moderate risk to the proposed harbor site.

SUPPORTING DOCUMENTATION

ECONOMICS

ECONOMICS

GENERAL

The objective of this study is to analyze the benefits for a light draft harbor serving the Hilo area commercial fishing needs (the recreational boating needs for the Hilo area are evaluated in another report). Three alternative size harbors were analyzed -- an additional small boat harbor of 161 berths (high projection), 117 berths (medium projection), and 67 berths (low projection). The benefits derived from each size harbor consist of navigation benefits to fishing craft that would be moored without the project; increased fish catch; and damage prevention. The computations are based on a 7-7/8 percent interest rate and a 50-year project life. The project base year, 1985, is when benefits are expected to begin accruing to the proposed harbor plans. Benefits are based on 1982 price levels.

METHOD OF ANALYSIS

The Hilo Tributary Area (consisting of Puna, South Hilo and North Hilo Districts) was designated as the study area. Without the project, the moored craft capacity of the Hilo Tributary Area will remain at its current level of 52 commercial and 54 recreational and four spaces for transients for a total of 110 spaces. With a new small boat harbor total moored spaces for commercial craft in the Hilo area would increase to 217 (157 proposed + 52 existing + 8 transient), 225 (113 + 52 + 8), and 123 (63 + 52 + 8) based on high, medium, and low projections of wet stored boating needs. It is assumed eight spaces (4 existing and 4 proposed) will be available for transient craft.

The data used in the evaluation process was obtained from field investigations, interviews with public and private interests and Federal, State, and local published reports, newspaper articles, and periodicals. A primary source of data was the State of Hawaii Boat Owner Survey, March 1980, Pacific Ocean Division, Corps of Engineers; "A Survey of Small Craft Fleet Parameters and Use Patterns Hilo, Hawaii Tributary Area," December 1979, POD, Corps of Engineers; "Geological, Biological and Water Quality Investigations Hilo Bay, Hawaii, Fishery Resource Survey," 1980, POD, Corps of Engineers; and "Benefit Analysis of Hilo Light Draft Harbor," August 1980, POD, Corps of Engineers.

RESOURCES AND ECONOMY

Hawaii is a prosperous State with a growing economy. The gross State product in 1979 amounted to $10 billion, or almost 6 times the 1960 total. The three largest contributors to the State economy are tourism ($3.0 billion), defense expenditures ($1.3 billion), sugar production ($594 million), and pineapple production ($223 million). The most rapid growth in the past decade has been in the tourist industry. Visitor expenditures have increased over 400 percent in the ten years from 1969 to 1979. Visitor spending in 1980 resulted in tax revenues of $323 million and generated 117,000 jobs.

Hawaii County experienced a population increase of 50 percent from 1960 to 1980, nearly equalling the State's overall increase of 52 percent for the same period. The resident population of the Hilo area (Puna, North Hilo and South Hilo districts) increased by 43 percent from 39,076 in 1960 to 55,708 in 1980. Sixty percent of the population on the island is centered in the Hilo area.

The basic elements of the economy of Hawaii County are tourism, agriculture and fishing, manufacturing, and scientific research with tourism being the number one industry. Visitor expenditures for Hawaii County grew from $50 million in 1969 to $172 million in 1979. While Hilo is not noted as a destination area, its role as a gateway to and from the State suggests a continued active role in the visitor industry. As the urban, commercial, and government center for the County, Hilo has a stronger orientation toward transportation, communications and utilities, trade, services, and government. It is expected that Hilo will continue to be the major urban center on the island. The following table summarizes the demographic, general social, and economic characteristics of the County.

TABLE 1
RESIDENT POPULATION OF HAWAII COUNTY AND DISTRICTS:
1960 TO 1980

	1960	1970	1980
The State	632,772	769,913	965,000
Hawaii	61,332	63,468	92,053
Puna	5,030	5,154	11,751
South Hilo	31,553	33,915	42,278
North Hilo	2,493	1,881	1,679
Hamakua	5,221	4,648	5,128
North Kohala	3,386	3,326	3,249
South Kohala	1,538	2,310	4,607
North Kona	4,451	4,832	13,748
South Kona	4,292	4,004	5,914
Ka'u	3,368	3,398	3,699
Median Years of School Completed1/	8.6	11.4	NA

1/ 25 years old and over.

Source: U.S. Bureau of the Census, U.S. Census of Population: 1970, PC(1)-A13, Table 10, and advance counts from the 1980 Census of Population.

TABLE 2
INCOME, LABOR FORCE, AND EMPLOYMENT

	1960	1970	1980
Personal Income ($ Millions)	100	241	650 2/
Per Capita Income ($)	1,630	3,785	7,760 2/
Civilian Labor Force	22,270 1/	28,300	35,450
Civilian Employment	21,520 1/	27,050	33,050
Unemployment (%)	3.4	4.4	6.7
Subcount by Industry			
Total Job (Non-agriculture)	16,040	28,870	28,400
Construction	820 1/	1,500	1,650
Manufacturing	3,300 1/	2,960	2,750
Transportation, Communication, and Utilities	970 1/	1,380	1,900
Trade	3,100 1/	5,010	7,000
Finance, Insurance and Real Estate	250 1/	900	1,100
Services	1,640 1/	3,730	7,450
Government	3,050 1/	4,370	6,550
Agriculture	2,910 1/	3,610	3,250

1/ Hawaii State Dept of Labor and Industrial Relations
2/ 1979 Estimate

Source: State of Hawaii Data Book 1981; County of Hawaii Data Book 1980 and 1979, Department of Research and Development.

TABLE 3

TOURISM HAWAII COUNTY

	1960	1970	1980
Visitor Arrivals	72,300	445,401	761,000
Visitor Expenditures ($ Millions)	5.6	53.4	172 1/
Hotel Room Inventory	558	3,092	6,260
Occupancy Rate (%)	NA	68.3	52.7

1/ 1979 Estimate

Source: County of Hawaii Data Book 1981, Department of Research and Development. The State of Hawaii Data Book, 1962, Department of Planning and Economic Development.

SMALL BOAT HARBORS

As population and income increase, a greater demand is being put on the existing boating facilities in Hawaii County. Twenty years ago, in 1962, there were only 4 principal harbors for small craft on the island. Total berthing capacity was 212 craft. In 1980, the number of harbors increased to seven but total berthing capacity increased to 329 or 55 percent. Boat registration since 1970 has increased 106 percent in the County.

Table 4 lists the small boat harbors in Hawaii County and their berthing capacities. Three of the harbors are located in the Hilo area but they are used primarily for recreational boating activities. They are Wailoa River, Radio Bay, and Reeds Bay. The Wailoa River site is located in central Hilo and is part of the Wailoa State Park. The facility has approximately 54 berthing spaces, 2-lane ramp, loading dock, parking for 20 cars with trailer, restrooms, picnic areas, boat wash area, and freshwater faucets. Radio Bay small boat harbor is located just east of the Hilo deep draft harbor facilities. The bay has approximately 11 berths with mooring by anchor in the middle of the bay for 10 more craft. The bay is used primarily for moorage of transient boats. It is also used to moor commercial fishing boats which come in from Kona to fish in the Hilo area. The Department of Transportation is considering plans to fill in a portion of the bays to expand the container storage yard at the commercial port.

Reeds Bay is a small inlet on the eastern side of Waiakea Peninsula next to the hotel district. It has long been considered a potential site for development of a small craft facility. Existing facilities in the bay include anchor moorings for approximately 16 sailboats, restrooms, and picnic area. The recreational boating needs for the Hilo area are expected to be partially met by the construction of a Federally authorized small boat harbor in Reeds Bay.

TABLE 4

PRINCIPAL HARBORS FOR SMALL CRAFT
HAWAII COUNTY

Harbor	Number of Berthing or Mooring Facilities 1962	1981
West Hawaii County		
Honokahau	0	164
Kawaihae	27	58
Kailua-Kona	49	9 1/
Keauhou	61 2/	16
East Hawaii County (Hilo area) 3/		
Wailoa River	75 4/	54 4/ 5/
Reeds Bay	0	16
Radio Bay	0	12

1/ The number of moorings have been reduced because the Bay is a high risk area for mooring. Honokahau now provdes refuge and permanent all weather wet storage for the area.
2/ Includes mooring capacity by anchor in middle of bay. (Area considered high risk today.)
3/ Field investigations and surveys indicated there were 110 moored craft in the Hilo area in 1980. The State Harbors Division reported available berthing capacity of 82 for the same period.
4/ Inlcudes Wailoa Sampan Basin which in 1981 had 12 berthing spaces.
5/ The decrease in number of berthing spaces is because commercial fishing boat no longer move side-by-side across Wailoa Sampan Basins.

Source: "Report on Survey of The Coasts of the Hawaiian Islands for Light-Draft Vessels," Jun 1967, Honolulu District, Corps of Engineers.
"Hawaii Water Resources Plan," Jan 1979, Hawaii Water Resources Regional Study, Board of Land and Natural Resources, State of Hawaii.
"Small Craft Mooring Facilities Utilization Report," Dec 1981, State of Hawaii, Department of Transportation.

BERTHING SPACE DEMAND

Requirements for berthing spaces were based on an analysis of historical trends, population, growth in vessel registration, latent demand and other factors. Table 5 shows historical and projected demand determinants for the Hilo Tributary Area.

Population. The Hawaii State Department of Planning and Economic Development (DPED) is the source for historical and projected population for the State and Hilo Tributary Area. The OBERS-E projections for the non-SMSA portion of OBERS Economic Region 173 (Hawaii) would ordinarily be applicable to the growth of Hawaii's islands other than Oahu. However, the OBERS projection, made in 1972, forecasts a declining population for this part of the State. In view of the rapid growth that these islands have experienced since 1972, and which seem to have every reason for continuing growth, the OBERS-E projections are not used in this analysis. The projections for the Hilo Tributary Area, based on DPED County growth rate forecasts, follow from historical trends and econometric projections for Series II-F, the state and its island components.

Existing and Projected Fleet. The State Department of Transportation (DOT), Harbors Division, maintains records of small craft registration by island (registered craft). Larger vessels, not required to register with the State, are documented with the U.S. Coast Guard (assumed to be 100% wet-stored). The DOT's Small Boat Harbor Utilization Report periodically lists the capacity, moorings and waiting lists for each harbor. This information is shown in Table 5.

The number of registered commercial craft statewide has been increasing steadily in recent years growing from 380 in 1970 to 1,155 in 1980. This represents an average growth of 11.8 percent per year. Plotting this growth indicates a general trend of growth exhibited by the high projection shown in Figure 1. By the year 2000, the total number of commercial craft in the State would be just over 2,800. The medium projection indicates a general trend of growth in craft, but at the declining rate experienced over the last few years. This trend indicates growth should reach a plateau of about 2,200 craft by year 2000. The medium projection represents an annual growth of 3.3 percent a year for the 20 year period 1980-2000.

The County of Hawaii is the second leading producer of seafood in the State. As a result, commercial waterborne activity on the "Big Island" has been in many instances indicative of overall statewide trends. Three sets of projections (Figure 2) were generated for the commercial fleet in the Hilo Tributary Area based on this analogy. The first projection (high projection, see Table 5) forecasts an increase in the size of the fleet over the next 20 years, based on a linear projection of historical data. The medium projection (Table 6) indicates a growth in total craft but at a decreasing rate and the low projection (Table 7) takes the 1980 ratio of commercial craft to 1000 population and holds it constant throughout the projection period.

Although only one growth projection was chosen for determining the recommended size of a small boat harbor, the range of alternative growth scenarios presented show the sensitivity of such projections in determining total future boating needs. For this study the high projection was selected to represent expected future growth in commercial craft in the study area. The high projection was selected because it represents a meaningful trendline of the historical growth in commercial craft over the past 10 years. The medium projection was discounted because the impact of the decline in commercial craft statewide in the past two years disproportionately affects the total future growth in commercial craft to year 2000. The low projection was discounted because the relationship assumed as a basis for making the projection is contrary to the historical growth in the ratio. The high projection makes a positive statement about growth in the Hilo Tributary Area and is competitive with expected future expansion of the commercial fleet statewide.

The number of berthing space applications for Hilo Tributary Area's harbors is a poor indication of demand. In recent years less than ten applications have been on file. Harbor construction and development in and around Hilo has been of such a small scale, and harbor berths are so few, that the overwhelming majority of Hawaii's boaters have been oriented to trailer-mounted vessels over the years. The demand for harbor space for wet storage is evident; however, waiting lists exist only where there are prospects for new capacity. Waiting lists at other harbors are usually small. There is little turnover, and Hawaii's boaters are accustomed to trailering, despite the problems associated with trailering the larger vessels required for boating in the island's rough waters.

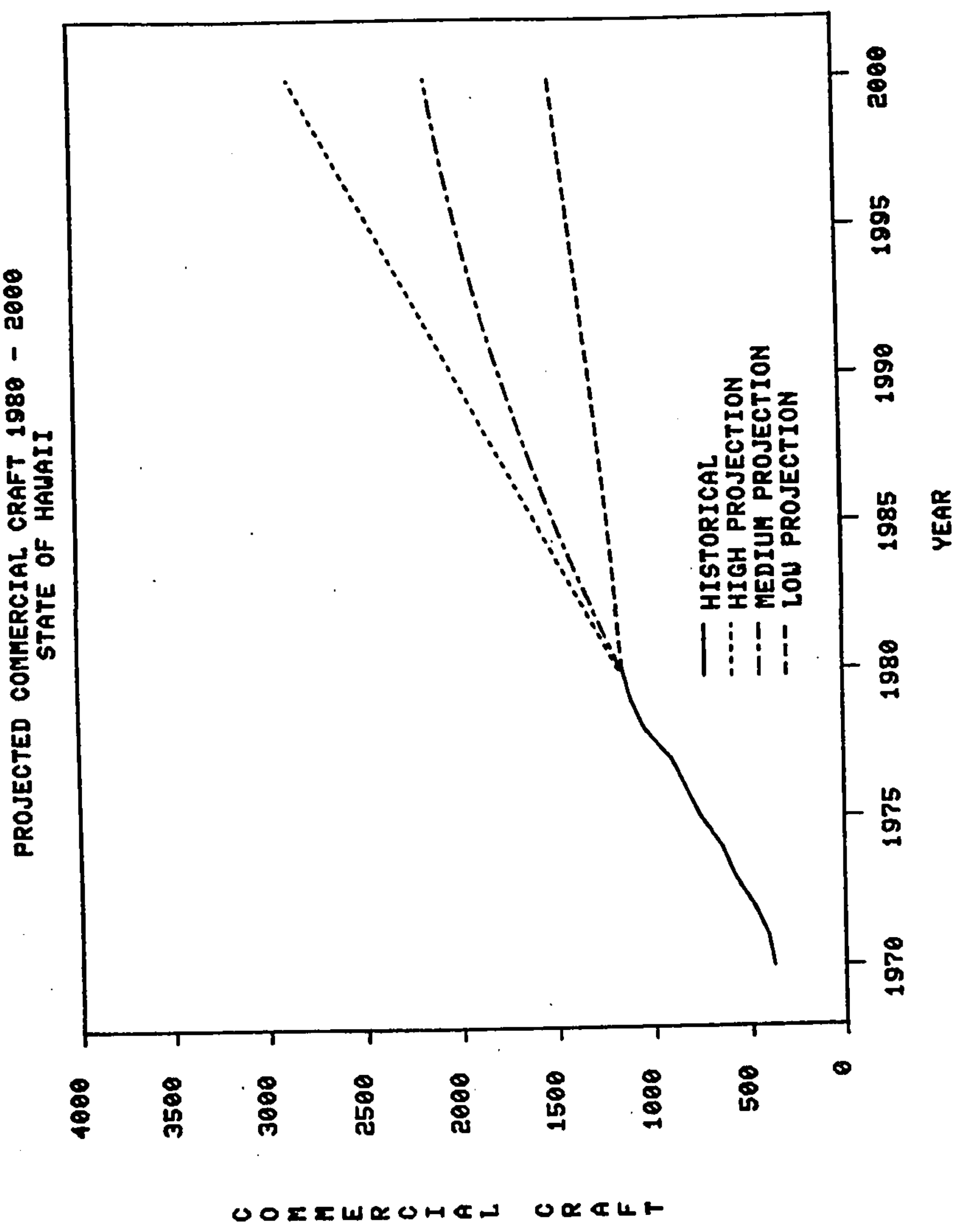
PROJECTED COMMERCIAL CRAFT 1980 - 2000
STATE OF HAWAII
HISTORICAL
HIGH PROJECTION
MEDIUM PROJECTION
LOW PROJECTION
YEAR
1970
1975
1980
1985
1990
1995
2000
COMMERCIAL CRAFT
0
500
1000
1500
2000
2500
3000
3500
4000

Figure 1

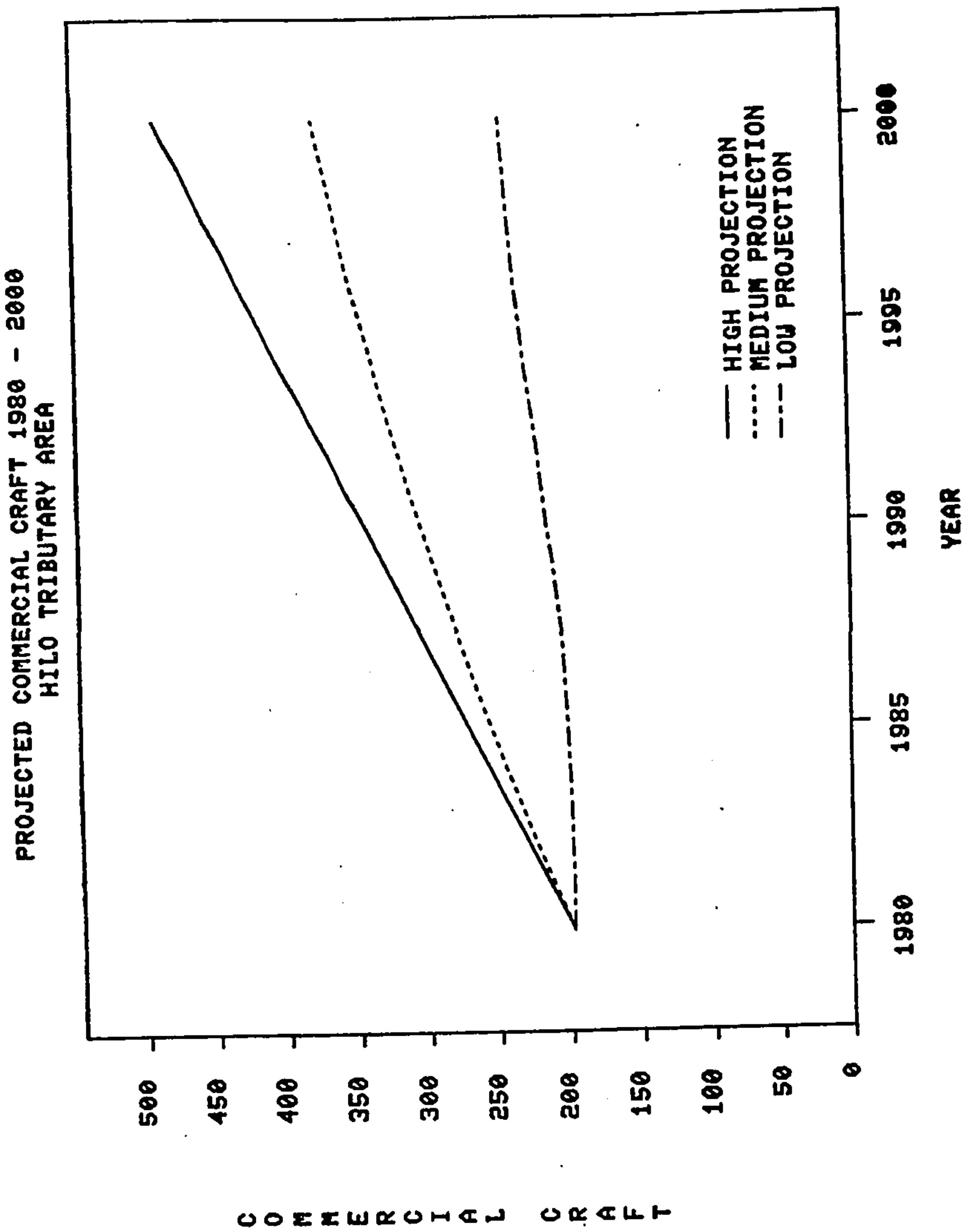
PROJECTED COMMERCIAL CRAFT 1980 - 2000
HILO TRIBUTARY AREA
HIGH PROJECTION
MEDIUM PROJECTION
LOW PROJECTION
1980
1985
1990
1995
2000
YEAR
0
50
100
150
200
250
300
350
400
450
500
COMMERCIAL CRAFT

Figure 2

During Corps of Engineers surveys of commercial boat owners (State of Hawaii Boat Owner Survey, March 1980), respondents were asked to indicate their preferred storage. Those owners of dry-stored craft indicating a preference for harbor berths represent effective demand for mooring berths. The following percentages of owners of dry-stored craft indicated preference for harbor space:

Full-Time Commercial Fishing: 50.0%
Part-Time Commercial Fishing: 23.3%

Existing capacity, coupled with existing and projected fleet sizes, produces a measure of excess demand for berthing spaces. Under the alternative conditions analyzed, this excess demand is assumed to be absorbed in 1985 (base year) and the fleet to then grow proportionately up to the planned harbor capacity constraint. Graphic extrapolation of the series indicates that the total commercial craft in the project base year is projected to be 198 (plus the 4 transient spaces). By 2000 commercial craft in the Hilo area will reach 488 (high projection), 377 (medium projection), and 243 (low projection).

DISTRIBUTION OF CRAFT TYPES

The distribution of the present fleet and average value of vessels and net returns to charter and fishing operations was determined from the boater surveys. Responses also yielded a prospective distribution under. For projection purposes, the percentage distribution between type of storage and values is kept constant. With harbor improvement, the "ideal" distribution would occur in 1985. The distribution of type of storage and values of craft is probably a conservative estimate for the remainder of the project life since there is a continuing statewide trend for an upgrading of the fleet to larger, more expensive craft.

TRANSIENT CRAFT

Hilo is often a destination for craft from other Hawaiian Islands ports. The demand for transient slips is substantial with over 160 transient craft registering with the Coast Guard in Hilo in 1979. Presently four slips are available for transient use in Radio Bay. It is anticipated that four additional transient slips in the proposed harbor would be fully utilized. The value of craft expected to use the transient slips was compiled as a weighted average of values of craft large enough to negotiate the seas between the islands. The average depreciated value per transient craft was determined to be $39,444.

ANNUAL RETURNS

The annual return that accrues to commercial fishing craft (Tables 18, 19 & 20) was derived from information provided by operators of these types of craft within the Hilo Tributary Area. Without a new small boat harbor, the average annual returns for a particular type of commercial fishing craft are expected to be the same as with a harbor. These craft are operated by professional seamen and will probably not be significantly affected by the proposed navigation improvements. However, based on owner responses, the distribution of the commercial fishing fleet would be expected to change -- with a shift toward more moored commercial fishing vessels.

CHARTER CRAFT RETURNS

During the statewide boating survey no responses were received from operators of charter sport fishing craft in the Hilo Tributary Area. At one time a vessel operated out of Hilo but it has since relocated to the Island of Maui. It was assumed, therefore, that no charter craft operate in the study area.

COMMERCIAL FISHING CRAFT RETURNS

1. Full-Time Fishing Craft

The surveys of fishing craft operators of full-time moored craft indicated that each craft averages 285 trips per year. Each craft catches an average of 380 pounds of seafood per trip with an average selling price of $1.46 per pound. Expenses included wages, depreciation, fuel, gear, supplies, maintenance and repair, and other came to $30,697 per craft. A salary of $31,200 per year based on returns to occupations requiring comparable skill and training was imputed to the owner/operator to yield total expenses of $61,897 per craft. Thus, the average full-time moored commercial fishing craft yielded a net catch value of $96,221.

Analysis of full-time trailered fishing craft returns indicated that the average number of trips per year for this group is 235, with a catch of 258 pounds per trip selling at an average of $1.46 per pound. Expenses of $11,648 were determined. A salary of $31,200 per year was imputed to the owner/operator to yield total expenses of $42,848 per craft. Thus, the average full-time trailered commercial fishing craft yielded a net catch value of $45,672.

2. Part-Time Fishing Craft

The State-Wide Boating Survey of part-time fishing craft operators included part-time moored craft and part-time trailer-mounted craft. Analysis of moored part-time fishing craft returns indicated that the average number of trips is 130 with a catch of 109 pounds per trip selling at an average of $1.40 per pound. Expenses totaled $3,536. A salary of $12,480 was imputed to the operator (130 trips x 8 hrs x $12/hr.). Thus, the average part-time moored commercial fishing craft yielded a net catch value of $3,822.

Analysis of trailered part-time fishing craft returns indicated that the average number of trips per year for this group is 105, with a catch of 89 pounds per trip selling at an average of $1.40 per pound. Expenses totalled $1,410. A salary of $10,080 was imputed to the operator (105 trips x 8 hrs. x 12/hr.). Thus, the average part-time trailered commercial fishing craft yielded a net catch value of $1,593.

DAMAGE PREVENTION BENEFITS

The damage prevention benefits are shown in Table 21. The size of the moored fleet without the harbor is expected to remain constant, while the size of the trailered fleet will increase to the year 2000 and then remain constant. Conservatively, the average annual damages were calculated using the 1985 prospective (without improvements) fleet (base year).

TABLE 5. EXISTING AND PROJECTED COMMERCIAL FISHING FLEET - STATE OF HAWAII AND HILO TRIBUTARY AREA-HIGH PROJECTION

YEAR	STATE POPULATION (1000)	STATE REGISTERED COMMERCIAL CRAFT	STATE COMMERCIAL CRAFT PROJECTED	STATE CRAFT/1,000 POPULATION	HILO TRIBUTARY AREA POPULATION (1000)	HILO TRIBUTARY AREA COMMERCIAL CRAFT PROJECTED	HILO TRIBUTARY AREA TOTAL MOORED CRAFT CAPACITY 7/	HILO TRIBUTARY AREA EXCESS DEMAND FOR MOORED SPACE	HILO TRIBUTARY AREA CRAFT/1,000 POPULATION
1970	775.1	380		0.5	41.0		43		
1971	797.4	410		0.5	42.9		43		
1972	820.7	482		0.6	43.6		67		
1973	840.5	582		0.7	45.2		99		
1974	853.5	648		0.8	46.9		100		
1975	868.0	756		0.9	48.4		100		
1976	882.4	832		0.9	49.4		100		
1977	892.8	906		1.0	50.7		100		
1978	902.4	1041		1.2	51.3		106 8/		
1979	914.7	1113		1.2	53.2		106		
1980	964.7 1/	1155		1.2	57.8 1/	198 5/	106	(42) 9/	3.4
1985	1,020.9 2/		1,500 3/	1.5	59.0 4/	272 6/		(65)	4.6
1990	1,091.5		1,780	1.6	63.0	344		(97)	5.5
1995	1,163.8		2,000	1.7	67.9	416		(127)	6.1
2000	1,225.9		2,200	1.8	71.5	488		(147)	6.8

NOTES:

( ) Projected or extrapolated

1/ Census (preliminary).
2/ Projections for 1985-2000 based on II-F projections by County, State Department of Planning and Economic Development, 1979 preliminary.
3/ Projected historical data per Report of Undocumented Vessel Registration, State of Hawaii, Department of Transportation 1970-1980 which indicates a decreasing rate of increase that will maximize at 2200 craft by year 2000.
4/ Puna, South Hilo, and North Hilo Districts, II-F projections, Hawaii Water Resources Regional Study, Social Base - Study Element Report, Page 36.
5/ Existing commercial craft.
6/ Projected based on a linear regression technique, see Figure 2 (High Projection).
7/ Includes recreational and commercial craft.
8/ Commercial craft occupy 52 of the mooring spaces.
9/ Determined from boater responses to Hawaii State-Wide Survey (1980), Commercial Craft.

TABLE 6. EXISTING AND PROJECTED COMMERCIAL FISHING FLEET
HILO TRIBUTARY AREA - MEDIUM PROJECTION

YEAR	HILO TRIBUTARY AREA POPULATION (1000)	TOTAL COMMERCIAL CRAFT PROJECTED	HILO TRIBUTARY AREA TOTAL MOORED CRAFT CAPACITY 5/	EXCESS COMMERCIAL DEMAND FOR MOORED SPACE	HILO TRIBUTARY AREA CRAFT/1,000 POPULATION
1970	41.0		43		
1971	42.9		43		
1972	43.6		67		
1973	45.2		99		
1974	46.9		100		
1975	48.4		100		
1976	49.4		100		
1977	50.7		100		
1978	51.3		106		
1979	53.2		106 6/		
1980	57.8 1/	198 3/		(42) 7/	3.4
1985	59.0 2/	257 4/		(61)	4.6
1990	63.0	305		(82)	4.8
1995	67.9	343		(98)	5.1
2000	71.5	377		(113)	5.3

NOTES:
( ) Projected or extrapolated.

1/ Census (preliminary).
2/ Puna, South Hilo, and North Hilo Districts, II-F Projections, Hawaii Water Resources Regional Study, Social Base-Study Element Report, Page 36.
3/ Existing commercial craft.
4/ Projected growth but at a decreasing rate, see Figure 2 (Medium Projection).
5/ Includes recreational and commercial craft.
6/ Commercial craft occupy 52 of the mooring spaces.
7/ Determined from boater responses to Hawaii State-Wide Survey (1980), commercial craft.

TABLE 7. EXISTING AND PROJECTED COMMERCIAL FISHING FLEET HILO TRIBUTARY AREA - LOW PROJECTION

YEAR	HILO TRIBUTARY AREA POPULATION (1000)	TOTAL COMMERCIAL CRAFT PROJECTED	HILO TRIBUTARY AREA TOTAL MOORED CRAFT CAPACITY 5/	EXCESS COMMERCIAL DEMAND FOR MOORED SPACE	HILO TRIBUTARY AREA CRAFT/1,000 POPULATION
1970	41.0		43		
1971	42.9		43		
1972	43.6		67		
1973	45.2		99		
1974	46.9		100		
1975	48.4		100		
1976	49.4		100		
1977	50.7		100		
1978	51.3		106		
1979	53.2		106 6/		
1980	57.8 1/	198 3/		(42) 7/	3.4
1985	59.0 2/	201 4/		(43)	3.4
1990	63.0	214		(49)	3.4
1995	67.9	231		(58)	3.4
2000	71.5	243		(63)	3.4

NOTES:

( ) Projected or extrapolated.

1/ Census (preliminary).
2/ Puna, South Hilo, and North Hilo Districts, II-F.Projections, Hawaii Water Resources Regional Study, Social Base-Study Element Report, Page 36.
3/ Existing commercial craft.
4/ Projected by holding the 1980 ratio of commercial craft to 1000 population (3.4) constant throughout the projection period, see Figure 2 (Low Projection).
5/ Includes recreational and commercial craft.
6/ Commercial craft occupy 52 of the mooring spaces.
7/ Determined from boater responses to Hawaii State-Wide Survey (1980), commercial craft.

TABLE 8. COMMERCIAL FISHING FLEET DISTRIBUTION-HILO TRIBUTARY AREA - HIGH PROJECTION

PARAMETERS				DISTRIBUTION					
				FULL-TIME FISHING		PART-TIME FISHING			
YEAR	NO. BOATS	WET STORED	DRY STORED	WET	DRY	WET	DRY	TOTAL	TRANSIENT
WITHOUT PROJECT									
1980	198	52	146	26	30	26	116	198	4
1985	272	52	220	26	51	26	169	272	4
1990	344	52	292	26	71	26	221	344	4
1995	416	52	364	26	92	26	272	416	4
2000	488	52	436	26	112	26	324	488	4
WITH PROJECT 1/									
1980	198	52	146	26	30	26	116	198	4
1985	272	117	155	52	25	65	130	272	8
1990	344	149	195	66	31	83	164	344	8
1995	416	179	237	80	38	99	199	416	8
2000	488	209	279	93	45	116	234	488	8

1/ Unconstrained after 1985.

TABLE 9. COMMERCIAL FISHING FLEET DISTRIBUTION-HILO TRIBUTARY AREA – MEDIUM PROJECTION

	PARAMETERS			DISTRIBUTION					
				FULL-TIME FISHING		PART-TIME FISHING			
YEAR	NO. BOATS	WET STORED	DRY STORED	WET	DRY	WET	DRY	TOTAL	TRANSIENT
WITHOUT PROJECT									
1980	198	52	146	26	30	26	116	198	4
1985	257	52	205	26	47	26	158	257	4
1990	305	52	253	26	60	26	193	305	4
1995	343	52	291	26	71	26	220	343	4
2000	377	52	325	26	81	26	244	377	4
WITH PROJECT 1/									
1980	198	52	146	26	30	26	116	198	4
1985	257	113	144	50	23	63	121	257	8
1990	305	134	171	59	27	75	144	305	8
1995	343	150	193	66	31	84	162	343	8
2000	377	165	212	73	34	92	178	377	8

1/ Unconstrained after 1985.

TABLE 10. COMMERCIAL FISHING FLEET DISTRIBUTION-HILO TRIBUTARY AREA - LOW PROJECTION

PARAMETERS				DISTRIBUTION					
				FULL-TIME FISHING		PART-TIME FISHING			
YEAR	NO. BOATS	WET STORED	DRY STORED	WET	DRY	WET	DRY	TOTAL	TRANSIENT
WITHOUT PROJECT									
1980	198	52	146	26	30	26	116	198	4
1985	201	52	149	26	31	26	118	201	4
1990	214	52	162	26	35	26	127	214	4
1995	231	52	179	26	39	26	140	231	4
2000	243	52	191	26	43	26	148	243	4
WITH PROJECT 1/									
1980	198	52	146	26	30	26	116	198	4
1985	201	95	106	42	15	53	91	201	8
1990	214	101	113	45	16	56	97	214	8
1995	231	110	121	49	17	61	104	231	8
2000	243	115	128	51	18	64	110	243	8

1/ Unconstrained after 1985.

TABLE 11. ESTIMATED AVERAGE ANNUAL OPERATING COST OF COMMERCIAL FISHING CRAFT 1/

	FULL-TIME FISHING		PART-TIME FISHING	
	WET	DRY	WET	DRY
Crew Wages	$ 8,918	$ 1,329	-	-
Operator Wages	31,200 2/	31,200 2/	12,480 2/	10,080 2/
Expenses	10,446 3/	8,559 3/	3,536 3/4/	1,410 3/4/
Depreciation	11,333	1,760	-	-
Total Cost	$61,897	$42,848	$16,016	$11,490
Average No. of Trips/ Year	285	235	130	105
Cost/Trip	$ 217	$ 182	$ 123	$ 109

1/ Tabulation and analysis of questionnaire data, State of Hawaii Boat Owner Survey, March 1980; "A Survey of Small Craft Fleet Parameters and Use Patterns Hilo, Hawaii Tributary Area," POD, Corps of Engineers, Dec 1979; "Geological, Biological and Water Quality Investigations Hilo Bay, Hawaii, Fishery Resource Survey," *POD Corps of Engineers*.
2/ Based on returns to occupations requiring comparable skills and training.
3/ Updated from date of survey to reflect increases in operation and maintenance costs.
4/ Includes crew wages and depreciation.

TABLE 12. PROSPECTIVE INCREASE IN FISH CATCH - HILO TRIBUTARY AREA - HIGH PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE FISH CTCH (w/o Project) (1,000 pounds)					
1985	2,816	3,092	368	1,579	7,855
1990	2,816	4,305	368	2,065	9,554
1995	2,816	5,578	368	2,542	11,304
2000	2,816	6,791	368	3,028	13,003
2035	2,816	6,791	368	3,028	13,003
PROSPECTIVE FISH CATCH (w/ Project) (1,000 pounds)					
1985	5,632	1,516	921	1,215	9,284
1990	7,148	1,880	1,176	1,533	11,737
1995	8,664	2,304	1,403	1,860	14,231
2000	10,072	2,728	1,644	2,187	16,631
2035	10,072	2,728	1,644	2,187	16,631
NET INCREASE IN FISH CATCH (1,000 pounds)					
1985	2,816	(1,576)	553	(364)	1,429
1990	4,332	(2,425)	808	(532)	2,183
1995	5,848	(3,274)	1,035	(682)	2,927
2000	7,256	(4,063)	1,276	(841)	3,628
2035	7,256	(4,063)	1,276	(841)	3,628

TABLE 13. PROSPECTIVE INCREASE IN FISH CATCH - HILO TRIBUTARY AREA - MEDIUM PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE FISH CATCH (w/o Project) (1,000 pounds)					
1985	2,816	2,850	368	1,477	7,511
1990	2,816	3,638	368	1,804	8,626
1995	2,816	4,305	368	2,056	9,545
2000	2,816	4,911	368	2,280	10,375
2035	2,816	4,911	368	2,280	10,375
PROSPECTIVE FISH CATCH (w/ Project) (1,000 pounds)					
1985	5,415	1,394	893	1,131	8,833
1990	6,390	1,637	1,063	1,346	10,436
1995	7,148	1,880	1,190	1,514	11,732
2000	7,906	2,061	1,304	1,663	12,934
2035	7,906	2,061	1,304	1,663	12,934
NET INCREASE IN FISH CATCH (1,000 pounds)					
1985	2,599	(1,456)	525	(346)	1,322
1990	3,574	(2,001)	695	(458)	1,810
1995	4,332	(2,425)	822	(542)	2,187
2000	5,090	(2,850)	936	(617)	2,559
2035	5,090	(2,850)	936	(617)	2,559

TABLE 14. PROSPECTIVE INCREASE IN FISH CATCH - HILO TRIBUTARY AREA - LOW PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE FISH CATCH (w/o Project) (1,000 pounds)					
1985	2,816	1,880	368	1,103	6,167
1990	2,816	2,122	368	1,187	6,493
1995	2,816	2,365	368	1,308	6,857
2000	2,816	2,607	368	1,383	7,174
2035	2,816	2,607	368	1,383	7,174
PROSPECTIVE FISH CATCH (w/ Project) (1,000 pounds)					
1985	4,549	909	751	850	7,059
1990	4,874	970	794	906	7,544
1995	5,307	1,031	864	972	8,174
2000	5,523	1,091	907	1,028	8,549
2035	5,523	1,091	907	1,028	8,549
NET INCREASE IN FISH CATCH (1,000 pounds)					
1985	1,733	(971)	383	(253)	892
1990	2,058	(1,152)	426	(281)	1,051
1995	2,491	(1,334)	496	(336)	1,317
2000	2,707	(1,516)	539	(355)	1,375
2035	2,707	(1,516)	539	(355)	1,375

TABLE 15. PROSPECTIVE REVENUE FROM FISH CATCH-HILO TRIBUTARY AREA - HIGH PROJECTION

YEAR	FULL-TIME FISHING		PART-TIME FISHING		TOTAL
	WET	DRY	WET	DRY	
PROSPECTIVE REVENUE (w/o Project) ($1,000)					
1985	4,111	4,515	516	2,211	11,353
1990	4,111	6,285	516	2,891	13,803
1995	4,111	8,144	516	3,559	16,330
2000	4,111	9,914	516	4,239	18,780
2035	4,111	9,914	516	4,239	18,780
PROSPECTIVE REVENUE (w/ Project) ($1,000)					
1985	8,222	2,213	1,289	1,701	13,425
1990	10,436	2,744	1,647	2,146	16,973
1995	12,649	3,364	1,964	2,604	20,581
2000	14,705	3,983	2,301	3,061	24,050
2035	14,705	3,983	2,301	3,061	24,050
INCREASED REVENUE ($1,000)					
1985	4,111	(2,302)	773	(510)	2,072
1990	6,325	(3,541)	1,131	(745)	3,170
1995	8,538	(4,780)	1,448	(955)	4,251
2000	10,594	(5,931)	1,785	(1,178)	5,270
2035	10,594	(5,931)	1,785	(1,178)	5,270

TABLE 16 PROSPECTIVE REVENUE FROM FISH CATCH - HILO TRIBUTARY AREA - MEDIUM PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE REVENUE (w/o Project) ($1,000)					
1985	4,111	4,160	516	2,067	10,854
1990	4,111	5,311	516	2,525	12,463
1995	4,111	6,285	516	2,878	13,790
2000	4,111	7,170	516	3,192	14,989
2035	4,111	7,170	516	3,192	14,989
PROSPECTIVE REVENUE (w/ Project) ($1,000)					
1985	7,906	2,036	1,250	1,583	12,775
1990	9,329	2,390	1,488	1,884	15,091
1995	10,436	2,744	1,666	2,119	16,965
2000	11,543	3,010	1,825	2,329	18,707
2035	11,543	3,010	1,825	2,329	18,707
INCREASED REVENUE ($1,000)					
1985	3,795	(2,124)	734	(484)	1,921
1990	5,218	(2,921)	972	(641)	2,628
1995	6,325	(3,541)	1,150	(759)	3,175
2000	7,432	(4,160)	1,309	(863)	3,718
2035	7,432	(4,160)	1,309	(863)	3,718

TABLE 17. PROSPECTIVE REVENUE FROM FISH CATCH - HILO TRIBUTARY AREA - LOW PROJECTION

YEAR	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL
PROSPECTIVE REVENUE (w/o Project) ($1,000)					
1985	4,111	2,744	516	1,544	8,915
1990	4,111	3,098	516	1,662	9,387
1995	4,111	3,452	516	1,832	9,911
2000	4,111	3,806	516	1,936	10,369
2035	4,111	3,806	516	1,936	10,369
PROSPECTIVE REVENUE (w/ Project) ($1,000)					
1985	6,641	1,328	1,051	1,191	10,211
1990	7,115	1,416	1,111	1,269	10,911
1995	7,748	1,505	1,210	1,361	11,824
2000	8,064	1,593	1,270	1,439	12,366
2035	8,064	1,593	1,270	1,439	12,366
INCREASED REVENUE ($1,000)					
1985	2,530	(1,416)	535	(353)	1,295
1990	3,004	(1,682)	595	(393)	1,524
1995	3,637	(1,947)	694	(471)	1,913
2000	3,953	(2,213)	754	(497)	1,997
2035	3,953	(2,213)	754	(497)	1,997

TABLE 18. COMMERCIAL FISHING BENEFITS - HILO TRIBUTARY AREA - HIGH PROJECTION

YEAR	NO. BOATS	WET STORED	DRY STORED	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL	TRANSIENT
PROSPECTIVE FLEET (w/o Project)									
1980	198	52	146	26	30	26	116	198	4
1985	272	52	220	26	51	26	169	272	4
1990	344	52	292	26	71	26	221	344	4
1995	416	52	364	26	92	26	272	416	4
2000	488	52	436	26	112	26	324	488	4
2035	488	52	436	26	112	26	324	488	4
PROSPECTIVE FLEET (w/ Project)									
1980	198	52	146	26	30	26	116	198	4
1985	272	117	155	52	25	65	130	272	8
1990	344	149	195	66	31	83	164	344	8
1995	416	179	237	80	38	99	199	416	8
2000	488	209	279	93	45	116	234	488	8
2035	488	209	279	93	45	116	234	488	8
RETURN/CRAFT ($)									
AVERAGE DEPRECIATED VALUE 1/				33,380	14,500	13,100	11,313		39,444 3/
% ANNUAL RETURN (Ideal Conditions)				2/	2/	2/	2/		9%
NET ANNUAL RETURN (w/ Project)				96,221	45,672	3,822	1,593		3,549
NET ANNUAL RETURN (w/o Project)				96,221	45,672	3,822	1,593		3,017
PERCENT NET ANNUAL RETURNS (w/o Project)									85%
ANNUAL RETURNS (w/o Project) ($)									
1985				2,501,746	2,329,272	99,372	269,217		26,264 4/
1990				2,501,746	3,242,712	99,372	352,053		26,264
1995				2,501,746	4,201,824	99,372	433,296		26,264
2000				2,501,746	5,115,264	99,372	516,132		26,264
2035				2,501,746	5,115,264	99,372	516,132		26,264
ANNUAL RETURNS (w/ Project) ($)									
1985				5,003,492	1,141,800	248,430	207,090		28,392
1990				6,350,586	1,415,832	317,226	261,252		28,392
1995				7,697,680	1,735,536	378,378	317,009		28,392
2000				8,948,553	2,055,240	443,352	372,762		28,392
2035				8,948,553	2,055,240	443,352	372,762		28,392
TOTAL BENEFIT GAIN ($)									
1985				2,501,746	(1,187,472)	149,058	(62,127)		2,128
1990				3,848,840	(1,826,880)	217,854	(90,801)		2,128
1995				5,195,934	(2,466,288)	279,006	(116,287)		2,128
2000				6,446,807	(3,060,024)	343,980	(142,370)		2,128
2035				6,446,807	(3,060,024)	343,980	(142,370)		2,128

SUMMARY OF COMMERCIAL BENEFITS ($)

YEAR	FULL-TIME	PART-TIME	TOTAL
1985	1,314,274	86,931	1,401,205
1990	2,021,960	127,053	2,149,013
1995	2,729,646	162,719	2,892,365
2000	3,386,783	201,610	3,588,393
2035	3,386,783	201,610	3,588,393

EQUIVALENT AVERAGE ANNUAL BENEFIT ($)

FULL-TIME	PART-TIME	TRANSIENT	TOTAL
2,592,786	157,461	2,128	2,752,375

NOTES:

1/ Derived from surveys of boat owners in Hawaii.

2/ Estimated returns for commercial fishing craft were derived from information provided by operators of these types of craft in the Hilo Tributary Area; the returns for with and without project conditions are expected to remain the same as these professional operators are probably not significantly affected by the channel conditions.

3/ Weighted average of the types of craft expected to stop as transients.

4/ Computed based on the full ideal net return on investment being realized by four boat operators and 85% of the ideal net return on investment of four other boat operators who would take advantage of available transient space, but are not able to.

TABLE 19. COMMERCIAL FISHING BENEFITS - HILO TRIBUTARY AREA - MEDIUM PROJECTION

YEAR	NO. BOATS	WET STORED	DRY STORED	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL	TRANSIENT
PROSPECTIVE FLEET (w/o Project)									
1980	198	52	146	26	30	26	116	198	4
1985	257	52	205	26	47	26	158	257	4
1990	305	52	253	26	60	26	193	305	4
1995	343	52	291	26	71	26	220	343	4
2000	377	52	325	26	81	26	244	377	4
2035	377	52	325	26	81	26	244	377	4
PROSPECTIVE FLEET (w/ Project)									
1980	198	52	146	26	30	26	116	198	4
1985	257	113	144	50	23	63	121	257	8
1990	305	134	171	59	27	75	144	305	8
1995	343	150	193	66	31	84	162	343	8
2000	377	165	212	73	34	92	178	377	8
2035	377	165	212	73	34	92	178	377	8
RETURN/CRAFT ($)									
AVERAGE DEPRECIATED VALUE 1/				33,380	14,500	13,100	11,313		39,444 3/
% ANNUAL RETURN (Ideal Conditions)				2/	2/	2/	2/		9%
NET ANNUAL RETURN (w/ Project)				96,221	45,672	3,822	1,593		3,549
NET ANNUAL RETURN (w/o Project)				96,221	45,672	3,822	1,593		3,017
PERCENT NET ANNUAL RETURN (w/o Project)									85%
ANNUAL RETURNS (w/o Project) ($)									
1985				2,501,746	2,146,584	99,372	251,694		26,264 4/
1990				2,501,746	2,740,320	99,372	307,449		26,264
1995				2,501,746	3,242,712	99,372	350,460		26,264
2000				2,501,746	3,699,432	99,372	388,692		26,264
2035				2,501,746	3,699,432	99,372	388,692		26,264
ANNUAL RETURNS (w/ Project) ($)									
1985				4,811,050	1,050,456	240,786	192,753		28,392
1990				5,677,039	1,233,144	286,650	229,392		28,392
1995				6,350,586	1,415,832	321,048	258,066		28,392
2000				7,024,133	1,552,848	351,624	283,554		28,392
2035				7,024,133	1,552,848	351,624	283,554		28,392
TOTAL BENEFIT GAIN ($)									
1985				2,309,304	(1,096,128)	141,414	(58,941)		2,128
1990				3,175,293	(1,507,176)	187,278	(78,057)		2,128
1995				3,848,840	(1,826,880)	221,676	(92,394)		2,128
2000				4,522,387	(2,146,584)	252,252	(105,138)		2,128
2035				4,522,387	(2,146,584)	252,252	(105,138)		2,128

SUMMARY OF COMMERCIAL BENEFITS ($)

YEAR	FULL-TIME	PART-TIME	TOTAL
1985	1,213,176	82,473	1,295,649
1990	1,668,117	109,221	1,777,338
1995	2,021,960	129,282	2,151,242
2000	2,375,803	147,114	2,522,917
2035	2,375,803	147,114	2,522,917

EQUIVALENT AVERAGE ANNUAL BENEFIT ($)

FULL-TIME	PART-TIME	TRANSIENT	TOTAL
1,949,380	124,162	2,128	2,075,670

NOTES:

1/ Derived from surveys of boat owners in Hawaii.

2/ Estimated returns for commercial fishing craft were derived from information provided by operators of these types of craft in the Hilo Tributary Area; the returns for with and without project conditions are expected to remain the same as these professional operators are probably not significantly affected by the channel conditions.

3/ Weighted average of the types of craft expected to stop as transients.

4/ Computed based on the full ideal net return on investment being realized by four boat operators and 85% of the ideal net on investment of four other boat operators who would take advantage of available transient space, but are not able to.

TABLE 20 . COMMERCIAL FISHING BENEFITS - HILO TRIBUTARY AREA - LOW PROJECTION

YEAR	NO. BOATS	WET STORED	DRY STORED	FULL-TIME FISHING WET	FULL-TIME FISHING DRY	PART-TIME FISHING WET	PART-TIME FISHING DRY	TOTAL	TRANSIENT
PROSPECTIVE FLEET (w/o Project)									
1980	198	52	146	26	30	26	116	198	4
1985	201	52	149	26	31	26	118	201	4
1990	214	52	162	26	35	26	127	214	4
1995	231	52	179	26	39	26	140	231	4
2000	243	52	191	26	43	26	148	243	4
2035	243	52	191	26	43	26	148	243	4
PROSPECTIVE FLEET (w/ Project)									
1980	198	52	146	26	30	26	116	198	4
1985	201	95	106	42	15	53	91	201	8
1990	214	101	113	45	16	56	97	214	8
1995	231	110	121	49	17	61	104	231	8
2000	243	115	128	51	18	64	110	243	8
2035	243	115	128	51	18	64	110	243	8
RETURN/CRAFT ($)									
AVERAGE DEPRECIATED VALUE ($)				33,380	14,500	13,100	11,313		39,444 3/
% ANNUAL RETURN (Ideal Condition)				2/	2/	2/	2/		9%
NET ANNUAL RETURN (w/ Project)				96,221	45,672	3,822	1,593		3,549
NET ANNUAL RETURN (w/o Project)				96,221	45,672	3,822	1,593		3,017
PERCENT NET ANNUAL RETURN (w/o Project)									85%
ANNUAL RETURNS (w/o Project) ($)									
1985				2,501,746	1,415,832	99,372	187,974		26,264 4/
1990				2,501,746	1,598,520	99,372	202,311		26,264
1995				2,501,746	1,781,208	99,372	223,020		26,264
2000				2,501,746	1,963,896	99,372	235,764		26,264
2035				2,501,746	1,963,896	99,372	235,764		26,264
ANNUAL RETURNS (w/ Project) ($)									
1985				4,041,282	685,080	202,566	114,963		28,392
1990				4,329,945	730,352	214,032	154,521		28,392
1995				4,714,829	776,424	233,140	165,672		28,392
2000				4,907,271	822,096	244,608	175,230		28,392
2035				4,907,271	822,096	244,608	175,230		28,392
TOTAL BENEFIT GAIN ($)									
1985				1,539,536	(730,752)	103,194	(43,011)		2,128
1990				1,828,199	(867,768)	114,660	(47,790)		2,128
1995				2,213,083	(1,004,784)	133,770	(57,348)		2,128
2000				2,405,525	(1,141,800)	145,236	(60,534)		2,128
2035				2,405,525	(1,141,800)	145,236	(60,534)		2,128

SUMMARY OF COMMERCIAL BENEFITS ($)

YEAR	FULL-TIME	PART-TIME	TOTAL
1985	808,784	60,183	868,967
1990	960,431	66,870	1,027,301
1995	1,208,299	76,422	1,284,721
2000	1,263,725	84,702	1,348,427
2035	1,263,725	84,702	1,348,427

EQUIVALENT AVERAGE ANNUAL BENEFIT ($)

FULL-TIME	PART-TIME	TRANSIENT	TOTAL
1,105,362	74,742	2,128	1,182,232

NOTES:

1/ Derived from surveys of boat owners in Hawaii.

2/ Estimated returns for commercial fishing craft were derived from information provided by operators of these types of craft in the Hilo Tributary Area; the returns for with and without project conditions are expected to remain the same as these professional operators are probably not significantly affected by the channel conditions.

3/ Weighted average of the types of craft expected to stop as transients.

4/ Computed based on the full ideal net return on investment being realized by four boat operators and 85% of the ideal net return on investment of four other boat operators who would take advantage of available transient space, but are not able to.

It is expected that the proposed improvements will prevent 80 percent of the reported damages. These include grounding, hitting bottom, collisions and other hazards often involved with the harbor or channel conditions.

TABLE 21

ANNUAL DAMAGE PREVENTION BENEFITS[1/]
HILO TRIBUTARY AREA

	Number of Boats	Average Annual Damage Per Boat	Total Annual Damage	Annual Damages Prevented (80%)
Transient	4	$171	$684	$547
Full-Time Commercial Fishing				
- Moored	26	$171	$4,446	$3,557
- Trailered	47	$68	$3,196	$2,557
Part-Time Commercial Fishing				
- Moored	26	$986	$25,036	$20,509
- Trailered	158	$144	$22,752	$18,202
Total	261		$56,114	$45,372

Source: "BENEFIT ANALYSIS OF HILO LIGHT DRAFT HARBOR," POD Corps of Engineers, August 1980.

1/ Tabulation and analysis of questionnaire data, State of Hawaii Boat Owner Survey, March 1980

NED EMPLOYMENT BENEFITS

The computation of EDA benefits is governed by Part IX of the Water Resource Council final rule, 14 December 1979. No such benefits were computed nor claimed for this project.

SUMMARY AND APPORTIONMENT OF BENEFITS

The average annual benefits anticipated for the three projected future conditions are summarized in Table 22.

TABLE 22 SUMMARY AND ALLOCATION OF PROJECT AVERAGE ANNUAL BENEFIT HILO TRIBUTARY AREA (7-7/8%) ($1,000's)

Benefit Category	High Projection 1/	Medium Projection 1/	Low Projection 1/
Full-Time Commercial	$2,592,786	$1,949,380	$1,105,362
Part-Time Commercial	157,461	124,162	75,742
Transient	2,128	2,128	2,128
Damage Prevention	45,372	45,372	45,372
Total	$2,797,747	$2,121,042	$1,228,604
Rounded	$2,800,000	$2,100,000	$1,200,000

1/ High projection annual benefits are based on a boat harbor of 161 berths, medium projection benefits 117 berths, and low projection benefits 67 berths.